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Determinants of Early Infant Feeding Practices in US Hospitals

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An abstract of

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2021

Abstract

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Exclusive breastfeeding (EBF) is the optimal feeding method for most infants for the first 6 months of life and is recommended globally. Despite global recommendations, approximately a fifth of US breastfed newborns are supplemented with infant formula within the first few days of life. This dissertation aimed to examine the relationship between sociodemographic factors, medical factors, breastfeeding intentions, and health care system breastfeeding support with in-hospital EBF among healthy, term newborns.

We examined the most common reasons reported by hospital staff for in-hospital infant formula supplementation of healthy, term, breastfed infants in hospitals using national data from the 2018 Maternity Practices in Infant Nutrition and Care survey (mPINC) (n=2,045 hospitals). These reasons included medical indications (70.0%); maternal request/preference/feelings about breastfeeding such as frustration or lack of confidence (55.9%); lactation management-related issues (51.3%); physical but non-medically indicated reasons (36.7%); social influences (18.8%); perceived cultural/societal/demographic factors (8.2%); and medical staff/institutional practices (4.7%).

Next, we examined the national maternity hospital implementation of the 2018 updated Ten Steps to Successful Breastfeeding and the association with in-hospital EBF prevalence using data from the mPINC survey. Steps with low implementation were rooming-in (18.9%), hospital policies (23.4%), and limited supplementation (28.2%). Limited supplementation was associated with the greatest difference in EBF prevalence [β= 17.2: 95% CI: 15.4, 19.1]. Other significant steps were prenatal breastfeeding education (β= 8.0; 95% CI: 4.0, 12.0), responsive feeding (β= 7.0; 95% CI: 4.1, 9.8), care right after birth (skin-to-skin) (β = 6.7; 95% CI: 5.0, 8.5), and rooming-in (β= 3.3; 95% CI: 1.1, 5.5). We also found a dose response relationship between the number of steps implemented and in-hospital EBF prevalence.

Third, we examined US in-hospital EBF prevalence and associations with Baby-Friendly designation and hospital neighborhood sociodemographic factors using data from the mPINC survey and the American Community Survey. Baby-Friendly designation was associated with 9.1 percentage points higher in-hospital %EBF prevalence compared to non-designated hospitals (95% CI: 7.0, 11.2]. Hospitals located in neighborhoods with a high percentage of Black residents and high percentage of poverty were associated with lower EBF prevalence (β= -3.3; 95% CI: -5.1, -1.4 and β= -3.8; 95% CI: -5.7, -1.8, respectively). Baby-friendly designation was associated with a 4.0 percentage point reduction in the EBF prevalence disparity due to poverty.

Lastly, we examined in-hospital EBF and the association with sociodemographic factors, medical factors, breastfeeding intentions, and breastfeeding support using medical record data (n=8,901 mother-infant dyads) from Grady Memorial Hospital. Black mothers had the lowest prevalence of EBF (27.2%) compared to all other races and ethnicities (Hispanic=31.9%; other=32.3%; Asian=33.2%; and White=48.4%). Factors with the largest associations with in-hospital EBF were maternal age [prevalence ratio (PR): 95% CI; 1.9: 1.4, 2.5 for $\geq$35 years compared to $\leq$17 years), breastfeeding intentions (PR: 95% CI; 0.2: 0.1, 0.2 for intending to formula feed only compared to intending to EBF), and neonatal hypoglycemia (PR: 95% CI; 0.5: 0.4, 0.6). Mother-infant dyads that received a lactation consult were more likely to EBF compared to those who did not (PR: 95% CI; 1.2: 1.2, 1.3).

Our findings signal the need to increase in-hospital breastfeeding support including the Ten Steps to Successful Breastfeeding, particularly limited formula supplementation; Baby-Friendly designation; and lactation support from trained professionals to improve in-hospital EBF. Ongoing, national surveillance of in-hospital EBF, including stratification by sociodemographic factors is needed to guide future intervention efforts.

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Dedication

I dedicate this dissertation to my parents, brother, and husband. Thank you for your constant support, prayers, and love. I also dedicate this dissertation to those souls in passing including my beloved, departed grandmother and to my sweet baby girl with the promise to come. I hope that this dissertation will continue to build a legacy and blaze trails while breaking barriers for the wellbeing of all.

List of abbreviations

ABM	Academy of Breastfeeding Medicine
ACS	American Community Survey
BFHI	Baby-Friendly Hospital Initiative
CBSA	Core based statistical area
CDC	Centers for Disease Control and Prevention
EBF	Exclusive breastfeeding
mPINC	Maternity Practices in Infant Nutrition and Care
NIS	National Immunization Survey
WHO	World Health Organization
ZCTA	Zip code tabulation area

Table of Contents

List of Tables

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

Chapter 7

List of Figures

Chapter 1: Introduction

Exclusive breastfeeding (EBF) for the first 6 months of life, followed by the introduction of complementary foods and continued breastfeeding for 1 year or beyond has been established as the optimal source of infant nutrition in the US (Eidelman, 2012). EBF for the first 6 months of life is also recommended globally, with the introduction of complementary foods beginning at 6 months and continued breastfeeding for 2 years or beyond [World Health Organization (WHO, 2011; Victora et al., 2016]. EBF is defined as feeding only breast milk, not feeding any other liquids (including infant formula or water) or foods, except for medications, vitamin supplements, or mineral supplements [Centers for Disease Control and Prevention (CDC, 2021a)]. The First 1,000 days of life is a critical period for proper growth and development (Victora et al., 2016). As the optimal source of nutrition for infants, EBF during the first 6 months of life is an important public health and clinical issue, with implications for both the infant and mother (Victora et al., 2016).

EBF has short- and long-term benefits for both infants and mothers (Victora et al., 2016). In high-income countries such as the US, breastfeeding is associated with protection against infections (such as otitis media, gastrointestinal tract infections, and respiratory tract infections), sudden infant death syndrome, and possible reductions in overweight and diabetes for the child later in life (Victora et al., 2016; Ip, 2007). A systematic review on the maternal health outcomes associated with breastfeeding in developed countries found that longer durations of breastfeeding were associated with reduced risk of breast cancer, ovarian cancer, hypertension, and type 2 diabetes (Feltner et al., 2018). A dose-response relationship exists between breastfeeding and the associated health benefits, in which greater intensity of breastfeeding is associated with greater health benefits (Victora et al., 2016).

Based on these benefits, several global authorities (WHO, 2011; Victora et al., 2016), US national authorities (US Department of Agriculture and US Department of Health and Human Services, 2020), and clinical guidelines (Lessen & Kavanagh, 2015; The American College of Obstetricians and Gynecologists, 2016; Eidelman, 2012) recommend EBF for about the first 6 months of life. In addition, mothers are recommended to initiate breastfeeding as soon as possible following birth, within the first hour after delivery (WHO, 2018). Early breastfeeding stimulates the production of breast milk (WHO, 2018).

Despite these benefits and recommendations, only 44% of infants were EBF during the first 6 months globally (based on 24 hour recall data on EBF in the previous day) in 2020 compared to the 2025 global target of 50% (WHO, 2015; WHO, 2021). In the US, 26% of infants were EBF until 6 months of life in the US (throughout the first 6 months), compared to Healthy People 2030 goal of 42% (CDC, 2021b; US Department of Health and Human Services, 2020). An estimated 19% of US breastfed infants were supplemented with infant formula in the first 2 days of life in 2017, which increased from 17% in 2016 (CDC, 2021b).

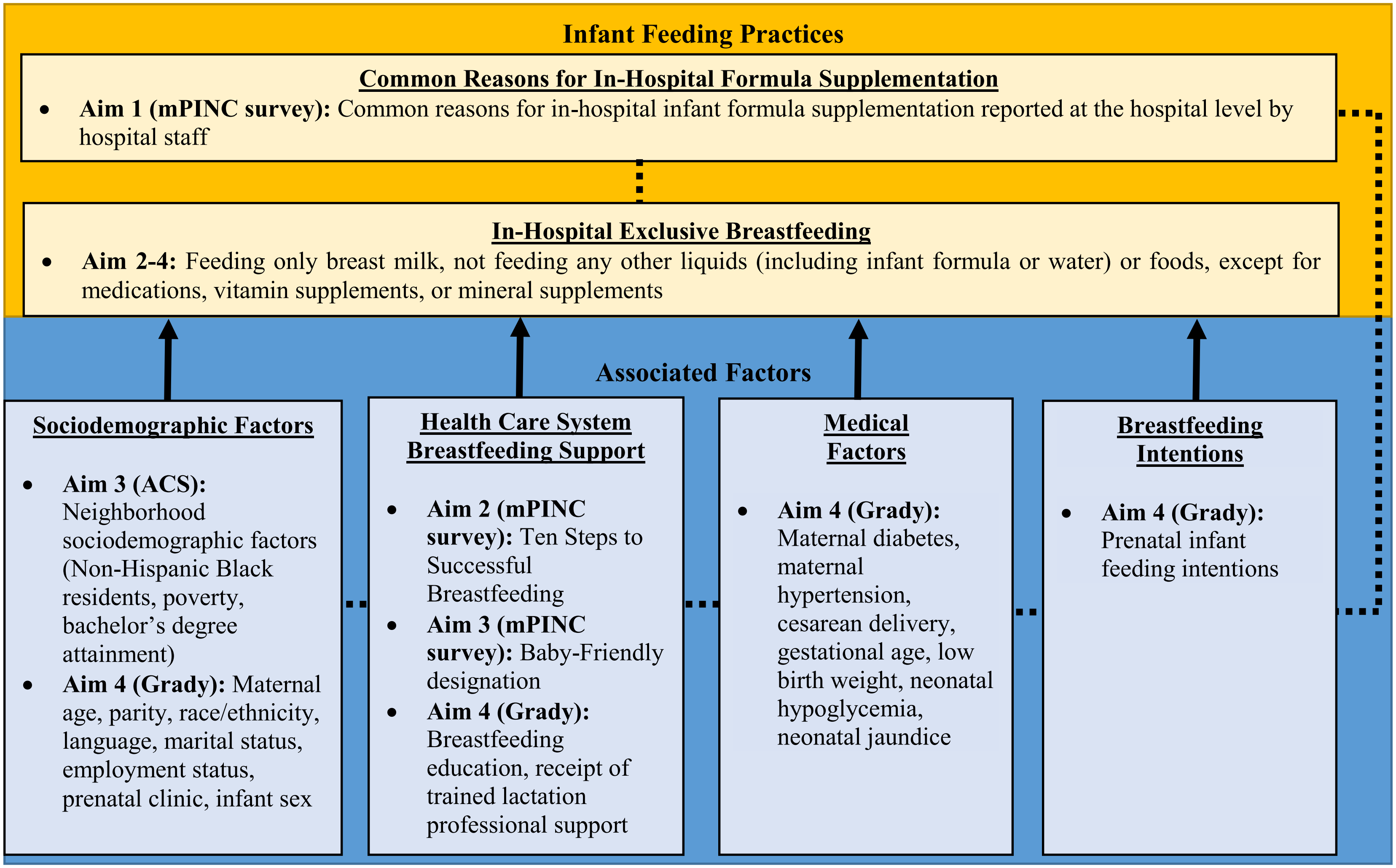
Furthermore, there are sociodemographic EBF disparities in the US (CDC, 2021b). The EBF prevalence at 6 months among non-Hispanic Black infants in 2017 was 21% compared to 29% among non-Hispanic White infants. Families who earned less than the federal poverty level had an EBF prevalence of 20% compared to 31% among families who earn 600% or greater than the federal poverty level in the US (CDC, 2021b). Mothers with less than a high school education had an EBF prevalence of 17% compared to 33% among mothers who completed college (CDC, 2021b).

EBF in the first few days of life is important for establishing a breast milk supply needed for longer durations of breastfeeding (Chantry et al., 2014; McCoy & Heggie, 2020). Formula supplementation, which is often initiated in the hospital, is associated with decreased breastfeeding duration at 1 month, up to the first year of life (Chantry et al., 2014; McCoy & Heggie, 2020). For example, one study found that the hazard of weaning in the first month of life among breastfed infants supplemented with infant formula while in the hospital was 4.1 times the hazard among infants who were EBF in the hospital (McCoy & Heggie, 2020). Few studies have examined the reasons for formula supplementation during the hospital stay following birth. There are several factors associated with breastfeeding initiation and duration in high income countries; however, little is known about in-hospital EBF (Cohen et al., 2018; Reeves & Woods-Giscombe, 2015; Turcksin et al., 2014). The Baby-Friendly Hospital Initiative includes the Ten Steps to Successful Breastfeeding (Ten Steps), a set of maternity care policies and practices that support breastfeeding that are associated with improved breastfeeding outcomes (WHO, 2018). These Ten Steps were updated in 2018, and the national hospital implementation of the updated steps and the association with in-hospital EBF is unknown (WHO, 2018). Few studies have examined if Baby-Friendly designation can modify in-hospital EBF disparities. In addition, there are hospital disparities in breastfeeding outcomes and medical factors that may reduce the likelihood of EBF (The Joint Commission, 2020; Cohen et al., 2018). Grady Memorial Hospital (GMH), which serves a high proportion of low income individuals and racial/ethnic minorities, has an EBF prevalence at hospital discharge of 29% which is below state (40%) and national (52%) averages (The Joint Commission, 2020). Among this marginalized population, prevalence of these factors and the magnitude of association with in-hospital EBF is unknown.

1.1 Objective & Specific Aims

The overall objective of this dissertation is to examine the relationship between sociodemographic factors, medical factors, and health care system breastfeeding support with in-hospital EBF among healthy, term newborns (Figure 1-1). To achieve this objective, we analyzed national, hospital level data and local, individual level data. First, national data from the 2018 Maternity Practices in Infant Nutrition and Care (mPINC) survey were utilized. The mPINC survey includes hospital level data on maternity care and infant feeding policies and practices. The mPINC survey does not collect data on patient sociodemographic characteristics. Therefore, mPINC data were linked to sociodemographic data of the neighborhood surrounding the hospital from the American Community Survey (ACS) including race/ethnicity, poverty, and education. Second, local level data were obtained from medical records of mother-infant dyads at GMH through the Grady Obstetrics and Gynecological Outcomes (GOGO) initiative. For both the national level and local level study at GMH, we focused our analysis on healthy, term, newborns without medical contraindications for breastfeeding. The overall objective was meet through the following four specific aims.

Figure 1-1. Dissertation framework for examining the relationship between sociodemographic factors, medical factors, breastfeeding intentions, and health care system breastfeeding support with in-hospital exclusive breastfeeding



Note. mPINC= Maternity Practices in Infant Nutrition and Care; ACS= American Community Survey

<u>Aim 1)</u> **To examine the most common reasons for in-hospital infant formula supplementation of healthy, term, breastfed infants using a national data set.**

- **Chapter 3:** We analyzed the answers to an open-ended question from the 2018 mPINC survey on the three most common reasons for formula supplementation for 2,045 hospitals. We conducted qualitative, thematic analysis and reported the national, hospital level frequencies for each theme and subcategories for each theme.

<u>Aim 2)</u> **To describe the national maternity hospital implementation of available indicators of the updated Ten Steps and the association with in-hospital EBF prevalence.**

- **Hypotheses**: Indicators of steps related to in-hospital EBF will be positively associated with in-hospital EBF prevalence. The number of steps implemented will be positively associated with in-hospital EBF prevalence.
- **Chapter 4:** We examined the prevalence of Ten Steps indicators utilizing data from the mPINC survey (each step and total number of steps implemented). We used linear regression to examine the association between each step related to in-hospital EBF. Additionally, we examined the relationship between the number of steps implemented and in-hospital EBF.

<u>Aim 3)</u> **To examine US in-hospital EBF prevalence and associations with Baby-Friendly designation and neighborhood sociodemographic factors. To assess if the association between neighborhood sociodemographic factors and in-hospital EBF are modified by Baby-Friendly designation.**

- **Hypotheses:** Baby-Friendly designation and sociodemographic factors will be associated with in-hospital EBF. Baby-Friendly designation will modify the disparities between sociodemographic factors and in-hospital EBF.

- **Chapter 5:** Utilizing data from the mPINC survey, we examined the national and geographic regional in-hospital EBF prevalence (n=2,024). Additionally, utilizing data from the ACS, we examined the association between Baby-Friendly designation and sociodemographic factors with in-hospital EBF prevalence. We conducted linear regression to examine the associations, which included examining effect measure modification terms between Baby-Friendly designation and each of the sociodemographic factors.

Aim 4) To examine the relationships between sociodemographic factors, medical factors, breastfeeding intentions, and health care system breastfeeding support with in-hospital EBF at GMH.

- **Hypotheses:** Sociodemographic factors, medical factors, breastfeeding intentions, and health care system breastfeeding support will be associated with in-hospital EBF.
- **Chapter 6:** Utilizing cross-sectional, medical record data from GMH, we conducted Poison regression analysis to examine the relationship between sociodemographic factors, medical factors, breastfeeding intentions, and health care system breastfeeding support with in-hospital EBF (n= 8,901 mother-infant dyads).

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Chapter 2: Literature Review

Breastfeeding provides protection against many conditions for both the infant and mother over the life course, ranging from protection against otitis media during infancy to protection against type 2 diabetes later in life for both the mother and child (Feltner, 2018; Ip et al., 2007; Victora et al., 2016). In addition to these individual level health benefits, breastfeeding is associated with societal benefits (Stuebe et al., 2017). For example a 5 percentage point increase in breastfeeding [any breastfeeding from birth through 12 months and exclusive breastfeeding (EBF) from birth through 6 months] is estimated to be associated with a reduction of approximately 100,000 cases of otitis media (Stuebe et al., 2017). This reduction in otitis media cases could save an estimated $31,000,000 in associated medical cost in the US (Stuebe et al., 2017). There are even broader global economic benefits and health benefits (Victora et al., 2016). Breastfeeding at a near universal level is estimated to prevent 823,000 annual deaths in children younger than 5 years and 20,000 annual deaths from breast cancer (Victora et al., 2016).

EBF is recommended for the first 6 months of life globally, with continued breastfeeding after the introduction of complementary foods for 1 year or beyond in the US and for two years or beyond by the World Health Organization (WHO) (WHO, 2011; US Department of Agriculture and US Department of Health and Human Services, 2020; Lessen & Kavanagh, 2015; The American College of Obstetricians and Gynecologists, 2016; Eidelman, 2012). Healthy People 2030 goals set in the US are to increase EBF at 6 months to 42.4%; in 2017, an estimated 26% of infants were EBF in the US (CDC, 2020a; US Department of Health and Human Services, 2020). There are sociodemographic disparities in EBF for the first 6 months of life in the US. For example, 21% of Non-Hispanic Black infants are EBF at 6 months compared to 29% of Non-Hispanic White infants in the US (CDC, 2020a). The prevalence of EBF at 6 months for families who earn less than the federal poverty level is 20% compared to 31% among families who earn 600% or greater than the federal poverty level in the US (CDC, 2020a). Among breastfed infants in the US, 19% are supplemented with infant formula in the first 2 days of life US (CDC, 2020a).

Reviews have identified determinants of breastfeeding to inform conceptual frameworks, including global reviews (Rollins et al., 2016), reviews in other high income countries such as the UK (Yngve & Sjöström, 2001), and reviews in the US (Feltner, 2018). Key components identified across these reviews include macrosystem factors, settings factors, and individual factors (Table 2-1). The macrosystem includes public policies at the local, state, and federal level that determine the support available such as national recommendations for infant feeding, surveillance systems, and maternity leave policies (Yngve & Sjöström, 2001). This also includes the cultural norms related to infant feeding, for example, reactions to breastfeeding in public and cultural practices such as discarding colostrum or prelacteal feeds due to the perception that colostrum is harmful (Rollins et al., 2016). Settings factors include health systems and services such as the Baby-Friendly Hospital Initiative Ten Steps to Successful Breastfeeding (Feltner, 2018; Rollins et al., 2016). Additional settings factors include family influence from mothers, sisters, partners, or peers and work place factors such as work-time breaks to breastfeed or pump (Feltner, 2018; Rollins et al., 2016). Individual factors include demographic attributes such as race/ethnicity, socioeconomic status, educational level, age of the mother, gender of the child, marital status, employment, etc. (Yngve & Sjöström, 2001). Individual factors also include medical factors that are present from the prenatal to early postnatal period such as maternal hypertension and neonatal hypoglycemia (Rollins et al., 2016). Breastfeeding intentions, as well as breastfeeding self-efficacy and perceptions such as perceived inadequate milk supply are individual factors (Rollins et al., 2016).

These previously developed conceptual frameworks broadly focus on early initiation, EBF, and continued breastfeeding (Feltner, 2018; Rollins et al., 2016; Yngve & Sjöström, 2001). Our work will add to these existing reviews by specifically focusing on in-hospital EBF and will include the factors listed in Table 2-1. At the macrosystem level, we will examine common reasons for in-hospital formula supplementation. Since our examination of common reasons for in-hospital formula supplementation included an open-ended response from hospital staff, this encompasses all three types of factors. Settings factors additionally include health care system breastfeeding support factors such as Baby-Friendly designation, Ten Steps to Successful Breastfeeding, breastfeeding education, and receipt of trained lactation professional support. Individual factors additionally include sociodemographic factors (e.g. race/ethnicity, poverty, education, etc.), medical factors (maternal diabetes, gestational age, neonatal hypoglycemia, etc.), and prenatal breastfeeding intentions.

This chapter provides relevant background information on the physiology of lactation, the exposures or factors examined in this dissertation, and in-hospital EBF in seven sections. First, we provide an overview of the physiology of lactation, including the timing and regulation of each phase. Second, we discuss formula supplementation and the relationship with breastfeeding duration, possible medical indications for formula supplementation, and non-medically indicated reasons for formula supplementation. The third section describes sociodemographic factors and disparities. The fourth section describes medical factors that are associated with lower breastfeeding outcomes such as diabetes, hypertension, body mass index, and cesarean deliveries among mothers and hypoglycemia, jaundice, birth weight, and gestational age among infants.

Fifth, we review the literature on the relationship between breastfeeding intentions and EBF. In the sixth section, we review health care system breastfeeding support (including the Ten Steps to Successful Breastfeeding and Baby-Friendly hospital designation) and the relationship with in-hospital EBF. The seventh section reviews the existing national data sources of EBF in the US. Lastly, we summarize the current literature and research gaps.

Table 2-1. Factors associated with breastfeeding initiation, exclusivity, and duration

Factors	Examples from previous frameworks	Factors examined related to in-hospital infant feeding
Individual	**Demographic attributes:** Factors such as race/ethnicity, socioeconomic status, educational level, age of the mother, marital status	• Common reasons for in-hospital infant formula supplementation • Race/ethnicity • Poverty • Education • Maternal age • Parity • Language • Marital status • Infant sex
	Medical factors: Maternal and infant medical factors that are present from the prenatal period through the early postnatal period. Example *maternal medical factors* include maternal diabetes, maternal hypertension, cesarean delivery, maternal obesity, thyroid disease, cystic fibrosis, polycystic ovarian syndrome, previous breast surgery, previous breast abscess, lack of noticeable breast enlargement or tenderness during puberty or pregnancy, history of infertility, conception assisted reproductive technology, medications or inadequate counseling on maternal medical safety in lactation, prolonged labor, long induction or augmentation of labor, postpartum hemorrhage, infection, breast anatomy (e.g. flat, inverted, or large nipples, etc.), and delayed lactogenesis II (onset of copious milk secretion). Example *infant medical factors* include gestational age, low birth weight, neonatal hypoglycemia, neonatal jaundice, multiples, oral anatomy (cleft lip or palate, anklyloglossia, macroglossia, etc.), neurologic problems (hypertonia, hypotonia, etc.), infection, respiratory distress, birth trauma, ineffective or sustained	• Common reasons for in-hospital infant formula supplementation • Maternal diabetes • Maternal hypertension • Cesarean delivery • Gestational age • Low birth weight • Neonatal hypoglycemia • Neonatal jaundice

	suckling, excessive weight loss (>7%-0% of birth weight), early pacifier use, and dehydration.	
	Psychosocial attributes: Breastfeeding intentions, breastfeeding self-efficacy, and perceptions (e.g. maternal perception of low milk supply). Other psychosocial conditions include mental health conditions such as depression and anxiety.	• Common reasons for in-hospital infant formula supplementation • Prenatal breastfeeding intentions
Settings	**Health systems and services:** Maternity care practices that are supportive of breastfeeding such as the Baby-Friendly Hospital Initiative Ten Steps to Successful Breastfeeding.	• Common reasons for in-hospital infant formula supplementation • Baby-Friendly Hospital Initiative designation • Ten Steps to Successful Breastfeeding • Breastfeeding education • Receipt of trained lactation professional support
	Family and community: Influence from mothers, sisters, partners, or peers	• Common reasons for in-hospital infant formula supplementation
	Workplace and employment: Early intention to return to work and work-time breaks to breastfeed or pump	• Common reasons for in-hospital infant formula supplementation • Employment status
Macrosystem	**Public policy:** Public policies at the local, state, and federal level that determine the support available such as national recommendations for infant feeding, surveillance systems, and maternity leave policies.	• Common reasons for in-hospital infant formula supplementation
	Cultural norms: Reactions to breastfeeding in public and cultural practices such discarding colostrum or prelacteal feeds due to the perception that colostrum is harmful.	• Common reasons for in-hospital infant formula supplementation

Note. Adapted from Yngve, 2001; Rollins, 2016; Feltner, 2018; and Feldman-Winter et al., 2020

2.1 Physiology of Lactation

Early exclusive breastfeeding (EBF) is important for establishing a breast milk supply needed for longer durations of breastfeeding, for which there is a dose response relationship between the duration and intensity of breastfeeding and the associated health benefits (McCoy & Heggie, 2020; Pang & Hartmann, 2007). The physiology of lactation occurs in response to the interplay of hormones and stimulation or removal of breast milk (Baker, 2013; Lawrence, 2016). There are five stages of breast changes that occur during pregnancy and breastfeeding, which are: 1) mammogensis (development of mammary glands), 2) lactogenesis I (secretory differentiation), 3) lactogenesis II (secretory activation), 4) lactogenesis III (galactopoesis), and 5) involution (weaning) (Baker, 2013; Lawrence, 2016).

Mammogenesis begins in utero and continues during puberty (Baker, 2013; Lawrence, 2016). During the first trimester of pregnancy, mammogenesis further includes the development of mammary glands and related structures of the breast, and the mammary cells become competent to secrete milk products (Baker, 2013; Lawrence, 2016). During pregnancy, multiple hormones stimulate mammogenesis (Baker, 2013). Acceleration of growth is stimulated by human placental lactogen, prolactin, human chorionic gonadotropin, and estrogen (Baker, 2013). Ductal sprouting is stimulated by estrogen (Baker, 2013).

Lactogenesis I occurs approximately around 16 weeks prenatally and colostrum (early milk) is produced (Baker, 2013; Lawrence, 2016). Colostrum is high density (gel-like), yellow in color (reflective of high levels of beta-carotene), and high in immune factors (such as secretory immunoglobulin A) (Baker, 2013; Lawrence, 2016). The primary function of colostrum is to provide a protective coat to the gut and is produced in volumes that are parallel to the infant's stomach capacity (Baker, 2013; Lawrence, 2016). High levels of progesterone produced by the placenta suppress the secretory activity or the release of colostrum (Baker, 2013; Lawrence, 2016).

Lactogenesis II is characterized by the onset of copious milk secretion, and this phase occurs between 30 to 72 hours after the delivery of the placenta (Baker, 2013; Lawrence, 2016). During lactogenesis II, the control of lactogenesis transitions from endocrine control (or control by hormones released from the placenta) to autocrine control (local control, or milk synthesis decreases as the breast fills with milk) (Gardner et al., 2015). Lactogenesis II, is a critical phase in breastfeeding connecting breastfeeding initiation and duration (Baker, 2013; Lawrence, 2016). There are several biological and behavioral factors for both mothers and infants associated with delayed lactogenesis II (Dewey, 2001). Maternal biological risk factors include parity, mode of delivery, smoking, breast or nipple abnormalities or surgery, anxiety, stress, obesity, diabetes, long stage II labor, retained placental fragments, and other maternal illness interfering with early breast milk removal (Scott et al. 2007; Chantry et al., 2011; Baker, 2013; Nommsen-Rivers et al., 2010; Dewey, 2001). Maternal behavioral factors include motivation to breastfeed, social support, nursing frequency, use of supplements, use of pacifiers, and breastfeeding experience (Dewey, 2001). Infant biological factors include birth weight, gestational age, and suckling ability (Dewey, 2001). Infant behavioral factors include temperament and suckling style (Dewey, 2001).

Lactogenesis III is the maintenance phase of lactation, which is dependent upon autocrine or local control (Baker, 2013; Lawrence, 2016). Milk synthesis during the fourth phase of lactogenesis is controlled by two local mechanisms within the breast: 1) the feedback inhibitor of lactation (FIL) and 2) prolactin (Baker, 2013; Lawrence, 2016). FIL down regulates milk synthesis, and removal of milk and FIL increases the rate of milk synthesis whereas milk stasis decreases the rate of milk synthesis (Baker, 2013; Lawrence, 2016). Similarly, milk accumulation in the breast distorts prolactin (the hormone responsible for milk production) receptors, impeding the binding of prolactin to the receptors, and preventing milk production (Baker, 2013; Lawrence, 2016). Therefore, the rate of milk synthesis is slower when milk accumulates in the breast and milk removal is needed to maintain the milk supply (Baker, 2013; Lawrence, 2016). In addition to these two local mechanisms that control milk synthesis during lactogenesis III, oxytocin is the hormone that stimulates the milk ejection reflex (Baker, 2013). Oxytocin causes the contraction of myoepithelial cells surrounding the alveoli, which forces milk to move into the collecting ducts of the breast (Baker, 2013). Maternal stress has been reported to interfere with the release of oxytocin (Dewey, 2001).

Involution, or the fifth phase, occurs when the milk-producing system is no longer stimulated by milk removal (Baker, 2013; Lawrence, 2016).

Considering the timing and control of each phase of lactogenesis, EBF during lactogenesis II is important for establishing a milk supply needed for longer durations of breastfeeding and the associated health benefits.

2.2 Formula Supplementation

Infant formula supplementation in the first few days of life can result in decreased removal of breast milk and can interfere with the normal physiology of lactation, particularly lactogenesis II, which is important for transitioning to the maintenance phase of lactation needed for longer durations of breastfeeding (Baker, 2013; Chantry et al., 2014; Lawrence, 2016; McCoy & Heggie, 2020; Pang & Hartmann, 2007).

2.2.1 Formula supplementation and breastfeeding duration

In-hospital formula supplementation during the hospital stay following birth is associated with decreased breastfeeding duration (Chantry et al., 2014; McCoy & Heggie, 2020). A national study using data from the 2005-2007 Infant Feeding Practices Study II found that after adjusting for maternal characteristics (e.g. maternal age, race/ethnicity, poverty-to-income ratio, education, etc.), not receiving supplemental feedings in the hospital was associated with 2.3 times the odds of meeting exclusive breastfeeding intentions compared to infants that received supplemental feedings (Perrine et al., 2012). A prospective study which followed mother-infant dyads from the prenatal period to 60 days after birth found that in-hospital formula supplementation use was associated with a 2.7-fold increased risk of breastfeeding cessation by day 60, after adjusting for infant feeding intentions (Chantry et al., 2014). A study conducted among participants in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) found that in-hospital formula supplementation was associated with 2.5 times higher risk of weaning within the first year of life (McCoy & Heggie, 2020).

