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NEONATAL READMISSION IN TERM INFANTS: MATERNAL, INFANT, PROVIDER AND INSTITUTIONAL FACTORS

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NEONATAL READMISSION IN TERM INFANTS: MATERNAL, INFANT, PROVIDER AND INSTITUTIONAL FACTORS

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ABSTRACT

Hospital readmissions are a patient safety and quality concern. Readmission rates in term-born infants in the past decade have been < 1.3% in the United States and < 8% globally. Most readmissions have been for jaundice/hyperbilirubinemia. Changes in exclusive breastfeeding rates, healthcare/institutional policies and demographics may have influenced the rate of neonatal readmission. Most literature on term-born neonatal readmission (within 28 days of birth) is conflicting and outdated. This study aimed to quantify the risk of maternal, infant, provider and institutional factors associated with neonatal readmission to the birth hospital in healthy term infants. Secondary aims estimated the incidence of neonatal readmission and characterized birth length of stay (in hours), readmission diagnosis, birth weight loss > 7% and breastfeeding quality ([LATCH score] ≤ 6). A nested case-control study (N=390) was conducted at a Level III hospital in the Northeastern United States. There were 11, 958 infants delivered between January 1, 2016 through May 8, 2017. A cohort of in-state domicile, healthy term ($37^{0/7}$ - $41^{6/7}$ weeks gestation) infants (n = 5,940) admitted directly to the well-baby nursery were identified. Cases (n =130) were infants from the cohort readmitted within 28 days of birth to the birth hospital. Controls (n =260) were randomly selected for each case (2:1) from the same cohort (matched on maternal age and infant birth date [+/- 7 days]). Descriptive statistics and conditional logistic regression were performed. Meleis's Transitions Theory guided variable selection. Significant factors associated with neonatal readmission were gestational age ($37^{0/6}$- $39^{6/7}$ weeks) ($p < 0.001$), maternal treatment for group B streptococcus (OR 2.55, $p = 0.012$), and jaundice on day two of life (OR 2.45, p =

0.002). Infants delivered by cesarean (OR 0.31, p = 0.014) and infants who received formula (when indicated) in the first three days of life, were 0.04% less likely to be readmitted (OR 0.96, p = 0.005) for every 10 milliliters of formula consumed. The exclusive breastfeeding rate was 47.7%. Birth weight loss > 7% and LATCH score ≤ 6 were not associated with neonatal readmission. The incidence rate of neonatal readmission was 2.2%. Most readmissions (93%) were for jaundice/ hyperbilirubinemia and all infants were readmitted within 8.6 days of birth. The average birth length of stay (in hours) was 54.6 ± 16.8 [16.53-126.30]. Future research on maternal group B streptococcus treatment and the risk of neonatal readmission in healthy term-born infants is needed. The findings highlight the need for a state-wide database and reporting of all neonatal readmissions (not just to the birth hospital) to assess the true scope of the problem.

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DEDICATION

This work is dedicated to two very special people: My husband Dharman Hensman and my late father Dr. Calixtus Christian.

To my beloved husband Dharman. Words cannot express your selfless generosity, kindness, encouragement and support. You did the heavy lifting in our family day in and day out all these years without ever complaining. You have always been so proud of me. You are my rock. I could not have done this without your support. I love you heaps, and I look forward to us travelling and spending a lot more time together.

Dad, you were an amazing role model, so kind and generous with all your family and extended family. Your integrity, honesty and perseverance have been an inspiration to us all. I wish you were around to share this accomplishment with me, but I know you are smiling down right now and I feel your joy. You left a legacy of curiosity, and a love for learning, that cannot be stopped. I love you dad, God Bless you.

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INTRODUCTION

The inpatient admission of a patient to the same or another hospital within 30 days of discharge is considered a readmission (Centers for Medicare and Medicaid Services, 2016). Readmissions are a patient safety and quality issue and preventing readmissions has become a top priority in the United States (US) (Press, et al., 2012). A readmission can be related or unrelated to the initial admission and it can be classified as planned or unplanned (Muri, Crawford, & Connors, 2010). Most readmissions may be preventable, although some readmissions may be difficult to predict, and may not be avoidable despite quality care (Manitoba Center for Health Policy, 2012).

A systematic review by van Walraven and colleagues (2011) estimated that 5 to 79% (median 27.1%) of all hospital readmissions were avoidable. These studies included medical, surgical and geriatric patients. Neonatal readmissions were not included. Avoidable readmissions were related to organizational factors such as the teaching status of the hospital, the transitional care received (how long patients were followed up after discharge), and whether all diagnoses had been considered (van Walraven et al., 2011). Goldfield and colleagues (2008) examined the indicators of the quality of care during an initial hospital stay. They reported that a readmission may be the result of actions taken by health care providers or omitted by them prior to discharge. There is a gap in knowledge about preventable neonatal readmissions.

The readmission of a newborn to the hospital can be an extremely distressing event to new parents and their families. Readmission places an undesirable, and costly burden on the hospital and the health care system (Young, Korgenski, & Buchi, 2013). Accurate information on the current incidence and factors associated with neonatal readmission have been difficult to obtain. The inability to track neonatal readmissions has been problematic especially when a baby is born in one hospital and then readmitted to another institution (Muri et al., 2010). This may result in underreporting of neonatal readmissions. The American Hospital Association estimates that about 50% of unplanned neonatal readmissions may be avoidable resulting in an average annual financial loss per hospital of approximately $126,000 (Muri et al., 2010). In 2018, this number may be considerably higher.

The US Center for Medicare Services (CMS) has initiated policies to reduce preventable readmissions and most hospitals depend on these policies for reimbursement of care services provided (Mittler, et al., 2013). Neonatal readmissions, defined as readmission within 28 days of birth, have not been affected by the CMS policies to date and continue to be reimbursed. To contain costs, hospital length of stay (LOS) for mothers and newborns following delivery have been shortening over the past several decades (Radmacher, Massey, & Adamkin, 2002). When a mother delivers a healthy term newborn, the hospital stay for the mother-infant dyad should be long enough to identify potential problems and allow caregivers time to prepare the infant (and family) for discharge to home (American Academy of Pediatrics (AAP): Committee on Fetus and the Newborn, 2010). Inadequate assessment by healthcare providers, and diagnostic errors (misdiagnosis), can place the infant at increased risk for readmission (AAP: Committee on Fetus and the Newborn, 2010).

Factors suspected to have an impact on neonatal readmission have been explored in the literature. These include maternal, neonatal, institutional and healthcare provider factors that influence readmission. An example of an institutional factor is early discharge from the hospital or a shortened LOS.

The Newborns' and Mothers' Health Protection Act of 1996 (Bragg, Rosenn, Khoury, Miodovnik, & Siddiqi, 1997; Marbella, Chetty, & Layde, 1998) established minimum requirements for insurance coverage for the mother and infant for childbirth (Centers for Medicare and Medicaid Services, 1996). A critical feature of this act established LOS requirements dependent on route of delivery (48 hours following vaginal delivery and 96 hours following a cesarean section). Early discharge and a shortened LOS dictated by the Newborns' and Mothers' Health Protection Act may be associated with an inadequate assessment of the readiness for maternal discharge (Weiss & Lokken, 2009; Farhat & Rajab, 2011; Goulet, Fall, D'Armour, & Pineault, 2007). Maternal factors such as maternal age < 20 years (Lain, Roberts, Bowen , & Nassar, 2015) and race (AAP: Committee on Fetus and the Newborn, 2010) are related to neonatal readmission. Neonatal factors include exclusive breastfeeding with feeding problems (Radmacher et al., 2002), jaundice, hemolytic disease (Burgos, Schmitt, Stevenson, & Phibbs, 2008; Hansen & Bratlid, 2012; Kavehmanesh, et al., 2008), infection, neonatal sepsis (Brown, et al., 1999; Tomashek, et al., 2006), and dehydration, hypernatremia (Davanzo, Canniotto, Ronfani, Monasta, & Demarini, 2013; Radmacher et al., 2002).

These factors related to neonatal readmission in infants of all gestational ages (GA) will be described in greater detail in Chapter three, followed by a literature review focused on neonatal readmission in term infants.

As part of providing quality care, top performing hospitals are accountable for reporting certain perinatal core measures to the Joint Commission (JC), the leading hospital accreditation body (The Joint Commission, 2013). Examples of core measures include elective delivery, cesarean section, antenatal steroids, and health care associated blood stream infections in newborns. In 2012, the JC expanded the reportable perinatal core measures for hospitals with more than 1,500 deliveries per year (The Joint Commission, 2013). This was following the initiation of the target to improve breastfeeding rates nationally to 84% as part of the Baby-Friendly initiative, one of the Healthy People 2020 program goals (Baby-Friendly USA, Inc, 2012).

The two perinatal core measures added in 2012, were exclusive breast milk feeding and exclusive breast feeding considering mothers choice (the belief that health care providers can influence a mother's choice) (The Joint Commission, 2013). Although neonatal readmission is not a core measure, breastfeeding has been associated with jaundice and neonatal readmission. Increases in the rate of breastfeeding may be contributing to increased rates of jaundice and neonatal readmissions (Liu et al., 2000).

There is a gap in the knowledge on neonatal readmission. Specifically, an accurate incidence of readmission as well as the factors that contribute to neonatal readmissions. Over the past decade factors such as institutional discharge policies and procedures, health care initiatives, sociodemographic changes in the population, and changing provider roles (such as increased advanced practice nurses and lactation consultants) may have impacted the neonatal readmission rates. However, these have not been examined together in a single study. In addition to known maternal and infant factors, there is a need to understand information on current pre-discharge provider and institutional factors that may impact neonatal readmission. Developing strategies to reduce potentially preventable readmissions are needed in order to decrease parent stress, unnecessary neonatal stress and and keep costs down.

Theoretical Framework

A middle-range theory by Meleis (2010) known as Transitions Theory is a useful guiding framework for exploring neonatal readmission to the hospital. It incorporates the three functions of theory which are to describe, explain and predict phenomena of interest (Butts & Rich, 2015).

Transitions Theory addresses the central focus of nursing, which is to enable clients (individuals, families and communities) to navigate and adapt to life transitions and changes (Kralik, Visentin, & van Loon, 2006). This is especially true when life changes result in health-illness events or health-related behaviors (Chick & Meleis, 1986). Several types of life transitions have been described in the nursing literature such as developmental, situational, health/illness, and organizational changes (Schumacher & Meleis, 1994). Becoming a mother is a developmental transition and adding a new member to the family unit, following the birth of a child, is a situational transition. Meleis's Transitions Theory can be used to examine the conditions, barriers, facilitators and nursing therapeutics related to neonatal readmission during these transition conditions.

The assumptions of Transition Theory include: 1) identifying transitions as being a nursing concern and central to the discipline of nursing; 2) supporting individuals who are going through transitions; 3) developing appropriate frameworks to facilitate individuals passage through a transition to achieve successful/healthy outcomes; and 4) advancing empirical evidence of nursing therapeutics that promote healthy outcomes (Meleis, 2010).

Purpose of the Research

The neonatal period is considered a critical period in the life of a newborn. It is defined as "the interval from birth to 28 days of age" (The Free Dictionary by Farlex, 2016). The purpose of this study was to quantify the risk of maternal, infant, provider and institutional factors associated with neonatal readmission. Additionally, it was to estimate the incidence of neonatal readmission in term infants ($37^{0/6}$ to $41^{6/7}$ weeks GA) at a large tertiary care center in the Northeastern region of the US, and to characterize the birth LOS and reasons for readmission to the birth hospital.

Primary Research Question

1) What are the maternal, infant, provider and institutional factors associated with neonatal readmissions in term infants?

Secondary Research Questions

2) Is significant weight loss from birth (> 7 %) and breastfeeding difficulty (sustained feeding and/or LATCH score $\leq$ 6) in term infants during the hospital stay and/or at discharge associated with increased neonatal readmission to the birth hospital?

3) What is the the incidence of all cause neonatal readmission (within 28 days of birth) in term infants to the birth hospital?
4) What is the length of stay (in hours) after birth and diagnosis associated with neonatal readmission in term infants?

Definition of Terms

Term Infants

Theoretical definition. Infants born at or after 37 weeks GA (American College of Obstetricians and Gynecologists [ACOG], 2013); reaffirmed in 2015.

Operational definition. Infants born between $37^{0/7}$ and $41^{6/7}$ weeks GA at the study site. The ACOG working group classify term pregnancy as follows:

- Early term: $37^{0/7}$ weeks through $38^{6/7}$ weeks
- Full term: $39^{0/7}$ weeks through $40^{6/7}$ weeks
- Late term: $41^{0/7}$ weeks through $41^{6/7}$ weeks
- Post term: $42^{0/7}$ weeks and beyond

(ACOG, 2013; reaffirmed in 2015)

Neonatal Readmission

Theoretical definition. Inpatient admission of a term infant to the birth hospital within four weeks (28 days) of birth following discharge to home.

Operational definition. Inpatient admission of a term infant ($37^{0/7}$ and $41^{6/7}$ weeks GA) to the study site within 28 days of birth, following discharge to home.

Emergency Room Visit

Theoretical definition. The planned or unplanned visit of an infant to a hospital emergency room (ER) to seek infant health care within 28 days of discharge from the hospital.

Operational definition. The planned or unplanned visit of an infant to the study site's Emergency Room following discharge to home from the study site, for seeking health care within 28 days of birth.

Feeding Difficulty.

Theoretical definition. An assessment of specific criteria to score key components of breastfeeding such as how well the infant latches, amount of audible swallowing noted, the type of nipple (inverted, flat), mother's level of comfort (breast/nipple) and mother's level of comfort with hold (positioning) during the birth hospitalization called the LATCH tool. Each of the specific five criteria has a maximum score of two from a total possible score of 10 (Jensen, Wallace, & Kelsey, 1994).

Operational definition. A LATCH score ≤ 6 on the LATCH Scoring Assessment Tool by Jensen et al. (1994).

Exclusive Breastfeeding

Theoretical definition. Consumption of only breast milk and no formula intake.

Operational definition. Consumption of only breast milk (except for vitamins, minerals and medications) during the birth hospitalization.

Formula Feeding

Theoretical definition. Formula intake only with no breastfeeding.

Operational definition. Consumption of formula feeds only in birth hospital.

Combined Feeding

Theoretical definition. Breast milk and/or formula feeds or formula supplementation after breastfeeding.

Operational definition. Breast milk and formula consumption in birth hospital.

Significant Weight Loss.

Theoretical definition. Weight loss (from birth) > 7% of total body weight at birth prior to or at discharge form the birth hospital. The evaluation of body weight gain after birth should involve a "body weight loss of no more than 7% from birth…" (AAP: Section on Breastfeeding, 2012)

Operational definition. The difference in the birth weight minus the current weight of the infant divided by the birth weight and multiplied by 100. Defined as > 7% of weight loss for this study prior to or at discharge from the birth hospital.

Clinical Jaundice

Theoretical definition. A visible yellow coloring of the skin and sclera which progresses in a cephalocaudal direction and appears within the first week of life. Includes ICD-10 codes P59.9 (neonatal jaundice unspecified), P59.8 (neonatal jaundice from other specified causes), P59.3 (neonatal jaundice from breast milk inhibitor), P58.0 (neonatal jaundice due to bruising), R17 (unspecified jaundice), or E80.6 (other disorders of bilirubin metabolism).

Operational definition. Visible yellow coloring of skin and sclera of the eyes in birth hospital.

Hyperbilirubinemia

Theoretical definition. The appearance of any jaundice within the first 24 hours of life or a Total Serum Bilirubin (TSB) level rate of increase of greater than 5 mg/dL within 24 hours or a TSB level that indicates elevated levels of bilirubin on the age-specific bilirubin nomogram requiring readmission to the hospital and/or treatment.

Operational definition. Elevated TSB level greater than the 95th percentile based on the age-specific bilirubin nomogram and GA at birth and requiring readmission to the hospital and treatment with phototherapy.

Treatment for Hyperbilirubinemia

Theoretical definition. The use of any intervention to decrease levels of serum bilirubin in the blood.

Operational definition. Interventions such as change in feeding type, phototherapy, and/or exchange transfusion to decrease the TSB in the blood.

Early Discharge

Theoretical definition. Shortened length of stay versus a longer length of stay based on delivery mode.

Operational definition. The discharge of an infant (calculated in hours from birth) from the hospital at 48 hours (or less) of vaginal birth or within 96 hours of a cesarean delivery.

Significance of this Study for the Discipline of Nursing

Previous research on neonatal readmission has focused on maternal and infant characteristics and the factors associated with neonatal readmission within seven, 14 and 28 days of life (Radmacher et al., 2002; Geiger, Pettiti, & Yao, 2001; Lain et al., 2015; Habib, 2013). Health care providers have determined readiness for discharge following evaluation of maternal, infant and social factors such as the ability of the parents/family to care for the infant at home (AAP: Committee on Fetus and the Newborn, 2010). Hospital discharge of newborns is an everyday occurrence for nurses (Weiss & Lokken, 2009). As the health care professional who spends the most time with the mother infant dyad postpartum, the nurse plays a key role in determining the mother-infant dyad’s readiness for discharge and follow up needs. The feasibility of collecting data on key variables and constructs of discharge such as education, LATCH scores, lactation consults at a large birthing center in the Northeastern region of the US are needed to assure if these tools are useful in assessing breast feeding quality and preventing readmission. An analysis in which all factors are considered such as information on maternal, infant, provider (private, clinic, physician, nurse practitioner) and institutional factors (discharge policies and procedures) can provide information related to nursing care. This can impact nursing care delivery, patient outcomes and future research in all four nursing domains (Client, Client-Nurse, Practice and Environment) described by Kim (2010).

Summary

Most of the available research on newborn readmission is over a decade old. There have been changes in the US health care system and health care organizations over the past decade. Current factors associated with neonatal readmission in healthy term infants need to be examined and may provide important data to identify and develop future implementation strategies to reduce preventable term neonatal readmissions. A descriptive observational study will provide incidence data on neonatal readmissions at the selected study site. It may generate new knowledge and information on the relative importance of provider and institutional factors associated with healthy term neonatal readmission and/or validate existing information. It may also generate hypotheses to empirically test Transitions Theory and the transition facilitators and barriers, nursing interventions and nursing therapeutics that may reduce preventable term neonatal readmissions.

CHAPTER 2

THEORY

This chapter will present an overview of Transitions Theory and the conceptual framework (Figure 1) used to guide this research. Studies reviewed to date on neonatal readmission have been atheoretical (Brown, et al., 1999; Burgos et al., 2008; Lain et al., 2015; Liu, et al., 2000). It is hypothesized that neonatal readmission may be a consequence of unsuccessful transition from birth hospitalization to home. Unsuccessful transition may be due to a host of factors including misdiagnosis, breastfeeding difficulty and or significant weight loss. It may also be due to the lack of maternal education and support for breastfeeding, or other maternal, infant, provider and institutional factors. Transitions Theory provides a framework for understanding and examining these complex situations (Meleis, Sawyer, Im, Messias, & Schumaker, 2000).

Transitions Theory was developed by the nurse scientist and theorist, Afaf Meleis (Meleis et al., 2000). It has been described as a middle-range theory (McEwen & Wills, 2011). The purpose of the theory is to answer questions related to strategies to prevent unhealthy or unsuccessful transitions, and to identify ways to support healthy transitions (Meleis, 2010). Transitions Theory emerged from the observations that nurses' work involves assisting individuals during different (developmental, situational, health and illness or organizational) life transitions. According to Meleis, Transitions Theory is significant to nursing because it helps individuals go through healthy transitions to achieve healthy outcomes (Meleis, 2010).

This chapter will describe Transitions Theory, define the concept of transitions, review the constructs, and provide an analysis of the theory. Finally, Transitions Theory will be applied to the current study to frame the process of transition from birth through discharge from the hospital, and to examine the indicators of neonatal readmission. The goal is to understand and examine the phenomena of neonatal readmissions to reduce the occurrence of preventable readmissions.

Theory Overview

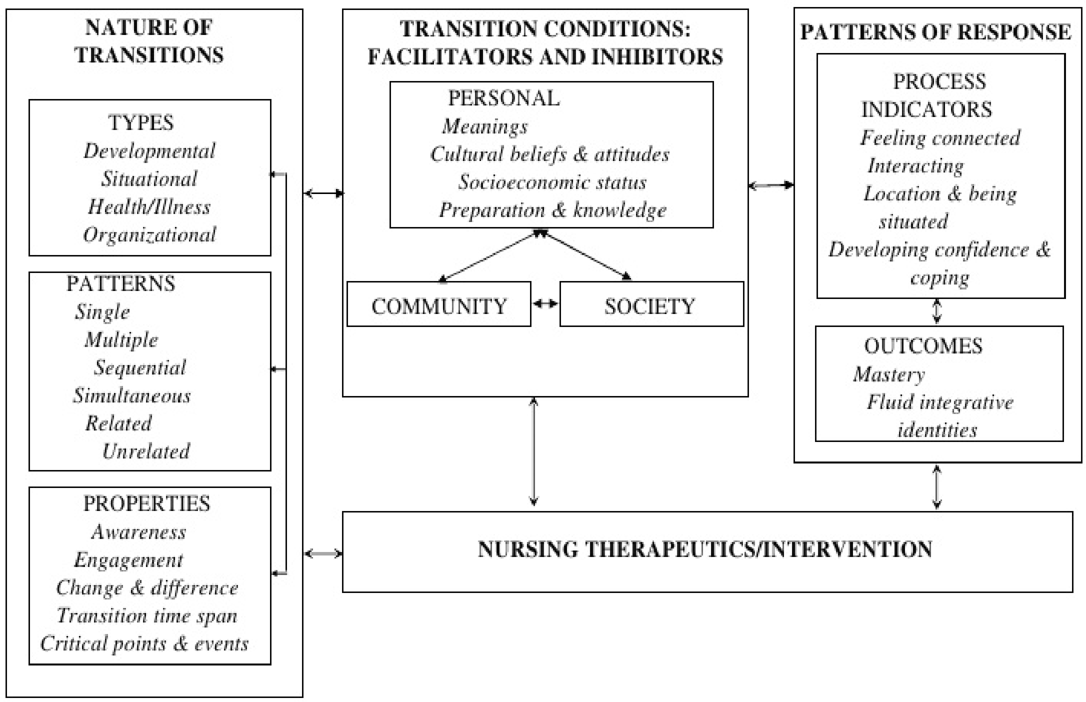
Transitions Theory was developed over a span of three decades by Afaf Meleis (2010). Transition has been described as "passage from one life phase, condition, or status to another, is a multiple concept embracing the elements of process, time span, and perception" (Meleis, 2010, p. 25). It was initially conceptualized to determine how nurses could facilitate and help prepare individuals for life transitions and avoid potential problems or barriers with transitions. Characteristics that define transition are "process, disconnectedness, perception, and patterns of response" (Meleis, 2010, p. 26). The framework for Transitions Theory is composed of 1) the nature of transitions, 2) transition conditions or facilitators and inhibitors and 3) patterns of response (Figure 1).

The Nature of Transitions

The types, patterns and properties of transition make up the nature of transitions and will be described in more detail.

Types of transitions. These include developmental transitions (e.g. entering adulthood or parenthood), situational transitions (e.g. discharge readiness or readmission), health/illness transitions (e.g. aging and or cancer), and organizational transitions (e.g. role transition, or the change of setting from hospital to community). Figure 1 depicts Meleis's Transitions Theory.

Figure 1. Transitions Theory by Meleis



From Meleis, A.I., Sawyer, L.M., Im, E-O., Hilfinger Messias, D.K., & Schumacher, K. (2000). Experiencing transitions: An emerging middle-range theory. *Advances in Nursing Science, 23,* 12-28. (Figure 1)

Patterns of transition. These could be single, multiple, sequential, simultaneous, related or unrelated, such as a transition to motherhood (developmental), and the simultaneous transition of a diagnosis of cancer or a post-operative infection (illness). The discipline of nursing needs to focus on all types of transitions and patterns (Meleis et al., 2000).

Properties of transition. The essential properties of transition such as awareness and recognizing and being knowledgeable about the transition are included in this construct. Change is a property present in all transitions. However, change does not necessarily mean a transition (Meleis et al., 2000). Engagement is another property of transition and the level of engagement can vary in individuals or families. It is influenced by awareness (Meleis et al., 2000). Critical time points may be life events such as birth, death, the diagnosis of a health condition, discharge or readmission to the hospital. Nursing attention and experience is essential during these critical time points. Time span has been characterized as the ebb and flow of time and movement (Meleis et al., 2000). This can also be post-birth but pre-discharge, or post-discharge.

Transition Conditions

These are the facilitators and inhibitors of transition and they consist of personal conditions of transition such as meaning, cultural beliefs and attitudes, socioeconomic status, preparation and knowledge (Meleis, 2010). Community conditions such as having community resources and support, societal conditions such as stereotyping and gender inequality, can be conditions that either facilitate or inhibit the transition (Meleis et al., 2000).

Patterns of response. This construct includes process indicators and outcomes. Process indicators encompasses staying connected to health care professionals (such as having follow up visits or a visiting nurse after discharge to home), interacting/having questions answered (i.e. a phone resource center such as warmline for parents). It also includes location and being situated (especially in cases of migration) and developing confidence and the ability to cope with the transition (Meleis et al., 2000). Outcomes includes mastery in managing a new behavior or skill in a new environment or condition, and the formulation of a fluid integrative identity. This is where the individual acquires the additional identity of another culture or environment and the perspective of two cultures (Meleis et al., 2000).

Theory Analysis

An analysis of the theory will enable a more critical examination of the theoretical components including advancing the empirical testing of Transitions Theory. Theory analysis involves looking at the theory both objectively and systematically (Walker & Avant, 2005). Theory synthesis includes presenting the factors that lead to or precede an event, shows the outcome of an event following a nursing intervention, and theoretically organizes scientific information (Walker & Avant, 2005). Therefore, understanding the nature of transitions, transition conditions (facilitators and inhibitors) and the patterns of response of exclusive breastfeeding, feeding difficulty and significant weight loss, may help to understand if there is an association to the outcome of neonatal readmission.

Transitions Theory may also describe, explain and predict the maternal, infant, provider and institutional factors that facilitate or inhibit preventable neonatal readmissions. The present study may advance empirical testing of Transitions Theory. The constructs of transition conditions include patient characteristics (maternal age, education, race, ethnicity, insurance, primary language and marital status, GA) and organizational structure (availability of lactation consultants and hospital policies such as Baby-Friendly). It also includes the nature of transitions and the constructs of hospitalization factors (LOS, significant weight loss [> 7 %] from birth, the number of LATCH scores ≤ 6), and nursing therapeutics (readiness and preparation for discharge home, nutrition/breastfeeding education, breastfeeding assessment [LATCH scores], discharge teaching with scheduled follow up appointments) to determine the outcome indicators (mastery of breastfeeding/education and readmission).

An analysis of Transitions Theory will be conducted using Walker and Avant's six steps of theory analysis (2005). The six steps include: 1) the identification of the origins; 2) examining the meaning; 3) analyzing the logical adequacy; 4) determining the usefulness; 5) define the degree of generalizability and parsimony, and; 6) determining the testability of the theory (Walker & Avant, 2005). Each of these six steps will be described and used to analyze Meleis's Transitions Theory.

Origins of the Theory

Transitions Theory was developed by the nurse theorist, Afaf Meleis (2010). She was convinced that humans experience transitions throughout life. She believed that how humans coped or did not cope with those transitions was important to nursing and the business of nurses. Her interest goes back decades to the 1990's when she had nursing support groups to assist people with developmental and health problems providing teaching and support. The original concepts identified and studied were role insufficiency, role supplementation and role mastery, and the relationships between the concepts and transition. Role insufficiency was described as inadequacy of self and how this made the individual feel and behave. Role supplementation was described as the identification of role insufficiency, and the provision of preventive and/or therapeutic interventions to achieve a successful transition. Role mastery indicated a healthy transition where the individual had acquired the skill and competence in a new role and successfully transitioned through the event and adjusted to a new status (Meleis, 2010).

Meaning of the Theory

According to Walker & Avant (2005), in examining the meaning of the theory, the researcher must look closely at the original language of the theorist, and how the original concepts relate to each other. The concepts described above were tested with nursing involvement in four major categories of transition: 1) developmental; 2) situational; 3) health-illness, and; 4) organizational (Meleis, 2010). Meleis defines "the goal of healthy transitions as mastery of behaviors, sentiments, cues, and symbols associated with new roles and identities as nonproblematic transitions" (2010, p. 3). Individuals suffer from transition experiences when they do not receive the proper preparation and support (role insufficiency). Preventive and or therapeutic role supplementation by the nurse can help to avoid unsuccessful transitions (Meleis, 2010). All the key concepts (role insufficiency, role supplementation and role mastery) of this theory are within the domains of nursing and are therefore appropriate. Concept derivation or applying the concept to a phenomenon it has previously not been used with, and the ability to view it from a different perspective, can be useful (Walker & Avant, 2005).

