2020

Impact of NICU Design on Feeding-Related Outcomes in Preterm Infants

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Digital Object Identifier: https://doi.org/10.13023/etd.2020.198

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IMPACT OF NICU DESIGN ON FEEDING-RELATED OUTCOMES IN PRETERM INFANTS

THESIS

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Communication Sciences and Disorders in the College of Health Sciences at the University of Kentucky

By

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2020

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ABSTRACT OF THESIS

IMPACT OF NICU DESIGN ON FEEDING-RELATED
OUTCOMES IN PRETERM INFANTS

Many NICUs around the country are moving away from traditional open-bay designs in favor of single-family rooms (SFRs) as more is understood about the impact of the sensory environment on neurodevelopment in preterm infants. SFRs house one infant and their family for the length of the infant's stay and are associated with improvements in numerous outcomes, including increased milk intake and weight gain and earlier transition to enteral feeding. Oral feeding remains a critical requirement for NICU discharge; however, the impact of NICU design on feeding outcomes remains unknown.

The purpose of this study was to compare feeding outcomes between infants cared for in an open-bay NICU and infants cared for in SFRs, via retrospective chart review. The primary outcome variable of interest was feeding-related length of stay (FRLOS). A secondary outcome measure was gestational age at first oral feeding.

The key findings from this study were no significant differences in either outcome measure between groups, suggesting that for relatively healthy preterm infants, NICU design has no significant impact on feeding-related length-of-stay or age at first oral feed. Infants progressed to full oral feeding at roughly the same rate whether cared for in an SFR or an open bay nursery.

KEYWORDS: NICU Design, Single-Family Rooms, Open-Bay NICU, Feeding Related Length-of-Stay, Low Birth Weight Infants

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04/10/2020

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ACKNOWLEDGEMENTS

While the following thesis is my own individual work, I owe my sincere thanks to everyone who has guided and supported me through the writing process.

First, I wish to thank my thesis chair, Dr. Gilson Capilouto. She is a brilliant teacher, clinician, and mentor who has both inspired and encouraged my interests in neonatology and pediatric feeding disorders. Dr. Capilouto constantly challenges each of her students by setting and maintaining the highest of standards, while providing the guidance and support necessary to fulfill them. It's been an incredible privilege to learn from and work with her.

Next, I would like to thank the other members of my thesis committee: Dr. Anne Olson and Dr. Jane Kleinert. Dr. Olson is an advocate and encourager and is quick to recognize passions in her students, to (lovingly) push us beyond our comfort zones, and to provide a listening ear whenever one is needed. Dr. Kleinert was the first to urge me, despite my own doubts, to pursue a thesis on the topic of infant feeding. She is a joy to be around and to learn from, and her enthusiasm for this profession is evident to all who interact with her. Their insights and feedback have been invaluable in the completion of my thesis. Each of these women has guided and encouraged me throughout this process, and I can't thank them enough for the roles they have played in shaping me as a student, a researcher, and a clinician. I am so grateful to have had such wonderful mentors as I finish my formal education and begin my career.

I would also like to thank Susan DeGraaff and Kentucky Children's Hospital who identified over 350 infants meeting our criteria and graciously provided us access to the information necessary to complete this study.

Finally, to my family (especially my mom): Thank you for being so selfless in your support of me, for challenging me when I become complacent, for being my loudest and proudest advocates, and for being a constant source of encouragement when I think I have nothing left to give. I wouldn't be where I am today without your ardent love and prayers.

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CHAPTER 1. INTRODUCTION

1.1 Background

According to the Centers for Disease Control and Prevention, 9.93% of babies born in the U.S. in 2017 were born preterm, and 8.28% were born low or very low birth weight. Both of these numbers mark an increase from the previous year, continuing a three-year trend of increases in low birth weight and premature births in the U.S. (Martin, Hamilton, Osterman, Driscoll, & Drake, 2018). These trends are in surprising opposition to decreased rates of multiple births, a statistic which usually correlates directly with the prematurity rate (Martin et al., 2018). The reason being that twins and other multiples are eight times more likely to be born preterm, thereby raising the overall prematurity rate (Martin & Osterman, 2018).

Other risk factors for premature birth and low birth weight include maternal history of premature births, poor prenatal care, insufficient weight gain during pregnancy, sexually transmitted infections, periodontal disease, drug and alcohol use during pregnancy, and use of fertility treatments. Premature birth is also more common among women younger than 17 and older than 35, women who are African American, and those from low socio-economic backgrounds (March of Dimes, 2018).

Low birth weight and prematurity are known to cause a number of complications including respiratory distress syndrome, fluid and electrolyte imbalances, apnea of prematurity, intraventricular hemorrhage, patent ductus arteriosus, poor thermoregulation or hypothermia, anemia, and increased susceptibility to infection

(Subramanian, Seo, Barton, & Montazami, 2014). Additionally, as many as 70% of preterm infants experience difficulties with oral feeding (Hawdon, Beauregard, Slattery, & Kennedy, 2000). Reasons for this include poor motor maturity, underdeveloped neural pathways, pathology of the respiratory and gastrointestinal systems, low tolerance for interaction, and unstable behavioral state organization (Jadcherla, 2019).

While advances in medicine and medical technology continue to improve outcomes for these babies, treatment and care typically require time in the neonatal intensive care unit (NICU) which is expensive and stressful for both babies and caregivers (Muraskas & Parsi, 2008). A single day in the NICU may cost upwards of $3500 and parents commonly report feelings of guilt, anxiety, depression, alienation, and lack of control (Muraskas & Parsi, 2008; Obeidat, Bond, & Callister, 2009). Recent studies have shown that having a child in the NICU can result in long-term post-traumatic stress disorder in caregivers (Clottey & Dillard, 2013).

These effects are compounded by the fact that in 2010, the average length of stay for an infant in the NICU was 13.2 days (March of Dimes, 2011). Further, for infants born at or before 32 weeks gestational age, the average hospital stay was estimated to last 46.2 days and resulted in charges of over $280,000 per baby (March of Dimes, 2011). Therefore, decreasing an infant's hospital length of stay is an important goal when providing care in the NICU. Many factors can impact the rate at which babies are able to meet the physiological and developmental milestones necessary for safe discharge home and the infant's sensory environment is thought to be one of the most important (Shahheidari & Homer, 2012).

