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The Impact of Patient Characteristics on Dysphagia Therapy Utilization and Feeding Outcomes for Premature Infants in the Neonatal Intensive Care Unit

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

by

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Contents

List of Tables

List of Figures

Abstract

Medical advances have significantly increased the survival rates of preterm infants at lower gestational ages. However, infants born at lower gestational ages have an increased risk for developmental disabilities and oral feeding difficulties. A stay in the neonatal intensive care unit (NICU) is very costly and inadequate oral feeding is the most common barrier to discharge for premature infants. Infants can receive dysphagia therapy services during their NICU stay that focuses on the development of oral feeding and swallowing skills. However, literature to this date has mainly focused on the impact of therapy services for premature infants after NICU discharge.

The purpose of this dissertation is to describe the scope of dysphagia therapy for preterm infants in a Level IV NICU and to determine the association between infant characteristics, dysphagia therapy utilization, and feeding outcomes. This study uses a correlational retrospective study design to analyze secondary data extracted from the electronic medical record for all eligible infants who were born at less than 37 weeks of gestation, with a history of admission to a Level IV NICU between January 2017 and December 2019. Variables for this study were selected using Gelberg's Behavioral Model for Vulnerable Populations by examining how preterm infant characteristics impact dysphagia therapy service utilization, which ultimately impact their feeding outcomes.

The results showed that mainly need factors, such as gestational age, birthweight, and medical complexity, were associated with receipt of dysphagia therapy referral, referral type, number of treatment sessions, and postmenstrual age (PMA) at independent oral feeding. Regression analysis showed that when controlling for infant characteristics, the receipt of dysphagia therapy was associated with higher PMA at independent oral feeding. This is likely due to infants who received dysphagia therapy referrals having higher medical complexities.

Findings from this study contributes to understanding of the provision of dysphagia therapy, which could lead to earlier identification of populations that are at higher risk for delayed achievement of independent oral feeding and the creation of protocols for the referral process for those infants. More research is needed to further understand and address factors that impact neonatal feeding outcomes and length of stay to ultimately decrease healthcare costs.

Keywords: feeding, occupational therapy, premature birth, rehabilitation, speech-language pathology, swallowing, therapy frequency, therapy referral

Chapter 1: Introduction

Seventy-five percent of admissions to the neonatal intensive care unit (NICU) are due to prematurity, and the most common barrier to discharge for premature infants is inadequate oral feeding (Edwards et al., 2019). Infants may receive dysphagia therapy services that address feeding and swallowing issues to facilitate oral feeding development while in the NICU. The purpose of this dissertation is to explore the association between patient characteristics, including clinical and social factors, on therapy services and feeding outcomes in premature infants who are admitted to the NICU.

There are a number of factors that influence the utilization of therapy services and health outcomes. However, research to date has examined preterm infant feeding only from a medical lens, without considering the social aspects of health service utilization and the impact on feeding. The first aim of this dissertation is to determine the scope of dysphagia therapy in a Level IV NICU for preterm infants. The second aim is to explore the association between patient characteristics and dysphagia therapy utilization and feeding outcomes. The third aim is to explore the association between dysphagia therapy utilization and feeding outcomes while controlling for patient characteristics for preterm infants in the NICU.

The purpose of this chapter is to provide a brief introduction to preterm infant feeding and to define key terms that will be used throughout the paper. This chapter will conclude with identifying the purpose of the study and key research questions. Subsequent chapters will provide a more in-depth review of the literature (Chapter 2) and the proposal study methods (Chapter 3).

Background

In the last 20 years, there have been advances in medical care for mothers in premature labor and for extremely premature infants (less than 28 weeks gestation) that have significantly increased survival rates of infants, with the largest increase for those born at 23- and 24-weeks gestation (Stoll et al., 2015). The Centers for Disease Control and Prevention (CDC, 2021) reported that in 2020, 1 in 10 infants were born preterm (less than 37 weeks) in the United States. Despite the medical care advances improving survival of extremely premature infants, Black infants are four times more likely to die from complications related to prematurity compared to White infants (Riddell et al., 2017). Interestingly, while White infants continue to show increasing survival rates, *mortality* among Black infants has plateaued over the last few years creating a disparity in infant mortality between Black and White infants (Riddell et al., 2017). Even after discharge from the hospital, Black infants have a 60% increased risk of mortality when compared to White infants (Karvonen et al., 2021).

There are also racial and ethnic disparities for neonatal morbidities. Black and Hispanic infants have higher rates of severe neonatal *morbidities,* with a two to four times increased risk of necrotizing enterocolitis, intraventricular hemorrhage, bronchopulmonary dysplasia, and retinopathy of prematurity when compared to White infants (Howell et al., 2018). Asian infants also have an increased risk of retinopathy of prematurity when compared to White infants (Janevic et al., 2018). Further, Black and Hispanic infants, especially those infants with respiratory distress syndrome and bronchopulmonary disease, are also more likely to be readmitted to the hospital after NICU discharge, (Karvonen et al., 2021).

When compared to full term counterparts, preterm infants have higher rates of disability. Those who are born at earlier gestational ages and lower birthweights have an even higher risk for serious disabilities such as breathing problems, feeding difficulties, cerebral palsy, developmental delay, vision problems, and hearing problems (CDC, 2021). Social factors, such as maternal stress and low socioeconomic status, also place preterm infants at an additional risk of developmental disabilities (Potijk et al., 2013; Schmeer et al., 2020). Prematurity impacts neurodevelopment, which in early development can manifest as poor behavioral state regulation, tolerance of handling, and muscle tone (Pineda et al., 2013; Schieve et al., 2016). Seventy-five percent of very preterm children, those who are born at <30 weeks gestation or have a birthweight <1,000 grams, have developmental disabilities at the age of 5 years (Potharst et al., 2011). Feeding problems are also prevalent in the first four years of life for those who were born <37 weeks gestation (Pados et al., 2021).

Prematurity and medical factors, such as gestational age, birthweight, certain neonatal morbidities, gender, and delivery route, impact body systems and skills that support oral feeding, thus, delaying achievement of oral feeding milestones (Brumbaugh et al., 2018; Gehle et al., 2022; Jackson et al., 2016; Park et al., 2015; Van Nostrand et al., 2015). Dysphagia therapy interventions including oral motor (Ghomi et al., 2019; Le et al., 2022; Lessen Knoll et al., 2019; Mahmoodi et al., 2019; Thakkar et al., 2018) and cue-based feeding (Chrupcala et al., 2015; Dalgleish et al., 2016; Fry et al., 2018; Gelfer et al., 2015; Osman et al., 2021; Settle & Francis, 2019; Wellington & Perlman, 2015) have been found to be effective interventions for the development of oral feeding skills for infants in the NICU. Other dysphagia interventions such as positioning, pacing, adjusting flow rate, thickening, and altering the temperature of the liquid can help with the coordination of suck-swallow-breathe and decrease the occurrence of liquid entering the airway (Ferrara et al., 2018; Frazier et al., 2016; Law-Morstatt et al., 2003; Pados et al., 2015; Park et al., 2014; Raczyńska et al., 2021; Raczyńska & Gulczyńska, 2019).

Research to date has mainly examined preterm infant feeding from a medical lens, without considering the social and cultural influences on the occupation of feeding. Therefore, this study will look at the complex nature of feeding by examining social and health service utilization factors to determine their impact on feeding outcomes. These factors are important to consider given the racial and ethnic differences in preterm birth rates and neonatal morbidities.

There can be variability in the role of dysphagia therapy based on organizational and individual factors. Not all hospitals have dysphagia therapists in the NICU, and there is significant variability across settings in terms of the role of the dysphagia therapist based on the therapist availability, the population(s) that they serve, training, and experience. The dysphagia therapy team in the NICU could also consist of different professions, such as occupational therapy, physical therapy, and/or speech-language pathology. This also could affect the provision of dysphagia therapy services. Despite the variability in the approach to dysphagia therapy services, there is a need to understand therapy utilization in the context of different social and medical factors.

Definitions

Dysphagia or swallowing disorders indicates that there is difficulty with at least one of the four phases of swallowing: oral, initiation of swallow, pharyngeal, or esophageal (Arvedson, 2008). *Feeding* disorders indicate that there are difficulties with feeding and eating activities, which can also impact swallowing (Arvedson, 2008). *Dysphagia therapy* includes assessment and interventions that address feeding and swallowing issues. *Dysphagia therapy interventions* could include implementation of cue-based/infant-driven feeding, oral sensorimotor stimulation, transitional feeding, and alteration in diet or apparatus (such as use of cold or thickened liquids or using different nipples or positioning). *Dysphagia therapists* most often include occupational therapists and speech-language pathologists who provide therapy services to address feeding and swallowing difficulties.

Significance

Oral feeding is most often the last milestone to be achieved prior to preterm infants being discharged from the NICU. Each day that an infant spends in the NICU can cost over $3,500 a day (Muraskas & Parsi, 2008). Given the high costs, coupled with families' desires to take their infants home, medical teams are faced with the challenging decision whether to keep the infant hospitalized until independent oral feeding is achieved or to discharge the infant home with tube feedings.

To help with decisions surrounding transition to oral feedings, the medical team often will consult with infant dysphagia therapists who have expertise regarding infant feeding and swallowing, as they are the members of the interdisciplinary team that assess and provide feeding interventions. This can contribute to the practice guidelines for therapy teams who support the discharge decision-making process in premature infants with oral feeding issues. It is important for therapists to consider the infant's characteristics when making recommendations and developing a plan of care for this population. Historically, research has focused on determining what clinical factors impact feeding outcomes. However, little is known about how clinical factors, in combination with social factors, may impact therapy utilization and feeding outcomes. This is significant to the profession of occupational therapy as feeding, eating, and swallowing is an activity of daily living (Occupational Therapy Practice Framework: Domain and Process—Fourth Edition, 2020).

Optimal feeding is essential to promote healthy growth and development (World Health Organization, 2021). It incorporates sensory and motor experiences that promote function, and it is a social activity based on relationships. Occupational therapists assess the client, environment, and occupation to optimize occupational performance. Therefore, occupational therapists play an essential role during an infant's NICU stay to support the development of an infant's feeding skills.

Theoretical Framework

This dissertation will be guided by the Behavioral Model for Vulnerable Populations, which provides a theoretical framework that examines factors that affect health services usage and health outcomes for vulnerable populations, which includes children (Gelberg et al., 2000; Waisel, 2013). This model posits that patient characteristics, which include predisposing, enabling, and need factors, impact health service utilization and health outcomes (Gelberg et al., 2000). Predisposing, enabling, and need factors including demographic, social structure, family resource, and health beliefs and will be explored to determine their influence on dysphagia therapy utilization and feeding outcomes.

Previous studies have found there are clinical and social factors that impact neonatal health outcomes (Brumbaugh et al., 2018; Gehle et al., 2022; Jackson et al., 2016; Park et al., 2015; Van Nostrand et al., 2015). Preterm infants are at risk for developmental delay and there is a greater risk for infants with families with certain social risk factors (Potijk et al., 2013; Schmeer et al., 2020). Research has mainly focused on therapy utilization and outcomes for infants and children after NICU discharge. However, there are existing clinical and social factors that impact an infant's development starting at birth and during their NICU stay. For most preterm infants and their families, the pathway to health and future functioning begins with their stay in the NICU. Therefore, it is important to examine the processes related to dysphagia therapy utilization and outcomes in the NICU setting.

This study will specifically focus on feeding-related outcomes and dysphagia-related therapy services. No studies to date have looked at NICU therapy utilization in relation to feeding outcomes.

Purpose

The purpose of this dissertation is to describe the scope of dysphagia therapy for preterm infants in a Level IV NICU and to determine the association between infant characteristics, dysphagia therapy utilization, and feeding outcomes.

Research Questions and Hypotheses

Research Aim 1: Determine the scope of dysphagia therapy and gastrostomy tube (GT) placement in a Level IV neonatal intensive care unit (NICU) for preterm infants.

Research Question 1.1: What is the prevalence of dysphagia therapy referrals, referral type (automatic or problem-based referral), and dysphagia therapy utilization (number of dysphagia therapy visits) for preterm infants in the UCSF NICU between 2017 and 2019?

Research Question 1.2: What is the prevalence of GT placement for preterm infants in the UCSF NICU between 2017 and 2019?

Research Aim 2: Determine which infant characteristics are associated with dysphagia therapy utilization and feeding outcomes for preterm infants in the NICU.

Research Question 2.1: What are the characteristics of infants who receive dysphagia therapy referrals in the NICU? What infant characteristics are associated with dysphagia therapy utilization in the NICU?

Hypothesis 2.1.1: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with receipt of dysphagia therapy referral in the NICU.

Hypothesis 2.1.2: Medical complexity and gestational age will be associated with receipt of automatic referrals in the NICU.

Hypothesis 2.1.3: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with the number of therapy sessions in the NICU.

Research Question 2.2: What are the characteristics of infants who receive GT placement? What infant characteristics are associated with feeding outcomes in the NICU?

Hypothesis 2.2.1: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with GT placement in the NICU.

Hypothesis 2.2.2: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with post-menstrual age (PMA) of independent oral feeding in the NICU.

Research Aim 3: Determine if dysphagia therapy utilization is associated with feeding outcomes while controlling for infant characteristics.

Research Question 3.1: Is dysphagia therapy utilization associated with PMA at independent oral feeding in the NICU while controlling for infant characteristics?

Hypothesis 3.1.1: Receipt of dysphagia therapy will be associated with lower PMA at independent oral feeding in the NICU while controlling for infant characteristics.

Hypothesis 3.1.2: Automatic therapy referral will be associated with lower PMA at independent oral feeding in the NICU while controlling for infant characteristics.

The exploration of hypothesis 2.2.1 is contingent upon results from research question 1.2 and if there is enough variability in GT placement within the sample. The exploration of hypothesis 2.1.2 and research question 3.2 are contingent upon results from research question 1.1 and if there is enough variability in referral mechanisms within the sample.

Study Design and Methodology

This study used a correlational retrospective study design to analyze already existing data pulled from ApeX, which is University of California San Francisco's (UCSF) EPIC based electronic medical record (EMR). Variables for this study were selected using the Behavioral Model for Vulnerable Populations by examining how preterm infant characteristics (that include clinical and social factors) impact dysphagia therapy service utilization, which ultimately impact their feeding outcomes. Data was extracted from the EMR for all eligible participants who were born at less than 37 weeks of gestation, with a history of admission to a 60-bed Level IV NICU between January 2017 and December 2019.

Expected Outcomes

Outcomes from this study could further inform the need for and access to therapy interventions to ensure equity in healthcare services and contribute to the knowledge base for best practices to improve developmental and feeding outcomes in premature infants. This could impact the mechanism for referrals to dysphagia therapy such as timing of when referrals are made and targeting which infants are most at risk for oral feeding issues by increasing access to therapy for these infants. Furthermore, this will directly inform dysphagia therapy practices and discharge recommendations for NICU infants; this is significant for optimizing the health and safety of the infants and for reducing hospital cost and length of stay.

Chapter Summary

Chapter 1 provided an introduction to preterm infant feeding, an overview of the study, and the significance of the study. Chapter 2 provides an in-depth examination of the literature on development of oral feeding in preterm infants, therapy utilization, and factors impacting feeding outcomes. Chapter 2 will also discuss the theoretical framework for this study. Chapter 3 describes the proposed study design, methodology, and statistical analyses plan.

Chapter 2: Literature Review

Introduction

For preterm infants, efforts have focused on improving mortality rates, yet more attention needs to be given to addressing the neurodevelopmental sequelae resulting from premature birth. Comorbidities related to prematurity can impact infant development within any domain. Delayed development in the ability to orally intake nutrition, or feeding problems, are common for this population. Immaturity and medical factors impact the development of feeding skills in infants born prematurely, and infants usually remain hospitalized due to inadequate oral feeding. Specific dysphagia therapy interventions have been found to positively affect feeding development, but not all infants are referred to or receive intervention for feeding problems. Therefore, it is important to understand how patient characteristics impact therapy utilization and outcomes so that we can support infants in achieving their feeding milestones.