2.2.2 Formula supplementation- Possible medical indications compared to non-medical factors

Formula supplementation is necessary in some cases and the Academy of Breastfeeding Medicine Clinical Protocol #3 on Supplementary Feedings in the Healthy, Term, Breastfed

Neonate outlines possible indications for supplemental feedings (Kellams et al., 2017). Possible infant indications for formula supplementation include asymptomatic hypoglycemia; clinical or laboratory evidence of significant dehydration; weight loss of ≥8-10% on day 5 or later; delayed bowel movements; and hyperbilirubinemia (Kellams et al., 2017). Maternal indications for formula supplementation include delayed secretory activation or lactogenesis II (day 3-5 or later and inadequate intake by the infant); primary glandular insufficiency; breast pathology or prior breast surgery resulting in poor milk production; temporary cessation of breastfeeding due to certain medications such as chemotherapy; and intolerable pain during feedings that is unrelieved by interventions (Kellams et al., 2017). Although these conditions may indicate formula supplementation, this protocol also outlines recommendations to support continued breastfeeding (Kellams et al., 2017). These recommendations include first preventing the need for supplementation by providing supportive clinical practices (e.g. prenatal education on lactation management, skin-to-skin, rooming-in, etc.) (Kellams et al., 2017). Second, possible indicators should be addressed early including notifying medical providers and assessing position, latch, and milk transfer before supplementation (Kellams et al., 2017). Third, the medical provider should determine on a case-by-case basis if the clinical benefits outweigh the negative consequences (Kellams et al., 2017). Additionally, expressed breast milk from the infant's mother should be the first choice for supplemental feeding, followed by donor human milk when available (Kellams et al., 2017).

Although there are some scenarios when formula supplementation is necessary, these situations are few, and in many cases formula supplementation is unnecessary. Studies have shown associations between non-medically indicated formula supplementation in the hospital setting and maternal sociodemographic factors, such as maternal race/ethnicity, educational level, and income (Garrison & Maisano, 2019; Nguyen et al., 2017). For example, a study conducted in New York hospitals found that breastfed Black and Hispanic newborns were 1.54 and 1.25 times, respectively, more likely to be supplemented with infant formula during the birth hospitalization compared to breastfed White newborns (Nguyen et al., 2017). This study also found that mothers with a high school education were 1.74 times more likely to be supplemented with infant formula during the birth hospitalization compared to mothers with a master's degree (Nguyen et al., 2017). There are some cultural beliefs related to maternal race and ethnicity that have been reported to be related to infant formula supplementation (Kaufman, 2010; Hohl, 2016; Wambach, 2016). For example, qualitative studies have reported that Black women understand the benefits of breastfeeding; however, there are reported concerns that breast milk alone does not provide sufficient nutrition among Black women (Kaufman, 2010). Furthermore, qualitative studies have reported that breastfeeding is a part of Hispanic cultural heritage; however, formula supplementation occurs due to adapting to life in the US, in which there is an economic pressure to work (Hohl, 2016; Wambach, 2016). Mothers with lower levels of education and lower incomes are reported to have jobs with less autonomy to pump at work, which has been reported to influence breastfeeding duration in qualitative studies; however, studies have not examined the effect of these factors on in-hospital formula supplementation (Hardison-Moody et al., 2018).

In addition, not attending a prenatal breastfeeding class, primiparous status, cesarean birth, no previous breastfeeding experience, birth weight, and neonates born at night are at greater risk for non-medically indicated formula supplementation (Garrison & Maisano, 2019; Pierro et al., 2016; Tender et al., 2009). Infants whose mothers did not attend a prenatal breastfeeding class was associated with 4.7 higher odds of in-hospital formula supplementation compared to those who did (Tender, 2009). Furthermore, there is overall increasing knowledge about the benefits of breastfeeding among mothers; however, women often lack practical knowledge of breastfeeding positioning and latching, particularly if they have no previous breastfeeding experience (including first time mothers) (Reeves & Woods-Giscombe, 2015). Cesarean section delivery is not a medical indication for formula supplementation; however, the effect of anesthesia and separation of the mother-infant dyad after delivery are potential mechanisms for the association between cesarean delivery and lower breastfeeding outcomes, including delayed lactogenesis II (onset of copious milk secretion) (Kutlucan et al., 2014; Martin et al., 2018; Dewey, 2001). Newborns with low birth weights may have poorly developed fat pads in their cheeks, which can influence the ability to sustain adequate levels of suction to feed at the breast (Genna, 2008). Lactation management support methods such as external counter pressure may assist low birth weight newborns to effectively feed at the breast (Genna, 2008). One study reported that the hazard of formula supplementation among infants born between 7 pm and 9 am was 1.6 times higher than those born during the remaining day hours (Gagnon, 2005). This was reported to be due to mothers being more tired and frustrated during the night hours compared to the day hours (Gagnon, 2005).

2.2.3 Reasons for formula supplementation

Few studies have examined reasons for formula supplementation. A study conducted among 150 WIC participants in Washington, DC found no medical indication for 87% of the formula supplementation of breastfed infants. In this study, maternal report of reasons for formula supplementation included mothers wanted the infant to get formula, mothers were unsure why the infant got formula (nurses fed infant formula without the mother's consent), mothers' perception of inadequate milk supply, infant illness, doctor or nurse recommendation, cesarean section and/or maternal medications, and poor latch (Tender et al., 2009). Another individual level study conducted among mother-infant dyads in an urban, community, teaching hospital found that the most common reasons for formula supplementation were perception of inadequate milk supply, desire for sleep, and a plan to breast and bottle feed (Pierro et al., 2016). A nation-wide analysis using data from the Maternity Practices in Infant Nutrition and Care survey (a national survey of maternity hospitals in the US completed by hospital staff that collects hospital level data) examined frequency of the reason for the provision of formula supplementation among healthy, term, breastfed newborns. This analysis found that 65% of breastfed infants were supplemented with infant formula for mothers' choice, 25% for doctors' orders, and 8.7 % for nurses' recommendations (Nelson et al., 2016).

In summary, studies have examined individual-level reasons for formula supplementation. However, little is known about reasons for formula supplementation, particularly at the hospital level using an open-ended question approach to examine the most common reasons for formula supplementation. Previously conducted national analyses may not capture the various factors that influence infant formula supplementation due to the use of a closed-ended question with the options of mothers' choice, doctors' orders, and nurses' recommendation (Nelson et al., 2016). Examples of other potential factors include sociodemographic factors, physical conditions that may require additional lactation management support but are not medical indications for formula supplementation such as birth weight and maternal knowledge of lactation management (Nguyen et al., 2017; Garrison & Maisano, 2019; Genna, 2008; Tender, 2009; Reeves & Woods-Giscombe, 2015). Therefore, an open-ended question could potentially help further understand the various common reasons for formula supplementation at the national level.

2.3 Sociodemographic Factors (Race/Ethnicity, Education, Income, Maternal Age)

With the existing data available, national disparities in breastfeeding practices have been reported by race/ethnicity, education, poverty, and geography (CDC, 2021a; Li et al., 2019; Anstey, 2017). Based on data from the National Immunization Survey (NIS) for children born in 2017, the national mean EBF prevalence at 3 months is 47% (CDC, 2021a). However, 39% and 42% of Non-Hispanic Black (Black) and Hispanic infants born in the US were EBF at 3 months, respectively, compared to 52% of Non-Hispanic White infants (White) (CDC, 2021a). Using NIS data, an analysis found that the adjusted difference for EBF at 6 months between Black and White infants increased from 0.5 to 4.5 percentage points from 2009-2010 to 2014-2015 (Li et al., 2019). Mothers without a college degree (45%) have an EBF prevalence at 3 months less than the national average (47%) (CDC, 2021a). Families who earn less than the federal poverty level have an EBF prevalence at 3 months of 39%, which is 8 percentage points lower than the national average (CDC, 2021a). There are also geographical differences in EBF. A previously conducted national analysis of infants born from 2010-2013 found that the EBF prevalence at 6 months among Black infants was significantly lower by at least 10 percentage points than White infants in 12 US states, of which 6 states were located in the Southeast and Midwest (Anstey et al., 2017). In addition, disparities exist among hospitals. Grady Memorial Hospital (GMH), which serves a high proportion of low income individuals and racial/ethnic minorities, has an in-hospital EBF prevalence of 32% which is below state (40%) and national (52%) averages (The Joint Commission, 2019).

Studies have examined the relationship between sociodemographic factors and in-hospital EBF. A study conducted in the state of New Jersey examined the association between neighborhood disadvantage (which was measured as indices of averages of income, poverty, public assistance, unemployment, and vacant housing) and in-hospital EBF prevalence with data collected from birth certificates (Yourkavitch et al., 2018). This study found that the odds of in-hospital EBF prevalence decreased as neighborhood disadvantage increased for Black, Hispanic, and Asian women (Yourkavitch et al., 2018). To our knowledge, only one study has examined the relationship between sociodemographic factors and in-hospital EBF prevalence in hospitals across the US (Patterson et al., 2018). This study utilized data from the American Community Survey for sociodemographic characteristics of the census tracts surrounding the hospital and the Joint Commission for in-hospital EBF prevalence (Patterson et al., 2018). At the time of this study, The Joint Commission required that hospitals with 1,100 births or more per year report their EBF prevalence (Patterson et al., 2018). This study found that EBF prevalence was positively associated with bachelor's degree attainment, income, and residents who identified as White or Asian (Patterson et al., 2018). In contrast, this study found that EBF prevalence was negatively associated with having less than a college education, living below poverty, and identifying as Black or Hispanic (Patterson et al., 2018). The regional differences in-hospital EBF are unknown.

Black infants have the lowest proportions of EBF at 3 and 6 months and there are persistent disparities compared to White infants, despite improvements in recent years (CDC, 2021a; Li et al., 2019). Black mothers and children are disproportionately affected by adverse health outcomes, such as obesity, diabetes, and hypertension, that may be reduced by breastfeeding (Cheng et al., 2019; Feltner, 2018; Ghosh et al., 2014; Hales et al., 2020; Ip et al., 2007; Victora et al., 2016). Therefore, understanding and addressing breastfeeding disparities among Black mother-infant dyads is important to addressing health disparities. Furthermore, breastfeeding outcomes disparities between Black and White mothers are reported to be mediated through differences in maternal age, employment, poverty, college education, and marital status (McKinney et al., 2016; Safon et al., 2021).

While studies have examined the associations between sociodemographic factors such as race/ethnicity and breastfeeding outcomes, it is important to distinguish these associations from determinants or causes of breastfeeding outcomes. Race is a social construct, and not a valid biologic construct (Duggan et al., 2020). Therefore, the use of race in statistical models represents broader social issues that impact individuals' experiences, such as racism (Duggan et al., 2020). Racism includes a system of structuring opportunity and assigning value based on social interpretation of how a person looks (Jones, 2000). In the past, public health research has adjusted for race or restricted studies to one racial group instead of exploring the etiology of disparities (Jones et al., 1991).

A theoretical framework for understanding race-associated differences in health outcomes includes 3 levels of racism: institutionalized, personally mediated, and internalized racism (Jones, 2000). Institutionalized racism is defined as differential access to goods, services and opportunities by race, such as lower access to maternity care practices supportive of breastfeeding (Jones, 2000; Lind et al., 2014). In addition, the origin of the relationship between socioeconomic status and race in the US is related to historical events such as slavery and Jim Crow laws, which limited economic mobility among the Black population (Jones, 2000). Personally mediated racism refers to prejudice (assumptions about individuals) and discrimination (differential actions toward others) based on their race, for example not providing breastfeeding support based on assumptions such as "Black women do not breastfeed" (Jones, 2000; Panchula, 2012). Internalized racism is the acceptance of members of stigmatized races of the messages relayed by others about them and their intrinsic worth (Jones, 2000). An example of internalized racism is the report of lower breastfeeding self-efficacy among US born, Black women (McCarter-Spaulding & Gore, 2009; Reeves & Woods-Giscombe, 2015). This theoretical framework further posits that addressing all types of racism is important; however, institutionalized racism is most critical to addressing racial health disparities.

In addition to racism, cultural beliefs and influences are reported to underlie racial/ethnic breastfeeding disparities (DeVane-Johnson et al., 2018; Reeves & Woods-Giscombe, 2015). Among Black women, some cultural beliefs stem from slavery, in which Black women were forced to prioritize breastfeeding children of White slave owners over caring for their own children (DeVane-Johnson et al., 2018; Reeves & Woods-Giscombe, 2015). This forced role or lack of choice created a negative image of breastfeeding among Black women (DeVane-Johnson et al., 2018) (Reeves & Woods-Giscombe, 2015). In addition, Black women who have family members who have breastfed are more likely to breastfeed (DeVane-Johnson et al., 2018; Reeves & Woods-Giscombe, 2015). However, qualitative studies report that Black women often lack exposure to family members who have breastfed, which can impact the mother's preference for formula and her confidence in breastfeeding (DeVane-Johnson et al., 2018; Reeves & Woods-Giscombe, 2015).

Breastfeeding disparities are also reported for lower income families or families with incomes below poverty and lower levels of education (CDC, 2021a). Qualitative studies have found that women living in poverty are potentially impacted by food insecurity, may be concerned that their diets are inadequate to supply enough breast milk to infants, and may choose to supplement with formula to assure that the infant is receiving enough nutrition (Gross et al., 2019; Hardison-Moody et al., 2018). Mothers with lower levels of education and lower incomes are more likely to work in positions with limited control of their schedules or autonomy including service jobs (e.g. fast food restaurants), factory positions, or temporary jobs (Hardison-Moody et al., 2018). This limited autonomy may influence breastfeeding duration; however, little is known about the relationship between poverty and education with in-hospital EBF (Barbosa et al., 2017; Hardison-Moody et al., 2018). In our previously conducted qualitative study at GMH, we found that mothers request formula from the in-hospital WIC clinic and postpartum nurses while in the hospital following delivery to prepare for their return to work (Bookhart et al., 2021). Therefore, there is evidence that employment, work factors, and income may influence infant feeding decisions while in the hospital following birth (Bookhart et al., 2021).

Younger mothers have been reported to be less likely to EBF than older mothers (Jones et al., 2011). For example, a study conducted in the US found that mothers who were ≤20 years of age were 59% less likely to EBF at 6 months compared to mothers who are ≥30 years of age (Jones et al., 2011). Studies have not examined if there are physiological differences in adolescent mothers; however, mammogenesis (development of mammary glands) continues into puberty and adolescent mothers may not have reached adult pre-pregnancy mammary development at the time that pregnancy occurs (Baker, 2013; Lawrence, 2016). Adolescent mothers are more likely to have low birth weight and preterm infants, which are factors associated with breastfeeding difficulties (DeMarco et al., 2021; Boies & Vaucher, 2016; Genna, 2008). Qualitative studies among adolescent mothers outside the US report barriers to breastfeeding such as difficulty latching and positioning during breastfeeding, lack of support from family, the desire to continue their social relationships and activities that they were involved in prior to pregnancy, and returning to school (Jama et al., 2017; Nesbitt et al., 2012). Advanced maternal age (>35 years of age) is associated with delayed lactogenesis II, which is important considering that the age of mothers has increased in the US (Nommsen-Rivers et al., 2012; Mathews & Hamilton, 2016). Mothers of advanced maternal age are more likely to have low birth weight and preterm infants, diabetes (pre-existing and gestational diabetes), hypertension disorders during pregnancy, and cesarean deliveries, which are associated with breastfeeding difficulties (Attali et al., 2021; Hummel et al., 2007; Kling et al., 2016; Kozhimannil et al., 2014; Longmore et al., 2020; Oza-Frank & Gunderson, 2017; Sparud-Lundin et al., 2011; Strapasson et al., 2018).

2.4 Medical Factors

Studies have found that medical factors are associated with lower breastfeeding outcomes. These medical factors include maternal conditions such as diabetes and hypertensive disorders, maternal obesity, and procedures such as cesarean deliveries (Hummel et al., 2007; Kling et al., 2016; Kozhimannil et al., 2014; Longmore et al., 2020; Oza-Frank & Gunderson, 2017; Sparud-Lundin et al., 2011; Strapasson et al., 2018; Bever Babendure et al., 2015). In addition, infant medical factors such as hypoglycemia, jaundice, low birth weight, and preterm birth are associated with breastfeeding difficulties (Feldman-Winter et al., 2020).

2.4.1 Diabetes

Type 1 diabetes (characterized by the inability or reduced production of insulin), type 2 diabetes (characterized by insulin insensitivity), and gestational diabetes (characterized as diabetes that is first diagnosed during pregnancy) are associated with lower breastfeeding outcomes compared to women without diabetes (Hummel et al., 2007; Longmore et al., 2020; Sparud-Lundin et al., 2011). Although type 1 diabetes, type 2 diabetes, and gestational diabetes are characterized by different etiologies, each type shares the underlying physiological mechanism of delayed lactogenesis II, or the delayed onset of copious milk secretion (De Bortoli & Amir, 2016; Hartmann & Cregan, 2001; Matias et al., 2014). Lactogenesis II typically begins between 30 to 72 hours after the delivery of the placenta and an onset after 72 hours is considered delayed (Baker, 2013; Lawrence, 2016). The beginning of this time frame occurs during the hospital stay following delivery (Baker, 2013; Lawrence, 2016). This delay in lactogenesis may be due to insulin and glucose metabolism disturbances during pregnancy (Baker, 2013; Lawrence, 2016). In addition, newborns of mothers with diabetes and poorer metabolic control are more likely to have neonatal hypoglycemia which is associated with higher risk of infant formula supplementation (De Bortoli & Amir, 2016).

Maternal type 1 diabetes was found to decrease the likelihood of EBF at 2 months and 3 months (Hummel et al., 2007; Sparud-Lundin et al., 2011). A previously conducted study in Australia found that type 2 diabetes was associated with a lower likelihood of in-hospital EBF (Longmore et al., 2020). A US study using data from the Pregnancy Risk Assessment Monitoring System found that mothers with gestational diabetes were less likely to EBF while in the hospital; however, this study was unable to control for potential confounding of breastfeeding intentions due to the unavailability of this information (Oza-Frank & Gunderson, 2017). Although there is evidence that diabetes is associated with decreased likelihood of EBF, these studies did not examine the association with in-hospital EBF, were conducted outside of the US, or may not account for breastfeeding intentions.

In addition, there are racial/ethnic differences in the prevalence of diabetes. The weight-, age-, and sex-adjusted prevalence of diabetes is 12.1% among non-Hispanic White adults and 20.4% for non-Hispanic Black adults (Cheng et al., 2019). Of note, diabetes was defined as self-reported diagnosis by a physician, measurements of hemoglobin A1c, fasting plasma glucose, or 2-hour plasma glucose; thus, this definition is not specific to type 1, type 2, or gestational diabetes (Cheng et al., 2019). In the US, the prevalence of gestational diabetes is highest among Asian/Pacific Islander women (12.4 per 100 deliveries) and Hispanic women (10.9 per 100 deliveries) and lowest among non-Hispanic White women (7.3 per 100 deliveries) and non-Hispanic Black women (7.4 per 100 deliveries) (CDC, 2020). There are also racial/ethnic differences in EBF (CDC, 2021a). Race/ethnicity is associated with both the exposure (diabetes) and the outcome (EBF); therefore, adjusting for race/ethnicity is important to obtaining the most accurate measure of association between diabetes and EBF.

2.4.2 Hypertension

Pre-existing, or chronic hypertension is diagnosed before pregnancy or before 20 weeks of pregnancy (CDC, 2021b). Gestational hypertension is typically diagnosed after 20 weeks of pregnancy or close to delivery (CDC, 2021b). Preeclampsia and eclampsia occur when a previously normotensive woman develops high blood pressure, protein in the urine, and other problems after 20 weeks of pregnancy (CDC, 2021b). Eclampsia is considered a medical emergency (CDC, 2021b). The proposed hypothesis for the underlying mechanism for the association between hypertensive conditions during pregnancy and lower breastfeeding outcomes includes that the condition of the infant often requires admission to the neonatal intensive care unit, particularly among women with eclampsia (Furuta et al., 2016). In addition, this relationship may reflect women with hypertensive disorders in pregnancy receiving antihypertensive treatment after delivery and erroneously advised against breastfeeding (Furuta et al., 2016). Other reported underlying reasons for this association include delayed onset of lactogenesis II, which may be due to postpartum edema leading to poor diffusion of water into mammary alveoli or difficulty in breast milk removal (Demirci et al., 2018).

Pre-existing or chronic hypertension, gestational hypertension, preeclampsia, and eclampsia are associated with lower EBF prevalence as early as 1 week postpartum compared to normotensive women (Kozhimannil et al., 2014; Strapasson et al., 2018).

Similar to diabetes, there are racial/ethnic differences in the prevalence of pregnancy related hypertensive disorders. Non-Hispanic Black women have higher odds of entering pregnancy with chronic hypertension and developing pre-eclampsia compared to non-Hispanic

White women (Ghosh et al., 2014). Therefore, adjusting for race/ethnicity are important to obtaining the most accurate measure of association between hypertensive disorders and EBF.

In a previously conducted qualitative study at Grady Memorial Hospital, we found that management of high risk patients with diabetes and hypertension may detract from the time spent discussing lactation management during the prenatal period by clinicians (Bookhart et al., 2021). Therefore, the physiological impact of diabetes and hypertension may not fully explain the relationship between these conditions and breastfeeding outcomes (Bookhart et al., 2021). Health care system breastfeeding support factors during the prenatal period, such as lactation management education, may be influential for mothers with these conditions (Bookhart et al., 2021).

2.4.3 Body Mass Index

Body mass index (BMI) screens for weight categories that may lead to health problems (CDC, 2021c). BMI is calculated by dividing weight in pounds by height in inches squared and multiplying by a conversion factor of 703 (CDC, 2021c). A BMI below 18.5 is defined as underweight, 18.5-24.9 is normal or healthy weight, 25.0-29.9 is overweight, and 30.0 and above is obese (CDC, 2021c). Obesity is further divided into the following categories: class 1: BMI of 30 to <35; class 2: BMI of 35 to <40; class 3: BMI of 40 or higher (CDC, 2021c). Maternal undernutrition and maternal over nutrition have been reported to impact lactation performance (Rasmussen, 1992). In the US, pre-pregnancy obesity increased from 26.1% in 2016 to 29.0% in 2019 and over nutrition is the primary concern in high-income countries with lactation performance (Driscoll & Gregory, 2020; Nomura et al., 2020). High weight gain during pregnancy may further impact the relationship between maternal overnutrition and lactation performance (Rasmussen, 2007).

A review of contributing factors to lower breastfeeding outcomes among obese women found that mechanical factors and delayed onset of lactogenesis II impacted early breastfeeding (Bever Babendure et al., 2015). Mechanical factors make latching and positioning more difficult and include edema of the breast and larger breast (due to adipose tissue) (Bever Babendure et al., 2015). Delayed lactogenesis II may be due to higher risk of postpartum edema and difficult labor, which is associated with blunted oxytocin (Nommsen-Rivers et al., 2010; Bogaerts et al.; 2013). This review also found that hormonal imbalances, psychosocial factors, and mammary hypoplasia impacted later breastfeeding outcomes (Bever Babendure et al., 2015). Free androgens were reported to increase with BMI and obesity may result in subclinical thyroid dysfunction that is undiagnosed (Bever Babendure et al., 2015). Psychosocial factors include reduced confidence in the ability to meet breastfeeding goals and body image concerns (Bever Babendure et al., 2015). Although obese women may have larger breast due to adipose tissue, obese women may also have reduced development of glandular tissue resulting in a lower milk supply (Bever Babendure et al., 2015). In addition to these factors, maternal obesity is associated with adverse outcomes such as gestational diabetes, hypertension, preeclampsia, cesarean delivery, preterm delivery, and large-for-gestational age (Gaillard et al., 2013; McDonald et al., 2010).

One recent meta-analysis found that overweight mothers (hazard ratio=1.16) and obese mothers (hazard ratio=1.45) were at increased risk of not continuing any breastfeeding or EBF (Nomura et al., 2020). However, the results of the meta-analysis combined continuing and any breastfeeding and EBF; EBF in most of the studies were evaluated at 6 months of age (Nomura et al., 2020). Another study found that women with a BMI ≥25 were less likely to EBF at 6 weeks compared to normal weight women (67% compared to 37%) (Marshall et al., 2019).

Furthermore, a dose response relationship was found between maternal obesity and EBF, where the odds of the termination of EBF increased with BMI (compared to normal weight women) at one week following delivery [over weight relative risk (RR)= 1.07; class I=1.19; class II=1.20; class III=1.40] (Baker et al., 2007). A study conducted among Latina women in Connecticut found that class II obesity was associated with 2.86 higher odds of not EBF at hospital discharge compared to overweight women (Martinez et al., 2016). Although many studies have reported the association between maternal obesity and EBF, few have examined this relationship with in-hospital EBF (Nomura et al., 2020; Marshall et al., 2019; Baker et al., 2007; Martinez et al., 2016). There are also racial differences in the prevalence of pre-pregnancy obesity, thus adjusting for race/ethnicity are important to obtaining the most accurate measure of association between maternal obesity and EBF (Driscoll & Gregory, 2020).

2.4.4 Cesarean delivery

Cesarean delivery is associated with lower breastfeeding outcomes; however, it is not a medical contraindication for breastfeeding (Kling et al., 2016; Hernandez-Aguilar et al., 2018). Proposed mechanisms for this association include delayed lactogenesis II, hormonal causes, difficulty positioning after surgery, and the effects of anesthesia (Scott et al., 2007; Vogl et al., 2006; Zanardo et al., 2010). In addition, maternity care practices may influence the association between cesarean delivery and in-hospital EBF (Martin et al., 2018; Hung & Berg, 2011). Separation of the mother-infant dyad after delivery is a reported mechanism for the association between cesarean delivery and lower breastfeeding outcomes (Martin et al., 2018). Delayed skin-to-skin contact between the mother and infant is another potential mechanism linking cesarean deliveries and lower breastfeeding outcomes (Hung & Berg, 2011). For example, one study found that infant formula supplementation in the hospital was decreased by 41% when skin-to-skin contact was implemented before 90 minutes after a cesarean birth compared to those who did not have skin-to-skin implemented by 90 minutes after a cesarean birth (Hung & Berg, 2011).

One study conducted in the US utilizing 2005-2007 data from the Infant Feeding Practices Study II found that cesarean delivery was associated with lower odds (odds ratio=0.41) of in-hospital EBF compared to women who gave birth vaginally (Kling et al., 2016). This study provides insight on the association between cesarean delivery and in-hospital EBF; however, the data set included few racial/ethnic minorities and selection bias was reported as a limitation (Kling et al., 2016). Therefore, the results may not be generalizable (Kling et al., 2016).

2.4.5 Neonatal hypoglycemia

Neonatal hypoglycemia is a possible indication for supplementation in healthy, term infants which may result in lower in-hospital EBF (Kellams et al., 2017). Hypoglycemia refers to low glucose concentration in the blood or plasma (Wight, 2021; Abramowski et al., 2021; Feldman-Winter et al., 2020). Transient hypoglycemia is a part of the physiological transition that occurs during the first few hours after birth (Wight, 2021; Abramowski et al., 2021; Feldman-Winter et al., 2020). In utero, the infant is completely dependent on the mother for glucose supplies (Wight, 2021; Abramowski et al., 2021; Feldman-Winter et al., 2020). After birth the maternal glucose supplies end, which typically causes a normal fall in glucose. During the third trimester, the neonate prepares for this transition to extrauterine life by storing glucose in the form of glycogen (Wight, 2021; Abramowski et al., 2021; Feldman-Winter et al., 2020). After birth, the infant produces counterregulatory hormones, such as glucagon, to mobilize glycogen into glucose, which causes blood glucose levels to slowly rise (Wight, 2021; Abramowski et al., 2021; Feldman-Winter et al., 2020). In the case of normal transient hypoglycemia, oral intake is not the main source of energy for healthy, term newborns in the first days of life (alternative fuel sources such as glycogen are); therefore, the volume of colostrum produced is typically sufficient for the nutritional needs of infants not at risk for clinically significant hypoglycemia (Feldman-Winter et al., 2020).

Although transient hypoglycemia occurs in almost every newborn, clinically significant hypoglycemia may result from disturbances to this regulated mechanism (Wight, 2021; Abramowski et al., 2021; Feldman-Winter et al., 2020). However, the thresholds for clinically significant hypoglycemia are not defined; therefore, the incidence of clinically significant hypoglycemia is unknown (Feldman-Winter et al., 2020; Wight, 2021). Risk factors for metabolic disturbances to this transition include mothers with diabetes and infants that are large- or small-for-gestational age (Feldman-Winter et al., 2020). Untreated neonatal hypoglycemia can result in brain damage and death (Achoki et al., 2010; Kerstjens et al., 2012). Clinical recommendations for treating hypoglycemia often include practices that protect EBF including glucose monitoring for infants with risk factors (not of all infants), infants requiring more frequent feedings should be supported with breastfeeding and/or receive expressed milk, and an increasing amount of evidence supports the use of glucose gels to treat low glucose levels (Barber et al., 2018; Edwards et al., 2021; Feldman-Winter et al., 2020; Ter et al., 2017; Wight, 2021).

Current literature on neonatal hypoglycemia focuses on different methods for defining hypoglycemia and ways to prevent clinically significant hypoglycemia while protecting the breastfeeding relationship, such as glucose gels (Barber et al., 2018; Edwards et al., 2021; Ter et al., 2017; Wight, 2021). However, to our knowledge no recent studies have examined the relationship between hypoglycemia and in-hospital EBF.

2.4.6 Neonatal jaundice

In addition to neonatal hypoglycemia, jaundice is a possible indication for supplementation in healthy, term infants, which may result in lower in-hospital EBF (Kellams et al., 2017). Similar to transient hypoglycemia, most newborns experience elevated bilirubin levels (compared to normal levels in adults) (Feldman-Winter et al., 2020; Kellams et al., 2017). This physiologic rise in bilirubin is due to immaturity of the enzyme glucuronyl transferase, which catalyzes bilirubin (Feldman-Winter et al., 2020). This enzyme increases in maturity with gestational age (Feldman-Winter et al., 2020). There are two types of pathologic jaundice: 1) suboptimal intake jaundice and 2) breast milk jaundice (Flaherman & Maisels, 2017). These two types of pathologic jaundice both have an onset of 2-5 days of age (Flaherman & Maisels, 2017). Suboptimal intake jaundice is characterized by ongoing weight loss; decreased stool and urine output and is rare for gestational ages of at least 40 weeks; and infants are often difficult to settle, sleepy, and difficult to wake during feedings (Flaherman & Maisels, 2017). In contrast breast milk jaundice is characterized by consistent weight gain, adequate stool and urine output, and normal feeding patterns of 8-12 times per day (Flaherman & Maisels, 2017). The mechanism for breast milk jaundice is unknown (Flaherman & Maisels, 2017).