Logical Adequacy of the Theory

To analyze the logical adequacy of a theory, the researcher needs to consider how well and accurately predictions can be made. The meaning of concepts and statements used in the theory must be independent of the structure of the theory (Walker & Avant, 2005). The definition and description of the concept and phenomenon are important when no concept development has occurred. Meleis defines transition as "a passage from one fairly stable state to another fairly stable state, and it is a process triggered by change" (Meleis, 2010, p. 11). The clarity of a theory has to do with the key concept being defined clearly. In his primer on theory construction, Paul Reynolds believed that finding agreement about the definition of a term is considered more important than what the actual form of the definition is (2007). He felt it it was difficult to differentiate the "process" from the "state" where measurement is concerned (Reynolds, 2007). However, Transitions Theory can be used as a framework to recognize that a process has been triggered when there is an event (Meleis, 2010).

A client can experience more than one transition at a time. An example is developmental transition to motherhood shared with a situational transition of neonatal readmission. Regardless of whether an event is long or short, continues indefinitely, is anticipated or not, transition boundaries may expand or contract depending on an individual's developmental, situational, health and illness or organizational transition (Meleis, 2010). The logical adequacy of a theory can be examined both inductively and deductively to determine if the premises are true. A theory must make sense in understanding the phenomena (Walker & Avant, 2005). Although there have been different definitions of transition, the definition put forth by Meleis (2010) has been extensively studied and is logically adequate (Meleis & Trangenstein, 1994; Ekim & Ocakci, 2016; Meleis et al., 2000; Schumacher & Meleis, 1994). It has made sense in understanding the transition phases of entry, passage and exit, and in testing the usefulness of the theory in nursing practice (Meleis & Trangenstein, 1994).

Usefulness of the Theory

The usefulness of a theory depends on how it relates to practice. Walker & Avant (2005) suggest three issues that enable the researcher to determine the usefulness of a theory. They involve: 1) the quantity of research the theory has generated; 2) the clinical problem or phenomenon being researched and how relevant the theory is to the phenomenon, and; 3) if nursing practice and or education, nursing research and or nursing administration can be influenced by the theory. Transition Theory has been extensively studied and used across different situation-specific topics (Meleis, 2010). These include menopause (Im, 2014) and culture (i.e. refugee and immigration (Baird, 2012). Developmental transitions include the passage to fatherhood (Draper, 2003), the transition to motherhood (Sawyer, 1999) and the transition to motherhood in the Neonatal Intensive Care Unit (NICU) (Galeano & Carvajal, 2016). A listing of studies by the theorist Dr. Meleis and coauthors can be found in Appendix A. A listing of studies using Transitions Theory by other authors can be found in Appendix B.

Transitions Theory has the potential to identify and organize factors that influence neonatal readmission and can lead to a better understanding of the facilitators and inhibitors of neonatal readmission. Table 1 is a listing of studies that have used a Transitions Theory framework or Transitional Care Model to examine discharge and readmission in populations other than neonates. This documentation of Transitions Theory in other populations and clinical transitions relevant to nurses' work supports its use in this study of neonatal readmission.

Table 1. Studies on Hospital Discharge and Readmission Using Transitions Theory

Study Title/ Author	Study Population/ Location	Sample Size (*N*)/ Type of study
Predictors and outcomes of postpartum mothers' perceptions of readiness for discharge after birth Weiss & Lokken (2009)	Mixed parity postpartum mothers US	141 mothers Correlation design with path analyses
Perceived Readiness for Hospital Discharge in Adult Medical-Surgical Patients Weiss, et al. (2007)	Adult medical surgical patients US	147 adults Correlational design with path analyses
Coping in Mothers of Premature Newborns After Hospital Discharge Galeano & Carvajal (2016)	Mothers of infants from 2 NICUs Colombia	144 mothers Prospective, descriptive correlation study
Efficacy of a Transition-Theory Based Planning Program for Childhood Asthma Management Ekim & Ocakci (2016)	Children with asthma and their parents Turkey	120 children Quasi - experimental
The Conceptual Structure of Transition to Motherhood in the Neonatal Intensive Care Unit Shin & White-Traut (2007)	Mothers of NICU infants Korea	10 mothers Concept analysis with purposive sampling

Note. NICU = Neonatal Intensive Care Unit

Transitions Theory offers the framework to organize factors that influence neonatal readmission and can lead to better understanding of the facilitators and inhibitors of neonatal readmission. It can be used to determine how transition conditions (family and community resources and follow up) and facilitators and inhibitors can impact neonatal readmission. Research is needed to examine the nursing therapeutics associated with reducing preventable neonatal readmission based on Meleis's Transitions Theory.

Degree of Generalizability and Parsimony of the Theory

Generalizability has to do with the application of the theory. The more applicable the theory is then the more generalizable it becomes to describe, explain and predict phenomenon (Walker & Avant, 2005). Transition Theory has potential to be generalizable to the populations relevant to nursing it has been tested in, depending on the sampling approach and the quality of the research design and methods. Transition research has explored developmental transitions (Barimani, Vicksrom, Rosander, Forslund, & Berlin, 2017; Draper, 2003; Galeano & Carvajal, 2016), situational transitions (Baird, 2012; Im, 2014), health/illness transitions (McEwen, Baird, & Gallegos, 2007; Ekwall, Temestedt, & Sorbe, 2007), and organizational transitions (Chang, Mu, & Tsay, 2006). It has also been integrated with Bioecological Theory (Joly, 2016) and Role Theory (Mercer, 2004).

Over the past decade there has been a great deal of research globally using the Transitions Theory framework. Interest has also been generated in Transitional Care Models and the cost-effectiveness of transitional care for the elderly and chronically ill (Meleis, 2010). Most research using a Transitions Theory framework has been situation-specific with purposive sampling and limited generalizability. Although there have been several randomized controlled trials using the Transitional Care

Model in older adults, there have been no randomized clinical trials using the model or the Transitions Theory framework in the infant population.

In the past decade, there has been no research specifically focused on healthy term infants and neonatal readmission in the US. In the present study, the transition outcome indicator 'neonatal readmission' is conceptualized to be influenced by nursing therapeutics such as education and assessment of breast-feeding (LATCH scores). Further research is needed in this area to draw conclusions about the utility and generalizability of Transitions Theory in the term neonatal population. The theory is not the most parsimonious, but a schematic (Figure 1) helps with clarity of the theory making understanding the theory easier (Meleis, 2010).

Testability of the Theory

A valid theory can be tested, and testing can lead to revision of the theory (Walker & Avant, 2005). The importance of Transitions Theory seems to be well supported and it has been tested extensively in the adult nursing literature (Meleis, 2010). The empirical work on situational transitions (discharge and relocation) looks at a range of transition experiences and breaks them down into the domains of the theory (nature of transitions, transition conditions and patterns of response). A qualitative study of relatives' experiences of nursing home entry found the theory incomplete as it did not account for the role and contributions of family caregivers in this study (Davies, 2010). This underscores the fact that testing a theory generates hypotheses and relational statements that may or may not support the theory but adds to the body of nursing knowledge (Walker & Avant, 2005). Many nursing scientists may not agree on the definition of transition but there is agreement that it is a process that individuals go through that involves change (Chick & Meleis, 1986). This suggests Transitions Theory can be tested for a study about developmental change in new parents of term infants, from birth transition to home, where they strive to achieve mastery of their new roles as parents. Achieving mastery may facilitate a healthy outcome and avoid the unexpected outcome of a neonatal readmission.

Application of the Theory

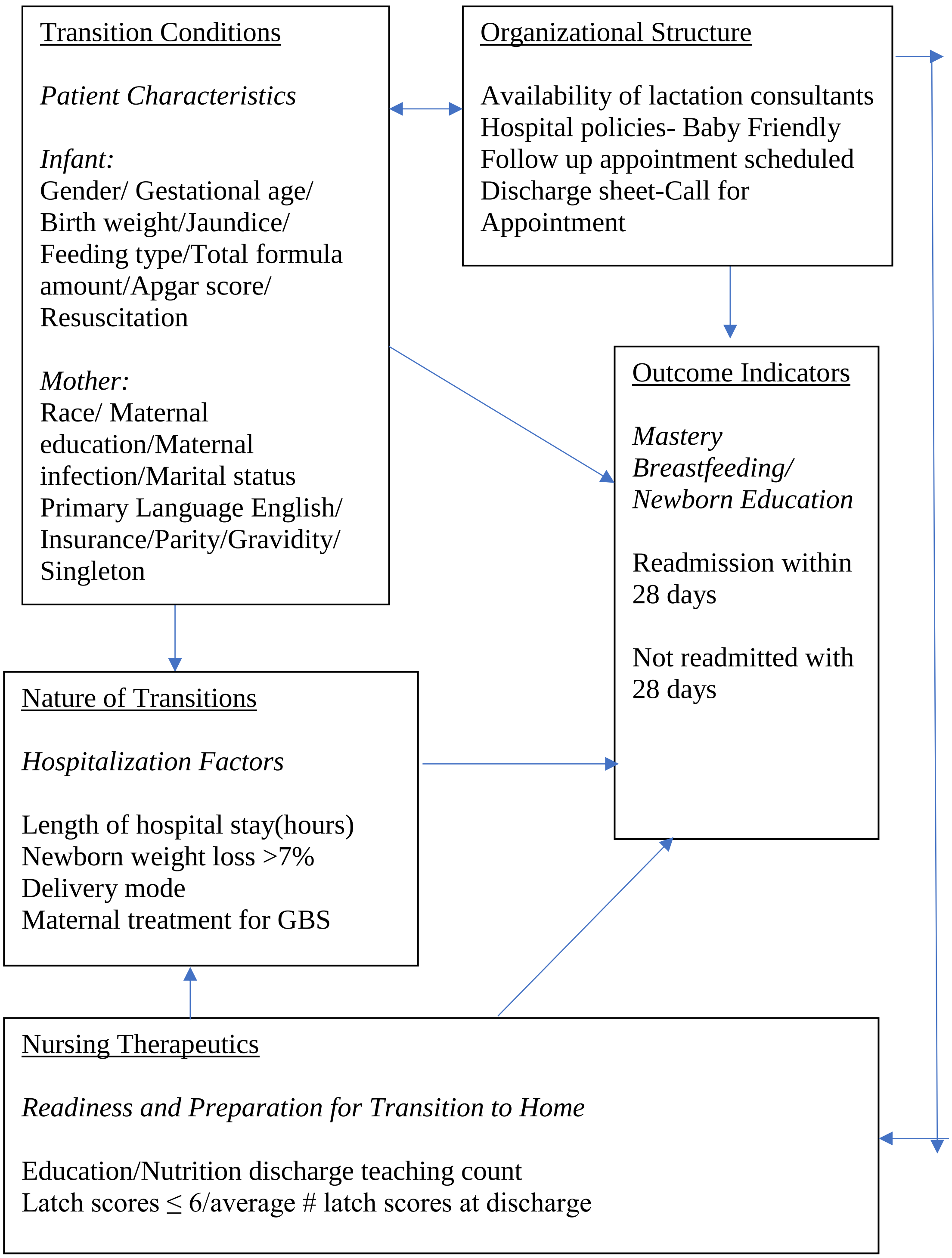
Transitions Theory has not specifically been used to examine healthy, term (exclusively or predominantly breastfed) infants who are readmitted to the birth hospital within 28 days of life. However, it appears to provide a suitable framework to do so. Investigation is needed on transitions of the mother-infant dyad during hospitalization for birth and readmission. Transition to motherhood is considered a developmental transition and neonatal readmission is a situation-specific transition (Meleis et al., 2000). The available knowledge on developmental transition has been descriptive rather than explanatory. Most research to date on transitions in adults has been qualitative focusing on role theory with a life-course perspective (events during a lifespan) (Meleis, 2010). A greater understanding of the facilitators and inhibitors of transition to motherhood and neonatal readmission can inform nurses about their work in preparing new parents for discharge to home and in the prevention of neonatal readmission.

A recent qualitative study by Barimani et al. (2017) successfully used Transitions Theory to describe parents' perceived transition conditions that facilitated and inhibited their transition to parenthood. In this study, 60 parents in Sweden were interviewed about their experiences during transition to parenthood. The study examined the parent’s experience in relation to parent-education groups and support from professionals, as well as follow up provided to them. The findings were used to recommend practices during the transition to parenthood (Barimani et al., 2017). Specific recommendations included ensuring the mother and her partner received preparation and advice related to healthcare and breastfeeding support. Other recommendations included having an adequate parent-education curriculum covering expectations regarding sleep disturbance, breastfeeding, and normal changes in the couple’s relationship. It was also important to ensure parent-education groups functioned well. The recommendations also included having group leaders reflect on their skills and competencies, provide parents opportunities to interact with health care professionals, and to discuss overwhelming feelings (anxiety, mood swings, loss of confidence) as well as gender issues, role conflicts and parental responsibilities (Barimani et al., 2017).

More information on the maternal and infant factors related to neonatal readmission in all infants, and specific information on provider and institutional factors related to healthy term infants are needed. This information may be useful to understand factors related to neonatal readmission and to develop strategies to reduce preventable neonatal readmissions in healthy term infants.

Figure 2 illustrates the application of the Transitions Theory framework to examine the factors related to neonatal readmission. Research should include the attributes of normal and/or disruptive transitions, and predictable or unpredictable transitions to help understand how the health and well-being of individuals can be

Figure 2. Transition Constructs and the Relationship to Neonatal Readmission



Note: Study constructs and variables adapted from Meleis's Transitions Theory framework (Meleis, 2010).

promoted (Meleis, 2010). Research using Transitions Theory has shown that role supplementation in the form of preventive and therapeutic interventions are needed when role insufficiency is identified in individuals going through a transition event or stage (Meleis, 2010; Baby-Friendly USA, Inc, 2012).

Therefore, nurses can facilitate the transition process that clients experience either preventively or therapeutically (Schumacher & Meleis, 1994). In the case of infant birth and neonatal readmission, the theoretical issues and reality related to the transition belongs to the client. The unit of analyses pertains to the client, which is the mother-infant dyad located in the Client domain within the four domains of Kim's typology of nursing knowledge (Kim, 2010).

Transition can encompass other domains as well, such as the Client-Nurse domain and the Practice domain as with nursing therapeutics. Nursing therapeutics can include education, counseling and home visits (Ekim & Ocakci, 2016). There can also be congruence with transition and the Environment domain such as the health care environment in the hospital during birth as well as the environment when the client transitions to home e.g., social support. Each transition is unique, and the knowledge gained from each transition process can be used to develop a nursing knowledge of neonatal readmission. It can also be used to identify nursing therapeutics to reduce preventable neonatal readmissions. Multiple methods of nursing inquiry are needed to translate knowledge into the practice setting and to add to nursing theory development (Roy, 2018).

Summary

This chapter presented an overview of Transitions Theory by the nurse theorist Afaf Meleis. This theoretical framework will be used to study neonatal readmission. Transition conditions (patient characteristics such as gender, age, GA, race), nature of transitions (hospitalization factors such as LOS, newborn weight loss and delivery mode), organizational structure (availability of lactation consultants and hospital policies such as Baby-Friendly), and nursing therapeutics (nutrition education and assessment of LATCH scores in breastfeeding mothers) will be examined. This examination is related to the outcome indicator (neonatal readmission). Transitions Theory is used as a guide for understanding the predictors of neonatal readmission. Constructs of transition conditions, nature of transitions and organizational structure (as illustrated in figure 2) from the Transitions framework will be used in the study analysis and may add to the understanding and empirical nursing knowledge on neonatal readmission and Transitions Theory.

CHAPTER 3

REVIEW OF LITERATURE

To elucidate the known factors associated with neonatal readmission this chapter will first describe some of the relevant literature on neonatal readmissions in all newborns. It will be followed by a focused search strategy and review of the literature on neonatal readmissions in term infants. Neonatal readmission rates vary among infants of different gestational ages such as preterm, late term, and early term etc. The labels (i.e. early term, late preterm) used to define GA groups are not consistent in the literature making comparisons of these groups difficult due to the wide variability in GA, definitions of readmission and timing of discharge (Marbella et al. 1998; Ruth, Roos, Hiddes-Ripstein, & Brownell, 2014; Burgos et al. 2008; Oddie, Hammel, Richmond, & Parker, 2005).

Previous studies have explored several predictor and outcome variables that have impacted neonatal readmission. These variables have included discharge LOS, discharge readiness, exclusive breastfeeding, feeding difficulty, jaundice, hemolytic disease, infection, neonatal sepsis, dehydration and hypernatremia. There is minimal research on the impact of pre-discharge institutional and provider factors associated with neonatal readmissions in term infants who are discharged home as healthy newborns.

Events over the past two decades may have unknowingly affected the incidence of neonatal readmissions. In 1991 the World Health Organization (WHO) and the United Nations Children’s Emergency Fund (UNICEF) launched a Baby

Friendly initiative (World Health Organization, 2017). The Baby-Friendly initiative was also part of the US Department of Health promotion called Healthy People 2020, which was introduced in 2000 to improve health and disease prevention programs (US Department of Health and Human Services, 2014). The goal of the initiative was to increase overall breast-feeding rates to 81.9 % prior to discharge from the hospital. In 2006, the reported national baseline rate for infants who had ever been breastfed was 74 %. The rate for infants in Rhode Island in 2011 was 79.1% (US Department of Health and Human Services, 2017). The Baby-Friendly initiative was intended to boost breast feeding rates. However, the number of hospitals with Baby-Friendly status in 2007 was only 2.9%. The Healthy People 2020 goal is to have 8.1% of all hospitals with baby-Friendly status (Baby-Friendly USA, Inc, 2012).

Exclusive breast feeding was considered optimal maternal-child care and hospitals were encouraged and recognized (with Baby-Friendly status) for providing this care. New mothers were encouraged to breastfeed and bond with their infants as part of the initiative and thus improve rates of breast feeding in the hospital prior to discharge home (Baby-Friendly USA, Inc, 2012).

The ten steps to successful breastfeeding to achieve Baby-Friendly status include limiting infants to breast milk unless medically indicated (Nickel, Labbok, Hudgens, & Daniels, 2013). Hospitals received Baby-Friendly status only when all ten steps of successful breastfeeding are achieved (Nickel et al., 2013). However, although exclusive breastfeeding to six months of age is recommended by the AAP, commercial infant formula is provided in 24% of maternity services within the first 48 hours after birth (AAP: Section on Breastfeeding, 2012).

Since breastfeeding begins in the hospital, breast feeding prior to hospital discharge has been encouraged to align with the Baby Friendly initiative (Baby-Friendly USA, Inc, 2012). Therefore, it is assumed that issues related to breast feeding difficulty may also be associated with the Baby-Friendly initiative which encourages breast feeding and the increasing breastfeeding rates. After discharge from the hospital, breastfeeding difficulty may exacerbate because mothers may not have adequate lactation support at home. Breastfeeding difficulty can lead to issues with the newborn including inadequate calories, volume and dehydration (Chen, et al., 2011). Difficulty with breastfeeding has also been associated with jaundice and hyperbilirubinemia which are the leading causes for neonatal readmission (Sgro, Campbell, & Shah, 2006).

Neonatal readmissions (within 28 days of birth) are a global concern. Readmission rates are as high as 10.1% outside the US (Bayoumi, et al., 2015). Neonatal readmission rates in the US have been reported as less than 1% (Geiger et al., 2001; Radmacher et al., 2002). However, this continues to be a concern. According to data from the National Perinatal Information Center (NPIC), the rate for all inborn neonatal readmissions in 2016 (among the 93-member hospitals included in the NPIC analysis) is approximately 1.0 to 2.6% (NPIC: Quality Analytics Services, 2017). Identifying and understanding the current factors associated with all cause neonatal readmissions and the factors that do not contribute to neonatal readmission are needed to decrease the number of avoidable neonatal readmissions.

Early Discharge/Length of Stay (LOS)

Studies have examined newborn readmissions in relation to early discharge following the Newborns' and Mothers' Health Protection Act of 1996 (Bragg et al., 1997; Marbella et al., 1998). This act established minimum requirements for insurance coverage of the mother and infant for childbirth (Centers for Medicare and Medicaid Services, 1996). A critical feature of this act was to establish LOS requirements dependent on route of delivery (discharge at 48 hours following a vaginal delivery and 96 hours following a cesarean section). The standard LOS in the hospital following vaginal delivery has been defined as a minimum of 48 hours in the US, with discharge prior to 48 hours considered as early discharge (Grullon & Grimes, 1997). LOS is considered the time spent in the hospital from the time of birth to the time of discharge to home. It is calculated by most insurers based on hospital days/nights in the hospital instead of the number of hours in the hospital which makes comparing studies on neonatal readmission and LOS difficult (Bragg et al., 1997).

Bragg et al. (1997) conducted a retrospective study in a tertiary medical center in the US. In this study, early discharge (within 24 hours of a vaginal delivery) was examined in relation to the effects of a structured program after discharge on neonatal readmissions (within 10 days of birth). The structured program was coordinated by nurse clinicians who scheduled visits to the home following early discharge. Trained registered nurses assessed the mother-infant dyads. The sample consisted of all live born infants not admitted to the NICU. The period of enrollment for the conventional discharge group (n =2739) was January 1, 1992 through June 30, 1993, and the early structured program group (n =3258) enrollment was July 1, 1993 through March 31,

1995. Inclusion criteria included mothers ≥ 18 years old with no history of substance abuse or medical complications, psychologically stable, and from a stable home environment (Bragg et al., 1997).

This study compared mother-infant dyads within 24 hours following a vaginal delivery before (conventional group) and after the early discharge structured program was implemented. Data collection included LOS in hours and hospital days (Bragg et al., 1997). The rate of neonatal readmission was 1.35% (*n* = 44 infants) in the conventional discharge group, and 1.24% (*n* = 34 infants) in the early discharge group. This did not reach statistical significance ($p = 0.71$) (Bragg et al., 1997).

Even though many of the mothers were of lower socio-economic status and received Medicaid there were factors that contributed to a safe early discharge without readmission. These included a stable home environment and the qualifications and skill level of the home health care nurses interacting with the mothers. Disadvantages of an early discharge were identified. They included inadequate time to establish lactation, insufficient time to observe the infant for medical problems while in the hospital, incomplete required metabolic screening prior to discharge, and insufficient time for discharge teaching (Bragg et al., 1997). The structured early discharge program, following vaginal, delivery included home follow up visits by a trained registered nurse to assess the mother-infant dyad and was not associated with increased neonatal readmissions. Further research on the cost implications of a structured program with nursing follow up at home are needed.

A retrospective study conducted in Canada assessed the potential impact of early discharge on neonatal readmission (Liu et al., 2000). Hospital discharge data were analyzed from the Canadian Institute for Health Information (CIHI). Data from fiscal year 1989/90 to fiscal year 1996/97 were used. Provinces with only a small number of discharges (Quebec, Nova Scotia, and Manitoba) were excluded. The sample consisted of all liveborn infants who were readmitted (N = 2,144,205). Infants less than 500 grams, and infants who had expired after birth were excluded. Data time points included readmission at seven days (n = 24,305) and 28 days (n = 68,557). A readmission was defined as "the admission of a newborn to any hospital after discharge from the hospital of birth" (Liu et al., 2000, p. 46). International Classification of Diseases, Ninth Revision (ICD-9) codes were used to assess all cause readmissions, as well as specific diagnostic categories possibly affected by discharge policies. The following ICD-9 codes were captured: jaundice-773.1, 774.2, 774.3, 774.6, 774.7; dehydration- 276.0, 276.5, 775.5, 778.4); inadequate weight gain-783.2, 783.4; feeding problems-779.3, 783.3, and sepsis-771.4, 771.8 (Liu et al., 2000).

Data were linked to readmission and birth records to adjust for differences in baseline characteristics. There was positive linkage of 94.5% of the readmission records with the birth records. Multiple logistic regression was performed. Rates of readmission at seven days were comparable with the rates of readmission at 28 days, but only the 28-day results were analyzed due to consideration of the sample size. The rate of neonatal readmission was 38.0 per 1000 infants (3.8%) in 1996/97, which was an increase of 1.07% (from 27.3 per 1000 infants [2.73%]) compared to 1989/90. There was substantial variation in timing of discharge at both seven and 28 days between the provinces and territories, with an increased rate and earlier neonatal readmission in Provinces and territories that had earlier hospital discharge from the birth hospital (Liu et al., 2000).

Confounding by indication for length of hospital stay was reported, and may have been substantial for individual cases, but was not as impactful at the province/territorial level when the odds ratios were adjusted. (Liu et al., 2000). A limitation of this study was the lack of available clinical data on readmission and possible coding errors. Other limitations included the lack of information on follow up resources to meet health care needs post discharge and information on infant deaths after discharge home. Six percent of the data could not be linked, which was another limitation of this study (Liu et al., 2000). These limitations make this study difficult to compare to other studies and it limits generalizability although the authors concluded that early discharge policies increased the neonatal readmission rate in Canada.

Discharge Readiness

Readiness for discharge to home for the mother-infant dyad following delivery/birth is determined by the pediatric and obstetric providers in conjunction with the mother and other healthcare providers including nurses (AAP: Committee on Fetus and the Newborn, 2010). The AAP recommends a toolkit (Safe and Healthy Beginnings) and a discharge-readiness checklist to assist in preparation for discharge (AAP: Committee on Fetus and the Newborn, 2010). Parental preparation and adequate scheduled follow up have been shown to decrease the risk of neonatal readmission (Weiss & Lokken, 2009).

Nursing assessment of discharge readiness following childbirth is an important component of the postpartum period in the hospital. The nurse is essential in assessing the needs of the mother in relation to discharge planning and teaching (Weiss & Lokken, 2009). Weiss & Lokken (2009) conducted a correlational study using Transitions Theory to examine discharge readiness. Transitions Theory provided a useful framework to examine readiness for discharge after childbirth and transition to home. The birth of an infant is considered a developmental transition. Transition conditions either facilitate or inhibit healthy outcomes (Meleis et al., 2000). The predictors and outcomes in this study included the postpartum mothers' perceptions of their readiness for discharge from the birth hospital, the role of discharge teaching by the nurses, and postpartum post discharge outcomes (calls to provider, family and friends, office and clinic visits, urgent care/ER visits). The study site was a tertiary care center in the US Midwest. The sample consisted of 141 postpartum mothers of mixed-parity who delivered normal healthy newborns by vaginal delivery or cesarean section (Weiss & Lokken, 2009).

Several questionnaires were completed by the mothers prior to discharge, including the Readiness for Hospital Discharge Scale (RHDS), and the Quality of Discharge Teaching Scale (QDTS). The Hollingshead Four Factor Index of Social Status was also used. Mothers were contacted by telephone three weeks post discharge. During this call, information was obtained for the Post-Discharge Coping Difficulty Scale (PDCDS) about health care utilization and the ability to cope (Weiss & Lokken, 2009).

Transition is a process triggered by change and Meleis's middle range nursing theory on transition has been used to help individuals go through transitions or changes with the goal of achieving healthy outcomes. In Weiss & Lokken's study

(2009), the Transition Theory variables (transition conditions [age, insurance payor], nature of transitions [delivery mode], nursing therapeutics [discharge teaching content and delivery]) were explored using path analysis. Outcome variables at the interval level (RHDS and PDCDS) were analyzed using multiple regression. Logistic regression was used for the outcome (utilization) variables measured at the nominal level. Only significant predictor variables were included in the final regression model, which assisted with retaining statistical power (Weiss & Lokken, 2009).

Weis & Lokken (2009) reported that mothers required varying amounts of informational material. They perceived a difference in the quality of discharge teaching based on the quantity of information and the skill of the nurses providing the discharge teaching. This explained a 38% variance in the mother's perception of their readiness for discharge. Most mothers (97%) felt ready for discharge on the discharge day. Birth hospitalization factors were not predictive of a mother's perception of readiness for discharge. Only one infant was readmitted to the hospital during the neonatal period in this study (Weiss & Lokken, 2009).