The purpose of this dissertation is to describe the scope of dysphagia therapy for preterm infants in a Level IV NICU and to determine the association between infant characteristics, dysphagia therapy utilization, and feeding outcomes. This chapter begins with an overview of premature births and the impact of prematurity on oral feeding development and then reviews the existing literature on dysphagia therapy interventions, NICU therapy utilization, and factors that impact oral feeding outcomes. This is followed by a discussion of the theoretical framework used to guide this study.

Premature Birth

Premature birth places significant medical, social, and economic costs on families and the United States (US) healthcare system due to lengthy hospital stays and lifelong morbidities (Beam et al., 2020). Approximately 15 million babies are born prematurely each year and this number continues to rise (World Health Organization, 2018). Risk factors for preterm births include having multiple pregnancies, infections, genetic influences, and chronic conditions such as diabetes and high blood pressure (Berghella, 2010; Lee et al., 2006). However, many times a cause is not identified.

The World Health Organization (2018) considers an infant as premature if they were born before 37 weeks of gestation. Gestational age can be calculated from the number of weeks since the first day of the mother's last menstrual period or by doing an ultrasound (Berghella, 2010). Gestational age is used to categorize prematurity into three subgroups: extremely preterm (less than 28 weeks), very preterm (28 to 32 weeks), and moderate to late preterm (32 to 37 weeks) (World Health Organization, 2018). Gestational age and birthweight are highly correlated, as birthweight typically increases with gestational age. The World Health Organization (n.d.) defines low birthweight as infants who have a weight at birth of less than 2500 grams. The American Academy of Pediatrics further subcategorizes low birthweight into moderately low birthweight (MLBW) (1500 to 2499 grams), very low birthweight (VLBW) (less than 1500 grams), and extremely low birthweight (ELBW) (less than 1000 grams) (AAP Committee on Fetus and Newborn and ACOG Committee on Obstetric Practice, 2017). Lower birthweight is associated with higher mortality and morbidity. Although complications related to preterm birth were the second leading cause of infant death in the US in 2020, overall survival rates have increased due to medical and technological advances (CDC, 2022; Stoll et al., 2015). As premature infants are surviving at younger gestational ages, there is a greater risk for neurodevelopmental sequelae such as cerebral palsy, learning disabilities, sensorineural impairments, and feeding problems, and the severity of these impairments increases with lower gestational age and birthweight (Berghella, 2010; Rommel et al., 2003; Saigal & Doyle, 2008; Viswanathan & Jadcherla, 2020).

Racial and ethnic disparities exist for preterm birth as preterm birth rates of Black women are 51% higher than the rate among women of all other races and ethnicities in the United States (March of Dimes, 2021). Previous research suggests that Black, mixed-race, and Hispanic infants are born at lower birthweights and gestational ages than White and Asian infants (Townsel et al., 2018), and Black infants experience four times more deaths due to prematurity (Riddell et al., 2017). While infant mortality has declined in White infants over the past decade and continues to decline, the progress in reducing infant mortality among Black infants has plateaued over the last few years, which has led to an increase in inequality in infant mortality between Black and White infants (Riddell et al., 2017). Racial and ethnic disparities also exist in very preterm infant health outcomes as Black and Hispanic infants have higher rates of severe neonatal morbidities including necrotizing enterocolitis, intraventricular hemorrhage, bronchopulmonary dysplasia, and retinopathy of prematurity when compared to Whites infants (Howell et al., 2018; Janevic et al., 2018).

Premature infants are admitted to the NICU to receive medical support until they mature enough that their body systems can function on their own (March of Dimes, 2019). There are significant alterations in lung function and physiology in premature infants, as preterm birth interrupts normal lung development that occurs in utero and the lungs are not considered “fully” developed for an infant until 37 weeks (Colin et al., 2010). Thus, many preterm infants require some type of respiratory support as their lungs continue to mature. Lung maturation can take anywhere from weeks to months depending on gestational age, birthweight, and severity of disease, which is why preterm infants have some of the highest healthcare expenses, averaging

$76,153 to $114,437 per stay in the NICU (Beam et al., 2020). Costs of NICU care are inversely related to gestational age and birthweight. Given the high costs of NICU care, it is important to identify any barriers to discharge and consider how they may be addressed.

Although technological and medical advances have greatly improved survival rates for preterm infants, there continues to be neurodevelopmental consequences that can impact an infant's long-term health and functioning. These improvements are also not seen across all racial and ethnic groups, as there are racial and ethnic disparities in mortality and morbidity related to preterm births. There are existing societal structures that foster racial discrimination in healthcare by reinforcing discriminatory beliefs, values, and distribution of resources driving health inequities and perpetuating these disparities (de Maio, 2021).

Structural Racism Impacting Healthcare

Structural racism is reinforced by policies, laws, and regulations that were created to maintain White supremacy and are implemented by different levels of the government which leads to inequitable access to healthcare and health outcomes (Johnson, 2020; Malina et al., 2021). Inequities in healthcare coverage, financing, and quality, persist due to structural racism in healthcare policy (Yearby et al., 2022). Racial differences found in studies can result from structural racism (Ioannidis et al., 2021).

Race is often used in health services research but there are limitations as race is poorly defined, its definition lacks consensus, it has no biologial basis, and instead, it is based on social constructs (Grant et al., 2021). The use of race within health services research can result in and continue to contribute to the structural racism that causes inequalities in health and healthcare, as researchers often use White as the reference standard to which others are normalized to (Ioannidis et al., 2021). Race as a variable is often used as a proxy for racism (Ioannidis et al., 2021). Although race itself is nonbiological, those experiencing racism can have biological effects that increase rates or disease and disability, as persistent racism in the healthcare system can lead to certain racial groups avoiding healthcare (Yearby, 2018). Eliminating racism should be the priority in healthcare.

Disparities in NICU Care

The NICU is not isolated from structural racism and social inequalities. The variation of quality of care provided within and between NICUs contributes to disparities in health outcomes, including mortality and morbidity, between racial and/or ethnic groups (Profit et al., 2017; Sigurdson et al., 2019). Disparities exist at the structural, process, and outcome levels of care and the care that is provided can be disparate.

Racial and/or ethnic disparities exist at the structural (the context in which care is delivered), process (transactions between patients and providers during healthcare delivery), and outcome (measurement of the effect of healthcare on people's health status) levels that often cause Black infants to be disadvantaged (Sigurdson et al., 2019). At a structural level, hospitals that have a higher proportion of Black infant patients have been shown to have higher understaffing of nurses and worse practice environments (Lake et al., 2015). At a process level, Black and Hispanic infants have been shown to demonstrate higher infection rates, less support of kangaroo care, less breastfeeding support, and fewer referrals for follow-up care after NICU discharge (Lake et al., 2015; Sigurdson et al., 2019). At an outcome level, Black infants are more likely to receive care at hospitals of lower quality, with studies demonstrating home and hospital location are often associated with higher neonatal mortality and morbidity (Janevic et al., 2021; Sigurdson et al., 2019). In a study by Janevic et al. (2021), very premature infants whose families lived in neighborhoods with higher proportions of Black residents and low-income households had a higher risk of neonatal morbidity and mortality than infants whose families lived in neighborhoods with a higher proportion of White residents.

Although there are adverse consequences on infant health outcomes due to differences in the direct care of infants, the impact of interactions between families and providers on the care of infants also need to be considered. Sigurdson et al. (2018) conducted a qualitative study to describe disparities in NICU quality of care from the viewpoint of providers and family advocates. Families' interactions with providers were influenced by the racial/ethnic, social, financial, cultural, and linguistic characteristics of the family, and had the potential to impact the care of the infant. Disparate treatment between racial and ethnic groups resulted in suboptimal care, which included treatment, interactions, and perceptions of the overall experience. Three themes of suboptimal care emerged: neglectful care (paying less attention to certain families), judgmental care (evaluating families’ moral status based on race, class, or immigration status), and systemic barriers to care (not addressing barriers families face such as transportation, childcare, housing, language needs, or cultural needs) (Sigurdson et al., 2018). These themes ultimately impact infant health outcomes, indicating that structural racism is present in the NICU setting.

There are a multitude of factors and various levels of care that have the potential to impact the care that an infant receives in the NICU and long-term health outcomes. Interactions between providers and patients can result in suboptimal care and there are disparities that exist at all three levels that impact the quality of care. The process of dysphagia therapy utilization and its impact on feeding outcomes will be explored in this study, which will begin with a review of the pathway to discharge for infants in the NICU.

Pathway to Discharge

Inadequate feeding is the main barrier to discharge for preterm infants, as an infant needs to demonstrate independent oral feeding to sustain appropriate growth while maintaining physiological stability to be discharged from the NICU (AAP Committee on Fetus and Newborn and ACOG Committee on Obstetric Practice, 2017; Edwards et al., 2019; Wang et al., 2004). Previous studies have shown that up to 69% of moderately preterm infants remain hospitalized at 36 weeks due to inadequate oral feeding while 75% of discharges were delayed due to feeding problems (Edwards et al., 2019; Wang et al., 2004). Given the number of preterm infants who are unable to go home each day due to inadequate oral feeding, it is imperative to provide interventions to facilitate the development of their oral feeding skills. In order to understand the interventions that facilitate development of oral feeding skills, it is important to understand how prematurity impacts infant feeding.

Preterm Oral Feeding

Immaturity and medical factors could interrupt the development of a normal feeding pattern and lead to difficulty swallowing, otherwise known as dysphagia (Kamity et al., 2021). Thirty percent of VLBW infants in the NICU have swallowing dysfunction, and 42% of former preterm infants have feeding problems in the first four years of life (Lee et al., 2011; Pados et al., 2021). The term ‘feeding problems’ is used to describe a variety of symptoms associated with inadequate nutritional oral intake and can be due to medical factors, oropharyngeal dysfunction, or behavioral issues (Kamity et al., 2021; Rommel et al., 2003). Behavioral feeding issues usually arise from persistent medical issues and/or oropharyngeal dysfunction. Medically necessary interventions and medical factors such as underdeveloped lungs requiring prolonged oxygen supplementation, brain injuries, illnesses requiring surgical intervention, or craniofacial anomalies can alter oral sensory and motor experiences, which can impact the development of swallowing at any stage (Kamity et al., 2021).

Swallowing starts at the mouth with the formation of the bolus which then is propelled to the pharynx triggering laryngeal elevation to close and protect the airway, as the infant coordinates sucking, swallowing, and breathing. Then the bolus is propelled down the esophagus with peristaltic waves before entering the stomach (Kamity et al., 2021; Viswanathan & Jadcherla, 2020). During the normal development of swallowing, isolated sucking, swallowing, and breathing is developed early in utero, however, maturation and integration of these functions occurs later (Viswanathan & Jadcherla, 2020). Swallowing amniotic fluid starts at 11 to 12 weeks of gestation and sucking appears at 18 to 20 weeks (Kamity et al., 2021; Viswanathan & Jadcherla, 2020). Rhythmic nonnutritive sucking appears around 28 to 32 weeks, and infants begin to coordinate sucking and swallowing around 32 to 34 weeks (Lemons, 2001). Infants coordinate breathing with sucking and swallowing after 34 weeks but it may not fully organize until they are 37 weeks (Lemons, 2001; Mizuno & Ueda, 2003). Although the normal development of swallowing occurs in stages around these gestational ages, an infant’s postmenstrual age is not the only factor that determines when and if an infant is ready to feed orally. Other factors such as weight, severity of illness, respiratory support, feeding readiness, and behavior/state also need to be considered as each of these factors also can impact each phase of swallowing (Breton & Steinwender, 2008).

Swallowing consists of three phases: oral, pharyngeal, and esophageal phase and physiological changes related to prematurity can impact all phases of swallowing (Viswanathan & Jadcherla, 2020). The oral phase consists of sucking to express milk and propelling it to the pharynx. This can be interrupted by absent, delayed, or weak oral reflexes and altered by medical interventions. The pharyngeal phase is when the bolus enters the pharynx. This is closely linked to respiratory function as there needs to be a coordinated response between swallowing and breathing. Immaturity or respiratory compromise could interrupt the coordination between swallowing and breathing. Lastly, the esophageal phase is when the bolus enters the esophagus and peristaltic wave-like reflexive movements are used to propel the bolus down the esophagus. Immaturity or compromise to this reflex could cause the bolus to be directed towards the airway (Kamity et al., 2021; Viswanathan & Jadcherla, 2020). Given the impact of prematurity on the development of oral feeding, coupled with high costs of NICU care and a family's desire to take their infant home, medical teams must decide whether to keep the infant in the hospital until independent oral feeding is demonstrated or discharge the infant home with alternative feeding methods.

Alternative Feeding Methods

When premature infants are unable to achieve independent oral feedings to sustain growth, alternative feeding methods, such as gavage feeding or gastronomy feeding, are considered (AAP Committee on Fetus and Newborn and ACOG Committee on Obstetric Practice, 2017). Although practices may vary based on the NICU, discharging a preterm infant home with a nasogastric tube (NG) feeding is usually only considered if the infant continues to require hospitalization after they have reached 40 weeks PMA due to oral feeding issues and/or caregivers demonstrate the ability to manage the NG independently in the home setting. NG feeding is a temporary solution as complications can include the tube becoming entangled, as one end of the NG tube is taped and hanging out of the nose, dislodged, or moved out of place. An NG tube can also cause irritation to the nasopharyngeal, esophageal, or stomach lining with repeated removal and insertion due to frequent dislodgement and need for replacement. A more serious complication is that the tube is accidentally placed in the airway and infiltrates the lungs. Thus, a long-term solution is a gastronomy tube (GT). A GT placement can be considered when the infant has made little to no progress with oral feedings, which may allow the infant to discharge from the hospital earlier and continue to develop competent oral feeding skills at home (AAP Committee on Fetus and Newborn and ACOG Committee on Obstetric Practice, 2017).

Dysphagia Therapy in the NICU

To facilitate achievement of feeding milestones and discharge planning for preterm infants in the NICU, dysphagia therapists collaborate with the medical team and families. The American Academy of Pediatrics recommends there to be at least one therapist with neonatal expertise in a Level III and IV NICU (AAP Committee on Fetus and Newborn and ACOG Committee on Obstetric Practice, 2017). Therapists in the NICU work with infants and families to promote optimal long-term developmental outcomes by addressing the neurobehavioral, neuromotor, neuroendocrine, musculoskeletal, sensory, and psychosocial neurodevelopmental systems (National Association of Neonatal Therapists, 2014). Dysphagia therapists specifically support the infant in meeting feeding milestones by assessing the physical and social environment as well as the infant's neurobehavioral neuromotor, musculoskeletal, and sensory systems as it impacts their oral feeding and swallowing functions (Craig & Smith, 2020). Jackson et al. (2016) conducted a multi-site study in New Zealand to investigate which factors impact oral feeding achievement in moderately preterm infants and found oral feedings were initiated later in units that did not have dysphagia therapists. Dysphagia therapists can provide direct services to infants and their families when they are a part of the medical team.

Dysphagia Therapy Interventions

Studies to date mainly focus on therapy interventions that dysphagia therapists may use to facilitate oral feeding development and outcomes. These can be categorized as cue-based feeding and oral-motor interventions. In addition to working directly with infants, dysphagia therapists provide education to caregivers and the care team on feeding strategies.

Cue-Based Feeding

Cue-based feeding uses a co-regulated approach that is infant-driven, developmentally appropriate, and individualized with a focus on each infant’s level of maturity and skill set, whereas previous feeding practices were practitioner and volume-driven based on an infant’s weight and gestational age (Lubbe, 2018; Shaker, 2013). Compared to infants who were fed using traditional approaches, infants who were fed utilizing a cue-based approach, achieved independent oral feedings three to 17 days earlier, demonstrated weight gain, discharged two to seven days earlier, and were less likely to be discharged with tube feedings, despite no difference in when oral feedings were initiated (Chrupcala et al., 2015; Dalgleish et al., 2016; Fry et al., 2018; Gelfer et al., 2015; Osman et al., 2021; Settle & Francis, 2019; Wellington & Perlman, 2015).