Risk factors for jaundice include preterm birth, bruising in the neonate, suboptimal intake (particularly among women at risk for delayed lactatogenesis II such as cesarean delivery), and mothers with Rh sensitization (Flaherman & Maisels, 2017). Untreated jaundice can result in kernicterus (brain damage from high bilirubin levels), cerebral palsy, and hearing loss; however, development of these conditions is rare in high-income countries (Flaherman & Maisels, 2017). Clinical recommendations for jaundice include assessment of milk production, breast milk transfer, feeding frequency, and weight loss (Feldman-Winter et al., 2020). If infant intake at the breast is determined to be sufficient, then EBF should continue with phototherapy (Feldman-Winter et al., 2020). If it is determined that intake at the breast is insufficient, then expressed maternal milk should be the first option for supplementation, followed by donor human milk (Feldman-Winter et al., 2020; Kellams et al., 2017).

There are inconsistent findings from studies that examine the relationship between jaundice and EBF. A study conducted in Singapore found that jaundice was negatively associated with in-hospital EBF (Lau et al., 2015). Studies conducted in Tawain and New Jersey did not find an association between jaundice and EBF during the hospitalization following birth or one week after birth, respectively (Chiu et al., 2021; Chu et al., 2021).

2.4.7 Birth weight and gestational age

Other infant medical factors that have been reported to be risk factors for breastfeeding difficulty include birth weight and gestational age (Feldman-Winter et al., 2020). Low birth weight is defined as weight at birth of <2,500 grams (5.5 pounds) regardless of gestational age (WHO, 2021b). Low birth weight can be caused by intrauterine growth restriction, prematurity, or both (intrauterine growth restriction and prematurity) (WHO, 2021b). In high income countries, such as the US, the cause of low birth weight is often prematurity; whereas, the cause of low birth weight in middle and low income countries is often intrauterine growth restriction (WHO, 2021b). When intrauterine growth restriction occurs, low birth weight babies are often classified as small-for-gestational age (Santiago et al., 2019). Small-for-gestational age is defined as <10th percentile of the birth weight-for-gestational age sex-specific, single/twin reference curve (Damhuis et al., 2021). Prematurity is defined as birth before the 37th week of gestation (CDC, 2019). Although the definitions may vary, the etiology for breastfeeding difficulties are similar for small-for-gestational age, prematurity, and low birth weight in which infants have low fat stores which are typically deposited during the later weeks of pregnancy (Genna, 2008). Infants with these conditions then have difficulty maintaining a suction to effectively feed at the breast (Boies & Vaucher, 2016; Genna, 2008). In addition, these infants may have less stamina and may be less alert also leading to breastfeeding difficulties (Boies & Vaucher, 2016). Premature infants are reported to have greater difficulty with coordinating the suck-swallow-breath process (Boies & Vaucher, 2016). There is also increasing evidence that early term infants (37-38 weeks of gestation) are at risk for reduced breastfeeding initiation and duration due to higher risk for conditions such as hyperbilirubinemia (Boies & Vaucher, 2016; Norman et al., 2015). These conditions among early term infants have been associated with hospital readmission, and one study found that jaundice and feeding problems account for 83% of the readmissions of early term newborns (Young et al., 2013). Large-for-gestational age is defined as >90th percentile of the birth-weight-for-gestational age sex-specific, single/twin reference curve, which is a reflection of excess nutrition in utero or may be less commonly due to genetic disorders (e.g. Beckwith–Wiedeman syndrome, Simpson–Golabi–Behmel syndrome, etc.) (Damhuis et al., 2021; Chiavaroli et al., 2016; Scifres, 2021). Infants born large-for-gestational age are at risk for hypoglycemia, which is associated with breastfeeding difficulties (Scifres, 2021). In addition, infants born large-for-gestational age are at risk for birth trauma conditions such as shoulder dystocia, brachial plexus injury, and clavicular fracture which can make positioning for breastfeeding difficult (Scifres, 2021).

Low birth weight infants, small-for-gestational-age infants, premature infants, and large-for-gestational age infants are more likely to have mothers with medical conditions such as diabetes or hypertension and are more likely to be born via cesarean delivery (Boies & Vaucher, 2016). These maternal medical conditions may impact the onset of lactogenesis II (De Bortoli &

Amir, 2016; Hartmann & Cregan, 2001; Matias et al., 2014; Demirci et al., 2018; Scott et al., 2007; Vogl et al., 2006; Zanardo et al., 2010). Infants with these conditions are also more likely to be separated from their mothers for treatment and monitoring (Boies & Vaucher, 2016).

Studies examining low birth weight, small-for-gestational age, and premature infants often assess the relationship of interventions such as skin-to-skin with breastfeeding outcomes. For example, a review conducted among studies in multiple sites (US, UK, India, Vietnam, etc.) of low birth weight infants found that skin-to-skin care after birth (compared to standard of care of breastfeeding only) was associated with a 203% increase of EBF at 6 months (Keats et al., 2021). The examination of the association between birth weight and gestational age with in-hospital EBF may be particularly important considering the early breastfeeding difficulties that infants with these conditions may face (Boies & Vaucher, 2016).

2.5 Breastfeeding Intentions

Breastfeeding intentions are associated with breastfeeding initiation and EBF duration (Donath & Amir, 2003; Bai et al., 2010). A study conducted in the UK, found that intended duration predicted 91% of breastfeeding initiation and 72% of infant feeding at 6 months (Donath & Amir, 2003). Another study conducted in Indiana, found a positive correlation between breastfeeding intentions and actual EBF duration (Bai et al., 2010). A more recent study conducted among Latina mothers in North Carolina found that mothers who decided about the infant feeding method before pregnancy were 3 times more likely to EBF while in the hospital following delivery compared to mothers who decided while pregnant or after the baby was born (Jones et al., 2018). Furthermore, studies have found that few women meet their breastfeeding intentions, which suggests that further efforts are needed to help breastfeeding mothers meet their intentions (Hundalani et al., 2013; Perrine et al., 2012).

Factors reported to influence breastfeeding intentions include maternal weight, prior breastfeeding experience, and maternity leave (Andres et al., 2016; Guelinckx et al., 2012; Whipps et al., 2021). Obese mothers have been reported to have lower prevalence of intending to breastfeed compared to normal weight women (68% compared to 92%) (Guelickx et al., 2012). A previous breastfeeding experience that included in-hospital formula supplementation has been reported to decrease the likelihood of breastfeeding initiation for subsequent children by >66% and was reported to reduce the duration of breastfeeding in subsequent children by >6 weeks (Whipps et al., 2021). In our formative, qualitative study conducted study at Grady Memorial Hospital, we found that previous feeding experience also influenced in-hospital EBF. Mothers reported that a positive previous breastfeeding experience was a facilitator to in-hospital EBF. In contrast, mothers who had breastfeeding difficulties with previously born children that resulted in formula supplementation reported that they continued formula supplementation with subsequent children (Bookhart et al., 2021).

2.6 Health Care System Breastfeeding Support Factors

The first few days of life are important for establishing lactation, and mother-infant dyads often stay in maternity care facilities during this time (WHO, 2018). Therefore, the breastfeeding support available in maternity care facilities is an important factor in early breastfeeding practices (WHO, 2018). The World Health Organization and the United Nations Children's Fund (UNICEF) launched the Baby Friendly Hospital Initiative (BFHI) in 1991, which includes Ten Steps of maternity care practices to protect, promote, and support breastfeeding (WHO, 2018). The WHO and UNICEF work with national authorities to administer the BFHI; in the US, this third party authority is Baby-Friendly USA (BFUSA) (BFUSA, 2021). Hospitals in the US become Baby-Friendly by completing the BFUSA designation process, which includes minimum standards for each of the Ten Steps that must be completed by each facility and a site visit (BFUSA, 2021). Hospitals that are not designated may be on the pathway to becoming Baby-Friendly, but have not yet achieved the designation (BFUSA, 2021). Some states implement programs based on the BFHI Ten Steps; however, some state programs recognize hospitals for implementing less than all Ten Steps, states may not require site visits, and states may not require additional fees (Texas Department of State Health Services, 2021; North Carolina Department of Health and Human Services, 2021). Hospitals may implement varying steps without a designation (BFUSA, 2021). The BFUSA Baby-Friendly designation has been associated with improved in-hospital EBF (Patterson et al., 2018 2018); however, only 28% of annual US births occur in Baby-Friendly designated hospitals (BFUSA, 2021).

2.6.1 Ten Steps to Successful Breastfeeding

The Ten Steps consist of 2 critical management procedures and 8 clinical practices and were updated in 2018 (Table 2-2) (WHO, 2018). Key updates include monitoring of EBF prevalence (step 1), assessing staff competency rather than staff training (step 2), preparing mothers for potential breastfeeding difficulties is the focus for practical support (step 5), and counseling mothers on the use and risks of artificial teats instead of prohibiting them (step 9) (WHO, 2018).

Table 2-2. Baby-Friendly Hospital Initiative Ten Steps to Successful Breastfeeding

Baby-Friendly Hospital Initiative Ten Steps to Successful Breastfeeding
Step 1: Hospital policies a. Comply fully with the *International Code of Marketing of Breast-milk Substitutes* and relevant World Health \ Assembly resolutions. b. Have a written infant feeding policy that is routinely communicated to staff and parents. c. Establish ongoing monitoring and data-management systems.
Step 2: Staff competency- Ensure that staff have sufficient knowledge, competence and skills to support breastfeeding.
Step 3: Prenatal education- Discuss the importance and management of breastfeeding with pregnant women and their families.
Step 4: Care right after birth- Facilitate immediate and uninterrupted skin-to-skin contact and support mothers to initiate breastfeeding as soon as possible after birth.
Step 5: Support with breastfeeding- Support mothers to initiate and maintain breastfeeding and manage common difficulties.
Step 6: Limited supplementation- Do not provide breastfed newborns any food or fluids other than breast milk, unless medically indicated.
Step 7: Rooming-in- Enable mothers and their infants to remain together and to practice rooming-in 24 hours a day.
Step 8: Responsive feeding- Support mothers to recognize and respond to their infants' cues for feeding.
Step 9: Bottles, nipples, and pacifiers- Counsel mothers on the use and risks of feeding bottles, teats and pacifiers.
Step 10: Care at discharge- Coordinate discharge so that parents and their infants have timely access to ongoing support and care.

Previous national analyses that examined trends of individual components of Ten Steps indicators found increasing prevalence of implementation over time. For example, the percentage of hospitals with a model breastfeeding policy increased from 14.1% in 2008 to 33.1% in 2015 (Nelson & Grossniklaus, 2019). Hospitals that encouraged at least 90% of women to practice early skin-to-skin contact increased from 40.4% in 2007 to 83.0% in 2015 for vaginal births and 29.3% in 2007 to 69.9% in 2015 for cesarean births (Boundy et al., 2018). Hospitals that provided non-breast milk supplements to at least 50% of breastfed newborns decreased from 31.5% in 2009 to 23.3% in 2013 (Barrera et al., 2018). The percentage of hospitals that reported the ideal rooming-in practices increased from 27.8% in 2007 to 51.4% in 2015 (Barrera et al., 2018). In addition, an analysis that examined the implementation of some indicators for each of the Ten Steps found an increase in implementation from 2007 to 2013 (Perrine et al., 2015).

These steps have been found to be positively associated with EBF among mothers who intend to EBF (Declercq et al., 2009; Perrine et al., 2012). With data from mothers who gave birth in 2005 that participated in the national Listening to Mothers II Survey, mothers who reported supplemental feedings (step 6) for their infant were 4.4 and 2.1 times less likely to achieve their intention to EBF, among primiparas and multiparas, respectively (Declercq et al., 2009). This study also found that primiparas who delivered in hospitals that practiced 6-7 of the steps were 6 times more likely to achieve their intention to EBF than those in hospitals that practiced 0-1 of the steps (Declercq et al., 2009). Another study similarly examined Baby-Friendly hospital practices and meeting in-hospital EBF intention using data from the 2005-2007 Infant Feeding Practices Study II, and found that not receiving supplemental feedings (step 6) was significantly associated 2.3 times the odds of meeting EBF intentions after adjusting for 5 other steps, respectively (Perrine et al., 2012). This study also found a dose-response relationship between the number of steps implemented and meeting EBF intentions (Perrine et al., 2012).

Other studies have examined maternity care policies and practices at the national level. For example, an analysis using 2013 data found that most individual maternity care practices related to the Ten Steps were significantly associated with in-hospital EBF prevalence (Patterson et al., 2019).

In summary, these previously conducted analyses provide evidence of increasing national hospital implementation of the Ten Steps. In addition, there is evidence that step 6 is a key factor for in-hospital EBF and a dose-response relationship exists between the number of steps implemented and meeting EBF intentions. This evidence is limited in that national hospital implementation of the 2018 updated Ten Steps is unknown. Furthermore, earlier studies only report up to seven out of the Ten Steps or are based on individual indicators when there are several components for each step.

2.6.2 Baby-Friendly Designation

In addition to the constituent steps, Baby-Friendly designation is associated with improved in-hospital EBF prevalence (Ducharme-Smith et al., 2021; Kivlighan et al., 2020; Patterson et al., 2018) (Feldman-Winter et al., 2017). A cross-sectional study conducted among participants in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) in Maryland (4 WIC agencies across the state were included) found that infants delivered at a Baby-Friendly designated hospital were more likely to EBF in the hospital (Ducharme-Smith et al., 2021). A study that compared EBF using a pre-Baby-Friendly hospital designation and post-Baby-Friendly hospital designation cohort design in New Mexico found that the post-designation cohort was more likely to EBF at 2-6 weeks postpartum compared to the pre-designation cohort (Kivlighan et al., 2020). Similarly a national level study found that Baby-Friendly hospital designation was associated with higher in-hospital EBF after controlling for neighborhood sociodemographic factors such as race/ethnicity, poverty, and education (Patterson et al., 2018). A nationwide initiative of 90 maternity care hospitals that aimed to increase breastfeeding and Baby-Friendly hospital designation found that hospitals in the program increased EBF from 39% to 61% (Feldman-Winter et al., 2017). From these local and national studies, it is evident that Baby-Friendly hospital designation is associated with higher EBF prevalence. However, the findings from local studies may not be generalizable to other areas. The nationwide studies were conducted among hospitals with at least 1,100 births or included a sample of hospitals that may not be representative of the entire nation.

2.7 Existing data sources

There are few existing national data sources that report breastfeeding practices in the US. The Maternity Practices in Infant Nutrition and Care (mPINC) survey is administered biennially by the CDC and all maternity hospitals in the US are invited to participate (CDC, 2021d). The mPINC survey is completed by hospital staff, specifically the staff person identified as most knowledgeable about the policies and practices at the facility, with input from others as necessary (CDC, 2021d). This survey collects information on routine maternity care and infant feeding policies and practices. The mPINC survey collects information on breastfeeding outcomes including the percent of healthy newborns EBF and supplemented with infant formula during the hospital stay at the hospital level. However, the mPINC survey does not collect sociodemographic data on the patient population served by maternity hospitals.

The National Immunization Survey (NIS) uses random-digit dialing to survey households with children and teens about receipt of routine vaccinations; respondents with children aged 19 to 35 months are also asked questions about breastfeeding (CDC, 2021a). Using NIS data, breastfeeding practices are reported at the national level by sociodemographic factors at birth, 3, 6, and 12 months (CDC, 2021a). Formula supplementation as early as the first two days of life is also reported at the national level. However, the NIS does not specifically include in-hospital EBF nor does it report maternity care practices related to breastfeeding.

Another data source is the Joint Commission, a leading hospital accreditation agency in the US, which requires hospitals with ≥300 births to publicly report their in-hospital EBF prevalence (The Joint Commission, 2021). The Joint Commission monitors EBF at hospital discharge as a core measure for accreditation (The Joint Commission, 2021). These data are collected from hospital medical records and are reported publicly by year for the hospital, state, and nation (The Joint Commission, 2021). The Joint Commission data differs from the NIS data in that it has specific exclusion criteria including infants admitted to the neonatal intensive care unit (NICU), length of stay greater than 120 days, and newborns less than 37 weeks of gestational age, and the data are reported at the hospital level. However, the Joint Commission's data are not reported by sociodemographic factors and maternity care practices related to breastfeeding are not reported (The Joint Commission, 2021).

The Pregnancy Risk Assessment Monitoring System (PRAMS) is a surveillance project that collects state-specific, population-based data on maternal attitudes and experiences before, during, and after pregnancy among women with a recent live birth (CDC, 2021e). PRAMS utilizes a stratified systematic sample from 46 US states, the District of Columbia, New York City, Northern Mariana Islands, and Puerto Rico and represents approximately 81% of all US live births (CDC, 2021e). PRAMS collects data on breastfeeding initiation, EBF, and duration up to 8 weeks and includes questions on the Ten Steps; however, not all states asks questions on EBF or the Ten Steps (CDC, 2021e).

In addition to these national level data sources, medical record data are available from hospitals. We used data from the Grady Obstetric & Gynecological Outcomes (GOGO) database that utilizes reports from the existing medical record system to generate data sets. GOGO is based at Grady Memorial Hospital, which is a large safety net institution and provides care to a high proportion of medically underserved patients. This data set includes sociodemographic factors, health care system breastfeeding support (including in-hospital breastfeeding education and receipt of trained lactation professional support), medical factors, and breastfeeding intentions. However, the results generated from this data source may not be generalizable to hospitals that serve different populations. There are also factors that may influence breastfeeding outcomes that are not collected by this data source such as some health care system breastfeeding support factors (e.g. rooming-in, skin-to-skin, etc.) because this information is not in the medical record in a format that can be obtained by reports.

2.7 Summary and Research Gaps

In summary, early EBF is important for establishing a breast milk supply needed for longer durations of breastfeeding (Chantry et al., 2014; McCoy & Heggie, 2020). Lactogenesis II typically begins between 30 to 72 hours following birth, mother infant dyads usually remain in maternity care facilities at the start of this period, which includes a critical transition to copious milk secretion (Baker, 2013; Lawrence, 2016; WHO, 2018).

In-hospital formula supplementation is associated with decreased duration of breastfeeding (Chantry et al., 2014; McCoy & Heggie, 2020). Few studies have examined reasons for in-hospital formula supplementation, and no studies to our knowledge have qualitatively examined common reasons for formula supplementation reported by hospital staff using a national data set.

There are several complex factors associated with early infant feeding practices and many questions remain. There are sociodemographic EBF disparities reported for factors such as race/ethnicity, poverty, education, and maternal age (Anstey et al., 2017; Li et al., 2019). Maternal medical conditions and procedures such as diabetes, hypertension, BMI, and cesarean sections are associated with delayed lactogenesis II and lower EBF (Hummel et al., 2007; Kling et al., 2016; Kozhimannil et al., 2014; Longmore et al., 2020; Oza-Frank & Gunderson, 2017; Sparud-Lundin et al., 2011; Strapasson et al., 2018). Although hypoglycemia and jaundice are possible medical indications for formula supplementation, there are clinical practices that prevent supplementation for these conditions and protect the breastfeeding relationship. Other neonatal conditions such as low birth weight and early term gestational age are associated with breastfeeding difficulties (Boies & Vaucher, 2016; Genna, 2008). Studies examining medical conditions often do not examine the relationship with in-hospital EBF; were conducted outside the US; may not adjust for confounders such as breastfeeding intentions; or were conducted in populations with few racial/ethnic minorities and may have limited generalizability.

The Ten Steps to Successful Breastfeeding are associated with improved in-hospital EBF; however, the steps were updated in 2018 and the national prevalence of implementation of these steps are unknown (Declercq et al., 2009; Perrine et al., 2012). Furthermore, previous studies that examined the Ten Steps only report up to seven out of the Ten Steps or are based on individual indicators when there are several components for each step. Studies examining the relationship between Baby-Friendly hospital designation and in-hospital EBF were conducted in geographically limited locations and may not be representative of hospitals across the nation or do not include hospitals with less than 1,100 births. This dissertation aims to address these research gaps in chapters 3-6.

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Chapter 3: A nation-wide study on the common reasons for infant formula supplementation among healthy, term, breastfed infants in US hospitals

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Abstract

In-hospital formula supplementation of breastfed infants reduces breastfeeding duration, yet little is known about reasons for formula supplementation. We examined the common reasons for in-hospital formula supplementation of healthy, term, breastfed infants in the US. Hospital data were obtained from the 2018 Maternity Practices in Infant Nutrition and Care survey (n=2,045). An open-ended question on the top three reasons for in-hospital formula supplementation was analyzed using thematic qualitative analysis and the frequencies for each reason were reported. Common reasons for supplementation included medical indications (70.0%); maternal request/preference/feelings (55.9%); lactation management-related issues (51.3%); physical but non-medically indicated reasons (36.7%); social influences (18.8%); perceived cultural/societal/demographic factors (8.2%); and medical staff/institutional practices (4.7%). These findings suggest that a variety of factors should be considered to address unnecessary formula supplementation.

Key Words: Breastfeeding, Breast Milk Substitutes, Infant Formula**,** Breastfeeding Initiation, Qualitative Methods, Developed Countries

Key Messages:

- Approximately 19% of US breastfed infants are supplemented with infant formula within the first two days of life; however, there is limited information on the common reasons for in-hospital formula supplementation.
- Using national data from 2,045 birth hospitals, commonly reported reasons for formula supplementation were found to be related to medical indications (70.0%); maternal request/preference/feelings about breastfeeding such as frustration or lack of confidence (55.9%); lactation management-related issues (51.3%); physical but non-medically indicated reasons (36.7%); social influences (18.8%); perceived cultural/societal/demographic factors (8.2%); and medical staff/institutional practices (4.7%).
- These findings suggest that a variety of factors should be considered to address unnecessary formula supplementation.

1. Introduction

Exclusive breastfeeding for the first 6 months of life has been established as the normative standard for infant feeding, with continued breastfeeding along with complementary foods for 1 year or beyond by the American Academy of Pediatrics (Eidelman, 2012) or 2 years and beyond by the World Health Organization (World Health Organization, 2011). The recent Dietary Guidelines for Americans, 2020-2025 also recommends exclusive breastfeeding for about the first 6 months of life (US Department of Agriculture and US Department of Health and Human Services, 2020). A dose response relationship exists between breastfeeding and the associated health benefits (Victora et al., 2016); thus, national Healthy People 2030 goals include improving exclusive breastfeeding and duration (Office of Disease Prevention and Health Promotion, 2020). In the US, 84% of children initiate breastfeeding; however, only 26% exclusively breastfeed for 6 months and 35% are breastfeeding for 1 year (Centers for Disease Control and Prevention, 2020a). In-hospital exclusive breastfeeding during the days immediately after birth has been shown to be important for continued duration (Chantry, Dewey, Peerson, Wagner, & Nommsen-Rivers, 2014). Yet 19% of US breastfed infants born in 2017 were supplemented with infant formula in the first 2 days of life, which is an increase from 17% in 2016 (Centers for Disease Control and Prevention, 2020a).

Infant formula supplementation of breastfed newborns often occurs during the intrapartum period, in which the mother-infant dyad remain in the hospital following delivery (Nelson, Perrine, Scanlon, & Li, 2016). In-hospital infant formula supplementation has been associated with decreased breastfeeding duration at 2 months (Chantry et al., 2014), up to the first year of life (McCoy & Heggie, 2020). Infant formula supplementation during this time can interfere with the supply and demand nature of this phase of lactogenesis (Pang & Hartmann,

2007) and can potentially lead to decreased supply and reduced breastfeeding duration, which may have long-term health impacts for the infant and mother (Victora et al., 2016; Feltner, Stuebe, Grodensky, Orr, & Viswanathan; 2018).

Formula supplementation of breastfed infants is necessary in some circumstances, after proper assessment identifies a medical indication, and when mothers' expressed milk or donor human milk are not available. The Academy of Breastfeeding Medicine (ABM) Clinical Protocol lists possible medical indications for supplementation such as weight loss greater than the 75th percentile for age for the infant or chemotherapy treatment for the mother (Kellams, Harrel, Omage, Gregory, & Rosen-Carole, 2017). However, non-medically indicated factors have been found to be associated with unnecessary in-hospital infant formula supplementation such as cesarean section birth and large-for-gestational age newborns (Garrison & Maisano, 2019). Lactation management-related factors have been previously reported as common reasons for in-hospital infant formula supplementation such as perceived insufficient milk supply, signs of inadequate intake, and poor latch (Chantry et al., 2014). Personalized lactation care may minimize formula supplementation for these non-medically indicated factors (Garrison & Maisano, 2019; Kellams et al., 2017; Medina Poeliniz, Engstrom, Hoban, Patel, & Meier, 2020). However, most existing studies on reasons for in-hospital infant formula supplementation were conducted in a single hospital. The purpose of this analysis was to examine the most common reasons for in-hospital infant formula supplementation of healthy, term, breastfed infants using a national data set.

2. Methods

2.1. Data source

Data were obtained from the 2018 Maternity Practices in Infant Nutrition and Care (mPINC) survey, which is a voluntary census administered biennially by the Centers for Disease Control and Prevention (CDC) to all maternity hospitals in the US and territories (Centers for Disease Control and Prevention, 2020b). Information on routine maternity care and infant feeding policies and practices are collected through a survey from each facility, specifically from the staff person identified as most knowledgeable about the policies and practices at the facility, with input from others as necessary. Often, a group of maternity care staff complete the survey. In 2018, hospital personnel were asked the following qualitative, open-ended question: "what are the 3 most common situations that lead to recommendations or requests for formula for healthy breastfed newborns during the hospital stay?" Other data obtained from the mPINC survey included hospital type; teaching status; Baby-Friendly hospital designation; and total annual live births.

2.2. Analysis

The responses to the open-ended question were analyzed using thematic analysis as described by Braun & Clarke (2006), which enabled the use of existing literature while also allowing flexibility to capture novel responses. To become familiar with the responses and to develop codes considering the large number of responses, a simple random sample (SRS) of 20% (n=409) of the responses to the qualitative mPINC question were taken using SAS 9.4 and imported to MAXQDA2020 to begin qualitative analysis. For this 20% SRS, the first author (LB) and an additional qualitative analyst (DE) reviewed the data while noting initial concepts; developed codes and a codebook; and independently applied codes. LB and DE discussed coding discrepancies, overarching categories for codes, and emerging themes. LB wrote memos on the resolution to the discrepancies; LB updated the codebook; and LB and DE made corrections to previously coded data. LB coded the remaining 80% of the responses using the updated codes; themes were further defined and reviewed using memo writing while also considering ABM Clinical Protocols (Hernandez-Aguilar, Bartick, Schreck, & Harrel, 2018; Holmes, McLeod, & Bunik, 2013; Kellams et al., 2017). Breastfeeding contraindications (e.g. illicit drug use, incompatible medication, and HIV), higher level of care for infants, prematurity, offering donor human milk for supplementation instead of infant formula, and other extenuating circumstances were not included in further analysis due to the focus on infant formula supplementation of healthy, term, breastfed newborns.

The results from the qualitative analysis were imported to SAS 9.4. Descriptive analysis was conducted to report the characteristics of the hospitals that responded to the mPINC survey. Descriptive analysis was also conducted to report the count and frequency of the themes and subcategories within the overarching themes. Some hospitals reported multiple subcategories from one theme; however, the descriptive statistics for themes only counted hospitals once if the theme was present. For example, a hospital may list hypoglycemia, jaundice, and inadequate elimination as the three most common reasons for infant formula supplementation; however, this hospital would only be counted once in the frequency for the overarching theme of medical indications.

3. Results

The characteristics of the 2,045 hospitals that responded to the 2018 mPINC survey qualitative question on common reasons for infant formula supplementation are listed in **Table 3-1**, which represents approximately 70% of all US hospitals that provide maternity care. Hospitals were mostly non-profit (77%) and teaching hospitals (69%) and 25% were designated Baby-Friendly.

Seven themes for common reasons for in-hospital formula supplementation were identified in the qualitative analysis: medical indications (70.0%); maternal request/preference/feelings (55.9%); lactation management-related issues (51.3%); physical but non-medically indicated reasons (36.7%); social influences (18.8%); perceived cultural/societal/demographic factors (8.2%); and medical staff/institutional practices (4.7%). Subcategories for each theme and theme definitions are reported in **Table 3-2**.

Medical indications were the most frequently reported theme; 70.0% of hospitals reported a medical indication for formula as listed in ABM Clinical Protocol #3 on Supplementary Feeding in the Healthy Term Breastfed Neonate as at least one of the most common situations leading to infant formula supplementation (Kellams et al., 2017). The highest subcategory within the theme medical indications was hypoglycemia in the infant (46.1%). The second highest subcategory was weight loss (36.5%), in which a range of responses were reported including a general mention of weight loss to specific mention of supplementation for weight loss beginning at 7% up to 12% of birth weight. Some hospitals reported that infants were supplemented despite treatment for jaundice with phototherapy.

Maternal request, preference, or feelings about breastfeeding was reported by 55.9% of hospitals. Request (34.8%) and preference (15.6%) of the mother were the most frequently reported subcategories for this theme. Some hospitals reported that requests for formula supplementation were made after the provision of lactation management education or support (4.0%). Some hospitals reported that mothers decided to supplement prior to admission for delivery (2.5%); for example, a hospital reported "patients that come in choosing both breastfeeding and formula feeding." Mothers' previous feeding experience of an older child included having formula fed other children or unpleasant previous breastfeeding experiences were reported as common reasons for infant formula supplementation (1.6%). Feelings about breastfeeding included hospitals reporting mothers' frustrations with feeding (3.0%) and mothers' lack of confidence (0.3%).

Lactation management-related issues were reported by 51.3% of all hospitals. The most frequently mentioned subcategory for this theme was perceived low milk supply by the mother (16.5%), which encompassed mothers mentioning that they have "no milk," and mothers mentioning not having "enough milk" to provide to the infant. Many hospitals that reported perceived low milk supply also reported concerns about infant hunger (14.0%) as a separate reason. The subcategory, concern about infant hunger, in contrast to perceived low milk supply included infants not "getting enough" and additionally included the infant not appearing satisfied after feeding, which was expressed through infant crying. A variety of other concepts were mentioned related to lactation management including latching issues (10.0%); inconsolable infants (6.1%); cluster feeding (closely spaced nursing sessions) or feeding frequency (4.5%); difficulty breastfeeding (4.9%); breastfeeding concerns that arise during night hours (3.7%); lack of knowledge (3.2%); and soreness or discomfort of the breast or nipple (2.6%). The subcategory pain specific to breastfeeding (2.4%) consisted of responses that listed "pain" due to concerns such as "nipple damage" or "cracked nipples." In contrast, the subcategory soreness or discomfort of the breast or nipple (2.6%) included less severe breast and nipple related issues.

A total of 36.7% of hospitals reported at least one of the most common situations leading to infant formula supplementation being *physical but non-medically indicated*. The medical conditions included in this theme are those that are not listed as a possible medical indication for infant formula supplementation in ABM Clinical Protocol #3 on Supplementary Feeding in the Healthy Term Breastfed Neonate (Kellams et al., 2017). This theme consisted mostly of concepts related to maternal exhaustion or fatigue (25.4%). Mothers' desire for rest following delivery and dyad separation (2.2%) often were reported together, for example a hospital mentioned "mothers want to sleep and want baby to stay in the nursery" as a common reason for infant formula supplementation. This theme also includes a general mention of unrelated health issues (6.7%), infant birth weight or size (1.8%), generalized pain/discomfort of the mother that is not specific to breastfeeding (1.6%), and a variety of other physical related reasons.