NICUs have traditionally consisted of large rooms shared by multiple infants without walls or partitions between their isolettes. This design, called an open-bay NICU, can create a noisy, crowded environment and research has shown that in some cases such a design may inhibit maternal interaction and prevent families from spending the night with their infant (Dunn, MacMillan-York, & Robson, 2016). Yet, the open bay design has remained the standard for NICUs in the United States since the first one opened in 1960. Interestingly, hospitals have abandoned open bay design for many other inpatient areas (Stiller, Salm, Bischoff, & Gastmeier, 2016). Initially, the open-bay design for NICUs was considered necessary to facilitate easy communication among staff and allow quick access to and continuous monitoring of critically ill infants. However, modern technology has made it increasingly more possible to provide this same standard of care while allowing infants and their caregivers a quieter, more private environment during their stay (Shahheidari & Homer, 2012).

As our understanding about the impact of the sensory environment on a preterm neonate's brain growth and development has increased, many NICUs have started to retire the traditional open-bay design in favor of more single-family rooms (SFRs). SFRs are designed to house one infant and their family for the entire length of the infant's stay (Carlson, Walsh, Wergin, Schwarzkopf, & Ecklund, 2006; Dunn et al., 2016). A number of researchers have shown improvements in certain outcomes for infants cared for in SFRs as compared to open bay designs including increased milk intake, greater weight at discharge, and earlier transition to enteral feeding (Stevens et al., 2012; Vohr et al., 2017). However, other studies have suggested that open-bay NICUs may encourage faster maturation of neural structures and provide vital social interaction for infants whose families cannot be present (Pineda et al., 2014).

1.2 Statement of Problem

To be discharged from the NICU, The American Academy of Pediatrics advises that infants meet several physiologic milestones, including demonstration of competent oral feeding skills (American Academy of Pediatrics Committee on Fetus and Newborn, 2008). An extended time-to-transition from tube feeding to independent oral feeding means a longer hospital stay, greater medical costs, increased maternal and family stress, and an increased likelihood of developing oral feeding aversion (Lau, 2016). Given the importance of the sensory environment on the preterm infant's neural development and the number of hospitals NICUs moving toward SFRs, it is critically important to understand how NICU design may impact the rate at which infants meet the milestones required for discharge, including independent oral feeding. The impact of single-family room NICU design on feeding-related outcomes has yet to be investigated.

1.3 Purpose of Study

The aim of the present study was to compare feeding-related outcomes between a group of infants cared for in an open-bay NICU design and a matched group of infants cared for in single-family rooms. Results of this study will add to a growing body of literature examining the differences in infant outcomes between SFR versus open-bay NICU design.

CHAPTER 2. LITERATURE REVIEW

The following literature review summarizes what is currently known regarding:

1) Feeding issues in preterm and low birth weight infants
2) Factors affecting the transition to oral feeding
3) Feeding-related length of stay
4) Impact of SFR design on NICU outcomes

2.1 Feeding Issues in Preterm and Low Birth Weight Infants

Safe and efficient oral feeding in neonates requires synchrony between the parallel processes of sucking, swallowing, and breathing (known as the suck-swallow-breathe cycle) and functional interaction of the lips, jaw, tongue, palate, pharynx, larynx and esophagus (BuLock, Woolridge, & Baum, 1990; Jadcherla, 2019). This cycle involves the coordination of the swallowing mechanism and related musculature with the respiratory and digestive systems. While the swallow reflex can be observed in utero as early as 15 weeks gestation, swallow rhythm is not present until 32 weeks gestational age and is not regular or well-defined until 35 weeks (Rogers & Arvedson, 2005). Further, the respiratory and digestive systems are not considered mature until 36 and 38 weeks, respectively (Grand, Watkins, & Torti, 1976; Langston, Kida, Reed, & Thurlbeck, 1984).

In most healthy term infants, a coordinated suck-swallow is present at birth (Jadcherla, 2019). However, for preterm infants who are still developing, coordinating the suck-swallow-breathe cycle presents a significant challenge. In addition to immature respiratory and digestive systems, many preterm infants are exposed to a range of invasive but necessary treatments and procedures; both of which have the potential to interfere with these fragile systems. Examples include feeding via nasogastric tube, mechanical ventilation, and intubation (Crapnell et al., 2013). Studies show that 40% to 70% of preterm infants display immature and atypical oral feeding skills, primarily resulting from immature or underdeveloped anatomical structures, physiologic functions, and neurological structures and pathways (Burklow, McGrath, Valerius, & Rudolph, 2002; Jadcherla, 2019). Additionally, once the necessary structures and corresponding functions are developed, the infant must learn to coordinate the separate activities of sucking, swallowing, and breathing to feed safely and efficiently (BuLock et al., 1990).

2.1.1 Maturation of Sucking

Sucking may be classified as either nutritive or nonnutritive, with nutritive sucking (NS) involving the ingestion of milk or another fluid and nonnutritive sucking (NNS) involving no ingestion of fluid (Wolf & Glass, 1992). Both behaviors consist of two distinct phases: compression and expression. Compression involves tongue compression of the nipple against the hard palate to create positive pressure. Expression involves the lowering of the jaw, while maintaining a closed lip seal against the nipple, to create the negative intraoral pressure required to draw, or express, liquid into the mouth. (Wolf &

Glass, 1992). A mature suck involves coordinated alternation of these phases. However, infants displaying an immature suck (i.e. expression only) may still be able to feed safely depending on the method of feeding (Lau, 2016).

In bottle feeding, expression alone may be sufficient for an infant to complete a feeding (Wolf & Glass, 1992). However, for reasons unknown, this is not thought to be the case for breastfeeding. Lau (2016) speculates that the suction phase may be more important in breastfeeding since it also serves to help infants maintain their latch, an issue not encountered as frequently in bottle feeding where a latch is not entirely necessary to express milk. As such, breastfeeding may present a greater challenge to infants displaying immature suck patterns (Lau, 2016).

NS involves the ingestion of fluid and requires coordination of compression and expression with swallowing, respiration, and esophageal transport of the bolus. If coordination is not present, there is increased risk of fluid aspiration into the airway and/or inefficient esophageal transport (Lau, 2016). Simultaneously, the infant's nervous system is generating sensory feedback that alerts them as to whether they should continue feeding or need to stop to protect respiration (Pickler, Best, Reyna, Gutcher, & Wetzel, 2006). Current literature posits that the coordination of the suck-swallow-breathe cycle relies on central pattern generators (CPGs) located in the medulla, suggesting that safe and efficient NS will not be observed until these CPGs are mature (Amaizu, Shulman, Schanler, & Lau, 2008; Barlow & Estep, 2006; Jean, 2001). By contrast, NNS, which is confined to the oral cavity and does not involve fluid transport, does not rely on these CPGs and so matures earlier. For this reason NNS, while a good indicator of an infant's ability to suck, is not considered predictive of the infant's ability to feed safely and efficiently by mouth (Pickler et al., 2006).