Oral Motor Interventions

Preterm infants often have poor oral motor control due to lower muscle tone and strength. Oral motor interventions that include facial, perioral, and intraoral stimulation are used to facilitate normal development of oral motor skills and to improve oral feeding (Gonzalez et al., 2021; Thakkar et al., 2018). The Premature Infant Oral Motor Intervention (PIOMI) is the only published oral stimulation protocol for preterm infants which has been found to be effective in helping infants achieve independent oral feedings earlier, feed more efficiently, and discharge sooner (Ghomi et al., 2019; Lessen Knoll et al., 2019; Mahmoodi et al., 2019; Thakkar et al., 2018). Infants who received PIOMI had their first oral feeding 2-7 days earlier, achieved independent oral feedings 13 days earlier, discharged 3-9 days earlier, and had no differences in weight when compared to infants who did not receive the intervention (Ghomi et al., 2019; Mahmoodi et al., 2019).

Oral stimulation can also be done with the use of breastmilk to add another sensory component and level of complexity to the intervention. Le et al. (2022) studied the effectiveness of using breastmilk with oral stimulation when compared to oral stimulation without breastmilk and no intervention. They found that infants who received oral stimulation with breastmilk initiated oral feeding earlier and demonstrated improved non-nutritive sucking compared to the other two groups though both groups that received oral stimulation transitioned to full oral feeding earlier than infants who received no intervention (Le et al., 2022).

Other Dysphagia Interventions

Other dysphagia interventions include positioning, pacing, providing cheek and jaw support, adjusting flow rate, and altering the viscosity of the liquid. Using a side lying positioning during feeding can decrease the number of choking episodes, increase the total amount consumed, and better support breathing regulation when compared to a semi-sitting position (Park et al., 2014; Raczyńska et al., 2021; Raczyńska & Gulczyńska, 2019). Pacing is when the milk is removed from the nipple every three to five sucks to impose breathing pauses and this has been shown to decrease incidences of vital instability during feedings and facilitate development of more efficient sucking patterns (Law-Morstatt et al., 2003). Providing cheek and jaw support can also help with sucking efficiency, as infants were found to have a greater intake when given cheek and jaw support (Hwang et al., 2010). Milk flow rate can also be manipulated by using different nipple types to help infants feed safely and efficiently, as flow rate can affect an infant's ability to manage the bolus and integrate breathing (Pados et al., 2015). The viscosity of the liquid can be altered by adding thickening agents or changing the temperature of the liquid to improve bolus management and decrease the occurrence of penetration (bolus enters the airway) and aspiration (bolus passes through the vocal folds) (Ferrara et al., 2018; Frazier et al., 2016; Ng et al., 2022).

NICU Therapy Utilization

Despite the literature supporting the benefits of early dysphagia therapy interventions on infant feeding outcomes, there are limited studies to date exploring the use of therapy including occupational therapy, physical therapy, and speech-language pathology, in the NICU. Ross et al. (2017) conducted a retrospective review to describe therapy services in a Level IV NICU. For infants receiving therapy services in this study, 100% of infants received occupational therapy and physical therapy, and 51% of infants received speech-language pathology. Occupational therapists (OTs), physical therapists (PTs), and speech-language pathologists (SLPs) provided 56 different types of interventions, as documented in the therapists' electronic documentation, indicating that therapists in the NICU possess a wide repertoire of therapeutic interventions that can be utilized in addressing the neurodevelopmental needs of infants (Ross et al., 2017). Although there was some overlap in interventions, each discipline has a unique role in optimizing neurodevelopmental outcomes of preterm infants and possesses unique skills based on their scope of practice. PTs addressed components to optimize movement; SLPs addressed swallowing performance; and OTs addressed components of development to optimize occupational participation. Both OTs and SLPs were found to provide feeding and oral motor interventions as it relates to occupational and swallowing performance.

Ross et al. (2017) also found that therapy services can start at an early postmenstrual age (PMA) for infants in the NICU and continue regularly until discharge to optimize functional and health outcomes. On average, occupational therapy and physical therapy were initiated at 30 weeks PMA, gestational age plus chronological age or age from birth, with a frequency of approximately twice a week. Infants received speech-language pathology about once a week with an average age of initiation at 36 weeks PMA, which coincides with the timing of oral feeding. However, it is unclear if the timing of speech-language pathology initiation was related to referral patterns (automatic orders versus problem-based referrals) (Ross et al., 2017).

Butera et al. (2023) further looked at frequency of therapy services in the NICU and risk factors that impacted the amount of therapy sessions received by infants born at less than 32 weeks gestation and had a NICU stay greater than 28 days. Infants at high risk for cerebral palsy (CP), as determined by the Generalized Movement Assessment, received more occupational therapy sessions than infants who are at low risk for CP. Non-White infants received more therapy sessions than White infants. However, medical risk was found to have no impact on the amount of therapy received. Weekly frequencies of occupational and physical therapy sessions increased during the infant's NICU admission, but weekly frequencies of speech therapy sessions decreased over time. Butera et al. (2023) attributed this to infants who have longer lengths of stays are likely to have prolonged feeding difficulty warranting GT placement or had reduced attempts at oral feeding. However, they suggested that infants with prolonged admission benefitted from more social and play interaction from occupational therapy.

Therapy sessions can be done concurrently with medical interventions (Butera et al., 2023; Ross et al., 2017). Ross et al. (2017) found that infants who required more medical interventions (i.e. infants who had respiratory support, sepsis, or brain injury) had occupational therapy and physical therapy initiated earlier and received more therapy services during their stay. However, more therapy did not equate to improved neurobehavioral outcomes, rather more medical complexities were attributed to more frequent therapy sessions (Ross et al., 2017).

Similarly, Kinney et al. (2022) conducted a study to investigate if the need for therapy predicts utilization of acute care occupational therapy services for adults, which included information related to sociodemographic factors and insurance type. They found that greater need for therapy, as measured by lower functional status, was associated with receiving occupational therapy services, but that it was moderated by sociodemographic factors (age, minoritized status, and significant other status) and insurance type, indicating that disparities in access may exist (Kinney et al., 2022).

Factors Impacting Therapy Utilization

Even after NICU discharge, all babies, regardless of gestation and birthweight, benefit from early follow up once at home (Das et al., 2020). One study found that ninety-one percent of infants born at less than 30 weeks gestation who were receiving therapy services in the NICU received referrals for follow-up therapy services after NICU discharge (Nwabara et al., 2017). However, if infants were not getting therapy services in the NICU, then the likelihood that they will be referred to follow-up services decreases.

Racial and ethnic disparities also exist after NICU discharge. Hintz et al. (2015) found that infants born to Black or Hispanic mothers were 50% less likely to be referred to High-Risk Infant Follow-Up (HRIF) clinic when discharged from the NICU. There were also greater odds of receiving a referral to HRIF for infants who discharged from higher level NICUs and units that have more VLBW infants (Hintz et al., 2015). Other studies have also found a lower number of referrals to early therapy services for Black non-Hispanic and non-insured children, with

Black children being less likely to receive services than children from other ethnic and racial backgrounds (Barfield et al., 2008; Rosenberg et al., 2008).

Even if the infant does receive a referral for therapy after NICU discharge, many infants who could benefit from early therapy services are not receiving those services (Roberts et al., 2008). A families' higher social risk, which is categorized by family structure, education of primary caregiver, occupation and employment status of primary income earner, primary language, and maternal age at birth, is correlated with not receiving early therapy services, which is concerning as rates of disability are higher in this population (Roberts et al., 2008). Feinberg et al. (2011) found that at 24 months of age, Black children were five times less likely to receive early therapy services than White children. Another study showed that families with lower English language proficiency have less access to early therapy services (Woolfenden et al., 2015).

Collectively, this body of work suggests that there are disparities in therapy utilization after NICU discharge based on social factors. However, this has not yet been explored in the NICU setting. Given that there are documented disparities in NICU care and therapy utilization after NICU discharge, it is important to explore how this may impact feeding outcomes.

Feeding Outcomes

Studies to date have mainly focused on the impact of infant clinical factors, such as birthweight and gestational age, on feeding outcomes. Feeding outcomes are measured by whether the infant achieved independent oral feeding, length of hospitalization, and oral feeding milestones such as PMA of first oral feeding and the time it takes to achieve independent oral feeding. Infants who make limited progress with their oral feeding may be discharged with a GT. It is important to understand the factors impacting GT placement when making the recommendation, as GT placement is associated with poorer progression of feeding milestones and neurodevelopmental outcomes (Jadcherla et al., 2017; Warren et al., 2019).

Oral Feeding Milestones

Clinical factors such as gestational age and birthweight have consistently been found to impact achievement of oral feeding milestones. Infants of lower gestational birth age and/or birthweight have been shown to start oral feeding later, attain independent oral feeding later, and discharge from the NICU later (Brumbaugh et al., 2018; Gehle et al., 2022; Jackson et al., 2016; Park et al., 2015; Van Nostrand et al., 2015). Earlier introduction of oral feeding, in contrast, has been associated with earlier attainment of independent oral feeding and quicker discharge (Brumbaugh et al., 2018; Gehle et al., 2022; Jackson et al., 2016). Comorbidities related to prematurity also can impact achievement of oral feeding milestones.

Respiratory conditions, which include respiratory distress syndrome, bronchopulmonary dysplasia, and receipt of mechanical ventilation, have been shown in multiple studies to impact oral feeding progression and outcomes. Premature infants with respiratory conditions have specifically been found to have later introduction of oral feeding and often require more time to attain independent oral feeding (Anderson et al., 2022; Edwards et al., 2019; Gehle et al., 2022; Jackson et al., 2016; Muir et al., 2021; Park et al., 2015; Van Nostrand et al., 2015). Other neonatal comorbidities such as patent ductus arteriosus, sepsis, necrotizing enterocolitis, and intraventricular hemorrhage/neurological risk can also negatively impact oral feeding progression and outcomes (Edwards et al., 2019; Park et al., 2015; Van Nostrand et al., 2015). Edwards et al. (2019) suggested that these morbidities may delay initiation of oral feeding and/or infants with these morbidities may experience more procedures and negative experiences impacting their oral skills progression.

Infant and maternal characteristics can also impact achievement of oral feeding milestones. Infant characteristics such as sex, race, and type of delivery can impact oral feeding progress (Brumbaugh et al., 2018; Edwards et al., 2019; Van Nostrand et al., 2015). Despite previously described racial health disparities in the NICU, Black preterm infants have been shown to achieve independent oral feeding sooner than Hispanic and White preterm infants, while Asian preterm infants took the longest to achieve independent oral feeding Brumbaugh et al., 2018; Van Nostrand et al., 2015). Previous studies have also shown that preterm infants who were female and delivered vaginally achieved independent oral feeding sooner than their counterparts, thus, discharging earlier (Edwards et al., 2019; Van Nostrand et al., 2015). Van Nostrand et al. (2015) found specifically that female infants achieved independent oral feeding one day sooner than male infants and infants who were born by vaginal delivery achieved independent oral feeding three days sooner than infants who were delivered by Caesarian section (c-section). Maternal characteristics that include maternal mental health conditions, particularly anxiety, stress, or depression, also have an association with poor oral feeding progression (Muir et al., 2021).

Gastrostomy Placement

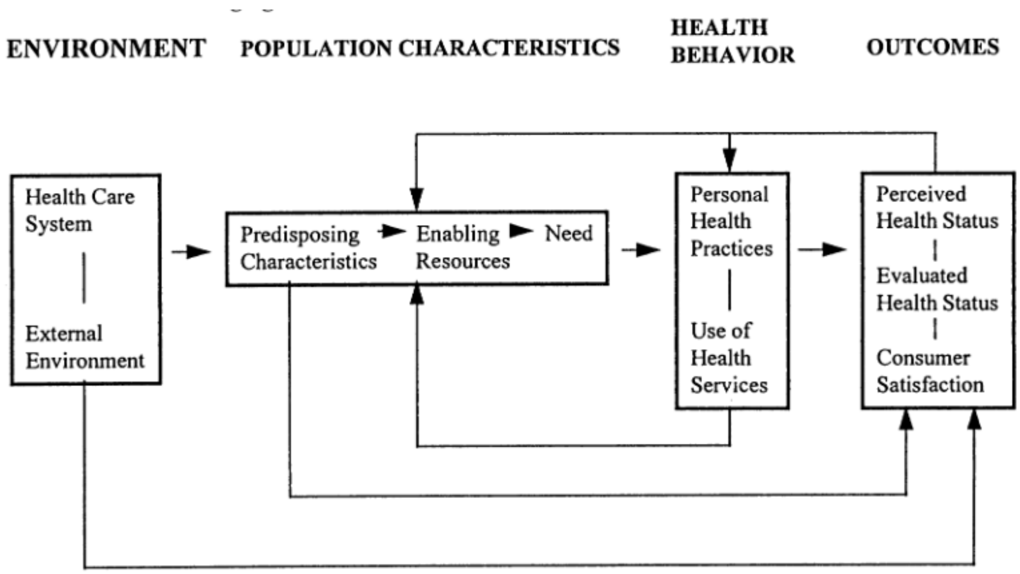
A GT, which is a tube that is surgically placed in the stomach in order to give supplemental feeding, hydration, or medication, may be considered when premature infants are unable to achieve independent oral feedings to sustain growth (AAP Committee on Fetus and Newborn and ACOG Committee on Obstetric Practice, 2017). One study found that rates of GT placement for preterm infants who are born <30 weeks gestation, varies based on NICU location, ranging anywhere from 0 to 20% percent and that higher gestational age, non-small for gestational age status, receipt of antenatal steroids, Hispanic ethnicity, and 7 to 10 Apgar scores had a lower likelihood of GT placement (Greene et al., 2019). Gehle et al. (2022) developed a predictive model for infants who were born <30 weeks gestation to identify those that will likely need a GT. Four factors were identified and used to place infants in categories of risk for inability to attain independent oral feeds. The four factors include: PMA at first oral feeding, gestational age, history of high frequency ventilation, and history of necrotizing enterocolitis stage II or III. Postmenstrual age at first oral feeding was most predictive of GT requirement, however, first oral feeding is likely dependent on respiratory status in most NICUs. To further investigate this relationship, a follow-up study was conducted which found that infants who were discharged with GTs were on significantly higher respiratory supports up until 36 weeks PMA than infants who achieved independent oral feeding (Anderson et al., 2022).

Theoretical Framework

This dissertation is guided by Gelberg's Behavioral Model for Vulnerable Populations (see Figure 1), which was revised from Andersen's Behavioral Model. This model provides a theoretical framework that examines factors that affect health services usage and health status for vulnerable populations (Gelberg et al., 2000). This model posits that population characteristics, which can be characterized as predisposing, enabling, and need factors, impact health service utilization and health outcomes (Gelberg et al., 2000). This theoretical framework will be used to determine the relationship between infant characteristics, therapy utilization, and feeding outcomes. Therefore, this section will begin with a review of Andersen's Behavioral Model, then explain the development of Gelberg's Behavioral Model for Vulnerable Populations, and finally discuss the application of the theoretical framework to this dissertation.

Figure 1

The Behavioral Model



From "Revisiting the behavioral model and access to medical care: Does it matter?" by R. M. Andersen, 1995, *Journal of Health Social Behavior*, *36*(1), p. 8.

Gelberg's Behavioral Model for Vulnerable Populations

In the late 1960's, Andersen (1995) developed a behavioral model to understand why people use healthcare services and to determine what impacts access to healthcare services. The behavioral model posits that people's likelihood of utilizing healthcare services is a result of the interaction between three factors: predisposing factors, factors that promote or inhibit use (enabling and need factors), and their need for care (Andersen, 1995).

Gelberg et al. (2000) revised Andersen's Behavioral Model initially for people experiencing homelessness, to reflect additional social issues that impact their health and access to care (Gelberg et al., 2000). The Behavioral Model for Vulnerable Populations was then developed to include variables and domains to further understand health services utilization of vulnerable populations. Vulnerable populations include children who are at higher risk for poorer healthcare access and outcomes (Waisel, 2013). This model was used to predict health outcomes and healthcare utilization of vulnerable populations by adding the healthcare utilization domain. Gelberg et al. (2000) separated the traditional and vulnerable domains, which focused on enabling resources and social structure.

