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Contributing Factors to Diaper Dermatitis in the NICU

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CONTRIBUTING FACTORS TO DIAPER DERMATITIS IN THE NICU

by

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ABSTRACT

CONTRIBUTING FACTORS TO DIAPER DERMATITIS IN THE NICU

by

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Purpose: Describe the prevalence of diaper dermatitis (DD) and clinical characteristics of the infants in the Neonatal Intensive Care Unit (NICU) that develop DD. Explore the relationships between clinical characteristics and the development of DD.

Design: Retrospective, exploratory, descriptive study

Setting: Level IV NICU in an urban community in Southeast Wisconsin**.**

Participants: A convenience sample of 611 infants who were born and admitted to the NICU within 12 hours of life and discharged from the same NICU. A final total of 537 infants remained after exclusion criteria were met.

Methods: Data were collected from the participant's electronic health records from birth until the infant was discharged to home.

Results: The prevalence of DD among the 537 infants was 34% (n = 180). A logistic regression demonstrated length of stay was significant, (B = 0.02, OR = 1.02, p = .002), indicating the odds of developing DD increased by ~2% for each additional day in the NICU. Days from birth to full feedings was also significant (B = -0.03, OR = 0.97, p = .023), indicating the odds of developing DD decreased by ~3% for each additional day to full feedings.

Conclusions: Increased preventative measures among preterm infants at risk for an extended length of stay can potentially decrease the prevalence of DD.

DEDICATION

To my husband, Eric, who has been my cheerleader, hand holder, and the most supportive person during this long journey. Thank you for your patience, love, and encouragement that led me to completing this long journey despite the challenges.

To my children, Trinity and Ethan, thank you for your understanding and love during this journey that must have seemed never-ending. I hope I have provided you the motivation to follow your dreams and achieve your goals.

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Chapter I: Introduction

Chapter Introduction

The purpose of this chapter is to provide the introduction and basis for the dissertation. The Skin Safety Model (SSM) is introduced as the theoretical model in the format of a manuscript. The focus of the manuscript in this chapter is to provide a platform for application of the SSM as a framework for the examination of DD among infants in the neonatal intensive care unit (NICU).

Background

Infants are a population that commonly experiences diaper dermatitis (DD). The preterm infant, born before 38 weeks gestation, with DD is not widely recognized in the literature. The hospitalized infant is described in the literature, but the neonatal intensive care unit (NICU) is often combined with other patient units or omitted completely (Murray, Noonan, Quigley, & Curley, 2013; Noonan, Quigley, & Curley, 2006). The NICU provides various levels of care, from subacute to critical, and provides access to multiple specialties (Anderson-Berry, 2014; Kaplan, Lannon, Walsh, Donovan, & Ohio Perinatal Quality Collaborative, 2011; Lake et al., 2015). The complexity of care these infants require can vary among infants in the NICU (American Academy of Pediatrics, 2012; Payne, Carpenter, Badger, Horbar, & Rogowski, 2004). This factor alone can set the infant up for multiple complications.

The infant in the NICU is unique from the infant at home due to the complex nature of the hospital environment. The hospital environment provides a variety of stimuli that include: daily cares, sounds from alarms, invasive procedures, and non-invasive procedure (Esser et al., 2018). The hospitalized infant can be preterm requiring specialized care to provide a developmentally supportive environment or term gestation requiring a variety of specialized care

that higher levels of NICU care provide. The characteristics of higher level NICU hospital settings, such as levels III and IV, are not clearly defined or described in the DD literature.

Infant skin is not fully functional at birth and matures over the following weeks to reach similar function to adult skin (Visscher & Narendran, 2014; Visscher et al., 2014). The preterm infant has immature skin function and physiology when born and requires a humid environment initially to assist in regulating transepidermal water loss (Ågren, Sjörs, & Sedin, 2006; Fluhr et al., 2010). Infants <32 weeks are typically placed in a humid isolette on admission until skin has matured and temperature stability is achieved when approximately 1600 grams (Ågren et al., 2006). The dryer environment after birth is required to facilitate skin maturation and keratinization; this is postponed in the preterm infant to ensure water balance is maintained until the skin has matured after birth (Hoeger & Enzmann, 2002).

Diaper dermatitis is an inflammatory skin injury that involves the skin of the groin, buttocks, and perianal regions (Coughlin, Eichenfield, & Frieden, 2014; Gaunder & Plummer, 1987; Ward, Fleischer, Feldman, & Krowchuk, 2000). Diapers create an overhydrated environment that creates the initial risk factor for developing breakdown (Visscher, Chatterjee, Munson, Pickens, & Hoath, 2000). The presence of stool and its interaction with urine and moisture changes the pH of the skin that leads to susceptibility to injury (Gaunder & Plummer, 1987). The friction from the diaper and wiping creates additional injury creating redness and breakdown. This cycle continues to cascade into worsening injury that results in pain, infection, and discoloration (Coughlin et al., 2014; Esser et al., 2018). This painful process has not been fully examined in the preterm infant hospitalized in the NICU.

Nutrition is an important aspect of the care provided the infant in the NICU. Hospitalized infants in the NICU are not provided the same nutrition as infants at home when first admitted to

the hospital (Anderson-Berry, 2014; Tudehope, 2013). Most infants do not receive enteral nutrition within the first days in the NICU which is different from infants born without complications (Tudehope, 2013). Infants in the NICU generally do not reach full enteral nutrition until a week or more after admission with few exceptions. Optimal nutrition for these infants is a priority and many infants receive parenteral nutrition intravenously until they reach full enteral nutrition. Infants do not stool regularly until they are consistently receiving enteral nutrition. The infants in the NICU require fortified human milk or higher calorie formula to promote optimal growth (Tudehope, 2013). There is a gap in the literature related to the impact higher calorie nutrition has on diapered skin, stool composition, and stooling patterns.

The NICU population is not homogenous with exposure to a variety of unique experiences that can potentially impact the vulnerability of skin in the diaper area (August, New, Ray, & Kandasamy, 2017; Grosvenor et al., 2016; Meszes et al., 2017). The clinical characteristics of the NICU population have a potential to influence the development of DD when examined for frequency and prominence. Skin vulnerability of the diaper area continues to be a gap worth examining among preterm and term infants alike.

Problem Statement

A large proportion of research and literature related to DD is focused on the term nonhospitalized infant. Infants in the NICU are vaguely recognized in regard to DD incidence with results describing assessment, prevention, and treatment without identification or correlation with clinical characteristics of the infant to DD. The commonality of DD in the typical infant community within the home setting creates an elevated concern for the hospitalized infant. The prominence of DD among hospitalized infants creates the basis for further examination of the unique circumstances of the most fragile infants. The NICU creates a unique

hospital environment to examine the prevalence of DD due to the variety of gestational ages and clinical needs. It is unclear if clinical characteristics specific to the infant in the NICU have an impact on the development of DD. There is a lack of evidence to support specialized preventative measures for preterm infants and term infants hospitalized in the NICU. The identification of clinical characteristics and the possibility of association to the development of DD is lacking in NICU research.

Target Population and Rationale

The target population for the proposed study will be all infants admitted to a level IV NICU in a metropolitan children's teaching hospital in southeast Wisconsin. The NICU is a 70-bed unit with private rooms that provides the highest level of care for the most critical of infants and offers trauma care and extracorporeal membrane oxygenation treatment (ECMO). The average number of infants admitted to this NICU yearly is about 750 including inborn and outborn. The NICU is connected to an adult teaching hospital's mother-baby and birthing unit which allow for direct admissions of infants. The population of infants cared for in the NICU range from extremely premature infants to infants requiring intensive care and close management by multiple specialty services.

Purpose Statement

The purpose of the study is to describe the prevalence of DD in the NICU and identify the clinical characteristics of infants with DD.

Research Questions

RQ #1: What is the prevalence of DD among infants hospitalized in a level IV NICU?

RQ #2: What are the characteristics of the infants, stratified by gestational age, that develop DD?

RQ #3: What are the relationships between clinical characteristics and the occurrence of DD?

Secondary Research Question

Describe the frequency of the following clinical characteristics: gestational age, nutrition, time from birth to full feedings, antibiotic exposure, mode of delivery, length of stay, and respiratory support observed among infants with DD in the NICU?

Conceptual Framework

The theoretical basis for the current study is described in the following manuscript. The manuscript presents the evidence to support the adaptation of the Skin Safety Model (SSM) to the NICU population. An adaptation of the SSM is presented based on a literature review of clinical characteristics extracted from studies focused on DD among infants ≤2 years of age. The adapted SSM will provide the framework to guide the methodology for the development of the study presented in this dissertation.

Manuscript 1: Infant Diaper Dermatitis in the NICU: An Adaptation of the Skin Safety Model

Abstract

Background: Diaper dermatitis (DD) is one of the ever present and common skin injuries among infants. Little is known about the prevalence of DD in the Neonatal Intensive Care Unit (NICU). The infant of the NICU is subject to numerous environmental stimuli, procedures, and stressors. It is unclear if there is an interconnection between factors of the NICU hospitalization and unique characteristics of the infant in the NICU. The skin of the infant <1 month of age post conceptual age has an inadequate immune system and skin barrier. Additional environmental factors in the NICU are not currently recognized in skin related frameworks or assessment tools.

Purpose: The aim of this paper is to adapt the Skin Safety Model (SSM) for the infant in the NICU to provide the theoretical underpinnings to explore factors that contribute to DD.

Conceptual Framework: The SSM was created for use in the adult intensive care population to describe the interconnection of antecedents that contribute to the development of skin vulnerability. The similarities between the antecedents and exacerbating elements within the original SSM and the NICU hospitalization support the ability to adapt the SSM for the infant in the NICU.

Method: The concepts of the SSM were adapted based on evidence synthesized from a review of DD literature. The review focused on clinical characteristics among infants <24 months with DD or undergoing treatment for DD. The characteristics were extracted, defined, and integrated into an adapted SSM model to provide a focus on the infant in the NICU.

Results: The adapted SSM for DD in the NICU provides concepts unique to the infant in the NICU. The adapted model demonstrates the interplay of clinical characteristics of the infant in the NICU and exacerbating elements that contribute to the development of DD.

Conclusion: It is likely that the NICU environment itself plays a major role in mediating and/or moderating risk factors associated with DD. It is imperative for researchers and/or clinicians to include all factors of the NICU experience in the modeling to accurately predict risk of skin vulnerability in this infant population.

Keywords: Skin Safety Model, Neonatal, Infant, NICU, Diaper Dermatitis

Background

Diaper dermatitis (DD) is a large-scale problem among healthy infants nationally and globally (Shin, 2014; Thaman & Eichenfield, 2014). Diaper dermatitis is also identified as "diaper rash", "irritant dermatitis", and "incontinence associated dermatitis" in the literature. The healthy newborn in the home setting develops diaper dermatitis within the first week of life and intermittently until no longer wearing diapers (Adalat, Wall, & Goodyear, 2007; Ersoy-Evans et al., 2016). Infants in the hospital also experience diaper dermatitis, but there remains a gap in the literature to demonstrate specific details leading up to its development including specific correlations with the hospitalization. Diaper dermatitis among infants in the Neonatal Intensive Care Unit (NICU) is a preventable skin injury, but remains a concern of parents and clinicians alike, with prevalence rates above 20% (Csoma et al., 2016; Esser, 2016; Heimall, Storey, Stellar, & Davis, 2012; Lund et al., 2001; Migoto, Souza, & Rossetto, 2013; Pasek et al., 2008).

Diaper Dermatitis

Diaper dermatitis is among the many skin injuries that hospitalized infants experience (Heimall, et al., 2012; Nist et al., 2016; Noonan et al., 2006). Diaper dermatitis can be painful and stressful for infants especially those with additional comorbidities and conditions who require intensive care (Stamatas & Tierney, 2014). The factors that contribute to the development of DD are inconsistently reported in the literature and lack a connection with the complex nature of infants in the NICU. Skin assessment tools for DD are not used consistently in the NICU and the tools that are used are not specific to DD (Buckley, Mantaring, Dofitas, Lapitan, & Monteagudo, 2016; Karakoc et al., 2017; Vance, Demel, Kirksey, Moynihan, & Hollis, 2015; Willock, Baharestani, & Anthony, 2009). A gap in the literature exists in the examination of the relationship between the infants' clinical characteristics and development of

DD. The aim of this paper is to adapt the Skin Safety Model (SSM) for the hospitalized infant in the NICU to provide a stronger basis for further exploration of DD among this population.

Diaper Dermatitis Model

Although DD is prevalent among infants, there is a lack of DD specific models or frameworks to guide scientific inquiry. Gaunder and Plummer (1987) introduced the only published conceptual model to describe development of DD among infants. The conceptual model identifies two main factors that contribute to DD; 1) wetness and 2) fecal enzymes. The interaction of these factors impacts the pH of healthy skin and in turn perpetuates a susceptibility to injury (Gaunder, & Plummer, 1987). The Gaunder and Plummer (1987) model created the basis for understanding the impact of DD on infant skin. The physiologic basis in this model could strengthen the understanding of the development of DD if paired with a model with theoretical concepts that include clinical characteristics of the infant. The marriage of a theoretical model, such as the Skin Safety Model (SSM), and the Gaunder & Plummer model of DD physiology can provide a basis for further study of those infants at highest risk.

Skin Safety Model (SSM)

The SSM describes the potential factors associated with skin vulnerability and their interconnection with the patient's unique experience during hospitalization. The SSM model was first reported by Campbell, et al. (2016), and provides a connection between skin injury, antecedents of care, and skin vulnerability using four constructs. The four constructs of the model relate to the aging adult in the hospital and include: 1) potential contributing factors; 2) exacerbating elements; 3) potential skin injury; and 4) the potential outcomes of skin injury (see Figure 1). The following sections will describe how the constructs of the SSM have been adapted

to the infant of the NICU with infant clinical characteristics and identified in a review of the literature.

Methods

A literature review was performed to identify the clinical characteristics for infants with DD and are hospitalized in the NICU. The following electronic databases were searched: PubMed and Web of Science between 1990 and 2018 to capture information after disposable diapers were widely used. The final search included the following keywords: diaper dermatitis, diaper rash, infant, and neonate. After an initial search failed to return results the prior keywords were combined with additional keywords that include: framework, conceptual model, and tool. The search was limited by language and types of publication to exclude medication trials, discussion papers, and review articles. The resulting articles were evaluated for incorporation of skin assessment or evaluation using physiologic measurements and/or visual tools that included infants/children less than two years of age in the hospital or home setting. The levels of evidence for each article were evaluated using the Melnyk & Fineout-Overholt (2010) guidelines (Melnyk, & Fineout-Overholt, 2010). Additionally, reference lists of chosen articles were also reviewed for further relevant studies between 1990-2018.

Results and Synthesis of Findings

A total of 454 studies (PubMed 282 and Web of Science 172) were retrieved for this literature review. Once the results were reviewed for duplicates and relevance to the purpose, 27 articles remained. The remaining articles focused on infant skin assessment and the type of treatments used for diaper dermatitis. The studies demonstrated consistent descriptions of infants and provided information related to gender, age, and weight. These descriptors were the most consistent characteristics among all the studies.

Additionally, the studies were reviewed for common, yet specific clinical characteristics for infants that develop DD. Clinical characteristics significant to DD and consistently presented among the studies include: type of feeds, stool frequency, history of DD, antibiotic exposure, delivery mode, and phototherapy. Once the clinical characteristics specific to infants with DD were identified, it became evident that these need to be organized within a framework. Taking the clinical characteristics and organizing them within a framework specific to DD will help researchers and clinicians develop improved prevention methods.