The nurses' skill in delivering discharge teaching (content and delivery) were positively predictive of discharge readiness. Most mothers felt the quantity and quality of the discharge teaching they received was adequate and positively associated with their readiness for discharge, while 6.6% felt it was inadequate. Other predictors included patient characteristics such as race/ethnicity, age, payor, socioeconomic status, living with the father of the baby, parity and type of delivery. The method of feeding was not significant predictor. Some mothers had more difficulty coping once they were at home. This was based on their readiness for discharge according to the results from the predictors of the PDCDS instrument, a negative predictor. These mothers reported a greater difficulty coping with stress, family, infant care management, self-care recovery and adjustment following discharge to home (Weiss & Lokken, 2009).

Mothers who made more ER and urgent care visits for newborn problems felt discharge teaching, delivered prior to discharge home by the nursing staff, was poor. Less than seven percent of mothers reported they received less discharge teaching than they needed or required. In Transitions Theory, transition conditions (patient characteristics) such as age and payor, and the nature of the transition (hospitalization factors) such as type of birth can influence nursing therapeutics (discharge teaching content and delivery). This can lead to patterns of response at discharge (readiness for discharge) and post discharge (difficulty coping, utilization of post discharge support and services including calls to friends and family, providers, office visits, and urgent and ER visits). It appears that Transitions Theory supports the construct of discharge teaching as a nursing therapeutic and the theory can be useful as a framework to guide assessment and measurement of outcomes in transitional situations (Weiss & Lokken, 2009).

A limitation of this study by Weiss and Lokken (2009) was recall bias. The perceptions of the mothers about the discharge teaching by the nurses may not have been the actual reality of what happened in the hospital. This data was also from one hospital and therefore does not reflect what occurs in other hospitals or with other types of complicated births thus it is not generalizable. A randomized clinical trial examining nursing therapeutics would advance understanding of the discharge education needs of new mothers.

Another study compared postpartum models of care and examined preparation for discharge, maternal satisfaction and newborn readmission for jaundice (Goulet et al., 2007). Three health regions in Canada, had three different models of care. The models of care included: 1) community-based model; 2) mixed hospital model, and; 3) mixed ambulatory model.

In the study by Goulet et al. (2007) the community-based model was commonly found in rural communities, where the local community centers monitored the newborns post discharge using home visits and phone calls. A transcutaneous bilirubinometer[1] measurement was done in the home by the community health nurse, but if needed phototherapy was not available for the home. In the mixed hospital model, the parents brought their infants in to the hospital for follow up. The nurses from the ambulatory care center made home visits and checked the infant's transcutaneous bilirubin levels in the mixed ambulatory model. They were able to provide phototherapy at home, if needed (Goulet et al., 2007).

An epidemiological survey of the three regions was conducted between February 20, 2002 to February 15, 2003. Eligibility criteria for the study included postpartum hospital stay < 60 hours, a single gestation, vaginal delivery with no complications, GA > 35 weeks, and birth weight ≥ 2300 grams. The total sample size was 1096 mothers. Eligible mothers participated in the survey phone interview a

[1] Transcutaneous bilirubinometry is a noninvasive skin-based method using an optical process of reflectance spectrophotometry to assess jaundice in infants when the device touches the infants skin. The process is painless (Brumbaugh & Gourley, 2012).

month following delivery of their infant. The survey response rate was 70.8% with a 63.5 to 77.9% variation between the three different health regions (Goulet et al., 2007). During the first week of life, 45.5% of the newborns presented with signs of jaundice (reported by the mother) and 3.2% were readmitted to the hospital. Signs of jaundice were more frequently reported under the mixed hospital model for phototherapy. No infants were readmitted for jaundice under the mixed ambulatory care model, since phototherapy was offered at home in this model. There were also significant differences in follow up procedures between the different models and the different regions. They included a call to the mother ≤ 24 hours after discharge ($p < 0.0001$), a home visit ≤ 72 hours after discharge ($p < 0.0001$), and an appointment ≤ 72 hour after discharge ($p < 0.0001$). Hospital LOS was perceived to be too short by 15% of the mothers and 25.3% of mothers perceived this in the region where the mixed ambulatory model was used ($p = 0.02$). The mother's hospital LOS, feeding practices, and demographic characteristics did not contribute to differences in preparation for discharge or maternal satisfaction (Goulet et al., 2007).

Limitations of this study included the identification of signs of jaundice by the mother and not via measured serum bilirubin levels. There may also have been recall bias since the phone calls to the mother were made one month after discharge from the hospital (Goulet et al., 2007). A strength of this study was the sample represented 80% of all deliveries in each region which was a strength of the study. Mothers ability to recognize the signs of jaundice in their newborns was an essential component of preparation for mothers and newborns discharged early from the hospital. In this study 84.5% of the mothers were aware of the signs of jaundice. Access to home phototherapy and effective coordination of this service also appears to be essential to preventing readmission to the hospital and possibly reducing costs (Goulet et al., 2007).

A national survey was conducted by the AAP, to determine the postpartum discharge preferences of 490 pediatricians who provided routine newborn care in a hospital nursery (Britton, Baker, Spino, & Bernstein, 2002). It was assumed that an infant was discharged home only when discharge readiness criteria were met. A five-point Likert scale was used to evaluate the pediatrician's perceptions of the 22 maternal and infant factors they considered important for discharge readiness. In particular the study explored what the pediatricians perceived as the minimal and optimal LOS for healthy normal newborns. A questionnaire containing 27 questions was sent to a 1634 US AAP member physicians. The response rate was 64%. Of the physicians who responded, 85% (490) reported they provided primary care to newborns. Factors considered in assessing discharge readiness in the infant included: 1) appropriate growth for GA; 2) stable, normal vital signs/thermal homeostasis; 3) normal physical exam; 4) uneventful postnatal hospital course; 5) successful feeding; 6) passage of stool, and; 7) passage of urine. Most pediatricians (81%) considered all seven of these infant factors as highly important (Britton et al., 2002)

Maternal factors, which the pediatricians considered important, included: 1) age (<18 years old); 2) educational level; 3) marital status; 4) low income/adequate resources; 5) maternal level of stress and fatigue; 6) first maternal experience, and; 7) adequacy of social support. These maternal factors were two to three times more likely to be rated as highly important by female pediatricians. Female pediatricians were also twice as likely (p = 0 .003) to rate a minimal LOS as > 24 hours (73%), and an optimal LOS as > 36 hours (69%). Rural community physicians (6%) were less likely to advocate for a LOS of > 36 hours as optimal compared to pediatricians in urban inner city (27%), urban non-inner city (22%) and suburban areas (20%) (p = 0.03) (Britton et al., 1994). Rural physicians felt that the mothers had more opportunities for follow up contact post discharge because of the smaller communities. However, the rural communities also had a more widely dispersed and more disadvantaged population. Optimal lengths of stay of > 36 hours were less likely to be identified by pediatricians who had a higher proportion of publicly insured or uninsured patients compared to their colleagues (Odds Ratio [OR] 0.53, 95% Confidence Interval [CI] [0.38,0.82]) (Britton et al., 2002).

The relationship between pediatric practitioner age and gender was significant. In this study female pediatricians were more likely to be younger (≤ 42 years of age) and the male providers were more likely to be older (> 42 years of age) (p < .001). Physician gender (female) was the most predictive in seeing the value in the adequacy of social support for the mother after controlling for the practice setting (AOR 2.44, 95% CI [1.54, 100]). This is a very wide confidence interval and is a concern. There were no practice preferences noted with feeding method, and office visits were scheduled within the first four weeks after discharge by almost all the respondents. Timing of the office visit did vary for breastfeeding infants who were significantly more likely to return for an office visit within a week following discharge compared to non-breastfeeding infants (46% vs 28%, p < 0 .01). Controlling for the practice setting (a potential confounder), male physicians were more likely to schedule office visits after the first week post discharge, for healthy term infants who were breastfeeding and not jaundiced, if they had been discharged after two days from birth compared to female physicians (AOR 1.50, 95% CI [1.03, 2.18]) (Britton et al., 2002). The gender of the provider may be an important provider characteristic.

Further regression models examined practice preferences, demographics and physician determinants for healthy, non-jaundiced term infants discharged after 48 hours and who had telephone contacts for scheduled nurse home visits. The models controlled for gender and patient insurance status. Nurse home visits were more likely to be scheduled within the first four weeks after discharge by older pediatricians for both breast-fed (Adjusted Odds Ratio [AOR] 1.37, 95% CI [1.14, 2.56]) and non-breast-fed infants (AOR 1.47, 95% CI [1.15, 4.55]). Physicians who had more publicly insured or uninsured patients were also more likely to schedule nurse home visits within the first month of discharge regardless of the feeding type (Britton et al., 2002).

It is important to note that gender played a key role in determining discharge readiness. Female pediatricians were more likely to consider maternal factors and advocated for longer length of stays as optimal when maternal age, skill, fatigue and education were accounted for. Follow up visits were also more likely to be scheduled within the first post discharge week by female providers.

The study reported that financially vulnerable patients were not deemed to require a longer LOS. More research related to this health disparity is needed, since the majority (80%) of the pediatricians felt that their decision as the patients' physician was the most important factor and insurance was a factor only 6% of the time (Britton et al., 2002). Provider characteristics such as gender and age as well as type of practice (i.e. rural or urban) may play a role in the follow up of infants and the timing of follow up. A limitation of this study included selection bias since the survey was sent to members of the AAP only (Britton et al., 2002). These results were therefore not representative of all pediatricians and is not generalizable to all pediatricians and practices. The results of this study suggest that there are many variations in provider and provider practice characteristics, as well as in institutional pre-discharge practices that need to be described and explained.

Exclusive Breastfeeding/Breastfeeding Difficulty

If there are no medical contraindications, exclusive breastfeeding is considered the ideal feeding method for infants (Seagraves, Brulte, McNeely, & Pritham, 2013). It is defined as the consumption of breast milk only (except for vitamins, minerals and medications) (Institute of Medicine, Committee on Nutritional Status During Pregnancy and Lactation, 1991). Adequate assessment of breastfeeding prior to discharge home, is necessary to identify infants who may be at risk for poor feeding. Breastfeeding difficulties can be associated with a poor latch and/or cracked, bleeding or sore nipples. Breastfeeding difficulties can result in inadequate milk intake by the infant and poor breastfeeding has been associated with dehydration and hyperbilirubinemia (Liu et al., 2000).

The LATCH score (Table 2) is a well-known assessment tool used to help identify feeding difficulties (Jensen, Wallace, & Kelsey, 1994). LATCH stands for [L = LATCH, A = audible swallowing, T = mother's nipple type, C = mothers level of comfort, and H = amount of help the mother needs to hold her infant to breast]. It is used by nurses, lactation consultants and others to assess breastfeeding and to facilitate documentation of breastfeeding assessments (Jensen et al., 1994). It was developed to provide a method of identifying concerns that would could then be addressed with necessary interventions. A score of 10 on the LATCH Score is the maximum possible score and suggests that breastfeeding is going well. Each of the five items on the LATCH score are worth two points. A lower LATCH score is a red flag. The lower the LATCH score, then the more intervention and teaching is needed to avoid breast feeding problems (Jensen et al., 1994).

Table 2. The LATCH Scoring Table

	0	1	2
L LATCH	Too sleepy or reluctant No latch achieved	Repeated attempts Hold nipple in mouth Stimulate to suck	Grasps breast Tongue down Lips flanged Rhythmic sucking
A Audible swallowing	None	A few with stimulation	Spontaneous and intermittent (< 24 hours old) Spontaneous and frequent (> 24 hours old)
T Type of nipple	Inverted	Flat	Everted (after stimulation)
C Comfort (breast/nipple)	Engorged Cracked, bleeding, large blisters, or bruises Severe discomfort	Filling Reddened/small blisters or bruises Mild/moderate discomfort	Soft Tender
H Hold (positioning)	Full assist (staff holds infant at breast)	Minimal assist (i.e., elevate head of bed; place pillows for support.) Teach one side; mother does other Staff holds then mother takes over	No assist from staff Mother able to position/hold infant

(Jensen, Wallace, & Kelsey, 1994, p. 29)

A study by Riordan, Bibb, Miller, & Rawlins (2001) used the LATCH assessment tool to assess the validity of the tool and to examine intended breastfeeding duration up to six weeks postpartum. They reported the LATCH tool was useful and valid in identifying mothers who were at risk of early breastfeeding weaning due to breastfeeding difficulties. Increased LATCH scores have been associated with an increased duration of breastfeeding (Riordan et al., 2001; Kumar, Mooney, Wieser, & Havstad, 2006). A consistent LATCH score < 6 documented on the day of discharge requires lactation intervention as soon as possible. Suboptimal feeding may occur if the LATCH score is not addressed (Mannel, 2011).

Decreased oral intake associated with breastfeeding difficulty can potentially lead to newborn dehydration and weight loss. The breastfeeding initiative known as Baby-Friendly has had an influence on breastfeeding and/or breastfeeding difficulties, weight loss, jaundice and decreased waste elimination in the first few days of life (Chen, et al. 2011). Although exclusive breastfeeding has many benefits for the infant and mother, issues such as dehydration, weight loss and jaundice are more common in exclusively breastfed infants. When coupled with early discharge, exclusive breastfeeding may lead to feeding difficulty (Chen, et al., 2011). A weight loss of $> 10\%$ from birth weight was associated with breastfeeding problems in a study by Bromiker, Bin-Nun, Schimmel, Hammerman, & Kaplan (2012). A study by Salas et al. (2010) reported increases in jaundice associated with weight loss due to inadequate oral intake. A weight loss $\geq 10\ \%$ associated with an increased risk of jaundice/hyperbilirubinemia can be found in many exclusively fed newborns (Flaherman et al., 2014).

Weight loss and breastfeeding difficulties in newborns generally results in supplementation with formula or discontinuing breastfeeding and a switch to the exclusive use of formula. This is problematic and contrary to the ten steps of successful breastfeeding from the Baby-Friendly initiative which advocates giving only human milk unless medically indicated (Nickel et al., 2013). A study by Nyuyen, Dennison, Fan, Xu, & Birkhead (2017) examined formula supplementation given to breastfeeding infants after birth. They reported variations in formula use by hospitals, and by maternal interest to use formula. Level I hospitals were less likely to supplement newborns with formula (18.2%) compared to higher level hospitals where supplementation with formula ranged from 50.6%-57.0%. Black, Asian and Hispanic infants, and infants of mothers with a 12th grade education or less were more likely to be advised to use formula supplementation. Other contributing factors for formula supplementation included insurance (Medicaid), maternal smoking, birth by cesarean section and maternal diabetes. Maternal request for formula supplementation however was the most common reason noted (Nyuyen et al., 2017). The need to establish breastfeeding in the first few days of life is critical. Interruptions of the mother-infant dyad during this critical timepoint have an impact on breastfeeding success and should be minimized (Morrison & Ludington-Hoe, 2012). Maternal and infant outcomes could be improved by changing hospital practices related to breastfeeding support and avoiding formula supplementation unless medically indicated (Nyuyen et al., 2017).

There is a lack of agreement on what constitutes average or normal weight loss in term newborns (Davanzo et al., 2013). According to the AAP, infants should not have a body weight loss of more than 7% after birth. They should also have no further weight loss after day five of birth (AAP: Section on Breastfeeding, 2012). Weight loss greater than 7%, especially around day 5-6 days of life in exclusively breastfed infants, increases the risk of hyperbilirubinemia and is cause for concern and suggests follow up (Evans, Marinelli, Taylor, & Academy of Breastfeeding Medicine, 2014). A "weight loss of greater than 7% from birth weight indicates possible feeding problems" (Salas et al., 2010, p. 48). Weight loss of individual infants can be recorded on a nomogram chart (http://www.newbornweight.org) and it can be used to track and identify infants at risk for excess weight loss (Flaherman, et al. 2014).

An epidemiologic study was done to investigate the type of feeding, and the incidence of neonatal jaundice in the first week of life. The authors concluded that "neonatal jaundice is not associated with breastfeeding per se but rather with increased weight loss after birth subsequent to fasting, suggesting the role of caloric intake in the regulation of serum bilirubin" (Bertini, Dani, Tronchin, & Rubaltelli, 2001, p.3).

Davanzo and colleagues (2013) examined breastfeeding and neonatal weight loss in healthy newborns. Early neonatal weight loss was compared in breast fed versus formula fed infants. The authors reported breastfeeding may not be a risk factor for weight loss when it is monitored routinely, assessed and supported, and when supplemented with formula as needed (Davanzo et al., 2013). The mean weight loss and time of nadir of weight loss in exclusively breastfed healthy term infants is not currently known (Thulier, 2016). On the other hand, early discharge ($\leq$ 48 hours from the birth hospital) has been associated with increased readmissions for jaundice and hyperbilirubinemia in term infants (Hall, Simon, & Smith, 2000). Early discharge from the hospital should not be considered without risk. It may lead to potentially missed diagnoses by the health care provider and lead to hyperbilirubinemia (Zimmerman, Klinger, & Merlob, 2003). An association requiring readmission within the first week following discharge to home was noted between breastfeeding and jaundice in the cohort studied by Radmacher et al. (2002).

A study was designed by Mannel (2011) in order to define lactation acuity levels. Acuity levels are how much nursing care is required in the hospital. The author proposed three lactation acuity levels based on combined and independent infant and maternal characteristics of severity of illness. As the lactation acuity level of the mother and infant increases more skills and resources to promote lactation are needed. Without acuity definitions, staff may attend to mothers who do not require as much help, and neglect mothers who do require more help. Defining the proposed three levels could improve patient safety and outcomes by requiring staff to work with patients with higher acuity levels first (Mannel, 2011).

The following identifies the criteria for the three levels. Acuity level I involves patients, being cared for by nursing staff, who have a basic knowledge and competency in breastfeeding. Acuity level I involves patients, who should be cared for by a registered lactation consultant or referred to one as soon as possible in the community. They should also have early follow up after discharge. Acuity level III involves patients who are still in the hospital who need need in-depth assessment and management by a registered lactation consultant. They also need early follow up after discharge (Mannel, 2011). When lactation acuity levels are assessed and standardized then adequate resources and interventions can be applied to improve breastfeeding initiation and duration (Mannel, 2011). This could potentially reduce readmission rates for hyperbilirubinemia.

A prospective study done in Taiwan examined the effectiveness of discharge instructions given to the mother on the frequency of breastfeeding in relation to post discharge weight (loss or gain) and the rate of hyperbilirubinemia (Chen, Yeh, & Chen, 2015). Infants admitted to the Special Care Nursery or NICU were excluded. The sample size consisted of 98 infants. At discharge, mothers received instructions to breastfeed frequently whenever their infant was hungry. They were also asked to document the frequency of the feeds and diaper changes daily. Infants were weighed at discharge. After discharge they were seen within 14 days of birth for a follow up visit. Infants were weighed at that follow up visit. Infants who breastfed ≥ 8 times a day had less hyperbilirubinemia ($p = 0.01$). The number of feeds per day ($p = 0.01$) and the number of diaper changes ($p = 0.06$) were reported to be positively correlated with less hyperbilirubinemia. There was no difference in weight noted at discharge and at the outpatient visit in the infants who were breast-fed ≥ 8 times a day or < 8 times a day (Chen et al., 2015).

A retrospective case control study by Oddie et al. (2005), included all infants readmitted to hospital during the first 28 days of life. The sample excluded infants < 35 weeks GA. The aim of the study was to determine the association and frequency of early discharge and infant readmission to hospital. Early discharge was defined as "discharge on the day of birth or the day after the day of birth" (Oddie et al., 2005, p.119). Data from a patient administration system collected in 1998 at 14 northern United Kingdom (UK) hospitals was utilized (Oddie et al., 2005). The neonatal readmission rate was 2.8% (*n* = 907). There were significant differences in readmission by birth hospital, but no significant differences were noted in the timing of discharge from the hospital. Risk factors for early discharge were identified using univariate and multivariate analyses, which used the readmissions from the five largest maternity hospitals only (*n* = 408). This was because control data could not be abstracted from some of the other hospitals records. The infants more likely to be readmitted to the hospital at < 29 days of age were born at 35-37 weeks gestation (AOR 1.72, 95% CI [1.15, 2.57]) compared to 38-40 weeks, and weighed < 2500 grams (AOR 1.95, 95% CI [1.16, 3.28]) compared to infants weighing 2500-4499 grams at birth (Oddie et al., 2005).

Exclusive breastfeeding led to fewer neonatal readmissions (AOR 0.69, 95% CI [0.53, 0.90]). However, this conclusion was not significant when confounding was accounted for (AOR 0.87, 95% CI [0.76,1.00]). Confounding variables included the type of hospital, mode of delivery, GA, parity, maternal age, birth weight, feeding at hospital discharge, deprivation quintile [a community-based deprivation score based on postcode and population] and early discharge (Oddie et al., 2005).

It is important to keep in mind this study was conducted in 1998 and the rate of infants breastfeeding at discharge was very low (13%). This study also raises the question of variability in provider characteristics, rather than in maternal and infant characteristics. Midwives played a larger role with post discharge follow up in the UK where post discharge visits to the home are the standard care. The frequency of the postdischarge visits were not reported (Oddie et al., 2005). Confounding due to early discharge (home on the day of birth or the next day after birth) appeared to be a major factor in this study and was not explained by maternal and infant characteristics. The authors report variation in provider culture and practice may have played a role in the factors associated with neonatal readmission and suggested clinical trials on early discharge policies and readmission are needed. Limitations of this study included a lack of documentation and information on diagnosis codes, feeding issues, weight loss, and the possible underestimation of the association between early discharge, readmission and deprivation (Oddie et al., 2005).

Breastfeeding jaundice is considered a disorder of the enterohepatic system and infants who are exclusively breastfed are at risk (Kaplan et al., 2015). Treatment for hyperbilirubinemia associated with breastfeeding includes phototherapy, formula supplementation and/or replacing breastfeeding with formula, and exchange transfusions, in severe cases (Burgos, Flaherman, & Newman, 2012). Supplementation with formula may be needed in cases of dehydration and weight loss. Prolonged jaundice beyond two weeks of life requires a lactation and nutrition history, weight checks, and an assessment of genetic polymorphisms associated with family history due to the possible risk of increased breast milk jaundice with certain conditions (Hansen & Bratlid, 2012). Most of the infants in a study by Kavehmanesh et al. (2008) were exclusively breastfed. There was no significant effect of feeding on jaundice in this study. There were significant differences which are described in detail in the next section on jaundice.

Breastfeeding difficulty in exclusively breastfed infants during the birth hospitalization must be addressed prior to discharge home. Formula supplementation is not recommended unless medically indicated and the use of formula should be carefully considered (Nickel et al., 2013). On the other hand, complementary formula feeding with breastfeeding or supplementary formula is considered appropriate when medically necessary such as with inadequate milk intake (Tyler & Hellings, 2005). The LATCH score can be a useful tool to assess breastfeeding in mother-infant dyads during the hospital stay (Jensen et al., 1994). It is important to determine if the mother and infant are ready for discharge and if the mother requires help from a lactation consultant prior to discharge home. The assessment of the nutritional status of the infant at the time of discharge is a critical part of the discharge process (AAP: Committee on Fetus and the Newborn, 2010).

A determination of the lactation acuity level of the mother-infant dyad can also help healthcare providers prioritize those mothers who require more assistance. Lactation support by the staff and use of available resources can be offered appropriately. Several studies have reported a decreased risk of readmission in newborns when adequate parental preparation, support and follow up is provided (Danielson, Castles, Damberg, & Gould, 2000; Oddie et al., 2005).

Jaundice (Icterus)/Hemolytic Disease

Jaundice, a yellow coloring of the infant's skin and sclera (whites of the eyes) is a manifestation of elevated levels of bilirubin (hyperbilirubinemia) in the blood related to hemolysis of red blood cells (Dennery, Seidman, & Stevenson, 2001). Bilirubin has been defined as the "orange-yellow pigment of bile, formed principally by the breakdown of hemoglobin in red blood cells after termination of their normal lifespan" (Urdang, 1983, p. 125). Increased production of bilirubin, and decreased excretion of bilirubin, can contribute to higher bilirubin levels in the blood. The cycle of bilirubin production, lysis of red blood cells, and elimination of bilirubin from the body is a continuous cycle. Bilirubin production is increased in newborns due to a shorter lifespan of circulating red blood cells compared to adults red blood cells (70-90 days versus 120 days) (Kaplan, Wong, Sibley, & Stevenson, 2015).

The amount of bilirubin produced by a newborn (8-10 mg/kg/day) is two to three times the amount produced by an adult (Kaplan et al., 2015). According to Stevenson, Maisels, & Watchko (2012), bilirubin is known to have both positive (salutary) and negative (toxic) effects. Hyperbilirubinemia, a negative effect, has been defined as as a TSB level ≥ 95^{th} percentile on an hour-specific nomogram (Bhutani, Johnson, & Sivieri, 1999). Jaundice and hyperbilirubinemia continue to be the most common reasons for neonatal readmissions (Escobar et al., 2005; Mateo, Lee, Barozzino, & Sgro, 2013).

Maternal factors associated with the risk of readmission for hyperbilirubinemia include maternal age ≥ 25 years, maternal diabetes, Asian race and exclusive breast milk feedings. Infant factors include male sex, GA of 35-36 weeks, jaundice in the first 24 hours, previous sibling with jaundice, positive direct Coombs, cephalohematoma and Glucose-6-phosphate dehydrogenase (G6PD) deficiency (Slaughter, Annibale, & Suresh, 2009). Jaundice can be classified as physiologic or nonphysiologic according to certain conditions. These conditions include the time of onset after delivery, the clinical course of the infant, the rate of rise of bilirubin levels, and how soon it resolved (Melton & Akinbi, 1999).

Physiologic Jaundice

Physiologic jaundice is seen in about 60% of all term newborns, most often during the first week of life (Maisels & McDonagh, 2008). It peaks on day three to five of life and usually does not require treatment. This may be indicative of its beneficial effects or antioxidant properties especially with countering oxidative stress (Hansen & Bratlid, 2012). Almost every newborn's TSB level exceeds 1 mg/dL (higher than the normal upper limit for an adult) at some point in the first week of life (Maisels & Newman, 2012). The skin becomes visibly yellow moving in a cephalocaudal direction. The human eye can detect jaundice at a TSB levels of approximately 5 mg/dL. Visual detection of jaundice is more difficult with infants who have a reddish (i.e. as seen in polycythemia) or darker skin color (Hansen & Bratlid, 2012). A normal phenomenon of physiologic jaundice is the breakdown of red blood cells and the release of bilirubin. This may be coupled with a decreased ability to excrete the bilirubin in the first few days of life due to low nutrient intake (secondary to feeding difficulties) and subsequent decreased intestinal transit time (Hansen & Bratlid, 2012).

Genetic, ethnic and cultural factors increase that the risk of physiologic jaundice in "Native American, Chinese, Japanese, Korean and other Asian term newborns…about double those of the white and African-American populations" (Kaplan et al., 2015, p. 1628). Male infants and infants who have a sibling with jaundice are at increased risk of hyperbilirubinemia (Burgos et al., 2008; Melton & Akinbi, 1999). Children of Asian race have an increased risk of hyperbilirubinemia, while infants born by cesarean delivery and children of African American race are not at increased risk (Burgos et al., 2008).

Nonphysiologic Jaundice

Nonphysiologic jaundice is related to disease conditions that cause increased hemolysis or decreased bilirubin clearance or both (Hansen & Bratlid, 2012). Jaundice that occurs at less than 24 hours of age (with evidence of hemolysis), and/or jaundice that persists for more than 10 days are predictive of nonphysiologic jaundice (Hansen & Bratlid, 2012). Other factors that may predict nonphysiologic jaundice and or hyperbilirubinemia include a bilirubin level rise of 0.5 mg/dL per hour, or greater than 5 mg/dL per day, and or bilirubin >15 mg/dL in a term infant (Hansen & Bratlid, 2012). Newborns with infection or septicemia are also known to have increased jaundice in the first few days of life (Hansen & Bratlid, 2012). Increasing jaundice and elevated levels of bilirubin can be detrimental to newborns in the first week of life when the infant is unable to clear the bilirubin. Readmission to the hospital may be required for treatment.

Bilirubin is measured as the TSB level or as a fraction (unconjugated or conjugated and delta bilirubin) in mg/dL or micromol/L (Van Leeuwen & Bladh, 2015). Unconjugated bilirubin which is water insoluble must be converted to water soluble conjugated bilirubin for it to be excreted in the bile (Kaplan et al., 2015). TSB has been defined as “the sum of unconjugated or indirect bilirubin, monoglucoronide, and diglucoronide, conjugated or direct bilirubin, and albumin bound delta bilirubin” (Van Leeuwen & Bladh, 2015, p. 207).