Utilization of Healthcare Services

Patient characteristics that include predisposing, enabling, and need factors influence how likely an individual is to use healthcare services. *Predisposing factors* are characteristics of individuals that predispose them to use health services more than others. They include family composition, social structure, and health beliefs regarding medical care (Andersen, 1968). Despite an individual's predisposition to using healthcare services, they must have the resources to obtain it. Family and community resources, such as insurance, income, and residence, are considered *enabling factors* (Andersen, 1968). Despite the presence of predisposing and enabling factors, there must be a perceived or evaluated (objective) need for services (Andersen, 1968). *Perceived need* represents an individual perception that there is an illness and determination of how they would respond to it. *Evaluated need* represents a professional assessment of an individual's health status and need for medical care (Andersen, 1995; Gelberg et al., 2000).

Utilization of healthcare services can be discretionary or non-discretionary (Andersen, 1968). The individual is highly involved in discretionary whereas, non-discretionary is primarily dictated by the provider. Predisposing and enabling factors describe more of the healthcare utilization behaviors when the behaviors are more discretionary. Need factors describe more of the healthcare utilization behaviors when the behaviors are non-discretionary (Andersen, 1968). This study will be focusing on the non-discretionary use of healthcare services, as the individuals are infants who are hospitalized, with the physician directing care, including referral to therapy services. Once a referral is received, and the evaluation completed, frequency and duration of services is determined by the therapist.

Gelberg's behavioral model measures access to healthcare services through potential access and realized access. Potential access is related to which enabling resources are present. There is a higher chance of healthcare services being used if there are more enabling resources. Realized access depends on whether the person actually uses the services. Factors of realized access impact whether access is equitable. Equitable access is when demographic and need variables explain more of the differences in utilization. Inequitable access is when access to care is based on social structure, health beliefs, and enabling resources (Andersen, 1995).

Andersen (1995) suggests that patient characteristics must be mutable in order to increase access. Predisposing factors such as demographic and social structure have low mutability. Need factors that include health beliefs have medium mutability. Enabling factors have high mutability (Andersen, 1995). The factors that make up patient characteristics inform the variables of interest for the proposed study.

Application of Gelberg's Behavioral Model for Vulnerable Populations

Figure 2 depicts the variables of interest chosen from this framework that will be used for this study. Research aim 1 will describe the scope of dysphagia therapy. Research aim 2 will explore the association between infant characteristics and dysphagia therapy utilization and feeding outcomes. Research aim 3 will explore the association between dysphagia therapy utilization and feeding outcomes while controlling for infant characteristics for preterm infants in the NICU. The specific predisposing, enabling, and need infant characteristics were chosen based on impacts on feeding outcomes of premature infants identified in the literature review.

Figure 2

Application of Behavioral Model for Vulnerable Populations

Infant Characteristics	**Use of Dysphagia Therapy Services**	**Feeding Outcomes**
Predisposing • Sociodemographic (maternal age, infant sex, infant race, infant Hispanic ethnicity, maternal marital status, preferred language) • Behavioral (Child Protective Services involvement, maternal mental illness, homelessness) *Enabling* • Socioeconomic (infant insurance, maternal employment, maternal social support) • Community resources (distance) *Need* • Evaluated health (type of delivery, medical complexity, respiratory conditions, history of mechanical ventilation, length of stay, PMA at discharge, gestational age, birthweight, multiple birth)	• Receipt of dysphagia therapy • Referral mechanism • Number of therapy sessions	• PMA at independent oral feeds • GT placement

Research Questions and Hypotheses

Research Aim 1: Determine the scope of dysphagia therapy and gastrostomy tube (GT) placement in a Level IV neonatal intensive care unit (NICU) for preterm infants.

Research Question 1.1: What is the prevalence of dysphagia therapy referrals, referral type (automatic or problem-based referral), and dysphagia therapy utilization (number of dysphagia therapy visits) for preterm infants in the UCSF NICU between 2017 and 2019?

Research Question 1.2: What is the prevalence of GT placement for preterm infants in the UCSF NICU between 2017 and 2019?

Research Aim 2: Determine which infant characteristics are associated with dysphagia therapy utilization and feeding outcomes for preterm infants in the NICU.

Research Question 2.1: What are the characteristics of infants who receive dysphagia therapy referrals in the NICU? What infant characteristics are associated with dysphagia therapy utilization in the NICU?

Hypothesis 2.1.1: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with receipt of dysphagia therapy referral in the NICU.

Hypothesis 2.1.2: Medical complexity and gestational age will be associated with receipt of automatic referrals in the NICU.

Hypothesis 2.1.3: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with the number of therapy sessions in the NICU.

Research Question 2.2: What are the characteristics of infants who receive GT placement? What infant characteristics are associated with feeding outcomes in the NICU?

Hypothesis 2.2.1: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with GT placement in the NICU.

Hypothesis 2.2.2: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with post-menstrual age (PMA) of independent oral feeding in the NICU.

Research Aim 3: Determine if dysphagia therapy utilization is associated with feeding outcomes while controlling for infant characteristics.

Research Question 3.1: Is dysphagia therapy utilization associated with PMA at independent oral feeding in the NICU while controlling for infant characteristics?

Hypothesis 3.1.1: Receipt of dysphagia therapy will be associated with lower PMA at independent oral feeding in the NICU while controlling for infant characteristics.

Hypothesis 3.1.2: Automatic therapy referral will be associated with lower PMA at independent oral feeding in the NICU while controlling for infant characteristics.

The exploration of hypothesis 2.2.1 is contingent upon results from research question 1.2 and if there is enough variability in GT placement within the sample. The exploration of hypothesis 2.1.2 and research question 3.2 are contingent upon results from research question 1.1 and if there is enough variability in referral mechanisms within the sample.

Chapter Summary

The number one barrier to discharge for preterm infants is inadequate oral feeding, as immaturity and medical factors impact development of feeding milestones. Dysphagia therapists work with this population to enhance oral feeding skills. Therapy can be started at an early gestational age and continues during an infant's NICU stay to maximize functional outcomes. This study seeks to examine the association between infant characteristics, dysphagia therapy utilization, and feeding outcomes for preterm infants in the NICU. Research on this vulnerable population can help define if there are gaps in accessing services that could be overcome to optimize health outcomes. Methodology for this study will be described in Chapter 3.

Chapter 3: Methodology

Overview

This chapter presents the study's research methodology. It includes the study design, sampling strategy, description of the variables, and data analysis procedures. This chapter ends with the study limitations.

Research Questions and Hypotheses

Research Aim 1: Determine the scope of dysphagia therapy and gastrostomy tube (GT) placement in a Level IV neonatal intensive care unit (NICU) for preterm infants.

Research Question 1.1: What is the prevalence of dysphagia therapy referrals, referral type (automatic or problem-based referral), and dysphagia therapy utilization (number of dysphagia therapy visits) for preterm infants in the UCSF NICU between 2017 and 2019?

Research Question 1.2: What is the prevalence of GT placement for preterm infants in the UCSF NICU between 2017 and 2019?

Research Aim 2: Determine which infant characteristics are associated with dysphagia therapy utilization and feeding outcomes for preterm infants in the NICU.

Research Question 2.1: What are the characteristics of infants who receive dysphagia therapy referrals in the NICU? What infant characteristics are associated with dysphagia therapy utilization in the NICU?

Hypothesis 2.1.1: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with receipt of dysphagia therapy referral in the NICU.

Hypothesis 2.1.2: Medical complexity and gestational age will be associated with receipt of automatic referrals in the NICU.

Hypothesis 2.1.3: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with the number of therapy sessions in the NICU.

Research Question 2.2: What are the characteristics of infants who receive GT placement? What infant characteristics are associated with feeding outcomes in the NICU?

Hypothesis 2.2.1: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with GT placement in the NICU.

Hypothesis 2.2.2: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with post-menstrual age (PMA) of independent oral feeding in the NICU.

Research Aim 3: Determine if dysphagia therapy utilization is associated with feeding outcomes while controlling for infant characteristics.

Research Question 3.1: Is dysphagia therapy utilization associated with PMA at independent oral feeding in the NICU while controlling for infant characteristics?

Hypothesis 3.1.1: Receipt of dysphagia therapy will be associated with lower PMA at independent oral feeding in the NICU while controlling for infant characteristics.

Hypothesis 3.1.2: Automatic therapy referral will be associated with lower PMA at independent oral feeding in the NICU while controlling for infant characteristics.

The exploration of hypothesis 2.2.1 is contingent upon results from research question 1.2 and if there is enough variability in GT placement within the sample. The exploration of hypothesis 2.1.2 and research question 3.2 are contingent upon results from research question 1.1 and if there is enough variability in referral mechanisms within the sample.

Study Design

This quantitative, correlational, retrospective, exploratory study analyzed already existing data pulled from ApeX, which is University of California San Francisco's (UCSF) EPIC based electronic medical record (EMR). Although causation cannot be determined with a retrospective study design, this study is intended to give preliminary information to further inform future dysphagia therapy interventions and research.

Study Setting

The UCSF Benioff Children's Hospital (BCH) is located in San Francisco, California and is a leader in the field of neonatology with a certified regional 60-bed, Level IV NICU that serves infants throughout Northern California. The UCSF BCH uses a multi-disciplinary approach to provide the most advanced care to critically ill infants who were born premature or with cardiopulmonary anomalies, gastrointestinal disorders, neurological disorders, and other illnesses requiring advanced life support. The UCSF BCH has over 1000 admissions a year to the NICU and approximately 43% of those admissions are due to prematurity. The UCSF BCH NICU serves a diverse racial population: 46% White, 21% Asian, 7% Black, 2% American Indian/Alaskan Native, 1% Native Hawaiian/Other Pacifier Islander, 18% other, and 5% unknown. Twenty percent identify as Hispanic. During the study period, the referral mechanism (automatic versus problem-based) for dysphagia therapy was provider dependent, usually based on the individual provider's identified medical risk of the infant. Automatic referrals were placed prior to initiating oral feeding for the preterm infants whereas problem-based referrals were placed after the infant had already started orally feeding with the nursing staff and then a feeding and/or swallowing concern arose after.

Role of Therapy at UCSF BCH NICU

At the UCSF BCH, the therapy team is composed of dysphagia therapists and developmental therapists. The dysphagia therapists consist of OTs and SLPs with expertise in infant feeding and swallowing and who have completed a dysphagia competency program at UCSF BCH. OTs on this team must also obtain an advanced practice certification in swallowing assessment, evaluation, and intervention from the California Board of Occupational Therapy. Dysphagia therapists at UCSF BCH use cue-based feeding and oral motor interventions when providing dysphagia therapy to preterm infants. Other dysphagia interventions such as positioning, pacing, providing cheek and jaw support, adjusting flow rate, and altering the viscosity of the liquid, are also utilized to support oral feeding.

Sample

The population of interest for this study was premature infants, who were born at less than 37 weeks of gestation and admitted to the UCSF BCH NICU. Data was extracted from the EMR for all eligible participants between January 2017 and December 2019. Premature infants who had transferred from another hospital, transferred to another hospital, or died will be excluded from the study.

Sample Size and Power

Sample size *a priori* was calculated for research question 3.1, in which the primary outcome is PMA at independent oral feeding. A rule of thumb to calculate sample size for multiple linear regression is 50 + 8 times the number of IVs (Tabachnick & Fidell, 2017). There was potentially a total of 22 IVs that could be included in this analysis so a sample size of 226 was required.

Variables of Interest

The variables for this study were chosen based on the literature review and Gelberg's Behavioral Model for Vulnerable Populations. See Table 1 for the dependent variables for this study.

Table 1

Dependent Study Variables

Research Question	Conceptual Model Measure	Variable	Operational Definition	Data Type
1.1: What is the prevalence of dysphagia therapy referrals, referral type (automatic or problem-based referral), and dysphagia therapy utilization (number of dysphagia therapy visits) for preterm infants in the UCSF NICU between 2017 and 2019? ***2.1:*** What are the characteristics of infants who receive dysphagia therapy referrals in the NICU? What is the association between infant characteristics and dysphagia therapy utilization in the NICU?	Use of health services	Received referral for dysphagia eval and treat	0 = No; 1 = Yes (as determined by CPT codes 92610 and 97166)	Categorical
1.1: What is the prevalence of dysphagia therapy referrals, referral type (automatic or problem-based referral), and dysphagia therapy utilization (number of dysphagia therapy visits) for preterm infants in the UCSF NICU between 2017 and 2019?	Use of health services	Automatic or problem-based referral	0 = Automatic (dysphagia therapy referral was placed prior to initiating oral feeds); 1 = Problem-based (dysphagia therapy referral was placed after	Categorical

			oral feeding was already initiated)	
1.1: What is the prevalence of dysphagia therapy referrals, referral type (automatic or problem-based referral), and dysphagia therapy utilization (number of dysphagia therapy visits) for preterm infants in the UCSF NICU between 2017 and 2019? ***2.1:*** What is the association between infant characteristics and dysphagia therapy utilization in the NICU?	Use of health services	Number of therapy sessions	# of completed dysphagia therapy sessions	Continuous
1.2: What is the prevalence of GT placement for preterm infants in the NICU? ***2.2:*** What are the characteristics of infants who receive GT placement? What is the association between infant characteristics and feeding outcomes in the NICU?	Health outcome	GT placement	0 = no; 1 = yes	Categorical
2.2: What is the association between infant characteristics and feeding outcomes in the NICU? ***3.1:*** Is receipt of dysphagia therapy associated with PMA at independent oral feeding the NICU while controlling for infant characteristics?	Health outcome	PMA at independent oral feeding	PMA at independent oral feeding as determined by when the last gavage feeding was documented	Continuous

See table 2 for the independent variables.

Table 2

Independent Study Variables

Conceptual Model Measure	**Variable**	**Operational Definition**	**Data Type**
Predisposing characteristics	Infant sex	0 = female; 1 = male	Categorical
	Infant race [a] and ethnicity	0 = White; 1 = Hispanic; 2 = Asian; 3 = Black/African American; 4 = Other (Native American, Alaska Native, Native Hawaiian, OPI); 5 = multi-race	Categorical
	Maternal age	Age of birth mother (years)	Continuous
	Maternal marital status	0 = married; 1 = not married (separated, divorced, widowed, unknown)	Categorical
	Maternal mental illness	0 = no history; 1 = yes (as determined by ICD-10 codes for postpartum depression, substance abuse, and mood disturbance in the mother's medical record)	Categorical
	Preferred language	0 = English; 1 = not English	Categorical
	Child Protective Services involvement	0 = no; 1 = yes	Categorical
	Homelessness (current)	0 = no; 1 = yes	Categorical
Enabling characteristics	Infant insurance	0 = Commercial; 1 = Medi-Cal	Categorical
	Maternal employment	0 = yes (full time, part time); 1 = no (unemployed); 2 = unknown	Categorical
	Maternal social support	0 = yes (immediate family, extended family, community, other); 1 = no; 2 = unknown	Categorical
	Distance [c]	0 = <7 miles 1 = 7-47 miles 2 = >47 miles	Categorical
	Type of delivery	0 = vaginal; 1 = c-section	Categorical

Need characteristics	Medical complexity [b]	0 = Children without chronic disease; 1 = Children with non-complex chronic disease; 2 = Children with complex chronic disease	Categorical
	Birthweight	Weight at birth (grams)	Continuous
	Gestational age	Gestational age at birth (weeks)	Continuous
	Respiratory conditions	Did the infant require respiratory support at 36 weeks? 0 = no; 1 = yes	Categorical
	History of mechanical ventilation	0 = no; 1 = yes	Categorical
	Length of stay	Length of stay from birth to hospital discharge (days)	Continuous
	PMA at discharge	Weeks	Continuous
	Multiple birth	0 = no; 1 = yes	Categorical

[a]Infant race is determined by parent. [b]The Pediatric Medical Complexity Algorithm (Simon et al., 2014) uses ICD-10 codes to classify children in the following categories: chronic complex disease (significant chronic conditions in at least two body systems or have a progressive condition), non-chronic complex disease (chronic a condition in one body system), and without chronic disease (acute non-chronic conditions or are healthy). [c]Distance was transformed from a continuous variable to a categorical variable due to it being skewed and kurtotic to reduce the impact of bias.