SSM Adaptation for Diaper Dermatitis in the NICU

The SSM was chosen to adapt to the infant in the NICU due to the challenges identified in the management of infant skin injuries, specifically DD. Skin safety for the infant of the NICU can be complicated and involves shifting of complexities within their experience in the hospital. The SSM includes the system and environmental factors that contribute to risk of skin injury (Campbell et al., 2016). The dynamic nature of the SSM provides a framework to integrate clinical characteristics that should be considered in providing the safest care for infant skin. Clinical characteristics abstracted from the literature review are provided below in the context of how they relate to the infant in the NICU for incorporation into a skin specific model (See Table 1). Each of these concepts are susceptible to changes and interaction that can contribute to skin vulnerability and the potential for skin injury (Campbell et al., 2016).

Potential Contributing Factors

The initial construct of "Potential Contributing Factors" consists of three concepts derived from the patient's hospital experience (Campbell et al., 2016). The concepts include: patient factors, stressors, and system factors. In the NICU these concepts may overlap and be interchangeable to describe infant care leading up to, during, and after delivery. Clinical

characteristics extracted from the literature review will be organized to form the construct of "Potential NICU Contributing Factors" and reflect the dynamic NICU environment's inclusion of all three concepts (See Table 1).

Skin physiology and gestational age considerations. The population of the NICU is unique and varies in age and complexity. It is important to understand how the skin of the infant in the NICU is different from the healthy newborn at home. Full term infants have functionally mature skin at birth which continues to evolve over the following weeks (Minami-Hori et al., 2014). During the month following birth, skin continues to mature, the surface hydration of the skin increases, and transepidermal water loss (TEWL) decreases (Visscher et al., 2000). However, preterm infants have less effective skin function due to immaturity and fewer layers of the stratum corneum at birth in contrast to term infants (Visscher, Adam, Brink, & Odio, 2015). Gestational age is a more reliable way to determine skin maturity rather than weight or size of the infant.

Additionally, preterm infants are also housed in high levels of humidity during the first week of life depending on gestational age at birth. Most preterm infants continue in ambient humidity until approximately 32 weeks gestational age and/or a weight of 1600 grams (Brandon, et al., 2018). The presence of humidity has not been studied in relation to the development of DD, but depending on when preterm infants develop DD it may be interesting to study how and if initial high levels of humidity impact DD development.

Microbiome. The microbiome of the skin also plays a major role in the infant's skin function. The vaginal vs. cesarean section birth the infant experiences, impacts the colonization or microbiome of the infants' skin (Dunlop et al., 2015; Rutayisire et al., 2016). Thus, the infants' skin bacteria are based on the type of birth they experienced, and is differentiated after

one-month age which continues throughout the first year of life (Capone et al., 2011). Although several researchers include mode of delivery when describing the patient population within DD studies, none report a relationship to the development of DD (Garcia Bartels et al., 2014; Yonezawa, Haruna, Matsuzaki, Shiraishi, & Kojima, 2018; Yonezawa, Haruna, Shiraishi, Matsuzaki, & Sanada, 2014). Further studies are needed to determine if and how the microbiome impacts the development of DD.

Infection and antibiotic exposure. The skin serves as a protective layer for the infant, but with fewer layers present. The decreased number of skin layers places the infant at increased risk for infection because of the risk of pathogenic invasion (Kalia, Nonato, Lund, & Guy, 1998). Infants in the NICU are at high risk for infection due to the immature nature of their immune system, skin integrity, and clinical condition. Infection can contribute to or be an outcome of severe skin injury. The infant in the NICU is at increased risk for infection because of numerous invasive procedures and iatrogenic skin injuries. The high risk for infection among these patients results in high rates of antibiotic administration. Antibiotic exposure has the potential to disrupt the innate immunity of the skin. Researchers have reported that oral antibiotics are thought to increase rates of DD among term infants, but lack definition of association with intravenous antibiotics (Adalat et al., 2007; Bağlam et al., 2015; Honig, Gribetz, Leyden, McGinley, & Burke, 1988).

Nutrition. Human milk diets are preferred for infants in the NICU and are often fortified with formula and other nutritional additives to optimize growth and nutrition (American Academy of Pediatrics, 1998; Vohr et al., 2006). Researchers have reported that DD rates are lower among infants that receive human milk, without mention of fortification (Alonso et al., 2013; Ersoy-Evans et al., 2016; Li, Zhu, & Dai, 2012). Fortification of human milk has been

loosely correlated with the development of DD, but sample sizes and additional factors of the infant need to be examined further to decipher the true relationship (Thoene et al., 2014). Nutrition in the NICU is often variable and difficult to describe in relationship to DD. The type of feeds provided in studies lack detailed descriptions of: nutritional content of human milk, formula, fortification, and portion of parental nutrition (Alonso et al., 2013). Nutrition is an important component of infant health, but a gap remains in the relationship of time to full feeds, nutritional content, and type of feeds associated with risk for DD development in the NICU (Alonso et al., 2013; Li et al., 2012; Liu, Wang, & Odio, 2011; Visscher, 2009; Visscher, Chatterjee, Munson, Bare, & Hoath, 2000).

Complexity of care and stressors. Stress is a major element of the NICU hospitalization. The events leading up to birth, the birth, and the environment of the NICU all contribute to the level of stress the infant experiences (Mirabzadeh et al., 2013). Socioeconomic status and family issues also contribute to the stress experienced by infants in the NICU (Cong et al., 2017). Additionally, complications during delivery such as preterm labor, premature rupture of membranes, intrapartum procedures, and maternal disorders also impact the level of stress the infant experiences before birth (André et al., 2018; Mirabzadeh et al., 2013).

The published studies on DD also demonstrate that infants in the NICU experience stress as a result of complexity of care, exacerbation of illness, length of stay, infection, previous episodes of DD, and additional family issues (Cong et al., 2017). Other stresses for the infant in NICU include type of assessment tools and product used in the care of infants. It is important for researchers and clinicians to understand the influence of the various stressors on the infant's skin integrity, and ultimately infant health impact the infant's risk to develop DD, and respond to treatment of DD.

When nurses care for infants at increased risk of preventing and treating DD, an abundance of nursing care may be required depending on the severity and extent of the injury. Nurse staffing, competency, and acuity of patients are all of factors that can impact the outcomes of skin integrity among infants in the NICU (Rogowski et al., 2015; Spence et al., 2006; Tucker, 2002). Thus, it will be important to incorporate system factors such as nurse staffing, competency, and acuity into the clinical characteristics of infants hospitalized in the NICU to create a fuller base to examine how DD develops, and can be prevented and treated.

Exacerbating Elements

The second construct, "exacerbating elements", describes additional elements of the hospital environment that impact the patient along the continuum of the care. This construct consists of three concepts: pressure/shear, skin irritants, and friction. These concepts are well described in the literature as contributory factors for skin vulnerability and injury among infants (Berg, 1988; Minami-Hori et al., 2014; Visscher, 2009).

The concepts within this construct will be evaluated for proper fit with the development of DD among infants of the NICU for the adaptation of the SSM. The first concept, pressure/shear, is not supported in the literature as an exacerbating element to DD in the NICU population. Although the concept of pressure/shear may be an exacerbating element for the development of skin injury it is not specific to DD in the NICU population and is eliminated.

Skin irritants, the second concept, can be described in DD literature as components of the environment known to impact skin integrity by producing an inflammatory reaction of the skin. These irritants include: stool content and frequency, urine, and easily absorbed chemicals that come in contact with the skin (Anderson, Bucher, Saeed, Lee, Davis, & Maibach, 1994; Berg, Milligan, & Sarbaugh, 1994). The Gaunder and Plummer (1987) conceptual model for DD injury

described two main factors that contribute to DD; 1) wetness and 2) fecal enzymes (Gaunder & Plummer, 1987). The interaction of wetness and fecal enzymes contribute to the development of DD and increase the susceptibility of injury in healthy diapered infant skin (Gaunder & Plummer, 1987). The literature review supports the inclusion of stool as an essential concept due to the consistency of importance surrounding the number of stools in relationship to DD development in a majority of the studies (Anderson et al., 1994; Berg et al., 1994). The interaction would not occur without the introduction of urine (wetness) and stool (contains fecal enzymes) therefore stool should be added as a concept in the adaptation of the exacerbating element construct.

Friction, the third concept, is defined as the action of two objects rubbing together (Atherton, 2001). This is described in DD studies as the function of diaper wear and the activity of wiping to remove urine or stool from the skin (August, New, Ray, & Kandasamy, 2017; Visscher et al., 2015). It is important to recognize the impact of commercial wipes in addition to the action of wiping as they demonstrate two exacerbating risks: potential skin irritant and friction.

Potential Skin Injury – Diaper Dermatitis

The SSM was designed to describe the construct of "potential skin injury" as a global descriptor for all iatrogenic skin injuries among the adult intensive care population. The "potential skin injury", as described here, is adapted to focus on the development or risk for development of DD specific to the infant in the NICU. The skin in the diaper area of the infant is complicated by the process of maturation and the potential skin injury is presented as the result of the process described in the Gaunder and Plummer (1987) model (Gaunder & Plummer, 1987). Infant skin begins to mature when exposed to a dryer environment than the womb. The

infants born prematurely require additional humidity to combat rapid water loss due to the immaturity of skin protection. Additionally, the infant skin struggles to mature in the diaper area due to the overhydrated environment and additional changes in the skin as a result of exposure to urine and stool (Gaunder & Plummer, 1987; Yonezawa et al., 2014). The combination of variable skin function, stool exposure, friction, the overhydrated diaper environment, and the incorporation of various contributing factors from the initial construct increase the NICU infant's susceptibility to DD development (Gaunder & Plummer, 1987; Visscher et al., 2000; Yonezawa et al., 2014).

Potential Outcomes

Potential outcomes of DD include pain and reoccurrence of DD among infants in the NICU. Pain is an obvious result of a skin injury, but is often underrecognized and undertreated in these infants. Untreated pain can increase length of stay, add to costs associated with extended length of stay, contribute to compromised clinical status, and lead to abnormal developmental functioning (Esser et al., 2018; Hornik et al., 2012).

The reoccurrence of DD is a clinical characteristic that is a common descriptor within DD studies among infants. Reoccurrence can be a result of poor assessment, inadequate prevention and treatment, and under recognition of factors that can promote prevention. Candida colonization and infection also play a role in the reoccurrence of DD (Atherton, 2001). Reoccurrence also leads to increased exposure to pain which can be prevented if proper prevention measures are developed.

Conclusion

It is likely that the NICU environment itself plays a major role in mediating and/or moderating risk factors associated with DD. To accurately predict skin vulnerability in the infant in the NICU, researchers and/or clinicians must include all factors of the NICU experience in the modeling to predict risk. The identification of these factors will also contribute to the development of assessment tools that will further define the severity of DD to enable improvements in clinical management. The SSM when used as a framework for NICU patients can influence care, cost, and outcomes associated with the skin health of NICU patients.

Assumptions

Assumptions for this study were that the clinical characteristics of the infants in the NICU describe the unique environment of the NICU hospitalization. Additionally, it is assumed that clinical characteristics will have a relationship to DD.

Dissertation Structure

This dissertation is comprised of an introduction and three manuscripts (chapters 1, 2, 4) and a chapter synthesizing the manuscripts and results of the current study (chapter 5).

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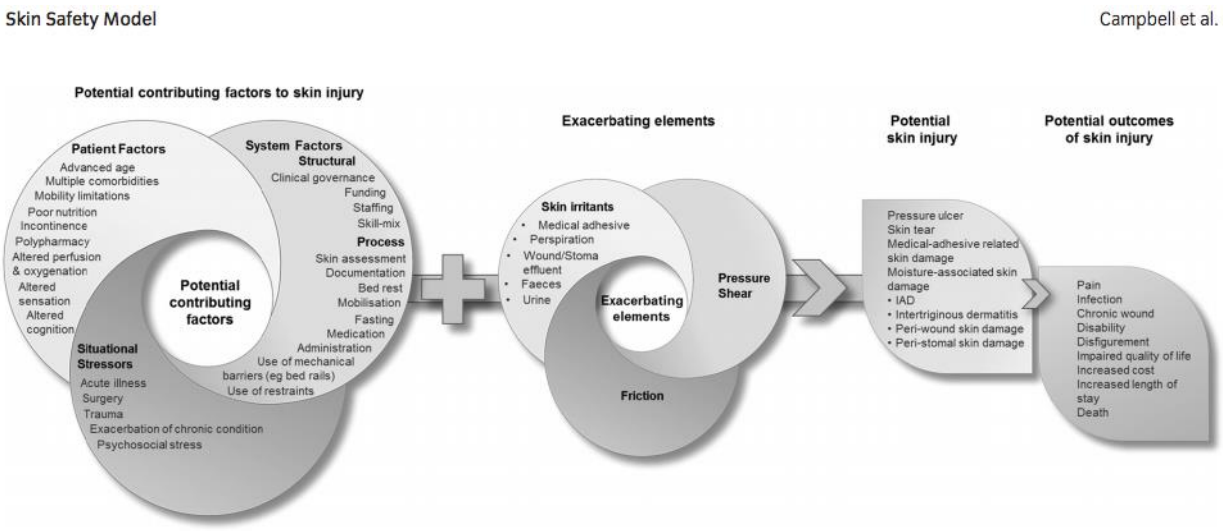

Figure 1. Skin Safety Model for Adult Patients of the Intensive Care Unit

Table 1. Adaptation of the Skin Safety Model Using NICU Clinical Characteristics

Potential NICU Contributing Factors	**SSM Contributing Factors**		
	Patient Factors	System Factors	Stressors
Skin Physiology and Gestational Age	x		
Microbiome	x		
Infection	x	x	x
Nutrition	x		x
Complexity of Care		x	x
Additional Skin Injuries		x	x
Exacerbating Elements of the NICU	**SSM Exacerbating Elements**		
	Pressure/Shear	Irritants	Friction
Urine		x	
Nutrition (type of feeds)		x	
Fecal Enzymes (stooling frequency)		x	
Chemicals Contained in Skin Products			
Diaper Wearing			x
Wiping During Diaper Change			x
Potential Skin Injury	**Potential Skin Injury**		
Diaper Dermatitis			
Outcomes in NICU	**Potential Outcomes**		
Pain			
Reoccurrence of Diaper Dermatitis			

**x indicates a relationship to SSM concepts

Chapter II: Literature Review

Chapter Introduction

This chapter will present the literature review that creates the basis for the study and adaptation of the Skin Safety Model in the previous chapter. The literature addresses the gap in the identification of clinical characteristics related to hospitalized infants especially those in the NICU. The review provides an examination of the literature related to infants <2 years of age to provide the rationale for the variables chosen for the methodology of the study. The manuscript has been formatted to the specifications of the Advances in Neonatal Care Journal and accepted for publication in August 2019.

Manuscript 2: An Integrative Review of Clinical Characteristics of Infants with Diaper Dermatitis

Abstract

Background: Diaper dermatitis (DD) severity is demonstrated by the degree of erythema and skin breakdown. Many studies describe diaper dermatitis, but lack a full description of clinical characteristic (CC) involvement.

Purpose: The purpose of this literature review is to explore the descriptions of CC of infants with DD provided within infant DD literature.

Search Strategy: PubMed and Web of Science were searched using the keywords: diaper dermatitis, diaper rash, infant, and neonate. The inclusion criteria for this project are as follows: published after 1990, English language, include skin assessment or evaluation, and infant/children < two years of age. Review and opinion articles were excluded.

Results: A total of 454 studies were retrieved, 27 remained after review for duplicates and relevance. The CC described most often were: type of feeds, stool frequency, history of DD, use of antibiotics, and delivery mode.

Synthesis of Evidence: The studies reported inconsistent CC and a lack of correlation between these characteristics and the condition of diapered skin. Many studies focused solely on the efficacy of interventions lacking description of possible relationships between DD and CC.

Implications for Practice: Skin condition outcome variables can be improved with the acknowledgment of the impact CC have on the development of DD. The combination of assessment measures and CC may ultimately demonstrate more merit or rigor for describing DD severity and skin condition.