Increased bilirubin levels may be due to disorders of production, conjugation or excretion. Disorders of production include G6PD deficiency and isoimmune hemolytic disease due to blood group incompatibility between the mother and infant. They are the most common pathologic causes of unconjugated hyperbilirubinemia (Kaplan et al., 2015). Genetic variation is increasingly being recognized as contributing to neonatal jaundice (Watchko & Lin, 2010). G6PD, uridine diphosphate glucoronosyl transferase 1A1 (UGT1A1), and solute carrier organic anion transporter polypeptide 1B1 (SLCO1B1) are polymorphisms across three genes that are involved in bilirubin production and metabolism and the genes vary among populations and ethnic groups (Watchko & Lin, 2010).

Disorders of conjugation include Crigler-Najjar Syndrome Type I and II, Lucy-Driscoll Syndrome (transient familial neonatal hyperbilirubinemia), pyloric stenosis and hypothyroidism (Kaplan et al., 2015). Disorders of excretion result from hepatocyte injury (Kaplan et al., 2015). The enterohepatic circulation involves a cycle of conjugation, deconjugation, uptake, excretion and reabsorption. Any condition (i.e. inadequate nutrition due to lack of or difficulty with feeding) that delays or interrupts the passage of intestinal contents can increase the enterohepatic circulation leading to increased levels of bilirubin in the blood (Hansen & Bratlid, 2012). Onset of jaundice on the third day of life or jaundice in association with other findings, such as a family history of significant hemolytic disease, lethargy, vomiting, fever, poor feeding, high-pitched cry, dark urine and light stools should be investigated further and not ignored (Newman & Maisels, 1992). It is believed that the blood-brain barrier of a neonate may be more permeable than an older infant. Bilirubin can potentially gain entry to the brain and have a toxic effect (Hansen & Bratlid, 2012).

Acute Bilirubin Encephalopathy (ABE) and Kernicterus

Excessive levels of bilirubin, if untreated, can lead to acute bilirubin encephalopathy (ABE) and kernicterus, which can have long lasting neurological effects on the infant (Dennery et al., 2001). The term ABE is used to describe early acute bilirubin encephalopathy which can progress clinically to kernicterus if there is no intervention/treatment. ABE is seen in the first few weeks after birth (Shapiro, 2012). The signs of ABE can be subtle and can be easily missed. They include tone abnormalities, irritability, lethargy, drowsiness, and decreased feeding (Johnson, Bhutani, Karp, Sivieri, & Shapiro, 2009). The term kernicterus is used to describe more chronic and permanent symptoms (Shapiro, 2012). They include arching of the neck and trunk, increased lethargy and poor feeding, increasing irritability with a shrill cry. Symptoms can progress to bicycling movements/seizures with cessation of feeding and coma (Johnson et al., 2009). Population based estimates of kernicterus in developed countries range from 1:50 000 to 1: 200 000 infants. Estimates in undeveloped countries may be much higher but are not known (Stevenson et al., 2012). Kernicterus is an irreversible condition in which necrosis of the nerve cells occurs following prolonged exposure to bilirubin toxicity (Maisels, 1992).

Bilirubin Induced Neurologic Dysfunction (BIND).

BIND is a term used to describe the collective and subtle neurological deficits resulting from unconjugated bilirubin entering the brain, but it does not have the typical findings of kernicterus (Shapiro, 2012). The pathophysiology of BIND is not fully understood. Research is ongoing to determine if the developing brain has enough plasticity to recover from brain injury during early life from BIND (Brites & Brito, 2012).

The early identification of jaundice is critical in the first few days to weeks of life. It is critical because initiating treatment for infants with jaundice may minimize the risk of hyperbilirubinemia and kernicterus (Alkalay, Bresee, & Simmons, 2010). Hyperbilirubinemia regardless of the primary cause has the potential to cause long-term neurological impairment (Barrington, Shankaran, & Canadian Pediatric Society, 2007).

Phototherapy is a highly desirable and effective treatment for hyperbilirubinemia and it should be initiated when high levels of bilirubin are detected in the newborn (Dennery et al., 2001). The BiliTool (www.bilitool.org) has been designed to help pediatric practitioners assess which infants, over 35 weeks GA, are at risk for developing jaundice or hyperbilirubinemia. This tool is based on the hour specific nomogram for risk stratification published by the AAP (AAP: Subcommittee on Hyperbilirubinemia, 2004). The age of the child between 12 and 146 hours, and the TSB value in either US (mg/dL) or Standard International Units [SI] (µmol/L) units, is entered into the online tool by the practitioner. A management plan is then suggested (BiliTool Inc, 2004-2014). Plotting TSB values on the bilirubin nomogram provides a more consistent approach to screening and management, but infants categorized as low risk may be at significant risk using the nomogram alone. Clinical risk factors must be evaluated as an adjunct to the nomogram (Slaughter et al., 2009).

Determining when hyperbilirubinemia leads to kernicterus is not clear. Studies on early postnatal discharge and readmission for jaundice have conflicting results (Lain et al., 2015). Early discharge from the hospital has been suggested as a reason for hyperbilirubinemia and kernicterus despite existing treatments such as phototherapy, prophylactic Rh immunoglobulin, and exchange transfusions. However, this has been difficult to document because of the rarity of the event (Burgos et al., 2008).

A study conducted in Iran examined the prevalence of readmission for jaundice within 14 days of life and the risk factors associated with jaundice in newborns $\geq$ 2500 grams (Kavehmanesh et al., 2008). This cross-sectional study was conducted from 2004-2005. The sample consisted of (N = 3112) mother-infant pairs who delivered/were born at a hospital in Tehran. Infants were healthy, singleton infants who weighed $\geq$ 2500 grams at birth. The mothers completed a questionnaire following delivery and prior to discharge home. They were instructed to call if they noted any signs of jaundice and were also contacted by phone on day three, seven, 10 and 14 of life to inquire about jaundice or readmission. However, the authors did not indicate how the mothers were taught to assess the signs of jaundice in this study (Kavehmanesh et al., 2008).

Readmission for jaundice was 12.6% within the first 14 days of birth, which is considerably higher than in the US. Criteria for readmission included a bilirubin level of $\geq$ 95% in the first 48 hours, plotted on the bilirubin nomogram or $\geq$ 15 mg/dL after the first 48 hours. Significant factors associated with elevated bilirubin levels included maternal race (increased in Arab mothers, $p = 0.001$), Rh group [(Rh negative

(17.9%) greater than Rh positive (12%), p = 0.001]) and drug consumption during pregnancy. However, no mention was made of the drugs consumed other than Oxytocin use during labor, which was documented. Oxytocin was not a significant risk factor (OR 1.20, 95% CI [0.54, 2.64]). This study only included infants delivered by vaginal delivery (Kavehmanesh, et al., 2008).

A retrospective cohort study in California (CA) examined population-based trends in readmission for neonatal jaundice. The costs for readmission in term and late preterm (34 to 36 weeks GA) infants readmitted within 14 days of birth for jaundice was also examined (Burgos et al., 2008). Infant vital statistics data and maternal and infant hospital discharge summaries, collected between 1991-2000 from the CA Office of Statewide Planning and Development, were linked. Healthy, routinely discharged infants with a readmission ICD-9 code for jaundice were included in the sample (N = 4,440,866).

The overall rate of neonatal readmission for jaundice peaked in 1998. The rate was 11.34 per 1000 (1.13%) (Burgos et al., 2008). There were no increased odds of readmission with LOS less than two days using regression analysis. The risk of readmission for infants at 35-36 weeks GA was three times greater than that of term infants. The risk factors for readmission associated with jaundice/hyperbilirubinemia included male gender (OR 1.37, 95% CI [1.35,1.40]), Asian race (OR 1.53, 95% CI [1.48,1.58]), and infants with birth weight < 2500 grams (OR 1.24, 95% CI [1.19,1.30]). Infants delivered by cesarean section (OR 0.44, 95% CI [0.42, 0.45]), and black race (OR 0.34, 95% CI [0.32, 0.36]) had a lower likelihood of being readmitted for jaundice/hyperbilirubinemia (Burgos et al., 2008).

Hispanics were more likely to be discharged earlier than recommended after birth, and although their bilirubin levels tended to be elevated they were less likely to be readmitted. This was explained as a possible protective factor in this population of mostly Mexican immigrants in CA, whereas Asian mothers had an increased risk of readmission for jaundice (Burgos et al., 2008).

Limitations of this study included practice variability in estimating costs and lack of information on the incidence of kernicterus. There was no data on the clinical guidelines or the discharge policies in use at the time of data collection for this study (Burgos et al., 2008). Neonatal hospital readmissions are costly. Estimated charges in this study were adjusted to 1991 hospital-specific costs (Burgos et al., 2008). The median cost of all neonatal readmissions was $1594 with a mean cost of $2764 per patient (Burgos et al., 2008).

Another study in 2012, by the same author, reported the average hospital readmission for hyperbilirubinemia (including treatment with phototherapy) can cost approximately $3000 per patient (Burgos et al., 2012). The cost of a neonatal readmission is likely to be much higher today. Preventing readmissions for hyperbilirubinemia is an important patient safety issue and an important cost issue. Efforts to improve prevention of hyperbilirubinemia following discharge from the birthing hospital have been underway throughout the last decade. The AAP Clinical Practice Guideline was developed to effectively recognize, treat and prevent hyperbilirubinemia (AAP: Subcommittee on Hyperbilirubinemia, 2004). The Fetus and Newborn Committee of the Canadian Paediatric Society recently reaffirmed their guidelines for the detection, management and prevention of hyperbilirubinemia in term and late-term newborn infants (Canadian Paediatric Society, 2016).

Although the AAP guideline to screen and treat infants with hyperbilirubinemia are being followed at most institutions, surveillance strategies to monitor and measure the impact of the guideline on the incidence of hyperbilirubinemia and kernicterus have been lacking. According to Bhutani & Johnson (2009b) it has been difficult to determine the effectiveness of these guidelines.

Two studies, since 2004, have examined the compliance with the AAP guidelines (Profit, Cambric-Hargrove, Tittle, Pietz, & Stark, 2009; Mateo et al., 2013). A retrospective chart review of every fifth patient within a pediatric provider network group of urban and suburban pediatricians was conducted. Of the 845 charts reviewed 698 met the eligibility criteria (first visit January through July 2006 and within four weeks of birth, GA $\geq$ 35 weeks and $\geq$ 2500 grams, and healthy newborns) (Profit et al., 2009). The number of infants seen prior to six days of age was 37% (44% delivered vaginally and 41% were exclusively breastfed). Thirty five percent of infants were seen after 10 days of age.

The study concluded that the implementation of the AAP guidelines was inconsistent, and information was needed to understand the reasons for delayed follow up. Data had been collected from the office records only and was reported as a limitation of the study. Length of birth hospital stay was not known. The authors also believed some pediatricians may have prioritized follow up with the use of predischarge bilirubin measurements (Profit et al., 2009).

The second study examined compliance with screening and management guidelines of the AAP and the Canadian Paediatric Society in Ontario, Canada (Mateo et al., 2013). General practitioners, pediatricians, midwives and family medicine practitioners were surveyed and 17% responded. The management of jaundice varied with practitioner type. Bilirubin levels were measured prior to discharge by 63% of the pediatricians, 42% of family physicians and 22 % of the midwives ($p < 0.001$). Completion of newborn follow up by 72 hours of discharge also varied by provider type (pediatricians 89%, family physicians 60% and midwives 100%). The authors reported multifactorial barriers to adherance of the guidelines which included a lack of awareness, agreement with, and lack of easy access to the guidelines. (Mateo et al., 2013).

The AAP policy statement on hospital stay for healthy newborns recommends deferring discharge until a mechanism for follow up is established if the infant cannot be scheduled for an appointment within 48 hours of discharge (AAP: Committee on Fetus and the Newborn, 2010). Variations in screening and management may contribute to readmissions to the hospital for jaundice when health care microsystems and macrosystems are not optimized (Schyve, 2004). Macrosystems are the health care organizations which include home health care, hospitals and clinics (Schyve, 2004). Micro systems are defined as “the processes that deliver care at the front lines” (Schyve, 2004, p. 591). This includes the patient, the people who deliver the care (including nursing care) in the hospital unit, physician offices and the patient’s home (Schyve, 2004).

Health care system failures have been identified as putting infants at risk (Carr, 2015). Infants discharged from the hospital with unrecognized jaundice can develop kernicterus, if hyperbilirubinemia is not diagnosed and treated promptly (Carr, 2015). The Institute of Medicine report states an error can be the failure of a planned action to be carried out or the execution of an incorrect plan to achieve an aim (error in planning) (Kohn, Corrigan, & Donaldson, 2000). The incidence of kernicterus is about one in seven in infants with TSB values > 30 mg/dL (Bhutani & Johnson, 2009a). If looked at "in analogy to aviation standards, acute kernicterus events are akin to airline crashes" (Bhutani & Johnson, 2009b, p. S5).

In the term infant, many factors have been associated with neonatal readmission for hyperbilirubinemia. They include LOS, breast feeding difficulty, dehydration, significant birth weight loss, ethnicity and hemolytic conditions (Melton & Akinbi, 1999). However, the most common cause of neonatal readmission remains jaundice/hyperbilirubinemia (Melton & Akinbi, 1999). Identifying infants who may be at risk of developing jaundice and/or hyperbilirubinemia prior to discharge is important in preventing avoidable neonatal readmissions. In some institutions, TSB levels are not routinely drawn prior to discharge. Instead of universal bilirubin screening, the standard at most of these institutions is bilirubin screening for infants at risk (Burgos et al., 2012). A study in CA reported a decrease in readmission rates in term and near-term infants [34-36.6 weeks GA] from 24 per 1000 live births to 3.7 per 1000 live births with the implementation of universal screening for bilirubin and hyperbilirubinemia. Guideline-based discharge education may also be useful in preventing avoidable neonatal readmissions (Waldrop, Anderson, & Brandon, 2013).

Infection/Neonatal Sepsis

Microorganisms are known to produce toxic products that may interfere with bilirubin excretion leading to increased levels of bilirubin in the blood. Bacterial, viral and protozoal infections can lead to increased erythrocyte destruction (Halamek & Stevenson, 1997). Urinary tract infections in the neonatal population are treated with antibiotics with resolution of the hyperbilirubinemia (Halamek & Stevenson, 1997). Brown et al. (1999) report other infections associated with readmission included chlamydia eye infections, aseptic meningitis and omphalitis in a study of mostly (94%) term infants.

Readmissions for infection and sepsis tends to occur in the second week of life (Brown et al., 1999). A retrospective multisite study conducted in 1995, examined the factors related to readmission of term and near-term infants, at nine hospitals in the greater New York city area. The sample included readmissions within 14 days of life of those infants who had been discharged from the newborn or transitional nursery (N = 395). Infants admitted from home following accidental injuries and those admitted directly to the NICU after delivery were excluded. Readmissions were categorized according to primary admission by the study neonatologists at each site (Brown et al., 1999).

Diagnosis codes were not provided but the most common diagnosis was infection at 40.7% (n = 159 infants). This was followed by hyperbilirubinemia at 39.1% (n = 153 infants) and feeding difficulties at 10.5 % (n = 41 infants). A TSB level ≥ 12.9 mg/dL was defined as hyperbilirubinemia for this study. During the first week of life, the readmission rate for infection was 19.1% and 65.1% for hyperbilirubinemia. In the second week of life, the leading cause of readmission was infection or suspected sepsis (73.4%). Fewer infants were admitted in the second week of life for hyperbilirubinemia (7.6%). The difference between the number of infants readmitted for hyperbilirubinemia between the first and second week of life was statistically significant ($p = < 0.001$) (Brown et al., 1999).

The high rate of readmission for infection differed by race. Hispanic and African American infants were readmitted at higher rates than other races. These mothers also had lower parity and were younger (< 24 years) than White or Asian mothers. It was not clear if a lack of knowledge or experience of the young mothers (< 18 years) may have contributed to the increased rate of neonatal readmissions for infection during the first two weeks of life. These mothers may not have received adequate education on handwashing and restricting the infant's contact with family members who showed signs of illness (Brown et al., 1999).

Of the infants who were formula fed, there was a statistically significant difference in infants readmitted for infection (51%) versus hyperbilirubinemia (22.0%) ($p < 0.05$). The rate of exclusive breastfeeding in African Americans and Hispanics was 9.7 and 9.1% respectively. This varies a great deal from the rates of exclusive breast feeding in Asian (25.0%) and white infants (57.5%). It is also important to keep in mind that this study was conducted in 1995 and breastfeeding rates may vary today (Brown et al., 1999).

A reported study limitation included not knowing how many infants had genitourinary abnormalities or how many discharged infants were readmitted to nonstudy hospitals. The higher rates of infection which was significant by race was not expected and was beyond the scope of the study analysis. (Brown et al., 1999).

In another retrospective cohort study, 10% of readmissions in the first week of life were due to infection in preterm infants and readmission rose to 60% by the second week of life. In term infants the rate of readmission was seven percent in the first week and 53% in the second week of life (Tomashek et al., 2006). The primary aim of this study was to compare the risk of neonatal morbidity between singleton, late preterm newborns and those born at term following vaginal delivery. Timing of readmission and the primary diagnosis on readmission were also examined. A population-based sample included all liveborn infants 34 to 41 weeks delivered vaginally from January 1, 1998 to November 30, 2002 at a Massachusetts hospital. The participants, who were Massachusetts residents, were discharged home at < 48 hours of age and later readmitted or observed in the hospital within 28 days of life. The final sample consisted of 1004 preterm infants and 24,320 term infants. (Tomashek et al., 2006).

Data were obtained from the Massachusetts Pregnancy to Early Life Longitudinal (PELL) Data Project and were linked to vital statistics (birth and death certificates) and inpatient postnatal hospital discharge data during the neonatal period. The percent of records linked with the birth certificates was 98%, 77% for the hospital discharge record at readmission, and 85% for postnatal observational stays. Any medical condition requiring readmission or observation in the hospital within 28 days of life was considered a neonatal morbidity. LOS was calculated by subtracting the date of birth (birth certificate) from the date of discharge (hospital discharge record) (Tomashek et al., 2006).

Frequency distributions and multivariate analysis was performed. Mantel-Haenszel crude and stratified risk ratios and 95% confidence intervals were calculated to assess effect-measure modification and confounding. The International Classification of Diseases (Ninth Edition) was used to classify the primary diagnoses. All models were adjusted for gender and parity. Of the infants readmitted, 45.7% of preterm and 60% of term infants were readmitted for jaundice, and 31.4% of the pre-terms and 33.5% of the term infants were readmitted for infection. The rate of readmission for breast fed preterm infants was significant at 3.5% versus 2.0% for term infants (AOR 1.8, 95% CI [1.3, 2.5]). Observational stay for the two groups was not significant (AOR 1.0, 95% CI [0.5, 2.0]). Overall morbidity was further adjusted for prenatal care utilization using the Kotelchuck Adequacy of Prenatal Care Utilization Index and was significant (AOR 1.5, 95% CI [1.1, 2.0]) (Tomashek et al., 2006).

Several limitations of the study were noted including the low linkage with the hospital readmission data due to a social security number not being available on every infant. This may have underestimated the neonatal morbidity in this population. ER data was also not available. The study information was based on mother's intention to breast feed and it was not known how many mothers followed through since post discharge services were not available. Also, readmission rates in this study for term infants are compared to studies completed before 2000 and may be dated. The rate of readmission in this study for term infants was 2.0% and 3.5% for late preterm infants (34-36 weeks completed gestation).

Intrapartum infection is also a concern. Group B streptococcus (GBS) bacteria are found in the rectum and vagina of 25% pregnant women. Colonization of the maternal rectal or vaginal tract can be asymptomatic. Vaginal delivery allows for vertical transmission of GBS to the infant (Centers for Disease Control and Prevention, 2016). Testing for GBS is routine at 35-37 weeks GA and mothers who are positive are treated during the intrapartum period to prevent passing the infection to the infant during birth (Centers for Disease Control and Prevention, 2016). Infants of mothers treated with an intrapartum antibiotic and who tested positive for GBS have a 1 in 4,000 chance of developing GBS at delivery versus untreated mothers whose infants have a 1 in 200 chance of developing GBS infection at delivery (Centers for Disease Control and Prevention, 2016).

In spite of the chance of developing GBS infection, a Cochrane Database of Systematic Reviews study on intrapartum antibiotics for known maternal GBS colonization concluded that there is a lack of evidence for the recommendation for intrapartum prophylaxis (Ohlsson & Shah, 2014). The role of maternal infection or colonization and treatment for GBS associated with neonatal readmission needs to be examined further. False-negative GBS cultures, missed screening and inadequate intrapartum antibiotic prophylaxis (IAP) were cited as some of the findings from a study of intrapartum GBS prophylaxis (Pulver, et al., 2009). Factors (e.g. early discharge and breastfeeding) related to newborn readmission in all newborns within three weeks of life found no association between the presence of a positive GBS cervical culture and readmission (Soskolne, Schumacher, Fyock, Young, & Schork, 1996).

The available literature suggests infection/sepsis is more common in the second week of life. The rates of infection are higher in younger and lower parity African American and Hispanic mothers compared to White and Asian mothers. There is insufficient information in published studies to determine the cause of this. Further investigation is needed to begin to understand if there are health disparities in access to care, perinatal education and intrapartum screening and treatment of mothers with GBS infection. Understanding the home environment is also important.

Dehydration /Hypernatremia

Inadequate breastfeeding and/or insufficient breast milk intake are problems associated with lactation that can lead to dehydration and hypernatremia (> 150 mEq/liter) in exclusively breastfed newborns (Staub & Wilkins, 2012). An increased sodium load in the mother's breast milk can indicate a poor breast milk supply. In the first 24-48 hours after birth, the mother's milk supply is limited to small amounts of colostrum and inadequate infant suck and maternal factors (i.e. fatigue, cracked nipples) can influence milk supply (Halamek & Stevenson, 1997). Inadequate lactose production during the early breastfeeding period and/or development of mastitis (an infection of the breast tissue) may also contribute to poor or inadequate feeding and an increased sodium load (Avery, Villee, Baker, & Wharton, 1988; Staub & Wilkins, 2012). Poor milk intake and underhydration in newborns can lead to delayed meconium passage and a state of starvation (Halamek & Stevenson, 1997). Dehydration and jaundice in exclusively breastfed infants has been associated with neonatal readmission (Liu et al., 2000). However, serum sodium levels > 150 mEq/l have been a rare event (0.2% in the first days of life and seen in only 0.3% of infants following discharge (Davanzo et al., 2013).

A study by Radmacher et al. (2002) examined the hidden morbidity of successful discharge in infants discharged early at ≤ 48 hours of age versus infants discharged at > 48 hours of age. Seventy-seven infants who were readmitted in the early discharge group and 33 infants who were readmitted in the late discharge group had electrolyte values available. Serum sodium values were found to be above 145 mEq/l in 36% of infants discharged at ≤ 48 hours, and 21% in infants discharged after 48 hours. There was a statistically significant ($p < 0.001$) difference in serum sodium values (86% elevated versus 45% normal) in 35 infants who were breastfeeding. Hypernatremia was believed to be a co-morbidity in infants who were readmitted to the hospital for jaundice (Radmacher et al., 2002).

A case-control study conducted in Iran prospectively examined the risk factors, symptoms, complications and incidence of neonatal hypernatremia dehydration (NHD) in healthy term infants who were breastfed. It also examined readmission within 27 of days of discharge after birth (Boskabadi et al., 2010). Breastfed, term infants who had a serum sodium level ≥150 mmol/L were enrolled into the case group ($n = 53$) between June 2006 and June 2007. Healthy term infants who were also breastfed, with serum sodium levels <150 mmol/L were enrolled into the control group ($n = 53$) from the same hospital. Weight loss was significant in the NHD (case) group [16.2%] versus the non-NHD (control) group [1.6%]. The frequency of feeding in the NHD group was less (7.6 vs 10.2, $p < 0.001$). Mothers of infants in the NHD (case) group had more breast problems (23 vs. 7, $p < 0.001$). Mastitis, and cracked or inverted nipples were more frequent in the NHD (case) group. The researchers concluded that breastfeeding difficulty/problems were associated with NHD. More frequent breast exams/assessments, and monitoring of infant weights and urine output daily were recommended in infants at risk between the first and third week of life (Boskabadi et al., 2010).

A birth weight loss of 5-7% with regained birth weight by day 10 of life was considered normal. Although less common, exclusive breastfeeding can lead to dehydration, weight loss, hypernatremia and neonatal readmission. Dehydration decreases the excretion of bilirubin in newborns and can lead to hyperbilirubinemia. Discharge readiness assessments should include assessment of breastfeeding quality, identification of breast problems and lactation support. Newborn nutrition education should be provided to the mother prior to discharge home. It should include information on tracking the number and duration of infant feeds and wet diapers. Although rare, if not identified and treated promptly, NHD can be lethal (Boskabadi et al., 2010).

Term Neonatal Readmissions: Search Strategy

A literature search was conducted to locate available research on neonatal readmissions in term infants ($37^{0/7}$ to $41^{6/7}$ weeks GA). The following databases were searched: PubMed (US National Library of Medicine), Cumulative Index of Nursing and Allied Health Literature (CINAHL), Web of Science, Scopus (Elsevier), Dissertations and Theses (ProQuest) and the Cochrane Library. Key search terms used were “neon* readmission” AND “term infants”, and “term infants” AND readmission OR rehospitalization. The key terms “postnatal discharge AND readmission” were also searched. English language only publications were searched with no date limits. A secondary search for relevant literature was conducted by reviewing the reference lists of articles about neonatal readmission in term infants.

Nine studies on neonatal readmission in term infants were located which met the relevant criteria for this review. Five of the nine studies examined early discharge from the hospital and/or LOS after delivery (Bayoumi et al., 2015; Geiger et al., 2001; Lain et al., 2015; Metcalfe, Mathai, Liu, Leon, & Joseph, 2016; Radmacher et al., 2002). Four studies examined readmission for jaundice/hyperbilirubinemia (Battersby, Michaelides, Upton, & Rennie, 2017; Geiger et al., 2001; Lain et al., 2015; Salas et al., 2010). The study by Battersby et al. (2017) also examined transitional care while the study by Geiger et al., (2001) examined both LOS and jaundice. Table 3. lists the nine studies.