Procedure

Institutional Review Board (IRB) approval was granted through UCSF and Virginia Commonwealth University. Since this study involved human subjects but was a retrospective review of data from the EMR, a waiver of consent was granted by both IRBs.

Data Extraction

Data was extracted by Clinical Data Research Consultations, a consultation service offered through UCSF. The clinical informaticist was responsible for extracting data from the EMR and transferring it to a secure platform, Research Analysis Environment, which hosts and computes data for UCSF. This author worked with the clinical informaticist to ensure the data extracted from the EMR were from the correct and most reliable locations in the EMR. Once the data was extracted, this author was the only person handling and analyzing the data to ensure it remains protected.

Data Analysis

Descriptive statistics were used to check for normality, data cleaning, and check for missing values. Outliers and missing values were checked for accuracy by verifying with the UCSF clinical informatics team to validate it against the direct source. Legitimate outliers were included in the analyses. If the value was truly missing, then that participant was eliminated by using complete case analysis (Field, 2018). IBM Statistical Product and Service Solution (SPSS) 29.0 was used for data analysis. See Table 3 for the statistical analysis that was used for each research question. A sensitivity analysis was also conducted at the end to evaluate the validity of the results to determine the influence of specific social factors that had too little variability to include in the primary analysis plan (Mowbray et al., 2022).

Table 3

Statistical Analysis by Research Question

Research Question	Hypothesis	Statistical Analysis
1.1: What is the prevalence of dysphagia therapy referrals, referral type (automatic or		Descriptive statistics

problem-based referral), and dysphagia therapy utilization (number of dysphagia therapy visits) for preterm infants in the UCSF NICU between 2017 and 2019?		
1.2: What is the prevalence of GT placement for preterm infants in the NICU?		Descriptive statistics
2.1: What are the characteristics of infants who receive dysphagia therapy referrals in the NICU? What infant characteristics are associated with dysphagia therapy utilization in the NICU?	*2.1.1*: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with receipt of dysphagia therapy referral in the NICU.	Independent samples *t*-test; Pearson's chi-square test; Fisher's exact
	2.1.2: Medical complexity and gestational age will be associated with receipt of automatic referrals in the NICU.	Independent samples *t*-test; Pearson's chi-square test; Fisher's exact
	2.1.3: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with the number of therapy sessions in the NICU.	Univariate linear regression
2.2: What are the characteristics of infants who receive GT placement? What is the association between infant characteristics and feeding outcomes in the NICU?	*2.2.1*: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with GT placement in the NICU.	Independent samples *t*-test; Pearson's chi-square test
	2.2.2: Medical complexity, gestational age, race/ethnicity, and insurance will be associated with post-menstrual age (PMA) of independent oral feeding in the NICU.	Univariate linear regression
3.1: Is receipt of dysphagia therapy associated with PMA	*3.1.1*: Receipt of dysphagia therapy will be associated	Multivariate linear regression

at independent oral feeding the NICU while controlling for infant characteristics?	with lower PMA at independent oral feeding in the NICU while controlling for infant characteristics	
	3.1.2: Automatic therapy referral will be associated with lower PMA at independent oral feeding in the NICU while controlling for infant characteristics.	Multivariate linear regression

Key assumptions specific to multiple linear regression were evaluated. The assumption of independence of observations was evaluated by using the Durbin-Watson statistic. A scatterplot and partial regression plots were used to determine linearity and homoscedasticity of residuals. Lastly, multicollinearity was determined with correlation coefficients and tolerance/variance inflation factor (VIF) values. If this assumption is violated, the offending variable can be removed (Tabachnick & Fidell, 2017). Multivariate normality was determined by examining residuals frequency distribution.

Potential Limitations and Solutions

A limitation to the use of race as a variable is that it is socially constructed and has no biological basis (Umek & Fischer, 2020). It is acknowledged that race itself does not impact therapy utilization and feeding outcomes, but that racism can through acceptance of inequitable treatment of certain races (Malina et al., 2021). Race intersects with other determinants of health so other biological and sociological variables are used in this study to help explain any race-based signals.

Selection and history are threats to this study's internal validity. To address selection bias resulting from preexisting differences between groups, infant characteristics were collected and analyzed prior to doing the correlational analyses for the remaining research aims. The time period that was chosen eliminated the confounding effects of the COVID-19 pandemic and a shorter time period of 3 years was chosen to minimize effects of the occurrence of external events that took place at the same time that could influence the outcomes. Statistical conclusion validity was addressed by calculating sample size and power a priori. Over sampling occurred in case there was missing or inaccurate data.

Chapter Summary

This chapter described the correlational, retrospective research design and quantitative analyses for the proposed study. A description about the sampling, variable measurement/definitions, and statistical analyses methods were explained. Potential limitations and solutions were also described at the end.

Chapter 4: Results

Chapter Overview

This chapter will review the results of the research study. Data collection, cleaning, and screening will be described. Then the results of the statistical analyses are presented.

Review of Data Collection

The initial dataset was received from Clinical Data Research Consultations on 6/22/23 with a total sample size of 1464 participants. This author assessed the completeness and accuracy of data and worked with the clinical informaticist to ensure the correct data was extracted from the correct locations in the EMR. After all data had been assessed and determined complete on 7/3/23, a total sample size of 1149 participants remained.

Review of Data: Screening and Cleaning

During preliminary analysis, the data set was examined for errors and missing data using descriptive statistics. The following numbers from the following variables were missing: 383 (33.3%) of birthweight, 298 (25.9%) of type of delivery, 193 (16.8%) of maternal age, 81 (7%) of infant race, 104 (9.1%) of ethnicity, and 196 (17.1%) of zip code were missing. The cases with missing data were removed using complete case analysis. Outliers and inaccurate data were examined and checked with the clinical informaticist. The cases that were truly errors were also removed, thus, leaving a total sample size of 560.

Assumptions for normality were tested for continuous variables (number of therapy sessions, PMA at independent oral feeding, gestational age, birthweight, length of stay, PMA at discharge, maternal age, distance). The following variables were found to be skewed and kurtotic: length of stay (skewness = 3.12, kurtosis = 14.79), PMA at discharge (skewness = 4.84, kurtosis = 36.02), and distance (skewness = 5.55, kurtosis = 31.06) (Byrne, 2010; Hair et al., 2010). To reduce the influence of extreme values, distance was transformed into a categorical variable. The categories were determined by the radius distance of San Francisco (<7 miles), San Francisco Bay Area (7-47 miles), and outside of San Francisco Bay Area (<47 miles). Then trimming was used to delete the cases that had extreme scores for length of stay (Field, 2018). Trimming can be based on a percentage rule or a standard deviation rule (Field, 2018). Participants that had length of stays that were three standard deviations from the mean were deleted as those who had extreme length of stays were likely to have an extremely complicated medical course compared to the rest of the sample. After trimming, the sample size remaining was 547 participants.

PMA at discharge and total number of treatments were still found to be slightly kurtotic (7.13 and 8.3 respectively) but the sample size was large enough so that the Central Limit Theorem applied, as in large samples, the shape of the data shouldn't affect significance tests (Field, 2018). The final sample had about a 10% reduction from the initial sample in those who had a history of mechanical ventilation, Medi-Cal insurance, not married maternal marital status, and not English as their preferred language (see Table 4).

Table 4

Distribution of Infant Characteristics Before and After Data Cleaning

Variable	Infant characteristics before data cleaning (N = 1149)	Infant characteristics after data cleaning (N = 547)
History of mechanical ventilation		
No	895 (77.9%)	501 (91.6%)
Yes	254 (22.1%)	46 (8.4%)
Infant insurance		
Commercial	594 (51.7%)	339 (62.0%)
Medi-Cal	555 (48.3%)	208 (38.0%)
Maternal marital status		

Married	718 (49.1%)	356 (65.1%)
Not married	743 (50.9%)	191 (34.9%)
Preferred language		
English	869 (75.6%)	512 (93.6%)
Not English	280 (24.4%)	35 (6.4%)

Note. Data presented as N(%)

Expected frequencies for categorical data (infant sex, type of delivery, medical complexity, history of mechanical ventilation, respiratory conditions, multiple birth, maternal age, infant race and ethnicity, infant insurance, maternal social support, maternal marital status, maternal employment, preferred language) were reviewed (Tabachnick & Fidell, 2017). The variables homelessness, CPS involvement, and maternal mental illness were found to have too little variability. Thus, a sensitivity analysis was completed at the end that excluded any participants that had at least one of the following: experienced homelessness, CPS involvement, or maternal mental illness to determine the influence of these social factors on the results. GT placement was also found to have little variability so inferential statistics were not done with GT placement as the outcome variable (hypothesis 2.2.1).

Key assumptions specific to multiple linear regression were evaluated. The assumption of independence of observations was met and evaluated by using the Durbin-Watson statistic. A scatterplot and partial regression plots were used to determine linearity and homoscedasticity of residuals. Both assumptions were met. Lastly, multicollinearity was determined with correlation coefficients and tolerance/variance inflation factor (VIF) values. Length of stay and gestational age were found to be the offending variables as they had high VIF values (>10) (Field, 2018). Gestational age is a more reliable measurement, more commonly used in research, and in previous research, was found to be associated with feeding outcomes so the length of stay was removed to meet the assumption of multicollinearity (Field, 2018; Tabachnick & Fidell, 2017). Once length of stay was removed, all tolerance/VIF values were within the accepted range (Field, 2018). Multivariate normality was determined by examining the residuals frequency distribution though multiple linear regression is robust to non-normality (Tabachnick & Fidell, 2017). Also, the sample size was large enough so that the Central Limit Theorem applied (Field, 2018).

Data Analysis

Research Question 1.1

What is the prevalence of dysphagia therapy referrals, referral type (automatic or problem-based referral), and dysphagia therapy utilization (number of dysphagia therapy visits) for preterm infants in the UCSF NICU between 2017 and 2019?

About 27.4% of preterm infants in the UCSF NICU between 2017 and 2019 received a dysphagia therapy referral with a median of three therapy sessions (see Table 5). Seventy-four percent of those referrals were problem-based referrals with a median of three therapy sessions. Twenty-six percent of those referrals were automatic referrals with a median of four therapy sessions. The number of therapy sessions ranged from zero to 25 for both automatic and problem-based referrals.

Table 5

Number of Infants who Received Dysphagia Therapy Referral and their Median Number of Therapy Sessions

	Overall (N = 547)	Median number of therapy sessions (IQR)
Did not receive dysphagia therapy referral	397 (72.6%)	
Received dysphagia therapy referral	150 (27.4%)	3 (1.00-5.25)
Automatic referrals	39 (26.0%)	4 (1.00-8.00)
Problem-based referrals	111 (74.0%)	3 (1.00-4.00)

Note. Data presented as N(%)

Research Question 1.2

What is the prevalence of GT placement for preterm infants in the UCSF NICU between 2017 and 2019?

Five preterm infants (0.9%) received GT placement in the UCSF NICU between 2017 and 2019 (see Table 6).

Table 6

Number of Infants who Received Gastrostomy Tube Placement

	Overall (N = 547)
Infants who did not receive GT	542 (99.1%)
Infants who did receive GT	5 (0.9%)

Note. Data presented as N(%)

Research Question 2.1

What are the characteristics of infants who received dysphagia therapy referrals in the NICU? What is the association between infant characteristics and dysphagia therapy utilization in the NICU?

There was a statistically significant association between medical complexity and receipt of dysphagia therapy, $X^2(2) = 14.83$, $p < .001$ (see Table 7). There was a low association between medical complexity and receipt of dysphagia therapy, V = .165, p < .001 (Crewson, 2016). There was a statistically significant association between history of mechanical ventilation and receipt of dysphagia therapy, $X^2(1) = 49.56$, $p < .001$. There was a moderate association between history of mechanical ventilation and receipt of dysphagia therapy, V = .301, $p < .001$. There was a statistically significant association between respiratory conditions and receipt of dysphagia therapy, $X^2(1) = 16.62$, $p < .001$. There was a low association between respiratory conditions and receipt of dysphagia therapy, V = .165, $p < .001$. There was a statistically significant association between distance and receipt of dysphagia therapy, $X^2(2) = 6.25$, $p = .044$. There was a low association between distance and receipt of dysphagia therapy, V = .107, $p = .044$. There was a statistically significant association between maternal employment and receipt of dysphagia therapy, $X^2(2) = 17.65$, $p < .001$. There was a low association between maternal employment and receipt of dysphagia therapy, V = .180, $p < .001$. Infants who had received dysphagia therapy referral, when compared to those who did not receive dysphagia therapy referral, were more medically complex (14% versus 4.6%), had a history of mechanical ventilation (22% versus 3.3%), had respiratory conditions (19.3% versus 7.3%), lived outside of the San Francisco Bay Area (30.7% versus 21.2%), and had mother's that were unemployed (30% vs 18.4%) (see Table 7).

There was a statistically significant association between gestational age and receipt of dysphagia therapy, $t(197.68) = 6.44$, $p < .001$, $d = 2.22$ (see Table 8) (Cohen, 1988). There was a statistically significant association between birthweight and receipt of dysphagia therapy, $t(545) = 6.75$, $p < .001$, $d = 583.08$. There was a statistically significant association between length of stay and receipt of dysphagia therapy, $t(179.36) = -10.09$, $p < .001$, $d = 18.26$. There was a statistically significant association between PMA at discharge and receipt of dysphagia therapy, *U* = 48887.00, *z* = 11.60, $p < .001$. There was a statistically significant association between maternal age and receipt of dysphagia therapy, $t(545) = 1.96$, $p = .050$, $d = 5.66$. There was a statistically significant association between PMA at independent oral feeding and receipt of dysphagia therapy, $t(190.10) = -10.47$, $p < .001$, $d = 1.23$. Infants who had received dysphagia therapy referral, when compared to those who did not receive dysphagia therapy referral, were born at lower gestational ages (32.35 versus 34.01), had lower birthweights (1854.79 versus 2231.99), had longer lengths of stay (38.56 versus 15.39), had higher PMA at discharge (37.29 versus 36.14), had younger mothers (37.25 versus 38.3), and had higher PMA at independent oral feeding (36.83 versus 35.32) (see Table 8).

Infants who had received dysphagia therapy referral, when compared to those who did not receive dysphagia therapy referral, also were homeless (3.3% versus 0.3%, $p = .007$) and had GT placement (2.7% versus 0.3%, $p = .022$) (see Table 9).