Implications for Research: Future research should expand this exploration to include environmental or contributing factors to continue to identify additional risk factors for DD.

Diaper dermatitis (DD) is a common condition in infants less than 12 months of age [1,2]. Diaper dermatitis is an inflammatory process that is a result of incontinence and irritation within the diaper area. The concept of DD in the infant population was first identified in the 1940s, and continues as a common condition today [3].

Diaper dermatitis is a prominent skin injury among hospitalized infants [4–8]. Although the exact prevalence of DD in neonatal intensive care unit (NICU) settings is unknown, Migoto, et al. (2013) described a 29.7% incidence of DD among a small sample in Brazil, while researchers from Hungary reported an incidence of 25% among a larger sample in a NICU that provided a higher level of care[6].

Several researchers describe efforts to reduce the incidence of DD using evidence-based practice and skin care guidelines [9–11]. An evidence-based national skin care guideline was created by researchers and clinical experts to provide a standard of care and promote consistency among skin care practices[12]. Nurses in different countries have led quality improvement initiatives have adapted the guideline to test methods that further investigate skin conditions such as DD in clinical settings[7,13,14].

Despite the numerous published reviews, guidelines, and studies that have examined DD, there is a lack of adequately studied clinical characteristics associated with the development, management, or treatment of DD. Clinical characteristics are often overlooked as potential risk factors when the primary focus for the study is on management or treatment of DD. The purpose of this literature review is to explore the descriptions of clinical characteristics of infants with DD provided within infant diaper dermatitis literature.

Methods

Search Strategy

The following databases were searched: PubMed, CINAHL, and Web of Science with the following keywords: diaper dermatitis, diaper rash, infant, and neonate. The inclusion criteria for this project are as follows: articles published since 1990s; published in English, studies that mention skin assessment or evaluation; articles that studied: 1) infant/children less than two years of age; and 2) any gestational age. The exclusion criteria were as follows: review articles; opinion articles; dissertations; book chapters and books; newspaper articles; retrospective studies.

Data Characteristics

Participant characteristics (demographic, maternal or delivery information, presence or absence of DD, and health status), purpose of the study, type of design, additional characteristics of the subjects, type of assessment tool including physiologic and visual tools, intervention type, and results were extracted from each study. How are these different from clinical characteristics?

Levels of Evidence

To provide level of rigor, each study was assigned an evidence level using the Melynk & Fineout-Overholt (2010) guidelines. The assignment of evidence level was as follows: Level I (systematic review of randomized control trials), Level II (evidence of a well-done RCT), Level III (quasi-experimental, well designed control trial), Level IV (evidence of case-control or cohort study), Level V (evidence from systematic review of descriptive studies), and Level VI (evidence of a descriptive study)[15].

Results

The search of the databases resulted in 454 studies, 282 from PubMed and 172 from Web of Science using Prisma methods. Inclusion and exclusion criteria were applied, and 27 articles remained after further review for duplicates and relevance to the purpose (See Figure 1). The remaining articles are presented in two tables based on the type of study performed and include: 1) assessment and prevention focused studies, and 2) treatment focused studies, and are displayed chronologically in Tables 1 and 2, respectively. Twenty of the studies presented a randomized control trial (RCT) design and demonstrated methodological and design rigor. In Table 3 the common clinical characteristics identified among the studies in Table 1 and 2 are presented.

Assessment and Prevention Studies

Fourteen studies demonstrated assessment or preventative themed designs and are presented in Table 1[5,16–28]. Several factors identified within the fourteen studies are associated with the development of DD to include: stool frequency, antibiotic usage, diarrhea, and oral thrush[5,8,16,27,29]. Researchers identified vaginal or cesarean section delivery as a clinical characteristic in two studies[20,26,28]. Researchers also identified protective elements against DD that include: human milk feeds and phototherapy[5,18,29]. Among all the studies, DD was not found in any infant during the day of birth or first day of life. In the studies that included preterm infants, DD developed in infants with higher gestational ages[5,27]. Colonization of mycological and bacterial organisms were common and did not appear to be a factor in the development of DD unless there was an increase in colonization[17,22]. These studies provide several consistent clinical characteristics among subjects with DD: age, gender, weight, type of feeding, stool frequency, history of DD, antibiotic use, and delivery type (Table 1, Table 3).

The studies in Table 1 lack further correlation between clinical characteristics and DD demonstrated by the exclusion of clinical characteristics in the analysis. This omission is also seen with a lack of description of potential exacerbating elements that may originate from examination of clinical characteristic relationships to DD.

Treatment Focused Studies

Thirteen studies describe treatment or intervention-based research studies and are displayed in Table 2[30–42]. Two of these studies were performed in a NICU hospital setting that included preterm infants greater than 32 weeks gestational age at birth[39,43]. Two of the studies in Table 2 acknowledge the type of feeding as informative to the study[39,41]. Previous episodes of DD were mentioned in three of the studies that highlight the significance and reoccurrence of DD[33,41,44]. Antibiotics are often used in hospital settings and may contribute to the development of DD but were not correlated consistently to DD in this review. Gozen, et al. (2014) was the only researcher to acknowledge and present the frequent use of antibiotics among infants in the NICU and include the concept as a clinical characteristic.

The treatment designs reported in the studies contained in Table 2 did not allow for the examination of relationships between clinical characteristics and DD in all cases. Despite the lack of association between clinical characteristics and DD, these studies provide several consistent demographic and clinical characteristics for subjects with DD such as: age, gender, weight, type of feeding, history of DD, and antibiotic use (Table 2, Table 3).

Discussion

This literature review demonstrates a prominence of the following clinical characteristics across the total of studies reviewed: age, stooling frequency, type of feeding, antibiotic exposure, previous episodes of DD, mode of delivery for birth, and phototherapy. The review provides a

better understanding of the clinical characteristics commonly observed within studies that examine DD as an outcome. The identification of commonality between types of studies such as assessment, prevention, or intervention provide a strong pool of clinical characteristics to promote further inquiry.

An important barrier to researchers' and clinicians' ability to prevent and treat DD is that clinical characteristics are inconsistently reported within DD studies and are not used as covariates. Clinical characteristics are often provided when descriptive statistics are performed, but researchers have not explored their relationships to DD within the objectives of the study. There is a need to examine the interaction of clinical characteristics of infants in the NICU with DD and associated skin integrity factors. This review provides the basis for further examination of specific clinical characteristics that may be useful to describe an at-risk population in the NICU for DD.

The studies presented in this review also demonstrate the variance in skin assessment. Physiologic measures (e.g. evaporimeteter, pH, skin hydration) for skin condition were used in nine of the studies in Table 1 to: assist in the assessment of skin condition, DD development, and quantify changes in DD skin condition[8,16,17,19,20,24,26,28,29]. Changes in skin condition were determined by the use of a visual assessment tool often paired with physiologic tools. Strength in the full description of skin condition may lie in the interpretation of physiologic measurements, but may be elevated when combined with visual assessment.

Comparatively, visual assessment tools were used abundantly within the intervention studies in Table 2 to provide subjective descriptions and quantify the effectiveness of the intervention on the severity of DD. Visual assessment may be the tool of choice in the determination of DD severity, but the physiologic components used in assessment studies can

nadd strength to the results. The difference in tool usage between types of studies demonstrates an additional gap in the literature related to skin assessment in the diaper area. Skin assessment tools in the NICU are vague and lack specification of area of involvement define, such as the diaper area. Further research can best be conducted using the clinical characteristics identified in this review to develop specific guidelines for a DD specific assessment tool. The development of a DD specific skin assessment tool can increase the prevention of DD if clinical characteristics can be correlated with DD development.

Clinical Characteristics and the Skin Safety Model

The Skin Safety Model (SSM) was identified as an ideal model and framework to guide the identification and interpretation of clinical characteristics in the context of skin vulnerability[45]. The SSM was originally designed for use among adult patients in the intensive care unit. The characteristics that define the NICU patient for which DD outcomes are extracted should include factors that relate to skin health. These characteristics can be translated into descriptors of the infant in the NICU which provides a guide to consider factors that contribute to subsequent skin injury outcomes[45]. Contributing factors within the SSM include patient factors, situational stressors, and system factors[45]. Additional exacerbating elements are also considered within the patient's environment and can be combined with the contributing factors to potentiate skin vulnerability and ultimately injury. The elements that have the greatest potential to exacerbate skin injury and vulnerability include friction, shear, and irritants to the skin[45].

The results of this review can be instrumental in the adaptation of the SSM. The significant clinical characteristics identified include: age, nutrition, previous episodes of DD, stooling frequency, antibiotic exposure, and delivery mode of birth. The clinical characteristics identified can be included in as concepts under the construct of "contributing factors" along with

inclusion among the construct of "exacerbating elements". A gap in the literature is present in the documentation of a clear connection between contributing factors during hospitalization, development of DD, and effective assessment to perform adequate treatment or eradication of DD.

Global Representation

Despite the vast geographical representation and cultural differences of child care, DD is recognized as a common condition of infants. The studies in Table 1 and 2 demonstrate that the issue of DD has been studied worldwide to include studies originating from several countries (see Table 4). The identification of DD as a globally studied condition demonstrates the importance of its continued investigation and need for prevention. The global demonstration of investigation into this condition prompts further discussion about how clinical characteristics of the infant impact the development of DD.

Implications for Research

As noted in this review, clinicians and researchers have identified many interventions utilized to decrease DD, but few accurately describe contributing factors. Future research should include the collection of clinical characteristics, environmental or contributing factors, to use to identify additional risk factors for DD. Another area of interest is the evaluation of the microbiome and the differentiation that occurs in the hospital versus home environment and the impact on DD development.

Additionally, the inconsistent use of physiologic measurement among intervention studies is a gap that needs to be addressed. Skin pigment and erythema are major components of the skin and its compromise, without physiologic measures the objectivity and rigor will continue to be lower among these types of studies. Objective measures of skin condition that

have been studied for reliability and validity, especially as the skin becomes irritated as seen with DD, would be beneficial to report to enhance treatments and management.

Implications for Practice

There is a gap in the research that identifies DD as a significant issue among the NICU population and thus the nursing profession has a unique opportunity to fill this gap. Showcasing the importance of clinical characteristics and the incorporation of a skin assessment tool may be helpful to: 1) identify the incidence and prevalence of DD, 2) uncover commonalities among degrees of severity, and 3) attribute the assessment of correlations with clinical outcomes specific to the NICU patient. The use of a reliable and valid skin assessment tool in daily care would provide nurses with the ability to identify, treat, and accurately document an infants' DD progression and healing.

Conclusion

The literature provided in this review demonstrates the variance among studies that evaluate DD in the infant population. This review demonstrated the lack of consistency to control for demographic and clinical characteristics among infants in a variety of settings. Researchers can use clinical characteristics of a sample to further analyze contributing factors or exacerbating elements that may increase an infants' risk for developing DD. Therefore, studies that include consistent clinical characteristics combined with rigorous research designs are critical for adequate assessment of an infants' risk of developing DD and may enhance the documentation of treatment outcomes for DD.

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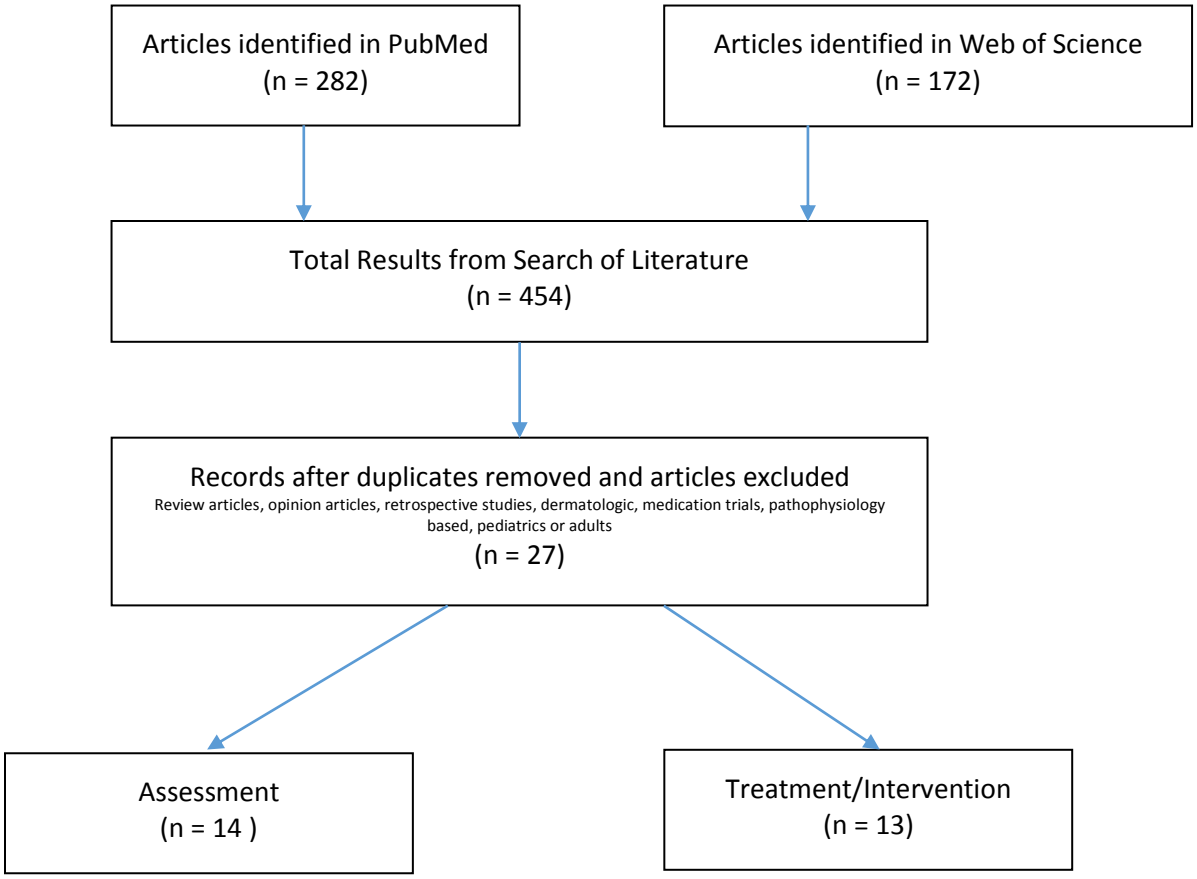

Figure 1. Inclusion and exclusion criteria for literature review.