Table 3. Research on Neonatal Readmissions – Term Infants

Author/ Year/ Location	Study Objective	Design Primary Outcome Variables /Definition	Sample	Results	Limitations	Readmission Rates	Factors Associated with Readmission/ Future Research Needs
1. Lain, Roberts, Bowen, & Nassar, 2015 Sydney, Australia	1) To examine the association between early discharge from the hospital after birth, week of gestational age, and readmission to hospital for jaundice among term infants; and 2) to investigate the perinatal risk factors for readmission to hospital for jaundice among infants discharged early	Design: Retrospective cohort study POV(s): Readmission to hospital in the first 14 days of life after discharge from the birth admission, with a diagnosis of jaundice (ICD-10-AM codes P58, P59, R17)- 80% sensitivity and 90.9% PPV	*N* = 781 074 Term live born infants -GA 37 to 41 weeks born to women in NSW from January 2001 through December 2010, discharged from the hospital in the first 14 days after birth. Infants with severe neonatal morbidity (using the Neonatal Adverse Outcome Indicator were excluded. Data obtained from the NSW Perinatal Data Collection (PDC) and the Admitted Patient Data Collection (APDC) Databases	Infants discharged in the first 2 days of life more likely to be readmitted to the hospital for jaundice compared with infants who had a longer hospital stay, particularly infants born at 37-38 weeks gestation.	Calculation of LOS in days rather than hours. Information about bilirubin levels at discharge and at readmission was also not available.	8 per 1000 infants were readmitted for jaundice. (0.8%)	Infants born at 37-38 weeks with LOS at birth of 0-2 days; For infants discharged at 0-2 days -vaginal birth, born to mothers from Asian country, born to first-time mothers, or being breast fed at discharge. Future Research: LOS in hours/informatio n about bilirubin levels at discharge
2. Radmacher, Massey, &	To determine if EDC in well term newborns	Design: Retrospective record review	*N* = 414 (Treated in ED -	Significant increase in hospital readmission rate for	Strict study eligibility criteria,	0.5% (EDC) & 0.9% (LDC)	Breastfeeding, LOS

Author/ Year/ Location	Study Objective	Design Primary Outcome Variables /Definition	Sample	Results	Limitations	Readmission Rates	Factors Associated with Readmission/ Future Research Needs
Adamkin, 2002 Kentucky, USA	influenced the rate of hospital readmission within the first week after hospital discharge when compared to LDC infants.	POV (s): Readmission or treatment in the ED within 7 days of postnatal discharge	*n* =281) (Readmitted *n* = 133) Normal newborns (38-42 weeks GA) born between January 1, 1994 and December 31st, 1998 and treated in ED or readmitted within 7 days of discharge.	LDC infants when compared to EDC infants. ED visits – 1.0% EDC vs. 2.2% LDC ($p < 0.001$) Readmissions- 0.5% EDC vs. 0.9% LDC ($p < 0.05$) Breast feeding rates- 78% readmissions vs 32% ED ($p < 0.001$)	population better educated/ higher paid with access to coordinated health care.		Future Research: Strategies to identify infants at risk for severe jaundice, breast-feeding-associated difficulties, and their sequelae; Are established discharge criteria met? Implement-action of MAJIC (Making Advances in Infant Care Against Jaundice) guidelines
3. Salas et al., 2010 La Paz, Bolivia	1. To determine the overall readmission rate due to hyperbilirubinem ia 2. To describe the association between TSB levels and	Design: Retrospective cohort study POV(s): Readmission for hyperbilirubinem ia and weight loss in the first two weeks of	*N* =79 readmitted Breastfed term infants who received phototherapy according to TSB levels and were readmitted within two weeks of life	Hyperbilirubinemia Readmission rate among breastfed infants = 5% Weak correlation between TSB levels and weight loss (r = 0.20, $p < 0.05$)	Lack of information regarding infant feeding Lack of data on timing and extent of out-patient follow up.	Overall readmission rate 64 per 1000 term infants (6.4%) 50 per 1000 exclusively breastfed infants (5%)	Significant weight loss in exclusively breastfed infants Future Research: Better data needed on outpatient follow up after

Author/ Year/ Location	Study Objective	Design Primary Outcome Variables /Definition	Sample	Results	Limitations	Readmission Rates	Factors Associated with Readmission/ Future Research Needs
	weight loss during the first two weeks of life in well term breastfed infants who were discharged home from the birth hospital	life.	between January 2005 and October 2008.	Hyperbilirubinemia was higher in infants with significant weight loss (46.7% vs. 18.4%, $p < 0.05$) Risk of hyperbilirubinemia with significant weight loss was approximately 4x higher (OR 3.9, 95% CI [1.4-10.8], p < 0.05). Mean age of readmission was 4.7 days	Inability to compare to newborn population		discharge home.
4. Metcalfe, Mathai, Liu, Leon, & Joseph, 2016 Canada	To determine LOS associated with the lowest neonatal readmission rate following childbirth by examining the incidence pattern of neonatal readmission for different LOS	Design: Retrospective cohort study POV(s): Neonatal readmissions within 30 days of birth. All-cause and cause specific	*N*=19,547 readmitted Term, singleton live births without congenital anomalies. .	2003-2005-readmissions increased from 4.1% to 4.6% in 2008-2010 for vaginal births and from 2.0% to 2.4% among caesarean births due to day specific readmission rates and not due to reductions in LOS	LOS calculated in days not in hours Lack of data on individual and community support and outpatient services Use of a single	3.99 per 100 live births Readmission after vaginal birth = 4.2% and after caesarean birth = 2.2%	Changes in day-specific readmission rates. i.e., lowering of the threshold for readmission. Future Research: should look at geographic variability in

Author/ Year/ Location	Study Objective	Design Primary Outcome Variables /Definition	Sample	Results	Limitations	Readmission Rates	Factors Associated with Readmission/ Future Research Needs
	using the Kitagawa decomposition	readmission for confirmed jaundice (ICD-10-CA P55-P59), infection (ICD-10-CA P35-P39) and dehydration (ICD-10-CA P74.1) were evaluated.			ICD-10-CA code to identify deliveries may have missed some.		community support for childbirth and childrearing and its relationship with readmission rates
5. Bayoumi et al., 2015 Cairo, Egypt	To compare the incidence of complications in patients and the causes of maternal and neonatal hospital readmission in patients discharged 24 versus 72 hours after cesarean section.	Design: Prospective randomized observational cohort study POV(s): Maternal symptoms and any cause for hospital readmission for both mother and neonate within 6 weeks after delivery	24 h D/C; *n*=1495 72 h D/C; *n*=1503 Maternal criteria: 20-40 years old; no known medical conditions; no obstetric complications; all patients discharge with their newborn Neonatal criteria: Term ≥ 37 weeks GA; no fetal problems, e.g., intrauterine growth retardation or major congenital anomalies.	Neonatal readmissions-152 neonates (10.1%) in the 24 h group and 88 neonates (5.9%) in the 72-h group ($p < 0.001$) Neonatal jaundice was the major cause of readmission Significant findings: 72 h group- success of breastfeeding and lower mood swings 24 h discharge did decrease the rate of initiating proper breastfeeding and	Outcome measures self-reported on the Symptom questionnaire and the Arabic version of the Edinburgh Postnatal Depression Scale and not confirmed.	24 h group = 10.1% 72 h group = 5.9% ($p<0.001$)	24 h discharge Future Research: Assess cost effectiveness of early discharge.

Author/ Year/ Location	Study Objective	Design Primary Outcome Variables /Definition	Sample	Results	Limitations	Readmission Rates	Factors Associated with Readmission/ Future Research Needs
				increased the rate of neonatal readmission for jaundice.			
6. Davanzo, Cannioto, Ronfani, Monasta, & Demarini, 2013 Trieste, Italy	To assess the extent of neonatal weight loss and its association with selected clinical variables in a population of healthy term infants cared for using a specific protocol on weight loss.	Design: Retrospective cohort study POV(s): Readmission within the first month of life; Weight loss;	*N* =27 readmitted Healthy term infants admitted to the regular nursery between January 1-August 15, 2007. .	Mean weight loss between 10 and 12% and > 12% were 6% and 0.3% Mean weight loss was significantly higher in formula fed vs. breastfed infants.	Limited number of variables related to weight loss studies which limits multivariate analysis Did not control for maternal factors and socio-demographic factors. Question of reverse causality with weight loss being the cause of formula feeding and not vice versa. No control groups.	2.7% of infants (27/1003) 17 out of 27 (1.7%) of the total population) were admitted for jaundice requiring phototherapy 10 infants readmitted due to dehydration after birth = 1%	Jaundice, dehydration Future Research: None suggested
7. Geiger, Petitti, & Yao, 2001	1. To determine whether re-hospitalization	Design: Case-control study	*n*= 153 cases *n* = 310 controls	Length of birth hospitalization did not differ between	Small population sizes especially	2 per 1000	Feeding difficulties and suspicion of

Author/ Year/ Location	Study Objective	Design Primary Outcome Variables /Definition	Sample	Results	Limitations	Readmission Rates	Factors Associated with Readmission/ Future Research Needs
California, USA	for jaundice is associated with length of hospital stay after birth 2. To identify risk factors for rehospitalization for jaundice in healthy newborns 3. To assess outcomes of re-hospitalization for jaundice in infants who were normal at birth.	POV(s): Readmission within 14 days of birth with an ICD-9-CM discharge code of 774. X (‘other perinatal jaundice’).	Normal term infants delivered vaginally (BW < 2500 gms) at any any of the 10 medical centers from 1 January 1992, to 17 December 1994.	cases and controls. Rehospitalization for jaundice was associated with race/ethnicity, primiparity, preterm birth (37 to < 38 weeks GA), breastfeeding, and suspicion of jaundice during birth hospitalization	at the extreme lengths of stay. Lack of infant blood typing- could not look at Rh incompatibility as a risk factor for jaundice. The use of jaundice diagnosis as clinically important jaundice. Assumption that there was no clinically important jaundice if there was no hospitalization.		jaundice Readmission for jaundice- white or Asian race/ethnicity; primiparity, premature birth (37 weeks GA); and breast feeding during hospitalization Future Research: On more than just length of stay- more understanding of feeding difficulties and support for breastfeeding is needed.
8. Habib, 2013 Jeddah, Saudi Arabia		Design: Cross-sectional study retrospective cohort study POV(s): Hospital	*N* = 12,728 Normal newborns- full term, with normal weight and no antenatal or perinatal problems born during	166 readmissions within 28 days of birth. Leading cause of readmission was sepsis on ≤ 7day readmission (32.3%),	Lack of follow up.	Readmission rate 1.3%	Neonatal sepsis, jaundice, respiratory problems, cardiac conditions, surgical conditions and

Author/ Year/ Location	Study Objective	Design Primary Outcome Variables /Definition	Sample	Results	Limitations	Readmission Rates	Factors Associated with Readmission/ Future Research Needs
		readmission during the neonatal period.	October 2008 to September 2011.	neonatal jaundice (41.5%). After 1 week of life 40.6% had neonatal sepsis and 16.8% had neonatal jaundice. 1.4% of early d/c were readmitted and 0.81% of late d/c infants were readmitted (p = 0.017)			miscellaneous.
9. Battersby, Michaelides, Upton, & Rennie, 2017 London, UK	To 1) Identify the primary reasons for admissions to neonatal units, 2) to determine the risk factors for admission for jaundice and 3) To estimate the proportion of infants who can be cared for in a transitional setting without separation of the mother and infant	Retrospective cohort study	Term infants (≥ 37 weeks GA) with no congenital anomalies or for whom data about their first episode(admission) for care was not missing, and who were admitted to neonatal units in England in 2011-2013.	The most common reason for admission in infants from the hospital was respiratory disease (24%) Jaundice was the most common (22%) reason for readmission from home. Most of these infants (99%) received special care versus high dependency care or intensive care.	Limited to the variables in the National Neonatal Research Database. Only one primary reason was permitted in this database and several infants may have had more than one reason related to jaundice and feeding difficulties. Data did not	7% of term infants born in England were readmitted to the hospital either from home or another hospital.	37 weeks gestation, male, low birth weight (1500-2499 grams), multiparous, and Asian Future Research: On barriers to implementation of transitional care in the community. Research on the use of transcutaneous bilirubinometer, TSB testing,

Author/ Year/ Location	Study Objective	Design Primary Outcome Variables /Definition	Sample	Results	Limitations	Readmission Rates	Factors Associated with Readmission/ Future Research Needs
					include post D/C follow up information and data on kernicterus.		compliance and uptake of NICE guidelines.

Note. BW = Birth weight, CI = Confidence interval, D/C= Discharge, ED= Emergency department, EDC = Early Discharge at ≤ 48 hours after birth, GA = Gestational age, LDC= Later Discharge at > 48 hours after birth, LOS = Length of stay, OR=Odds ratio, NICE = National Institute for Clinical Excellence, POV = Primary outcome variable, PPV = Positive Predictive Value, TSB = Total Serum Bilirubin

Review of Studies on Neonatal Readmission in Term Infants

The criteria for readmission in term infants varies a great deal among studies. Many prior studies have used term infants as the reference group (where infants of different gestational ages have been compared to infants at 40 weeks). Few studies examine the factors related to healthy term-born neonatal readmission specifically. Neonatal readmissions, because of previously reported low rates in the past two decades, are not always viewed by institutions as a quality improvement or systems problem.

Taking a healthy term infant home from the birth hospital can be a joyous occasion for the parents, but it is also filled with fear and trepidation for many new mothers and fathers. Infants who are exclusively breast fed may have more feeding problems prior to, and after discharge to home. This places the infant at an increased risk of being readmitted to the hospital within 28 days of birth. A hospital readmission can be fraught with fear and emotion for the parents and family who have just taken a healthy term-born infant home. Financial and social stressors on the parents, family and the health care system, also makes neonatal readmission an undesirable outcome. It is important to understand the incidence of neonatal readmission and the factors influencing preventable neonatal readmission before conducting research on strategies to reduce preventable readmission. This makes neonatal readmission a relevant and current topic to examine. Nine studies on neonatal readmission in term infants have been published and are discussed below beginning with the earliest study.

In 2001, a case-control study was conducted to assess whether rehospitalization for jaundice in term infants was related to length of hospital stay. The study also explored the risk factors and outcomes of rehospitalization for jaundice in vaginally delivered liveborn, singleton infants without complications (Diagnosis Related Group [DRG] code 373) (Geiger et al., 2001). Exclusion criteria included infants with birth weight < 2500 grams discharged against medical advice and hospital transfers. The study was conducted at 10 Kaiser Permanente Southern California Medical Care program (KPSC) centers in CA. The medical records of eligible mother-infant dyads (January 1, 1992 to December 17, 1994) were reviewed and abstracted by trained staff. Infants readmitted to the hospital within 14 days of birth for jaundice (ICD-9-CM code 774.x other perinatal jaundice) were included as cases. Two controls were selected at random from infants not hospitalized within 90 days of birth for each case. The final sample size was 463 infants (153 cases and 310 controls) (Geiger et al., 2001).

Descriptive statistics and odds ratios with 95% confidence intervals were calculated using logistic regression models. Birthweight was not included in the model due to multicollinearity. There were less readmissions for jaundice in African-American (OR 0.30, [0.11,0.82]). Readmissions for Hispanic (OR 0.66 [0.40-1.07]) and Asian (OR 1.67 [0.85-3.30]) infants did not reach significance. Feeding information was reported as breast only, bottle only or both. Breastfeeding increased the risk of readmission for jaundice during the birth hospitalization (OR 4.62 [2.00-10.65]). Suspicion of jaundice by the nurse was associated with a higher risk of readmission even without a bilirubin level for diagnosis (OR 6.66 [1.80-24.69]).

Infants who had feeding difficulties during the hospital stay were also at higher risk of readmission (OR 1.85 [1.08-3.16]) (Geiger et al., 2001).

There was no significant increase in readmission for jaundice when comparing infants discharged < 24 hours versus 24 to 48 hours after birth. Risk factors associated with readmission for jaundice were race, ethnicity, prolonged or premature rupture of membranes, primiparity, breast feeding and GA < 38 weeks. A strength of the study was the ability to calculate LOS in hours instead of in days. Unfortunately, the group with readmissions ≤ 12 hours was too small (two cases [1.3%] and 9 controls [2.9%]) to determine the risk of readmission, which was a limitation of the study. Blood typing was also not standard and was not available at discharge. This limited the ability to compare the TSB levels at discharge to determine risk. Another limitation was the use of readmissions for jaundice instead of a diagnosis for jaundice. This made absence of readmission the indicator that clinical jaundice was not present. Suspicion of jaundice and feeding difficulty during the hospital stay were strong indicators for readmission. More support for breastfeeding mothers, both pre and post discharge, may help to prevent readmission for jaundice which disrupts families and is an undesirable health outcome (Geiger et al., 2001).

Radmacher et al. (2002) conducted a retrospective study to investigate the hidden morbidity associated with successful early discharge (≤ 48 hours from birth) in well newborns at Norton Hospital in Kentucky, who were delivered between January 1, 1994 and December 31, 1998. The aim of the study was to compare the readmission rate of infants discharged early (≤ 48 hours from birth) versus infants discharged later (> 48 hours from birth) by treatment, LOS and final diagnosis.

Treatment was categorized into either: 1) readmission within seven days of discharge to the children's hospital or 2) treatment in the emergency department (ED). Final diagnosis for readmission was categorized into five groups 1) jaundice, 2) rule out sepsis, 3) respiratory, 4) feeding and 5) other. Diagnoses that did not fit into the first four groups were categorized as other. Medical records of all infants were reviewed. Of the 21,628 infants screened during the study period, 16,734 were in the early discharge group (EDC) and 4,894 were in the late discharge group (LDC). A total of 281 infants (EDC [n = 174] and LDC [n = 107]) were treated in the ED, and 133 infants (EDC [n = 90]and LDC (n = 43]) were readmitted to the hospital (Radmacher et al., 2002).

Descriptive statistics were done, and a z-test was performed to determine proportional differences. The readmission rate was lower in the EDC group (0.5% vs. 0.9%, $p < 0.05$). ED treatment was higher in the LDC group (1.0% vs. 2.2%, p = 0.002) in the EDC group versus. 2.2 % in the LDC group (p = 0.002). When level of treatment (ED or readmission) was analyzed 78% of the infants who were breastfed were readmitted compared to 32% who were seen in the ED. This was statistically significant for level of treatment without considering neonatal LOS. Readmission for jaundice was higher in the EDC group (0.22% vs. 0.16%, $p < 0.001$). In one in five infants hospitalized for jaundice, serum bilirubin levels were > 25 mg/dL on readmission (Radmacher et al., 2002).

Limitations of the study included its lack generalizability to high risk socio-economically disadvantaged groups due to the strict eligibility criterion, and a different better-educated population with higher incomes and better access to health care. The association between breastfeeding and jaundice in this study warrants a closer follow up of infants who are breastfeeding at discharge from the birth hospital. This is needed to ensure signs of inadequate milk intake, such as dehydration, are not missed. It is not clear how many infants had inadequate milk intake and how many mothers required lactation support in the first few days post discharge (Radmacher et al., 2002).

In this study by Radmacher et al. (2002) an association was found between breastfeeding and jaundice requiring readmission. The authors recommended breast feeding support prior to and post discharge for mothers who experience breast feeding difficulty and who are discharged home early (within 48 hours). They also recommended that mothers needed more education on how often to feed the infant to promote meconium passage and to maintain adequate caloric intake in their infants. Additionally, mothers need to be aware of their infant's urine output and make sure the number of wet diapers the infant has daily were monitored (Radmacher et al., 2002).

A study was published investigating significant weight loss in breastfed term infants readmitted with hyperbilirubinemia to a tertiary care center in La Paz, Bolivia (Salas et al., 2010). The aim of this retrospective study was to determine the readmission rate for hyperbilirubinemia and the association between weight loss and serum bilirubin levels within the first two weeks of life. Infants born between January 2005 and October 2008 at the center and then discharged as healthy term infants, were eligible to participate in the study if they were readmitted to the hospital within 14 days of life. Other eligibility criteria included 39 - 41 weeks GA and birth weight

> 2500 grams. Infants with an infection, hemolytic disease, major congenital anomalies, feeding intolerance, respiratory distress, cephalohematoma and mild bruising were excluded to avoid potential confounding (Salas et al., 2010).

The sample consisted of 79 term infants who met the inclusion criteria. The overall readmission rate for hyperbilirubinemia was 6.4% or 64 per 1000 infants, and the readmission rate for exclusively breastfed infants was 5.0% or 50 per 1000 infants. Of the infants readmitted, 38% had significant weight loss which was "defined as weight loss from birth weight greater than 7%" (Salas, et al., 2010, p. 49). Sixty percent of the patients readmitted had weight loss > 10%. Infants with a TSB < 20mg/dL were categorized as having significant hyperbilirubinemia and infants with a TSB ≥ 20 mg/dL were categorized as having severe hyperbilirubinemia. Descriptive and correlation statistics were performed (Salas et al., 2010).

There was a significant difference in age at readmission in the infants admitted for hyperbilirubinemia. The mean age of readmission for infants with significant hyperbilirubinemia was four days, whereas readmission for severe hyperbilirubinemia was 6.3 days ($p < 0.05$). The mean TSB level in all infants was 18 mg/dL. There were no significant differences between groups readmitted for hyperbilirubinemia in birth weight, gender, maternal age, route of delivery, weight at readmission, and LOS. Infants readmitted with significant hyperbilirubinemia (TSB < 20 mg/dL) had a fourfold greater risk of having significant weight loss versus infants with weight loss that was considered acceptable (OR 3.9, 95% CI [1.4, 10.8], $p < 0.05$). This risk increased even more if the infant had >10% weight loss (OR 4.2, 95% CI [1.4, 12.7],

$p < 0.05$). There was a weak but positive linear correlation between TSB levels and significant weight loss in exclusively breastfed term infants ($r = 0.20$, $p < 0.05$). Therefore, in this study only 20% of the variability in weight loss was explained by the TSB level, and there were other factors that may have impacted weight loss (Salas et al., 2010).

Limitations of this study included the lack of information on the timing of initial discharge from the hospital, infant feeding, and outpatient follow up. The study did not compare the findings to normal newborns due to the lack of a control group. The authors suggested the altitude of the center may have increased the incidence of hyperbilirubinemia (Salas et al., 2010). Altitude has been shown to decrease oxygen availability resulting in increased bilirubin production and delayed bilirubin clearance (Leibson et al., 1989). Significant weight loss may be a useful indicator to screen infants for neonatal readmission due to hyperbilirubinemia especially in settings where a TSB level prior to discharge is not the routine standard of care (Salas et al., 2010).

A retrospective study by Davanzo et al. (2013) in Trieste, Italy studied breastfeeding and neonatal weight loss in healthy term infants. They analyzed readmissions ($N = 1003$) related to weight loss and its associated complications during the first month of life. The specific study aim was to determine the extent of weight loss in healthy term infants cared for using a specific protocol on weight loss. They also examined the relationship of preselected clinical variables to weight loss. Some of the variables included type of feeding, time of the year, type of delivery, treatment or no treatment for jaundice, birth weight, length of hospital stay, and hypernatremia. Specific interventions were suggested in the protocol based on the amount of weight loss (%), the infant's physical exam and an evaluation of breastfeeding. Infants with ≥ 8% birth weight loss were included in this study (Davanzo et al., 2013).

Hospital records of the infants admitted to the maternity hospital (Level III) between January 1, 2007 and August 15, 2007 were reviewed. All eligible infants were weighed naked daily between 8 and 10 am by a nurse. Feeding types were categorized for the analysis. The types included breastfeeding (exclusive breastfeeding and predominant breastfeeding) or formula feeding (complementary feeding and no breastfeeding). Infants were assessed and identified to have jaundice if they had a serum bilirubin test following the detection of obvious yellow coloring of the skin (detected by the pediatrician and/or nurse). If serum bilirubin levels required treatment with phototherapy, this was considered clinically relevant jaundice. Infants with weight loss ≥ 8 % had serum sodium concentrations drawn. Hypernatremia was defined as a serum sodium level >150 mEq/L. Infants were discharged from the hospital if they met weight loss criteria (< 10% weight loss) at ≥ 36 hours of life. The infant's weight was rechecked by a midwife or registered nurse at the outpatient clinic within 2-4 days after discharge to home. Some infants were rechecked at the hospital if they had breastfeeding concerns, greater weight loss (≥ 8%)in the hospital, and required screening for jaundice (Davanzo et al., 2013).

Descriptive statistics and multivariate logistic regression were performed. In the final regression model, outcome variables with a p value > 0.1 were excluded. The percent mean weight loss for this sample of infants was 6.7% ± 2.2%. Weight loss varied between 0% and 13.2% in the study population during the hospital stay. Six percent of infants had a weight loss between 10% and 12% and 0.3% of the infants had a weight loss ≥ 12%. More of the infants, who were delivered vaginally, had a weight loss of ≥ 8% compared to infants who were delivered by cesarean section (45% versus 23% respectively). The rate of readmission within 30 days of birth was 2.7% (27/1003). Jaundice requiring phototherapy was the most common reason for readmission for the whole population (1.7% or 17 infants). Ten infants (1%) were readmitted for dehydration with excessive weight loss, and three of the readmitted infants had hypernatremia. Prior to discharge from the birth hospital, five variables were independently associated with ≥ 8% weight loss. They included: 1) hot versus cold time of the year; 2) formula fed versus exclusively breast fed or predominant breast feeding; 3) appropriate and large for gestational age versus small for gestational age; 4) jaundice not requiring phototherapy versus no jaundice, and; 5) cesarean versus vaginal delivery. The results of the analysis also show that weight loss was greater in the formula fed group (7.5%) than in the breastfed group (6.3%). Small for gestational age was a protective factor in this study population (Davanzo et al., 2013).

Limitations of this study included the large number of variables studied related to weight loss. The authors stated they did not control for maternal, clinical and sociodemographic factors. There may have been reverse causality due to weight loss occurring prior to the decision to formula feed. The documentation was limited. There was no control group thus comparisons of clinical effectiveness with the protocol could not be made. The authors concluded that breastfeeding was not a risk factor for increased weight loss in the early neonatal period (Davanzo et al., 2013).

A cross-sectional study was done to assess the impact of hospital discharge on the rate and etiology of neonatal readmission following the initial birth hospitalization in Jeddah, Saudi Arabia (Habib, 2013). All normal newborns, delivered at a University hospital from October 2008 to September 2011, were included if they did not meet any of the exclusion criteria (preterm or multiple birth, intrauterine growth restriction, congenital malformation(s), respiratory distress and birth asphyxia). Data was abstracted from the hospital Discharge Abstract Database. Hospital discharge at ≤ 48 hours after birth was considered early discharge and discharge after 48 hours was considered late discharge. There were 9,927 in the early discharge groups and 2,801 in the late discharge group (N = 12,728 infants) (Habib, 2013).

Descriptive statistics and chi square test were calculated. The readmission rate for all infants was 1.3% (n =166) within 28 days of birth. Neonatal sepsis was the major cause of readmission. Infants delivered vaginally were discharged early (≤ 48 hours) and infants delivered by cesarean section were discharged late (> 48 hours). Within the first week after birth, 65 infants (39.2%) were readmitted. Jaundice was the leading cause (41%) of readmission in this group. Neonatal sepsis was the second most frequent cause of readmission (32%). After the first week of life, 101 infants (61%) were readmitted. In the second week, neonatal sepsis was the leading cause of readmission (41%) whereas 17% of the infants were readmitted for jaundice. There was a significant difference in the number of infants readmitted within 14 days. More infants in the early discharge group were readmitted (0.81% vs. 1.45%, p = 0.017) (Habib, 2013).

Limitations of this study included possible readmission at other hospitals thus making it difficult to track readmission. Only full-term infants with normal weights were included. The authors did not define a normal weight and it is assumed the infants birth weights were appropriate for their GA.

The authors recommended that screening for discharge readiness was important and should be accomplished with the use of checklists to determine a mother's readiness for discharge, and the infant's readiness for breastfeeding. Hospital discharge was recommended after 48 hours for infants born vaginally, and between 48 hours and 72 hours for infants delivered by cesarean section. GBS screening was also recommended (Habib, 2013).

A retrospective cohort study was conducted in Sydney, Australia. The purpose was to examine the associations between early discharge from the birth hospital, GA, and readmission to the hospital for jaundice among term infants (Lain et al., 2015). It also examined the perinatal risk factors for readmission to the hospital for jaundice among infants discharged earlier than standard care (≤ 48 hours after birth). Participants were term infants (37 to 41 weeks) born to women in New South Wales (NSW) between January 2001 and December 2010 who were discharged from the birth hospital within two days of birth and readmitted within 14 days of birth. Infants with severe neonatal morbidity (using the Neonatal Adverse Outcome Indicator) were excluded (Lain et al., 2015).

Data was obtained from the NSW Perinatal Data Collection (PDC) and the Admitted Patient Data Collection (APDC) databases. An Australian modification of the International Classification of Diseases, tenth revision (ICD-10-AM) codes P58, P59, R17 was used. There was 98% record linkage. The day of discharge was subtracted from the date of birth to provide the LOS variable and inter-hospital transfers were included. There were three categories of LOS: 0-2 days (≤ 72 hours), 3 - 4 days and ≥ 5 days. Maternal and infant characteristics were described, and multivariable logistic regression was performed to adjust for confounding factors. A sensitivity analysis on feeding status was done to assess whether there was confounding (> 10% change in the AOR from exclusive breastfeeding) between LOS/GA and jaundice. (Lain et al., 2015).

Infants discharged in the first two days of life were more likely to be readmitted to the hospital for jaundice compared with infants who had a longer hospital stay, particularly if the infant was born at 37-38 weeks gestation. The readmission rate for jaundice within the first 14 days of life was 0.8% (eight per 1000 term infants). Jaundice was the primary diagnosis in the majority of readmissions (91%). Infants who were 37 weeks GA were over nine times more likely to be readmitted for jaundice if they had a birth LOS of two days or less (AOR 9.4, 95% CI [8.34, 10.67]). Infants at 38 weeks GA had over a four times greater risk of being readmitted for jaundice if their birth LOS was less than two days (AOR 4.05, 95% CI [3.62, 4.54]). The risk decreased as the GA advanced (Lain et al., 2015).

The study also examined the number needed to treat (NNT) to avoid one readmission for jaundice. At 37 and 38 weeks GA, the NNT was 31 and 83 respectively. The LOS was not the most important factor to prevent one readmission. The risk of readmission was related to other factors as well. Perinatal risk factors for jaundice included infants born to first-time mothers, Asian mothers, vaginal birth and breastfeeding at discharge (Lain et al., 2015). The limitations included the method of calculating LOS in days rather than hours, and the lack of information about bilirubin levels at discharge and at readmission (Lain et al., 2015).