2.1.2 Maturation of Swallowing

Suck-swallow-breathe coordination is significantly more challenging for preterm infants compared to term infants because of underdeveloped musculature and immature neural pathways. Another challenge is the fact that preterm babies do not have as many opportunities to practice swallowing in utero. At birth, term infants will have had approximately 18 weeks of practice swallowing amniotic fluid in amounts of up to 1,000mL per day (Miller, Sonies, & Macedonia, 2003; M. G. Ross & Nijland, 1998). In contrast, preterm infants will have had significantly fewer weeks for practice depending on how early they are born.

Safe and efficient swallowing involves three phases: oral, pharyngeal, and esophageal. While each of these is distinct and involves separate musculature, a disruption or delay in any one phase can interrupt the swallow process, increasing the risk of adverse events such as choking, aspiration, and respiratory disruptions (Lau, 2012; Wolf & Glass, 1992). Each phase is described below.

Oral Phase

The oral phase of the swallow involves compression and expression of fluid from the nipple followed by lingual transport of the fluid. (Wolf & Glass, 1992) The tongue seals the oral cavity to produce the positive and negative pressures necessary for compression and expression and works in conjunction with the lips, jaw, soft palate and hard palate to obtain the volume of fluid necessary to initiate the swallow (da Costa, van den Engel-Hoek, & Bos, 2008).

Aside from the development of mature and typical suck patterns, there are several other components to the oral phase which impact an infant's ability to feed safely and efficiently and develop as the infant develops. With maturation and practice infants can handle larger bolus volumes because of greater tongue strength and increased ability to propel a bolus posteriorly toward the pharynx (Selley, Ellis, Flack, & Brooks, 1990). Swallow rate also increases as infants mature, as does their ability to form and hold a bolus in the oral cavity prior to swallowing, resulting in safer and more efficient suck-swallow interaction (Lau, Smith, & Schanler, 2003; Omari et al., 1999).

Pharyngeal Phase

The pharyngeal phase of the swallow begins when the bolus reaches the posterior pharyngeal wall which triggers the swallow reflex. From this point the movement of the bolus through the pharynx relies on swift and efficient pharyngeal contraction and peristalsis (Lau, 2016).

Infants born preterm display weaker peak pharyngeal pressures as compared to term infants (Omari et al., 1999). Preterm infants are also more likely to experience discoordination between pharyngeal peristalsis and the opening of the upper esophageal sphincter (UES), leading to retention of material within the pharynx and possibly aspiration of that material after the swallow (Rommel et al., 2011)

Esophageal Phase

Once the bolus enters the esophagus, the muscles of the esophagus contract in waves called peristalsis. Peristaltic waves may be anterograde or retrograde in nature. Anterograde waves move the bolus "forward," or downward toward the stomach. Retrograde waves move the bolus "backward," or upward toward the pharynx. Nonperistaltic contractions may also be observed (Omari et al., 1999). Strong and timely anterograde peristaltic waves are required to move a bolus efficiently through the esophagus and into the stomach, and to avoid reflux and regurgitation (Lau, 2016).

For preterm infants, nonperistaltic contractions predominate peristaltic contractions contributing to poor esophageal clearance (Omari et al., 1999) A disproportionate amount of retrograde contraction is also observed, leading to higher instances of reflux and regurgitation as compared to term infants (Lau, 2016). As an infant matures, the occurrence of nonperistaltic contractions and retrograde peristalsis decrease and anterograde peristalsis increases, resulting in a more mature esophageal swallow (Omari et al., 1995).

2.1.3 Frequency and Quality of Opportunities

Historically, the perspective regarding development of competent oral feeding has been that it will improve with time and is driven by central nervous system maturation. However, recent research has highlighted the fact that allowing infants ample opportunities to practice feeding is equally important (Tubbs-Cooley, Pickler, & Meinzen-Derr, 2015). Tubbs-Cooley and colleagues (2015) found a direct correlation between proportion of missed oral feeding opportunities, transition time to full oral feeding, and hospital length of stay. They reported that the higher proportion of oral feeding opportunities an infant missed, the longer they took to transition to oral feeding and the longer their hospital stay. Consistent with this finding, Pickler and Reyna (2003) found that the more bottles an infant was offered each day, the fewer days they took to transition to full oral feeding.

2.2 Factors Affecting the Transition to Oral Feeding

During their stay in the NICU, many preterm infants require invasive treatments and procedures such as intubation and mechanical ventilation, frequent suctioning, and long-term use of orogastric or nasogastric feeding tubes (Malcolm, 2014). Unfortunately, these interventions, while medically necessary, often contribute to feeding problems in neonates, especially those who are particularly fragile or medically complex (Crapnell et al., 2013). There are also non-interventional factors which can impact a preterm infant's ability and desire to feed which may not be a factor for healthy term infants learning to feed. These include medical complexity, behavioral state organization, exposure to aversive oral feeding experiences, and extent of family presence and involvement in care.

2.2.1 Medical Complexity

Preterm infants are more likely than their term counterparts to experience significant medical and developmental sequelae, any of which may have a profound impact on oral feeding skills (Burklow et al., 2002). Respiratory challenges, including underdeveloped lung structures and low amounts of surfactant, are common among preterm infants. These infants tend to be the most negatively affected due to the need to suppress breathing during swallowing to protect the airway. Further, oxygen supplementation can contribute to oral sensory deprivation and a restriction in range and type of oral movements, limiting the development of areas of the brain critical for oral feeding (Stumm et al., 2007). Many preterm infants also experience significant gastrointestinal issues which can increase episodes of reflux and emesis following oral intake and delaying their ability to begin oral feeding. (Jadcherla, 2016)

2.2.2 Behavioral State Organization

Brazelton and Nugent (1995) described six behavioral states or states of consciousness through which infants cycle: deep sleep, light sleep, drowsiness, quiet alert, active alert, and crying. These states are defined according to body activity levels, movements of the eyes and face, regularity of respiration, vocalization, and responsiveness to stimuli. Healthy term infants display distinct periods of sleep and wakefulness and are able to transition smoothly between states (Foreman, Thomas, & Blackburn, 2008). In contrast, preterm infants have a difficult time transitioning between states due to an immature central nervous system which is reflected in the instability of sleep-wake states and lack of sleep cycling (Foreman et al., 2008). As infants mature and their ability to self-regulate increases, they are able to transition more smoothly between states, spend more time in states of wakefulness, and display longer periods of sleep (Griffith, Rankin, & White-Traut, 2017). This is an important prefeeding skill, as there is a strong relationship between behavioral state and oral feeding efficiency (Pickler, Best, Reyna, Wetzel, & Gutcher, 2005).