Table 1. DD Assessment and/or Prevention Studies

Author/ Year	Purpose	Study Design	Sample Size	Sample Age	Setting	Clinical Characteristics	
Visscher, et. al. (2000)	To examine the stages of DD within the initial 28 days of life	Descriptive, observational study	n = 31	37-42 wks	Hospital/ Home	• Gender • DOL • BW • Race	• Frequency of feeds • Frequency of diaper changes • Frequency of stools/urine
Odio, et. al. (2000)	To determine the effects of two different diaper technologies on DD development and skin erythema.	Two study groups (A&B): double blinded, randomized parallel group	n = 391	8-24 months	Outpatient	• Gender • Age • DOL	• Days of diaper use
Ferrazzini, et. al. (2003)	To determine severity of DD when correlated with bacterial colonization.	Muli-center, correlational study	n = 76	2-24 months	Outpatient	• Gender • Age • Weight • Height	• Race • Hx of DD • Type of DD • Concurrent illness
Visscher, et. al. (2009)	To examine the effect of diaper wipes vs water wipes on the diaper area skin condition.	Randomized, single blind study	n = 130	23 to ≥38 wks	Hospital	• Gender • GA at birth • BW	• Frequency of diaper changes • Frequency of stools/urine
Stamatas, et. al. (2011)	To examine DD pathophysiology and its relationship to skin barrier function.	Observational, descriptive study	n = 35	3-24 months	Outpatient	None reported	
Liu, et. al (2011)	To determine severity and presence of DD with the use of cloth diapers.	Observational Study	n = 694	3 to 9 months	Outpatient /Home	• Gender • Age • Location • Type of feeds	• Frequency of diaper changes • Use of skin care products • Frequency of DD • Presence of diarrhea and teething
Lavender, et. al. (2012)	To evaluate the use of a specially formulated wipe vs cloth and water on skin hydration.	Prospective, assessor blinded, randomized controlled equivalence study	n = 280	>37 wks at birth	Hospital/ Home	• Gender • BW • Type of feeds	• # of diaper changes • Frequency of bathing • Maternal factors
Li, et. al. (2012)	To examine rate of DD in children 1-24 months of age and associated risk factors.	Cross sectional, observational study	n = 1036	1-24 months	Outpatient	• Gender • Age • Type of feeds • Presence of diarrhea • Frequency of diaper changes and stools	• Type of skin cleansers • Type of diaper • Barrier cream use • Frequency of bathing • Maternal factors
Alonso, et. al. (2013)	To examine petrolatum jelly as a preventative treatment for DD and assess the relationship with nutrition and other treatments.	Randomized, controlled, single blinded study with 2 parallel groups	n = 213	Up to 38 wks GA	Hospital (Medium care unit)	• Gender • GA • DOL at admit and start of study • BW • Type of feeds and # days on feeds	• Temperature • Type of bed and Humidity if in incubator • # days on IVF • # of stools • DD Treatments

Yonezawa, et. al. (2014)	To examine the relationship between DD in the first month of life and skin barrier function.	Prospective Cohort study	n = 88	>35 wks GA	Home	• Gender • Age • BW • Ratio of BF to other types of feeds	• # of stool/urine • Type of diaper, soaps, and wipes • Maternal factors
Garcia Bartels, et. al. (2014)	To examine the effect of diaper care treatments on skin barrier function comparing diapered and nondiapered skin.	Single center, randomized control trial	n = 83	39 wks GA at birth	Outpatient	• Gender • GA at birth • Weight, length, and OFC at birth • Ethnicity	• Type of feeds • Fitzpatrick skin type • Maternal factors
Ersoy-Evans, et. al. (2016)	In a review of DD cases, demographic and clinical descriptions were examined.	Descriptive study	n = 63	Birth to 12 months	Outpatient	• Gender • Type of feeds • Underlying disorders • Cleansing method • Type of diaper	• Presence of DD candida • Type of DD treatment • Maternal factors • Primary caregiver
Owa, et. al. (2017)	To examine the relationship between TEWL, pH, & DD.	Cross sectional, descriptive study	n = 424	2 days - 23 months	Outpatient	• Age • Social class • Previous DD	• Type of bath soap • Secondary caregiver
Yonezawa, et. al. (2018)	To examine skin barrier function in relation to moisturizing skin care regimens.	Randomized parallel comparison control trial	n = 202	1 wk - 3 months and > 35 wks GA	Outpatient	• Gender • GA • Presence of skin problems	• Amount of vernix on whole body • Maternal factors

***Key:** # = Number or number of, BF = Breastfeed or breastfed, BW = Birth weight, DD = Diaper dermatitis, DOL = Day of life, GA = Gestational age, Hx = History, IVF = Intervenous fluids, TEWL = Transepidermal water loss

Table 2. DD Treatment/Intervention Studies

Author/ Year	Purpose	Study Design	Sample Size	Sample Age	Setting	Clinical Characteristics	
Concannon, et. al. (2001)	Examine and compare effectiveness of Miconazole Nitrate 0.25% vs zinc oxide on DD.	Double blind, randomized, placebo controlled, parallel group study	n = 202	2-13 months	Outpatient	• Gender • Age	• Adverse events
Al-Waili (2005)	Examine the effects of a honey mixture on DD.	Comparative study	n = 12	3-18 months	Outpatient	• Gender	• Age
Sabzghabaee, et. al. (2011)	Evaluate the use of menthol for DD.	Randomized comparative study	n = 70	< 28 days	Hospital	• Gender • GA	• Weight
Gunes, et. al. (2013)	Examine the effectiveness of guaiazulene on DD.	Controlled prospective study	n = 30	22-67 days	Hospital (NICU)	• Gender • GA at birth	• BW
Bonifaz, et. al. (2013)	Examine the effects of sertaconazole cream (2%) on DD.	Descriptive, prospective non-comparative study	n = 27	2-22 months	Dermatology unit*	• Gender • Age	
Farahani, et. al. (2013)	Examine the effectiveness of human milk vs hydrocortisone 1% on DD.	Randomized study	n = 141	0-24 months	Pediatric unit*	• Age	• Maternal & infant health hx
Gozen, et. al. (2014)	Examine the effectiveness of barrier cream vs breastmilk on DD.	Randomized, controlled, prospective study	n = 63	Preterm & term	Hospital (NICU)	• Gender • GA • Feeding type	• Antibiotics • Type of cleansing • Ventilation
Adib-Hajbaghery, et. al. (2014)	Examine and compare the effectiveness of Bentonite and Calendula on DD.	Randomized, double blind control study	n = 60	1-24 months	Outpatient	• Gender • Age	
Mahmoudi, et. al. (2015)	Examine and compare the effects of Bentonite and Calendula on DD.	Prospective, double blind, randomized control trial	n = 100	1-24 months	Outpatient	• Gender • Age • Weight • Type of feeds	• History of DD • # of diaper changes • Maternal factors
Goodarzi, et. al. (2016)	Examine and compare the effects of Nystatin, Clotrimazole, and Muprocin on DD.	Randomized control trial	n = 112	4 months to 2 yrs	Outpatient	• Gender • Age • Infectious disease hx	• # of diaper changes • Frequency of cleansing • Type of diaper
Keshavarz, et. al. (2016)	Examine and compare the effects of Henna and Hydrocortisone on DD.	Triple blinded, randomized control trial	n = 82	< 2 years	Hospital	• Gender • Age • Nutrition • Hx of DD treatments	• Type of diaper • Frequency of cleansing • Cleansing products • Medical hx
Seifi, et. al. (2017)	Examine effect of breastmilk vs no treatment on DD.	Randomized, case control study	n = 30	0-12 months	Home	• Gender • Age • Parent employment • Family income	• Type of diaper • # of diaper changes • # of rashes
Dastgheib, et. al. (2017)	Examine cure rate of Coriandrum sativum extract cream vs hydrocortisone 1% on DD.	Non-randomized case control study	n = 58	< 2 years	Home	• Gender	• Age

Key: # = Number or number of, BF = Breastfeed or breastfed, BW = Birth weight, DD = Diaper dermatitis, DOL = Day of life, GA = Gestational age, Hx = History, TEWL = Transepidermal water loss
* unclear if unit is an inpatient unit of a hospital

Table 3. Significant clinical characteristics

Clinical Characteristics	Assessment/Prevention Studies	Treatment/Intervention Studies
Type of Feeds	• Liu, et. al (2011) • Lavender, et. al. (2012) • Li, et. al. (2012) • Alonso, et. al. (2013) • Yonezawa, et. al. (2014) • Bartels, et. al. (2014) • Ersoy-Evans, et. al. (2016)	• Gozen, et. al. (2013) • Mahmoudi, et. al. (2015)
Stool Frequency	• Visscher, et. al. (2000) • Visscher, et. al. (2009) • Li, et. al. (2012) • Alonso, et. al. (2013) • Yonezawa, et. al. (2014)	
History of DD	• Ferrazzini, et. al. (2003) • Liu, et. al (2011) • Owa, et. al. (2017)	• Mahmoudi, et. al. (2015) • Keshavarz, et. al. (2016) • Seifi, et. al. (2017)
Use of Antibiotics	• Alonso, et. al. (2013)	• Gozen, et. al. (2013)
Delivery Mode	• Lavender, et. al. (2012) • Yonezawa, et. al. (2014) • Bartels, et. al. (2014) • Yonezawa, et. al. (2018)	

Table 4. Countries of origin within the literature review

Country	Assessment/Prevention Type Studies	Treatment/Intervention Studies	Total
Africa	1		1
Australia		1	1
China	2		2
Germany	1		1
Iran		8	8
Istanbul		1	1
Japan	2		2
Mexico		1	1
Spain	1		1
Switzerland	1		1
Turkey	1	1	2
United Arab of Emirates		1	1
United Kingdom	1		1
United States	4		4

Table 5. Summary Table (required for publication)

Summary of Recommendations for Practice and Research	
What we know:	• Diaper dermatitis is a common issue among infants • Diaper dermatitis pathophysiology and treatments are more prominent in the literature • Clinical characteristics of infants with diaper dermatitis are not consistently described in research
What needs to be studied:	• Hospitalized infants in the NICU differentiated by clinical characteristics such as gestational age, type of feeds, stooling frequency, and diagnosis • Comparison of timing of diaper dermatitis among infants of the NICU compared to infants not hospitalized within the first year of life • The impact of consistent diaper dermatitis practices on infants in the NICU
What we can do today:	• Recognize that diaper dermatitis is a common issue in the NICU • Take clinical characteristics into consideration when developing diaper dermatitis guidelines • Incorporate skin assessment tools into diaper dermatitis management to objectively describe severity of injury to ensure adequate methods of treatment

Chapter III: Methods

Chapter Introduction

This retrospective exploratory study was performed to identify the prevalence of DD in a level IV NICU. This study will also identify the relationships between clinical characteristics and DD among the infants of the NICU.

Setting

The data was gathered from infants admitted to the NICU in a large metropolitan children's hospital in Southeast Wisconsin. The population of infants cared for in the NICU range from extremely premature infants to infants requiring intensive care and close management for multiple specialty services.

Sample

The sample of 611 infants was obtained from the Neonatology Division that maintains a continuous database of all infants admitted to the NICU of study and includes basic demographic data, maternal data, and clinical data information. Inclusion criteria include all infants admitted to the NICU between January 1, 2016 to December 31, 2017. Exclusion criteria are as follows: 1) outborn or transferred from an outside hospital, 2) infants with dermatologic diagnoses, 3) those with imperforate anus diagnosis or infants requiring diversion of stool to an ostomy for any portion of the NICU hospitalization, 4) infants transferred out of the NICU at any point during stay, 5) readmission to the NICU, and 6) infants discharged after December 31, 2017.

Demographic data from the NDD was provided on each subject as listed in Appendix A. Once the data was obtained retrospective chart review was performed to obtain the information related to DD and is presented in Appendices A and B. An assumption of the data is that infants did not have the condition (diaper dermatitis) at the beginning of data collection as this would be

at birth for all subjects. Infants in the sample will have had the opportunity to experience causative factors and common clinical outcomes as a result of their diagnoses and stay in the NICU that contribute to the complexity and length of stay (LOS) of the infant and may be associated with DD.

Procedure

The study was approved by the Institutional Review Board (IRB) at the hospital of study and the University of Wisconsin Milwaukee. A waiver of informed consent was obtained from the IRB as an expedited review due to the minimal risk to infants in the study and the retrospective nature of the study. All infants in the NICU received standardized skin care protocol. The NICU under study initiated a diaper dermatitis algorithm in 2015 to provide consistency to prevent, manage and treat DD. Internal audits of the use of the algorithm have revealed compliance in nursing care. The standardized practice allows the principle investigator (P.I.) to conduct the proposed study to assess clinical characteristics that impact incidence of DD with less variation due to staffing compliance and DD barrier product consistency within the realm of DD care.

Measures

The collection of these measures will provide information about all infants in the NICU and assist to determine the types of patients and their clinical characteristics for later use in exploring their relationship with DD. The Neonatal Division Database does not provide the information related to DD, therefore; additional data will be collected from the electronic health record (EHR) once the list of patients is obtained from the Neonatal Division Database. The EHR of each patient will be reviewed for the documentation of DD.

Gestational age. Gestational age (GA) is based on ultrasound of the woman at 18-20 weeks gestation of pregnancy. Infants are divided into two groups: ≤32 weeks (32 6/7) GA, and infants ≥33 weeks GA.

Birth weight. The first documented weight on admission to the NICU.

Gender. Collected as male or female.

Maternal and delivery factors. These variables include: delivery type such as cesarean section or vaginal delivery, and race as provided by maternal race in the H&P.

Days to full feeds. Time from birth to the infant receiving all enteral feeds when intravenous fluid discontinued.

Reached full feeds within the first week. The infant received all enteral feeds without any intravenous fluid by seven days of life.

Length of stay. Time from birth to discharge using number of days in the NICU.

Total number of IVs. The total number of peripheral intravenous lines placed in the infant successfully as documented in the EHR by the nurse.

Total number of skin injuries. The total number of skin injuries other than DD documented in the EHR by the nurse.

Diaper Dermatitis. Diaper dermatitis, the outcome variable, in the setting of this study is defined by the presence of DD as documented by the nurse in the EHR. The following measures were collected on the infants with DD describing the initial episode.

Number of DD episodes. The number of episodes collected did not exceed three. Consecutive episodes were collected if documented seven days after the prior episode. Episodes of DD documented within seven days of the previous episode were included in the previous episode's timeframe.

Day of life at time of each DD episode. Days from birth to each DD episode.

Gestational age at time of each DD episode. The corrected GA from birth to the each episode of DD.

Weight at time of each DD episode. The corrected weight at the time of the each episode of DD.

Feeds at time of DD. The presence or absence of enteral feeds at any time during the 24 hours of the day of each episode of DD. The types of nutrition are described below. When collected, if multiple types of feeds were administered during the initial day of DD all were documented.

Mother's milk or breastfeeding. The infant received unfortified human milk from the mother or breastfed by the mother at any time during the 24 hours of the day of each episode of DD.

Donor Human milk. The infant received pasteurized human donor milk with human milk fortification at any time during the 24 hours of the day of each episode of DD.

Formula. The infant received any type of formula at any time during the 24 hours of the day of each episode of DD.

Fortified Human Milk. The infant received human milk with added nutrition such as formula or bovine milk-based fortifier at any time during the 24 hours of the day of each episode of DD.

Parental Nutrition. The infant received intravenous nutrition at any time during the 24 hours of the day of each episode of DD

Central line present within 1 week prior to DD. The infant had a central line within seven days prior to the each episode of DD.

Antibiotics within 1 week prior to DD. The infant had an antibiotic within seven days prior to each episode of DD.

Positive blood culture within 1 week prior to DD. The infant had a positive blood culture within seven days prior to each episode of DD.

Received respiratory support within 1 week prior to DD. The infant had any type of respiratory support within seven days prior to each episode of DD.

Data Management

The data management plan was implemented to include the following steps:

1. A list of infants that met inclusion criteria were obtained from the Neonatology Division Database. A list of patient names and corresponding medical record numbers (MRN) were maintained for the duration of the study in a password-protected computer folder. The MRNs were used to retrieve additional clinical characteristics related to DD. All patients were coded to ensure confidentiality once entered into the database. Study data was only made available to study investigators.
2. Study data were collected by the primary investigator and entered into REDCap (Research Electronic Data Capture) electronic data capture tools hosted at the Medical College of Wisconsin. (Harris, Taylor, Thielke, Payne, Gonzalez, & Conde, 2009). REDCap is a secure, web-based application designed to support data capture for research studies, providing 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources.
3. Coded data was then placed into SPSS® statistics 26 to create the code book.

4. The data was screened for errors and corrected using SPSS® statistics 26 until the data was completely cleaned. All changes and errors with data were documented in a log book.
5. The data in SPSS® statistics 26 was examined for missing data and subjects were excluded if clinical characteristics included in the analysis were missing.

Plan for Data Analysis

The data was analyzed using SPSS® version 26. Descriptive statistics were performed to obtain frequency, means, and proportions of all clinical characteristics (independent variables). To examine associations between the clinical characteristics (independent variables) and diaper dermatitis (dependent variable) Pearson's chi-square test and odds ratio (OR) with corresponding 95% confidence intervals (CI) were executed. Multivariate logistic regression analysis was performed using clinical characteristics found in the total sample to identify association of these factors with DD. A P-value <0.05 was considered statistically significant.