Table 7

Overall Participant Characteristics and Frequencies and Pearson's Chi-Square Results for Comparison of Participant Characteristics for Infants who Received and Did not Receive Dysphagia Therapy Referral

Participant Characteristics	Overall (N = 547)	Did not receive dysphagia therapy referral (n = 397)	Received dysphagia therapy referral (n = 150)	X^2	*p*-value	Cramer's V
Infant sex				3.19	.074	.076
Female	249 (45.5%)	190 (47.9%)	59 (39.3%)			
Male	298 (54.5%)	207 (52.1%)	91 (60.7%)			
Type of delivery				3.78	.052	.083
Vaginal	274 (50.1%)	209 (52.6%)	65 (43.3%)			
C-section	273 (49.9%)	188 (47.4%)	85 (56.7%)			

Medical complexity				14.83	<.001*	.165
Children without complex chronic disease	508 (92.9%)	379 (95.5%)	129 (86.0%)			
Children with non-complex chronic disease	29 (5.3%)	13 (3.3%)	16 (10.7%)			
Children with chronic disease	10 (1.8%)	5 (1.3%)	5 (3.3%)			
History of mechanical ventilation				49.56	<.001*	.301
No	501 (91.6%)	384 (96.7%)	117 (78.0%)			
Yes	46 (8.4%)	13 (3.3%)	33 (22.0%)			
Respiratory conditions				16.62	<.001*	.174
No	489 (89.4%)	368 (92.7%)	121 (80.7%)			
Yes	58 (10.6%)	29 (7.3%)	29 (19.3%)			
Multiple birth				0.45	.503	.029
No	405 (74.0%)	297 (74.8%)	108 (72.0%)			
Yes	142 (26.0%)	100 (25.2%)	42 (28.0%)			
Distance				6.25	.044*	.107
<7 miles	221 (40.4%)	170 (42.8%)	51 (34.0%)			
7-47 miles	196 (35.8%)	143 (36.0%)	53 (35.3%)			
>47 miles	130 (23.8%)	84 (21.2%)	46 (30.7%)			
Infant race and ethnicity				9.78	.082	.134
White	205 (37.5%)	143 (36.0%)	62 (41.3%)			
Hispanic	109 (19.9%)	88 (22.2%)	21 (14.0%)			
Asian	92 (16.8%)	73 (18.4%)	19 (12.7%)			
Black	51 (9.3%)	33 (8.3%)	18 (12.0%)			
Other	49 (9.0%)	33 (8.3%)	16 (10.7%)			
Multi-Race	41 (7.5%)	27 (6.8%)	14 (9.3%)			
Infant insurance				2.47	.116	.067
Commercial	339 (62.0%)	254 (64.0%)	85 (56.7%)			
Medi-Cal	208 (38.0%)	143 (36.0%)	65 (43.3%)			
Maternal social support				5.88	.053	.104
Yes	509 (93.1%)	368 (92.7%)	141 (94.0%)			
No	16 (2.9%)	9 (2.3%)	7 (4.7%)			
Unknown	22 (4.0%)	20 (5.0%)	2 (1.3%)			
Maternal marital status				2.35	.125	.066
Married	356 (65.1%)	266 (67.0%)	90 (60.0%)			
Not married	191 (34.9%)	131 (33.0%)	60 (40.0%)			

Maternal employment				17.65	<.001*	.180
Yes	255 (46.6%)	179 (45.1%)	76 (50.7%)			
No	118 (21.6%)	73 (18.4%)	45 (30.0%)			
Unknown	174 (31.9%)	145 (36.5%)	29 (19.3%)			
Preferred language				0.89	.347	.040
English	512 (93.6%)	374 (94.2%)	138 (92.0%)			
Not English	35 (6.4%)	23 (5.8%)	12 (8.0%)			

Note. Data presented as N(%).

*$p < .05$.

Table 8

Overall Participant Characteristics and Means and T-Test Results for Comparison of Participant Characteristics for Infants who Received and Did not Receive Dysphagia Therapy Referral

Participant Characteristics	Overall (N = 547)	Did not receive dysphagia therapy referral (n = 397)	Received dysphagia therapy referral (n = 150)	*t*(df)	*p*-value	Cohen's *d*
Gestational age	33.55±2.34	34.01±1.89	32.35±2.93	6.44(197.68)	<.001*	2.22**
Birthweight	2128.55±606.41	2231.99±582.46	1854.79±584.71	6.75(545)	<.001*	583.08**
Length of stay	21.74±21.00	15.39±13.75	38.56±26.83	-10.09(179.36)	<.001*	18.28**
PMA at discharge	36.43	36.14	37.29	n/a[a]	<.001*	n/a[a]
Maternal age	38.02±5.68	38.31±5.77	37.25±5.37	1.96(545)	.050*	5.66**
PMA at independent oral feeding	35.73±1.40	35.32±1.04	36.83±1.63	-10.47(190.10)	<.001*	1.23**

Note. Data presented as mean±SD or median.

[a]Independent Samples Mann-Whitney U Test was used.

*$p \leq .05$.

**large effect size.

Table 9

Supplemental Table of Overall Participant Characteristics and Comparison of Participant Characteristics for Infants who Received and Did not Receive Dysphagia Therapy Referral

Participant Characteristics	Overall (N = 547)	Did not receive dysphagia therapy referral (n = 397)	Received dysphagia therapy referral (n = 150)	*p*-value
Homelessness (current)				.007*
No	541 (98.9%)	396 (99.7%)	145 (96.7%)	
Yes	6 (1.1%)	1 (0.3%)	5 (3.3%)	
Child Protective Services involvement				1.000
No	544 (99.5%)	395 (99.5%)	149 (99.3%)	
Yes	3 (.5%)	2 (0.5%)	1 (0.7%)	
Maternal mental illness				.668
No	541 (98.9%)	393 (99.0%)	148 (98.7%)	
Yes	6 (1.1%)	4 (1.0%)	2 (1.3%)	
GT placement				.022*
No	542 (99.1%)	396 (99.7%)	146 (97.3%)	
Yes	5 (0.9%)	1 (0.3%)	4 (2.7%)	

Note. Data presented as N(%). Fisher's exact test was used given small sample sizes.

*$p < .05$.

There was a statistically significant association between history of mechanical ventilation and referral type, $X^2(1) = 11.12$, $p < .001$ (see Table 10). There was a low association between history of mechanical ventilation and referral type, V = .272, $p < .001$ (Crewson, 2016). There was a statistically significant association between respiratory conditions and referral type, $X^2(1) = 6.62$, $p = .010$. There was a low association between respiratory conditions and referral type, V = .210, $p < .001$. Infants who had received an automatic referral, when compared to those who received a problem-based referral, had a history of mechanical ventilation (41% versus 15.3%) and had respiratory conditions (33.3% versus 14.4%) (see Table 10).

There was a statistically significant association between gestational age and referral type, $t(52.46) = -5.20$, $p < .001$, $d = 2.63$ (see Table 11) (Cohen, 1988). There was a statistically significant association between birthweight and referral type, $t(53.98) = -4.46$, $p < .001$, $d = 541.16$. There was a statistically significant association between length of stay and referral type, $t(57.98) = 6.23$, $p < .001$, $d = 23.53$. There was a statistically significant association between PMA at discharge and referral type $t(148) = 3.47$, $p < .001$, $d = 1.95$. There was a statistically significant association between PMA at independent oral feeding and referral type, $t(144) = 2.05$, $p = .043$, $d = 1.61$. Infants who had received an automatic referral, when compared to those who received a problem-based referral, were born at lower gestational ages (30.15 versus 33.13), had lower birthweights (1474.99 versus 1988.24), had longer lengths of stay (60.49 versus 30.86), had higher PMA at discharge (38.80 versus 37.53), and had higher PMA at independent oral feeding (37.31 versus 36.68) (see Table 11).

Table 10

Frequencies and Pearson's Chi-Square Results for Comparison of Participant Characteristics for Infants who Received Automatic and Problem-Based Referrals

Participant Characteristics	Automatic referrals (n = 39)	Problem-based referrals (n = 111)	X^2	*p*-value	Cramer's V
Infant sex			0.40	.527	.052
Female	17 (43.6%)	44 (37.8%)			
Male	22 (56.4%)	69 (62.2%)			
Type of delivery			3.39	.066	.150
Vaginal	12 (30.8%)	53 (47.7%)			
C-section	27 (69.2%)	58 (52.3%)			
History of mechanical ventilation			11.12	<.001*	.272
No	23 (59.0%)	94 (84.7%)			
Yes	16 (41.0%)	17 (15.3%)			

Respiratory conditions			6.62	.010*	.210
No	26 (66.7%)	95 (85.6%)			
Yes	13 (33.3%)	16 (14.4%)			
Multiple birth			1.47	.226	.099
No	31 (79.5%)	77 (69.4%)			
Yes	8 (20.5%)	34 (30.6%)			
Distance			0.69	.708	.068
<7 miles	12 (30.8%)	39 (35.1%)			
7-47 miles	13 (33.3%)	40 (36.0%)			
>47 miles	14 (35.9%)	32 (28.8%)			
Infant insurance			0.001	.970	.003
Commercial	22 (56.4%)	63 (56.8%)			
Medi-Cal	17 (43.6%)	48 (43.2%)			
Maternal marital status			0.98	.323	.081
Married	26 (66.7%)	64 (57.7%)			
Not married	13 (33.3%)	47 (42.3%)			
Maternal employment			0.07	.967	.021
Yes	20 (51.3%)	56 (50.5%)			
No	12 (30.8%)	33 (29.7%)			
Unknown	7 (17.9%)	22 (19.8%)			
Preferred language			0.37	.546	.049
English	35 (89.7%)	103(92.8%)			
Not English	4 (10.3%)	8 (7.2%)			

Note. Data presented as N(%).

*$p < .05$.

Table 11

Means and T-Test Results for Comparison of Participant Characteristics for Infants who Received Automatic and Problem-Based Referrals

Participant Characteristics	Automatic referrals (n = 39)	Problem-based referrals (n = 111)	*t*(df)	*p*-value	Cohen's *d*
Gestational age	30.15±3.28	33.13±2.36	-5.20 (52.46)	<.001*	2.63**
Birthweight	1474.99±656.22	1988.24±495.23	-4.46 (53.98)	<.001*	541.16**
Length of stay	60.49±26.61	30.86±22.37	6.23 (57.98)	<.001*	23.53**
PMA at discharge	38.80±2.26	37.53±2.26	3.47 (148)	<.001*	1.95**
Maternal age	38.15±4.49	36.93±5.63	1.23 (148)	.221	5.36**
Total number of treatments	4	3	n/a[a]	.081	n/a[a]
PMA at independent oral feeding	37.31±1.70	36.68±1.58	2.05 (144)	.043*	1.61**

Note. Data presented as mean±SD or median.

[a]Independent Samples Mann-Whitney U Test was used.

*p < .05.

**large effect size.

Table 12

Supplemental Table for Comparison of Participant Characteristics for Infants who Received Automatic and Problem-Based Referrals

Participant Characteristics	Automatic referrals N(%)	Problem-based referrals N(%)	*p*-value
Medical complexity			.009*[a]
Children without complex chronic disease	29 (74.4%)	100 (90.1%)	
Children with non-complex chronic disease	6 (15.4%)	10 (9.0%)	
Children with chronic disease	4 (10.3%)	1 (0.9%)	

Infant race and ethnicity			.772 [a]
White	27 (43.6%)	45 (40.5%)	
Hispanic	7 (17.9%)	14 (12.6%)	
Asian	6 (15.4%)	13 (11.7%)	
Black	4 (10.3%)	14 (12.6%)	
Other	3 (7.7%)	13 (11.7%)	
Multi-Race	2 (5.1%)	12 (10.8%)	
Homelessness (current)			.327
No	39 (100%)	106 (95.5%)	
Yes	0 (0%)	5 (4.5%)	
Child Protective Services involvement			1.000
No	39 (100%)	110 (99.1%)	
Yes	0 (0%)	1 (0.9%)	
Maternal social support			.694 [a]
Yes	37 (94.9%)	104 (93.7%)	
No	2 (5.1%)	5 (4.5%)	
Unknown	0 (0.0%)	2 (1.8%)	
Maternal mental illness			.454
No	38 (97.4%)	110 (99.1%)	
Yes	1 (2.6%)	1 (0.9%)	
GT placement			.054
No	36 (92.3%)	110 (99.1%)	
Yes	3 (7.7%)	1 (0.9%)	

Note. Data presented as N(%). Fisher's exact test was used given small sample sizes.

[a]Interpret with caution given that these *p*-values are for Pearson's chi-square test.

*$p < .05$.

Infants with lower gestational age ($p = .011$, adjusted $R^2 = .036$), higher medical complexity ($p = .002$, adjusted $R^2 = .070$), history of mechanical ventilation ($p = .042$, adjusted $R^2 = .021$), respiratory conditions ($p = .008$, adjusted $R^2 = .040$), longer length of stay ($p < .001$, adjusted $R^2 = .133$M), higher PMA at discharge ($p < .001$, adjusted $R^2 = .162$M), and Medi-Cal insurance ($p = .023$, adjusted $R^2 = .028$) had a higher number of treatment sessions. Infants who identified as Hispanic, Black, Other, or Multi-Race had a higher number of treatment sessions than infants who identified as White while infants who identified as Asian had a lower number of treatment sessions than infants who identified as White (p = .009, adjusted R^2 = .069) (see Table 13).

Table 13

Univariate Linear Regression of Associations Between Participant Characteristics and Number of Therapy Sessions

Participant Characteristics	Unstandardized beta (S.E.)	95% CI		*p*-value	Adjusted R^2
		Lower	Upper		
Gestational age	-.320 (.125)	-.567	-.073	.011*	.036
Birthweight	-.001 (.001)	-.002	.000	.175	.006
Infant sex					-.006
Female	Ref				
Male	.207 (.763)	-1.300	1.715	.786	
Type of delivery					-.005
Vaginal	Ref				
C-section	.387 (.751)	-1.098	1.872	.607	
Medical complexity				.002*	.070
Children without complex chronic disease	Ref				
Children with non-complex chronic disease	2.160 (1.163)	-.138	4.458		
Children with chronic disease	6.473 (2.000)	2.521	10.425		
History of mechanical ventilation				.042*	.021
No	Ref				
Yes	1.821 (.887)	.068	3.574		
Respiratory conditions				.008*	.040
No	Ref				
Yes	2.470 (.922)	.648	4.291		
Length of stay	.063 (.013)	.038	.089	<.001*	.133
PMA at discharge	.919 (.169)	.586	1.253	<.001*	.162
Multiple birth				.177	.006
No	Ref				
Yes	-1.120 (.825)	-2.751	.510		

Maternal age	-.057 (.069)	-.195	.080	.411	-.002
Distance				.223	.007
<7 miles	Ref				
7-47 miles	-.948 (.889)	-2.705	.810		
>47 miles	.621 (.922)	-1.200	2.443		
Infant race and ethnicity				.009*	.069
White	Ref				
Hispanic	4.016 (1.108)	1.825	6.207		
Asian	-.352 (1.151)	-2.628	1.923		
Black	1.016 (1.175)	-1.307	3.341		
Other	2.079 (1.231)	-.355	4.512		
Multi-Race	1.373 (1.299)	-1.194	3.941		
Infant insurance				.023*	.028
Commercial	Ref				
Medi-Cal	1.703 (.739)	.243	3.164		
Maternal social support				.836	-.011
Yes	Ref				
No	.914 (1.771)	-2.587	4.415		
Unknown	-.943 (3.258)	-7.381	5.496		
Maternal marital status				.234	.003
Married	Ref				
Not married	.906 (.757)	-5.91	2.402		
Maternal employment				.205	.008
Yes	Ref				
No	1.099 (.852)	-.585	2.784		
Unknown	-.755 (.989)	-2.709	1.199		
Preferred language				.345	-.001
English	Ref				
Not English	1.297 (1.370)	-1.410	4.004		

Note. Ref = reference group

*$p < .05$.

Research Question 2.1 Hypotheses Testing

Hypothesis 2.1.1 Testing

Medical complexity, gestational age, race/ethnicity, and insurance will be associated with receipt of dysphagia therapy referral in the NICU.

Hypothesis 2.1.1 testing was completed using independent samples *t*-tests and Pearson's chi-square. With regards to medical complexity, the hypothesis was accepted with a *p*-value of <.001 (see Table 7). With regards to gestational age, the hypothesis was accepted with a *p*-value of <.001 (see Table 8). With regards to race and ethnicity, the hypothesis was rejected with a *p*-value of .082 (see Table 7). Lastly, with regards to insurance, the hypothesis was rejected with a *p*-value of .116 (see Table 7).

Hypothesis 2.1.2 Testing

Medical complexity and gestational age will be associated with receipt of automatic referrals in the NICU.

Hypothesis 2.1.2 testing was completed using independent samples *t*-test. With regards to medical complexity, the hypothesis was neither accepted nor rejected due to the small sample size (see Table 12). With regards to gestational age, the hypothesis was accepted with a *p*-value of <.001 (see Table 11).

Hypothesis 2.1.3 Testing

Medical complexity, gestational age, race/ethnicity, and insurance will be associated with the number of therapy sessions in the NICU.

Hypothesis 2.1.3 testing was completed using univariate linear regression (see Table 13). With regards to medical complexity, the hypothesis was accepted with a *p*-value of .002. With regards to gestational age, the hypothesis was accepted with a *p*-value of .011. With regards to race and ethnicity, the hypothesis was accepted with a *p*-value of .009. Lastly, with regards to insurance, the hypothesis was accepted with a *p*-value of .023.