Pickler (2005) and Griffith (2017) both found that alert states prior to feeding are strong predictors of oral feeding efficiency. Robust alertness has also been shown to correlate with shorter transition to oral feeding and may serve to prepare infants to remain alert for the duration of a feeding; a necessary skill for safe and efficient oral feeding (McGrath & Medoff-Cooper, 2002). Infant crying, typically regarded as a late hunger cue, has also been shown to correlate with greater oral feeding efficiency and may actually be a stronger predictor of efficient feeding than awake state (Griffith et al., 2017).

2.2.3 Exposure to Aversive Oral Feeding Experiences

Many of the invasive medical treatments necessary to sustain life for preterm infants can compromise their progress in oral feeding by delaying the start of oral feeds, the need to alter the way they are fed, and limiting the number of positive oral feeding experiences they have (Crapnell et al., 2013). Such treatments include intubation and mechanical ventilation, frequent suctioning, and long-term use of orogastric or nasogastric feeding tubes. (Malcolm, 2014) Infants may also develop an oral aversion to feeding because of other experiences, including forced oral feedings and the incidence of adverse events during oral feeding such as choking, reflux, apnea, and bradycardia (Rudolph & Link, 2002).

Repeated adverse events associated with oral feeding may lead to infants resisting or refusing other stimuli around their mouth and face which impedes their ability to feed orally and necessitates continued enteral feeding (Rudolph & Link, 2002). Oral aversions are more common in preterm infants and other NICU populations, as compared to healthy term infants, due to the medical complexity associated with prematurity and the increased need for intubation, ventilation, and tube feedings (Malcolm, 2014).

2.2.4 Amount of Family Presence and Involvement in Care

The relationship of parent-child interaction on developmental outcomes is well understood, and for preterm infants, this relationship begins in the NICU. Parent presence and involvement in NICU care has been shown to mitigate feelings of helplessness and anxiety in parents and improve the ability of the infant to cope with stressors associated with NICU care (Pineda et al., 2018). Infants who are held skin-to-skin demonstrate short-term and long-term outcomes including better reflex development and less asymmetry at term and better gross motor development at 4-5 years old (Pineda et al., 2018). Skin-to-skin contact, or "kangaroo care," has also been shown to increase ability for state regulation, decrease stress behavior, and improve overall organization of the neurobehavioral system(Ohgi et al., 2002).

Greater amounts of family presence and involvement in care have also been associated with improved feeding-related outcomes. Parent presence, holding in arms, and skin-to-skin care are all associated with improved weight gain and greater breastmilk intake at discharge (Pineda et al., 2018). Parent involvement in care is also associated with greater weight gain and increased exclusive breastfeeding (O’Brien et al., 2018).

2.3 Feeding-Related Length of Stay

Length of stay (LOS) is considered an important metric for determining effective care practice in the NICU. The idea is that the shorter the length of stay, the higher the likelihood that a particular care practice has been effective. For the purposes of this study, the interest was specifically in feeding-related length of stay (FRLOS). FRLOS was defined as the number of days that lapsed from an infant's first oral feed (minimum 3-5mL) to the day of discharge when they were consuming all feedings by mouth. FRLOS is an effective measure of the timeliness of an infant's transition to oral feeding since it correlates closely with the maturity of an infant's nutritive suck, as measured by NS frequency and suck smoothness (Capilouto, Cunningham, Giannone, & Grider, 2019).

2.4 Impact of SFR Design on NICU Outcomes

The first studies investigating the differences between SFRs and open-bay NICUs outlined two major advantages of SFR NICUs for infants: greater protection against nosocomial infections and increased interaction between parents and their infants (White, 2010). Benefits for families included increased parental satisfaction, more active participation in medical discussions, and greater competence in caring for their infant. Differences have also been found between SFR and open-bay NICUs with respect to infant medical outcomes and hospital course. A randomized control trial conducted in Sweden found that infants cared for in SFRs experienced shorter stays and reduced risk of pulmonary morbidity than those cared for in an open-bay ward. (Ortenstrand et al., 2010).

The studies also identify several challenges for SFR NICUs, including higher construction and maintenance costs as compared to open-bay NICUs, a decrease in the ease with which nurses could communicate with families and other nurses, and fewer opportunities for interaction among families (White, 2010). Pineda et al. (2014) suggested that SFRs also inhibit neurodevelopment as evidenced by lower cerebral maturation scores at term gestational age and lower language and motor scores based on standardized testing at 2 years.

CHAPTER 3. METHODS

3.1 Methods

This study was a retrospective chart review conducted at a tertiary level academic medical center with a Level IV Neonatal Intensive Care Unit (NICU). Participants included infants admitted to the to the NICU between April 2017 and April 2019. The study was approved by the Institutional Review Board where the work was carried out.

Based on previously published work (Capilouto, et al., 2019), power analysis revealed a sample size of 60 subjects per group (non-randomized) would be required for 80% power to detect a statistically significant difference (two-tailed hypothesis; set at $p \leq .05$) between groups.

3.2 Participants

The study population included 120 infants born with low birth weight (1500-2499 grams). Neonates in the study included those cared for in an open-bay NICU (OBG; *N* = 60) and those cared for in a single-family room (SFG; *N* = 60). Infants were excluded from the study if they had anomalies or disorders known to interfere with feeding (e.g. cleft lip and/or palate), congenital disorders, chromosomal abnormalities or major congenital anomalies, known perinatal exposure to toxic substances, a history of intraventricular hemorrhage greater than Grade II or history of white matter disease such as PVL.

The Neonatal Medical Index (NMI), a comorbidity index, was used to further ensure that the two groups were as homogenous as possible. Infants receiving an NMI score of 3 or 4 were excluded, as these scores indicated prolonged time on oxygen or ventilation which is known to interfere with feeding. Demographic variables and population characteristics of interest for the study population are presented in Table 1 and Table 2.