Prevalence of DD was calculated by taking the total number of initial DD episodes in the sample and dividing by the total number of participants. Prevalence of DD among preterm infants will be calculated by the total number of DD episodes divided by the total number of preterm infants in the sample. Prevalence of DD among term infants was calculated by the total number of DD episodes divided by the total number of term infants in the sample. Bivariate analysis using chi-square, t-test, or repeated measure ANOVA was used to explore differences in clinical characteristics of the sample with gestational age and DD. Statistical significance was determined by p values less than 0.05.

Limitations

Severity of diaper dermatitis was not collected due to the lack of incorporation of a published reliable and valid tool. The lack of quantification of skin injury associated with the occurrence of DD provides an abundance of subjectivity. Since DD episodes were collected from one section of the EHR, if the nurse did not document in that section the episode would be missed and potentially leading to missing data. Another limitation of the data is the description of GA at birth. Birth GA is reflected as number of completed weeks so there may be a slight variance in the length to full feeds and the occurrence of DD that are collected in actual GA. The type of feeds preceding the collection of feedings for this study was not described. It is unknown the impact of prior feeds on the development of DD in this dataset. Type of DD was not described specifically in the data and does not reflect significance of candida in the development of DD or variances in treatment.

Chapter IV: Results

Chapter Introduction

The results of the retrospective exploratory study are presented in this chapter. The results demonstrate the frequencies and associations of clinical characteristics found among both groups; those affected by DD and those without DD. Additional exploration of evidence-based clinical characteristics frequently found in DD research are presented for the sample affected by DD.

Manuscript 3: Contributing Factors to Diaper Dermatitis in the NICU

Abstract

Background: Diaper dermatitis (DD) among infants in the Neonatal Intensive Care Unit (NICU) is an under recognized and preventable skin injury with prevalence rates above 20%. Most of the literature focuses on management and treatment, rather than prevention. There is a gap in the literature related to relationships between clinical characteristics of the infant in the NICU and DD. The aim of this study is to identify the prevalence of DD in the NICU and describe the association between clinical characteristics of the infant in the NICU with the occurrence of DD.

Conceptual Framework: An adapted Skin Safety Model was used to provide a framework to guide the examination of clinical characteristics that when combined with exacerbating elements may contribute to DD.

Method: A retrospective chart review was performed on all infants in a level IV NICU over a two-year period. The sample was divided by gestational age into two groups (≤32 completed weeks and ≥33 completed weeks).

Results: A DD prevalence of 34% (n = 180) was calculated from this study. The majority of infants were born by cesarean section (57%), Caucasian (61%), and male (58%). The highest percentage of DD (72%) was identified among infants ≤32 weeks GA who received a majority of human milk fortified with bovine milk-based protein (76%). Infants ≥33 weeks received the most formula (62%) at the time of DD. Logistic regression demonstrated length of stay was significant, for each additional day an infant stays in the NICU, the odds of developing DD increased by approximately 2% (OR = 1.02, 95% CI = [1.01, 1.03], p = .002). Timing from birth to full feeds was significant, for each additional day to full feeds, the odds of developing DD decreased by approximately 3% (OR = 0.97, 95% CI = [-0.94, 0.99], p = .023).

Conclusion: The clinical characteristics unique to infants in the NICU may play an integral role in mediating and/or moderating risk factors associated with DD. Improvements in preventative measures could benefit from continued exploration of the impact nutrition and length of stay have on DD development.

Keywords: Neonatal, Infant, NICU, Skin Safety Model, Diaper Dermatitis, Clinical Characteristics

Contributing Factors to Diaper Dermatitis in the NICU

Diaper dermatitis (DD) is an underreported skin injury among infants in the neonatal intensive care unit (NICU). Rates of DD among hospitalized infants vary from 4-67% (Adalat et al., 2007; Csoma et al., 2016; Kayaoglu, Kivanc-Altunay, & Sarikaya, 2015; Migoto, Souza, & Rossetto, 2013). The large variance may be attributed to the lack of recognition of the involvement of additional factors of the infant's environment that contribute to DD. Many DD studies recognize additional factors as important in reporting, but lack further explanation or proposal of future studies for investigation into relationships between DD and risk factors. Clinical characteristics that were prominently associated with DD in the literature among hospitalized infants include: type and amount of feeding, number of stools, age, race, gender, and weight (Esser & Johnson, n.d.). Additionally, in the literature on premature infants with DD, there is a gap in the literature that pinpoints a specific gestational age group that experiences DD more frequently. Moreover, relationships between DD and additional characteristics have not been described thoroughly among the NICU population.

Background

Diaper Dermatitis

Diaper dermatitis is an inflammatory process that affects numerous infants (Shin, 2014). The severity of DD is demonstrated by the degree of erythema and skin breakdown in the diaper area. The impact of moisture, friction, stool, and urine are reported abundantly in the literature as contributing factors to the risk of DD, but the impact of factors such as age, antibiotics, nutrition, and length of stay are lacking (Stamatas & Tierney, 2014). Infants in the NICU may be at highest risk to develop DD due to impaired skin function that occurs in premature infants and within the first month of life in term infants, combined with continued exposure to wetness while wearing diapers (Visscher, Chatterjee, Munson, Pickens, et al., 2000). The goal of this study is to identify

the prevalence of DD in the NICU and describe the association between clinical characteristics of the infant in the NICU with the occurrence of DD.

Preliminary Data

Esser, Schindler, & Clinton (2015) identified a DD prevalence of 29% (n = 139) in a level IV NICU. To determine the influence of gestational age, weight, and feeding exposure on the development of DD, Esser (2017) identified that infants developed DD after a month in the NICU (~42 days of age) and weighed ~2500g or more. Additionally, infants of term gestational age were 5 times more likely to develop DD when they received feeds, than when not fed (Esser, 2017). The results of the QI project provide the basis for continued examination of clinical characteristics of the infant in the NICU and their relationship to DD.

Methods

A retrospective exploratory study was conducted of all neonates admitted to a 70-bed level IV NICU between January 1, 2016 to December 31, 2017. The population of infants cared for in the NICU range from extremely premature infants to infants requiring intensive care and close management for multiple specialty services with an average of 750 admissions yearly. The NICU under study initiated a diaper dermatitis algorithm in 2015 to help clinicians provide consistency in care and to prevent, manage and treat DD (Esser et al., 2015). Internal audits of the use of the algorithm have revealed compliance in nursing care and standardization of practice decreasing the variation of DD documentation and care.

The study was approved by the University of Wisconsin-Milwaukee and Children's Hospital Institutional Review Boards. Data was extracted from the electronic health record (EHR) for all infants admitted to the NICU during the approved time frame. Infants were excluded based on the following criteria: 1) transferred from an outside hospital after 24hrs of

birth, 2) infants with dermatologic diagnoses, 3) infants with imperforate anus diagnosis or infants requiring diversion of stool to an ostomy for any portion of the NICU hospitalization, 4) infants transferred out of the NICU at any point during stay, 5) readmission to the NICU, and 6) infants discharged after December 31, 2017.

Measurements

Diaper Dermatitis Prevalence

Diaper dermatitis, the outcome (or dependent variable) variable, for this study, is defined as the documented presence of DD. This documentation was completed by the bedside nurse. Episodes of DD documented within seven days of the previous episode were included in the previous episode's timeframe. Recurring episodes of DD were recorded as separate episodes if documented $\geq$ seven days after the prior episode.

Clinical Characteristics of Interest

Clinical characteristics of interest for the sample were chosen based on the use of a framework for skin vulnerability adapted for NICU infants (Campbell et al., 2016). The main clinical characteristic of interest is gestational age (GA). Gestational age is the main factor in determining skin maturity in the absence of dermatologic disease (Visscher et al., 2014). The GA groups were determined based on skin maturity and environmental needs. Group one (22- $\leq$32 weeks) of the GA grouping reflects the most premature infants of the NICU. The lower GA infants are cared for in an isolette until approximately 33 weeks corrected GA. Group two ($\geq$33-42 weeks) includes infants with more developed skin at birth and the potential for improved skin maturity.

Clinical characteristics were chosen based on impact to skin, and the factors associated with DD. Demographic characteristics are listed in Table 1 for the entire sample and then broken

down by GA group affected by DD in Table 2. Type of delivery (Cesarean section versus vaginal) are collected to provide data related to factors that could be related to skin flora. Length of stay was collected to describe the days from birth to discharge for each infant.

Feedings are an important factor in the development of DD as the interaction of stool and urine within the diaper environment potentiates the skin's vulnerability to DD. Time to full feeds was chosen to describe the time when all infants in the sample reached this milestone and to use as a benchmark in identifying the relationship of time to first episode of DD. Full feeds were gathered as the day of life from birth that peripheral intravenous fluids were discontinued and the infant received all enteral feeds. The type of feeding was chosen to assist in describing the frequency of infants that develop DD receiving a specific type of feeding. Skin integrity plays an important role in protection from bacterial invasion, therefore; number of peripheral intravenous (IV) lines and skin injuries other than DD were documented for each infant. The list of NICU related clinical characteristics and additional factors important in the exploration of DD in the sample are listed in Table 1 with categorical variables listed as frequencies and continuous variables listed as means with standard deviations.

Results

A total of 611 infants were extracted from the EHR, and then filtered for exclusion. A final total of 537 infants were included in the analysis (see figure 1). The data demonstrated a 34% (n = 180) prevalence of DD with 6% (n = 32) of those that developed a second occurrence of DD (see table 1). The majority of infants in the total sample were born by cesarean section (57%), Caucasian (61%), and male (58%). Division of the total sample into infants ≤ 32 weeks and ≥33 weeks completed GA was analyzed to provide information related to GA and total subjects within each grouping.

Table 1

Frequency Table for Clinical Characteristics of Total Sample (n = 537)

Clinical Characteristics	*N* (*%*)	*Mean* (*SD*)
Gestational Age by Group (mean)		
22-32 weeks GA	204 (37.99%)	
33-42 weeks GA	333 (62.01%)	
Birth Weight (grams)		2210.98 (917.26)
Ethnicity		
Black	139 (25.88%)	
Caucasian	327 (60.89%)	
Other	71 (13.22%)	
Gender		
Male	309 (57.54%)	
Female	228 (42.46%)	
C-section Delivery	304 (56.61%)	
Vaginal Delivery	233 (43.39%)	
Total Episodes of DD	180 (34.00%)	
1	148 (27.56%)	
2	28 (5.21%)	
3	4 (0.74%)	
Days to Full Feeds		7.88 (9.25)
Reach Full Feeds by 7 Days	378 (70.39%)	
Reached Full Feeds After 7 Days	159 (29.61%)	
Length of Stay (days)		34.93 (30.86)
Total Number of IVs		2.74 (2.87)
Total Number of Skin Injuries (not DD)		0.73 (1.49)

Clinical Characteristics of Infants with DD

The data was then split to provide a sample of the subjects with DD. The data was analyzed for the frequency of clinical characteristics among the infants with DD (see Table 2). Gestational age groups were used to assess the frequencies of clinical characteristics within the groups. A higher percentage of DD (54%) was identified among infants ≤32 weeks as compared to 45% among ≥33 weeks. Infants in the lowest GA group also experienced a longer length of stay, longer period to the first episode of DD, higher number of C-section deliveries, higher

number of infants fed fortified human milk at the time of DD, and increased rates of reoccurrence (see Table 2 and 3). The timing to full feeds across the two GA groups appears to be consistently established at 7-10 days from birth. Alternatively, the days to the first DD episode were consistently observed after full feeds are established. The longest interval from the establishment of full feeds to the initial occurrence of DD was observed in the lowest gestational age group.

Table 2

Clinical Characteristics of Infants with DD (1st Episode) Stratified by Gestational Age Group

Clinical Characteristics	22-≤32 weeks (*n* = 98)	≥33-42 weeks (*n* = 82)	*p*
Gestational Age at Birth	29.48 (2.36)	35.11 (2.15)	<.001
Race (Black, Caucasian, Other)	(24%, 69%, 6%)	(10%, 71%, 18%)	.002
Male	47 (48%)	54 (66%)	0.16
Female	51 (52%)	28 (34%)	
Born by Cesarean Section Delivery	70 (71%)	42 (51%)	.005
Birthweight	1385.78 (438.35)	2486.44 (819.53)	<.001
Total IVs	3.50 (3.83)	2.91 (2.52)	.237
Total Skin Injuries Other Than DD	1.59 (2.38)	0.56 (0.86)	<.001
Central Line Present within 1 Week Prior to DD	12 (12%)	22 (27%)	.014
Antibiotics within 1 Week Prior to DD	10 (10%)	22 (27%)	.004
Positive Blood Culture within 1 Week Prior to DD	0 (0%)	2 (2%)	
Required Respiratory Support at Time of DD	42 (43%)	10 (12%)	<.001
Received Feeds at Time of DD	98 (100%)	78 (96%)	.055
Reached Full Feeds within 7 Days of Life	63 (64%)	60 (73%)	.202
Days From Birth to DD Episode	22.84 (16.77)	14.38 (11.18)	<.001
GA at Time of DD	33.17 (2.52)	37.46 (2.85)	<.001
Weight at Time of DD (grams)	1721.89 (534.30)	2597.44 (851.77)	<.001
Total DD Episodes (up to 3)	1.32 (0.55)	1.06 (0.24)	<.001
Length of Stay	61.34 (33.35)	30.50 (20.12)	<.001

Feedings appear to be an important clinical characteristic in the examination of DD with a majority of infants affected by DD receiving feedings at the time of the first episode (Table 3). All of the infants ≤32 weeks GA received feeds at the time of DD, and 76% of those infants were fed human milk fortified with bovine milk-based protein. Comparatively, 96% of infants ≥33 weeks GA were fed at the time of DD, 42% received fortified human milk and 62% received formula. Infants with DD were least often fed pasteurized donor human milk or provided parenteral nutrition.

Table 3

Frequency Table for Nutrition at Time of First DD Episode

Nutrition	22-≤32 weeks GA (*n* = 98)	≥33-42 weeks GA (*n* = 82)	*p*
Infants That Received Enteral Nutrition	98 (100%)	78 (96%)	.091
Mother's Milk or Breastfeeding	3 (3%)	19 (25%)	<.001
Pasteurized Donor Human Milk (PDHM)	14 (14%)	1 (1%)	.002
Artificial Formula (any type)	29 (30%)	48 (62%)	<.001
Human Milk Fortified (bovine milk-based fortifier)	74 (76%)	36 (47%)	<.001
Parenteral Nutrition	1 (1%)	8 (10%)	.012

Note. Due to rounding errors, column wise percentages may not equal 100%.

The clinical characteristics extracted for the total sample were placed in a regression model that was evaluated based on an alpha of 0.05. The overall model was significant, $\chi^2(8) = 56.32$, $p < .001$, suggesting that gender, birth weight, delivery type, length of stay, total number of IVs, total number of skin injuries (not DD), additional days from birth to full feeds, and GA groups had a significant effect on the odds of observing the occurrence of DD.

Two clinical characteristics were significant in demonstrating a relationship to the development of DD. The regression coefficient for length of stay was significant, Wald = 9.39, *OR* = 1.02, 95% CI = [1.01, 1.03], $p = .002$, indicating that for each additional day an infant

stays in the NICU, the odds of developing DD increased by approximately 2%. The regression coefficient for days from birth to full feeds was significant, Wald = 5.14, *OR* = 0.97, 95% CI = [-0.94, 0.99], $p = .023$, indicating that for each additional day to full feeds, the odds of developing DD decreased by approximately 3%. The remaining clinical characteristics that were placed in the model were not significant in predicting the occurrence of DD (See Table 4).