A randomized study of term infants investigated if there was a difference in LOS in the hospital (24 vs. 72 hours) following a cesarean section (Bayoumi et al., 2015). The aim of the study was to compare postpartum neonatal and maternal complications in this population who delivered at a maternity hospital in Cairo, Egypt between June 2012 and February 2014. Following written consent, patients were randomized to either 24-hour (n = 1495) or 72-hour (n = 1503) discharge following cesarean section. Exclusion criteria included mothers < 20 years or > 40 years old, those with some known medical conditions, < 37 weeks at delivery, obstetric complications, any fetal problem diagnosed after delivery, or any patient who did not meet the criteria for discharge at the interval chosen (Bayoumi et al., 2015).

Infants/mothers were randomized by opening a sealed envelope after 24 hours for assignment to the discharge group. They were discharged per protocol if they met discharge criteria (i.e. no postpartum or neonatal complications). Instructions were given on breast feeding and wound care prior to discharge but no home visits were offered. Patients had access to a 24-hour ED and a morning outpatient clinic. A six-week postpartum check was mandatory. A symptom questionnaire was completed by the patient at the six-week visit to assess postpartum complications. The Edinburgh Postnatal Depression Scale (in Arabic) was administered to assess postpartum depression of the mothers. Data on all causes of maternal and infant readmission were collected from the hospital records (Bayoumi et al., 2015).

Descriptive statistics and odds ratios with 95% confidence intervals were calculated. Of the 1890 patients randomized to the 24-hour discharge group, 7% (n=132) of the mothers did not want to be discharged after 24 hours and wanted to stay longer in the hospital. In the 72-hour group (n = 1896) 9.9 % (n = 1 88) wanted to leave before 72 hours. Loss to follow-up was 13.9% (n = 263) in the 24-hours group and 10.8 % (n = 205) in the 72-hour group. This resulted in a sample of 1495 infants in the 24-hour group and 1503 infants in the 72-hour group. The rate of maternal readmission was not significant during the six-week follow up period. However, the readmission rate for newborns was significant. More infants in the 24-hour group were readmitted within the six-week period (10.1% vs. 5.9, $p < 0.001$) (Bayoumi et al., 2015).

The leading cause of readmission in both groups was jaundice. Breastfeeding success was significantly higher and postnatal depression was significantly lower in the 72-hour discharge group. There was a greater difference in breast feeding success among the women discharged after 72 hours versus those who were discharged at 24 hours (68% vs. 62%, $p = 0.001$). Mothers who were discharged earlier may not have received the needed lactation support before breastfeeding was established. Secondary analysis of primary versus repeat cesarean section was done. Mothers who had a repeat cesarean section were more comfortable breastfeeding and were more successful (Bayoumi et al., 2015).

Limitations of this study included self-reported outcome measures. Services were free of charge in this government run hospital and cost effectiveness was not assessed. Although 24-hour discharge did not increase maternal readmission, it did increase the rate of neonatal readmission for jaundice. The authors suggest breastfeeding may not have been well established prior to discharge from the hospital. They recommended 72-hour discharge after cesarean delivery, although discharge at 24 hours may be appropriate under certain situations. This includes when lactation has been established and there is early follow up and psychological support for the mother related to breastfeeding and wound infections as well as screening of the infant for jaundice (Bayoumi et al., 2015).

More recently, a retrospective population-based study conducted in Canada (excluding the Province of Quebec), examined the LOS associated with the lowest number of neonatal readmissions to any hospital within 30 days after childbirth (Metcalfe et al., 2016). The sample (N = 1,875,322) consisted of term, singleton infants who were born alive (ICD-10-CA code Z37.0- singleton, live birth) between 2003 to 2010 and discharged home on the same day of birth. Exclusion criteria included infants with congenital anomalies, multiple gestation pregnancies, premature births (<37 weeks GA) and maternal deaths. Data was obtained from the Canadian Institute for Health Information Discharge Abstract Database (DAD). The date of birth was subtracted from the date of discharge to obtain the LOS, which meant the LOS was documented in days and not recorded in hours of age. This study examined cause-specific and all-cause readmissions. Cause-specific readmissions were examined for jaundice, dehydration and infection by ICD-10-CA codes (Metcalfe et al., 2016).

The Kitagawa decomposition test was used to determine temporal changes in the LOS and on the overall readmission rate for cause specific and all cause readmission for vaginal and cesarean births separately. The analysis compared eligible infants born between 2003-2005 to eligible infants born between 2008-2010. No reason was given for not including infants from 2006-2007. All infants born by vaginal birth, who were readmitted in the 2003-2005 group (*n* =19,547) had a readmission rate of 3.99% (3.99 readmissions per 100 live births). The cesarean section birth readmissions (*n* = 3460) accounted for 2.16% during this same period. In the 2008-2010 group the readmission rate was 4.51% for vaginal and 2.57% for cesarean section deliveries. There was a 13% higher rate of overall readmission of vaginal births for 2008-2010 compared to 2003-2005 (4.51% vs. 3.99%). This higher trend in the overall readmission rate was also seen with cesarean births. The readmission rate was 19% higher in the period from 2008-2010 compared to 2003-2005 (2.57% vs. 2.16 %). For the entire study period jaundice was the leading cause of readmission in almost half (49.9%)of the readmissions. Respiratory conditions followed at 8.1%, feeding problems at 5.2%, sepsis at 4%, and dehydration at 3.3% (Metcalfe et al., 2016).

The differences in the readmission rates for vaginal deliveries were not due to changes in LOS but rather in day-specific (lowering of readmission threshold) readmission rates. The fewest neonatal readmissions following a hospital stay for vaginal deliveries appears to be 1-2 days and 2-4 days following cesarean deliveries. This study was not able to determine how many readmissions may have been preventable. Although the authors felt the rates were low in Canada, they felt it was important to make sure outpatient follow-up care of the infant was considered. They suggested future studies should look at geographic availability of resources and community support post discharge (Metcalfe et al., 2016).

The large sample size and the inclusion of only healthy term newborns was a strength of this study. Limitations included confounding by indication for LOS. Infants may have had longer stays for the same reason they were readmitted. It is not clear if reducing the threshold for readmission is due to maternal morbidities or the lower health status of the infant. Using a single ICD-10-CA code may not have have captured infants whose mothers had other maternal morbidities and obstetrical complications. However, since the study was examining healthy term infants this limitation would have been minimal. There was also no data collected on post discharge services which may have impacted neonatal readmissions (Metcalfe et al., 2016).

A recent retrospective cohort study on term infants and the role of transitional care was conducted in England (Battersby et al., 2017). The study had three aims: 1) to determine the primary reason for admission to a neonatal unit; 2) to determine the risk factors for admission for jaundice both from the hospital (local ward) and home; and 3) to estimate the proportion of infants who could benefit from a transitional care setting where the mother and infant were not separated. This study used neonatal admission data between 2011 and 2013 from the National Neonatal Research Database which included 163 neonatal units in England. Term infants ($\geq$ 37 weeks GA) with no congenital anomalies were included. Infants whose first episode of care (admission) was not available were excluded. Chi square test and the Mann-Whitney U test were done to compare proportions and medians. Statistical significance was set at $p = 0.05$ (Battersby et al., 2017).

The study reported respiratory disease as the most common (24%) diagnosis for admission to the neonatal unit from the hospital (local ward). Jaundice was the most common (22%) diagnosis for admission from home (Battersby et al., 2017). Three levels of care were available in the neonatal units (special care, high dependency care and intensive care). Most (99%) of the infants admitted for jaundice received special care, while 4.9% who were admitted needed high dependency care and 3.6% needed intensive care. Risk factors for admission for jaundice included gender (male), 37 weeks GA, low birth weight (1500-2499 grams) and Asian race. In infants with the above risk factors, this study recommended an assessment of breastfeeding and jaundice prior to discharge home between day one and day five of life. Infants admitted from home were readmitted at a median age of 3.9 days versus infants admitted from the hospital at 1.7 postnatal days, $p < 0.001$ (Battersby et al., 2017).

The dates of the nine studies reviewed on term neonatal readmission spanned over 16 years (2001 through 2017). Only two of the studies were done in the US, in 2001 and 2002. Most of the readmissions in the first week of life for all the studies were for jaundice and hyperbilirubinemia. Neonatal sepsis was the leading cause of readmission in the second week of life. The primary outcomes of the studies varied. The outcomes included hyperbilirubinemia (14 days through 28 days), LOS, and weight loss in exclusively breastfed infants readmitted for hyperbilirubinemia. Exclusive breastfeeding and feeding difficulty may have contributed to increased levels of bilirubin in the blood. This may have been caused by decreased intake, dehydration and decreased bilirubin excretion. These studies did not collect data on the number or amount of feeds and on the infant's output (number of diaper changes for urine and/or stool). None of the studies discussed the discharge policies and guidelines in place at the time of discharge.

Unplanned readmissions are not ideal, and they may be potentially related to inadequate readiness of the mother and infant for discharge (AAP: Committee on Fetus and the Newborn, 2010). Unplanned readmissions have also been considered a quality and safety issue, but this remains controversial as readmissions may prevent the consequences of hyperbilirubinemia such as kernicterus and other bilirubin induced diagnoses such as ABE and BIND.

Summary

This chapter provided a review of the available published literature on neonatal readmission and the factors associated with it during the past two decades. Although there has been a great deal of research on LOS following the Newborns' and Mothers Protection Act in 1996, these studies are difficult to compare due to the use of different definitions of neonatal readmission, especially the timing of LOS in days versus hours. There was a lack of information in this literature on the policies and procedures used to determine readiness for discharge and compliance with the policies that were in place. The lack of a control group, altitude of the center location, lack of TSB levels at discharge, maternal education and socioeconomic status and the large number of variables related to weight loss made comparison difficult. Inadequate documentation of discharge timing, infant feeding, and outpatient follow up were some of the other limitations cited by the authors. Neonatal readmission to a hospital other than the birth hospital was also a major limitation of these studies as the incidence of readmission may be underrepresented. Only two of the nine studies conducted solely on term infants and neonatal readmission were done in the US. This was over a decade ago and more current research is needed in the US on this topic.

There is a gap in the literature on current rates of neonatal readmission and the maternal, neonatal, and pre-discharge provider and institutional factors related to neonatal readmission in the US and around the world. This knowledge is needed for nurses and other health care professionals to understand the best ways to support the mother-infant dyad during the transition to home from the birth hospital. It is also needed to develop best practices and cost-effective ways to reduce preventable neonatal readmissions in term infants discharged home as healthy newborns.

CHAPTER 4

METHODOLOGY

This chapter begins with a brief orientation of the study purpose and four research questions followed by a description of the study design. The procedures used to select the study cohort and study sample are then described. Finally, this chapter includes detailed statistical procedures used to analyze each of the four study research questions.

Purpose

The purpose of this study was to quantify the risk of maternal, infant, provider and institutional factors associated with neonatal readmission in healthy term ($37^{0/6}$ to $41^{6/7}$ weeks gestation) infants at a large tertiary care center in the Northeastern region of the US. Additionally, it was to estimate the incidence of neonatal readmission in these healthy term infants, and to characterize the birth LOS and the reasons for neonatal readmission to the birth hospital.

Primary Research Question

1) What are the maternal, infant, provider and institutional factors associated with neonatal readmissions in term infants?

Secondary Research Question(s)

2) Is significant weight loss from birth (> 7 %) and breastfeeding difficulty (sustained feeding and/or LATCH score ≤ 6) in term infants during the hospital stay and/or at discharge associated with increased neonatal readmission to the birth hospital?

3) What is the the incidence of all cause neonatal readmission (within 28 days of birth) in term infants to the birth hospital?
4) What is the length of stay (in hours) after birth and diagnosis of neonatal readmission in term infants?

Research Design and Setting

A nested case-control study design was conducted to quantify the risk of neonatal readmission, and to determine the maternal, infant, provider and institutional factors related to neonatal readmission. The study setting is a large tertiary care hospital in the Northeastern region of the US. In 2016, there were almost 9,000 deliveries at this hospital. This study design was selected due to the large number of deliveries per year, the feasibility and cost of retrospective data collection on a large sample, and the rare study outcome (Gordis, 2014).

According to data from the National Perinatal Information Center (NPIC) the rate for all inborn neonatal readmissions for 2016 (among the 93-member hospitals) was approximately 1.0 to 2.6% (NPIC: Quality Analytics Services, 2017). Neonatal readmissions for jaundice ranges from <1 to 1.3% in the US, and <1% to 8% across the world (De Luca & Carnielli, 2009).

Protection of Human Subjects

Institutional Review Board approval was obtained for the conduct of this study from the site hospital and the University of Rhode Island. Data were collected on the hospital secure server and de-identified prior to analysis. The master list (screening log) of infants with the link to the electronic medical record (EMR) also was maintained on the hospital secure server and accessed through a password protected

Virtual Desktop Interface (VDI) to maintain confidentiality and protect subject's personal health information.

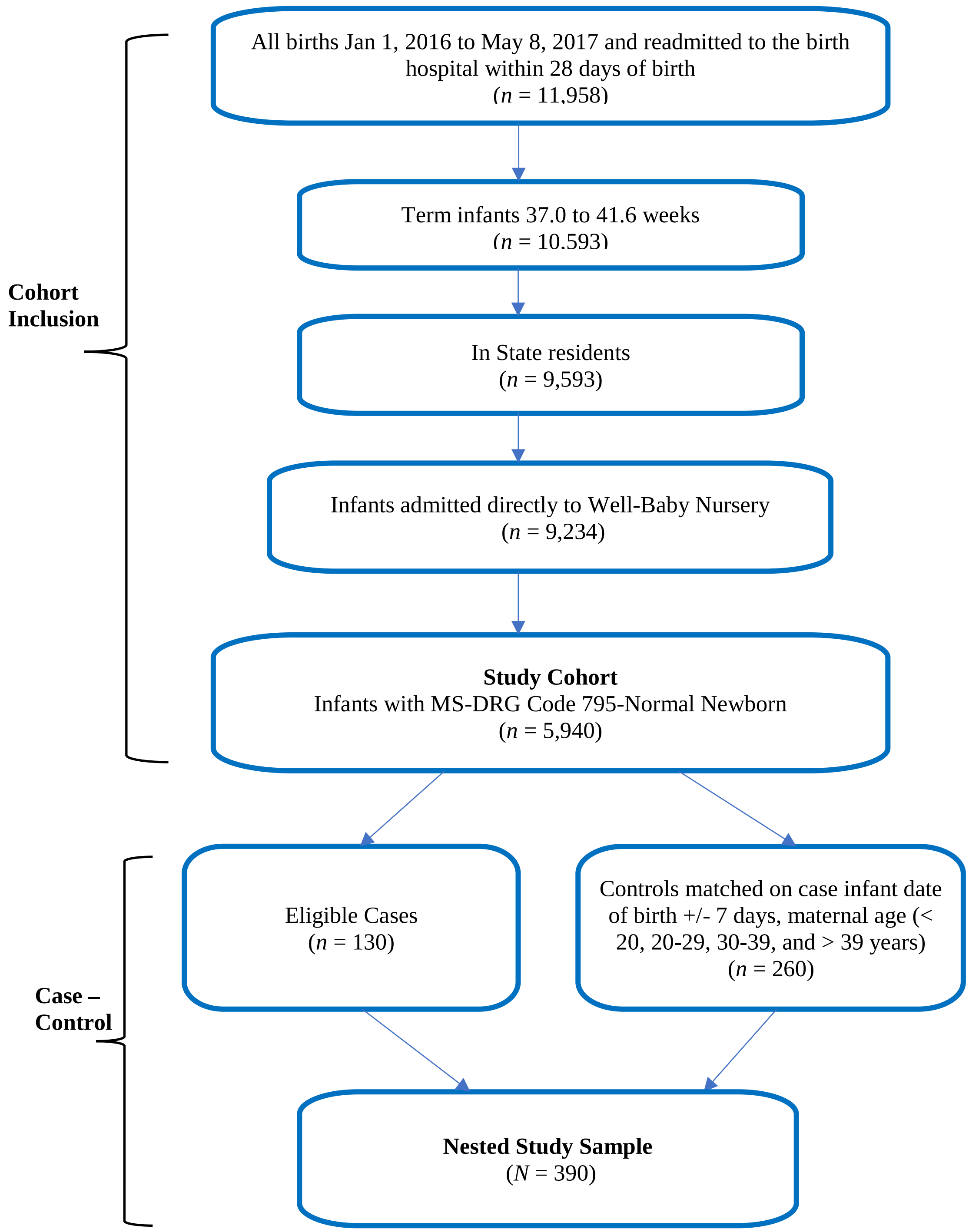
Sample Size

Approximately 146 infants were readmitted to the study site in calendar year 2016 (NPIC: Quality Analytics Services, 2017). A sample size calculation was done using EpiTools. The expected proportion exposed in controls of exclusively/ predominantly breastfed infants was estimated to be 40%. An assumed odds ratio of two, [compared to findings in (Geiger et al., 2001)], two-sided alpha value of 0.05 and desired statistical power of 0.80 was used. A sample of 130 infants per group for a total sample of 260 infants was required. Sample size calculations did not account for matching in this study. Instead, two controls per case were included (*N*=390). This was done to minimize information loss and statistical power if matched controls could not be found (Kleinbaum & Klein, 2010).

Study Cohort Selection

To achieve the study aims a cohort that would serve as the source population to conduct a nested case-control study was first assembled. Lists in Excel of all deliveries and readmissions/inpatient observations for January 1, 2016 through June 30, 2017 were obtained. Data, from multiple hospital sources and departments (Clinical Informatics, Fiscal and Pediatrics), were required to compile the information needed for the cohort selection. These lists contained the state of residence, GA, the unit the infant was admitted following delivery, DRG codes and maternal age. The final list was filtered based on the study inclusion criteria (Figure 3).

Figure 3. Study Sample Inclusion and Exclusion Criteria



Note: Well-Baby Nursery = WBN, Neonatal Intensive Care Unit = NICU, Blood Groups = ABO

All infants who met the term GA criteria were selected from all births at the study site. Term infants were defined as infants $37^{0/7}$ weeks gestation through $41^{6/7}$ weeks gestation (ACOG, 2013). Next, infants who were in-state residents were included. Healthy infants (those admitted to the Well Baby Nursery [WBN]) were then selected. Infants coded as normal newborns (code 795) according to the DRG Classification System codes were included from the infants admitted to the WBN.

The final study cohort consisted of 5,940 term gestation, in-state, healthy newborns admitted to the WBN following birth who had a normal newborn DRG code. This cohort of 5,940 infants was utilized to estimate the incidence of neonatal readmission. To quantify the risk of maternal, infant, provider and institutional factors on neonatal readmission, a nested matched case-control study (N = 390) within this cohort was conducted.

Nested Sample Selection

The study sample of cases and controls were selected from the study cohort described in the previous section. Cases were infants readmitted within 28 days of birth to the birth hospital. Controls were selected from the the same cohort using incidence density sampling without replacement in a ratio of 2:1 due to the large cohort. For each case (n = 130) a pool of control infants with a similar date of birth (+/- 1 week) and maternal age of the index infant's mother (categorized as < 20 years, 20-29 years and > 39 years) were identified. Two controls (n = 260) from each pool of identified controls was selected per case. No cases had to be excluded due to lack of a matched control. Screening was continued into 2017 to have the full sample size needed for adequate power.

Infants coded as inpatient observations (within 28 days of discharge following birth) were treated during their inpatient stay and were included as readmits. All cases (readmits) and controls (no readmit) were added to a screening log maintained on the hospital secure server and assigned a unique study number. Following data collection, infant's age, time of discharge, percent weight loss at discharge and readmission (for cases) was converted into hours. Personal Health Information(PHI) was removed to de-identify the data for analysis.

Data Collection

A retrospective review of the entire maternal and infant EMR for the delivery and readmission was done to abstract the data. Maternal data was collected from the mother's prenatal record and the delivery admission. Infant data were collected from the infant's birth admission record. For readmitted infants, data was collected from the first readmission within 28 days. There was no way to determine if an infant discharged from the study site was readmitted to another hospital and therefore only infants admitted to the study site (birth hospital) were included.

Maternal data. The variables abstracted included the mother's medical record number, name, age in years, ethnicity (Hispanic or Latina, Not Hispanic or Latina, Unknown or Not reported), race (White, Black, Asian, American Indian or Alaskan Native, More than one race, Unknown or not reported), gravidity, parity, marital status (Married, Single, Divorced, Widowed or Separated, Not reported), level of education (8^{th} grade or less, 9-12^{th} grade, no diploma, High school graduate or GED, Some college credit, no degree, Associate degree, Bachelor's degree, Master's degree, Doctorate, Not reported), and type of insurance (Public, Private/Commercial, Self-pay).

Other variables abstracted included prenatal history and obstetrical history. A [Yes/No] was recorded for diabetes mellitus (DM) diagnosed during pregnancy or DM diagnosed prior to pregnancy, insulin given prior to pregnancy, hypertension diagnosed during pregnancy, hypertension diagnosed prior to pregnancy, antenatal hemorrhage, chorioamnionitis, maternal GBS testing, maternal GBS treatment and rupture of membranes (ROM), maternal antibody screen prior to delivery, primary language English and singleton birth. Maternal GBS (Positive/Negative), ROM date and time, documentation of blood groups (O, A, B, AB and Rh [Positive/Negative]), type of delivery (Vaginal, Cesarean section/primary, Cesarean section/repeat, Vacuum extraction, Instrument) data were also abstracted.

Infant data. Variables abstracted from the infant's chart included the medical record number, name, date of birth, time of birth, gender, resuscitation (none, oxygen, bagging and mask, Intubation), Apgar scores at one minute and 5 minutes (1-10), GA, genetic and or medical diagnosis (ICD-10 code), LATCH scores (1 through 10), birth weight and daily weights in grams.

Daily information was collected for days one through 6 of life. The date of birth was recorded as day one of life. Variables collected daily included feeding method (breast, bottle), type and amount of feed, number of stools, number of wet diapers, feeding difficulty (Sustained LATCH, latched with occasional/frequent swallows) and lactation consults (Yes/No), jaundice (documented following clinical assessment) (Yes/No), jaundice location (Head, Upper chest, Entire chest, Umbilicus, Groin, Legs and Feet), phototherapy (Yes/No), highest TSB levels- during hospitalization, prior to readmission [outpatient] and at/or during readmission were collected. Discharge teaching (date and time), discharge diagnosis (ICD-10 codes), age at discharge, neonatal readmissions, LOS and age at readmission and readmission diagnosis were also collected and/or derived from dates and times in the chart.

Infant readmission data by the 10th edition of the International Classification of Diseases (ICD-10 codes) was obtained from the EMR. Other variables abstracted included the discharge day of the week (Sunday through Monday), follow up appointment scheduled prior to discharge (Yes/No), time follow up appointment scheduled after discharge (<48 hours, 48 to 72 hours, > 72 hours and < one week), > one week, Unknown), and follow up provider recommended (Private pediatrician, Clinic pediatrician, Private Advanced Practice Nurse (APRN), Clinic APRN, Unknown).

Instrument Reliability and Validity

This was an observational nested case-control study involving retrospective data collection from the maternal and infant EMR. Data were collected into an electronic database by one individual (the student researcher) to minimize variability in data collection and coding errors. Items on the data collection form were defined in a list of variables, which was used during the abstraction. No surveys or questionnaire instruments were used in this study.

Data Analysis Plan

IBM SPSS Statistics for Windows, version 24.0 (IBM Corp., Armonk, N.Y., USA) was used for data analysis. The data were first reviewed and edited to identify missing values, outliers and data entry errors. Descriptive statistics were done to summarize the data and screen for normality, including variance, skewness, and kurtosis. Categorical variables of interest were examined using the Chi- Square test or Fisher's Exact Test to determine if significant differences in proportions existed between groups. Histograms were used to examine the normality and distribution of the continuous variables. Student's t-test for independent samples was used to compare the means of the continuous variables in the two groups (cases/readmits and controls/no readmit). Mann-Whitney U test was done for continuous variables not normally distributed.

Derived variables. To de-identify the data set per the study site policy, identifiable variables were derived from the dates and times of admission, discharge and readmission and the dates and times were then deleted from the final data set for analysis. Derived variables included *age in hours at discharge (LOS), percent weight loss from birth to discharge, age in hours at readmission, percent weight loss/gain since birth at readmission, and readmission LOS in hours.*

The variables LATCH scores and education assessment were sparsely populated and could not be used in the regression analysis. Instead, the *LATCH count* for the infant stay, *average number of LATCH scores, minimum, median and maximum LATCH scores* for the hospital stay were calculated for the first three days. *Minimum LATCH score for the first three days* were also calculated. Similarly, a count of the number of times a mother was educated on breastfeeding/infant nutrition (*count of education three days)* during the first three days of life were calculated and transposed to three groups by the number of times the mother had received education on breast or bottle feeding. (1 = 0-4, 2 = 5-6, 3 = 7-13). The amount of formula was collected on all infants and who received any breast milk (BM) and formula. type for the first three days was transposed to three groups *feeding type three days (*1 = Breast milk, 2 = Formula, 3 = Breast milk and Formula).

The statistical procedures used to analyze the four research questions will be outlined in detail below.

Research Question One

What are the maternal, infant, provider and institutional factors associate with neonatal readmissions in term infants?

Guided by Meleis's Transitions Theory (Meleis, 2010) a framework for neonatal readmission was adapted for conditional logistic regression and was used to answer this question. Constructs of maternal, infant, provider, and institutional factors were defined by the theory. Bivariate analysis was done on the continuous variables and the variables of interest. Correlations were examined on all continuous variables for relationships among the variables and to screen for multicollinearity using Pearson's correlation coefficient. Clinically significant variables with correlations above 0.3 but less than 0.8 were identified for the regression model (Field, 2009). Statistical significance was set at $p < 0.05$. The hierarchical conditional logistic regression model was developed by identifying significant predictors in each construct and adjusting for confounding variables. Odds ratios were calculated for the predictor variables.

The mean age at discharge home was (2.37 days ± 0.756 [0.69 - 4.78]). Therefore, data were analyzed only for day one through three of life to include the days with sufficient data for a regression analysis. Infants discharged home prior to day three were assigned a code of not applicable for the day three variables.

Dependent variable. The dependent variable readmits (0 = No readmit, 1 = Readmit) was transformed into a time variable (Readmit for Conditional) with all controls censored at the later time or having a larger positive number than the cases (1 = Readmit; 2 = No readmit) (IBM SPSS, 2017). The binary outcome of Readmit Yes/No was also transformed into a numeric variable to run a correlation check for multicollinearity prior to the regression analysis (1 = Readmit/0 = No Readmit). The normality assumption was not met with several of the continuous variables and Spearman's Rho was used instead of Pearson correlation. The conditional logistic regression analysis was done using Cox survival analysis in SPSS with the grouping variable for time (Readmit for Conditional).

Independent variables (IV). IV's were selected for the conditional logistic regression model based on the literature, the research question and Transitions Theory constructs proposed for neonatal readmission. Univariate analyses were performed on each variable included in the constructs of the Transitions Theory framework (Figure 2 in Chapter 2). SPSS Cox survival analysis categorical covariates (IV's) are converted into a set of dummy variables, omitting one category (IBM SPSS, 2017). The reference group (indicator) was set to the first group or the lowest number code

(0 = No or Not Applicable). The IV maternal GBS dummy variable maternal GBS positive and the variable maternal GBS treatment was transformed to (N/A = for infants who were not positive for GBS or no test done, 1 = No treatment and 2 =Yes [for treated prior to delivery]). The variable length of stay, total formula amount, and all the LATCH score variables were not normally distributed. The Mann-Whitney U test was run instead to test for significance. The *p* values were examined and the significant variables ($p < 0.05$) were selected to fit the model (Table 4).

With hierarchical modeling the individual predictors are added first, followed by the interactional predictors, and the institutional predictors (Harlow, 2014). Although product terms on some variables of interest (such as LATCH score and significant weight loss) were created for the model they were not significant and were not included. Each construct from the theoretical framework was entered in the conditional logistic regression model using the backward stepwise logistic regression method. A *p* value of 0.1 was set for removal and to determine the most important predictors to be included in the final model. Odds ratios and the 95% confidence interval (95% CI) were calculated on the predictor variables for the two groups in the final model.