Table 1: Means (standard deviations) of variables of interest

VARIABLE	POPULATION (N = 120)	
	Open Bay Group (n = 60)	SFR Group (n = 60)
M:F[1]	34:26	32:28
GESTATIONAL AGE (WEEKS)	34.6 (1.6)	35.1 (1.6)
BIRTHWEIGHT (GRAMS)	2063 (296)	2075 (277)
NMI SCORE[2]	1 = 26; 2 = 34	1 = 27; 2 = 33
INCIDENCE OF C-SECTION	29	40
FRLOS[3] (DAYS)	9 (5.6)	8.4 (5.3)
GA AT FIRST ORAL FEEDING[4]	35.2 (1.5)	35.3 (1.4)

[1]Male to female ratio; [2]Neonatal Medical Index Score; [3]Feeding related length of stay calculated from the date of first oral feeding to the date of discharge; [4]Gestational age at first oral feeding

Table 2: Frequency (percent) of race, by population

RACE	POPULATION (N = 120)	
	Open Bay Group (n = 60)	SFR Group (n = 60)
WHITE	45 (75)	49 (81.6)
BLACK	7 (11.7)	7 (11.7)
BIRACIAL	2 (3.3)	0 (0)
HISPANIC	5 (8.3)	1 (1.7)
ASIAN	0 (0)	3 (5)
OTHER	1 (1.7)	0 (0)

3.3 Procedures

Discharge summaries were used to collect the data of interest. For data that was not included in discharge summaries or in cases where information was unclear, progress notes were also used. If necessary information was not explicitly stated anywhere in the chart, such as the date of an infant's first oral feeding, the infant was excluded from the study. Infants included in the study were then matched based on gender and birthweight.

To meet the aims of the study, the following data were collected: gender, race, date of birth, date of discharge, gestational age, birthweight, and delivery method. Additional measures used to calculate NMI score were also collected, including use of assisted ventilation; days on oxygen; and history of apnea or bradycardia, patent ductus arteriosus, meningitis, or seizures.

The primary outcome variable of interest was feeding-related length of stay (FRLOS). FRLOS was calculated from the date of the first oral feeding to the date of discharge. The secondary outcome measure was gestational age at first oral feeding.

3.4 Statistical Analysis

All data were analyzed using SPSS Version 23. Statistical significance was set at $p \leq .05$. Sample population characteristics were analyzed using one-way univariate analysis of variance. Multiple regression analysis was used to evaluate the differences in FRLOS and age at first oral feeding between groups.

CHAPTER 4. RESULTS

Analyses indicated a significant difference in the incidence of C-section deliveries between groups ($p < .05$); infants in the single room group were significantly more likely to be born via C-section as compared to infants in the open bay group. No other comparisons were significant.

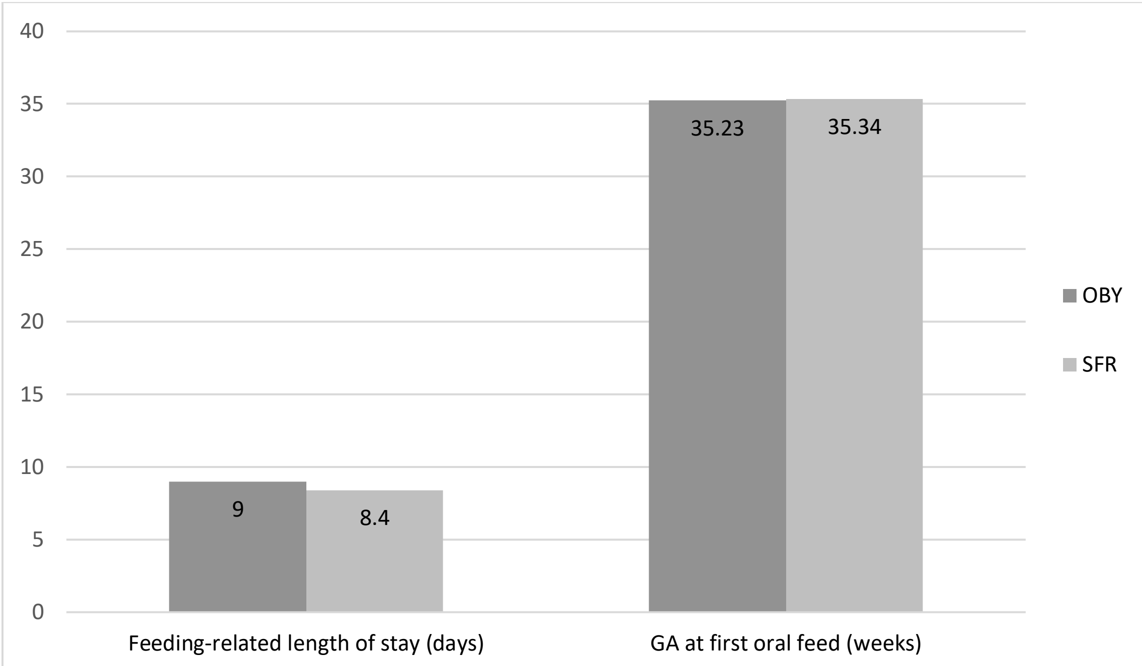
Table 3: Comparison of means (ONEWAY ANOVA) of variables of interest

VARIABLE	*F* (1, 118)	*P*-VALUE
M:F[1]	1.193	.277
GESTATIONAL AGE (WEEKS)	.161	.689
BIRTHWEIGHT (GRAMS)	.058	.810
RACE	.638	.426
NMI SCORE[2]	.033	.856
INCIDENCE OF C-SECTION	4.202	.043*
FRLOS[3]	.352	.554
GA AT FIRST ORAL FEEDING[4]	.151	.698

[1]Male to female ratio; [2]Neonatal Medical Index Score; [3]Feeding related length of stay calculated from the date of first oral feeding to the date of discharge; [4]Gestational age at first oral feeding

Post hoc multiple regression analyses were used to determine between-group differences in the outcome variables of interest (gestational age at first oral feeding and FRLOS), after adjusting for the incidence of C-section. Results indicated no significant difference between groups for gestational age at first oral feed (p = .582) or FRLOS (p = .793) after adjusting for the differences in incidence of C-section.