Table 4

Logistic Regression Results with Gender, Birth Weight, Type of Delivery, Length of Stay, Total Number of IVs, Total Skin Injuries (not DD), Days from Birth to Full Feeds, and GA Groups Predicting DD

Clinical Characteristic	*B*	Wald	*OR*	95.0% CI	*p*
(Constant)	-0.55	0.85	0.58		.356
Female Gender	0.02	0.01	1.02	[0.69, 1.51]	.914
Birth Weight	-0.00	1.25	1.00	[0.99, 1.00]	.263
Vaginal Delivery	-0.08	0.16	0.92	[0.62, 1.37]	.687
Length of Stay	0.02	9.39	1.02	[1.01, 1.03]	**.002**
Total # of IVs	0.00	0.00	1.00	[0.92, 1.09]	.962
Total Skin Injuries (not DD)	0.07	0.71	1.08	[0.91, 1.28]	.399
Days from Birth to Full Feeds	-0.03	5.14	0.97	[0.94, 0.99]	**.023**
22-32 weeks GA at Birth	-0.16	0.32	0.85	[0.49, 1.49]	.572

Note. $\chi^2(8) = 56.32$, $p < .001$, McFadden $R^2 = 0.08$.

Limitations

The quantification of DD severity is lacking in this sample with the absence of a standardized tool to assess of DD. The DD affected sample reflects an abundant amount of subjectivity in how DD is documented in this study, as well as most clinical settings. Another limitation of the data is the inability to examine the relationship of clinical characteristics among infants that developed DD due to the sample size of infants affected by DD. Additionally, the data does not reflect the significance of candida as it contributes to DD or variances in treatment. The lack of a standardized tool that incorporates skin color/tone into the assessment may also

contribute to an extended length of time until discovery of DD or recognition of early erythema due to darkened pigment. Nutrition is limited in this study as it identifies one moment in time that relies on the accuracy of the documentation of DD. The feeding type was extracted based on the types of feeding documented within the full twenty-four hours of the initial documented day of DD. Due to the small number of infants with DD, large number of variables, and lack of equal comparison to infants without DD, the clinical characteristics could not be analyzed for significant relationships with DD.

Discussion

This study is the first to report the prevalence of DD among infants in a level IV NICU in addition to identification of frequently observed clinical characteristics among those with DD. Length of stay and time from birth to full feeds were the most significant clinical characteristics. Overall the total sample of the study reached full feeds generally by the first week of life. A large proportion of infants ≤32 weeks GA experienced DD and often had longer lengths of stay. Lower GA infants would be expected to have a longer length of stay versus the older GA groups due to maturity and increased risk for complications (Hornik et al., 2012; Kaplan et al., 2011). The length of stay could also be influenced by clinical complexity which may be captured by the presence of antibiotics, central lines, IVs, respiratory support, and number of additional skin injuries. The regression failed to demonstrate an association between GA and DD development. Despite the lack of association in this study, many studies identified increased prevalence of DD among older infants compared to younger (Adalat, et al., 2007; Esser, 2017).

The results of this study expand on the Esser (2017) QI study that recognized a possible relationship between DD and additional characteristics of the infant in the NICU (Esser et al., 2017). Esser (2017) identified GA, weight, and nutrition as clinical characteristics of importance.

Comparatively, the results of the current study are consistent with DD occurrence later in the hospital stay, but provide a more rigorous observation of timing of DD. The current study also provides a consistent observation with DD and the presence of enteral nutrition.

Enteral nutrition is also an important clinical characteristic that influences health of the infant in the NICU. Human milk is the ideal form of nutrition for infants, especially among the most premature (Thoene, et al., 2014; Tudelope, 2013; Vohr, et al., 2006). Although bovine fortification is often added to mother's own milk or pasteurized donor human milk, it is unknown to what degree both bovine milk-based fortifier and human milk may impact the infant's risk for DD. Thoene, et al., 2014 reported that DD was observed more frequently among infants that received human milk fortified with bovine milk-based protein in the NICU (Thoene, et al., 2014). In this study 76% of infants with DD received bovine milk-based fortifier, which supports a potential relationship between bovine milk-based fortifier and DD (Thoene, et al., 2014). The information gathered from this study provides the basis for a prospective examination of infants with and without DD to compare the clinical characteristics found to have higher frequencies within each GA group.

Future work should explore relationships between the clinical characteristics provided in this study and their impact on skin vulnerability. Nutrition is an important factor for the infant in the NICU and it is unclear of the impact it has on overall health of the infant in the NICU. Future research should examine the type of nutrition infants receive leading up to the occurrence of DD, growth velocity, and relationships between changes in nutritional content to skin vulnerability. A closer look at nutrition, including an expanded examination of the type of feed leading up to the development of DD not just at the time of DD could also benefit preventative measures. Additionally, stool pH can be quantified and compared from when full feeds are met up to the

development of DD. The addition of a skin assessment tool to quantify the severity of DD can be helpful in the interpretation of timing and degree of injury. The examination of skin properties leading up to and at the time of DD, such as skin hydration, transepidermal water loss, and pH, may also contribute to the definition of DD development. Additionally, the exploration of clinical complexity for each infant may assist in further definition of vulnerability to DD and other skin injuries. Further work to identify clinical characteristics that may be predictors of DD will be key to decrease the number of infants that experience DD in the NICU.

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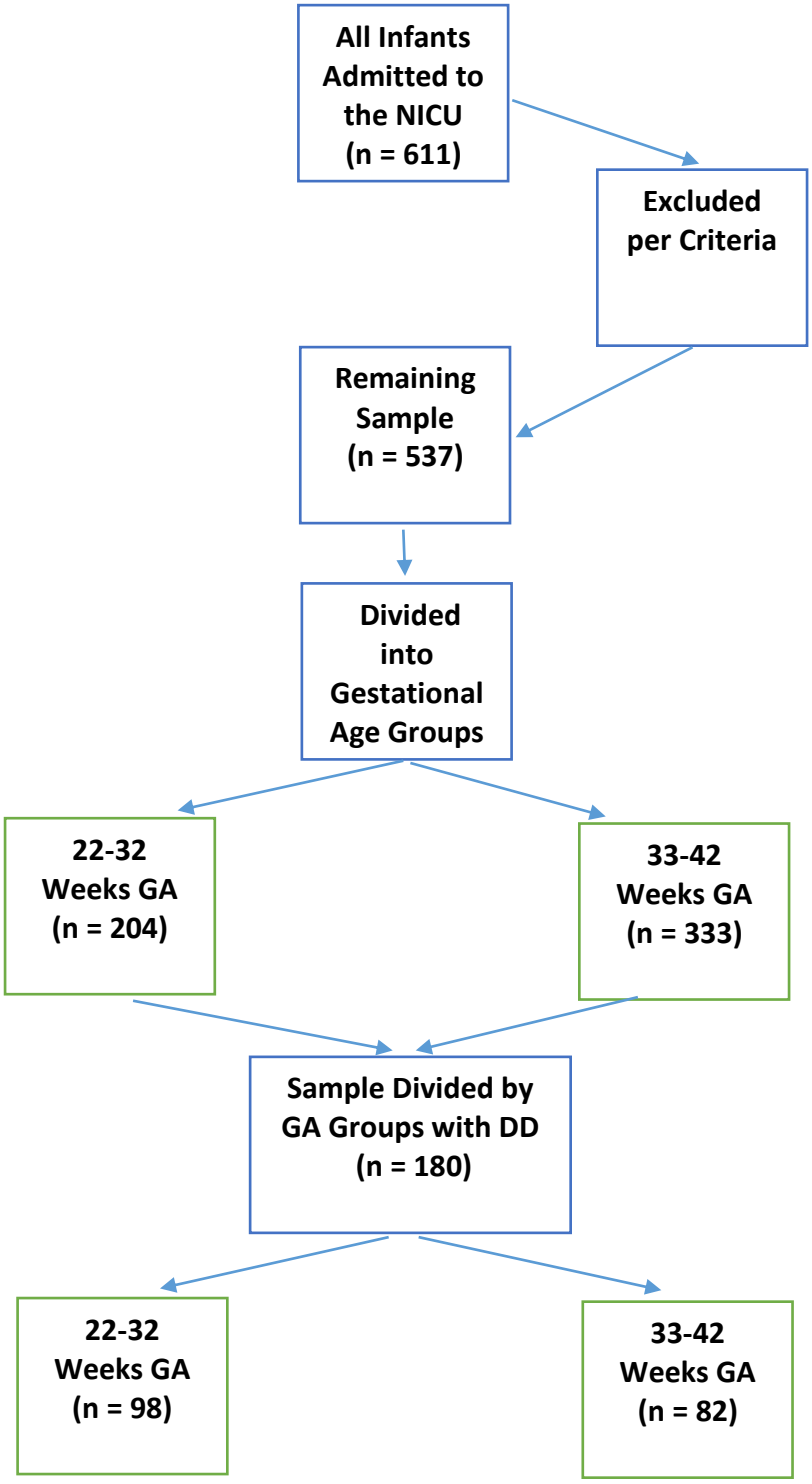
Figure 1. Study Flow Chart



Chapter V: Discussion

Diaper dermatitis (DD) is a challenging condition for caregivers and if improperly recognized and treated leads to increased pain, discomfort, and risk of infection in the infant. This study explored the prevalence of DD and clinical characteristics of the infant hospitalized in the NICU. The study identified clinical characteristics frequently found in those infants with DD to address the gap in the literature related to relationships between clinical characteristics and DD. The findings in this study demonstrated that DD was almost always identified after feedings were initiated, and among infants who had been hospitalized longer. In this discussion, I will include information about skin specific frameworks, practice implications, policy considerations, and future research.

Adaptation of the Skin Safety Model (SSM) for NICU DD

The results of this study demonstrate the usefulness of a NICU specific framework. The SSM was initially adapted to focus on the NICU infant with an emphasis on DD. The adapted SSM for NICU DD was useful in guiding the literature review and design of the study. Clinical characteristics were chosen to capture the clinical complexity and unique nature of infant skin within the NICU environment. The clinical characteristics that were theorized to impact skin vulnerability included: presence of central lines, antibiotic exposure, positive blood cultures, and type of respiratory support. These characteristics were included in data collection and within the initial SSM for NICU DD adaptation to capture the potential relationship with clinical complexity among infants in the NICU with DD. Ultimately, these clinical characteristics were not identified as appropriate additions to the final adaptation of the SSM for NICU DD due to the low frequency these clinical characteristics were identified among the sample of infants with DD in this study.

The final adaptation of the model was created based on the results of the study and identified specific clinical characteristics appropriate to support and add to the concept of "contributing factors" within the model. The clinical characteristics appropriate for the final adaptation of the SSM for NICU DD are those that have been identified as frequently observed among the infants with DD. Clinical characteristics less frequently observed were eliminated in the final adaptation.

Limitations

The limitations of this study relate to the convenient nature of the sample, documentation, and subjectivity within the setting of a high level NICU setting. Results can be generalized to similar NICU settings but may not apply to a lower level NICU or newborn nursery. The limitations are due to the variance in gestational age (GA) in addition to the complex needs of lower GA infants seen in higher more complex level NICUs. The levels of NICU care vary from low intervention and resources to highly specialized interventions and abundant resources (AAP, C.F.N, 2012). Infants in lower levels of NICU care may only be inpatient for a few days and will not benefit from the interpretation of this study's results. Although the limitation of setting can be acknowledged, there may be benefit to understanding the difference between GA, feeds, and length of stay in relation to DD development in most moderate to high levels of NICU care.

Despite the limitation of convenience, the setting of this study provided a consistent area for documentation of DD although the accuracy of the data was dependent on the subjective observation of the nurse. The setting of the study lacked an assessment tool specific to DD. Many assessment tools are available for the adult, but there are few published to reliably and accurately assess DD in the infant population. Visscher (2009) presents a DD tool that appears to include the main points for determination of severity and skin condition, but does not include

skin pigment and integration of levels of intervention. Buckley, et al. (2016) adapted a skin assessment tool nonspecific to DD and incorporated skin pigment, but the tool has not been validated in follow up studies. The lack of a standardized tool creates subjectivity in the DD assessment without an objective method to accurately assess skin pigment with severity or skin condition.

In addition, skin pigment may have contributed to the higher prevalence of DD among Caucasian infants versus African American infants. The pigment of infant skin is not acknowledged as a significant factor for assessment in infant DD studies (Esser & Johnson, n.d.). Darker skin demonstrates an elusive erythema not easily observed in most hospital settings (Doughty & McNichol, 2016). The difference in skin pigment and lack of a reliable and valid objective tool could have contributed to a lack of early identification and treatment of DD in darker pigmented infants. All infants in the study were provided consistent preventative DD care, but it is unknown if there were early signs of DD that were missed among infants with darker skin pigmentation.

There is also a lack of specific observations related to neurodevelopmental care related to DD in this study. The high prevalence of DD among infants ≤32 weeks GA in this study demonstrates the need to acknowledge the presence of neurodevelopmental protective techniques during the provision of DD care. Esser, et al., (2018) provided a basis for the use of neurodevelopmentally protective techniques during diaper care. The routine nature of the diaper change creates a repetitive behavior that may not include developmental care inclusion (Esser, et al., 2018). Due to the retrospective nature of the study, data was limited to information in the EHR and provision of neurodevelopmental protection during diaper changes is not specifically documented. The SSM for NICU DD accounts for the need for neurodevelopmental

considerations when listing age as a contributing factor, but could benefit from further emphasis related to neurodevelopmental provisions.

Nutrition is described in detail for the infant that developed DD in this study, but was lacking for those without DD. This lack of detail was due to the inability of the researcher to identify a similar timeframe to collect nutritional data among infants without DD because of the retrospective design of the study. The detail of nutrition for infants with DD is complicated in this study due to the multiplicity of feeding types at the time of DD. The infant could have been fed fortified human milk, formula, unfortified human milk, or received parenteral nutrition within the 24-hour period of data collection. Nutrition is an important component in wound healing among adults, but has not been studied in the NICU (Doughty & McNichol, 2016). This study also lacked the examination of growth velocity which could add strength to the impact of nutrition on skin vulnerability and DD development. Researchers have documented the impact administration of proper nutrition and specifically human milk can have on infant health outcomes (Abrams et al., 2014; Embleton et al., 2017).

Lastly, stooling frequency was not collected due to the standardized nature of diaper changes within the setting where the study was conducted. Although stooling frequency was mentioned as a clinical characteristic among many DD studies, it is unclear if diaper changes were done with each stool occurrence or a standardized approach (Alonso, et al., 2013; Li, Zhu, & Dai, 2012; Visscher, 2009; Visscher, Chatterjee, Munson, Pickens, & Hoath, 2000). The infants in the study had diaper changes every three hours which created difficulty in collecting accurate stooling frequency data.

Policy Revision

The results of this study provide evidence to support a revision to the national skin care guideline. The guideline was produced to provide a consistent reference for health professionals that provide skin care to infants. The current guideline lacks acknowledgement and integration of a specific guiding framework. The addition of the SSM for NICU DD can be added to provide a guide for the care, assessment, prevention, and research of DD in the NICU, but an adaptation of The SSM for NICU focused on all skin injuries may be more intuitive to guide the next revision overall.

The current national guideline also lacks delineation of DD care among infants of varying gestational age. Currently the guidelines do not provide detailed guidance for DD care for the extremely premature infant which, when open to interpretation, may provide a lack of preventative measures in those infants. This study demonstrated that DD did not occur until after infants reached full feedings and often that was after the first week of life. The extremely premature infant requires strict neurodevelopmental care during the first week of life including decreased stimulation and interventions if able. Preventative DD care could begin once the extremely premature infant begins stooling if after the first few days of life or once feedings are close to reaching goal. The results of this study support a waiting period in aggressive preventative care for the extremely premature infant. The guideline includes developmental bathing techniques and should consider the inclusion of developmental DD care to provide an added layer of neurodevelopmental protection.