Social influences were among the top reasons for infant formula supplementation for 18.8% of hospitals. This includes the specific mention of "parents" making decisions (8.4%) or requests related to infant feeding. Family and friends (4.8%) were reported to encourage formula feeding or not be supportive of breastfeeding, which led to formula supplementation. For example, one hospital reported that "family members pressure mothers to provide formula." The subcategory family and friends also included report of mothers not wanting to breastfeed in front of family and friends, so they choose to feed infant formula during these visits.

A total of 8.2% of hospitals reported *perceived cultural/societal/demographic factors.* This included a general mention of cultural beliefs (4.6%). Some hospitals specifically mentioned Hispanic culture (1.5%) as one of the most common reasons leading to infant formula supplementation, which included cultural norms of perceived low milk supply. Some hospitals further explained that "Hispanic populations feel that first milk is no good." In addition, other factors were related to societal factors such as returning to work and demographic factors such as young age.

Concepts related to *medical staff/institutional practices* were the least reported theme (4.7%). Several of the hospitals reported doctors' requests in conjunction with medical indications or physical/medical related conditions. However, 3.2% of hospitals reported doctors' requests without further explanation. Additionally, there was mention of staff lacking knowledge and staff not providing adequate education to patients (1.0%) as reported by one hospital: "staff's lack of support and ability/willingness to educate patient and family."

4. Discussion

This analysis provides insight into the common reasons for infant formula supplementation of healthy, term, breastfed infants in hospitals across the US. Over half of responding hospitals reported possible medical indications; maternal request/preference/feelings; and lactation management-related issues as common reasons for formula supplementation. Less frequently reported common reasons for formula supplementation were physical/medical related conditions; social influences; perceived cultural/societal/demographic factors; and medical staff/institutional practices.

In contrast to previously conducted studies, we found that the most frequently reported reasons for infant formula supplementation were related to the ABM's possible medical indications for formula supplementation. Other studies have found 75% to 90% of in-hospital infant formula supplementation was not medically indicated (Biggs et al., 2018; Boban & Zakarija-Grković, 2016; Tender et al., 2009). However, these studies used medical records and surveys with mothers to collect data, whereas the mPINC survey is conducted among hospital staff (Biggs et al., 2018; Boban & Zakarija-Grković, 2016; Tender et al., 2009). In addition, these studies were conducted in small samples and in other countries, which defined medical indications of infant formula supplementation differently from the US (Biggs et al., 2018; Boban & Zakarija-Grković, 2016; Tender et al., 2009). The onset and development of some medical indications may not begin until after hospital discharge; for example, the onset of jaundice typically ranges from 2-5 days of life (Flaherman & Maisels, 2017). ABM Clinical Protocols include provision of appropriate lactation management support, and it is unclear if hospitals reporting medical indications provide lactation management support prior to infant formula supplementation. Further work is needed to understand if appropriate testing for conditions such as hypoglycemia and jaundice or if appropriate lactation management support are provided before infant formula supplementation is given, as recommended by the ABM Clinical Protocols. This includes reviewing policies and practices among clinicians to assure that infant formula supplementation is not automatically given without proper assessment when these potential medical indications arise.

A previously conducted analysis using 2013 mPINC data among US birth hospitals, reported that the average hospital reported 65% of infants were supplemented with infant formula due to maternal request (Nelson et al., 2016). A qualitative study conducted among low income women found that maternal request for in-hospital infant formula supplementation of healthy, breastfed infants was due to lack of preparation related to anticipatory guidance about infant behavior (DaMota, Bañuelos, Goldbronn, Vera-Beccera, & Heinig, 2012). Our analysis found that hospitals report that maternal requests are sometimes made after patient education is provided in the hospital setting, suggesting the need for more education before admission to the hospital for delivery.

The most common lactation management concern reported was mothers' perceived low milk supply, which has been frequently reported by other studies (Boban & Zakarija-Grković, 2016; Pierro, Abulaimoun, Roth, & Blau, 2016). Though research about primary insufficient breast milk supply related to concerns of the breast tissue is lacking, one older study suggests that it is rare, and is often secondary to practices that interrupt the normal physiology of breastfeeding (Neifert et al., 1990). The prevalence of pre-pregnancy obesity and older age at first birth are increasing nationally, and these factors may impact the onset of lactogenesis II, in which copious milk secretion occurs (Driscoll & Gregory, 2020; Mathews & Hamilton, 2016; Nommsen-Rivers, Dolan, & Huang, 2012). More research is needed to determine if low milk supply during the first few days following birth is primary (directly related to the physiology) or secondary (related to practices that interrupt the normal physiology of lactation). Mothers' perceived low milk supply has been found to be related to perceived hunger of the child, which is expressed by crying and number or frequency of feedings (Gatti, 2008). Professional support that guides parents to early optimal latching and informs signs of efficacious infant suckling may help to reduce mothers' perceived low milk supply and other related factors that potentially lead to infant formula supplementation (Galipeau, Dumas, & Lepage, 2017; Gatti, 2008). In addition, some hospitals reported that many of the lactation management-related issues arise during the night hours. One study reported that infants born at night had double the odds of in-hospital infant formula supplementation compared to infants born during the day (Grassley, Schleis, Bennett, Chapman, & Lind, 2014). Lactation management support during the night hours may be an important support for breastfeeding mother- infant dyads.

Similar to other studies, we found that physical conditions such as exhaustion and mothers' desire for sleep were common reasons for infant formula supplementation (Pierro et al., 2016). Although formula feeding enables others, including family and medical staff, to feed the infant while the mother rests, the potential consequence includes disrupting the normal physiology of lactation resulting in a decreased milk supply and shorter duration of breastfeeding (Chantry et al., 2014; McCoy & Heggie, 2020). Other physical conditions have been reported, in which infants born via cesarean section and large-for-gestational-age infants were at greater risk for non-medically indicated formula supplementation (Garrison & Maisano, 2019).

The role of social influences on infant formula supplementation and non-exclusive breastfeeding has been reported previously in qualitative literature which suggests that this may be due to limited family experience and limited family lactation management knowledge (Asiodu, Waters, Dailey, & Lyndon, 2017; Deubel, Miller, Hernandez, Boyer, & Louis-Jacques, 2019). Another study found that fathers' preference for infant formula supplementation was significantly associated with in-hospital formula supplementation (Parry, Ip, Chau, Wu, & Tarrant, 2013). Similarly, many hospitals in our analysis used the term "parents," which suggests that mothers were not alone in their decision making, and that fathers or partners may also have a role in the decision-making process for in-hospital infant formula supplementation. Further work is needed to understand the influence of partners and the potential joint decisions made between mothers and partners.

In alignment with other studies, perceived culture was also found to influence in-hospital infant feeding decisions (Asiodu et al., 2017; Hawley et al., 2015; Hohl, Thompson, Escareno, & Duggan, 2016; Pierro et al., 2016). Bias and stereotyping in healthcare may influence medical staff perceptions and behavior toward patients of specific backgrounds (FitzGerald & Hurst, 2017). There are some common racial and ethnically driven misconceptions and stereotyping in breastfeeding practices, such as "Hispanics do las dos cosas (both formula feeding and breastfeeding)" or "black women do not breastfeed" (Panchula, 2012). Although this may be true in some cases, it is crucial not to generalize any behavior for all mother-infant dyads of the same racial/ethnic group as this may negatively impact patient care (Hughes et al., 2020). A potential solution to dispelling myths includes maternity care staff training that focuses on the cultural humility approach, which is a lifelong commitment to building awareness about their own cultural biases and truly learning about patients as unique individuals with their own personal cultural background (Hughes et al., 2020; Tervalon & Murray-García, 1998). In addition, qualitative studies report that cultural differences may be related to factors such as lack of support networks that normalize breastfeeding among African American women and pressure to adopt the behaviors of US culture among Hispanic women (Deubel, 2019; Wambach, 2016). Peer breastfeeding support may be useful in overcoming cultural barriers and may facilitate delivery of culturally relevant support in hospitals with limited access to trained lactation professionals (Chapman & Pérez-Escamilla, 2012; Lutenbacher, Elkins, Dietrich, & Riggs, 2018).

A previously conducted analysis using 2013 mPINC data among US birth hospitals, reported that on average across hospitals 25% of breastfed infants were supplemented with infant formula for doctors' orders and 9% for nurses' recommendations (Nelson et al., 2016). We found that hospitals report that less than 5% of the most common reasons for infant formula supplementation were related to medical staff or institutional practices. There are two key differences between the 2013 and 2018 mPINC survey questions on reasons for formula supplementation. First, the 2013 survey question provided 4 choices (doctors' orders, nurses' recommendation, mothers' choice, and other), whereas the 2018 survey utilizes an open-ended question. Second, the 2013 survey asks the percentages supplemented due to the 4 choices, which summed to 100%, whereas the 2018 survey asks about the 3 most common reasons for formula supplementation. From our analysis, we are unable to determine if the requests made by medical staff are based on proper assessment of medical conditions and provision of lactation management support before infant formula supplementation. Continued work is needed to further minimize this reason as the American Academy of Pediatrics endorses the World Health Organization/United Nation's Children's Fund "Ten Steps to Successful Breastfeeding," which recommends that formula is not given to breastfed infants unless medically indicated (Eidelman, 2012; World Health Organization and UNICEF, 2018).

This study offers insight into the most common reasons for infant formula supplementation of breastfed newborns; however, key limitations exist. First, responses to the mPINC survey may be based on estimates made by the survey respondent and may or may not be based on data routinely collected by the hospital. To ensure accuracy of the data, the CDC takes additional steps to ensure the survey is delivered to the person who is most knowledgeable of the hospital's maternity care and infant feeding practices (Centers for Disease Control and Prevention, 2020b). The CDC also encourages the respondent to get input from key staff as needed, and often the survey is completed by a group (Centers for Disease Control and Prevention, 2020b). Second, nonresponse bias is possible; however, 70% of all US hospitals providing maternity care completed the survey. Third, hospitals were asked to report the three most common situations that lead to recommendations or requests for formula (reported at the aggregate, hospital level). Therefore, hospitals reported multiple reasons, the report of reasons for formula supplementation are not mutually exclusive, and the mother-infant dyad level prevalence of reasons for formula supplementation is unknown. However, the purpose of this analysis was to qualitatively examine the reasons for formula supplementation, to inform future survey questions, and to generate hypotheses for future analyses. Fourth, due to the open-ended nature of the question, some hospitals reported common reasons for formula supplementation that fall into multiple subcategories within a theme. To address this, the overall frequency for the theme counts hospitals only once if the subcategory is reported. Fifth, we are unable to determine if these situations led to the practice of providing formula to breastfed newborns.

5. Conclusion

National data from the mPINC survey on the most common reasons for in-hospital infant formula supplementation suggests that a variety of factors should be considered to address unnecessary formula supplementation. The most frequently reported reason for formula supplementation were related to medical indications; however, proper assessment and lactation management support could potentially decrease unnecessary formula supplementation. Lactation management-related issues were frequently reported, which further supports that increased lactation management support could potentially reduce unnecessary formula supplementation. Continued work is needed to understand the underlying mechanisms of formula supplementation and to reduce the prevalence of formula supplementation.

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Table 3-1. Characteristics of hospitals responding to the most common reasons for formula supplementation – mPINC 2018 (n=2,045)

Characteristic	n (%)
Hospital type	
Government	85 (4.2%)
Non-profit	1,569 (76.7%)
Private	385 (18.8%)
Military	6 (0.3%)
Teaching hospital	1,411 (69.0%)
Baby-Friendly hospital designation	504 (24.7%)
Total live births	
1 – 499	717 (35.1%)
500 – 999	437 (21.4%)
1000 – 1999	450 (22.0%)
2000 – 4999	391 (19.1%)
≥ 5000	50 (2.4%)

Note. mPINC= Maternity Practices in Infant Nutrition and Care.

Table 3-2. Themes, theme definitions, and subcategories for reasons for formula supplementation of healthy breastfed newborns-mPINC 2018 (n=2,045)

Reasons for Formula Supplementation			
Theme: Definition	n (%)	Subcategories	n (%)
Medical indications: Possible medical indications for supplementation in healthy, term infants as listed in ABM Clinical Protocol #3 on Supplementary Feeding in the Healthy Term Breastfed Neonate.	1431 (70.0%)	Hypoglycemia	943 (46.1%)
		Weight loss	747 (36.5%)
		Jaundice	555 (27.1%)
		Inadequate elimination	44 (2.2%)
		Lethargic	18 (0.9%)
		Dehydration	17 (0.8%)
		Medications	14 (0.7%)
		Breast pathology/ prior breast surgery	11 (0.5%)
		Intake concerns	8 (0.4%)
		Delayed secretory activation	8 (0.4%)
		Elevated sodium	2 (0.1%)
		Insufficient glandular tissue	1 (0.1%)
Maternal request/preference/ feelings: Mothers' specific requests and preferences and the discussion of feelings related to breastfeeding such as lack of confidence or frustration.	1144 (55.9%)	Request of mother	712 (34.8%)
		Preference of mother	318 (15.6%)
		Formula supplementation requested after education provided	82 (4.0%)
		Frustration	61 (3.0%)
		Maternal plans	51 (2.5%)
		Previous feeding experience	32 (1.6%)
		Convenience	11 (0.5%)
		Lack of confidence	6 (0.3%)
		Mothers waiting until they go home to begin breastfeeding	3 (0.2%)
		Lack of breastfeeding effort	1 (0.1%)
		Perception that infant does not "like" breastfeeding	1 (0.1%)
		Body image	1 (0.1%)
Lactation management-related issues: Reasons that are directly related to lactation and the act of breastfeeding for the mother and infant.	1048 (51.3%)	Mothers' perceived low milk supply	338 (16.5%)
		Concern about infant hunger	286 (14.0%)
		Latching issues	205 (10.0%)
		Inconsolable infant/fussiness	124 (6.1%)
		Difficulty breastfeeding	101 (4.9%)

Reasons for Formula Supplementation			
Theme: Definition	n (%)	Subcategories	n (%)
		Low milk supply only	96 (4.7%)
		Cluster feeding/feeding frequency	92 (4.5%)
		Concerns during the night	75 (3.7%)
		Mothers lack of lactation management knowledge	65 (3.2%)
		Soreness/discomfort of breast or nipple	54 (2.6%)
		Ineffective suckling	49 (2.4%)
		Pain specific to breastfeeding	48 (2.4%)
		Challenging anatomy for breastfeeding	12 (0.6%)
		Extended feedings	2 (0.1%)
		Breastfeeding assistance device usage	1 (0.1%)
Physical but non-medically indicated: Reasons related to the physical state of the mother or infant that are not listed in ABM† Clinical Protocol #3 and that are not directly related to breastfeeding.	751 (36.7%)	Maternal exhaustion/ fatigue	520 (25.4%)
		Unknown medical reasons	136 (6.7%)
		Dyad separation	44 (2.2%)
		Birth weight/size	36 (1.8%)
		Generalized pain/discomfort of the mother	33 (1.6%)
		Neonatal abstinence syndrome	18 (0.9%)
		Concern about infant nutrition	14 (0.7%)
		Labor/delivery issues	14 (0.7%)
		Surgery	10 (0.5%)
		Diabetes	9 (0.4%)
		Mental health	8 (0.4%)
		Tongue tie	6 (0.3%)
		Lack of sleep for the infant	4 (0.2%)
		Hemorrhage/postpartum bleeding	4 (0.2%)
		Hypertension/ pre-eclampsia	3 (0.2%)
		Positive Coombs test	3 (0.2%)
		Congenital anomalies/cleft	3 (0.2%)
		Failure to thrive	2 (0.1%)
		Reflux	2 (0.1%)
		Abnormal lab	2 (0.1%)
		Sepsis	2 (0.1%)

Reasons for Formula Supplementation			
Theme: Definition	n (%)	Subcategories	n (%)
		Edema	1 (0.1%)
		Maternal concern of own nutrition	1 (0.1%)
		Low body temperature	1 (0.1%)
		Post resuscitation	1 (0.1%)
Social influences: The influence of mothers' closest relationships such as family and friends and decisions made by parents.	384 (18.8%)	Requests by parents	172 (8.4%)
		Family and friends influence	98 (4.8%)
		Parents concern	51 (2.5%)
		Preference/choice of parents	48 (2.4%)
		Preference/choice of family	6 (0.3%)
		Lack of support	23 (1.1%)
		Requests by family	16 (0.8%)
		Perceived low milk supply by parents	13 (0.6%)
		Perceived low milk supply by family	8 (0.4%)
Perceived cultural/ societal/ demographic related factors: Reasons related to perceived cultural norms, societal factors, or demographics of the population served.	167 (8.2%)	Cultural beliefs	94 (4.6%)
		Hispanic culture	30 (1.5%)
		Perceived low milk supply by the culture	19 (0.9%)
		Preference/ choice-culture	11 (0.5%)
		Returning to work	9 (0.4%)
		External environment	3 (0.2%)
		Young age	8 (0.4%)
Medical staff/ institutional practices: Doctors or nurses requests or orders; medical staff's limited knowledge or skills related to lactation management; or hospital polices or practices.	97 (4.7%)	Doctors' request (non-specific)	66 (3.2%)
		Limited knowledge or practices of staff	20 (1.0%)
		Staff related (non-specific)	11 (0.5%)
		Understaffed	7 (0.3%)
		Standing orders/policy	3 (0.2%)

Note. Theme subcategories do not total to 100% because hospitals were counted once for frequency of themes and were counted more than once if applicable for each subcategory. (For example a hospital may list hypoglycemia, jaundice, and inadequate elimination as the most common reasons for formula supplementation; however, this hospital would be counted once in the frequency for the overarching theme of medical indications.) mPINC= Maternity Practices in Infant Nutrition and Care survey.
†ABM=Academy of Breastfeeding Medicine.

Chapter 4: A dose-response relationship found between the Ten Steps to Successful Breastfeeding indicators and in-hospital exclusive breastfeeding in US hospitals

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Submitted to clearance for the Centers for Disease Control and Prevention.

Key messages:

- Hospital implementation was low for rooming-in, facility policies, and limited formula supplementation.
- Steps positively and significantly associated with in-hospital exclusive breastfeeding (EBF) prevalence after adjusting for hospital characteristics and all other related steps included limited formula supplementation, prenatal breastfeeding education, responsive feeding, immediate postnatal care, and rooming-in.
- A dose response relationship was found between the total number of steps implemented by a hospital and in-hospital EBF prevalence.
- Although individual steps were positively associated with in-hospital EBF prevalence, the dose response relationship between the number of steps implemented and in-hospital EBF prevalence provide evidence that increased implementation of all the related steps may improve in-hospital EBF prevalence.

Abstract

In-hospital exclusive breastfeeding (EBF) is associated with longer breastfeeding durations, yet only 64% of US newborns are EBF for 7 days. The Ten Steps to Successful Breastfeeding (Ten Steps) are a set of evidenced-based maternity practices shown to improve breastfeeding outcomes. Using hospital-level data from the 2018 Maternity Practices in Infant Nutrition and Care Survey (n=2,045 hospitals), we examined the prevalence of implementation of Ten Steps indicators (each step and total number of steps implemented). Using linear regression, we also examined the association between the steps and EBF prevalence adjusted for hospital characteristics and all other steps. Discharge support was not included in the models since it primarily occurs after hospital discharge. The most frequently implemented step was the provision of prenatal breastfeeding education (95.6%). Steps with low implementation included rooming-in (18.9%), facility policies supportive of breastfeeding (23.4%), and limited formula supplementation (28.2%). After adjusting for hospital characteristics and all other steps, limited formula supplementation [β=17.2: 95% confidence interval (CI): 15.4, 19.1], prenatal breastfeeding education (β=8.0; 95% CI: 4.0, 12.0), responsive feeding (β=7.0; 95% CI: 4.1, 9.8), care right after birth (skin-to-skin) (β=6.7; 95% CI: 5.0, 8.5), and rooming-in (β=3.3; 95% CI: 1.1, 5.5) were associated with higher in-hospital EBF prevalence. We found a dose response relationship between the number of steps implemented and in-hospital EBF prevalence. Increased implementation of the Ten Steps may improve EBF and infant and maternal health outcomes.

1. Introduction

A growing body of evidence supports that exclusive breastfeeding (EBF) during the hospital stay following birth is associated with increased breastfeeding duration (Chantry et al., 2014; McCoy & Heggie, 2020). Although EBF is recommended for the first 6 months of life [(Eidelman, 2012; World Health Organization (WHO), 2018; US Department of Agriculture and US Department of Health and Human Services, 2020)], 64% of US newborns are EBF at 7 days and only 26% meet the recommendation of EBF for 6 months [(Centers for Disease Control and Prevention (CDC), 2021a)].

The first few days of life, which are often spent in maternity care facilities, are important for providing support to successfully breastfeed (WHO, 2018). The Baby-Friendly Hospital Initiative is a global program that supports broad-scale implementation of the evidenced-based Ten Steps (Ten Steps) to Successful Breastfeeding at facilities providing maternity and newborn services (WHO, 2018). Originally released by the WHO and UNICEF in 1991, the Ten Steps were updated in 2018 (WHO, 2018). Examples of key updates include monitoring EBF prevalence internally (step 1), focusing on competency assessment of staff rather than staff training (step 2), preparing mothers for potential breastfeeding difficulties is the focus for practical support (step 5), and counseling mothers on the use and risks of artificial teats instead of prohibiting them (step 9) (WHO, 2018). BFHI promotes the implementation of each of the Ten Steps; however, some hospitals may not fully implement each step and some facilities may implement varying combinations of steps (WHO, 2018).

Previously conducted national analyses have examined trends in individual components of Ten Steps indicators such as hospitals implementing a model breastfeeding policy (Nelson & Grossniklaus, 2019), skin-to-skin contact (Boundy et al., 2018), the provision of non-breast milk supplements to healthy breastfed newborns (Nelson et al., 2016), and rooming-in (Barrera et al., 2018) and have found increasing prevalence of implementation of these policies and practices over time. In addition, an analysis that examined the implementation of some indicators for each of the Ten Steps found an increase in implementation from 2007 to 2013 (Perrine et al., 2015). An analysis using 2013 data found that most individual maternity care practices related to the Ten Steps were significantly associated with in-hospital EBF prevalence (Patterson et al., 2019).

National hospital implementation of each of the updated Ten Steps and the association between implementation and in-hospital EBF prevalence has not been described. To address this gap, we aimed to describe the national maternity hospital implementation of available indicators of the revised Ten Steps and the association with in-hospital EBF prevalence.

2. Methods

Data for this analysis were obtained from the 2018 Maternity Practices in Infant Nutrition and Care (mPINC) survey. The mPINC survey is conducted biennially by the CDC and all maternity care hospitals in the US and territories are invited to participate (CDC, 2021b). Of the 2,913 eligible maternity hospitals, 2,045 hospitals responded, which is approximately 70% of all maternity care hospitals in the US and territories. Facilities report information on infant feeding policies, infant feeding practices, and routine maternity care. The manager of the labor and delivery unit or the mother-baby nurse manager is contacted to help identify the most knowledgeable staff person to receive the survey, and the survey is typically completed by a group of staff.

The outcome for this analysis was in-hospital EBF prevalence, which included responses to the mPINC survey question on the percent of healthy newborns fed only breast milk during the hospital stay reported for each hospital. The exposures included indicators of implementation for each of the Ten Steps and the total number of the Ten Steps implemented. The mPINC Ten Steps Assessment Tool, which aligns the 2018 mPINC survey questions with the updated 2018 BFHI Implementation Guidance, was used to identify survey questions related to each of the Ten Steps **(Table 1)** (CDC, 2021c). Although the tool aligns mPINC survey questions with the Ten Steps, the mPINC questions do not comprehensively assess each step; therefore, it provides indicators related to each step. mPINC survey questions that were not related to EBF were not included as indicators of the Ten Steps including skin-to-skin contact after vaginal or Cesarean delivery if not breastfeeding and instructions of formula feeding techniques and safe preparation and handling of formula. Indicators for most of the Ten Steps included multiple survey questions. All responses were dichotomized (implementing the ideal standard or not implementing the ideal standard) based on the mPINC Ten Steps Assessment Tool (CDC, 2021c). Hospitals were then categorized as either "implementing the Ten Step indicator" if they reported the ideal standard for each survey question related to the respective step or as "not implementing the Ten Step indicator" if at least one of the responses was not the ideal standard. The predictors are derived from the Ten Steps; however, since the outcome for the linear regression (EBF) occurs in-hospital, care at discharge (step 10) was not included in the linear regression. Therefore, implementation of the steps for the linear regression refers to steps 1-9. The total number of steps implemented by each hospital were calculated and categorized into low (0 to 3 steps), mid (4 to 6 steps), and high (7 to 9 steps) implementation. Hospital characteristics were covariates and included hospital type (non-profit, private, government, or military), teaching hospital (yes or no), and total live births (annual number of births categorized as 1-499, 500-999, 1000-1999, or ≥2000).

Descriptive analyses were conducted to report the hospital characteristics and the prevalence of hospital implementation of the indicators of the steps. We conducted linear regression to examine the relationship between implementation of steps 1-9 and in-hospital EBF prevalence using three sets of models. The first set of models examined the bivariate associations between each of the nine steps individually and EBF prevalence. The second set of models included each step individually and EBF prevalence adjusted for hospital characteristics (hospital type, teaching status, and total live births). The third model was the same as the second model, additionally adjusted for all other steps 1-9. Next we examined the association between the total number of steps implemented and the association with EBF prevalence using bivariate linear regression and multivariable linear regression to adjust for hospital characteristics. Model diagnostics were conducted, the residuals were normally distributed, and multicollinearity was not found among the variables using a cutoff of <0.10 for tolerance. Statistical significance was set at $p<0.05$. Analyses were completed using SAS 9.4 (SAS Institute Inc., Cary, NC). The Internal Review Board of Emory University determined that this research did not involve human subjects since no identifiable, individual data were obtained.

3. Results

Hospital characteristics are reported in **Table 4-2**. Of the 2,045 responding hospitals, 24.7% were Baby-Friendly designated. The majority of hospitals were non-profit hospitals (76.7%) and teaching hospitals (69.0%). Hospitals with 499 births or less represented the largest category of total live births (35.1%).

The provision of prenatal information (step 3) was the most frequently reported step (95.6%) **(Table 4-3)**. The next most frequently reported steps were responsive feeding (step 8; 87.8%) and care at discharge (step 10; 79.5%). Steps with low levels of implementation were rooming-in (step 7; 18.9%), hospital policies (step 1; 23.4%), and limited supplementation (step 6; 28.2%).

The average in-hospital EBF prevalence was 55.1%. Positive, significant bivariate associations were found between indicators of each of the steps examined and EBF prevalence **(Table 4-4)**. Similarly, the steps remained positively and significantly associated with EBF prevalence after adjusting for hospital characteristics. In the model adjusted for hospital characteristics and the other steps, limited supplementation (step 6) was associated with the greatest difference in EBF prevalence; the EBF prevalence for hospitals was 17.2 percentage points higher than hospitals that did not implement this step [95% confidence interval (CI): 15.4, 19.1]. The provision of prenatal breastfeeding information (step 3; β=8.0; 95% CI: 4.0, 12.0), responsive feeding (step 8; β=7.0; 95% CI: 4.1, 9.8), care right after birth (step 4; β=6.7; 95% CI: 5.0, 8.5), and rooming-in (step 7; β=3.3; 95% CI: 1.1, 5.5) were significantly and positively associated with EBF prevalence.

The total number of steps implemented and the association with in-hospital EBF prevalence are reported in **Table 4-5**. Low implementation of steps (0-3 steps) was reported by 24.5% of hospitals, mid implementation (4-6 steps) was reported by 48.9% of hospitals, and high implementation (7-9 steps) of steps was reported by 26.6% of hospitals. The average EBF prevalence was 46.0% for hospitals with low implementation, 54.6% for hospitals with mid implementation, and 64.4% for hospitals with high implementation. Mid implementation of the steps was associated with 9.0 percentage points higher EBF prevalence (95% CI: 6.9, 11.1) and high implementation was associated with 19.5 percentage points higher EBF prevalence (95% CI: 17.1, 21.9) compared to low level implementation.

4. Discussion

Using national hospital data on maternity care practices in infant nutrition and care, we examined maternity hospital implementation of indicators of the Ten Steps to Successful Breastfeeding and the associations with in-hospital EBF prevalence. We found that the most frequently implemented step was the provision of prenatal breastfeeding education (step 3). The least frequently implemented step was rooming-in (step 7). Limited supplementation of breastfed newborns (step 6) was associated with the greatest difference in EBF prevalence compared to hospitals that did not implement this step. In addition, the provision of prenatal breastfeeding education (step 3), care right after birth (step 4), rooming-in (step 7), and responsive feeding (step 8) were significantly associated with higher in-hospital EBF prevalence after adjusting for hospital characteristics and all other steps 1-9. We also found a dose-response relationship between the number of steps implemented and in-hospital EBF prevalence.

Previously conducted national analyses using mPINC data have found increasing implementation of components of the Ten Steps. Hospitals reporting having a model breastfeeding policy increased from 14.1% in 2009 to 33.1% in 2015 (Nelson & Grossniklaus, 2019). Skin-to-skin contact improved from 40.4% in 2007 to 83.0% in 2015 for vaginal births and 29.3% in 2007 to 69.9% in 2015 for cesarean births (Boundy et al., 2018). The provision of non-breast milk supplements to healthy breastfed newborns to at least 50% of newborns decreased from 31.5% in 2009 to 23.3% in 2013 (Nelson et al., 2016). Rooming-in increased from 27.8% in 2007 to 51.4% in 2015 (Barrera et al., 2018). The mPINC survey was redesigned for the 2018 implementation, including wording of the questions and cut-offs for categorization of response options, so data from this survey cannot be directly compared to previous survey cycles. Additionally, this analysis used more than one component or question for the indicators for most of the steps versus previous studies of the Ten Steps using mPINC data which have typically used only one survey item as a proxy to represent implementation of one of the Ten Steps.

Staff competency (step 2) was associated with higher EBF prevalence in the bivariate analysis and the model that adjusted for hospital characteristics. However, a significant, inverse relationship was found between step 2 and EBF prevalence when additionally adjusting for all other steps 1-9. This indicates that this step alone is not associated with increased EBF prevalence, and the positive association with in-hospital EBF prevalence may rely on implementation of the other steps.