Research Question 2.2

What are the characteristics of infants who received GT placement? What is the association between infant characteristics and feeding outcomes in the NICU?

Given the limited variability of infants who received GT placement, the first part of this research question was not answered.

Infants with lower gestational age (p < .001, adjusted R^2 = .020), lower birthweight (p < .001, adjusted R^2 = .027), C-section delivery (p = .026, adjusted R^2 = .007), higher medical complexity (p < .001, adjusted R^2 = .059), history of mechanical ventilation (p < .001, adjusted R^2 = .117), respiratory conditions (p < .001, adjusted R^2 = .123), longer length of stay (p < .001, adjusted R^2 = .321), higher PMA at discharge (p < .001, adjusted R^2 = .767), and lived further away (p = .022, adjusted R^2 = .010) (see Table 14). Infants who had mothers that were employed had a lower PMA at independent oral feeding (p = .033, adjusted R^2 = .009) (see Table 14).

Table 14

Univariate Linear Regression of Associations Between Participant Characteristics and Post-Menstrual Age at Independent Oral Feeding

Participant Characteristics	Unstandardized β (S.E.)	95% CI		*p*-value	Adjusted R^2
		Lower	Upper		
Gestational age	-.089 (.025)	-.139	-.039	<.001*	.020
Birthweight	-.000388 (.00010)	-.00058	.00020	<.001*	.027
Infant sex				.360	.000
Female	Ref				
Male	.110 (.120)	-.126	.347		
Type of delivery				.026*	.007
Vaginal	Ref				
C-section	.267 (.120)	.032	.502		

Medical complexity					<.001*	.059
	Children without complex chronic disease	Ref				
	Children with non-complex chronic disease	1.119 (.268)	.594	1.645		
	Children with chronic disease	2.014 (.456)	1.119	2.909		
History of mechanical ventilation					<.001*	.117
	No	Ref				
	Yes	1.797 (.211)	1.383	2.211		
Respiratory conditions					<.001*	.123
	No	Ref				
	Yes	1.594 (.182)	1.237	1.952		
Length of stay		.038 (.002)	.033	.043	<.001*	.321**
PMA at discharge		.795 (.019)	.758	.832	<.001*	.767**
Multiple birth					.484	-.001
	No	Ref				
	Yes	.096 (.137)	-.173	.365		
Maternal age		-.008 (.011)	-.028	.013	.465	-.001
Distance					.022*	.010
	<7 miles	Ref				
	7-47 miles	.033 (.137)	-.236	.301		
	>47 miles	.405 (.155)	.101	.709		
Infant race and ethnicity					.152	.006
	White	Ref				
	Hispanic	-.136 (.167)	-.464	.192		
	Asian	-.431 (.175)	-.775	-.087		
	Black or African American	-.084 (.218)	-.512	.345		
	Other	.095 (.222)	-.341	.530		
	Multi-Race	.102 (.238)	-.366	.571		

Infant insurance				.876	-.002
Commercial	Ref				
Medi-Cal	-.019 (.124)	-.263	.224		
Maternal social support				.545	-.002
Yes	Ref				
No	-.367 (.355)	-1.064	.330		
Unknown	.105 (.304)	-.493	.703		
Maternal marital status				.230	.001
Married	Ref				
Not married	.151 (.126)	-.096	.399		
Maternal employment				.033*	.009
Yes	Ref				
No	-.114 (.156)	-.420	.192		
Unknown	-.358 (.137)	-.628	-.089		
Preferred language				.386	.000
English	Ref				
Not English	-.215 (.248)	-.701	.272		

Note. Ref = reference group

*$p < .05$.

**large effect size.

Research Question 2.2 Hypotheses Testing

Hypothesis 2.2.1 Testing

Medical complexity, gestational age, race/ethnicity, and insurance will be associated with GT placement in the NICU.

Hypothesis 2.2.1 testing was not completed given small sample size, as there was limited variability in GT placement (see Table 6).

Hypothesis 2.2.2 Testing

Medical complexity, gestational age, race/ethnicity, and insurance will be associated with PMA of independent oral feeding in the NICU.

Hypothesis 2.2.2 testing was completed using univariate linear regression (see Table 14). With regards to medical complexity, the hypothesis was accepted with a *p*-value of <.001. With regards to gestational age, the hypothesis was accepted with a *p*-value of <.001. With regards to race and ethnicity, the hypothesis was rejected with a *p*-value of .152. Lastly, with regards to insurance, the hypothesis was rejected with a *p*-value of .876.

Research Question 3.1

Is receipt of dysphagia therapy associated with PMA at independent oral feeding in the NICU while controlling for infant characteristics?

Length of stay was removed from this analysis given the high VIF (>10) indicating issues with multicollinearity.

C-section birth delivery type, higher PMA at discharge, and receipt of dysphagia therapy referral were associated with higher PMA at independent oral feeding (see Table 15). This model accounted for 77.4% of the variation with an adjusted R^2 of .774, which is a large effect size (Cohen, 1988). This model statistically significantly predicted PMA at discharge, $F(13, 528) = 143.90$, $p < .001$. While controlling for infant characteristics (gestational age, birthweight, type of delivery, medical complexity, history of mechanical ventilation, respiratory conditions, PMA at discharge, distance, and maternal employment), PMA at independent oral feeds for those who received dysphagia therapy is .336 weeks greater than those who did not receive dysphagia therapy.

Table 15

Multiple Linear Regression of Association Between Receipt of Dysphagia Therapy and Post-Menstrual Age at Independent Oral Feeding

	Unstandardized β (S.E.)	95% Confidence Interval		*p*-value
		Lower bound	Upper bound	
Gestational age	.019 (-.019)	-.018	.056	.317
Birthweight	-.00005 (.00007)	.00018	.00009	.519
C-section birth delivery type	-.118 (.060)	.235	-.001	.048*
Children with non-complex chronic disease	-.025 (.138)	-.296	.246	.857
Children with chronic disease	-.217 (.233)	-.673	.240	.352
Had a history of mechanical ventilation	.146 (.127)	-.104	.397	.251
Had respiratory conditions	-.059 (.106)	-.267	.149	.580
PMA at discharge	.757 (.024)	.710	.803	<.001*
Distance (7-47 miles)	.042 (.066)	-.088	.172	.529
Distance (>47 miles)	.043 (.077)	-.109	.195	.579
Maternal unemployment	-.038 (.076)	-.188	.111	.614
Unknown maternal unemployment	-.037 (.069)	-.172	.098	.592
Received dysphagia therapy referral	.336 (0.76)	.186	.486	<.001*

*$p < .05$.

C-section birth delivery type, having respiratory conditions, higher PMA at discharge, living between 7-47 miles away from the hospital, and maternal unemployment were associated with higher PMA at independent oral feeding (see Table 16). This model accounted for 82.5% of the variation with an adjusted R^2 of .825, which is a large effect size (Cohen, 1988). This model statistically significantly predicted PMA at discharge, $F(13, 132) = 53.50$, $p < .001$. While controlling for infant characteristics (gestational age, birthweight, type of delivery, medical complexity, history of mechanical ventilation, respiratory conditions, PMA at discharge, distance, and maternal employment), referral type is not associated with PMA at independent oral feeds.

Table 16

Multiple Linear Regression of Association Between Referral Type and Post-Menstrual Age at Independent Oral Feeding

	Unstandardized β (S.E.)	95% Confidence Interval		*p*-value
		Lower bound	Upper bound	
Gestational age	.016 (.036)	-.055	.087	.661
Birthweight	.00007 (.00017)	-.00026	.00040	.674
C-section birth delivery type	-.326 (.121)	-.565	-.086	.008*
Children with non-complex chronic disease	-.102 (.210)	-.517	.312	.626
Children with chronic disease	-.235 (.371)	-.970	.499	.527
Had a history of mechanical ventilation	.253 (.175)	-.093	.598	.150
Had respiratory conditions	-.528	-.872	-.183	.003*
PMA at discharge	.858 (.040)	.779	.936	<.001*
Distance (7-47 miles)	.292 (.140)	.014	.569	.040*
Distance (>47 miles)	.201 (.149)	-.094	.496	.180
Maternal unemployment	-.342 (.133)	-.605	-.078	.011*
Unknown maternal unemployment	-.223 (.155)	-.530	.084	.152
Problem-based referral	-.124 (.157)	-.436	.187	.432

*$p < .05$.

Research Question 3.1 Hypotheses Testing

Hypothesis 3.1.1 Testing

Receipt of dysphagia therapy will be associated with PMA at independent oral feeding in the NICU while controlling for infant characteristics.

Directionality was removed from this hypothesis to test this relationship in both directions. Hypothesis 3.1.1 testing was completed using multiple linear regression. This hypothesis was accepted with a p-value of <.001 (see Table 15).

Hypothesis 3.1.2 Testing

Automatic therapy referral will be associated with PMA at independent oral feeding in the NICU while controlling for infant characteristics.

Directionality was removed from this hypothesis to test this relationship in both directions. Hypothesis 3.1.2 testing was completed using multiple linear regression. This hypothesis was rejected with a p-value of .432 (see Table 16).

Sensitivity Analysis

Given limited variability in the following social factors: homelessness, CPS involvement, and maternal mental illness, a sensitivity analysis was completed to evaluate the validity of the results of the primary analysis. The analysis for research question 3 was repeated excluding participants who had experienced homelessness, had CPS involvement, or had maternal mental illness to determine the impact of receipt of dysphagia therapy and type of dysphagia therapy referral on PMA at independent oral feeds. The results remained the same, thus, the results from research question 3 remain robust (see Tables 17 and 18).

Table 17

Sensitivity Analysis: Multiple Linear Regression of Association Between Receipt of Dysphagia Therapy and Post-Menstrual Age at Independent Oral Feeding Excluding Participants Who Experienced Homelessness, CPS Involvement, or Maternal Mental Illness

	Unstandardized β (S.E.)	95% Confidence Interval		*p*-value	Adjusted R^2
		Lower bound	Upper bound		
Received dysphagia therapy	.336 (0.78)	.183	.489	<.001*	.770

*$p < .05$.

Table 18

Sensitivity Analysis: Multiple Linear Regression of Association Between Referral Type and Post-Menstrual Age at Independent Oral Feeding Excluding Participants Who Experienced Homelessness, CPS Involvement, or Maternal Mental Illness

	Unstandardized β (S.E.)	95% Confidence Interval		*p*-value	Adjusted R^2
		Lower bound	Upper bound		
Problem-based referral	-.079 (.157)	-.389	.231	.615	.832

Power Analysis

Power was calculated post hoc for research question 3.1, in which the primary outcome was PMA at independent oral feeding. Multiple linear regression was used to answer this research question. The final sample size, effect size, significance level of .05, and number of predictors (13) were used to calculate power by using a power analysis program that is commonly used in social and behavioral research called G*Power (Faul et al., 2007). For hypothesis 3.1.1, the final sample size was 547 and effect size was .774 was calculated to have a power of 1. For hypothesis 3.1.2., the final sample size was 150 and effect size was .825 was calculated to have a power of 1. Thus, this study was found to have sufficient power (Field, 2018).

Chapter Summary

Chapter 4 reviewed the data cleaning process. Then the data analyses of the study to determine the impact of infant characteristics on dysphagia therapy utilization and feeding outcomes were presented for each research question and hypothesis. Lastly, the chapter ended by reporting the results of the sensitivity analysis and power analysis.

Chapter V: Discussion

Chapter Overview

This chapter discusses the major findings and relevant implications from the findings. Then this chapter discusses the limitations, potential for future research, and major conclusions.

Summary of Problem, Theoretical Framework, and Methodology Overview

The purpose of this study was to determine the impact of infant characteristics on dysphagia therapy utilization and feeding outcomes. The goal of this study was to learn about the provision of dysphagia therapy services and how to improve the process and access to services. This study was guided by Gelberg's Behavioral Model for Vulnerable Populations, which is a theoretical framework that examines factors that affect health services usage and health status for vulnerable populations (Gelberg et al., 2000). This model posits that population characteristics, which can be characterized as predisposing, enabling, and need factors, impact health service utilization and health outcomes (Gelberg et al., 2000). This quantitative, correlational, retrospective, exploratory study analyzed already existing data pulled from an EMR, which included data on premature infants who were admitted to a Level IV NICU between January 2017 and December 2019 to determine the relationship between infant characteristics, dysphagia therapy utilization, and feeding outcomes. Hypothesis testing used independent samples *t*-test, Pearson's chi-square, and linear regression.

Major Findings

Dysphagia Therapy Utilization

Twenty-seven percent of premature infants in the UCSF NICU received a dysphagia therapy referral and a majority of them (74%) were problem-based referrals. Need and enabling factors from Gelberg's Behavioral Model for Vulnerable Populations were found to be associated with dysphagia therapy utilization. An infant's evaluated need for dysphagia therapy is determined by the provider by looking at different medical factors (Gelberg et al., 2000). The need factors that were associated with receipt of dysphagia therapy referral included: lower gestational age, lower birthweight, higher medical complexity, having a history of mechanical ventilation, having respiratory conditions, longer length of stay, and higher PMA at discharge. Thus, medical providers appear to be ordering dysphagia therapy referrals for infants who are generally more medically complex and thus, more at risk for having feeding and swallowing delays. When examining what referral types that medical providers are ordering, automatic orders were associated with the need factors of lower gestational age, lower birthweight, having a history of mechanical ventilation, having respiratory conditions, longer lengths of stay, and higher PMA at discharge. Both having a dysphagia therapy referral (versus not having a dysphagia therapy referral) and having an automatic referral (versus having a problem-based referral) were also associated with higher PMA at independent oral feeding likely due to the higher medical complexity of these infants. For those who had received dysphagia therapy referrals, lower gestational age, higher medical complexity, history of mechanical ventilation, respiratory conditions, longer length of stay, and higher PMA at discharge were associated with having a higher number of therapy sessions. Thus, infants who are receiving more therapy sessions appear to be more medically complex and infants who are hospitalized for longer inherently have more time to receive therapy sessions.

Enabling factors include social factors that enable one to obtain therapy services (Andersen, 1968). However, enabling factors describe more of discretionary healthcare utilization behaviors when the individual is highly involved, but this study focuses on non-discretionary therapy utilization behaviors as it is primarily dictated by the provider given that this study focuses on premature infants in an inpatient NICU setting (Andersen, 1968). The distance families lived from the hospital and maternal employment were found to be associated with receipt of dysphagia therapy. Infants who had families that lived outside of the San Francisco Bay Area or who had mothers that were unemployed were more likely to have received a dysphagia therapy referral. It is possible that families who lived outside of the San Francisco Bay Area specially came to UCSF, as it is one of the regional Level IV NICUs, to give birth if they were experiencing a high-risk pregnancy. It is also possible that providers were more inclined to order therapy services for families who lived further away, as these families may not have been able to visit as easily as families who lived closer. Perhaps the perception was that families who lived further away and/or mothers that are unemployed may benefit from the extra training and education that therapists are able to provide when the family is able to visit. More research needs to be done to determine the cause of this relationship.

Predisposing factors are characteristics of individuals that predispose them to use health services (Andersen, 1968). There were no predisposing sociodemographic factors that were associated with the type of therapy referral. However, for those who had received a dysphagia therapy referral, race and ethnicity (predisposing sociodemographic factor) and insurance (enabling socioeconomic factor) were found to be associated with the number of therapy sessions. Infants who identified as Hispanic, Black, Other, or Multi-Race had a higher number of treatment sessions than infants who identified as White while infants who identified as Asian had a lower number of treatment sessions than infants who identified as White. It is possible that the difference in number of treatment sessions by race and ethnicity is due to the subsample population not being reflective of the population served by the UCSF NICU. When comparing the study subsample of infants who had received dysphagia therapy to the population served by the UCSF NICU, there were more infants who identified as Black and less infants who identified as Hispanic, White, and Asian within the study subsample (see Table 19). Given that infants who received dysphagia therapy were found to have more medical risk, it is possible that Black infants received more therapy sessions given the increased percentage in the subsample when compared to the population served by the UCSF NICU, whereas Asian and White infants received less therapy sessions given the decreased percentage in the subsample when compared to the population served by the UCSF NICU.