It would also be important for the skin care guideline to acknowledge that safety and quality of outcomes should be emphasized in the provision of skin care, specifically prevention. Currently the guideline does not include recommendations for continuous surveillance to guide

continued quality improvement of skin care. The guideline could benefit from the addition of a toolkit that includes strategies to develop methods for continuous data collection and guidance related to development of quality improvement protocols. The toolkit addition can provide the necessary resources health professionals need to further explore the prevalence of skin injury and begin targeted quality improvement to decrease and ultimately eliminate skin injuries.

Practice Implications

The prevalence of DD observed in this study combined with the documented number of additional skin injuries among these infants demonstrates a need for process improvement for skin care of all infants requiring complex care especially within a Level IV NICU. Continued prevalence of DD promotes deeper examination into DD care prevention and treatment practices within this study setting. In this NICU setting health care practitioners or team members already follow a consistent standardized practice guideline for DD care, but the methods have not been adjusted since its implementation. Based on the moderate prevalence of DD in this setting, it will be important to reexamine prevention and treatment strategies in combination with DD product evaluation. The prevalence and work involved to decrease the DD rate provides a strong rationale to develop a team of experts to continue to address the prevalence of DD and other skin injuries.

The implementation of a skin team can assist to develop and implement a skin focused process improvement (Nist, et al., 2016). Skin team development has shown to increase awareness to skin injury while providing health care team members with support to provide consistent skin care for all infants in the NICU (Nist, et al., 2016). The skin team can incorporate safety principles from already established safety programs in the NICU such as prevention of central line infections and ventilator assisted pneumonia to elevate the culture of safety (White &

Dudley-Brown, 2012). The skin team can also contribute to safety programs that have components of skin care such as the prevention of surgical site infections or maintenance of central lines. Additionally, the skin team can provide sustained quality improvement which can include: education, identification of deficiencies in care, monthly reviews and education surrounding areas of concern, and the implementation of tools to build continued teamwork and safety (Nist et al., 2016; White & Dudley-Brown, 2012). Ultimately, the additional expertise that is provided by a specialized skin team can reinforce a culture of safety and continue to promote an environment of safety that supports optimal growth and development for all infants.

The inclusion of skin related data is lacking among national datasets such as Vermont Oxford Network (VON), a data repository that NICUs worldwide utilize to facilitate quality improvement initiatives and benchmark NICU outcomes. Pressure ulcer prevalence is a nationally recognized benchmark for skin injury among adults and more recently children (Murray et al., 2013). Additionally, pressure ulcers are considered preventable and a hospital acquired injury which may not be reimbursed by insurance companies for adults. There is potential for similar reimbursement issues among hospitalized children. Currently pressure ulcers among the NICU population are misunderstood and misdiagnosed in many NICU centers.

This study demonstrates not only the prevalence of DD among a fragile population, but also supports the need to recognize DD as an important benchmark for NICU outcomes. The clinical characteristics explored in this study reflect several benchmarks included in national datasets, such as the Vermont Oxford Network, including sepsis, respiratory support, and length of stay. The significance of the relationship between length of stay and DD in this study can be significant for exploring discrepancies in benchmark data meaningful to either preterm or term infants within the various networks or collaboratives.

Creating a benchmark for DD in the large datasets would promote development of skin related prevention and treatment data collection strategies and additional opportunities for nurse driven quality improvement. Including a prominent and common skin injury such as DD can lead to recognition of additional opportunities for research and implementation of clinically based prevention and early treatment efforts. Hospital acquired conditions are another focus of large datasets and benchmarking for quality of care. The hospital acquired conditions are considered preventable and include: ventilator assisted pneumonia, surgical site infections, central line blood stream infections, pressure ulcers, falls, and catheter associated urinary tract infections (Centers for Medicare and Medicaid Services, 2019).

Hospital acquired conditions are highlighted for patients of all ages due to the impact they have on morbidity and mortality (Patrick, et al., 2014; Visscher & Taylor, 2014). The impact of hospital acquired conditions are often the result of sepsis which skin serves as an important barrier. Data related to skin injury could add diversity to the explanation of overall morbidity and mortality in the NICU. Each of the hospital acquired conditions has a link to skin integrity or injury. The development and inclusion of skin related benchmark data would promote the use of additional preventative strategies for iatrogenic skin injury and hospital acquired conditions related to skin injuries. A reduction in skin injuries can impact the quality of care and potentially improve each infant's ability to attain their optimal growth and development in addition to other quality measures.

Future Research

The data in this study provides an exploratory view of DD within a single NICU that utilizes a standardized method for early detection, prevention, and treatment of DD. It is the ideal setting for continued investigation into DD among this population. This study provides the basis

for many areas of future DD research including assessment tool development, examination of microbiome involvement, examination of nutritional impact, and qualitative studies.

Despite the ideal setting there is a need to identify a reliable and valid tool to accurately assess skin condition in order to identify early risk, prevention, and treatment strategies for DD. The Neonatal Skin Condition Score (NSCS) is the most widely referenced skin condition tool, but has not had reliability or validity testing specific to the measurement of diaper dermatitis and lacks consideration of skin pigment (Lund & Osborn, 2004). Additionally, Visscher, et. al. (2014) presented an assessment tool that can be applied to DD including instruction, but lacks consideration for skin pigment. Buckley, et. al. (2016) presents the most reliable and valid tool to measure diaper dermatitis, but further application of this tool has not been published. These studies are mentioned due to the rigor demonstrated in the foundation of the each of the tools' development. However, although there is strength in each tool there are components missing that are integral to improving DD outcomes.

The DD assessment tools that were previously discussed also lack acknowledgement of the impact NICU clinical characteristics can have on development and severity of DD. The results of this study support the need to develop and/or adapt a tool to enable complete assessment of DD that would include acknowledgement of efficacy for prevention and management. The NSCS assessment tool is the most reliable and valid assessment tool for neonatal skin and would be the tool of choice to adapt. Adaptation of the tool would include the addition of skin pigment visualization and differentiation. These additional components need to be further examined to incorporate them into quantitative scoring and guidance for management. Skin pigment is an important component to include due to the diversity of skin tones among infants in the NICU. Identifying the various degrees of severity among darker skin tones may

contribute to improved DD prevention and early treatment to decrease the severity of the skin condition and pain these infants often experience. Having a well-developed reliable and valid skin assessment tool for use in the NICU is important to: 1) accurately identify the incidence of DD, 2) provide early identification of injury to provide early preventative management, 3) uncover commonalities among degrees of severity of DD, and 4) connect DD with specific clinical characteristics of the NICU. Additionally, the integration of a skin assessment tool within the EHR for daily nursing care would provide a mechanism for collecting reliable, ongoing quality data related to DD documentation. Healthcare providers not only need reliable and valid tools, but also need to consistently define clinical characteristics that predispose the patient to skin injury.

Microbiome

Researchers have noted a difference in the microbiome for infants born vaginally versus by cesarean section, which may be a factor that contributes to skin vulnerability in infant (Capone et al., 2011; Dunlop et al., 2015; Younge, Araujo-Perez, Brandon, & Seed, 2018). The majority of infants in this study with DD were ≤ 32 weeks GA with a high frequency of cesarean section birth and human milk enteral feedings, both of which impact the intestinal microbiome. Since the microbiome plays an integral role in the development of the innate immunity of the infant, we suspect the infant ≤ 32 weeks GA experiences a disruption that results in skin vulnerability (Visscher & Narendran, 2014). Skin pH, skin hydration, and transepidermal water loss also contribute to the innate immunity along with the development of DD in many infants (Visscher, et al., 1999; Visscher & Narendran, 2014; Visscher, et al., 2014)

Future studies should include physiologic measurements of skin (diapered and nondiapered) combined with microbial swabs at regular intervals during the NICU

hospitalization to provide additional information to fill the gap between microbiome and DD development. The continued examination of microbiome with physiologic measurements is important to further the understand the role skin physiology plays in the development of DD.

Nutritional Investigation

Nutrition is a common characteristic observed in many DD studies. The assumption in most studies is that the presence of feeds precipitates stooling therefore important in setting the context of the development of DD (Jordan, Lawson, Berg, Franxman, & Marrer, 1986). Intestinal microbiome can be influenced by feeding type including the additives provided within human milk (Shafizadeh, 2019). Nutrition practices vary by NICU, but consistently include the promotion of human milk administration and fortification of enteral feedings to provide optimal growth (Ehrenkranz, 2014; Menon & Williams, 2013; Thoene, et al., 2014; Tudehope, 2013; Wight et al., 2008). Numerous DD studies acknowledge feeding type, but do not examine significant relationships with DD (Esser & Johnson (n.d.)).

Human milk contains protective elements for immune function, but lacks specific nutrients required for optimal growth and nutrition in the premature infant (Tudehope, 2013). Premature infants require additional additives to human milk which is provided with bovine milk-based fortifier (AAP, 2012). Human milk fortifier can be provided as a non-human additive or as a human-milk additive to support optimal nutrition and caloric content in premature infants (AAP, 2012; Thoene, et al., 2014; Tudehope, 2013).

Many feeding types were collected in this study at one point in time. This study highlights enteral feeds limited to infants with DD. Future studies should collect type of enteral feeds among all infants longitudinally in association to DD development. A prospective,

longitudinal study would also provide the opportunity to collect growth velocity and humidity data from infants along the continuum of the NICU hospitalization.

Qualitative Research

Diaper dermatitis is also an experience of the caregiver. The results of this study do not capture the experience of the caregiver. Previous research used questionnaires targeted at the caregiver to gather information, but lacked incorporation of the caregiver experience (Esser & Johnson, n.d.). The diaper change is an important experience for specifically the parents, as it provides an opportunity to engage with their infant in a "normal" activity (Esser, et al., 2018). A study designed to collect parent experience can provide additional information related to consistency of DD management, severity assessment, management techniques, and opportunities for improvement (Fuber, et al., 2012).

Integrating family directed research and qualitative methods using the caregiver perceptions of DD could be helpful to build a basis for an expanded holistic approach in the NICU. Diapering is such an important part of the perception of parenting, that clinician collaboration can help parents develop confidence and independence in providing care for their infant. This engagement and support throughout the NICU hospitalization sets the stage for a successful transition home (Esser, et al., 2018). Obtaining a parental perspective to DD care, assessment, and management can improve outcomes and improve the methodology of future DD research.

Conclusion

Diaper dermatitis is preventable yet poorly recognized as a serious component for quality improvement among health care professionals in the NICU. Acknowledgement of the gap between identification of DD and the relationship to clinical characteristics of the infant in the

NICU is key to develop additional preventative strategies. This study demonstrates: 1) the usefulness of a skin specific model to guide research, 2) prevalence of DD among infants in the NICU, and 3) the identification of clinical characteristics of infants with and without DD in the NICU.

Furthermore, this study presents several areas for potential investigation to fill the gap in understanding DD among infants in the NICU. Morbidity and mortality are of major concern for the infant in the NICU and continued research related to not only DD, but factors leading to the skin injury has the potential to improve many other outcomes. Process improvements to develop skin teams and reevaluate current skin care management can also positively impact morbidity and mortality in the NICU. Diaper dermatitis is only one skin injury experienced by infants in the NICU. Further adaptation of the SSM targeting additional clinical characteristics specific to all skin injuries among infants in the NICU can expand the understanding of the role the NICU environment plays in skin vulnerability and health care providers and parents' ability to identify, prevent, and administer early treatment to further deterioration of the skin environment.

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Appendices:

Appendix A: Independent Variables (Demographics and Maternal Factors)

Variable	Definition	Data collection
Birth Weight of Infant	Weight of infant on admission to NICU	Weight in kg
Gestational Age at Delivery of Infant	Based on US at 18-20 weeks of pregnancy and documented as completed weeks at birth	As determined by US in weeks and days
Infant Gender	Sex of the infant	1=male 2=female
Infant LOS	Number of days after initial admission until discharge home	As determined by number of days
Race (maternal)		0=Unknown 1= African American 2= White/Caucasian 3 = Asian/Pacific Islander 4= American Indian or Alaska Native 5= Other
Delivery Method	The type of delivery method	1 = Vaginal 2 = Cesarean

Appendix B: Independent Variables (Clinical Characteristics)

Variable	Definition	Data Collection
Day of Life at Full Feeds	The day of life that intravenous IV fluids are discontinued	Day of life from birth
Date of Full Feeds	The date that intravenous IV fluid is discontinued	As determined by day, month, year
Total Number Skin Injuries Other Than DD	Skin injuries other than DD and surgical as documented by the RN in the EHR	Total number
Central Line Present	Central line presence within the 7 days before DD	1 = Yes 2 = No
Antibiotic exposure	Antibiotic use within the 7 days before DD.	1 = Yes 2 = No
Feeds at Time of DD	Presence of any type of enteral feeds at time of DD	1 = Yes 2 = No
Human Milk Feeds at Time of DD	Infant enteral feedings consist of breastfeeding or non-fortified human milk documented by the RN during the day of the initial documentation of DD	1 = Yes 2 = No
Pasteurized Human Donor Milk Feeds at Time of DD	Infant enteral feedings consist of pasteurized human donor milk documented by the RN during the day of the initial documentation of DD	1 = Yes 2 = No
Formula Feeds at Time of DD	Infant enteral feedings consist of formula documented by the RN during the day of the initial documentation of DD	1 = Yes 2 = No
Human Milk Fortified Feeds at Time of DD	Infant enteral feedings consist of human milk fortified with bovine milk-based fortifier or formula documented by the RN during the day of the initial documentation of DD	1 = Yes 2 = No
Parental Nutrition via IV at Time of DD	Infant received parenteral nutrition (TPN) intravenously documented by the RN during the day of the initial documentation of DD	1 = Yes 2 = No
Initial Date at Time of DD	Date that DD was entered in the EHR	As determined by Month, day, year
Resolution date of DD	Date documented as end date	As determined by Month, day, year
Gestational Age at Time of DD	Gestational age of the infant on the initial day DD was documented	As determined by US in weeks and days from birth
Weight at Time of DD	Weight of the infant on the initial day DD was documented	Documented as grams
Frequency of DD	The number of DD " new" occurrences charted that occur at least 7 days after the previous if more than one episode	1 = Yes 2 = No

Appendix C: Dependent Variable (Diaper Dermatitis)

Variable	Definition	Data Collection
Diaper Dermatitis (DD)	Diaper dermatitis is an inflammatory process that occurs in the diaper area of infants. Documented by the RN in the EHR when recognized on physical assessment.	1 = Yes 2 = No

CURRICULUM VITAE

Media S. Esser RN, MSN, NNP-BC, CWN

Biographical Information

Preferred Contact Information

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Education

Ph.D. 2016-2019	**University of Wisconsin- Milwaukee, School of Nursing**
Ph.D. 2014-2016	**University of Phoenix, School of Nursing (transferred to UWM)**
CWOCN 2016	**WebWOCN Nursing Education Program:** Wound, Ostomy
M.S.N. 2010	**Stony Brook University, School of Nursing**; Neonatal Nurse Practitioner
B.S.N. 2003	**Alverno College, School of Nursing**.