The provision of prenatal breastfeeding education (step 3) was reported to be the most frequently implemented step and was associated with EBF prevalence that were 8.0 percentage points higher (compared to non-implementing hospitals). Step 3 has previously been reported to be one of the most difficult to implement steps as it is often provided in outlying primary health-care clinics and hospitals may not have direct authority over the care delivered in these settings (Munn et al., 2016; WHO, 2018). The quality of prenatal breastfeeding education has been previously reported to be less consistently delivered at outlying clinics compared to clinics that are located within hospitals (Bookhart et al., 2021). However, BFHI Implementation Guidance recommends that hospitals work with outlying clinics to ensure that mothers and families receive prenatal breastfeeding education (WHO, 2018). BFHI Implementation Guidance recommends not only providing information on the importance of breastfeeding, but also on the importance of Baby-Friendly practices and the basics of breastfeeding positioning and latching (WHO, 2018). BFHI Implementation Guidance also supports delivering prenatal breastfeeding education to both pregnant women and their families (WHO, 2018). A systematic review that examined step

3, found that prenatal breastfeeding education is most effective at increasing breastfeeding outcomes (including exclusive breastfeeding) if they also include the support of women's partners or family (Wouk et al., 2017). Based on the indicator used in our analysis that is available through the 2018 mPINC survey, we are unable to determine the topics covered and the delivery method. Further work is needed to understand the relationship between the quality of implementation of step 3 (e.g. topics covered, involvement of partners/family, etc.) and the association with in-hospital EBF.

We found that immediate postnatal care, in which mothers and newborns remain in uninterrupted skin-to-skin contact until the first breastfeeding is completed after vaginal and cesarean deliveries (step 4) was significantly associated with EBF prevalence that were 6.7 percentage points higher (compared to non-implementing hospitals). Another study using mother-infant dyad level electronic medical records similarly found that skin-to-skin contact for one hour reduced the risk of infant formula supplementation by 44% compared to mother-infant dyads that did not complete skin-to-skin contact for one hour (Kalmakoff et al., 2018). Immediate skin-to-skin contact helps to facilitate early initiation of breastfeeding, accelerate lactogenesis II, and can be critical to establishing a milk supply (WHO, 2018).

Limited formula supplementation (step 6) was one of the least frequently implemented steps (28.2%); however, step 6 was significantly associated with the greatest difference in EBF prevalence (17.2 percentage points). Step 6 includes not providing breastfed newborns any food or fluids other than breast milk, unless medically indicated (WHO, 2018). The Academy of Breastfeeding Medicine Clinical Protocol on Supplementary Feedings in the Healthy Term Breastfed Neonate, outlines possible medical indications for formula supplementation and there are some circumstances (e.g. hypoglycemia, hyperbilirubinemia, etc.), in which supplementation should occur (Kellams et al., 2017). This protocol also supports proper assessment of medical indications, supports strategies to prevent supplementation (e.g. skin-to-skin, rooming-in, etc.), recommends the provision of lactation management support before supplementation, and recommends expressed breast milk from the infant's mother as the first choice for supplementation (Kellams et al., 2017). Furthermore, the American Academy of Pediatrics also places emphasis on the need to discontinue policies that provide non-breast milk supplements to breastfed infants (Eidelman, 2012). Additional work is needed to examine if appropriate steps to prevent supplementation with non-breast milk supplements are implemented in hospitals.

Rooming-in (step 7) was significantly associated with EBF prevalence; implementing hospitals were 3.3 percentage points higher than non-implementing hospitals; however, it was the least frequently reported implemented step (18.9%). In 2015, greater than 50% of hospitals reported implementation of rooming-in (Barrera et al., 2018). However, the 2018 survey included additional components of this indicator including routine procedures completed in the mother's room and observation protocols to ensure safety while rooming-in, which may have resulted in lower frequency of implementation of this step compared to the 2015 results. Rooming-in is an important structural component of the maternity care workflow, which may have implications for other steps (Pérez-Escamilla et al., 2016). For example, if step 7 is not properly implemented, separated mother-infant dyads cannot comply with step 4 (care right after birth), in which newborns receive skin-to-skin contact with their mothers after delivery, or step 8 (responsive feeding), in which mothers are taught to respond to early infant feeding cues and to breastfeed as long and often as the newborn wants (Pérez-Escamilla et al., 2016). Therefore, increasing implementation of this step may facilitate increased implementation of other steps.

We found a positive association between hospitals that implemented a greater number of steps and higher in-hospital EBF prevalence. The Ten Steps have previously been found to have a dose response relationship between the number of steps implemented and breastfeeding outcomes (Pérez-Escamilla et al., 2016). Our findings further support the need for implementation of steps 1-9 to increase the prevalence of in-hospital EBF.

There are three key limitations for this analysis. First, hospitals may or may not routinely collect the data collected in the survey; therefore, the responses may be based on estimates made by the survey respondent (CDC, 2021b). The CDC takes steps to deliver the survey to the person deemed most knowledgeable of survey topics, and the survey is often completed by a group of hospital staff (CDC, 2021b). Second, nonresponse bias is possible; however, 70% of US maternity care hospitals responded to the 2018 mPINC survey. Third, this analysis utilized some indicators for each of the Ten Steps, but these indicators are not comprehensive for each step. Some elements of the Ten Steps are not collected in the mPINC survey.

5. Conclusion

Indicators of the Ten Steps to Successful Breastfeeding were associated with increased in-hospital EBF prevalence. However, the majority of hospitals did not implement most steps. Greater implementation of steps 1-9 may be important considering the dose-response relationship between the number of steps implemented and higher EBF prevalence.

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Table 4-1. Maternity Practices in Infant Nutrition and Care survey question numbers and the related Ten Steps to Successful Breastfeeding indicators component topics

Ten Step Indicators Component Topic(s)
Step 1: Hospital policies Acquisition of infant formula at fair market price Gifts or free samples of infant formula, teats, coupons, educational materials from companies who make/sell infant formula, etc. are not provided Written policy includes 10 model policy elements Hospital records exclusive breastfeeding throughout entire hospitalization
Step 2: Staff competency Nurses are required to demonstrate 6 clinical skills Requirement of formal clinical competency assessment for nurses
Step 3: Prenatal education Prenatal breastfeeding education provided
Step 4: Care right after birth Uninterrupted skin-to-skin contact until the first breastfeeding is completed after vaginal delivery ≥80% Uninterrupted skin-to-skin contact until the first breastfeeding is completed after Cesarean delivery ≥80%
Step 5: Support with breastfeeding Education/support with position & latch ≥80% Education/support on assessing effective breastfeeding by observing their newborn's latch and the presence of audible swallowing ≥80% Education/support on assessing effective breastfeeding by observing their newborn’s elimination patterns ≥80% Education/support on hand expressing breast milk ≥80%
Step 6: Limited supplementation (Do not provide breastfed newborns any food or fluids other than breast milk unless medically indicated) Percent of healthy, term breastfed newborns who are fed infant formula <20% Counseling on the risk of infant formula for breastfeeding dyads ≥80%
Step 7: Rooming-in Vaginally-delivered newborns separated from their mothers before starting rooming-in <20% Newborns who room with their mothers for at least 23 hours per day ≥80% Infants remain in mothers’ room during procedures such as pediatric exams, hearing screening, routine labs, etc. Observation of mother-infant dyads to ensure safety
Step 8: Responsive feeding

Ten Step Indicators Component Topic(s)
Mothers are taught to respond to feeding cues ≥80% Mothers are taught to breastfeed as long/often as newborn wants ≥80%
Step 9: Bottles, nipples, and pacifiers Education and support on risk of teats
Step 10: Care at discharge Coordination of discharge to ensure appropriate follow-up care Coordination of discharge to ensure ongoing breastfeeding support

Table 4-2. Characteristics of the 2,045 hospital respondents to the 2018 Maternity Practices in Infant Nutrition and Care survey

Characteristic	n (%)
Baby-Friendly hospital designation	
Designated	504 (24.7%)
Not designated	1,541 (75.4%)
Hospital type	
Non-profit	1,569 (76.7%)
Private	385 (18.8%)
Government or military	91 (4.5%)
Teaching hospital	
Yes	1,411 (69.0%)
No	634 (31.0%)
Total live births	
1 – 499	717 (35.1%)
500 – 999	437 (21.4%)
1000 – 1999	450 (22.0%)
≥2000	441 (21.6%)

Table 4-3. Percentage of hospitals with ideal standard on indicators of the Ten Steps to Successful Breastfeeding, 2018 Maternity Practices in Infant Nutrition and Care survey

Ten Steps	n (%)
Step 1: Hospital policies	478 (23.4%)
Step 2: Staff competency	979 (47.9%)
Step 3: Prenatal education	1,955 (95.6%)
Step 4: Care right after birth	1,133 (55.4%)
Step 5: Support with breastfeeding	1,350 (66.0%)
Step 6: Limited supplementation	576 (28.2%)
Step 7: Rooming-in	386 (18.9%)
Step 8: Responsive feeding	1,796 (87.8%)
Step 9: Bottles, nipples, and pacifiers	1,539 (75.3%)
Step 10: Care at discharge	1,626 (79.5%)

Table 4-4. In-hospital exclusive breastfeeding prevalence and the association with indicators of steps 1-9 of the Ten Steps to Successful Breastfeeding

Ten Steps	Bivariate	Multivariate: Adjusted for hospital characteristics[a]	Multivariate: Adjusted for hospital characteristics[a] and all other steps 1-9
	β (95% CI)[b]		
Step 1: Hospital policies	7.7 (5.6, 9.8)*	8.5 (6.4, 10.7)*	1.7 (-0.5, 3.8)
Step 2: Staff competency	2.7 (0.9, 4.6)*	3.7 (1.9, 5.5)*	-2.9 (-4.6, -1.1)*
Step 3: Prenatal education	11.9 (7.5, 16.4)*	13.7 (9.2, 18.1)*	8.0 (4.0, 12.0)*
Step 4: Care right after birth	11.7 (9.9, 13.4)*	11.6 (9.8, 13.3)*	6.7 (5.0, 8.5)*
Step 5: Support with breastfeeding	6.5 (4.6, 8.4)*	7.0 (5.1, 8.8)*	-0.5 (-2.6, 1.7)
Step 6: Limited supplementation	20.8 (18.9, 22.6)*	20.0 (18.2, 21.8)*	17.2 (15.4, 19.1)*
Step 7: Rooming-in	7.8 (5.5, 10.1)*	8.9 (6.6, 11.2)*	3.3 (1.1, 5.5)*
Step 8: Responsive feeding	13.5 (10.8, 16.3)*	13.6 (10.9, 16.3)*	7.0 (4.1, 9.8)*
Step 9: Bottles, nipples, and pacifiers	8.7 (6.6, 10.8)*	9.2 (7.1, 11.2)*	-0.6 (-3.0, 1.8)

[a]Adjusted for hospital type, teaching hospital, and total live births

[b]β is the difference in in-hospital exclusive breastfeeding prevalence between hospitals fully implementing the step compared to hospitals that have not fully implemented the step

*p-value<0.05

Table 4-5. Level of implementation of ideal standard of steps 1-9 of the Ten Steps to Successful Breastfeeding and the association with in-hospital exclusive breastfeeding prevalence

Number of steps implemented	n (%)	Average % of infants exclusively breastfed	Bivariate analysis	Adjusted for hospital characteristics[a]
Low (0-3 Steps)	501 (24.5%)	46.0±20.7	Ref.	
Mid (4-6 Steps)	1,000 (48.9%)	54.6±20.6	8.6 (6.4, 10.7)*	9.0 (6.9, 11.1)*
High (7-9 Steps)	544 (26.6%)	64.4±18.0	18.4 (16.0, 20.9)*	19.5 (17.1, 21.9)*

[a]Adjusted for hospital type, teaching hospital, and total live births

*p-value<0.05

Chapter 5: Associations between sociodemographic factors and Baby-Friendly Hospital designation with in-hospital exclusive breastfeeding prevalence in the US

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Abbreviations:

ACS- American Community Survey

BFHI- Baby-Friendly Hospital Initiative

CBSA- Core based statistical areas

CDC- Centers for Disease Control and Prevention

CI- Confidence Interval

EBF- Exclusive Breastfeeding

mPINC- Maternity Practices in Infant Nutrition and Care Survey

WIC- Special Supplemental Nutrition Program for Women, Infants, and Children

ZCTA- Zip code tabulation area

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Abstract

Objectives: To examine US in-hospital exclusive breastfeeding (EBF) and associations with Baby-Friendly designation and neighborhood sociodemographic factors. To assess if the association between sociodemographic factors and in-hospital EBF are modified by Baby-Friendly designation.

Methods: Hospital data from the 2018 Maternity Practices in Infant Nutrition and Care survey were linked to hospital zip code tabulation area (ZCTA) sociodemographic data from the American Community Survey (n=2,024). Using linear regression, we examined the associations and effect measure modification between Baby-Friendly designation and hospital ZCTA sociodemographic factors (non-Hispanic Black residents, poverty, and bachelor's degree attainment) with in-hospital EBF prevalence. We adjusted for ZCTA population total and hospital factors.

Results: US mean in-hospital EBF prevalence was 55.1%, ranging from 41.0% to 67.5% in the Southeast and Western regions, respectively. Baby-Friendly designation was associated with 9.1 percentage points higher in-hospital EBF prevalence compared to non-designated hospitals [95% confidence interval (CI): 7.0, 11.2]. Hospitals located in ZCTAs with a high percentage of Black residents and high percentage of poverty were associated with lower EBF prevalence [β= -3.3; 95% CI: -5.1, -1.4) and β= -3.8; 95% CI: -5.7, -1.8]. Hospitals located in ZCTAs with a high percentage of residents with bachelor's degrees were associated with higher EBF prevalence (β= 6.7; 95% CI: 4.1, 9.4). Baby-friendly designation was associated with a 4.0 percentage point reduction in the EBF prevalence disparity due to poverty.

Conclusions: Baby-Friendly designation may improve in-hospital EBF prevalence and reduce the national disparity in EBF attributed to poverty.

What's known on this subject: Few infants exclusively breastfeed (EBF) for the recommended 6 months. There are known sociodemographic disparities in EBF prevalence, yet little is known about sociodemographic factors associated with in-hospital EBF.

What this study adds: Hospitals in neighborhoods with higher percentages of Black residents and poverty were associated with lower in-hospital EBF prevalence, whereas higher education was associated with higher EBF prevalence. Baby-Friendly designation may reduce EBF disparities among hospitals located in high poverty neighborhoods.

1. Introduction

Exclusive breastfeeding (EBF) in the first few days of life is important for establishing a breast milk supply needed for continued duration and the associated child health benefits.[2-4] For example, EBF and longer durations of breastfeeding are associated with risk reductions for otitis media, sudden infant death syndrome, childhood obesity, and type 2 diabetes later in life.[4] Formula supplementation during the first few days of life is associated with decreased breastfeeding duration.[2, 3, 5] Among breastfed US infants, 19% are supplemented with infant formula within the first 2 days of life.[6]

There are national EBF sociodemographic and geographic disparities.[6-8] For infants born in 2017, 39% of non-Hispanic Black (Black) infants were EBF for the first 3 months of life [compared to 52% of non-Hispanic White (White) infants].[6] Infants whose families earn less than 100% of the poverty income ratio have an EBF prevalence for the first 3 months of life of 39% (compared to 56% among infants whose families earn more than 600% of the poverty income ratio).[6] Among infants whose mothers have less than a high school education, 31% EBF for the first 3 months of life (compared to 57% among infants whose mothers have graduated college).[6] A previous national analysis of infants born between 2010-2013 found that EBF prevalence for the first 6 months of life among Black infants were significantly lower by at least 10 percentage points than White infants in 12 US states, of which 6 states were located in the Southeast and Midwest.[8] These results indicate geographic differences in EBF.[8] Although these sociodemographic and geographic disparities have been reported for EBF as early as the first 3 months of life, limited data exists on in-hospital EBF stratified by sociodemographic information and US geographic region.

The World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) launched the Baby-Friendly Hospital Initiative (BFHI) in 1991, which is a global program that includes Ten Steps to Successful Breastfeeding, consisting of maternity care practices to protect, promote, and support breastfeeding.[9] The WHO and UNICEF work with national authorities to administer the BFHI; in the US, this third party authority is Baby-Friendly USA (BFUSA).[10] Baby-Friendly designation has been associated with improved likelihood of in-hospital EBF following birth and up to 2-6 weeks postpartum.[11, 12, 13] Another analysis, which included 2014 US data, found that Baby-Friendly designation was associated with higher in-hospital EBF prevalence after controlling for hospital neighborhood sociodemographic factors such as race/ethnicity and education of residents.[14] While these previous analyses provide evidence that Baby-Friendly designation improves EBF prevalence independent of sociodemographic factors, they were conducted within one state or included hospitals with 1,100 births or more, or do not account for potential geographic differences.

Our objective was to expand on previous work by examining the relationship among Baby-Friendly designation and hospital neighborhood sociodemographic factors with in-hospital EBF prevalence in the US, while considering underlying regional variation in EBF across the US. We also assessed whether in-hospital EBF sociodemographic disparities are modified by Baby-Friendly designation.

2. Methods

Data sources

Data were obtained from two sources: 1) the 2018 Maternity Practices in Infant Nutrition and Care (mPINC) survey[15] and 2) the 2018 American Community Survey (ACS)[16]. The mPINC survey is administered by the Centers for Disease Control and Prevention (CDC) biennially to maternity care hospitals in the US and territories. The 2018 survey included 2,045 hospital respondents **(Figure 5-1)**. The CDC contacts the manager of the labor and delivery unit or the mother-baby nurse manager to help identify the staff person most knowledgeable about the facility's maternity care practices and policies. The survey is often completed by a group of staff. Data from the mPINC survey included in-hospital EBF prevalence reported by each hospital, as the percent of healthy newborns fed only breast milk during the hospital stay. In addition, Baby-Friendly designation; hospital characteristics (hospital type, teaching hospital, and total live births); and US geographic region were obtained from the mPINC survey. Three hospitals were missing responses to mPINC survey questions used in this analysis.

Patient sociodemographic data are not collected through the mPINC survey; therefore, mPINC data were linked to sociodemographic data from the ACS of the hospital zip code tabulation area (ZCTA). The ACS is conducted by the US Census Bureau and ZCTA level sociodemographic data were obtained for the 5 year period from 2014 to 2018.[16] ZCTA sociodemographic variables obtained included percentage of Black residents, percentage of poverty (families and people whose income in the past 12 months were below the poverty level), and percentage of residents above 25 years of age with bachelor's degrees. ZCTA level data were unavailable for 18 hospitals. ZCTAs are generalized representations of US Postal Service (USPS) zip code service areas that are created by the US Census Bureau every ten years.[17] Zip codes are changed at the discretion of the USPS, and the unavailability of the data is potentially due to changes in zip codes that are not yet aligned with ZCTAs.[17] The EBF prevalence for hospitals without ZCTA data available was 57.4%, whereas the EBF prevalence for hospitals with ZCTA data available was 57.4%; however, the difference in EBF prevalence was not statistically significant (t test p value= 0.63; data not shown). The final data set included a total of 2,024 hospitals.

Outcome

The outcome of interest was the percent of healthy newborns fed only breast milk throughout their hospital stay reported for each hospital, which was normally distributed, and was analyzed as a continuous variable.

Exposures

The exposure variables included Baby-Friendly designation (reported by hospitals in the mPINC survey as designated or not designated) and hospital ZCTA sociodemographic variables. To ensure that the ZCTA race/ethnicity variable categories were mutually exclusive (hospitals did not fall into multiple race/ethnicity categories), one race/ethnicity was analyzed, which was non-Hispanic Black (the race/ethnicity with the highest EBF disparities).[6] To account for differences in concentrations of sociodemographic factors across the nation, we dichotomized the sociodemographic variables based on the contextual mean of areas surrounding the ZCTA. The contextual mean was calculated using core based statistical areas (CBSAs) and county mean percentages. CBSAs are clusters of 10,000 or more residents with adjacent counties with economic ties within a commutable area and US Census data are reported at this level for the 2018 ACS.[18] Of the 2,024 hospitals, 1,593 were located in CBSAs, and there were 684 unique CBSAs. For ZCTAs located in areas with a population of <10,000 (n=431), the sociodemographic variables were dichotomized based on the county mean percentages. For a sensitivity analysis, we also dichotomized the sociodemographic variables based on the national means, which was 13.4% for Black residents, 10.5% for residents below poverty, and 31.5% for residents with bachelor's degrees.[19]

Covariates

Rural areas are reported to have higher proportions of sociodemographic factors, such as poverty and have previously been reported to have hospitals with lower maternity care practices supportive of breastfeeding, which may impact in-hospital EBF; therefore, we adjusted for ZCTA total population.[20, 21] We also adjusted for hospital characteristics (hospital type, teaching hospital, and total live births).

Statistical analysis

Descriptive analyses were conducted to report the hospital characteristics; hospital ZCTA sociodemographic factors; and the mean EBF prevalence for the US and by geographic region (using the US Department of Agriculture Food and Nutrition Services' classification of regions).[22] In-hospital EBF prevalence was reported for the US as a whole, and separately by US geographic region. Four separate linear regression models were analyzed to examine the unadjusted associations between Baby-Friendly designation and the hospital ZCTA sociodemographic factors (percentage Black, percentage below poverty, and percentage with bachelor's degrees) dichotomized based on the contextual mean with in-hospital EBF prevalence. We built a multiple linear regression model with in-hospital EBF as the outcome, which included Baby-Friendly hospital designation and hospital ZCTA sociodemographic factors dichotomized based on the contextual mean, which were adjusted for covariates (ZCTA total population and hospital characteristics). The multiple linear regression model included effect measure modification terms for each of the sociodemographic factors with Baby-Friendly designation. Backward elimination of the three effect measure modification terms was conducted to eliminate terms that were not statistically significant. For a sensitivity analysis, the descriptive analyses, linear regression for the unadjusted associations, and the multiple linear regression were conducted for sociodemographic factors dichotomized based on the national mean. The sensitivity analysis multiple linear regression model was additionally adjusted for region since there is evidence that sociodemographic factors and EBF prevalence vary by region. Model diagnostics were conducted on all models to examine linear regression assumptions. The residuals were normally distributed. Multicollinearity was not found among the variables using a cutoff of <0.10 for tolerance. Statistical significance was set at $p<0.05$. Analyses were completed using SAS 9.4. The Institutional Review Board of Emory University determined that this research did not involve human subjects since no identifiable, individual data were obtained.

3. Results

Of the 2,024 hospitals in this analysis, 24.6% were Baby-Friendly designated. The majority of hospitals were non-profit (76.8%) and teaching hospitals (68.9%) **(Table 5-1)**. The largest category of total live births were hospitals reporting 1-499 births (35.3%). Hospitals in each region ranged from 9.1% in the Northeast to 24.0% in the Midwest. A total of 52.1% of the hospitals were located in ZCTAs with a high percentage of Black residents, 42.2% were located in ZCTAs with a high percentage of poverty, and 86.2% were located in ZCTAs with a high percentage of residents with bachelor's degrees. The mean in-hospital EBF prevalence for the US was 55.1% **(Figure 5-2)**. Regional in-hospital EBF prevalence ranged from 41.0% in the Southeast to 67.5% in the Western region.

Significant unadjusted and adjusted associations were found between Baby-Friendly designation and all of the hospital ZCTA sociodemographic factors with in-hospital EBF prevalence **(Table 5-2)**. In the adjusted model, Baby-Friendly designation was associated with 9.1 percentage points higher in-hospital EBF prevalence compared to non-designated hospitals [95% confidence interval (CI): 7.0, 11.2]. Hospitals located in ZCTAs with a high percentage of

Black residents were associated with 3.3 percentage points lower EBF prevalence compared to hospitals located in ZCTAs with a low percentage of Black residents (95% CI: -5.1, -1.4). Similarly, hospitals located in ZCTAs with a high percentage of poverty were significantly associated with 3.8 percentage points lower EBF prevalence compared to hospitals located in ZCTAs with a low percentage of poverty (95% CI: -5.7 -1.8). In contrast, hospitals located in ZCTAs with a high percentage of residents with bachelor's degrees were associated with 6.7 percentage points higher EBF prevalence compared to hospitals located in ZCTAs with a low percentage of residents with bachelor's degrees (95% CI: 4.1, 9.4).

We found that Baby-Friendly designation significantly modified the disparity between hospitals located in ZCTAs with a high percentage of poverty and hospitals located in ZCTAs with a low percentage of poverty by 4 percentage points **(Table 5-3).** The adjusted difference in EBF prevalence between hospitals located in areas with high poverty and hospitals located in areas with low poverty was 0.7 percentage points (95% CI: -3.0, 4.4) among Baby-Friendly designated hospitals and 4.7 percentage points (95% CI: 2.6, 6.9) among non-designated hospitals. The Baby-Friendly effect measure modification terms with percentage of Black residents and percentage with bachelor's degrees were not statistically significant and were not included in the final adjusted model.

The results were similar for the analysis with the hospital ZCTA sociodemographic factors dichotomized by the national mean **(Supplemental Tables 5-1, 5-2, 5-3)**. However, the measures of association (βs) for percentage of Black residents and percentage of poverty were larger for the models using the ZCTA variables dichotomized by the national mean.

4. Discussion

The mean in-hospital EBF prevalence in the US was 55.1%, with the lowest prevalence in the Southeast (41.0%) and the highest prevalence in the Western region (67.5%). Baby Friendly designation was significantly associated with higher in-hospital EBF prevalence after adjusting for hospital ZCTA sociodemographic factors and other hospital characteristics. Hospitals located in ZCTAs with a high percentage of Black residents and poverty were associated with lower in-hospital EBF prevalence, while hospitals located in ZCTAs with a high percentage of residents with bachelor's degrees were associated with higher in-hospital EBF prevalence. In addition, we found that Baby-Friendly designation significantly modified the in-hospital EBF disparity for hospitals located in ZCTAs with a high percentage of poverty.

Our finding that Baby-Friendly designation was associated with higher in-hospital EBF prevalence after adjusting for hospital characteristics and hospital ZCTA sociodemographic factors is consistent with findings from a previous analyses using data from 2014-2016.[14] Another study examined if in-hospital EBF prevalence (using national data from 2018-2019) was different between Baby-Friendly designated hospitals and non-designated hospitals across different levels of neighborhood area deprivation index.[23] The ADI is a socioeconomic indicator that includes 17 components, such as educational attainment, employment status, and family income.[23] This study similarly found that in-hospital EBF was significantly higher in Baby-Friendly designated hospitals across all levels of ADI compared to non-designated hospitals.[23] Our analysis additionally accounted for regional variation and was not limited by hospital birthing volume. Baby-Friendly designation and the Ten Steps are a package of evidenced-based policies and practices that support breastfeeding, and many of the steps are interrelated.[9] For example, rooming-in (step 7) is important for care right after birth (step 4) and responsive feeding (step 8).[24] Only 24.6% of the hospitals included in our analytic data set were Baby-Friendly designated. There are existing efforts to increase compliance with the Ten Steps. For example, some states implement hospital recognition programs; however, key differences between state designations and Baby-Friendly designation include that hospitals may be recognized for implementing fewer than all Ten Steps and site visits are not typically required.[25] [26] Furthermore, hospitals may implement varying steps without a designation or may be on the pathway to becoming designated.[27] These efforts may have contributed to increased EBF prevalence independent of Baby-Friendly designation. Therefore, the difference in EBF prevalence may be even greater between designated and non-designated hospitals if the analytic data set excluded hospitals on the pathway to becoming Baby-Friendly or participating in state recognition programs.

Also similar to the previously conducted study, we found that the percentage of Black residents and the percentage of poverty were negatively associated with EBF prevalence and the percentage of residents with bachelor's degrees were positively associated with EBF prevalence after adjusting for sociodemographic factors.[14] This significant adjusted association between the sociodemographic factors and in-hospital EBF prevalence indicates independent associations between each of the sociodemographic factors and in-hospital EBF prevalence.

The adjusted EBF prevalence at 6 months has improved for Black infants; however, the disparities have been persistent between Black and White infants.[7] A previous analysis reported neighborhood racial disparities in access to breastfeeding supportive maternity care practices.[28] Recent initiatives have aimed to decrease breastfeeding disparities among Black infants. Communities and Hospitals Advancing Maternity Practices (CHAMPS) was implemented from 2014-2017 in the Southern region of the US.[29] CHAMPS resulted in Baby-Friendly designation of 14 hospitals by 2018 and increased in-hospital EBF prevalence among Black infants.[29] In addition, the CDC has funded the National Association of County and City Health Officials (NACCHO) to implement the Reducing Disparities in Breastfeeding through Peer and Professional Lactation Support project since 2014.[30] Although our results indicate EBF disparities among Black residents after adjusting for Baby-Friendly designation, the effect of these recent efforts may still be in progress and may result in improvements achieved after what is captured in our 2018 analytic data set.

We found that Baby-Friendly designation was significantly associated with a reduction in the in-hospital EBF prevalence disparity due to poverty. Our findings from this national data set, in addition to findings from local studies, suggests that EBF prevalence disparities may significantly decrease among low-income populations when provided with access to hospitals with Baby-Friendly designation.[31] Potential barriers to achieving Baby-Friendly designation include financial and personnel resources.[37] There have been efforts in addition to Baby-Friendly designation to provide support among mother-infant dyads who are low income, particularly among participants of the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC).[32, 33] Our finding that EBF prevalence remained lower among hospitals located in high poverty ZCTAs after adjusting for Baby-Friendly designation further supports the need for continued similar efforts among low income populations, along with access to Baby-Friendly hospitals.

In addition, we found that hospitals located in ZCTAs with a high percentage of residents with bachelor's degrees were associated with higher in-hospital EBF prevalence. Using the contextual mean to dichotomize the hospital ZCTA sociodemographic variables, we found that 86.2% of hospitals were located in areas with a high percentage of residents with bachelor's degrees. Therefore, hospitals may be more likely to be located in areas of high education due to their affiliations with universities and colleges; however, we adjusted for teaching status of hospitals. The independent association that we found indicates that further work may be needed to better understand and address maternal knowledge of lactation management, maternal knowledge of the risk of formula supplementation, and mother's attitudes and behaviors.[9, 34]

Limitations

There are four key limitations. First, sociodemographic variables that are reported for ZCTAs may not be representative of the women that deliver at that hospital. However, sociodemographic factors are not reported by hospitals, most US residents are admitted to hospitals near their residence,[35] and this approach has previously been used by other studies assessing hospital disparities.[28] Second, hospital ZCTA sociodemographic variables were dichotomized. Using this approach assumes that every value above or below the mean are the same when there may be heterogeneity in each of the two groups. We dichotomized the variables to capture hospitals located in areas with an above average percentage of sociodemographic characteristics. We also examined the associations using the same modeling strategy with the sociodemographic variables dichotomized by the national level mean, while adjusting additionally for region and found similar results for the direction of the differences. The estimates from the models that utilized the sociodemographic variables dichotomized based on the national mean were greater than the models that utilized sociodemographic variables dichotomized based on the contextual mean for percentage of Black residents and percentage of poverty. This suggests that there may be residual regional confounding when using the sociodemographic variables dichotomized based on the national mean. Third, hospitals may or may not routinely collect the data collected in the survey; therefore, the responses may be based on estimates made by the survey respondent.[15] The CDC takes additional steps to deliver the survey to the person deemed most knowledgeable of survey topics, and the survey is often completed by a group of hospital staff.[15] Fourth, nonresponse bias is possible; however, 70% of all maternity hospitals completed the survey.