Transition Conditions (patient characteristics) were added first. Patient characteristics were separated into maternal and infant characteristics. This was followed by the Nature of Transitions (hospitalization factors), Nursing Therapeutics (readiness and preparation for home) and lastly the Organizational Structure (provider and institutional factors). Table 4 shows the significant variables for each construct added to fit the model and the variable coding. The Outcome Indicator in the

Transitions Theory conceptual framework is neonatal readmission within 28 days of birth (No Readmit/Readmit).

Table 4. Transitions Theory Constructs and Significant Variables (*p* < 0.05)

Construct	Variable	Variable Coding	*p* Value
Transition Conditions- Patient Characteristics - Maternal			
	Maternal GBS Positive	0 = N/A (Not tested)/Negative; 1= Positive	0.034
	ROM prior to delivery	Hours	0.003
	Race	1 = White; 2= Black; 3 = Asian; 4 = Other/Unknown	0.026
	Parity	0 = None; 1 = ≥ 1 viable infant	0.003
	Chorioamnionitis	0 = No; 1 = Yes	0.047
Transition Conditions- Patient Characteristics - Infant			
	Gender	1 = Male; 2 = Female	0.026
	Jaundice day two	0 = No; 1 = Yes	< 0.001
	Jaundice day three	0 = No; 1 = Yes	0.020
	Gestational Age (GA) in weeks	1 = 37.0-37.6; 2 = 38.0 -38.6; 3 = 39.0-39.6; 4 = 40.0 - 40.6; 5 = 41.0 - 41.6	< 0.001
	Total formula amount (first 3 days)	Milliliters	< 0.001
Nature of Transitions- Hospitalization Factors			
	Maternal GBS treatment	0 = N/A; 1 = No; 2 =Yes	0.004
	Delivery mode	1 = Vaginal; 2 = C/S	< 0.001
	Length of stay	Hours	0.005
Nursing Therapeutics- Readiness and Preparation for Transition to Home			
	Education Count (3 Days)	1 = 0 - 4; 2 = 5- 6; 3 = 7 - 13	0.001
	Sum of LATCH scores (first 3 days)	Count	< 0.001
Organizational Structure- Provider and Institutional Factors			
	Follow up scheduled	0 =No; 1 =Yes	< 0.001
	Call for follow up appointment	0 =N/A; 1 = No; 2 = Yes	0.023

Note. C/S = Cesarean section, Education count = Number of times education on feeding by the nurse was documented, GBS = Group B Streptococcus; N/A = Not applicable; ROM = Rupture of membranes.

Table 5a through Table 5e shows the model for each construct and the outcome of the predictor variables after backward stepwise regression. The reference group was set to the first category. The GA variable was transformed to make $40^{0/6}$ to $40^{6/7}$ weeks GA the reference group.

Table 5 a. Predictors of Neonatal Readmission- Transition Conditions (Maternal)

Variable Statistics				
Model 1	OR	95% CI		*p* value
Patient Characteristics- *Maternal*		Lower	Upper	
Maternal GBS Positive	1.64	0.92	2.95	0.096*
Race				0.113*
Parity (2 groups)	0.54	0.31	0.92	0.024
Chorioamnionitis	3.40	0.95	12.19	0.060*

Note. *Variables dropped from model 1 (not significant). CI= Confidence Interval

Table 5 b. Predictors of Neonatal Readmission- Transition Conditions (Infants)

Variable Statistics

Model 2 Patient Characteristics- *Infant*	OR	95% CI Lower	 Upper	*p* value
Gender	0.60	0.36	1.02	0.059*
Jaundice day two	3.00	1.75	5.12	< 0.001
Gestational age in weeks				< 0.001
37.0-37.6	14.32	4.69	43.67	< 0.001
38.0-38.6	6.47	2.28	18.37	< 0.001
39.0-39.6	3.92	1.56	9.87	0.004
40.0- 40.6 [Ref]	**1.0**			**< 0.001**
41.0-41.6	3.02	0.94	9.69	0.064
Total formula amount 3 days (mls)	0.995	0.992	0.997	< 0.001

Note. CI= Confidence Interval, mls = milliliters, Ref = reference group. * Variables dropped from model 2 (not significant).

Table 5 c. Predictors of Neonatal Readmission- Nature of Transitions

Variable Statistics				
Model 3	OR	95% CI		*p* value
Hospitalization Factors		Lower	Upper	
Maternal GBS treatment [Ref]	**1.0**			**0.039**
Maternal GBS treatment (No)	0.27	0.03	2.33	0.233
Maternal GBS treatment (Yes)	1.92	1.07	3.45	0.028
Delivery mode	0.19	0.09	0.43	< 0.001

Note. CI= Confidence Interval, GBS = Group B streptococcus, Delivery mode reference group = vaginal delivery, N/A = Not applicable; Ref= Reference group.

Table 5 d. Predictors of Neonatal Readmission - Nursing Therapeutics

Variable Statistics				
Model 4	OR	95% CI		*p* value
Readiness for Transition to Home		Lower	Upper	
Education count – 3 days = 0 – 4 [Ref]	**1.0**			**< 0.001**
Education count – 3 days = 5 - 6	0.74	0.41	1.33	0.313
Education count – 3 days = 7-13	0.24	0.12	0.49	< 0.001
Sum of LATCH scores 3 days	1.03	1.01	1.04	< 0.001

Note. CI = Confidence Interval, Education count = Number of times education on feeding by the nurse was documented in the first 3 days, Ref = Reference group.

Table 5 e. Predictors of Neonatal Readmission – Organizational Structure

Variable Statistics				
Model 5 Provider and Institutional Factors	OR	95% CI Lower	 Upper	*p* value
Follow up scheduled prior to discharge	0.51	0.33	0.78	0.002

Note. Call for appointment = Parents asked to call pediatrician's office for an appointment after discharge, CI = Confidence Interval, Ref = reference group.

Table 6. shows the results of the backward stepwise regression when the significant predictors from all constructs were included in the final model. The maternal variable parity was not significant in the final model and was dropped. Infant predictor variables gender and jaundice on day three were dropped. None of the nursing therapeutic variables education count three days and sum of LATCH scores three days remained in the final model and the provider variable follow up scheduled was also dropped in the final backward regression with all significant construct variables.

Table 6. Predictors of Neonatal Readmission

Variable Statistics				
Final Model– All constructs	OR	95% CI		*p* value
		Lower	Upper	
Jaundice day two	2.45	1.40	4.30	0.002
Gestational age in weeks				
37.0-37.6	20.45	6.11	68.41	< 0.001
38.0-38.6	6.42	2.18	18.93	0.001
39.0-39.6	4.97	1.91	12.99	0.001
40.0- 40.6 [Ref]	**1.0**			**< 0.001**
41.0-41.6	3.18	0.95	10.68	0.061
Total formula amount 3 days (mls)	0.996	0.993	0.999	0.005
Maternal GBS treatment (N/A) [Ref]	**1.0**			**0.033**
Maternal GBS treatment (No)	0.48	0.04	5.83	0.561
Maternal GBS treatment (Yes))	2.55	1.23	5.28	0.012
Delivery mode -Vaginal	0.31	0.12	0.79	0.014
Sum LATCH score 3 days	1.02	0.999	1.02	0.063*

Note. CI= Confidence Interval, Delivery mode reference group = vaginal delivery
GBS = Group B streptococcus, Ref= Reference group, N/A = Not applicable.
* Variable not significant in the final model in backward stepwise regression.

Research Question Two

Is significant weight loss from birth (> 7 %) and breastfeeding difficulty (sustained feeding and/or LATCH score ≤ 6) in term infants during the hospital stay and/or at discharge associated with increased neonatal readmission to the birth hospital?

To address this question a subset of exclusively breast-fed infants who received no formula during the first three days of life was created. Table 7 shows the breakdown of the proportions by the feeding type for the first three days of life.

Table 7. Feeding Type in the First Three Days of Life

	Total (%)	Readmit (%)	No Readmit (%)	*p* value
Exclusively breast-fed	186 (47.7)	76 (58.5)	110 (42.3)	0.003
Formula only	47 (12.1)	7 (5.4)	40 (15.4)	0.004
Breast milk & formula	157 (40.3)	47 (36.2)	110 (42.3)	0.243
Total	390 (100.0)	130 (100.0)	260 (100.0)	

The total formula in milliliters (mls) in the first three days was recoded into exclusive breast feeding (1 = Lowest through 0 mls and 2 = 1 ml through highest). To obtain the *p* values, each category was dummy coded adjusting for all other types of feeds. The weight loss at discharge variable was recoded into ≤ 7% and > 7 % and the minimum LATCH score variable for three days was recoded into a score of ≤ 6 and > 6. A Chi Square test was run with the two recoded independent variables (LATCH score ≤ 6, *p* value = 0.559, and weight loss > 7 % *p* = 0.883).

Further analysis. A conditional logistic regression (Cox Survival Model) was also run using the two variables weight loss > 7% and LATCH score ≤ 6 with readmit as the status and the matched set variable as the strata. The two variables were also run using the feeding type breast milk and formula.

Research Question Three

What is the the incidence of all cause neonatal readmission (within 28 days of birth) in term infants to the birth hospital?

The incidence rate or incidence density is a more accurate measure of the risk when people are observed for different periods of time (Gordis, 2014). Individual infants were observed for different periods of time prior to readmission and the incidence rate (or incidence density) was calculated in person-time (person-days).

For this research question the denominator included all deliveries during the study period (January 1, 2016 through May 8, 2017) to the study site. The numerator included all readmission/inpatient observations to the study site during the same period. All inpatient observations received phototherapy treatment and or breastfeeding support during their inpatient stay following discharge home and they were included in the readmission rate.

Each infant born during the person-time (study) period was observed for either 28 days (not readmitted) or the time from birth to readmission using the formula:

Incidence rate per 1,000 =

$$\frac{\text{Number of NEW cases of readmission occurring in a population during a specified period of time}}{\text{Total person-time (sum of the periods of observation of each infant who was observed for all or part of the entire period)}} \times 1000$$

(Gordis, 2014).

There were 11, 958 infants born at the study site during the study period and of these infants 202 infants were readmitted within 28 days of life. The cohort consisted of 49% (5,940 infants) of the total number of births at the site. Of these infants, 135 infants were readmitted within 28 days of birth to the birth hospital.

All ICD-10 codes at readmission were recorded. The data abstracted did not always reflect the primary diagnosis for readmission. Several infants had ICD-10 codes that fell into more than one readmission reason/diagnosis category and therefore the number of ICD-10 codes did not total 130 readmit cases. Similar diagnoses were grouped together by ICD-10 codes into the top four groups.

Research Question Four

What is the length of stay (in hours) after birth and diagnosis of neonatal readmission in term infants?

The “length of stay (LOS) in hours” variable was derived from the date and time of discharge minus the date and time of birth (age in hours at discharge variable). A comparison of the means of the two groups was run to determine the mean LOS in hours at discharge for the two groups (Controls/No Readmit and Cases/Readmit) within 28 days.

Further Analysis. A one-way ANOVA test was run on the age in days at discharge variable as the dependent variable and delivery mode as the factor variable.

Summary

This chapter described the research methods used to select the study sample for this nested case-control study. The data abstraction process per IRB and HIPPA guidelines to protect patient information were outlined. A detailed description of variable selection including the dependent, independent and derived variables using selected constructs of Transitions Theory and the steps and logic for recoding certain variables were described. Finally, the statistical procedures used to analyze and answer each of the four research questions were described in detail.

CHAPTER 5

FINDINGS

Transitions Theory was used as a guide to quantify the risk factors in neonatal readmission in term ($37^{0/7}$ through $41^{6/7}$ weeks gestation) infants. Additionally, an estimate of the incidence of neonatal readmission was assessed and LOS of the birth hospitalization and reasons for readmission were characterized. The results of the analysis for each research question are presented in this chapter.

Analysis of the Data and Results

The target study cohort of 5,940 infants was selected from a population of 11,958 newborns delivered at a large tertiary care center in the Northeastern US. The cohort consisted of healthy, term gestation ($37^{0/7}$ to $41^{6/7}$ weeks), in-state domicile infants admitted to the WBN following birth, and all infants who had a DRG code of normal newborn per the DRG Classification System. Eligible cases (n = 130) and controls (n = 260) (matched on maternal age and infants birth date +/- 7 days) were retrospectively identified beginning with infants born January 1, 2016 until 130 readmissions/cases were identified through May 8, 2017.

The demographic and clinical characteristics of the infants in this nested case-control study sample are summarized in Table 8.

Table 8. Infant Demographic and Clinical Characteristics

Characteristic	Total (N = 390)	No Readmit/ Controls (n = 260)	Readmit/ Cases (n = 130)	p value
Gender				0.026
Male	191 (49.0)	117 (45.0)	74 (56.9)	
Female	199 (51.0)	143 (55.0)	56 (43.1)	
Birth Weight				0.961
2000 - 2999 grams	81 (20.8)	53 (20.4)	28 (21.5)	
3000 – 3999 grams	278 (71.3)	186 (71.5)	92 (70.8)	
4000 – 4999 grams	31 (7.9)	21 (8.1)	10 (7.7)	
Gestational Age				< 0.001
37.0 - 37.6 weeks	57 (14.6)	22 (8.5)	35 (26.9)	
38.0 - 38.6 weeks	69 (17.7)	39 (15.0)	30 (23.1)	
39.0 - 39.6 weeks	160 (41.0)	113 (43.5)	47 (36.2)	
40.0 – 40.6 weeks	66 (17.2)	60 (23.1)	7 (5.4)	
41.0 – 41.6 weeks	37 (9.5)	26 (10.0)	11 (8.5)	
Weight loss at discharge				0.413
> 7%	4 (11.3)	27 (10.4)	17 (13.2)	
≤ 7 %	345 (88.7)	233 (89.6)	112 (86.8)	

Note. *n* or *N* (%). Birth weight was recoded into 3 categories. Gestational age was recorded into 5 categories by week of gestation.

Maternal demographic and clinical characteristics are summarized in Table 9. The mean age of mothers in the sample was 29.6 years (29.6 ± 5.34, [15- 44]) and the ages were negatively skewed with no difference between the two groups.

There were no significant differences in case (readmits) versus controls (no readmit) in gravida, maternal education, marital status, primary language spoken at home, singleton versus multiple births, Apgar scores at 1 minute, Apgar score at 5 minutes, and resuscitation. Parity was recoded into two groups (0 = No viable births and 1 = ≥1 viable birth) from eight groups and remained significant following recoding ($p = 0.003$). The number of nulliparous mothers in the control/no readmit group was 33.8% vs. 49.2% in the cases/readmit group.

Lactation consult (Yes/No) on days one through three was not significant ($p = 0.526$, $p = 0.313$ and $p = 0.425$ respectively). Breastfeeding quality (sustained feeds or latched, occasional/frequent swallows) on day one through three had more than 10% missing data for each day and was not included in the regression analysis. The variables maternal antibody screen prior to delivery, antenatal hemorrhage, and single birth (Yes/No) had no variability and were not used in the model. Infant factors including phototherapy on days one to three had no variability and these variables were also excluded. The provider factor follow-up appointment recommended was excluded as well for no variability in the data.

Table 9. Maternal Demographic and Clinical Characteristics

Characteristic	Total (*N* = 390)	No Readmit/ Controls (*n* = 260)	Readmit/ Cases (*n* = 130)	*p* value
Ethnicity				0.337
Hispanic or Latina	120 (30.8)	81 (31.2)	39 30.0)	
Not Hispanic/Latina	265 (67.9)	174 (66.9)	91(70.0)	
Not reported	5 (1.3)	5 (1.9)	0 (0.0)	
Race				0.026
White	236 (60.5)	156 (60.0)	80 (61.5)	
Black	27 (6.9)	24 (9.2)	3 (2.3)	
Asian	26 (6.7)	13 (5.0)	13 (10.0)	
Other or Unknown	101 (25.9)	67 (25.8)	34 (26.2)	
Insurance (payor)				0.283
Private/commercial	189 (48.5)	121 (46.5)	68 (52.3)	
Public/military	201 (51.5)	139 (53.5)	62 (47.7)	
Delivery Mode				< 0.001
Vaginal	314 (80.5)	191 (73.5)	123 (94.6)	
Cesarean section	76 (19.5)	69 (26.5)	7 (5.4)	

Note. n or N= (%). American Indian or Alaskan Native, Other/Unknown race and more than one race collapsed into Other/Unknown. Delivery mode (primary and repeat c/s, instrument and vacuum extraction) collapsed to 2 groups. Insurance recoded from 3 groups (public, private and self-pay) to 2 groups.

Research Question One

What are the maternal, infant, provider and institutional factors associate with neonatal readmissions in term infants?

The final model included the variables jaundice on day two, GA, total formula amount (mls), maternal GBS treatment, delivery mode, follow up scheduled and sum of LATCH scores for three days. The OR computed in the final model were adjusted for all the other variables in the model. Significant maternal predictors of readmission at $p < 0.05$ were delivery mode (OR 0.31, 95% CI [0.12, 0.79], $p = 0.014$) and maternal GBS treatment (OR 2.55, 95% CI [1.23, 5.28], $p = 0.012$). Infant factors included jaundice on day two of life (OR 2.45, 95% CI [1.40, 4.30], $p = 0.002$), GA 37 through 40 weeks (37 weeks OR 20.45, 95% CI [6.11, 68.41], $p < 0.001$; 38 weeks OR 6.42, 95% CI [2.18, 18.93], $p = 0.001$; 39 weeks OR 4.97, 95% CI [1.91,12.99], $p = 0.001$), and total formula amount received in the first three days (combined breastfeeding and formula intake) (OR 0.996, 95% CI [0.993,0.999], $p = 0.005$). None of the institutional factors remained in the final conditional logistic regression model.

Research Question Two

Is significant weight loss from birth (> 7 %) and breastfeeding difficulty (sustained feeding and/or LATCH score ≤ 6) in term infants during the hospital stay and/or at discharge associated with increased neonatal readmission to the birth hospital?

H_0 = There is no difference in the readmission rate of infants due to the proportion of weight loss from birth > 7 % and LATCH scores ≤ 6 during hospital stay between the two groups.

H_1 = There is a difference in the rate of readmission of infants in the two groups due to weight loss > 7% and LATCH scores ≤ 6 during hospital stay.

The two recoded independent variables were not significant (LATCH score ≤ 6, *p* value = 0.559, and weight loss > 7 % *p* = 0.883). The null hypothesis (H_0) was accepted. Weight loss (> 7%) and LATCH scores ≤ 6 are independent of readmission. They are not statistically related. There is no difference in the proportion of weight loss from birth > 7 % and LATCH scores ≤ 6 during the hospital stay between the two groups (No Readmit/Controls and Readmit/Cases).

Further analysis. A conditional logistic regression of the variables weight loss > 7% and LATCH score ≤ 6 by feeding type was not significant for the exclusive breast milk group (Table 10a). Feeding type breast milk and formula was also not significant (Table 10b).

Table 10 a. Sub Analysis: Exclusive Breast Milk*- Weight Loss > 7 %, Latch Scores ≤ 6 and Neonatal Readmission

	OR	95% CI		*p* value
		Lower	Upper	
Weight loss > 7%	0.98	0 .30	3.19	0.967
LATCH Score ≤ 6	1.09	0 .54	2.19	0.812

Note. * Feeding Type (3 Days) = Exclusive breast milk (no formula). CI = Confidence Interval

Table 10 b. Sub Analysis: Breast Milk and Formula*- Weight Loss > 7 %, Latch Scores ≤ 6 and Neonatal Readmission

	OR	95 % CI		*p* value
		Lower	Upper	
Weight loss > 7%	0.84	0.11	6.57	0.865
LATCH Score ≤ 6	2.03	0.65	6.40	0.225

Note. * Feeding Type (3 Days) = Breast milk and formula. CI = Confidence Interval.

Research Question Three

What is the the incidence of all cause neonatal readmission (within 28 days of birth) in term infants to the birth hospital?

There were 11, 958 infants born at the study site during the study period and 202 infants were readmitted within 28 days of life. The study cohort consisted of 49% (5,940 infants) of the total population. One hundred and thirty eligible infants were readmitted within 28 days of birth to the birth hospital.

The incidence rate of neonatal readmission per 1,000 infants was 0.65 person-days for all infants born at the study site. The incidence rate per 1,000 infants for the cohort was 0.83 person-days. The incidence of all readmission was 1.69 % and the incidence of readmission within 28 days of birth in term infants in the cohort is 2.22%.

All ICD-10 codes at readmission were recorded. Several infants had ICD-10 codes that fell into more than one readmission reason/diagnosis category. Similar diagnoses were grouped together by ICD-10 codes into the top four groups. Most infants (93%) were readmitted for jaundice. The reasons for readmission are listed in Table 11.

Table 11. Reasons for Readmission by ICD-10 Diagnosis Codes

Reason	ICD-10 codes	Number
Jaundice	P59.9 Neonatal jaundice unspecified	121
	E80.6 Other disorders of bilirubin metabolism	43
	P59.8 Neonatal jaundice from other specified causes	7
	P59.3 Neonatal jaundice from breast milk inhibitor	6
	R17 Unspecified jaundice	4
	P58.0 Neonatal jaundice due to bruising	1
Feeding Problems/ Dehydration	P74.1 Dehydration of newborn	9
	R63.4 Abnormal weight loss	3
	E87.0 Hyperosmolality and hypernatremia	3
	P92.9 Feeding problem of newborn unspecified	3
	R34 Anuria and oliguria	2
	E86 Dehydration	1
	P92.8 Other feeding problems of newborn	1
	R63.3 Feeding difficulties	1
	Q38.1 Ankyloglossia	1
	Q31.5 Congenital laryngomalacia	1
Hypothermia	P80.9 Hypothermia of newborn unspecified	3
	P80.8 Other hypothermia of newborn	1
	T68.XXXA Hypothermia, initial encounter	1
Respiratory	R06.1 Stridor	1
	P28.89 Other specified respiratory conditions of newborn	1
	R68.131 Apparent life-threatening event in infant	1
	P28.4 Other-apnea of newborn	1

Note. Several infants had ICD-10 codes that fell into more than one reason category. Several codes did not fall into any of the above categories.

Research Question Four

What is the LOS (in hours) after birth and diagnosis of neonatal readmission in term infants?

The mean hospital LOS of all healthy term infants from birth (in hours) in the study sample was (54.6 ± 16.8, [16.53-126.30], $p < 0.001$). This suggests that readmitted infants experience significantly less time in the hospital after birth than do infants who are not readmitted. Infants not readmitted spent an average of 57.09 ± 18.2 hours in the hospital while infants readmitted were discharge at 50.23 ± 12.81 hours.

Further Analysis. A significant ($p < 0.001$) difference in the LOS between infants born via vaginal delivery and cesarean section was found, which is may be explained by the longer required surgical stay for cesarean section mothers. The mean LOS for vaginal deliveries in the study sample was (48.78 ± 10.77, [16.53-126.30] hours). For cesarean deliveries the mean LOS in hours was (79.69 ± 14.76 [49.28-114.78] hours). The LOS in days was 3.32 days versus 2.03 days cesarean sections vs. vaginal delivery. Vaginal delivery, n = 314 (2.03 ± 0.45, 95% CI [1.99, 2.08]) days and cesarean section, n=76 (3.32 ± 0.61, 95% CI [3.18, 3.46]) days.

Other Findings - TSB levels on Readmitted Patients

The highest outpatient and readmission TSB levels were recorded for readmitted infants in this study. Of the 130 infants readmitted, 111 had outpatient TSB levels drawn prior to readmission and 127 had levels drawn at or during readmission (Table 12). Nineteen infants (17.1%) had outpatient TSB values ≥ 20 mg/dL. Seventeen infants (13.4%) had TSB level ≥ 20 mg/dL at or during readmission. Hyperbilirubinemia has been defined as a TSB level ≥ 20 mg/dL (Ip, et al., 2004). It has also been defined as a TSB level ≥ 95^{th} percentile on a hour specific nomogram (Bhutani et al ., 1999). According to the AAP Subcommittee on Hyperbilirubinemia technical report, “it is evident that the preponderance of kernicterus cases occurred in infants with high bilirubin (more than 20 mg/dL)” (Ip, et al., 2004). Screening and monitoring bilirubin levels in jaundiced infants is essential. Radmacher and colleagues (2002) reported serum bilirubin levels > 25 mg/dL on readmission in one in five infants hospitalized for jaundice. It has been suggested that infants with unexplained TSB levels > 25 mg/dL should have further hematologic and pathologic testing if the Direct Antiglobulin Test (DAT) is negative to screen for the underlying cause of hemolysis and hyperbilirubinemia (Christensen, et al., 2013).

Table 12. Total Serum Bilirubin (TSB) Outpatient and Readmission Values

Outpatient TSB (n) Readmission TSB (n)	Minimum TSB level	Maximum TSB level	Mean TSB level
Out- patient TSB levels prior to readmission (n=111)	7.4 mg/dL	29.7 mg/dL	18.3 mg/dL
Highest TSB level at or during readmission (n=127)	5.1 mg/dL	23.7 mg/dL	15.6 mg/dL

Note: Readmitted patients only

Summary

Descriptive statistics and conditional logistic regression were used to analyze the data abstracted for this nested case-control study. The results of the four research questions are described in detail in this chapter. The infant factors found to be predictive or associated with neonatal readmission in healthy term infants were GA at 37- 39 weeks and documented jaundice on day two of life. A maternal/provider factor predictive of neonatal readmission was maternal treatment for GBS. The provider factors predictive of a decreased likelihood of readmission included delivery mode (cesarean section), and combined breast milk and formula feeds in the first three days of life. This last factor can also be considered a maternal factor if it involves the decision of the mother instead of the provider to introduce formula into the infant's diet. Each of these predictors/factors will be discussed in detail in Chapter 6.

CHAPTER 6

CONCLUSION

This chapter gives an overview of the research problem and the conceptual framework used for this study. The findings, limitations, and conclusions of the study are discussed in detail. Implications for nursing practice, research, and theory development and health policy have been provided.

Discussion

Over the past decade neonatal readmissions in term infants have ranged from <1 to 1.3% in the US to <1% to 8% across the world. Most of these readmissions have been due to jaundice (De Luca & Carnielli, 2009). Changes and variations over this same period in discharge policies and provider roles (increased number of advanced practice nurses), health care initiatives (Baby Friendly) and sociodemographic changes in the population have taken place. Transitions Theory by Meleis (2010) was useful to understand the variables and their relationship to neonatal readmission. This enabled the selection of the variables for conditional logistic regression to quantify the risk of maternal, infant, provider and institutional factors associated with neonatal readmission, and to understand the current incidence of neonatal readmission in healthy term infants.

It is only natural that parents of healthy term infants experience some level of anxiety when taking their newborn home from the hospital. The nurse can assist the mother-infant dyad in a successful transition to home (Meleis, 2010). Reducing the number of preventable neonatal readmissions in infants born and discharged home as healthy term infants may reduce the emotional burden and associated cost to the parents. It may also reduce the financial burden to the health care system. The CMS has associated reducing readmissions with better quality of care (Centers for Medicare and Medicaid Services, 2016).

Theoretical Framework

Transitions Theory was utilized to identify the maternal, infant, provider and institutional predictive factors of neonatal readmission in healthy term infants related to neonatal readmission. The constructs of transition conditions (maternal and infant characteristics), nature of transition (hospitalization factors), nursing therapeutics (readiness for discharge home) and organizational structure (provider and institutional factors) were used to build the conditional logistic regression model for analysis. Significant variables ($p < 0.05$) that remained in the final regression model after backward stepwise regression were determined to be predictors of neonatal readmission after adjusting for all other variables in the model (see Table 6). These predictors could be useful in the development of nursing research to better understand the facilitators and barriers of nursing therapeutics in reducing preventable readmissions. This makes Transitions Theory a useful theory to examine neonatal readmissions.

Factors predictive of neonatal readmission. The factors found to be predictive or associated with neonatal readmission in healthy term infants in this study were: 1) GA 37- 39 weeks; 2) maternal treatment for GBS, and; 3) documented jaundice on day two of life. Each of these predictors/factors are discussed in detail.

1) Gestational age. As in previously reported studies GA was significant. The risk of readmission for infants born at 37 weeks was 20 times greater than that of the reference group (40 weeks) (OR 20.45, 95% CI [6.11, 68.41]). It was also significant for all other gestations below 40 weeks. For 38 weeks GA the risk was over six times greater (OR 6.42, 95% CI [2.18, 18.93]), and at 39 weeks almost five times greater (OR 4.97, 95% CI [1.91,12.99]) when compared to the reference group. The readmission rate for infants at 41 weeks GA when compared to the reference group (40 weeks GA) was not significant (OR 3.18, 95% CI [0.95,10.68]). These results are consistent with prior studies of late preterm and term infants (Young et al., 2013; Brown et al., 1999).