Publications

- Esser, M., Johnson, T.S. (2019). *An Integrative review of clinical characteristics of infants with diaper dermatitis.* Manuscript submitted for publication.
- Esser, M., et. al. (2018). Applying developmentally supportive principles to diapering in the NICU: What we know. *Neonatal Network,* 37(3), 149-154. doi: 10.1891/0730-0832.37.3.149
- Esser, M. & Anderson, S. (2018, 2019). Neonatal Skin Care Chapter 97. In Bhat, R., Kumar, P., & Vidyasagar, D. (Eds.), *The Handbook of Neonatology* (pp. 966-974). New Delhi, India: Indian Journal of Pediatrics.
- Esser, M. (2017, December). Diaper dermatitis: A common but serious issue in the NICU. Retrieved from https://resources.nurse.com/self-care-diaper-dermatitis-serious-issue-in-nicu
- Esser, M. (2017) *Diaper dermatitis in the NICU: Comparing occurrence with gestational age.* Advances in Neonatal Care, *Advances in Neonatal Care,* (online only).
- Esser, M. (2017). Case of the month: Leptospermum Honey for wound care in an extremely premature Infant. *Advances in Neonatal Care, 17*(1), 27-32.
- Esser, M. (2016). Case of the month: Diaper dermatitis: What do we do next? *Advances in Neonatal Care.16,* S21-25.
- Esser, M. (2014). The full term infant without congenital defects: Hospitalized infant diaper dermatitis care. In Das, UG, Liedel, JL, and Welak, SR. (Eds.), *The Medical College of Wisconsin Handbook for Care of the Ill Newborn and the Infant in the NICU, 7th ed.* (pp.127).

Licensure/Certifications

2003	Registered Nurse (RN) Wisconsin
2010	Advanced Practice Nurse (APN) Wisconsin
2010	BC-NNP, National Certification Corporation (NCC)
2011	NRP, Neonatal Resuscitation Provider, Certified Instructor, American Academy of Pediatrics
2016	Certified Wound Nurse (CWN)
2018	Registered Nurse (RN) New York

Experience

2010-	**Neonatal Nurse Practitioner, Children's Hospital of Wisconsin,** Milwaukee, Wisconsin
2019-	**Neonatal Nurse Practitioner Program Chair, Alverno College**, Milwaukee, Wisconsin
2013-2018	**Neonatal Nurse Practitioner, St. Mary's Madison**, Madison, Wisconsin
2015-2016	**Neonatal Skin Care Consultant,** Neotech Products, Inc. Valencia, California
2015-2018	**Neonatal Skin Care Consultant, Huggies Nursing Advisory Council,** Kimberly Clark, Inc,
2011-2013	**Neonatal Nurse Practitioner,** Aurora Medical Center Grafton, Grafton, Wisconsin
2009-2011	**Staff Nurse**, Waukesha Memorial Hospital, Waukesha, Wisconsin
2008-2009	**Nursing Administrative Supervisor**, Oconomowoc Memorial Hospital, Oconomowoc, Wisconsin
2008-2008	**Staff Nurse**, Rady's Children's Hospital of San Diego, San Diego, California
2003-2008	**Staff Nurse**, Children's Hospital of Wisconsin, Milwaukee, Wisconsin

Teaching Experience

2019-	Course Faculty Med-Ed, North Carolina Neonatal Certification Review Course
Fall 2018	Course Faculty PACE University- College of Nursing NURS 484: Improving the Health of the Population NURS 481: Core Competencies for Multidimensional Care NURS 489: Spirit of Inquiry: Nursing Research Accelerated Bachelor of Nursing Undergraduate Level Courses
Summer 2018	Course Faculty PACE University- College of Nursing NURS 484: Improving the Health of the Population NURS 426: Organizational and System Leadership in Nursing Accelerated Bachelor of Nursing Undergraduate Level Courses
Spring 2018	Course Faculty PACE University- College of Nursing

NURS 484: Improving the Health of the Population
NURS 489: Spirit of Inquiry: Nursing Research
Accelerated Bachelor of Nursing Undergraduate Level Courses

2016- Course Faculty
QTSC, New York
Neonatal Certification Review Course

2010-2011 Course Faculty
Alverno College of Nursing
N260: Nursing Physical Assessment
Bachelor of Nursing Undergraduate Level Course

Spring 2009 Adjunct Faculty
Cardinal Stritch University, College of Nursing
NRS 111: OB Clinical
Bachelor of Nursing Undergraduate Level Course

Fall 2007 Adjunct Faculty
Alverno College of Nursing
Clinical in Medical Surgical Clinical
Bachelor of Nursing Undergraduate Level Course

Honors, Awards, and Research Grants

2019 **Eta Nu Chapter of STTI Poster Award**
2019 **Eta Nu Chapter of STTI Excellence in Nursing Practice Award**
2019 **Finalist for 3MT at UWM**
2019 **Eta Nu Chapter of STTI Poster Award (1st Place)**
2018 **Nomination for Nurse Practitioner Excellence Award,** Children's Hospital of Wisconsin
2018 **Chancellor Award ($6,000 Fall/Spring 2018-2019),** University of Wisconsin Milwaukee
2016 **Chancellor Award ($12,000 Fall/Spring 2016-2017),** University of Wisconsin Milwaukee
2016-2019 **Nurse Faculty Loan Program (NFLP),** University of Wisconsin Milwaukee
2015 **Wound Ostomy and Continence Nurses Society** (**WOCN) Accredited Application Scholarship** ($2000)
2015 **Sigma Theta Tau International Omicron Delta Chapter Scholarship** ($1000)
2012, 2013 **Nomination for Nurse Excellence Award,** Children's Hospital of Wisconsin
2007 **Initial Fellow of Evidence Based Practice Fellowship;** focus on hospital wide skin care practices, Children's Hospital of Wisconsin.
2005-2007 **Nursing Education Loan Repayment**, HRSA
2002 **President's Scholarship**, Children's Hospital of Wisconsin

Professional Memberships and Certification

2019- Member, Sigma Theta Tau International Nursing Honor Society, Eta Nu Chapter
2018- Association of Women's Health, Obstetrics, and Neonatal Nurses (AWHONN)
2018- Midwest Nursing Research Society (MNRS)
2016- American Association of Critical Care Nurses (AACN)
2016- Wound Ostomy Continence Nurse Society (WOCN)
2012- Member, Sigma Theta Tau International Nursing Honor Society, Alpha Beta Chapter
2012- Member, Sigma Theta Tau International Nursing Honor Society
2010- National Association of Neonatal Nurses Southern Wisconsin Chapter
2008- National Association of Neonatal Nurses (NANN)

Presentations

- Esser, M., & Anderson, S. (2019). Commonly Seen and Treated Neonatal Skin Injuries. Annual State of Wisconsin Neonatal Nurses Conference, Milwaukee, WI. *Invited Speaker*
- Esser, M. (2019). Using the skin safety model to investigate diaper dermatitis in the neonatal intensive care unit. Accepted Podium Presentation. Sigma Theta Tau International 30th Annual Nursing Research Congress 2019, Calgary, Canada
- Esser, M. (2018). An Examination of the Association Between Diaper Dermatitis and Antibiotic Exposure in the Neonatal Patient. Accepted Podium Presentation. Sigma Theta Tau International 29th Annual Nursing Research Congress 2018, Melbourne, Australia
- Esser, M. (2018). No Baby Unhugged: The role you play and its lasting impact on infant development. 8th Annual National Association of Neonatal Therapists, Charlotte, NC. *Invited Speaker*
- Esser, M. (2017). Diaper Dermatitis in the NICU: Comparing Occurrence with Gestational Age. National Association of Neonatal Nurses Research Summit, Scottsdale, AZ.
- Esser, M., & Anderson, S. (2017). Leptospermum Honey in the NICU: Investigation of Usefulness in Wound Care. National Association of Neonatal Nurses, Iowa Chapter Conference, Cedar Rapids, IA. *Invited Speaker*
- Esser, M., & Anderson, S. (2017). Tiny People, Giant Problems: Commonly Seen and Treated Neonatal Skin Injuries. 33nd Annual National Association of Neonatal Nurses Conference, Providence, RI. *Invited Speaker*
- Esser, M. (2016, June). Skin Injuries in the NICU. [Webinar]. Neotech Cares Webinars. Retrieved from: http://www.neotech-cares-webinars.com/
- Jelinek, A., Esser, M., & Eisele, K. (2016, April). *Sweet Success! Healing an Extensive Wound in a Micro-Preemie with Active Leptospermum Honey.* Poster session presented at the National Association of Neonatal Nurses: Southern Wisconsin Chapter Conference, Waukesha, WI.
- Esser, M., & Anderson, S. (2016). Skin in the NICU. Neonatology Conference Presentation at Children's Hospital of WI. Milwaukee, WI
- Esser, M. (2016). Neonatal Skin and Wounds: Concepts & Considerations. Neonatology/Surgery Conference Presentation at Children's Hospital of WI. Milwaukee, WI

- Esser, M., Ludwig, S., & Kelly, K. (2016). Every Change Matters™: A New Look at Diapering for Healthy Skin and Development at 32nd Annual National Association of Neonatal Nurses Conference, Palm Springs, CA. *Invited Speaker*
- Esser, M. (2015, January). To Serve, Protect, and Treat: Two Neonatal Skin Care Challenges. [Webinar]. In Dandle LION Webinars. Retrieved from: http://www.dandlelion-webinars.com/previous-teleclasses/2015-2/archive-january-2015/
- Esser, M. (2015, August). *Skin Injuries in the NICU: Crunching numbers and moving forward.* Podium presentation at the Neotech Cares Conference. Valencia, CA.
- Esser, M. (2014). Skin Care Update: Focus on Diaper Dermatitis. RN Education Day. Fox Valley, WI.
- Esser, M. (2014). That Poor Little Bum! The Trials and Tribulations of Diaper Dermatitis. Oral presentation at WAPC Conference. Wisconsin Dells, WI.
- Esser, M. (2014). A case presentation of an infant with a full thickness wound. Case Presentation at Children's Hospital of WI. Milwaukee, WI
- Esser, M. (2014). That Poor Little Bum! The Trials and Tribulations of Diaper Dermatitis. Oral presentation at 2014 Pediatric Nursing Conference. Milwaukee, WI.
- Esser, M. (2013). Med School 101: Promoting Children's Hospital of WI's Neonatal ICU. Milwaukee, WI
- Esser, M. (2013). Skin Care Update: Focus on Diaper Dermatitis. RN Education Day. Milwaukee, WI.
- Esser, M. (2013). SWANN Journal Club Presentation**.** The use of INO in infants. Milwaukee, WI
- Esser, M. (2012). Infant Mortality panel presentation Sigma Theta Tau Joint Chapter Dinner. Milwaukee, WI.
- Esser, M. (2008). Semipermeable Membranes Usage in Controlling Transepidermal Water Loss in Premature Infants: An Integrative Review. Oral presentation for the National Association of Neonatal Nurses (NANN) Convention. Miami, FL

Poster Presentations

- Esser, M., & Johnson, T. S. (2019). *Diaper dermatitis factors: An integrative review.* Accepted for Midwest Nursing Research Society Conference 2019, Kansas City, Missouri
- Dore, S., Esser, M., Fitzgerald, F., Kelley, K., Kuller, J., Ludwig, S., & Peterman, D. (2018). *No baby unhugged: The lasting touch of a hospital hugger/cuddler volunteer program.* Presented at NANT 2018 Conference, Charlotte, North Carolina.
- Anderson, S., Paradise, J., & Esser, M. (2018). *Olmsted Syndrome: A Case of Skin Treatments for Twin Premature Girls.* Presented at SWANN 2018 Conference, Milwaukee, WI.
- Anderson, S., Paradise, J., & Esser, M. (2018). *Olmsted Syndrome: A Case of Skin Treatments for Twin Premature Girls.* Presented at the 34th Annual National Association of Neonatal Nurses Conference, Anaheim, CA.
- Jelinek, A., Esser, M., & Eisele, K. (2016, October). *Sweet Success! Healing an Extensive Wound in a Micro-Preemie with Active Leptospermum Honey.* Poster session presented at the 32nd Annual National

Association of Neonatal Nurses Conference, Palm Springs, CA.

- Esser, M. (2015, November). *Keeping Skin in the Game: Bringing Awareness to Neonatal Skin Injuries.* Poster session presented at the Sigma Theta Tau International Biennial Conference, Las Vegas, NV.
- Esser, M. (2015, October). *What Happened to My Arm! A Case Presentation on Management of a Full Thickness Skin Injury.* Poster session presented at the National Association of Neonatal Nurses Conference, Dallas, TX.
- Esser, M. (2015, September). *Keeping Skin in the Game: Bringing Awareness to Neonatal Skin Injuries.* Poster session presented at the Vermont Oxford Network (VON) Conference, Chicago, IL.
- Esser, M. (2014). Neonatal Skin Care with a Focus on Diaper Dermatitis: Creating and Implementing a Successful Policy Revision. Poster presented at the National Association of Neonatal Nurses (NANN). Phoenix, AZ
- Esser, M. (2014). That Poor Little Bum! The Trials and Tribulations of Diaper Dermatitis. Poster presented at the National Association of Neonatal Nurses (NANN) Conference. Phoenix, AZ.
- Esser, M. (2014). That Poor Little Bum! The Trials and Tribulations of Diaper Dermatitis. Poster presented at 2014 Pediatric Nursing Conference. Milwaukee, WI.
- Esser, M. (2014). That Poor Little Bum! The Trials and Tribulations of Diaper Dermatitis. Poster presented at Vermont Oxford Network (VON) Conference. Chicago, IL.

Professional Activities

2018- **Director-At-Large** National Association of Neonatal Nurses (NANN)

- Participate in strategic planning and policy setting to guide present and future decisions of the organization based on input from the members, stakeholders, and committees
- Represent the needs of the members to advance the profession of neonatal nursing while keeping the economic impact in mind
- Ensure effective use and management of resources
- Monitor and strengthen programs and services
- Maintain accountability while ensuring legal and ethical integrity
- Oversee the establishment of the annual budget and continual monitoring of finances of the organization
- Oversee the research pillar of the organization to ensure the committees' actions are consistent with the NANN mission and strategic plan as well as communicating board decisions to the committees
- Collaboratively oversee the development and production of the annual NANN Research Summit

2019- Liaison for the Neonatal Perinatal Section of the American Academy of Pediatrics for NANN

2019 **Reviewer,** British Journal of Nursing

2017-2018 **NNP Excellence Award Selections Committee member**, National Association of Neonatal Nurses (NANN)

2016- **Newborn and Fetal Concerns (NBFC) Research Council member**, Children's Hospital of Wisconsin

2016, 2018 **Reviewer,** Advances in Neonatal Care

2015 **Course Reviewer**, Skin-to-Skin Module, Aptara Inc.

2015-2018 **Conference Planning Committee Member**, 18th Annual Southeastern Wisconsin Nursing Research Conference, Milwaukee, Wisconsin

- Collaborated with the Southeastern Wisconsin Nursing Research Consortium members to plan the 18th annual conference
- Assisted with the coordination of vendor booths
- Participated in poster and podium abstract review

2014-2015 **Fellow, Maternal Child Health Leadership Academy, Sigma Theta Tau International,** Indianapolis, Indiana

- Participated in leadership retreats and intensive training to prepare to the development of a clinical project
- Developed a project highlighting the types of skin injuries documented in the NICU
- Coordinated a visiting scholar to present about neonatal skin care
- Presented a poster outlining the project development and results

2013-2018 **Vendor Coordinator,** National Association of Neonatal Nurses Southern Wisconsin Chapter Conference

- Identify up to 25-30 vendors for the local chapter conference
- Coordinate management of vendor needs including payments and specific needs for the conference
- Served as a resource for vendor relations with the chapter

2012-2017 **Nursing Research Council Member and Neonatal ICU representative**, Children's Hospital of Wisconsin

2014 **Conference Planning Committee Chair**, National Association of Neonatal Nurses Southern Wisconsin Chapter Conference (2014), Milwaukee, Wisconsin

2010-2015 **President**, National Association of Neonatal Nurses Southern Wisconsin Chapter

- Revitalized a nonactive chapter
- Recruited nurses from Milwaukee area NICUs with a final membership number of ~100 neonatal nurses and nurse practitioners before stepping down
- Coordinated vendor and outside sponsorship to build capital for chapter growth
- Developed yearly t-shirt drive to promote growth in capital
- Developed yearly educational meetings supported by vendors
- Oversaw the development of the revitalized chapter's first local conference