Figure 1: Comparison of means of outcome variables



CHAPTER 5. DISCUSSION

5.1 Discussion

The key findings from this study were no significant differences in the primary or secondary outcomes of interest between groups. The results suggest that for relatively healthy preterm infants (i.e. birthweight >1500g, minimal need for respiratory support, no major comorbidities), NICU design does not seem to be a factor in feeding-related length of stay or age at first oral feed. These results are in contrast to the extant literature on NICU design, which has suggested that SFRs may be associated with poorer developmental and feeding-related outcomes. Studies such as those by Pickler (2013) and Ortenstrand (2010) suggest that the benefits of SFRs are largely limited to clinical outcomes and satisfaction of caregivers and staff.

The results of this study suggest that infants progress to full oral feeding at roughly the same rate in an SFR NICU as compared to an open bay NICU. This is interesting given the findings of Pineda et al. (2014) which reported that SFRs may slow neurodevelopment in infants, delaying their achievement of developmental milestones. The results here would challenge that conclusion since there were no significant differences between groups in the neurodevelopmental milestone of full oral feeding.

The fact that the LBW infants in this study did not progress to full oral feeds any slower in an SFR NICU than in an open bay is encouraging. The finding suggests that infants in the SFR group are not missing significantly more oral feeding opportunities; a reasonable possibility given the greater work involved in feeding multiple infants at the same time when they are not located in the same room. It also suggests that the paucity of social interaction inherent in SFRs is not significant enough to impact neurodevelopment related to feeding. This is especially important for the facility where the study was conducted since the population it serves represents a large geographical region. As such, many families must return home before their infants are discharged from the NICU and are limited by time and resources in their ability to visit regularly during their infant's stay.

Some researchers have suggested that infants are able to tolerate enteral feedings earlier in SFRs than open bay NICUs (Domanico, Davis, Coleman, & Davis, 2011). This was not investigated in the current study; however, no significant difference was found between groups in the age at which infants transitioned to oral feeding. Thus, earlier transitions to enteral feeding may simply reflect an earlier introduction of enteral feeding rather than a greater tolerance on the part of the infant. Further, this same study did not find significant differences in length of stay between the SFR group and the open-bay group (Domanico et al., 2011).

These results, though encouraging, must be taken with caution as previous research has shown that feeding outcomes at NICU discharge are not necessarily predictive of continued feeding outcomes (E. S. Ross & Browne, 2013). Ross and Brown (2013) found that even for infants who appear to have adequate feeding skills at discharge, feeding difficulties often become more apparent in the first two years of life. This is especially true as children are introduced to a greater variety of food types and textures and the process of feeding and swallowing becomes more complex.

5.2 Study Strengths and Limitations

The fact that the infants included in the study were of low birth weight and relatively healthy limits the generalizability of the findings. The nature of the study population may have impacted key findings, as NICU design may play a larger role in feeding outcomes for smaller, sicker infants whose motor and sensory systems are more profoundly impacted by their environments. Additionally, the hospital where the work was carried out transitioned completely from an open-bay NICU to a single-family room design, so infants were not truly randomized.

Another limitation of the current study is the fact that caregiver presence could not be accounted for since this information is not typically recorded in the EMR. The only information regarding caregiver presence was specifically related to the completion of required caregiver education at discharge. Consequently, it is difficult to know the extent to which outcomes of the study were influenced by the degree of interaction each infant had with their caregiver(s).

5.3 Future Directions

To improve generalizability of outcomes, future studies should include more complex and medically fragile infants, including those who are very low birth weight and extremely low birth weight and those who have higher levels of comorbidity. Conducting future studies as randomized control trials rather than retrospective chart reviews would further improve generalizability and allow for greater control of possible confounding factors.

Future studies should investigate parent confidence in infant feeding, as it may differ significantly between SFR and open-bay groups. Given the inherent differences in interaction with and availability of NICU staff and proximity to other NICU parents, the quality and/or amount of parent education and peer support may vary greatly between environments, potentially leading to differences in infant feeding outcomes. Studies should also collect long-term follow-up data for both groups to track rates of continued feeding difficulties, the emergence of new feeding difficulties when transitioning to new feeding stages, and rates of referrals for feeding services in infancy and toddlerhood.

REFERENCES

Amaizu, N., Shulman, R. J., Schanler, R. J., & Lau, C. (2008). Maturation of oral feeding skills in preterm infants. *Acta Paediatrica, 97*, 61-67. doi:10.1111/j.1651-2227.2007.00548.x

American Academy of Pediatrics Committee on Fetus and Newborn. (2008). Hospital discharge of the high-risk neonate. *Pediatrics, 122*(5), 1119-1126. doi:10.1542/peds.2008-2174

Barlow, S. M., & Estep, M. (2006). Central pattern generation and the motor infrastructure for suck, respiration, and speech. *Journal of Communication Disorders, 39*, 366-380. doi:10.1016/j.jcomdis.2006.06.011

Brazelton, T. B., & Nugent, J. K. (1995). Neonatal Behavioral Assessment Scale. In (3rd ed.). London: Mac Keith Press.

BuLock, F., Woolridge, M., & Baum, J. D. (1990). Development of co-ordination of sucking, swallowing and breathing: ultrasound study of term and preterm infants. *Developmental Medicine and Child Neurology, 32*, 669-678. doi:10.1111/j.1469-8749.1990.tb08427.x

Burklow, K. A., McGrath, A. M., Valerius, K. S., & Rudolph, C. (2002). Relationship between feeding difficulties, medical complexity, and gestational age. *Nutrition in Clinical Practice, 17*(6), 373-378. doi:10.1177/0115426502017006373

Capilouto, G. J., Cunningham, T. J., Giannone, P. J., & Grider, D. (2019). A comparison of the nutritive sucking performance of full term and preterm neonates at hospital discharge: A prospective study. *Early Human Development, 134*, 26-30. doi:10.1016/j.earlhumdev.2019.05.007

Carlson, B., Walsh, S., Wergin, T., Schwarzkopf, K., & Ecklund, S. (2006). Challenges in design and transition to a private room model in the neonatal intensive care unit. *Advances in Neonatal Care, 6*(5), 271-280. doi:10.1016/j.adnc.2006.06.008

Clottey, M., & Dillard, D. M. (2013). Post-traumatic stress disorder and neonatal intensive care. *International Journal of Childbirth Education, 28*, 23-29.