5. Conclusion

Baby-Friendly designation was associated with improved in-hospital EBF prevalence. There were sociodemographic disparities in in-hospital EBF prevalence, and Baby-Friendly designation reduced this disparity among high poverty populations. However, only a quarter of US maternity hospitals are Baby-Friendly designated, which calls for continued efforts to increase Baby-Friendly hospital designation.

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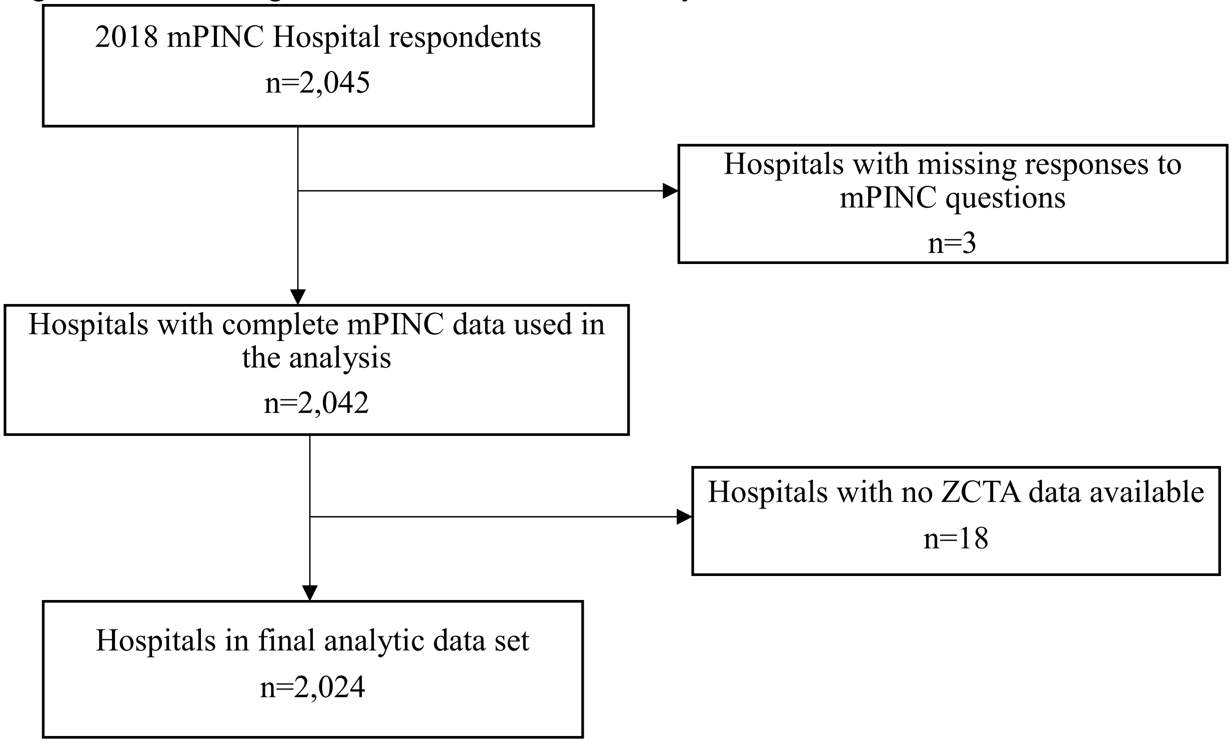
Figure 5-1. Flow diagram of data set used in the analysis



Note. mPINC= Maternity Practices in Infant Nutrition and Care; ZCTA=zip code tabulation area.

Table 5-1. Hospital characteristics and hospital zip code tabulation area sociodemographic factors

Characteristic	n (%)
Baby-Friendly hospital designation	
Designated	498 (24.6%)
Not designated	1,526 (75.4%)
Hospital type	
Non-profit	1,555 (76.8%)
Private	385 (19.0%)
Government or military	84 (4.2%)
Teaching hospital	
Yes	1,395 (68.9%)
No	629 (31.1%)
Total live births	
1 – 499	714 (35.3%)
500 – 999	432 (21.3%)
1000 – 1999	446 (22.0%)
≥2000	432 (21.3%)
Region	
Western	265 (13.1%)
Southwest	319 (15.8%)
Southeast	326 (16.1%)
Northeast	184 (9.1%)
Mountain Plains	223 (11.0%)
Midwest	486 (24.0%)
Mid-Atlantic	221 (10.9%)
Percentage of Black residents[a]	
Low (≤ contextual mean[b] %)	969 (47.9%)
High (> contextual mean %)	1,055 (52.1%)
Percentage of residents below poverty line	
Low (≤ contextual mean %)	1,170 (57.8%)
High (> contextual mean %)	854 (42.2%)
Percentage of residents with bachelor's degrees	
Low (≤ contextual mean %)	280 (13.8%)
High (> contextual mean %)	1,744 (86.2%)

[a]Percentage of residents in hospital zip code tabulation area
[b]Sociodemographic variables were dichotomized as ≤core based statistical area mean [or ≤county mean for areas with population clusters of less than 10,000 residents (low)] or >core based statistical area mean [or >county mean for areas with population clusters of less than 10,000 residents (high)]

Figure 5-2. In-hospital exclusive breastfeeding prevalence stratified by region

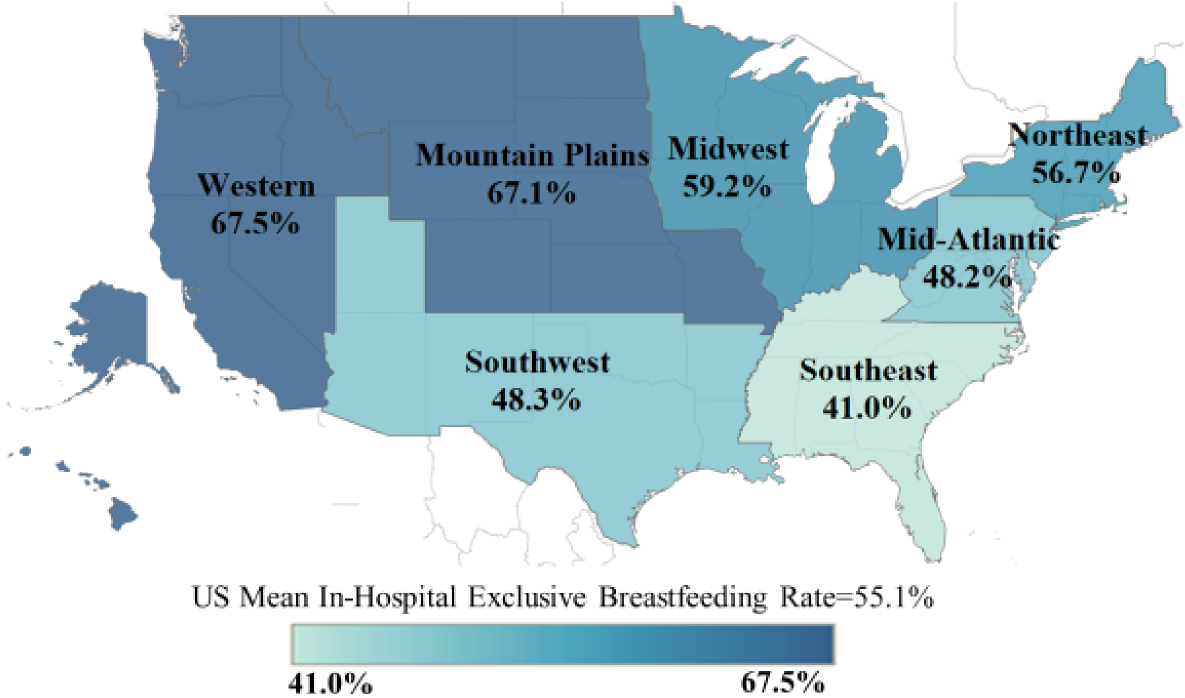


Table 5-2. Associations among Baby-Friendly hospital designation and hospital zip code tabulation sociodemographic factors with in-hospital exclusive breastfeeding prevalence

	Unadjusted	Adjusted[a]
	β[b] (95% CI)	
Baby-Friendly hospital designation		
Non-designated	**Ref.**	**Ref.**
Designated	**8.0 (5.9, 10.1)**	**9.1 (7.0, 11.2)**
Percentage[c] Black		
Low (≤contextual[d] mean)	**Ref.**	
High (>contextual mean)	**-2.6 (-4.5, -0.8)**	**-3.3 (-5.1, -1.4)**
Percentage below poverty line		
Low (≤contextual mean)	**Ref.**	**Ref.**
High (>contextual mean)	**-6.8 (-8.6, -5.0)**	**-3.8 (-5.7, -1.8)**
Percentage with bachelor's degrees		
Low (≤contextual mean)	**Ref.**	**Ref.**
High (>contextual mean)	**8.1 (5.4, 10.7)**	**6.7 (4.1, 9.4)**

Note. Statistically significant results ($p<0.05$) are bolded and CI=confidence interval.
[a]Adjusted for Baby-Friendly hospital designation, all other sociodemographic variables, zip code tabulation area population total, and hospital factors (hospital type, teaching hospital, and total live births).
[d]β is the difference in exclusive breastfeeding prevalence between hospitals located in zip code tabulations with a low mean of the sociodemographic and hospitals located in zip code tabulations with a high mean of the sociodemographic factor.
[c]Percentage of residents in hospital zip code tabulation area.
[d]Sociodemographic variables were dichotomized as ≤core based statistical area mean [or ≤county mean for areas with population clusters of less than 10,000 residents (low)] or >core based statistical area mean [or >county mean for areas with population clusters of less than 10,000 residents (high)]

Table 5-3. Adjusted mean in-hospital exclusive breastfeeding prevalence of percentage of residents below poverty stratified by Baby-Friendly designation

	Baby-Friendly Designated	Not Baby-Friendly Designated	
	Mean Exclusive Breastfeeding Hospital Prevalence (95% CI)[a]		
Percentage[b] below poverty line			0.05
Low (≤mean)	**58.1 (55.2, 61.1)**	**50.7 (48.4, 53.0)**	
High (>mean)	**57.4 (54.4, 60.5)**	**46.0 (43.7, 48.2)**	
Difference	0.7 (-3.0, 4.4)	**4.7 (2.6, 6.9)**	

Note. Statistically significant results (p<0.05) are bolded and CI=confidence interval.

[a] Adjusted for Baby-Friendly hospital designation, all other sociodemographic variables, zip code tabulation area population total, and hospital factors (hospital type, teaching hospital, and total live births).

[b]Percentage of residents in hospital zip code tabulation

Supplemental Table 5-1. Hospital zip code tabulation area sociodemographic factors dichotomized by the national mean

Characteristic	n (%)
Percentage of Black residents[a]	
Low (≤national mean %)	1,528 (75.5%)
High (> national mean %)	496 (24.5%)
Percentage of residents below poverty line[a]	
Low (≤national mean %)	1,118 (55.2%)
High (>national mean %)	906 (44.8%)
Percentage of residents with bachelor's degrees[a]	
Low (≤national mean %)	1,322 (65.3%)
High (>national mean %)	702 (34.7%)

[a]Percentage of residents in Hospital zip code tabulation area

Supplemental Table 5-2. Associations between Baby-Friendly hospital designation and hospital zip code tabulation sociodemographic factors dichotomized by the national mean with in-hospital exclusive breastfeeding prevalence

	Unadjusted	Adjusted[a]
	β[b] (95% CI)	
Baby-Friendly hospital designation		
Non-designated	**Ref.**	**Ref.**
Designated	**8.0 (5.9, 10.1)**	**8.1 (6.2, 9.9)**
Percentage[c] Black		
Low (≤national[d] mean)	**Ref.**	
High (>national mean)	**-16.5 (-18.5, -14.5)**	**-8.0 (-9.9, -5.9)**
Percentage below poverty line		
Low (≤national mean)	**Ref.**	**Ref.**
High (>national mean)	**-13.3 (-15.1, -11.6)**	**-5.7 (-7.5, -3.9)**
Percentage[e] with bachelor's degrees		
Low (≤national mean)	**Ref.**	**Ref.**
High (>national mean)	**8.9 (7.0, 10.8)**	**7.2 (5.3, 9.2)**

Note. Statistically significant results ($p<0.05$) are bolded and CI=confidence interval.
[a]Adjusted for Baby-Friendly hospital designation, all other sociodemographic variables, zip code tabulation area population total, and hospital factors (hospital type, teaching hospital, total live births, and region).
[b]β is the difference in exclusive breastfeeding prevalence between hospitals located in zip code tabulations with a low mean of the sociodemographic factor and hospitals located in zip code tabulations with a high mean of the sociodemographic factor.
[c]Percentage of residents in hospital zip code tabulation area.
[d]Sociodemographic variables were dichotomized and categorized as ≤ national mean (low) or > national mean (high)

Supplemental Table 5-3. Adjusted mean in-hospital exclusive breastfeeding prevalence of percentage of residents below poverty dichotomized by the national mean stratified by Baby-Friendly designation

	Baby-Friendly Designated	Not Baby-Friendly Designated	
	Mean Exclusive Breastfeeding Hospital Prevalence (95% CI)[a]		
Percentage[b] below poverty line			0.04
Low (≤mean)	**60.8 (58.3, 63.2)**	**54.4 (52.6, 56.3)**	
High (>mean)	**57.9 (55.3, 60.5)**	**47.8 (45.8, 49.8)**	
Difference	**2.8 (0.1, 6.8)**	**6.6 (4.7, 8.5)**	

Note. Statistically significant results ($p<0.05$) are bolded and CI=confidence interval.

[a]Adjusted for Baby-Friendly hospital designation, all other sociodemographic variables, zip code tabulation area population total, and hospital factors (hospital type, teaching hospital, total live births, region).

[b]Percentage of residents in hospital zip code tabulation area

Chapter 6: Factors associated with in-hospital exclusive breastfeeding among a diverse patient population

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This manuscript is in progress.

Abstract

Title: Factors associated with in-hospital exclusive breastfeeding among a diverse patient population

Objective: To examine in-hospital exclusive breastfeeding (EBF) and the association with sociodemographic factors, medical factors, breastfeeding intentions, and breastfeeding support.

Methods: We conducted a retrospective, cross-sectional study using medical records of healthy, term infants without breastfeeding contraindications at a public, teaching hospital serving a diverse patient population between January 1, 2015 and December 31, 2019 (n=8,901). Using Poisson regression, we examined the associations between sociodemographic factors, medical factors, breastfeeding intentions, and breastfeeding support with in-hospital EBF. The first set of models included each factor adjusted for length of stay and birth year; the second, fully adjusted model was additionally adjusted for all factors that were significant in the first set of models.

Results: The prevalence of in-hospital EBF was 29.0% and remained relatively stable from 2015-2019. In the fully adjusted model, in-hospital EBF was positively associated with maternal age [prevalence ratio (PR): 95% confidence interval (CI); 1.89: 1.42, 2.51; ≥35 years compared to ≤17 years], marital status (PR: 95% CI; 1.33: 1.23, 1.44; married compared to not married), full-time employment (PR: 95% CI; 1.14: 1.06, 1.23; full-time compared to unemployed), and mothers who were White (PR: 95% CI; 1.44: 1.21, 1.70 compared to Black). Maternal diabetes (PR: 95% CI; 0.82: 0.71, 0.96), pre-existing hypertension (PR: 95% CI; 0.82: 0.69, 0.98), pre-eclampsia/eclampsia (PR: 95% CI; 0.81: 0.69, 0.94), cesarean delivery (PR: 95% CI; 0.81: 0.73, 0.89), neonatal hypoglycemia (PR: 95% CI; 0.50: 0.39, 0.64), and breastfeeding intentions (PR: 95% CI; 0.15: 0.10, 0.23; intending to formula feed only compared to intending to EBF) were

negatively associated with in-hospital EBF. Mother-infant dyads that received a lactation consult were more likely to EBF compared to those who did not (PR: 95% CI; 1.24: 1.15, 1.33).

Conclusion: Black mothers, adolescent mothers, those intending to formula feed only in the prenatal period, and infants with hypoglycemia are potential factors to target to improve in-hospital EBF. Increased support from trained lactation professionals may be an effective approach to improve in-hospital EBF.

1. Introduction

Breastfeeding reduces the risk of adverse health conditions across the life course for both the mother and child.[2-4] This includes reduced risk for hypertension, type 2 diabetes, breast cancer, and ovarian cancer for the mother later in life.[2, 3] For the child, this includes reduced risk of sudden infant death syndrome and various infections, and possible reductions in overweight and diabetes for the child later in life.[3, 4] There is a dose-response relationship between breastfeeding (which includes both exclusivity and duration of breastfeeding) and the reduction of health risks.[3] Several global and national authorities recommend exclusive breastfeeding (EBF) for the first 6 months of life.[3, 5-8] Early EBF is important for establishing a breast milk supply needed for longer durations of breastfeeding, for which there are greater health benefits and lower health risks.[9-11] Despite the reduction in risk for adverse health conditions and EBF recommendations, an estimated 19% of breastfed infants were supplemented with infant formula within the first 2 days of life in 2017.[12] Early formula supplementation prevalence has been reported to have decreased from 23.3% in 2009 to 17.2% in 2015.[13] However, socioeconomic disparities in early formula supplementation have been reported by race/ethnicity in which 23.2% of Hispanic infants and 20.9% of non-Hispanic Black (Black) infants were supplemented with infant formula within the first 2 days of life, compared to 12.7% of non-Hispanic White (White) infants.[13] Early formula supplementation, and thus lack of early EBF, could potentially contribute to health disparities considering that minority women have a higher prevalence of conditions for which breastfeeding offers protection.[14, 15]

Medical factors and breastfeeding intentions have been found to be associated with breastfeeding outcomes. Maternal medical conditions and procedures such as diabetes, hypertension, and cesarean sections are associated with lower EBF.[16-22] For example, a US study using data from the Pregnancy Risk Assessment Monitoring System found that mothers with gestational diabetes were less likely to EBF while in the hospital.[20] However, this study was unable to control for breastfeeding intentions due to the unavailability of this information, which is a potential confounder.[20] Considering that the prevalence of medical conditions such as diabetes and early breastfeeding outcomes vary by race/ethnicity, it is important to control for these factors to obtain accurate measures of associations with early EBF.[14, 15] Infant medical conditions are also reported to be associated with in-hospital EBF. One study conducted outside of the US, found that neonatal jaundice was negatively associated with in-hospital EBF; however, the results are inconsistent with those conducted within the US, which did not find a statistically significant association.[23, 24] Furthermore, a study conducted among Latina mothers in North Carolina, found that deciding about feeding method before pregnancy was a significant factor associated with in-hospital EBF.[25]

Few studies have included not only predisposing factors such as medical conditions and breastfeeding intentions but also health care system breastfeeding support which, is critical during the early postpartum period.[26] A previously conducted study in hospitals in the southeastern US found that improved hospital support (such as skin-to-skin and rooming-in practices) was associated with an increase of 17 percentage points in EBF prevalence among Black mothers from 2014 to 2017.[27] We conducted a formative, qualitative research study to examine facilitators and barriers to in-hospital EBF among mothers who delivered at Grady Memorial Hospital (GMH), a public, teaching hospital serving a diverse patient population.[28] This study also examined facilitators and barriers to providing support to mothers and included key stakeholders such as clinicians, community organizations' staff, and administrators.[28] GMH achieved Baby-Friendly Hospital Initiative designation in 2015 (a hospital designation achieved after the implementation of evidenced-based Ten Steps to Successful Breastfeeding including policies and clinical practices such as practical support with breastfeeding).[26] We found that factors that influence in-hospital EBF included multiple levels of the socioecological model such as inadequate time to provide prenatal breastfeeding education during the prenatal period to high risk patients with condition such as gestational diabetes and hypertension at the institutional level to cultural norms of a diverse patient population at the macrosystem level.[28] GMH key stakeholders sought to utilize the findings from the qualitative study to inform a quantitative examination of factors associated with in-hospital EBF.[28]

There is evidence that sociodemographic factors, medical factors, breastfeeding intentions, and breastfeeding support are broadly associated with breastfeeding outcomes. However, studies often do not examine the relationship with *in-hospital EBF*; were conducted outside the US; may not adjust for confounders such as breastfeeding intentions; or were conducted in populations with few racial/ethnic minorities. Further work is needed to examine disparities, particularly among hospitals serving a high proportion of minority and socioeconomically disadvantaged patients. This study aimed to address these gaps and examined in-hospital EBF and the association with sociodemographic factors, medical factors, breastfeeding intentions, and breastfeeding support in a diverse patient population.

2. Methods

Study population

We conducted a retrospective, cross-sectional study using medical records of live births at Grady Memorial Hospital (GMH) between January 1, 2015 and December 31, 2019 from the Grady Obstetric & Gynecological Outcomes (GOGO) initiative. Approval for this study was obtained from Emory University's Institutional Review Board and GMH's Research Oversight

Committee. Exclusion criteria were mothers and infants with medical contraindications for breastfeeding, as defined by the Academy of Breastfeeding Medicine.[29] Exclusion criteria for mothers were Ebola virus; herpes virus; human immunodeficiency virus infection (HIV); human T-lymphotropic viruses type 1 (HTLV-1) and type II (HTLV-II); varicella; brucella; tuberculosis; chemotherapy drugs; and illicit drug use. Exclusion criteria for infants were galactosemia, congenital lactase deficiency, phenylketonuria, and maple syrup urine disease. In addition, exclusion criteria included mothers with multiples; infants less than 37 weeks gestation; infants who were admitted to the neonatal intensive care unit; parenteral nutrition administered to the infant; length of stay exceeding 7 days following birth, and patients transferred to another hospital.

Outcome

In-hospital EBF was the outcome of interest, which was defined as receiving only breast milk (including direct breastfeeding and expressed breast milk feeding), and no other fluids or foods except medications or supplements.

Independent variables

Five categories of independent variables were analyzed: sociodemographic factors, maternal medical factors, infant medical factors, prenatal feeding intentions, and health care system breastfeeding support. Sociodemographic factors included maternal age, parity, race/ethnicity, language, marital status, employment, number of prenatal care visits, prenatal care clinic (956 mothers did not receive prenatal care and were not included in this variable), and infant sex. Maternal medical factors examined were pre-existing or unspecified diabetes, gestational diabetes, pre-existing hypertension, gestational hypertension, pre-eclampsia/eclampsia, and cesarean delivery. Infant medical factors included gestational age (early term or 37-38 weeks, full term or 39-40 weeks, late term or 41 weeks, and post term or ≥42 weeks),[49] low birth weight (<2,500 grams), hypoglycemia, and jaundice. Prenatal feeding intentions included four levels: EBF, both breastfeeding and formula, formula only, and undecided. Health care system breastfeeding support included in-hospital breastfeeding education, in which mothers verbalized understanding the education delivered during the hospital stay, and a completed lactation consult from a trained lactation consultant.

Covariates

We adjusted all models for infant length of stay following birth and birth year.

Analytic data set and statistical analysis

A total of 8,971 mother-infant dyads met the study criteria **(Figure 6-1)**. Mother-infant dyads were excluded from the analysis if missing data, which included the variables parity (n=28), race/ethnicity (n=1), infant sex (n=1), and low birth weight (n=43). Three mother-infant dyads had implausible values for gestational age. Some mother-infant dyads were missing data on more than 1 variable, resulting in a final analytic data set of 8,901. The EBF prevalence for those missing data was 29.0%, whereas the EBF prevalence for dyads without missing data was 31.9%; however, the difference in EBF prevalence was not statistically significant (Chi square p value= 0.6; data not shown). Descriptive analyses were conducted to report the count and frequency of each factor. We also conducted descriptive analyses to report the total in-hospital EBF prevalence stratified by year and race/ethnicity. We conducted Poisson regression with robust variance estimates to determine prevalence ratios for determinants of in-hospital EBF using two sets of models. The first set of models included each individual factor, adjusted for infant length of stay following birth and birth year. The second model was the same as the first model, additionally adjusted for the statistically significant factors found in the first set of models. We examined effect measure modification terms for statistically significant demographic factors and breastfeeding intentions from the second set of models with breastfeeding support factors using backward elimination. These effect measure modification terms were not statistically significant and were not included in further analysis. There was no evidence of multicollinearity in the models. SAS 9.4 was used for all analysis. Statistical significance was set at $p<0.05$.

3. Results

The sociodemographic factors, medical factors, breastfeeding intentions, and health care system breastfeeding support among the mother-infant dyads in the study are reported in **Table 6-1**. Among the mothers in the study, 34.8% were 18-24 years old, 67.3% were multiparous, 67.9% were Black or African American (Black), and 41.7% were not employed. The in-hospital EBF prevalence for GMH for all years from 2015 to 2019 was relatively stable **(Supplemental Figure 6-1)**, with an overall mean of 29.0%.

In the models adjusted for birth year and infant length of stay (model set 1), the majority of the exposure factors were significantly associated with in-hospital EBF with the exception of parity, prenatal care visits, infant sex, gestational hypertension, jaundice, and in-hospital breastfeeding education **(Table 6-2)**. In model set 2, which was additionally adjusted for all other significant factors from model set 1, mothers greater than 18 years of age [≤17 years compared to ≥35 years, prevalence ratio (PR): 95% confidence interval (CI); 1.89: 1.42, 2.51], mothers who were married (compared to unmarried, PR: 95% CI; 1.33: 1.23, 1.44), and mothers who were employed full time (compared to not employed, PR: 95% CI; 1.14: 1.06, 1.23) were more likely to EBF. White mothers were more likely to EBF compared to Black mothers (PR: 95% CI; 1.44: 1.21, 1.70). Mothers with diabetes (PR: 95% CI; 0.82: 0.71, 0.96), pre-existing hypertension (PR: 95% CI; 0.82: 0.69, 0.98), and pre-eclampsia/eclampsia (PR: 95% CI; 0.81: 0.69, 0.94) were less likely to EBF, compared to mothers without these conditions. Mothers who gave birth via cesarean delivery were less likely to EBF compared to mothers who gave birth via vaginal delivery (PR: 95% CI; 0.81: 0.73, 0.89). Infants with hypoglycemia were less likely to EBF, compared to infants without hypoglycemia (PR: 95% CI; 0.50: 0.39, 0.64). Compared to mothers who indicated that they intended to EBF, mothers were less likely to EBF if they indicated that they intended to both breastfeed and formula feed, only formula feed, or were undecided (PR: 95% CI; 0.53: 0.47, 0.60; 0.15: 0.10, 0.23; and 0.76: 0.71, 0.82, respectively). Mother-infant dyads that received a lactation consult were more likely to EBF, compared to mothers-infant dyads who did not receive a lactation consult (PR: 95% CI; 1.24: 1.15, 1.33).

4. Discussion

In this study of factors associated with in-hospital EBF at a public, teaching hospital serving a diverse patient population, we found that the EBF prevalence was 29.0% and remained relatively stable from 2015-2019 after achieving Baby-Friendly Hospital Designation in 2015. Black mothers had the lowest in-hospital EBF prevalence compared to all other races/ethnicities. We found that several factors were significantly associated with in-hospital EBF including sociodemographic factors, medical factors, breastfeeding intentions, and breastfeeding support. In-hospital EBF was positively associated with maternal age, marital status, full-time employment, and mothers who were White. In contrast, medical factors such as maternal diabetes, pre-existing hypertension, pre-eclampsia/eclampsia, cesarean delivery, and neonatal hypoglycemia were negatively associated with EBF. The largest associations with in-hospital EBF were maternal age, breastfeeding intentions, and neonatal hypoglycemia. In addition, receipt of a lactation consult was positively and significantly associated with in-hospital EBF.

These results are similar to previously conducted studies that examined factors associated with breastfeeding outcomes.[16-22, 25, 45-46] Our study further adds to this existing literature by examining the association between these factors with in-hospital EBF.

Our finding of fairly stable in-hospital EBF from 2015 to 2019 for all races could potentially be due to GMH achieving Baby-Friendly designation in 2015, and thus achieving the gains in EBF associated with improved maternity care practices before 2015. The Baby-Friendly designation is a process that includes 4 steps that occurs over several months which in brief include1) discovery (self-appraisal), 2) development (a plan is developed to implement the steps, 3) dissemination (implementation of the plan), and 4) designation (on-site assessment by an external committee).[30] Therefore, it is likely that the greatest gains in EBF occurred during the process of becoming Baby-Friendly. GMH is a Baby-Friendly hospital, yet has an in-hospital EBF prevalence that is only 29.0%; additional interventions are warranted to improve in-hospital EBF among this diverse patient population.

The prevalence of in-hospital EBF was the lowest among Black mothers at GMH. Qualitative studies conducted among predominately Black mothers have reported lack of family history of breastfeeding, which influenced infant feeding decisions, and contributed to formula supplementation.[31, 32] Our formative, qualitative study at GMH, found that family experience and family support were key factors that influence in-hospital EBF.[28] In particular, we found that family members who lack breastfeeding experience may be unfamiliar with breastfed newborn behavior such as cluster feeding (frequent feeding in short intervals, especially in the early days) and encourage formula supplementation.[28] Family members who will provide child care when the mother is later separated due to work or school were reported to have concerns about adequate expressed breast milk supply and may encourage formula supplementation while in the hospital following delivery.[28] Future efforts to improve in-hospital EBF at GMH and other hospitals serving a high proportion of Black mothers may want to consider including family.[28, 31-34] Peer breastfeeding support is an additional method to provide social support to mothers who do not have a family history of breastfeeding or family support.[33, 34]

Maternal medical factors such as maternal diabetes, pre-existing hypertension, pre-eclampsia/eclampsia, and cesarean delivery were negatively associated with in-hospital EBF. The prevalence of these factors at GMH were approximately the same or in some cases lower than the national prevalence. For example, the prevalence of gestational diabetes was 6.1% at GMH compared to 6.0% nationally and the prevalence of cesarean deliveries at GMH was 23.7% compared to 31.7% nationally.[50-51] Other studies were conducted outside of the US, were unable to control for breastfeeding intentions, or examined EBF beyond the hospital stay have similarly found that these maternal factors are significantly associated with EBF.[16-22] These maternal conditions are reported to interfere with lactogenesis II (copious breast milk production).[35-37] However, we found in our qualitative study at GMH that obstetricians have limited time to provide prenatal breastfeeding education during prenatal visits to high risk mothers with conditions such as diabetes and hypertension, which could impact infant feeding decisions for these mothers.[28] The provision of prenatal breastfeeding education by clinical extenders such as nurses, lactation consultants, and health educators could potentially improve in-hospital EBF for high risk mothers.[28]

In addition to maternal medical factors, neonatal hypoglycemia was negatively associated with in-hospital EBF. Untreated neonatal hypoglycemia can result in further adverse health consequences such as brain damage or death.[38, 39] Clinical recommendations for treating hypoglycemia often include practices that protect EBF such as supporting breastfeeding and mother's milk expression to provide to infants requiring more frequent feedings.[40, 41] There is also an increasing amount of evidence that supports the use of glucose gels to treat low glucose levels.[42-44]

In our study, over half of mothers were undecided about their infant feeding plans during the prenatal period. A study conducted among Latina mothers in North Carolina, found that deciding about feeding method before pregnancy was significantly associated with in-hospital EBF. [25] These findings suggest that efforts that aim to impact breastfeeding decisions are most effective if delivered early in the decision making process.[25]

Other studies have recently reported that lactation support from professionals trained to assess the breastfeeding relationship such as latch, breast milk transfer, and concerns about milk supply is associated with breastfeeding duration and exclusivity as early as 3 months, including among high risk patients with conditions such as gestational diabetes.[45, 46] Our study further adds to these findings, and we found that mother-infant dyads that received a lactation consult in-hospital were more likely to EBF compared to those who did not. Our qualitative study also found that practical support with breastfeeding was a key facilitator to in-hospital EBF; however, we also found that there was inadequate staffing to provide lactation management support.[28] Increased lactation support from trained professionals could potentially improve in-hospital EBF.[28, 45, 46]

There are three key limitations to our findings. First, we analyzed data from a single, non-profit, teaching hospital with approximately 3,000 births per year located in an urban setting serving a high proportion of Black, socioeconomically disadvantaged population. The results may not be generalizable to hospitals that do not have similar characteristics. However, other hospitals could potentially use this study as a framework to understand setting specific factors associated with in-hospital EBF to target quality improvement efforts. Second, there are other factors that may influence in-hospital EBF that we were unable examine in this study due to the unavailability of these data in a format that was extractable using medical records reporting in an efficient manner considering the volume of births.[40] These factors include health care system breastfeeding support factors such as prenatal breastfeeding education, skin-to-skin, early initiation of breastfeeding, rooming-in, and timing of the receipt of lactation consults (e.g. first day of life compared to second day of life).[28,40] Examples of other factors not included are birth country, social support, participation in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC), and maternal obesity.[28,40] Future research that examines in-hospital EBF could potentially consider prospectively collecting the data from medical records to more efficiently collect this information. Third, although we were able to examine the prevalence of factors and the association with in-hospital EBF, a measure that incorporates both prevalence and association simultaneously may be useful. Therefore, next steps include calculating the population attributable fraction to measure the portion of EBF that would be improved if a modifiable factor were to be improved such as breastfeeding intentions and lactation support.