2) Maternal GBS treatment. In this study, infants of mothers who were treated for GBS were almost three times more likely (OR 2.55, 95 % CI [1.23, 5.28], p = 0.012) to be readmitted when compared to the reference group (GBS treatment not applicable due to negative GBS test or no GBS test) than infants not treated. Infection is believed to play a role in jaundice in the newborn by increasing the production of bilirubin as a stress response to infection (Stevenson, Maisels, & Watchko, 2012). According to Cohen, Wong, & Stevenson (2010), intrauterine infection causes an increase in bilirubin production and unconjugated hyperbilirubinemia. A recent in-vitro study on neonatal blood culture isolates showed that antibacterial properties may be present in bilirubin against GBS, and there may be a mechanisms through which GBS adapts to bilirubin exposure (Hansen, et al., 2018).

A study in Saudi Arabia, where there was no maternal GBS screening reported, the leading cause of readmission as neonatal sepsis. The authors recommended screening for maternal GBS prior to delivery (Habib, 2013). A systematic review also estimated the risk of GBS disease and the effect of intrapartum antibiotic prophylaxis (IAP). The results were similar to previous studies which showed a linear association between increased IAP and a decreased early onset GBS infection in the infant (Russell et al., 2017). Identifying mothers who are GBS positive and/or treated has been useful for preventing early onset infection (Pulver et al., 2009).

In current US practice GBS is not considered a risk factor when mothers have received adequate IAP (at least 4 hours prior to delivery) or have intact membranes or when the infant is delivered by cesarean section (Polin & Newborn, 2012). Due to variations in how the CDC guidelines are followed identifying these mothers and infants as “at risk”, especially if discharged early, may be useful to make sure the infant is assessed and follow up is provided in a timely manner.

This study adds to the body of literature regarding the role of intrapartum infection and the risk of developing jaundice and hyperbilirubinemia. A multi-site study may be useful to examine these finding in diverse populations and hospitals with different standards of care for screening and treatment of maternal GBS infection. Discharge procedures may need to be modified based on maternal GBS status and treatment.

3) Presence of jaundice on day two of life. Documentation of the presence of jaundice on day two of life was a strong indicator of readmission in this study after adjusting for other variables in the model (OR 2.45, 95% CI [1.40, 4.30], $p = 0.002$). Infants were more than twice as likely to be readmitted if jaundice was seen on day two of life compared to infants who did not have jaundice on day two. Similar findings were reported in a study by Geiger et al. (2001). In multivariate analysis, jaundice suspected by a nurse during the hospital stay increased the likelihood of readmission within 14 days due to jaundice (OR 6.66, 95% CI [1.80, 24.69] (Geiger et al., 2001). Visual detection of jaundice may be possible at 5-6 mg/dL depending on lighting conditions but it has been known to vary with the observer (Hansen & Bratlid, 2012). This makes visual detection of jaundice a risk factor that may not always be reliable. Screening tools such as TSB levels or a non-invasive transcutaneous bilirubin measurement are needed for infants at risk where jaundice is noted. Carefully considering the bilirubin rate of rise is also essential and this can be achieved in the first 48 hours of life with two measurements 12-24 hours apart (De Luca & Carnielli, 2009).

Of the 130 infants readmitted within 28 days of birth to the birth hospital in this study 93% (121) had a diagnosis of jaundice and or hyperbilirubinemia. This is similar to a study of 34 - 42 weeks GA infants by Young et al. (2013) in which almost 90% of the readmissions within the first week of life were for jaundice. In the current study all readmissions were within 205 hours of birth (8.6 days). Ninety seven percent or 126 infants were readmitted within 7 days of birth. A study by Hall et al. (2000) reported that infants readmitted for hyperbilirubinemia within two weeks of life had a mean TSB value of 22.8 mg/dL. Their weight loss from birth was also >12% (Hall et al., 2000).

Measurements of TSB or a non-invasive transcutaneous bilirubin measurement should be done in infants > 35 weeks of age and over 24 hours old with visible jaundice (Battersby et al., 2017). The National Institute for Health Care and

Excellence (NICE) guidelines in the U.K. also recommend healthcare professionals and parents visually inspect the sclerae and gums of infants for jaundice preferably in bright and or natural light. Signs of jaundice should be checked by blanching the skin (pressing on the skin lightly). If jaundice is suspected a bilirubin level should be obtained (National Institute for Health and Care Excellance, 2010).

In this study, a lack of documentation of the signs of jaundice in the EMR was interpreted as no jaundice. Not only should the presence of jaundice be documented but also the absence of jaundice during the birth hospitalization. This should be documented to ensure this assessment is not being overlooked. Differences in assessment and recognition of jaundice by health care providers have been noted in other studies and standardization is needed (Brown et al., 1999). A nursing checklist could be developed and used in the clinical setting to ensure that assessments for jaundice are part of the required nursing assessment of all infants each shift. This may be useful in the clinical arena to make sure that infants are ready for discharge in order to decrease neonatal readmission. Education/training on this assessment approach could provide good agreement across nursing staff and facilitate a patient safety culture in the unit whereby nurses can ask a colleague to verify when there are questionable findings.

Factors less likely to cause readmission. The factors associated with a decreased likelihood of being readmission include: 1) Delivery mode, and; 2) combined breast milk and formula feeds in the first three days of life were

1) Cesarean delivery. Delivery mode was significant ($p = 0.014$) in this study. This was most likely due to the extended stay in the hospital for cesarean section deliveries versus vaginal deliveries. After adjusting for all other variables in the final model, infants who were delivered by cesarean section when compared to infants delivered vaginally were 69% less likely to be readmitted within 28 days of birth (OR 0.31,95% CI [0.12, 0.79]). Infants who were delivered by vaginal delivery versus cesarean section had shorter mean lengths of stays (48.78 vs. 79.69 hours) for vaginal and cesarean sections respectively. This also means that many infants go home prior to 48 hours of age with some discharged home as early as 17 hours of age. Calculated in days, the mean LOS in this study was (2.37 ± 0.76 [0.69 – 4.78], $p = 0.005$). LOS was significantly different between infants delivered vaginally versus by cesarean section. Vaginal delivery, $n = 314$ (2.03 ± 0.45, 95% CI [1.99, 2.08]) and cesarean section, $n = 76$ (3.32 ± 0.61, 95% CI [3.18, 3.46], $p < 0.001$).

Although previous studies have shown that a shortened LOS may be safe, it is recommended that discharge readiness should be individualized (Britton, Britton, & Beebe, 1994). When assessing the risks and benefits of early discharge, health care providers need to include the psycho-social needs of the parents (Liu et al., 2000). Early discharge at ≤ 48 hours may not allow adequate time for the mother and family to prepare in areas such as breastfeeding and in assessing the presence of jaundice (Brown et al., 1999; Chen , Wang, Tseng, & Lu, 2005). This study examined LOS in hours. Most studies have collected information on LOS from administrative databases which do not always have the time of discharge noted (Harron, Gilbert, Cromwell, Oddie, & van der Meulan, 2017). In this study, longer length of stay was due to the mode of delivery (cesarean delivery) and the longer LOS required decreased the likelihood of the infant being readmitted within 28 days of birth. This may be due to the longer timeframe available to assess the infant for jaundice and may have resulted in more opportunities for the mother to receive breastfeeding support from the nursing staff and lactation consultants.

2) Combined breast milk and formula feeds (Total amount of formula in the first three days of life). Infants in this study who received combined feeds of breast milk and/or formula in the first three days of life were less likely (OR 0.996, 95% CI [0.996, 0.993] to be readmitted compared to infants who were readmitted. Data were not collected on the reason for receiving formula. It is likely that these were infants of mothers whose milk had not come in by day three, or who were having difficulty breastfeeding. Some mothers either requested or were prescribed formula feeds and/or supplemental feeds after breastfeeding. A total of 186 infants (47.7%) in this study were exclusively breastfed and received no formula at all in the first three days of life (see Table 7). Of the infants who received any formula, the mean volume was 110 mls with a range of 0-692 mls. Sixteen infants received at least 20 mls of formula in the first three days of life. Limited formula use, when indicated in the first three days of life, may be a useful strategy to support breastfeeding and reduce preventable neonatal readmission in infants at risk.

A recent study on early limited formula use for healthy infants with weight loss $\geq 75^{th}$ percentile reported no interference with breast feeding at one month (Flaherman, et al., 2018). Four infants (4.8%) in the control group (exclusively breastfed) were readmitted within the first week of life compared to none of the infants receiving early limited formula feeds (Flaherman et al., 2018).

In the current study although data were abstracted on LATCH scores, the documentation of LATCH scores in the EMR was inconsistent and inadequate for regression analysis. In the first three days of life, mean LATCH score assessment in all infants was 4.12 with a range of 0 - 12. In bivariate analysis the average number of LATCH scores in the first 3 days was significant ($p < 0.001$) with infants who were readmitted having more LATCH scores documented. This may reflect the need for more support with breastfeeding.

A recent prospective comparative study found that term infants who had LATCH scores ≥ 7 received at least 50% of the expected volume for that feed and the rate of exclusive breastfeeding in this group was 51.2%. These findings indicate that more support is needed for mothers of term infants as well (Nilgun, Mesut, Serpil, Cem, & Fatih, 2015).

In the current study there was no difference in the day of the week the infant was discharged or the rates of readmission for public versus private insurers. More consistent documentation is needed to understand the needs of breastfeeding mothers to prevent readmissions. The averages and the sums of the education count and number of LATCH scores were not significant and were dropped in the regression model. Although having a follow up appointment scheduled prior to discharge was significant in bivariate analysis ($p < 0.001$) it did not remain in the final model. More consistent documentation was needed on the discharge summary given to the parents as several discharge summaries had inadequate or incomplete discharge instructions.

Incidence of neonatal readmission. This study also examined the incidence of neonatal readmission to the birth hospital during the study period. The incidence rate (IR) for all term infants born at the study site was 1.69 %. In the cohort of healthy term infants, the IR was 2.22%. Many infants admitted to the normal or well-baby nursery had MS-DRG codes for neonate with other significant problems; or full-term neonate with other major problems. The IR rate in normal newborns is slightly higher than the rates in the literature for the US and bears close monitoring. The reason many newborns admitted to the WBN after delivery did not have normal newborn MS-DRG codes could be that they had other minor diagnoses that did not require Level II or Level III care.

This study cohort included infants who were admitted to the normal nursery and had a MS-DRG code of normal newborn. The risk of readmission in infants born at 37 weeks was 20 times greater than that of the reference group ($40^{0/6}$- $40^{6/7}$ weeks) when adjusted for other variables in the model (jaundice on day two, total formula received in the first three days, maternal GBS treatment, and delivery mode). It was six times greater in infants born at $38^{0/6}$ -$38^{6/7}$ weeks, four times greater in infants born at $39^{0/6}$ -$39^{6/7}$ weeks, and three times greater for infants $41^{0/7}$ - $41^{6/7}$ weeks when compared to the reference group and adjusted for the other variables in the model. A higher rate of readmission in younger infants is consistent with other studies but the likelihood of readmission in the group born at 37 weeks was much larger than the neonatal readmissions seen in other studies. Term infants less than 38 weeks were more than four times more likely to be readmitted in the study by Geiger et al. (2001) and more than nine times more likely to be readmitted in the study by Lain et al. (2015). The reason for the higher OR in this study is not clear (may be due to the smaller sample of 37 week GA infants) but it can be speculated that term infants at lower gestational ages require more breastfeeding support and lactation consults as well as closer monitoring of jaundice especially on day 2 of life.

Most of these infants (93%) were readmitted for jaundice and required phototherapy and breastfeeding support (lactation consults), and formula feeds after readmission. Most of the infants readmitted had several ICD-10 codes at readmission, although the four main categories were jaundice, feeding difficulty and dehydration, hypothermia and respiratory problems. This is consistent with the findings of a study by Metcalfe et al. (2016) where most (49.9%) of the readmissions within 30 days from birth were for jaundice, 8.1% for respiratory causes, 5.2% for feeding issues, 4.0% for sepsis and 3.3% were related to dehydration (Metcalfe et al., 2016). Although some infants in this study were dehydrated and hypernatremic at readmission sodium levels on the infants readmitted in this study were too sparse for analysis.

Strengths and Limitations

There were several notable strengths of this study. The first was the use of Transitions Theory to guide the variables/predictor constructs selected for the conditional logistic regression model. This can also be used to develop further hypotheses to test the theory (Polit & Beck, 2017). Possible hypotheses include examining breastfeeding quality, LATCH score documentation, discharge readiness, and follow up timing with the primary care provider.

With LOS decreasing worldwide, the ability to calculate LOS in hours, was a strength of this study. This differed from some previous studies, where LOS was calculated in days with data from administrative data sets, and/or how many nights were spent in the hospital. The amount of data that were abstracted and analyzed with this study design (to examine associations to neonatal readmission) strengthened the literature on neonatal readmission in healthy term-born infants. Matching *a priori* eliminated some confounding, and the main benefit of using a matched case-control design was the gain in efficiency (less time and cost) and increase in the sample size and power to examine a rare outcome.

Selection or ascertainment bias was possible however, it was minimized by the selection of all cases from within the larger identifiable cohort and a random selection of controls from the same cohort with similar attributes (matched on the infant's birth date [+/- 7 days] and maternal age [< 20, 20 -29, 30 – 39, > 39 years], suggesting a similar chance of being readmitted within 28 days).

A limitation was possible errors in MS-DRG miscoding. EMR data is dependent upon the accuracy of documentation, by many professionals across the hospital stay. The coding is done based on documentation in the chart. Lack of documentation or poor documentation may also lead to miscoding of diagnoses. Another limitation included the wider CI in 37-week GA infants due to fewer infants in the sample of this gestation, which may have resulted in an unstable estimate. Finally, the inability to determine if infants were readmitted to hospitals other than the birth hospital was a limitation of this study. It could account for underestimating the risk of readmission in these infants although it is believed that most readmissions within 28 days are readmitted to the study site hospital.

Conclusion

This nested case-control study conducted in a large level III hospital in the northeastern US identified several factors associated with neonatal readmission. The factors included: 1) maternal GBS treatment, 2) GA 37- 39 weeks, and 3) documented jaundice on day two of life. Factors that were less likely to cause readmission included: delivery mode, and combined breast milk and formula feeds. Factors considered provider and institutional factors *a priori* were not significant in the final conditional logistic regression model. However, treatment for maternal GBS, delivery mode and total amount of formula in the first three days could be considered provider/institutional factors based on policies and procedures. LATCH scores and weight loss at discharge were also not significant. The birth hospitalization average LOS for healthy term infants in this study was 2.28 days or 54.6 hours.

Most readmissions (97%) in healthy term-born infants were within seven days of birth. The main reason for readmission was jaundice and feeding related diagnoses. This is consistent with previous studies conducted on all newborns (Escobar et al., 2005; Danielson et al., 2000). The IR of neonatal readmission for all infants delivered at the study site during the study period was 1.69% and the IR in the cohort for this study was 2.22%. This is slightly higher than the reported rates (< 1 to 1.3%) in the literature for infants in the US over the past decade (De Luca & Carnielli, 2009). There is concern this rate may be trending upward based on recent NPIC data and confirmed by this study. More consistent assessment and documentation of breastfeeding adequacy and monitoring of breastfeeding quality are needed.

Underreporting of race in the medical record can have implications for screening and identifying infants who may be at risk of neonatal readmission for jaundice/hyperbilirubinemia. Screening and identifying infants who may be at risk is important to assure they are ready to be discharged home and to reduce preventable readmissions.

Implications for Nursing Practice

Although information on maternal GBS and GBS prophylaxis is currently completed in most infant's EMR the nursing documentation needs to be more consistent and thorough to identify these infants and follow them more closely. A standardized nursing checklist required to be completed at discharge could be useful to make sure that important findings and assessments are not overlooked. Jaundice was documented only if it was noted during the nursing assessment. The absence of jaundice was not documented. The assumption was that it would be documented if it was present. However, to be sure that assessments for jaundice have been completed it is important that this item be documented daily in the EMR by nurses as either jaundice present or jaundice absent.

As part of nursing therapeutics, nurses may need to be reminded to assess the transition process the mother and family are going through in order to support them and help them achieve a healthy transition with the goal of reducing preventable readmissions. The constructs of Transition Theory, related to neonatal readmission, should be used. There is potential to apply this theory to generate more knowledge in this area. This may help to implement procedures related to education and assessment of newborn feeding, including the documentation of LATCH scores and lactation consults. More nursing documentation is needed to generate more knowledge in this area. Although the current discharge summary indicated that follow up with a primary care provider should be scheduled within a certain time frame, many of the discharge summary sheets did not have an appointment date and time documented. In several cases there was no documentation in the EMR requesting the parents to call the provider for a follow up appointment. In a few cases, it was noted in the medical record and not in the discharge summary and this documentation was inconsistent.

None of the institutional factors were significant in the final model. This may have been due in part to a lack of documentation in the chart on many of the institutional variables. Race was not a predictor of jaundice in this study which is contrary to other studies (Geiger et al. 2001). Asian race was not significant for readmission due to jaundice in this study. This may have also been due to the small number of Asian mothers in the sample and/or inadequate documentation in the EMR. Although there was no significant difference in race as a variable in the regression analysis race was significant ($p = 0.026$) for readmission in bivariate analysis. For this study race was obtained from the birth worksheet. The information in the birth worksheet is self-reported by the parent(s). It was also noted that several parent(s) who reported their ethnicity as Hispanic did not report a race. This is not an unusual finding.

In the literature, as many as 70% of Hispanic mothers define themselves as Hispanic only, with no reference to race (Beal et al., 2006). Mothers of multi race infants are not fully represented when determining the risk of hyperbilirubinemia, and their likelihood of being at risk for hyperbilirubinemia may be underrepresented. Ethnicity was also a risk factor for some conditions such as G6PD where infants of Greek, East Asian and African descent had higher levels of bilirubin than white infants. East Asian and Native American infants also had higher levels of bilirubin than White infants (Melton & Akinbi, 1999).

Implications for Future Research

This study showed how a Transitions Theory can be used to examine and understand the process of neonatal readmission. Transition Theory can be used in future studies of neonatal readmission targeted to focus on specific transition conditions (maternal or infant characteristics), nature of transitions (hospitalization factors, e. g in vaginal deliveries only), nursing therapeutics (breastfeeding education, lactation consults, documentation of LATCH scores) and organization structures (provider and institutional factors such as making sure a follow up appointment is scheduled prior to discharge).

Future studies can be developed to examine the facilitators and barriers to successful transitions for mother-infant dyads to reduce preventable readmissions. This is an important step towards improving quality of care. Barriers and facilitators of breastfeeding include attitudes and beliefs of staff towards breastfeeding and the education of hospital decision makers (Bartick, Stuebe, Shealy, Walker, & Grummer-Strawn, 2009). Breastfeeding quality metrics and cost analyses are also needed to understand the return on investment for reducing preventable readmissions and the development of cost-neutral discharge policies that promote quality and safety.

Future research related to the amount and type of support offered to mothers and the availability of lactation consultants on the WBN floors are needed. Data on the use of formula supplementation to prevent readmission and specific research on provider and institutional factors such as the timing of follow up appointments and compliance with AAP guidelines is also needed to understand institutional factors that may impact neonatal readmission.

Nurses are in a unique position at the frontline of care to evaluate mother-infant dyads prior to discharge home (AAP: Committee on Fetus and the Newborn, 2010). Data should be gathered on nursing sensitive indicators to evaluate structure, process and outcomes related to discharge preparedness and outcomes using the Transition Theory constructs. Many institutional and provider factors related to neonatal readmission have implications for nursing. Multi-site studies would generate more knowledge in this area and would be useful for developing standards for nursing practice.

Implications for Nursing Theory Development

In addition to new empirical nursing knowledge on neonatal readmissions, nurses need to utilize and apply existing nursing knowledge in all nursing domains to achieve healthy outcomes and translate research to practice. Some of the findings of this study corroborate prior findings from other studies and strengthens nursing knowledge. It also raises further questions for the development and testing of Transitions Theory and nursing therapeutics to reduce preventable neonatal readmissions. There are no studies on neonatal readmission in healthy term-born infants using Transitions Theory and theory development can be an important aspect of research on neonatal readmission.

The steps in theory construction involve identifying and defining concepts, assumptions and the context of the theory (McEwen & Wills, 2011). This study has added to knowledge on neonatal readmissions and the context it can be used in the analysis and applicability of the theory to test the factors that can influence neonatal readmission. Future studies can be developed to validate the facilitators and barriers of breast feeding assessments such as LATCH scores and lactation consults as well as other institutional aspects of hospitalization conditions and organizational structure which are some of the constructs of Transitions Theory. The role of nursing therapeutics and nursing documentation of breastfeeding and jaundice education may be useful to determine if the rate of preventable neonatal readmissions can be reduced. Congruency of the theory's goals can be established in this way (McEwen & Wills, 2011). In this stage, the researcher can validate if Transitions Theory's goals are congruent with nursing practice in term healthy neonates.

Implications for Health Policy

Many health policies and guidelines at discharge are based on prior research. These include screening for jaundice and the risk factors for jaundice prior to discharge and following up on high risk infants after discharge. However, screening is not mandatory, and the criteria used by hospitals and providers may vary. This study has shown that assessment of the absence or presence of jaundice documentation prior to discharge is an important risk factor for readmission and is essential to document in the EMR on every infant prior to discharge. It has also shown that infants treated for maternal GBS are at an increased risk of being readmitted.

An increase of millennials in the workforce has led to the loss of experienced nurses and has resulted in a nursing experience gap. The loss of knowledge previously held by experienced nurses may compromise safe quality care (Werrlein, 2018). Therefore, identifying infants at risk may require more standardized assessments, checklists and better documentation by nurses. Nursing leaders need to encourage experienced and new nurses to work together to transfer knowledge to the next generation of nurses (Werrlein, 2018).

This study highlights the need for a state-wide data base of neonatal readmissions to all hospitals (not just the birth hospital) to assess the scope of the problem. Collaboration is needed from all in-State hospitals with a delivery service and the Department of Health. For hospital systems, value (quality divided by cost) is an important consideration. Public reporting of neonatal readmissions or report cards may help to monitor quality and safety. It will focus needed attention on reducing neonatal readmission through research on cost-neutral strategies, discharge documentation and patient satisfaction scores.

APPENDIX A

Publications by Meleis Using Transitions Theory

- Chick, N., & Meleis, A.I. Transitions: A nursing concern. In P.L. Chinn (Ed.). (1986). Nursing research methodology. (pp. 237-257). Boulder, CO: Aspen Publication.
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- Meleis, A.I. (1987). Role transition and health. Kango Kenkyo: The Japanese Journal of Nursing Research, 20(1), 81, 69-89.
- Meleis, A.I. (1995). On transitions and knowledge development. Nursing Beyond Art and Science: Annotated Edition. Japan Academy of Nursing Science. 10 (2)
- Meleis, A.I. (1997). Immigrant transitions and health care: An action plan. Nursing Outlook, 45(1), p. 42.

- Meleis, A.I. (2010). Transitions Theory: Middle Range and Situation Specific Theories in Research and Practice. New York, NY: Springer Publishing Company.
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- Meleis, A.I. (2015). Transitions Theory. In Smith, M.; Parker, M., Nursing Theories and Nursing Practice (4th Ed). Philadelphia, PA: FA Davis Co.
- Meleis, A.I. (2017). Theoretical nursing: Development and Progress (6th Ed.). Philadelphia: Lippincott Wolters, Kluwer.
- Meleis, A.I., & Im, E.O. From fragmentation to integration: Situation specific theories. In N.L. Chaska (Ed.). (2000). The Nursing Profession: Tomorrow and Beyond, (pp. 881-891). Thousand Oaks, CA: Sage Publications.
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- Meleis, A.I., & Schumacher, K.L. Transitions and health. In J.J. Fitzpatrick and Meredith Wallace Kazer (Ed.). (2011). Encyclopedia of Nursing Research (3rd Ed.). New Jersey: Springer Publishing.
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- Meleis, A.I., Sawyer L., Im, E., Schumacher, K., & Messias, D. (2000). Experiencing transitions: An emerging middle range theory. Advances in Nursing Science, 23(1), 12-28.
- Schumacher, K. L., Jones, P. S., & Meleis, A. I. (1999). Helping elderly persons in transition: A framework for research and practice. In E. A. Swanson & T. Tripp-Reimer (Eds.), Life transitions in the older adult: Issues for nurses and other health professionals (pp. 1- 26). New York: Springer.
- Schumacher, K., & Meleis, A.I. (1994). Transitions: A Central concept in nursing. Image: Journal of Nursing Scholarship, 26(2), 119-127.
- Schumacher, K.L., Jones, P.S., & Meleis, A.I. Helping elderly persons in transition: A framework for research and practice. In L. Swanson & T. Tripp Reimer (Eds.). (1999). Advances in Gerontological Nursing: Life transitions in the older adult, (vol 3), (pp. 1-26). New York: Springer Publishing.
- Shih, F.J., Meleis, A.I., Yu, P.J., Hu, W.Y., Lou, M.F., & Huang, G.S. (1998). Taiwanese patients' concerns and coping strategies: Transition to cardiac surgery. Heart and Lung, 27(2), 82-98.

(Meleis, 2018a)

APPENDIX B

Recent Publications Using Meleis Transitions Theory

- American Academy of Pediatrics & American Academy of Family Physicians. (2011). Supporting the health care transition from adolescence to adulthood in the medical home.
- Baird, M. B. (2012). Well-being in refugee women experiencing cultural transition. ANS. Advances in Nursing Science, 35(3), 249–263.
- Baird, M.B. and Reed, P.G. (2015). Liminality in cultural transition: Applying ID-EA to advance a concept into theory-based practice. Research and Theory for Nursing Practice: An International Journal, 29(1), 25–37.
- Betz, C. L., Smith, K. A., Van Speybroeck, A., Hernandez, F. V., & Jacobs, R. A. (2016). Movin'On Up: An Innovative Nurse-Led Interdisciplinary Health Care Transition Program. Journal of Pediatric Health Care, 30(4), 323-338.
- Bohner, K. (2016). Theory Description, Critical Reflection, and Theory Evaluation of the Transitions Theory of Meleis et al according to Chinn and Kramer (2011). Advances in Nursing Science, 0(0), 1-19.
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- Djukanović, I., & Peterson, U. (2016). Experiences of the transition into retirement: An interview study. Nordic Journal of Nursing Research, 36(4), 224-232.

- Fegran, L., Hall, E. O., Uhrenfeldt, L., Aagaard, H., & Ludvigsen, M. S. (2014). Adolescents' and young adults' transition experiences when transferring from pediatric to adult care: a qualitative metasynthesis. International Journal of Nursing Studies, 51(1), 123-135.
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- Geary, C. R., & Schumacher, K. L. (2012). Care transitions: Integrating transition theory and complexity science concepts. Advances in Nursing Science, 35(3), 236-248.
- Im, E. O. (2011). Transitions theory: A trajectory of theoretical development in nursing. Nursing Outlook, 59(5), 278-285.
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- Long, J., Briggs, M., Long, A., & Astin, F. (2016). Starting where I am: a grounded theory exploration of mindfulness as a facilitator of transition in living with a long-term condition. Journal of Advanced Nursing, 72(10), 2445-2456.
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- Malley, A., Kenner, C., Kim, T., & Blakeney, B. (2015). The Role of the Nurse and the Preoperative Assessment in Patient Transitions. AORN Journal, 102(2), 181-e1.
- Maten-Speksnijder, A. T., Pool, A., Grypdonck, M., Meurs, P., & Staa, A. (2015). Driven by Ambitions: The Nurse Practitioner's Role Transition in Dutch Hospital Care. Journal of Nursing Scholarship, 47(6), 544-554.
- Mi, Y. U. (2016). Development of a Transition Process Scale for High-risk Infant's Caregiver. Iranian Journal of Public Health, 45(2), 158.
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- Müller, C., Puls, J., Lautenschläger, S., Stephan, A., & Meyer, G. (2016). Interventions to support people with dementia and their informal caregivers during the transition from home care to nursing home care–a protocol for a systematic review. International Journal of Health Professions, 3(2), 122-135.
- Ramsay, P., Huby, G., Thompson, A., & Walsh, T. (2014). Intensive care survivors' experiences of ward-based care: Meleis' theory of nursing transitions and role development among critical care outreach services. Journal of Clinical Nursing, 23(5-6), 605-615.
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