Crapnell, T. L., Rogers, C. E., Neil, J. J., Inder, T. E., Woodward, L. J., & Pineda, R. G. (2013). Factors associated with infant feeding difficulties in the very preterm infant. *Acta Paediatrica, 102*(12), 539-545. doi:10.1111/apa.12393.

da Costa, S. P., van den Engel-Hoek, L., & Bos, A. F. (2008). Sucking and swallowing in infants and diagnostic tools. *Journal of Perinatology, 28*(4), 247-257. doi:10.1038/sj.jp.7211924

Domanico, R., Davis, D. K., Coleman, F., & Davis, B. O. (2011). Documenting the NICU design dilemma: comparative patient progress in open-ward and single family room units. *Journal of Perinatology, 31*, 281-288. doi:10.1038/jp.2010.120

Dunn, M. S., MacMillan-York, E., & Robson, K. (2016). Single family rooms for the NICU: pros, cons, and the way forward. *Newborn and Infant Nursing Reviews, 16*, 218-221. doi:10.1053/j.nainr.2016.09.011

Foreman, S. W., Thomas, K. A., & Blackburn, S. T. (2008). Preterm Infant State Development: Individual and Gender Differences Matter. *Journal of Obstetric,* *Gynecologic, & Neonatal Nursing, 37*(6), 657-665. doi:10.1111/j.1552-6909.2008.00292.x

Grand, R. J., Watkins, J. B., & Torti, F. M. (1976). Development of the human gastrointestinal tract: a review. *Progress in Gastroenterology, 70*(5), 790-810.

Griffith, T., Rankin, K., & White-Traut, R. (2017). The Relationship between Behavioral States and Oral Feeding Efficiency in Preterm Infants. *Advances in Neonatal Care, 17*(1), E12-E19. doi:10.1097/ANC.0000000000000318.

Hawdon, J. M., Beauregard, N., Slattery, J., & Kennedy, G. (2000). Identification of neonates at risk of developing feeding problems in infancy. *Developmental Medicine and Child Neurology, 42*, 235-239.

Jadcherla, S. (2016). Dysphagia in the high-risk infant: potential factors and mechanisms. *American Journal of Clinical Nutrition, 103*, 622S-628S.

Jadcherla, S. (2019). Neonatal oral feeding difficulties due to sucking and swallowing disorders. In *UpToDate*. Retrieved from https://www.uptodate.com/contents/neonatal-oral-feeding-difficulties-due-to-sucking-and-swallowing-disorders

Jean, A. (2001). Brain stem control of swallowing: neuronal network and cellular mechanisms. *Brain stem control of swallowing: neuronal network and cellular mechanisms, 81*(2), 929-969. doi:10.1152/physrev.2001.81.2.929

Langston, C., Kida, K., Reed, M., & Thurlbeck, W. (1984). Human lung growth in late gestation and in the neonate. *The American Review of Respiratory Disease, 129*(4), 607-613.

Lau, C. (2012). Development of oral feeding skills in the preterm infant. In *Handbook of Growth and Growth Monitoring in Health and Disease* (pp. 499-512). New York, NY: Springer.

Lau, C. (2016). Development of infant oral feeding skills: what do we know? *American Journal of Clinical Nutrition, 103*(2), 616-621. doi:10.3945/ajcn.115.109603

Lau, C., Smith, E. O., & Schanler, R. J. (2003). Coordination of suck-swallow and swallow respiration in preterm infants. *Acta Paediatrica, 92*(6), 721-727. doi:10.1111/j.1651-2227.2003.tb00607.x

Malcolm, W. F. (2014). Feeding Issues in the NICU Graduate. In *Beyond the NICU: Comprehensive Care of the High-Risk Infant*: McGraw-Hill Education.

March of Dimes. (2011). *Special Care Nursery Admissions*. Retrieved from https://www.marchofdimes.org/peristats/pdfdocs/nicu_summary_final.pdf

March of Dimes. (2018). Preterm Labor and Premature Birth: Are You at Risk? Retrieved from https://www.marchofdimes.org/complications/preterm-labor-and-premature-birth-are-you-at-risk.aspx

Martin, J. A., Hamilton, B. E., Osterman, M. J. K., Driscoll, A. K., & Drake, P. (2018). *Births: Final Data for 2017*. Retrieved from https://www.cdc.gov/nchs/fastats/birthweight.htm

Martin, J. A., & Osterman, M. J. K. (2018). *Describing the Increase in Preterm Births in the United States, 2014–2016* (no. 312). Retrieved from https://www.cdc.gov/nchs/data/databriefs/db312.pdf

McGrath, J. M., & Medoff-Cooper, B. (2002). Alertness and feeding competence in extremely early born preterm infants. *Newborn and Infant Nursing Reviews, 2*(3), 174.

Miller, J. L., Sonies, B. C., & Macedonia, C. (2003). Emergence of oropharyngeal, laryngeal and swallowing activity in the developing fetal upper aerodigestive tract: an ultrasound evaluation. *Early Human Development, 71*, 61-87.

Muraskas, J., & Parsi, K. (2008). The cost of saving the tiniest lives: NICUs versus prevention. *Journal of Ethics, 10*(10), 655-658. doi:10.1001/virtualmentor.2008.10.10.pfor1-0810

O'Brien, K., Robson, K., Bracht, M., Cruz, M., Lui, K., & Alvaro, R. (2018). Effectiveness of Family Integrated Care in neonatal intensive care units on infant and parent outcomes: a multicentre, multinational, cluster-randomised controlled trial. *Child and Adolescent Health, 2*(4), 245-254. doi:10.1016/S2352-4642(18)30039-7

Obeidat, H. M., Bond, E. A., & Callister, L. C. (2009). The parental experience of having an infant in the newborn intensive care unit. *The Journal of Perinatal Education, 18*, 23-29. doi:10.1624/105812409X461199

Ohgi, S., Fukuda, M., Moriuchi, H., Kusumoto, T., Akiyama, T., PhD, J. K. N., . . . Saitoh, H. (2002). Comparison of Kangaroo Care and Standard Care: Behavioral Organization, Development, and Temperament in Healthy, Low-Birth-Weight Infants Through 1 Year. *Journal of Perinatology, 22*, 374-379. doi:10.1038/sj.jp.7210749

Omari, T., Miki, K., Fraser, R., Davidson, G., Haslam, R., Goldsworthy, W., . . . Dent, J. (1995). Esophageal body and lower esophageal sphincter function in healthy premature infants. *Gastroenterology, 109*(6), 1757-1764. doi:10.1016/0016-5085(95)90741-6