5. Conclusion

In addition to Baby-Friendly Hospital designation, further work is needed to improve in-hospital EBF at this public, teaching hospital serving a diverse patient population. Efforts that address race/ethnicity disparities are needed. Adolescent mothers, those intending to formula feed only in the prenatal period, and infants with neonatal hypoglycemia are potential factors to target to improve in-hospital EBF. In-hospital breastfeeding support following delivery from trained lactation professionals may be key to improving in-hospital EBF.

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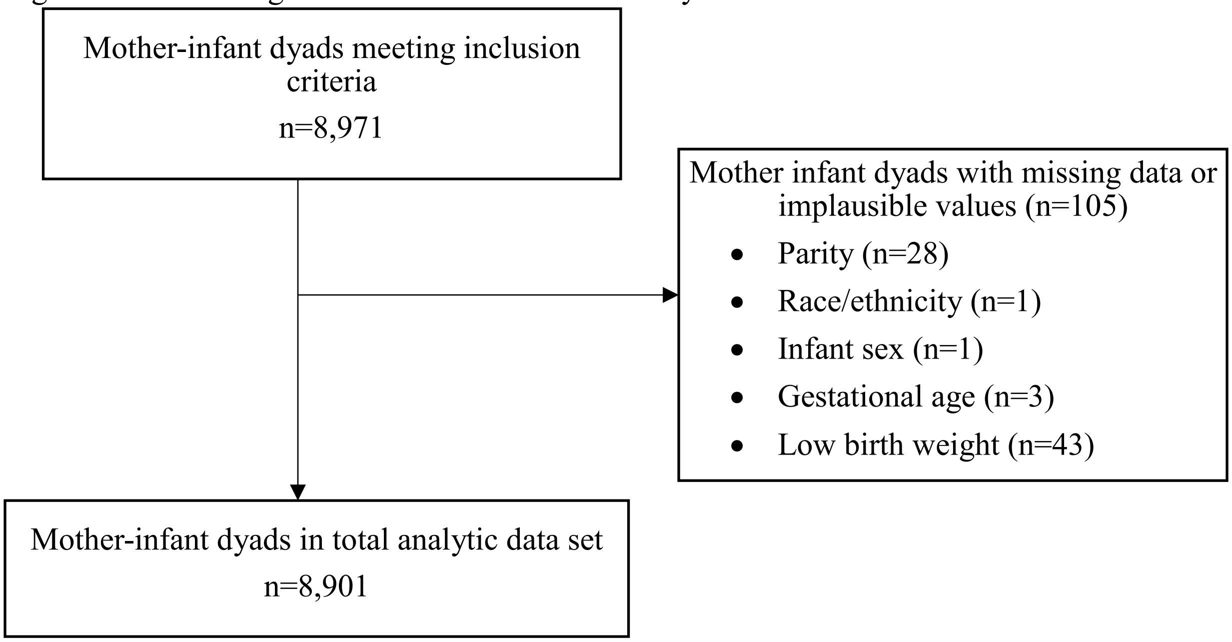
Figure 6-1. Flow diagram of data set used in the analysis



Note: Some mother-infant dyads were missing data on more than 1 variable

Table 6-1. Sociodemographic factors, medical factors, prenatal feeding intentions, and health care system breastfeeding support among mother-infant dyads at GMH, 2015 – 2019

Characteristic	Total (n=8901)	Prevalence of exclusive breastfeeding (n=2585)
Total		29.0%
Sociodemographic factors		
Maternal age		
≤17	324 (3.6%)	14.2%
18-24	3100 (34.8%)	27.1%
25-29	2394 (26.9%)	31.4%
30-34	1840 (20.7%)	30.7%
≥35	1243 (14.0%)	30.7%
Parity		
Primiparous	2909 (32.7%)	28.5%
Multiparous	5992 (67.3%)	29.3%
Race/ethnicity		
Black	6041 (67.9%)	27.2%
Hispanic	2143 (24.1%)	31.9%
Other	341 (3.8%)	2.3%
Asian	217 (2.4%)	33.2%
White	159 (1.8%)	48.4%
Language		
English	6346 (71.3%)	27.5%
Spanish	1902 (21.4%)	32.3%
Other	653 (7.3%)	34.9%
Marital status		
Married	2063 (23.2%)	38.9%
Unmarried	6838 (76.8%)	26.1%
Employment		
Not employed	3708 (41.7%)	27.4%
Unknown	2883 (32.4%)	31.2%
Full time	1452 (16.3%)	29.5%
Part time	858 (9.6%)	28.3%
Prenatal visits[a]		
0-4	3053 (34.3%)	27.8%
5-9	3772 (42.4%)	30.1%
≥10	2076 (23.3%)	28.9%
Prenatal care at Grady Memorial Hospital		
Grady Memorial Hospital clinic	5646 (63.4%)	27.8%
Outlying clinic	2299 (28.94%)	31.2%
Birth hospitalization length of stay		
1 day	1286 (14.5%)	43.8%
2 days	4675 (52.5%)	31.0%
3 days	2573 (28.9%)	20.7%
4-7 days	367 (4.1%)	10.9%

Infant sex (female)		
Female	4391 (49.3%)	30.1%
Male	4510 (50.7%)	28.0%
Maternal medical factors		
Pre-existing or unspecified diabetes	142 (1.6%)	16.9%
Gestational diabetes	539 (6.1%)	20.6%
Pre-existing hypertension	603 (6.8%)	19.4%
Gestational hypertension	1458 (16.4%)	22.5%
Pre-eclampsia/eclampsia	870 (9.8%)	17.9%
Cesarean delivery	2111 (23.7%)	21.6%
Infant medical factors		
Gestational age		
Early term (37-38 weeks)	2880 (32.4%)	26.2%
Full term (39-40 weeks)	5321 (59.8%)	30.2%
Late term (41 weeks)	662 (7.4%)	32.0%
Post term (≥42 weeks)	38 (0.4%)	26.3%
Low birth weight	275 (3.1%)	22.2%
Hypoglycemia	430 (4.8%)	12.1%
Jaundice	921 (10.4%)	23.0%
Prenatal feeding intentions		
Exclusive breastfeeding	2278 (25.6%)	38.8%
Both breastfeeding and formula	1318 (14.8%)	20.5%
Formula only	448 (5.0%)	5.4%
Undecided	4857 (54.6%)	29.0%
Health care system breastfeeding support		
In-hospital breastfeeding education	3027 (34.0%)	28.8%
In-hospital lactation consult completed	2239 (25.2%)	33.1%

[a]Some women did not receive prenatal care (n=956) and were not included in the denominator for prenatal care at Grady Memorial Hospital.

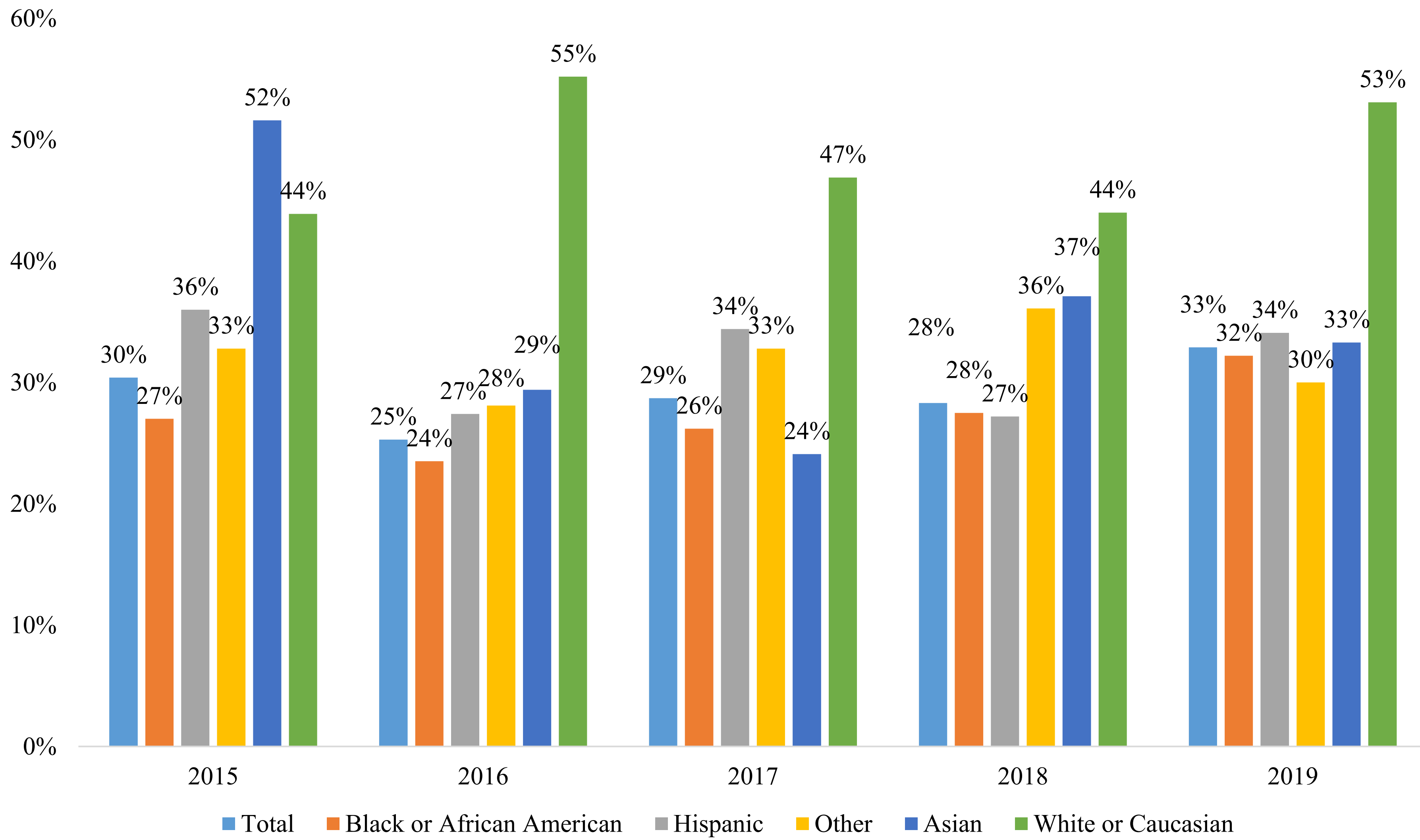
Table 6-2. Sociodemographic factors, medical factors, prenatal feeding intentions, and health care system breastfeeding support associated with in-hospital exclusive breastfeeding among mother-infant dyads at GMH, 2015 – 2019

	Model Set 1[a]			Model 2[b]		
	PR	95% CI	P value	PR	95% CI	P value
Sociodemographic factors						
Maternal age (Ref. ≤17)			<0.0001			<0.0001
18-24	**1.81**	**1.38, 2.37**		**1.71**	**1.30, 2.25**	
25-29	**2.09**	**1.59, 2.73**		**1.84**	**1.40, 2.42**	
30-34	**2.04**	**1.56, 2.67**		**1.76**	**1.33, 2.32**	
≥35	**2.14**	**1.63, 2.81**		**1.89**	**1.42, 2.51**	
Primiparous (Ref. multiparous)	1.05	0.98, 1.13	0.14			
Race/ethnicity (Black)			<0.0001			0.002
White	**1.74**	**1.48, 2.04**		**1.44**	**1.21, 1.70**	
Hispanic	**1.07**	**1.00, 1.15**		0.90	0.76, 1.07	
Asian	**1.22**	**1.01, 1.47**		0.88	0.71, 1.08	
Other	1.17	1.00, 1.37		0.93	0.78, 1.10	
Language (Ref. English)			0.0003			0.77
Spanish	1.07	1.00, 1.16		1.03	0.87, 1.23	
Other	**1.26**	**1.13, 1.41**		0.96	0.85, 1.09	
Married (Ref. not married)	**1.48**	**1.38, 1.58**	<0.0001	**1.33**	**1.23, 1.44**	<0.0001
Employment (Not employed)			0.003			0.003
Unknown	**1.14**	**1.06, 1.23**		**1.14**	**1.06, 1.23**	
Full Time	1.08	0.99, 1.19		**1.14**	**1.04, 1.25**	
Part Time	1.04	0.93, 1.17		1.08	0.96, 1.21	
Prenatal visits (Ref. 0-4)			0.20			
5-9	1.03	0.95, 1.12				
≥10	1.01	0.92, 1.11				
Prenatal care at GMH (Ref. outlying clinics)	**0.88**	**0.82, 0.94**	0.0004	0.94	0.86, 1.02	0.14
Infant sex (Ref. female)	0.95	0.89, 1.01	0.13			
Maternal medical factors						
Pre-existing, unspecified diabetes, or gestational diabetes	**0.71**	**0.61, 0.83**	<0.0001	**0.82**	**0.71, 0.96**	0.01
Pre-existing hypertension	**0.74**	**0.63, 0.87**	<0.0001	**0.82**	**0.69, 0.98**	0.007

	Model Set 1[a]			Model 2[b]		
	PR	95% CI	P value	PR	95% CI	P value
Gestational hypertension	0.95	0.85, 1.06	0.35			
Pre-eclampsia/eclampsia	**0.79**	**0.68, 0.92**	0.001	**0.81**	**0.69, 0.94**	0.004
Cesarean delivery (Ref. vaginal delivery)	**0.86**	**0.78, 0.94**	0.0009	**0.81**	**0.73, 0.89**	<0.0001
Infant medical factors						
Gestational age [Ref. full term (39-40 weeks)]			0.0005			0.25
Early term (37-38 weeks)	**0.88**	**0.82, 0.95**		0.94	0.87, 1.02	
Late & post term (≥41 weeks)	1.07	0.96, 1.20		1.01	0.90, 1.14	
Low birth weight <2500 g (Ref. ≥2500 g)	**0.79**	**0.64, 0.99**	0.02	0.88	0.71, 1.10	0.24
Hypoglycemia	**0.43**	**0.34, 0.56**	<0.0001	**0.50**	**0.39, 0.64**	<0.0001
Jaundice	0.93	0.82, 1.05	0.20			
Prenatal feeding intentions (Ref. exclusive breastfeeding)			<0.0001			<0.0001
Both breastfeeding and formula	**0.53**	**0.47, 0.60**		**0.53**	**0.47, 0.60**	
Formula only	**0.15**	**0.10, 0.23**		**0.15**	**0.10, 0.23**	
Undecided	**0.76**	**0.71, 0.82**		**0.76**	**0.71, 0.82**	
Health care system breastfeeding support						
In-hospital breastfeeding education	1.01	0.94, 1.08	0.74			
In-hospital lactation consult completed	**1.28**	**1.19, 1.37**	<0.0001	**1.24**	**1.15, 1.33**	<0.0001

Note. Statistically significant results for comparisons within variables are bolded.
[a]Adjusted for infant length of stay and birth year.
[b]Adjusted for infant length of stay, birth year, and all other statistically significant factors from model set.

Supplemental Figure 6-1. In-hospital exclusive breastfeeding prevalence stratified by year and race/ethnicity at Grady Memorial Hospital



Chapter 7: Discussion

The use of a national level data set and local level hospital data from a diverse patient population enabled us to examine several factors that influence in-hospital exclusive breastfeeding (EBF) ranging from medical factors to hospital policies and practices. This discussion will first provide an overview of the main findings and key contributions to the literature from each of the four aims. We found that underlying many of the common reasons for formula supplementation is potentially lack of lactation management support; we reported the national prevalence of the 2018 updated Ten Steps; we found that in-hospital EBF was lower in hospitals located in areas with a high percentage of Black residents and poverty; and we identified factors to target among a medically underserved patient population. Third, this discussion will triangulate the key findings across the aims in conjunction with the existing literature to provide research implications for future studies and intervention implications for program development to support in-hospital EBF.

7.1 Main Findings

Aim 1) To examine the most common reasons for in-hospital infant formula supplementation of healthy, term, breastfed infants using a national data set.

We obtained national data from the 2018 Maternity Practices in Infant Nutrition and Care (mPINC) survey. This included the open-ended, hospital response to the most common reasons for in-hospital infant formula supplementation of healthy, term, breastfed infants. Commonly reported reasons for formula supplementation were found to be related to medical indications (70.0%); maternal request/preference/feelings about breastfeeding such as frustration or lack of confidence (55.9%); lactation management-related issues (51.3%); physical but non-medically indicated reasons (36.7%); social influences (18.8%); perceived cultural/societal/demographic factors (8.2%); and medical staff/institutional practices (4.7%). Underlying many of these common reasons for formula supplementation, is potentially lack of lactation management support. These findings suggest that a variety of factors should be considered to address unnecessary formula supplementation. In addition, this was the first national level analysis of an open-ended question on the common reasons for in-hospital formula supplementation reported by hosptial staff.

Aim 2) To describe the national maternity hospital implementation of available indicators of the updated Ten Steps and the association with in-hospital EBF prevalence.

We obtained data from the 2018 mPINC survey based on the mPINC Ten Steps Assessment Tool, which aligns the mPINC survey questions with the Ten Steps. The most frequently implemented step was the provision of prenatal breastfeeding education (step 3; 95.6%). Steps with low implementation were rooming-in (step 7; 18.9%), hospital policies (step 1; 23.4%), and limited supplementation (step 6; 28.2%). Limited supplementation (step 6) was associated with the greatest difference in EBF prevalence. Hospitals that implemented this step had an EBF prevalence that was 17.2 percentage points higher than hospitals that did not implement this step. Other steps significantly associated with in-hospital EBF prevalence after adjusting for hospital characteristics and all other steps were the provision of prenatal breastfeeding education (step 3), care right after birth (step 4), rooming-in (step 7), and responsive feeding (step 8). We also found a dose-response relationship between the number of steps implemented and in-hospital EBF prevalence. These findings provide further evidence that increased implementation of the steps may improve in-hospital EBF. Our analysis further adds to the previously conducted analyses by examining indicators of the 2018 updated Ten Steps.

Aim 3) To examine US in-hospital EBF and associations with Baby-Friendly designation and neighborhood sociodemographic factors. To assess if the association between neighborhood sociodemographic factors and in-hospital EBF are modified by Baby-Friendly designation.

In order to exaime the association of in-hospital EBF with race, poverty, and bachelor's degree attainment we linked 2018 mPINC survey data and the American Community Survey data on the sociodemographic factors for the neighborhood surrounding the hospital. The overall US mean in-hospital EBF prevalence was 55.1%. The Southeast region had the lowest EBF prevalence (41.0%) and the Western region had the highest EBF prevalence (67.5%). We found that Baby-Friendly designation was associated with 9.1 percentage points higher in-hospital EBF prevalence. Hospitals located in neighborhoods with a high percentage of Black residents and poverty were associated with lower in-hospital EBF prevalence (3.3 and 3.8 percentage points, respectively). Hospitals located in neighborhoods with a high percentage of residents with bachelor's degrees were associated with higher in-hospital EBF prevalence (6.7 percentage points). Baby-friendly designation significantly reduced the EBF prevalence disparity due to poverty by 4.7 percentage points. Our study provided novel data that Baby-Friendly designation may improve in-hospital EBF and may reduce the national disparity in EBF attributed to poverty.

Aim 4) To examine in-hospital EBF and the association with sociodemographic factors, medical factors, breastfeeding intentions, and health care system breastfeeding support at Grady Memorial Hospital (GMH).

We conducted a retrospective, cross-sectional study using medical record data obtained from the Grady Obstetric & Gynecological Outcomes (GOGO) initiative of live births between January 1, 2015 to December 31, 2019 without medical contraindications for breastfeeding. The yearly prevalence of EBF remained stable from 2015 to 2019 at 29.0%. The prevalence of EBF among mothers who were Black or African American (27.2%) was lower than all other races/ethnicities (White or Caucasian=48.4%; Asian=33.2%; other=32.3%; Hispanic=31.9%). Mothers who were greater than 17 years of age, married, and employed full time were more likely to EBF. Mothers with gestational diabetes, pre-exisiting hypertension, pre-eclampsia/eclampsia, and who gave birth via cesarean section were less likely to EBF. Infants with hypoglycemia were less likely to EBF. Mother infant dyads that received a lactation consult were more likely to EBF. In summary, this study identified key factors associated with in-EBF among a vulnerable population. Future efforts should target Black mothers, adolescent mothers, those intending to formula feed during the prenatal period, and mother-infant dyads at risk for hypoglycemia. Increased support from trained lactation professionals may be an effective approach to improve in-hospital EBF.

7.2 Strengths and Limitations

7.2.1 Strengths

A key strength of this dissertation is the use of mPINC survey data, in which all hospitals providing maternity care across the nation are invited to participate [Centers for Disease Control and Prevention (CDC), 2020]. Approximately 70% of all US hospitals providing maternity care completed the survey. All fifty US states and territories are represented in this data set. Many of the studies that examined reasons for formula supplementation and Baby-Friendly designation were conducted in geographically limited samples (Pierro et al., 2016; Tender et al., 2009). In addition, previous analyses did not include hospitals with less than 1,100 births (Patterson et al., 2021); the mPINC survey does not exclude hospitals based on the number of births. This is important considering that over half of the hospitals included in the mPINC survey have less than 1,100 births.

Hospital staff complete the mPINC survey (CDC, 2020), which may lend to more accurate report of the delivery of health care system breastfeeding support provided to mothers at the hospital level. Other studies have relied on maternal report of health care system breastfeeding support and mothers were surveyed after discharge from the hospital; therefore, the data are subject to recall bias (Declercq et al., 2009; Perrine et al., 2012). However, hospital staff may be more likely to report higher implementation of maternity care policies and practices that are supportive of breastfeeding (compared to the actual implementation).

A key strength for our analysis on the common reasons for formula supplementation conducted in Aim 1 includes that we analyzed the responses to an open-ended question, whereas previous studies examined questions with categorical, predetermined responses (Nelson et al., 2016; Pierro et al., 2016; Tender et al., 2009). Our analysis of the open-ended response enabled us to field all the potential common reasons for formula supplementation, which can be used to inform future surveys. For example, there were 3 categories that we found using this open-ended question that were not captured by previous analyses of in-hospital formula supplementation, which were physical but non-medically indicated reasons, social influences, and perceived cultural/societal/demographic factors.

We included steps 1-9 in our examination of the association between the Ten Steps and in-hospital EBF, which is more than previous analyses. For example, other studies did not examine the association between prenatal education (step 3) and in-hospital EBF (Declercq et al., 2009; Perrine et al., 2012). Although prenatal education does not occur during the hospital stay following delivery, it precedes the hospital stay. We found a significant association between prenatal education and in-hospital EBF, which may be indicative of adequate preparation for breastfeeding before delivery. We used multiple indicator components for each step similar to the global standards outlined in the 2018 Baby-Friendly Hospital Initiative (BFHI) Implementation Guidance, which may provide a more comprehensive analysis of each of the steps [World Health Organization (WHO), 2018].

An important strength of our analysis of the association between sociodemographic factors and Baby-Friendly designation in Aim 3 is that we accounted for regional variations in EBF. To our knowledge, previous studies have not accounted for this factor when examining these relationships (Patterson et al., 2021; Patterson et al., 2018). The findings from the regional variations in in-hospital EBF further supports continued efforts to address lower breastfeeding outcomes in the Southeastern states.

Our work conducted at GMH, included data from a diverse patient population across four years. Approximately 68% of the mother-infant dyads in this analytic data set were Black or

African American and 24% were Hispanic. Other studies examining factors, such as maternal medical factors, infant medical factors, and breastfeeding intentions, were conducted in populations that were not racially/ethnic diverse or were conducted outside of the US (Declercq et al., 2009; Hummel et al., 2007; Kling et al., 2016; Kozhimannil et al., 2014; Longmore et al., 2020; Oza-Frank & Gunderson, 2017; Perrine et al., 2012; Sparud-Lundin et al., 2011; Strapasson et al., 2018). The study at GMH utilized medical records data. Other studies that have examined medical factors conducted in the US have relied on self-reported data, which may be subject to recall bias (mothers may not accurately remember information due to timing of the survey after hospital discharge) or knowledge bias (mothers may not know the information, particularly for medical information). Depending on the completeness, medical record data may be a more accurate representation of medical factors.

7.2.2 Limitations

Although the mPINC survey includes data from hospitals across the nation, 30% of the invited hospitals did not pariticipate. Therefore, these data are subject to non-response bias, in which hospitals that provide less maternity care support may be less likely to respond. The characteristics of hospitals that did not respond to the mPINC survey are unknown. Thus, we are unable to predict how non-responding hospitals would have responded.

In addition, responses to the mPINC survey may be based on estimates made by the survey respondent and may or may not be based on data routinely collected by the hospital (CDC, 2020). However, the CDC takes additional steps to ensure the survey is delivered to the person who is most knowledgeable of the hospital's maternity care and infant feeding practices (CDC, 2020).

For our analysis on the common reasons for formula supplementation using mPINC survey data, hospitals were asked to report the three most common reasons for formula supplementation. Since there was not one response per hospital, the mutual exclusive requirement for linear regression was not met, and we are unable to further connect these data to the percentage of healthy, breastfed newborns fed infant formula during the hospital stay following delivery. This question was intended for hypotheses generation and to potentially inform future survey designs.

Our analysis of the Ten Steps did not include some indicators because they were unavailable in the mPINC survey. For example, the global standards for prenatal care (step 3) includes a protocol for antenatal education that covers specific topics such as the importance of breastfeeding; global recommendations on EBF for the first 6 months of life and the risk of infant formula supplementation; and the importance of other Baby-Friendly clinical practices (e.g. skin-to-skin, early initiation of breastfeeding, rooming-in, etc.) (WHO, 2018). However, the mPINC survey is not intended to cover all components detailed in the BFHI Implementation Guidance (CDC, 2020). Future research could potentially collect data on the global standards for all the Ten Steps to provide a more comprehensive analysis of each step in the US (WHO, 2018).

Neighborhood sociodemographic variables obtained from the American Community Survey (US Census Bureau, 2020) were proxies for patient sociodemographic factors and may not be representative of the patient population. We utilized data from the neighborhoods surrounding the hospital to examine the association between in-hospital EBF and sociodemographic factors since data on in-hospital EBF are not reported stratified by sociodemographic factors. Previous analyses have shown that neighborhood sociodemographic factors are a useful method for understanding hospital level breastfeeding disparities (Lind, 2014; Patterson et al., 2018; Patterson; 2021). Although many factors may influence the use of health care services, including the delivery hospital, research has shown that individuals are mostly likely to utilize health care services closest to their residence (Kozhimannil et al., 2016; Mazul et al., 2017; Wennberg, 1998). Future mPINC surveys could potentially ask hospitals to provide the sociodemographic characteristics of the mothers who deliver at the hospital.

The study conducted at GMH includes data from a single, non-profit, urban, teaching hospital with approximately 3,000 births per year located in an urban setting serving socioeconomically disadvantaged and a majority Black population. Therefore, the results may not be generalizable to other hospitals that do not have similar characteristics. However, this approach could be used by other hospitals that aim to improve in-hospital EBF.

Futhermore, GMH medical record data were available for only two health care system breastfeeding support factors, which were in-hospital breastfeeding education and reciept of in-hospital, individualized support from a lactation professional. We were unable to determine the timing of the receipt of individualized support from a lactation professional and our qualitative study conducted at GMH found that receipt of breastfeeding support before complications arise is a facilitator of in-hospital EBF (Bookhart et al., 2021). There are other health care system breastfeeding support factors that may be associated with in-hospital EBF such as prenatal breastfeeding education, skin-to-skin, early initiation of breastfeeding, rooming-in, etc (Feldman-Winter et al., 2020; McCoy & Heggie, 2020). There are also several other factors previously identified that may influence in-hospital EBF that we were not able to assess in this quantititave analysis using the available medical record data such as maternal BMI, social support, and participation in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) (Feldman-Winter, 2020). However, we were able to use the results from our previously conducted qualitative study at GMH to further understand the influence of some of these factors (Bookhart et al., 2021). Future quality improvement efforts should address efficient collection of the additional factors [e.g. clinical practices of the Ten Steps that occur during or before the hospital stay (steps 3-9), social factors (family history of breastfeeding), medical factors (maternal obesity), etc.] that may influence in-hospital EBF and future research studies should examine the relationship between these factors and in-hospital EBF to further target interventions.

7.3 Public Health Implications

This section reviews future research implications, recommendations for national level monitoring, and intervention or quality improvement implications.