Table 19

Comparison of Race and Ethnicity Makeup of Population and Study Subsample

	San Francisco[a]	UCSF NICU	Study sample of infants who received dysphagia therapy referral
White	39.2%	45.9%	41.3%
Hispanic	15.4%	20.8%	14.0%
Asian	34.4%	20.9%	12.7%
Black	5.2%	7.4%	12.0%
American Indian an Alaska Native	0.5%	1.6%	Combined with other
Native Hawaiian and Other Pacific Islander	0.4%	0.8%	Combined with other
Other	Not reported	18.1%	10.7%
Multi-Race	8.4%	Not reported	9.3%

[a]Retrieved from https://www.census.gov/quickfacts/fact/table/sanfranciscocitycalifornia/PST045222 (U.S Census Bureau, 2022)

Infants with Medi-Cal insurance were associated with a higher number of treatment sessions than infants with private insurance. For infants who are uninsured, there is a social worker who guides the families in obtaining Medi-Cal in the first 30 days of birth, thus increasing the number of infants who have Medi-Cal. Insurance type may also be a proxy for socioeconomic status, which can increase medical risk for these infants who have public insurance or who are uninsured, thus, receiving more therapy sessions.

According to Gelberg's behavioral model, utilization of healthcare services can be discretionary, where the individual is highly involved, or non-discretionary, where the provider primarily dictates (Andersen, 1968). This study focused on the non-discretionary healthcare utilization, as the study setting is an inpatient NICU setting where medical providers directed the infants' medical care. Predisposing and enabling factors describe more of the healthcare utilization behaviors when the behaviors are more discretionary and need factors describe more of the healthcare utilization behaviors when the behaviors are non-discretionary (Andersen, 1968). This study aligns with Gelberg's behavioral model as it was found that the need factors described more of the therapy utilization behavior.

Gelberg's behavioral model also measures access to healthcare services. Equitable access is when demographic and need variables explain more of the differences in utilization and inequitable access is when access to care is based on social structure, health beliefs, and enabling resources (Andersen, 1995). Access to dysphagia therapy services at UCSF NICU appears to be equitable as the need variables explain a majority of the differences in therapy utilization in the referral process, referral type, and number of therapy sessions. In order to increase access to health services, the patient characteristics must be mutable. Andersen (1995) report that evaluated need factors (as evaluated by the provider) can be changed to influence the use of health services. Thus, the findings from this study could impact how the provider makes referrals based on the need factors that are associated with increased PMA at independent oral feedings.

Feeding Outcomes

Only a small percentage of premature infants received GTs (0.9%) in the UCSF NICU. Due to a small sample size from limited variability in the feeding outcomes of GT placement, hypothesis 2.2.1 was not tested so hypothesis testing focused on the feeding outcome of PMA at independent oral feeding.

A majority of need factors were also found to be associated with feeding outcomes. Lower gestational age, lower birthweight, c-section delivery, higher medical complexity, history of mechanical ventilation, respiratory conditions, longer length of stay, and higher PMA at discharge were associated with higher PMA at independent oral feeding. Two enabling factors that were associated with feeding outcomes were distance and maternal employment. Infants who had families that lived further away or had mothers that were unemployed were associated with higher PMA at independent oral feeding. It is possible that families who lived further away and were experiencing a high-risk pregnancy specially came to UCSF to give birth given that it is a regional Level IV NICU. Thus, those infants may be more medically complex, which could impact the feeding outcome. It is also possible that families who live further away or mothers that were unemployed may have had a more difficult time visiting their babies due to transportation and financial constraints so there may be less carryover of interventions that could help with the infant's feeding development, thus, these infants were older when independent feeding was achieved. More research needs to be done to determine the cause of these relationships.

Lastly, this study found that receipt of dysphagia therapy was associated with higher PMA at independent oral feeding in the NICU. While receipt of dysphagia therapy likely benefits infants in achieving independent oral feeding, infants who are referred to therapy services are not necessarily going to achieve oral feeds sooner than infants who do not receive dysphagia therapy given that the infants who had received a dysphagia therapy referral had more medical risk factors. It is also likely that the medical risk factors also impacted oral feeding development. No association was found between the type of therapy referral and PMA at independent oral feeding in the NICU. Given that there was limited variability in the following predisposing behavioral factors: CPS involvement, homelessness, and maternal mental illness, these variables were grouped together in a sensitivity analysis. The sensitivity analysis revealed that the predisposing behavioral factors did not impact the results from the primary multiple linear regression model, thus making it robust. See Figure 3for a summary of major findings as it relates to Gelberg's Behavioral Model for Vulnerable Populations.

Figure 3

Summary of Findings Using the Behavioral Model for Vulnerable Populations

Infant Characteristics	**Use of Dysphagia Therapy Services**	**Feeding Outcomes**
Enabling • Socioeconomic: maternal employment • Community resources: distance • Maternal age *Need* • Lower gestational age, lower birthweight, higher medical complexity, having a history of mechanical ventilation, having respiratory conditions, longer length of stay, and higher PMA at discharge •	Receipt of dysphagia therapy referral	

Need • Lower gestational age, lower birthweight, having a history of mechanical ventilation, having respiratory conditions, longer lengths of stay, and higher PMA at discharge →	Automatic referrals	
Predisposing • Sociodemographic (infant race and ethnicity) *Enabling* → • Socioeconomic: insurance *Need* • Lower gestational age, higher medical complexity, history of mechanical ventilation, respiratory conditions, longer length of stay, and higher PMA at discharge	Higher number of therapy sessions	
Enabling • Socioeconomic: maternal employment • Community resources: distance → *Need* • Lower gestational age, lower birthweight, c-section delivery, higher medical complexity, history of mechanical ventilation, respiratory conditions, longer length of stay, and higher PMA at discharge		Higher PMA at independent oral feeding
	Receipt of dysphagia therapy referral →	Higher PMA at independent oral feeding

Major Implications

The first aim of this study was to determine the scope of dysphagia therapy in a Level IV NICU for preterm infants. About a third of premature infants admitted to the UCSF NICU received a dysphagia therapy referral and a majority of them were problem-based referrals, meaning that the referral was placed after the infant had already started orally feeding with the nursing staff and then a feeding and/or swallowing concern arose after. The number of therapy sessions ranged from zero to 25 with a median number of three therapy sessions. This contributes to the literature to further understand the provision of dysphagia therapy services in a Level IV NICU, as previous studies focused on therapy utilization only for infants who are already receiving developmental and dysphagia therapy services (OT, PT, and SLP) and their neurodevelopmental outcomes (Butera et al., 2023; Ross et al., 2017). This study specifically adds to the literature by looking at who gets dysphagia therapy referrals and whether they are automatic or problem-based referrals.

The second aim was to explore the association between infant characteristics and dysphagia therapy utilization and feeding outcomes. This study found that many need factors (gestational age, birthweight, medical complexity, history of mechanical ventilation, respiratory conditions, length of stay, PMA at discharge) were associated with receipt of dysphagia therapy referral, referral type, and number of treatment sessions. Butera et al. (2023) also found that those infants with higher risk for cerebral palsy received 0.12 more therapy sessions than infants who were at low risk for cerebral palsy. However, when looking at overall medical risk, Butera et al. (2023) did not find that it was associated with the number of therapy sessions. The difference may be due to the type of therapy services as Butera et al. (2023) looked at all therapy services (OT, PT, and SLP) whereas this study only specifically looked at dysphagia therapy services.

When looking at predisposing sociodemographic factors, previous literature found that there are racial and ethnic disparities (specifically for Black and Hispanic infants compared to other ethnic and racial backgrounds) for referral and receipt of services (Barfield et al., 2008; Feinberg et al., 2011; Hintz et al., 2019; Rosenberg et al., 2008), whereas this study did not find an association between race and ethnicity with the receipt of dysphagia therapy referral. This may be due to difference in practice setting as the studies previously cited focused on therapy follow up services after NICU discharge whereas this study looked at services while the infant was admitted in the NICU. In terms of number of therapy sessions, this study did find that infants who identified as Black, Hispanic, Other, and Multi-Race had more therapy sessions than infants who identified as White. Similarly, Butera et al. (2023) also found that White infants received less therapy sessions than non-White infants within a NICU setting.

Roberts et al. (2008) found that those with higher social risk, which is categorized by family structure, education of primary caregiver, occupation and employment status of primary income earner, primary language, and maternal age at birth, were less likely to receive early intervention therapy services despite having a referral in place. However, this study did not find an association between social risk factors such as maternal age at birth, family structure, employment status, and primary language, and therapy utilization. This may also be due to a difference in practice as Roberts et al. (2008) looked at therapy services within the community setting whereas this study specifically looked at dysphagia therapy services during the NICU admission. When a referral is placed within the community, it is possible that there may be other barriers (families' work schedules, transportation, etc.…) that prevent infants from receiving therapy services, as according to Gelberg's behavioral model, that discretionary utilization of healthcare services is described more by predisposing and enabling factors. Whereas within the hospital setting the utilization of healthcare services are non-discretionary and providers do not have to work around families' work schedules and transportation issues.

Different from Roberts et al. (2008) findings, this study also found that infants who also have Medi-Cal insurance had a higher number of treatment sessions than those who have private insurance. Insurance type has been found to be associated with poorer maternal and neonatal outcomes (Almli et al., 2017; El Ayadi et al., 2022). Thus, according to Almli et al. (2017) and El Ayadi et al. (2022), if infants with Medi-Cal insurance have more medical risk then it is possible that they were provided more therapy sessions. This contributes to the literature to further understand dysphagia therapy utilization in the context of different medical and social factors within a Level IV NICU.

Specifically, the feeding outcome that was examined was PMA at independent oral feeding, as there was not enough variability to explore the impact on GT placement. The need factors of gestational age, birthweight, history of mechanical ventilation, respiratory conditions, and delivery type were found to be associated with PMA at independent oral feeding. Similar to Brumbaugh et al. (2018), Gehle et al. (2022), Jackson et al. (2016), Park et al. (2015), and Van Nostrand et al. (2015), this study found that lower gestational age and birthweight negatively impacted feeding outcomes, as infants achieved independent oral feeding at a higher PMA. Similar to Anderson et al. (2022), Edwards et al. (2019), Gehle et al. (2022), Jackson et al. (2016), Muir et al. (2021), Park et al. (2015), and Van Nostrand et al. (2015), this study found that history of mechanical ventilation and presence of respiratory conditions negatively impact feeding outcomes. It is possible that infants who are on respiratory support for longer periods of time have experienced more negative orofacial stimulation and procedures, likely related to their medical complexity, delaying initiation of oral feeding. Similar to Van Nostrand et al. (2015), this study found that infants who were born by vaginal delivery had better feeding outcomes and achieved independent oral feeding at a lower PMA.

Predisposing factors were not found to be associated with PMA at independent oral feeding. Unlike Brumbaugh et al. (2018), Edwards et al. (2019), and Van Nostrand et al. (2015) this study did not find sex or race to impact feeding outcomes. This may be due to a difference in patient population based on location as Brumbaugh et al. (2018) and Edwards et al. (2019) looked at preterm infants across multiple hospitals and Van Nostrand et al. (2015) looked at preterm infants in a hospital in Illinois, whereas this study looked at preterm infants in a hospital located in San Francisco, California. Brumbaugh et al. (2018) and Edwards et al. (2019) also only looked at moderately preterm infants and Van Nostrand et al. (2015) looked at infants in a Level III NICU, whereas this study looked at all preterm infants in a Level IV NICU, which is a higher level of acuity.

The third aim was to explore the association between dysphagia therapy utilization and feeding outcomes while controlling for patient characteristics for preterm infants in the NICU. Similar to Ross et al. (2017), therapy utilization did not necessarily equate to better outcomes but that infants with higher medical complexities had more therapy referrals and number of therapy sessions. For the infants that did receive therapy referrals, the infants who are at higher risk for developmental and feeding delays (i.e. those at lower gestational ages and birthweights) were associated with receiving automatic referrals. Having automatic referrals compared to problem-based referrals did not necessarily impact feeding outcomes but this may be due to those infants that had automatic referrals are at higher risk for developmental and feeding delays, thus achieving independent oral feeding at a higher PMA. Future studies should group infants with similar risk factors (i.e. gestational age or birthweight) to determine if having an automatic or problem-based referrals impacts feeding outcomes.

The results from this study can impact the mechanism for referrals to dysphagia therapy such as timing of referrals and targeting infants that are most at risk for oral feeding issues given the identified infant characteristics associated with higher PMA at independent oral feeding. These findings can also help guide medical providers when making referrals and therapists when making recommendations, developing a plan of care, and advocating for the infants who would most benefit from therapy. This contributes to the knowledge base for best practices to improve feeding outcomes in premature infants.

Limitations

This study collected many confounding, intersecting, and complex variables in an attempt to isolate factors that impact feeding in preterm infants in the NICU. Secondary data was also used so reliability and accuracy of the data could be impacted. Because multiple comparisons were made, the study is at risk of Type I error and the ability to fully untangle this complex question is limited. However, the statistical model was optimized to address these risks by checking for multicollinearity.

Reliability of data could be impacted by how clinicians recorded information in the EMR, leading to missing data, incomplete data, or inaccurate data. These potential limitations were addressed during the data cleaning process by checking for accuracy (i.e. the data point may have been inputted incorrectly, miscalculated, or measured incorrectly). If the data was truly missing, then the case was removed. Data was transformed to meet the assumptions for each statistical analysis plan as needed.

Data from the EMR also has its limitations as certain information may be difficult to collect, such as interventions used and NG placement. Specific interventions used during the therapy session and duration of those interventions could impact the feeding outcomes. NG placement was also not collected as it was unclear if some infants were discharged with an NG, though it is not a common practice at UCSF. If infants were sent home with an NG or developed oral feeding difficulties after discharge, it is possible for infants to receive GT placement after they've been discharged from the NICU, in which that data was also not collected.

Data regarding the individuals involved in the care of the infant that could not be collected from the EMR is another limitation. Staffing and census data were not collected for this study. Decreased staffing or high census could impact the number of treatment sessions provided. Direct caregiver involvement in therapy sessions was also not collected. This could also impact the number of therapy sessions provided and feeding outcomes.

Given that UCSF is a large academic medical center in a metropolitan area that serves a diverse population, this study could be generalizable to similar institutions that have a Level IV NICU that serves a diverse population. This study subsample was found to not be reflective of the general population of San Francisco as the study subsample has a higher percentage of Black infants and lower percentage of Asian infants when compared to the San Francisco demographic makeup (see Table 19). However, it may not be generalizable to rural or isolated hospitals who may not have a Level IV NICU. It also may not be generalizable to other levels of NICUs.

Future Research

Future research should consider looking at factors that impact GT placement by using a larger sample size or looking at other NICUs that may have higher rates of GT placement to determine the cause of the difference in prevalence and if therapy utilization has an impact on it. To further explore if dysphagia therapy has an impact on feeding outcomes, future research should also look at other medical centers who may not have dysphagia therapists and determine if there is a difference in feeding outcomes based on the availability of dysphagia therapy services, which could also include staffing and frequency of therapy sessions. Infants could also be grouped based on medical complexity (such as by gestational age or birthweight) to determine whether providing dysphagia therapy services or referral type impact feeding outcomes. Lastly, future research could also further expand to look at all therapy services and include developmental outcomes.

Conclusion

This study explored factors that impact the provision of dysphagia therapy in a Level IV NICU. Gaining an understanding of the provision of dysphagia therapy could lead to earlier identification of populations that are at higher risk for delayed achievement of independent oral feeding and the creation of protocols for the referral process for those infants. More efficient pathways would help to optimize services for these infants leading to improved feeding outcomes and decreased length of stay. Further research is warranted to continue to address factors that impact neonatal feeding outcomes, length of stay, and ultimately, decrease healthcare costs.

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