Omari, T., Snel, A., Barnett, C., Davidson, G., Haslam, R., & Dent, J. (1999). Measurement of upper esophageal sphincter tone and relaxation during swallowing in premature infants. *American Journal of Physiology, 277*(4), G862-866. doi:10.1152/ajpgi.1999.277.4.G862

Ortenstrand, A., Westrup, B., Broström, E. B., Sarman, I., Akerström, S., Brune, T., . . . Waldenström, U. (2010). The Stockholm neonatal family centered care study: effects on length of stay and infant morbidity. *Pediatrics, 125*(2), 278-285. doi:10.1542/peds.2009-1511

Pickler, R. H., Best, A. M., Reyna, B. A., Gutcher, G., & Wetzel, P. A. (2006). Predictors of nutritive sucking in preterm infants. *Journal of Perinatology, 26*(11), 693-699. doi:10.1038/sj.jp.7211590

Pickler, R. H., Best, A. M., Reyna, B. A., Wetzel, P. A., & Gutcher, G. R. (2005). Prediction of feeding performance in preterm infants. *Newborn and Infant Nursing Reviews, 5*(3), 116-123.

Pickler, R. H., McGrath, J., Reyna, B., Tubbs-Cooley, H., Best, A., Lewis, M., . . . Wetzel, P. (2013). Effects of the neonatal intensive care unit environment on preterm infant oral feeding. *Research and Reports in Neonatology, 2013*(3), 15-20. doi:10.2147/RRN.S41280

Pickler, R. H., & Reyna, B. A. (2003). A Descriptive Study of Bottle-Feeding Opportunities in Preterm Infants. *Advances in Neonatal Care, 3*(3), 139-146. doi:10.1016/S1536-0903(03)00074-2

Pineda, R. G., Bender, J., Hall, B., Shabosky, L., Annecca, A., & Smith, J. (2018). Parent participation in the neonatal intensive care unit: Predictors and relationships to neurobehavior and developmental outcomes. *Early Human Development, 117*, 32-38. doi:10.1016/j.earlhumdev.2017.12.008

Pineda, R. G., Neil, J., Dierker, D., Smyser, C. D., Wallendorf, M., Kidokoro, H., . . . Inder, T. (2014). Alterations in brain structure and neurodevelopmental outcome in preterm infants hospitalized in different neonatal intensive care unit environments. *The Journal of Pediatrics, 164*(1), 54-62. doi:10.1016/j.jpeds.2013.08.047

Rogers, B., & Arvedson, J. (2005). Assessment of infant oral sensorimotor and swallowing function. *Mental Retardation and Developmental Disabilities Research Reviews, 11*, 74-82. doi:10.1002/mrdd.200557

Rommel, N., Wijk, M. v., Boets, B., Hebbard, G., Haslam, R., Davidson, G., & Omari, T. (2011). Development of pharyngo-esophageal physiology during swallowing in the preterm infant. *Neurogastroenterology and Motility, 23*(10), 401-408. doi:10.1111/j.1365-2982.2011.01763.x.

Ross, E. S., & Browne, J. V. (2013). Feeding Outcomes in Preterm Infants After Discharge From the Neonatal Intensive Care Unit (NICU): A Systematic Review. *Newborn and Infant Nursing Reviews, 13*(2), 87-93. doi:10.1053/j.nainr.2013.04.003

Ross, M. G., & Nijland, M. J. M. (1998). Development of ingestive behavior. *American Journal of Physiology*, R879-893.

Rudolph, C. D., & Link, D. T. (2002). Feeding disorders in infants and children. *Pediatric Gastroenterology and Nutrition, 49*, 97-112. doi:10.1016/S0031-3955(03)00110-X

Selley, W. G., Ellis, R. E., Flack, F. C., & Brooks, W. A. (1990). Coordination of sucking, swallowing and breathing in the newborn: Its relationship to infant feeding and normal development. *International Journal of Language and Communication Disorders, 25*(3), 311-327. doi:10.3109/13682829009011980

Shahheidari, M., & Homer, C. (2012). Impact of the design of neonatal intensive care units on neonates, staff, and families. *Journal of Perinatal and Neonatal Nursing, 36*(3), 260-266. doi:10.1097/JPN.0b013e318261ca1d

Stevens, D. C., Helseth, C. C., Thompson, P. A., Pottala, J. V., Khan, M. A., & Munson, D. P. (2012). A comprehensive comparison of open-bay and single-family-room neonatal intensive care units at sanford children's hospital. *Health Environments Research & Design Journal, 5*(4), 23-39. doi:10.1177/193758671200500403

Stiller, A., Salm, F., Bischoff, P., & Gastmeier, P. (2016). Relationship between hospital ward design and healthcare-associated infection rates: a systematic review and meta-analysis. *Antimicrobial Resistance & Infection Control, 5*(51). doi:10.1186/s13756-016-0152-1

Stumm, S. L., Barlow, S. M., Estep, M., Lee, J., Cannon, S., Carlson, J., & Finan, D. (2007). Respiratory distress syndrome degrades the fine structure of the non-nutritive suck in preterm infants. *Journal of Neonatal Nursing, 14*(1), 9-16. doi:10.1016/j.jnn.2007.11.001

Subramanian, K. N. S., Seo, S. C., Barton, A. M., & Montazami, S. (2014). Extremely low birth weight infant. In *MedScape*. Retrieved from https://emedicine.medscape.com/article/979717-overview

Tubbs-Cooley, H. L., Pickler, R. H., & Meinzen-Derr, J. K. (2015). Missed oral feeding opportunities and preterm infants' time to achieve full oral feedings and eonatal intensive care unit discharge. *American Journal of Perinatology, 32*, 1-8. doi:10.1055/s-0034-1372426.

Vohr, B., McGowan, E., McKinley, L., Tucker, R., Keszler, L., & Alksninis, B. (2017). Differential effects of the single-family room neonatal intensive care unit on 18- to 2-month Bayley scores of preterm infants. *The Journal of Pediatrics, 185*, 42-49. doi:10.1016/j.jpeds.2017.01.056

White, R. D. (2010). Single-family room design in the neonatal intensive care unit—challenges and opportunities. *Newborn and Infant Nursing Reviews, 10*(2), 83-86. doi:10.1053/j.nainr.2010.03.011

Wolf, L. S., & Glass, R. P. (1992). *Feeding and Swallowing Disorders in Infancy: Assessment and Management*. Tucson, Arizona: Therapy Skill Builders.

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