7.3.1 Aim 1: Reasons for formula supplementation

Medical indications

In our analysis examining the reasons for formula supplementation, we found that medical indications as listed in the Academy of Breastfeeding Medicine's *Clinical Protocol #3 on Supplementary Feedings in the Healthy Term Breastfed Neonate* as at least one of the most common reasons for formula supplementation (Kellams et al., 2017). These medical indications reported by hospitals in our study were mostly neonatal conditions and included hypoglycemia, weight loss, and jaundice. Although these are potential medical indications and in some cases formula supplementation is necessary, we were unable to determine if three key preventative steps were followed before formula supplementation is given. These preventative steps first include proper assessment of medical indications. Proper assessment is important to distinguish between normal physiologic transition from intrauterine life to extrauterine life and pathologic levels of low glucose, weight loss, and elevated bilirubin (Kellams et al., 2017). For example, newborns lose weight because of physiologic diuresis of extracellular fluid and passage of meconium and supplementation is not recommended unless there is weight loss of ≥8-10% on day 5 of life (Kellams et al., 2017). However, a study conducted in over 160,000 healthy, breastfed infants found that >10% of infants born via cesarean section lost ≥10% of their birth weight by 48 hours after birth (Grossman et al., 2012). Research is lacking in these areas, and sensitive methods that properly identify newborns at risk for pathologic consequences are needed (Feldman-Winter et al., 2020). Second, the provision of lactation management support is recommended to prevent formula supplementation for medical conditions (Kellams et al., 2017). Lactation management support includes evaluating and providing practical assistance with position, latch, and breast milk transfer (Kellams et al., 2017). Third, the expressed breast milk from the infant's mother should be the first choice for supplementation, followed by donor human milk. Provision of mothers' expressed breast milk facilitates the transition to lactogenesis II and helps to protect the breast milk supply (Feldman-Winter et al., 2020). Access to breast pumps and support with breast milk expression are needed to facilitate use of mothers' expressed breast milk (WHO, 2018). Provision of mother's expressed breast milk also reduces the risk of formula supplementation to the infant, in which even brief episodes of formula supplementation changes the gut microbiota (Carvalho et al., 2018; Forbes et al., 2018). When available, pasteurized donor human milk may protect the gut microbiome (Kellams et al., 2017).

Future mPINC surveys and analyses can potentially address some of the remaining gaps in understanding related to the reasons for formula supplementation that we were unable to address. First, future surveys could examine if hospitals have policies or procedures for the clinical assessment and formula supplementation of possible medical indications such as hypoglycemia, weight loss, jaundice, etc. Second, future surveys could examine if lactation management support (e.g. practical assistance with position, latch, and breast milk transfer) is provided before formula supplementation is given. Third, future surveys could ask the single most common reason for formula supplementation and use the themes from this survey to inform the categories. Asking the single most common reason for formula supplementation will meet the mutually exclusive requirement of linear regression and would enable an analysis that examines the association between the most common reason for formula supplementation and the prevalence of formula supplementation. For medical staff/institutional practices, examining if documentation of a medical indication is required for doctors' requests or orders for infant formula supplementation may also be key. In addition to mPINC survey data, further research is needed to develop sensitive methods that properly identify newborns at risk for pathologic consequences of neonatal medical conditions including hypoglycemia, jaundice, and weight loss (Feldman-Winter et al., 2020).

Mothers' perceived low milk supply

Mothers' perceived low milk supply (16.5%) was the most frequently reported subcategory for the theme lactation management related issues. However, we were unable to determine if this was due to mothers' perception because of lack of knowledge related to the volume of colostrum produced during the first few days of life, primary (directly related to physiology), or secondary (related to practices that interrupt the normal physiology of lactation).

Low milk supply could be a concern for mothers, particularly in the early days of breastfeeding when milk production volume may be lower than expected by mothers but adequate to meet the needs of the neonate (Boban & Zakarija-Grković, 2016; Kellams et al., 2017; Pierro et al., 2016). Our qualitative study at GMH found that mothers' perceived low milk supply was a barrier to in-hospital EBF (Bookhart et al., 2021) and other studies have previously discussed this as a reason for formula supplementation in the early days of life (Boban & Zakarija-Grković, 2016; Pierro et al., 2016). The support of health care professionals to guide optimal early latching and inform signs of efficacious infant suckling may help to reduce mothers' perceived low milk supply (Galipeau et al., 2017; Gatti, 2008).

One older study suggests that primary low milk supply is rare (Neifert et al., 1990). However, the prevalence of pre-pregnancy obesity and older age at first birth are increasing nationally, and these factors are reported to impact the onset of lactogenesis II, which could contribute to primary low milk supply (Hales et al., 2020; Mathews & Hamilton, 2016; Nommsen-Rivers et al., 2012). Therefore, more research is needed to understand the etiology of low milk supply.

Perceived low cultural, societal, and demographic related factors

Although only 8.2% of hospitals reported perceived cultural, societal, and demographic related factors as common reasons for formula supplementation, addressing this reason may be of particular importance considering the sociodemographic disparities that exist in early infant formula supplementation (Li et al., 2020). Hospital staff report of this theme could potentially be due to personally mediated racism as described in *Levels of Racism: A Theoretic Framework and a Gardener's Tale*, which provides a framework for understanding race-associated differences in health outcomes (Mead et al., 2017). Personally mediated racism refers to prejudice (assumptions about individuals) and discrimination (differential actions toward others) based on their race. An example of this related to breastfeeding would include not providing breastfeeding support based on assumptions such as “Black women do not breastfeed” or “Hispanics do las dos cosas (both formula feeding and breastfeeding)” (Jones, 2000; Panchula, 2012). Cultural humility training could potentially address this reason for formula supplementation. The cultural humility approach is a lifelong commitment to building awareness about ones’ own cultural biases and truly learning about patients as unique individuals with their own personal cultural background (Hughes et al., 2020; Tervalon & Murray-García, 1998). A second potential underlying reason for the report of cultural, societal, and demographic related factors is the influence of ones’ culture on infant feeding decisions (DeVane-Johnson et al., 2018; Reeves & Woods-Giscombe, 2015). Peer support delivered throughout the prenatal period into the postpartum period that addresses cultural beliefs regarding infant feeding and formula supplementation, while also providing practical advice for breastfeeding could potentially address this reason for formula supplementation (Chapman & Pérez-Escamilla, 2012; Lutenbacher, Elkins, Dietrich, & Riggs, 2018.

7.3.2 Aim 2: Ten Steps to Successful Breastfeeding

Limited formula supplementation (step 6)

We found in our analysis examining the associations between the Ten Steps to Successful Breastfeeding and in-hospital EBF that limited supplementation (step 6) was among the least frequently implemented steps (28%), but had the greatest independent association with in-hospital EBF (difference in EBF 17.2%). Our results are consistent with other findings from studies that examined the association between achieving EBF intentions and maternal report of experience of Baby-Friendly hospital practices. These studies found that after adjusting for sociodemographic factors and other steps, in-hospital formula supplementation was significantly associated with lower odds of meeting EBF intentions (Declercq et al., 2009; Perrine et al., 2012). Similarly, these individual level studies found that in-hospital formula supplementation was the hospital practice with the largest measure of association with meeting EBF intentions. In our analysis of limited supplementation (step 6), hospitals were considered to have implemented this step if few (<20%) infants were supplemented with infant formula and counseling on risk of infant formula supplementation for breastfeeding dyads were provided to at least 80% of families. A study that examined the associations between maternity care practices using data from the mPINC survey and EBF prevalence from The Joint Commission found that the percentage of healthy, term infants supplemented with non-breast milk substitutes was the maternity care practice with the largest R^2 (Patterson et al., 2019). This finding indicates that the majority of the variance of EBF was explained by in-hospital formula supplementation

(Patterson et al., 2019). Although formula supplementation is the converse of EBF among breastfeeding newborns at the individual level, our findings along with the findings from Patterson et al., provide evidence that the routine practice of providing formula supplementation in the hospital can impact the overall in-hospital EBF prevalence (Patterson et al., 2019). The American Academy of Pediatrics also supports the need to discontinue policies that provide non-breast milk supplements to breastfed infants (Eidelman, 2012). Our findings from Aim 1 (reasons for formula supplementation) provide understanding of potential barriers to implementing step 6, such as medical indications, maternal requests, lactation management-related issues, physical but non-medically indicated reasons, social influences, and medical staff or institutional practices. The research and quality improvement implications for Aim 1 on the reasons for formula supplementation are also applicable to limited formula supplementation.

Prenatal education (Step 3)

Step 3 (prenatal education) was found to have a significant association with in-hospital EBF after controlling for hospital factors and all other steps related to in-hospital EBF. Among the hospitals that completed the 2018 mPINC survey, 95.6% reported implementing prenatal education and this step had the second largest difference in EBF prevalence [difference in EBF: 8.0 (95% CI: 4.0, 12.0)]. The indicator that we used in our study asked if the hospital provides the opportunity for women to receive prenatal breastfeeding education (in either group or individual settings) provided by the hospital and/or a hospital affiliated clinic or service. The global standards for prenatal education described in the 2018 BFHI Implementation Guidance include that hospitals have a protocol for prenatal discussion of breastfeeding that covers the importance of breastfeeding; global recommendations on EBF for the first 6 months; the importance of clinical practices such as early initiation and rooming-in; the basics of good positioning and attachment; and the recognition of feeding cues (WHO, 2018). The global standards also include that at least 80% of mothers who received prenatal care at the facility are able to adequately describe what was discussed for at least two of the topics (WHO, 2018). Therefore, we were unable to determine the components included in the prenatal education provided to mothers or the quality of the delivery. In our formative qualitative study conducted at GMH, we found that there were gaps in the topics covered in the prenatal education provided, in which few women reported that they received education on positioning and attachment (Bookhart et al., 2021). There were also gaps in the delivery across clinics; women who received prenatal care at outlying clinics less frequently reported receiving education on the benefits of breastfeeding or information on BFHI clinical practices (Bookhart et al., 2021).

A second consideration for the implementation of prenatal education is the inclusion of family (WHO, 2018). Our formative qualitative study at GMH provides evidence that family experience, knowledge, attitudes, and support were key factors that influenced in-hospital (EBF) (Bookhart et al., 2021). We also found in our national analysis that 18.8% of hospitals reported social influences including the parents (not just the mother alone), family, and friends as one of the most common reasons for in-hospital formula supplementation (Aim 1-Reasons for formula supplementation). The role of social influences on non-EBF has been reported in previously conducted qualitative literature (Asiodu et al., 2017; Deubel et al., 2019). One other study found that fathers' preference for infant formula supplementation was significantly associated with in-hospital formula supplementation (Parry et al., 2013). Therefore, providing this prenatal education to not only mothers, but also to family members (particularly partners) may be instrumental in improving in-hospital EBF (Asiodu et al., 2017; Bookhart et al., 2021; Deubel et al., 2019; Parry et al., 2013).

Care after birth (Step 4), Rooming-in (Step 7), & Responsive feeding (Step 8)

Care after birth, including early breastfeeding initiation and skin-to-skin care (step 4); rooming-in (step 7); and responsive feeding (step 8) were also found to have significant associations after controlling for hospital factors and all other steps related to in-hospital EBF. Rooming-in is a key structural component that connects steps such as care after birth and responsive feeding (Pérez-Escamilla et al., 2016). Rooming-in supports care after birth by keeping mothers and infants together to facilitate skin-to-skin contact and early initiation of breastfeeding (Pérez-Escamilla et al., 2016; WHO, 2018). Rooming-in also supports responsive feeding by enabling mothers and infants to remain together day and night so that mothers can recognize hunger cues and feed the infant as frequent and as long as the infant wants (Perez-Escamilla et al., 2016; WHO, 2018).

Dose-response relationship with Ten Steps to Successful Breastfeeding

Other studies have similarly found a dose-response relationship between the number of steps implemented and breastfeeding outcomes (Perrine et al., 2012; Declercq et al., 2009). For example, one study found that mothers who experienced 6 steps were 2.7 times more likely to meet their breastfeeding intentions (Perrine et al., 2012). We also found that the EBF prevalence was 46.0% for hospitals with low implementation, 54.6% for hospitals with mid implementation, and 64.4% for hospitals with high implementation of the Ten Steps. This supports the implementation of steps 1-9 to increase in-hospital EBF. The Ten Steps are interrelated and were designed to be implemented jointly, along with a site visit assessment and continued monitoring for Baby-Friendly designated hospitals (WHO, 2018). Considering this dose response relationship, increased implementation of steps 1-9 could improve in-hospital EBF. Continued monitoring of the implementation of these steps at both the national level and within hospitals may be a potential first step. Considering the low prevalence and the significant associations with in-hospital EBF at the national level, priorities for monitoring should include limited supplementation (step 6) and rooming-in (step 7). Hospital staff can utilize the mPINC Ten Steps Assessment Tool for monitoring and to inform quality improvement efforts (CDC, 2021).

We conducted latent class analyses to understand the clustering of implementation of the steps (results not shown). We found that the implementation of the steps were similar to the findings in Table 4-3 and Table 4-5. Class 1 included approximately 23% of hospitals that had high implementation of prenatal education (step 3), high implementation of responsive feeding (step 8), and low implementation of all other steps 1-9. In addition to steps 3 and step 8, class 2 (46% of hospitals) had higher implementation of support with breastfeeding (step 5) and bottles, nipples, and pacifiers (step 9). Class 3 included 31% of hospitals and additionally included higher implementation of step 2 (staff competency) and step 4 (care right after birth).

Although this study adds to the observational evidence that there is a dose response relationship between the number of steps implemented and in-hospital EBF, randomized controlled trials (RCT) are needed in the US to better understand the impact of the Ten Steps on breastfeeding outcomes (Perez-Escamilla et al., 2016). RCTs are the highest level of evidence as it accounts for social differences, in which breastfeeding practices have been reported to be highly dependent upon and are difficult to measure (Perez-Escamilla et al., 2016; Kramer et al., 2001). Due to the strong evidence that optimal breastfeeding behaviors are associated with improved child and maternal health outcomes, it is unethical to randomize mother-infant dyads to breastfeed or not (Perez-Escamilla et al., 2016; Kramer et al., 2001). Therefore, RCTs that examine the relationship between breastfeeding supportive maternity care policies and practices with breastfeeding outcomes include randomizing mother-infant dyads to receive interventions that promote breastfeeding (Perez-Escamilla et al., 2016; Kramer et al., 2001).

The PROBIT RCT study conducted in Belarus is an example of a high-quality study design, in which hospitals were randomized to implement the Ten Steps (experimental group) or to continue with usual care (control group) (Kramer et al., 2001). This study found that infants in the experimental group were more likely to EBF at 3 months and 6 months compared to the control group (43.3% vs 6.4% and 7.9% vs 0.6%, respectively) (Kramer et al., 2001). The findings for this study may not apply to the US due to social and cultural differences (Perez-Escamilla et al., 2016; Feltner et al., 2018). Future studies in the US that examine the relationship between the Ten Steps and breastfeeding outcomes could utilize a study design similar to the PROBIT RCT study (Kramer et al., 2001). This could include the examination of the association between the Ten Steps and breastfeeding outcomes (e.g. initiation, in-hospital EBF, and EBF through 6 months, and continued breastfeeding) with a focus on populations with sociodemographic breastfeeding disparities including Black and Hispanic populations, poverty, and the Southeastern US.

7.3.3 Aim 3: Baby-Friendly designation & neighborhood sociodemographic factors

A. Baby-Friendly designation

We found that Baby-Friendly designation was associated with 9.1 percentage points higher in-hospital EBF prevalence (compared to non-designated hospitals) after adjusting for neighborhood sociodemographic factors and hospital factors. A previously conducted study using 2014-2016 data, which examined the associations between sociodemographic factors and in-hospital EBF, similarly found that Baby-Friendly hospital designation was associated with higher EBF (Patterson et al., 2018). However, only 25% of hospitals in our analysis were Baby-

Friendly designated, which indicates the need to increase the number of Baby-Friendly designated hospitals to improve in-hospital EBF. Efforts to increase Baby-Friendly designation should focus on hospitals that serve populations with in-hospital EBF disparities that were identified in this dissertation, including Black mothers, high poverty populations, and hospitals located in the Southeastern US.

B. Sociodemographic factors

Although previously conducted studies have found regional variations in breastfeeding outcomes for EBF at 6 months, this dissertation also adds to this evidence that there are regional variations in in-hospital EBF (Anstey et al., 2017). States located in the Southeast region of the US had the lowest in-hospital EBF prevalence. We found independent associations between each of the sociodemographic factors examined and in-hospital EBF prevalence. Hospitals located in ZCTAs with a high a percentage of Black residents and poverty were associated with lower in-hospital EBF prevalence, while hospitals located in ZCTAs with a high percentage of residents with bachelor's degrees were associated with higher in-hospital EBF prevalence. Baby-Friendly designation significantly modified the in-hospital EBF disparity for hospitals located in ZCTAs with a high percentage of poverty. To our knowledge, only two other nation-wide analyses have examined the relationship between neighborhood sociodemographic factors and in-hospital EBF at the hospital level (Patterson et al., 2018; Patterson et al., 2021). This first analysis similarly found that EBF prevalence was negatively associated with residents who identified as Black or Hispanic and individuals below poverty and was positively associated with individuals with bachelor's degree attainment (Patterson et al., 2018). However, this study did not include data from hospitals with less than 1,100 births (Patterson et al., 2018). Greater than 50% of the hospitals in our analytic data set reported less than 1,100 births. We also found regional variations in in-hospital EBF prevalence and accounted for this in our analysis. The second analysis examined area deprivation index (ADI), a measure of the relative socioeconomic disadvantage of a neighborhood, which includes factors such as educational attainment of the population, employment status, housing-quality, family income, access to transportation, and poverty indicators (Patterson et al., 2021). This analysis also evaluated if there were differences in EBF prevalence in Baby-Friendly hospitals and non-Baby-Friendly hospitals across ADI categories (Patterson et al., 2021). This second analysis found that EBF prevalence was 4.9 percentage points lower in highly deprived areas compared to lower deprivation and Baby-Friendly designation was associated with higher EBF prevalence for all ADI categories (Patterson et al., 2021). These adjusted, significant relationships between sociodemographic factors and in-hospital EBF found in previous analyses and our current analysis indicate that there are in-hospital EBF disparities (Patterson et al., 2021; Patterson et al., 2018). However, Baby-Friendly hospital designation may modify these disparities (Merewood et al., 2019; Patterson et al., 2021; Patterson et al., 2018).

There are initiatives to increase Baby-Friendly designation, particularly among populations with breastfeeding outcomes disparities. For example, Communities and Hospitals Advancing Maternity Practices (CHAMPS) was implemented from 2014-2017 in the southern region of the US, which has some of the greatest racial breastfeeding disparities (Merewood et al., 2019). CHAMPS resulted in Baby-Friendly designation of 14 hospitals by 2018 and increased in-hospital EBF prevalence among Black infants (Merewood et al., 2019). The CDC has funded the National Association of County and City Health Officials (NACCHO) through a cooperative agreement to implement the Reducing Disparities in Breastfeeding through Peer and Professional Lactation Support project (Breastfeeding Project) since 2014 (Keitt et al., 2018). The

Breastfeeding Project has resulted in an increase in breastfeeding support programs to Black and low-income women and has increased direct lactation support (Keitt et al., 2018). In addition to these programs, the intervention and quality improvement implications discussed for perceived cultural/societal/demographic related factors in Aim 1 on the reasons for formula supplementation are applicable to addressing race/ethnicity disparities. For example, these efforts could incorporate cultural humility training into staff breastfeeding training and provide culturally relevant peer support to mothers beginning in the prenatal period through the postpartum period.

Our findings from this national data set, in addition to findings from local studies (Nobari et al., 2017), suggests that EBF prevalence disparities may significantly decrease among low-income populations when Baby-Friendly designation is increased. A first step in further understanding this relationship may be to examine if there are differences in Baby-Friendly designation among low income populations. In addition to Baby-Friendly designation, many efforts have been implemented to provide support among mother-infant dyads who are low income, particularly among participants of the WIC program including multicomponent interventions aimed to improve EBF and breastfeeding peer counselors (Edmunds et al., 2017; Eldridge et al., 2017). Furthermore, workplace related factors have been reported to influence breastfeeding duration; however, further work is needed to understand how these factors may potentially influence early infant feeding decisions while in the hospital (Barbosa et al., 2017; Hardison-Moody et al., 2018). These disparities, support the needed for continued and additional efforts to increase Baby-Friendly designation and reduce disparities.

A limitation of our analysis of sociodemographic factors was the use of neighborhood sociodemographic factors as proxies for sociodemographic factors. The mPINC survey could potentially ask hospitals to report the sociodemographic factors of the mother-infant dyads who deliver at the hospital. This would enable national monitoring of in-hospital EBF prevalence stratified by sociodemographic factors and could further enable targeting of interventions to reduce disparities.

7.3.4 Aim 4: Factors associated with in-hospital EBF at Grady Memorial Hospital

Sociodemographic factors

Our analysis at GMH, enabled an examination of individual level factors associated with in-hospital EBF. Similar to our results from Aim 3 on Baby-Friendly designation and neighborhood sociodemographic factors, we found sociodemographic disparities in in-hospital EBF at GMH. For example at GMH, 27.2% of Black or African American mothers and 31.9% of Hispanic mothers EBF while in the hospital compared to 48.4% of White or Caucasian mothers. We were able to control for sociodemographic factors such as maternal age, employment, marital status, as well as medical factors and breastfeeding intentions. We found that White women were 1.44 times more likely to EBF than Black women, after adjusting for other factors. Therefore, this indicates a significant, independent association; however, we were unable to adjust for other potential confounders such as poverty, education, and WIC participation due to the unavailability of these variables in the medical record data set. This potential significant, independent association at the individual level suggests that cultural factors may need to be addressed to provide equitable breastfeeding support to Black women. Other qualitative studies have found that family factors may be key considerations when providing breastfeeding support to Black mothers (DeVane-Johnson et al., 2018; Reeves & Woods-Giscombe, 2015). These studies report that Black mothers may not have exposure to family members who have breastfed which may stem from historical traumas, in which Black women were forced to prioritize breastfeeding the children of White slave owners over their own children (DeVane-Johnson et al., 2018; Reeves & Woods-Giscombe, 2015). This historical trauma may have resulted in the preference for formula among Black women when it became available (DeVane-Johnson et al., 2018; Reeves & Woods-Giscombe, 2015). Our qualitative study at GMH similarly reported that lack of family *experience* is a barrier to in-hospital EBF, in which family without breastfeeding experience may have limited knowledge of normal infant behavior in the early days of breastfeeding and may encourage formula supplementation (Bookhart et al., 2021). Lack of family *support* was also a barrier to in-hospital EBF, particularly among family members that would later serve as caregivers due to concerns about breastfeeding management when the mother is separated from the infant later (Bookhart et al., 2021). Therefore, incorporating family members into breastfeeding counseling during the prenatal period may be an effective strategy to increase in-hospital EBF, particularly among Black mothers (Bookhart et al., 2021). Furthermore, peer breastfeeding support beginning in the prenatal period through the postpartum period may also be an effective strategy to providing culturally relevant breastfeeding support (Chapman & Pérez-Escamilla, 2012; Lutenbacher et al., 2018).

Medical factors

In our study at GMH, the medical factor with the largest association with in-hospital EBF was neonatal hypoglycemia. Infants with hypoglycemia were 50% less likely to EBF compared to infants without hypoglycemia. Our qualitative study at GMH also found that there were conflicts on practices among clinicians and extenders about formula supplementation for medical factors such as neonatal hypoglycemia (Bookhart et al., 2021). Nurses who provided lactation management support at GMH during the hospital stay following delivery reported being disempowered to advocate for patients to avoid supplementation (Bookhart et al., 2021). The quantitative and qualitative findings from these studies at GMH suggest the need to update and clarify the infant formula supplementation policy, particularly for infants with hypoglycemia that is communicated to all providing clinical support to breastfeeding mothers (Bookhart et al., 2021). A potential barrier that may need to be addressed to implement this policy is communication across the complex organizational structure at GMH which includes resident and attending physicians from Emory and Morehouse School of Medicine, as well as nurses and lactation consultants employed by GMH (Bookhart et al., 2021). Our national level analysis found that hypoglycemia was the most frequently reported subcategory with 46% of hospitals reporting this as a common reason for formula supplementation (Aim 1 on reasons for formula supplementation). These national level findings further support the need for continued work to support breastfeeding among infants with hypoglycemia. Maternal diabetes and hypertensive disorders were also found to be significantly associated with a lower prevalence of in-hospital EBF. Obstetrics and gynecology (OB/GYN) clinicians in our qualitative study at GMH reported that there is limited time for breastfeeding education for high-risk patients with conditions such as gestational diabetes and hypertension during prenatal visits (Bookhart et al., 2021). These quantitative and qualitative results support the need for targeted breastfeeding counseling for high-risk patients during the prenatal period, potentially by clinicians beyond OB/GYNs such as nurses, lactation consultants, nutritionists, and health educators (Bookhart et al., 2021).

Breastfeeding intentions

Our study at GMH, enabled an examination of the association between breastfeeding intentions and in-hospital EBF. We found that mothers who were undecided about feeding were 30% less likely to EBF than women who were planning to EBF. Key stakeholders who provide care during the hospital stay following delivery, reported that providing breastfeeding education after delivery is not as effective as during the prenatal period because mothers are often overwhelmed during the birthing process (Bookhart et al., 2021). Our results are similar to a study conducted in North Carolina, which found that deciding about feeding method before pregnancy was a significant factor associated with EBF (Jones et al., 2018). Evidence suggests that breastfeeding education strategies could improve EBF at 3 months by 102% (Keats et al., 2021). Breastfeeding educational interventions that influence breastfeeding interventions may be most effective if delivered beginning in early pregnancy (Jones et al., 2018).

Lactation consults

We were able to examine the relationship between lactation support from a trained professional and in-hospital EBF. We found that mother-infant dyads that received a lactation consult were 20% more likely to EBF during the hospital stay after controlling for sociodemographic factors, medical factors, and breastfeeding intentions. Our qualitative study at GMH also found that practical support was a key facilitator of in-hospital EBF; however, there was inadequate staffing to provide the support needed and there was limited support provided at night and on the weekends (Bookhart et al., 2021). These findings support the need to increase lactation management support to mother-infant dyads while in the hospital following delivery (Bookhart et al., 2021). Considering the sociodemographic disparities and the qualitative finding that there is a diverse patient population in regards to several factors such as race, ethnicity, religions, countries of origin, languages, and ages there is a need to assure that the support provided is reflective of the patient population and delivered in a culturally sensitive manner (Bookhart et al., 2021).

A key strength of this study at GMH is that we first conducted formative qualitative research to provide contextualized evidence of facilitators and barriers to breastfeeding among mothers and to providing support among key stakeholders. This qualitative study informed our quantitative analysis and provided insight on the mechanisms through which associated factors may act. Although we conducted a formative qualitative research study to inform our study of factors associated with in-hospital EBF, some potential factors were unavailable in the medical record. Future research that examines in-hospital EBF could potentially consider prospectively collecting the data from medical records described by Feldman-Winter et al. in *Evidence-Based Updates on the First Week of Exclusive Breastfeeding Among Infants ≥35 Weeks* (Feldman-Winter et al, 2020) and listed in Table 2-1. Triangulating the results from the qualitative and quantitative studies at GMH, priorities for additional data collection include WIC participation, previous feeding experience, and family experience with breastfeeding. In addition, it is recommended to incorporate collecting health care system breastfeeding support that aligns with the clinical practices detailed in steps 3-10 of the Ten Steps into the collection of medical record data in a completed or not completed manner. This would help streamline hospital wide monitoring of these critical steps and could facilitate quality improvement efforts.

In summary, there are several public health implications of this work. There are four key topics that could potentially improve in-hospital EBF: 1) lactation management support, 2) provision of culturally relative/sensitive care to address sociodemographic disparities, 3) prenatal breastfeeding education, and 4) health system breastfeeding support (Table 7-1). Lactation management support from trained professionals may be critical to addressing breastfeeding difficulties especially among mother-infant dyads at risk for breastfeeding difficulties. To address sociodemographic disparities, cultural humility training would reduce health care provider bias in the delivery of breastfeeding support and peer breastfeeding support could address cultural beliefs that influence infant feeding decisions. Prenatal breastfeeding education could be instrumental in addressing breastfeeding intentions and equipping mothers with practical knowledge about lactation management before delivery. Incorporating family into prenatal discussions about infant feeding would promote family support. Prenatal breastfeeding education should target high risk patients with conditions such as diabetes and hypertension who are more likely to experience breastfeeding difficulties. To improve the delivery of health care system breastfeeding support, continued monitoring is needed for the implementation of the Ten Steps to Successful Breastfeeding, particularly limited infant formula supplementation (step 6). Development and implementation of formula supplementation policies and clinical guidelines are needed, particularly among infants at risk for conditions such as hypoglycemia and jaundice. To further understand sociodemographic disparities, the collection of sociodemographic factors from mother infant-dyads is needed. Quality improvement efforts could be improved by incorporating the collection of Baby-Friendly Ten Steps and other factors that may influence in-hospital EBF into the medical record data collection in a format that can be efficiently analyzed. This would assist with monitoring the implementation of health care system breastfeeding support and EBF outcomes.

Table 7-1. Research and public health implications and recommendations

Research & Public Health Implications/Recommendations	
Lactation management support	• Provide lactation management support from trained professionals to those at risk for breastfeeding difficulties.
Sociodemographic disparities	• Incorporate cultural humility training for staff. • Provide peer breastfeeding support to mothers who may lack social support such as mothers without a family history of breastfeeding.
Prenatal breastfeeding education	• Prenatal breastfeeding education should include family/partners, begin during early pregnancy when possible, and should target high risk patients with conditions such as diabetes and hypertension.
Health care system breastfeeding support	• Continue to monitor implementation of the Ten Steps to Successful Breastfeeding using the global standards, particularly limited infant formula supplementation (step 6) and rooming-in (step 7). • Develop and implement formula supplementation policies and guidelines, particularly for infants at risk for hypoglycemia and jaundice. • Continued implementation of Baby-Friendly designation, particularly targeted at hospitals serving those with sociodemographic disparities such as poverty. • Collection of sociodemographic factors of mother-infant dyads from hospitals. • Incorporate the collection of Baby-Friendly Ten Steps and other factors that may influence in-hospital EBF into the medical record data collection in a format that can be efficiently analyzed.

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Chapter 8: Conclusion

This dissertation aimed to examine a variety of factors associated with in-hospital exclusive breastfeeding (EBF) and common reasons for formula supplementation. Many of the common reasons for formula supplementation are potentially related to the lack of lactation management support and suggests that a variety of factors should be considered to address unnecessary formula supplementation. This work also provides further evidence that increased implementation of the Ten Steps to Successful Breastfeeding may improve in-hospital EBF. Furthermore, Baby-Friendly designation may improve in-hospital EBF and may reduce the national disparity in EBF attributed to poverty. At Grady Memorial Hospital (GMH), key factors associated with in-hospital EBF were race/ethnicity, adolescent mothers, those intending to formula feed during the prenatal period, and mother-infant dyads at risk for hypoglycemia. Increased breastfeeding support from trained lactation professionals may be an effective approach to improve in-hospital EBF.

Further work is needed to understand reasons for formula supplementation, particularly for potential medical indications, such as neonatal hypoglycemia. Efforts to increase implementation of all Ten Steps are warranted, and limited supplementation (step 6) and rooming-in (step 7) are potential priority areas. Future mPINC surveys should potentially collect data on sociodemographic factors of the mother-infant dyads that deliver at hospitals responding to the mPINC survey to further examine in-hospital EBF stratified by sociodemographic factors. Increased Baby-Friendly designation is warranted, particularly in hospitals serving populations with sociodemographic disparities. Recommendations at GMH include incorporating family members into breastfeeding counseling, updating and clarifying infant formula supplementation policies for neonatal hypoglycemia, targeting breastfeeding support to mothers with conditions such as diabetes and hypertensive disorders, and increasing the support available from trained lactation support personnel.