PRESSURE ULCERS AND PREVENTION AMONG PEDIATRIC PATIENTS AND FACTORS ASSOCIATED WITH THEIR OCCURRENCE IN ACUTE CARE HOSPITALS

BY

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Abstract

Introduction: Pressure ulcers are a health-care concern for all patient populations; however, younger patients, including infants, have different etiologies associated with pressure ulcer development. The influence of hospital, unit, and nursing factors on hospital-acquired pressure ulcers (HAPU) rates have not been evaluated in pediatric patients. Comparative data for pediatric patients is necessary for hospitals to improve the care related to prevention and treatment of pediatric pressure ulcers.

Purpose: The purpose of this study was to describe (a) the pressure ulcer prevalence rate and the rate of HAPU in pediatric patients; (b) the frequency of patient pressure ulcer risk assessment and prevention interventions; and (c) patient pressure ulcer risk and prevention interventions, microsystem factors, and mesosystem factors associated with HAPU among pediatric patients in U.S. hospitals.

Method: A descriptive correlational secondary analysis was performed on National Database for Nursing Quality Indicators® (NDNQI®) pressure ulcer data for 2012.

Results: This study found a pressure ulcer prevalence of 1.4% and a 1.1% rate of HAPU among pediatric patients 1 day to 18 years of age. HAPU rates were highest among children ages 9 to18 years (1.6%) and ages 5 to 8 years (1.4%) and among patients in the pediatric critical care units (3.7%) and pediatric rehabilitation units (4.6%). Most of the HAPU were Stage I and Stage II pressure ulcers (65.6%); 14.3% were suspected Deep Tissue Injury and 10.1% were unstageable pressure ulcers. The odds for a HAPU were 9.42 times higher among patients who were determined to be at risk for pressure ulcers (OR = 9.42, 95% CI [7.28, 12.17], p <.001) compared to those patients not at risk for pressure ulcers. Patients from pediatric hospitals had 2.67 higher odds for a HAPU compared to patients from nonpediatric hospitals (OR = 2.67, 95% CI [1.5,

4.76, $p = .001$). Among the 11,203 pediatric patients at risk for pressure ulcers, 95.8% received one or more prevention interventions. There were no prevention interventions associated with lower HAPU.

Conclusions: Acutely ill children develop pressure ulcers. Study findings provide baseline data on HAPU among hospitalized children and microsystem and mesosystem factors associated with their HAPU.

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Chapter 1

INTRODUCTION

Pressure ulcers are a health-care concern for all patient populations, and prevention of pressure ulcers is a focus of health care globally because these wounds cause considerable tissue harm and discomfort to patients (Peiper, Langemo, & Cuddingham, 2009). In addition to pain, pressure ulcers can cause altered body image due to physical changes as well as cause emotional, mental, and social consequences due to loss of independence associated with a pressure ulcer (Agency for Healthcare Research and Quality [AHRQ], 2012). Pressure ulcers are associated with a patient's decline in health-care status and an increase in patient health-care needs and hospital length of stay. Treatment costs are as high as $70,000 for a single pressure ulcer, and the extra total cost for treatment of pressure ulcers in the United States is estimated at $11 billion per year (Reddy, Gill, & Rochon, 2006; Russo, Steiner, & Spector, 2008: Russo, Steiner, & Spector, 2012). In the United Kingdom, researchers estimated costs to be 2.1 to 3.2 billion U.S. dollars annually due to higher daily costs of treatment and additional lengths of stay (Bennett, Dealey, & Posnett, 2004; Dealey, Posnett, & Walker, 2012).

Many critically and acutely ill children develop hospital-acquired pressure ulcers (HAPU). Nevertheless, there is limited information regarding the rate of HAPU among children and different pediatric populations. The detrimental iatrogenic effects of pressure ulcers in children include loss of the skin's protection, altered thermoregulation, deficiencies in metabolism, compromised immunity, and decreased sensation. Compromise of the epidermis or dermis from a pressure ulcer injury increases the risk for infection, other care complications, and possible psychosocial effects related to tissue damage and scarring (Schindler et al., 2011). In 1992, the U.S. AHRQ, formerly known as the Agency for Health Care Policy and Research,

provided guidelines on pressure ulcer prevention. These guidelines have served as the foundation for pressure ulcer prevention practice and for building new knowledge to treat pressure ulcers for the past 20 years. However, early and updated clinical practice guidelines for pressure ulcer prevention have focused on adult patients with limited application to pediatric patients (AHRQ, 1992; European Pressure Ulcer Advisory Panel [EPUAP] & National Pressure Ulcer Advisory Panel [NPUAP], 2009; EPUAP, NPUAP, & Pan Pacific Pressure Injury Alliance [PPPIA], 2014). There is a paucity of data on pressure ulcer prevention for children. There is also a need for valid and reliable instruments to assess patient pressure ulcer risk as the etiology differs in younger patients, including infants. In addition, there is limited evidence concerning risk factors that lead to pressure ulcer development in the pediatric population.

This chapter presents the background information about pediatric pressure ulcers and the problems pressure ulcers create in the health-care community. The research aims of this study are identified with the specific research questions listed. Justification for this study and definitions of key terms are provided.

Background

Pressure ulcers are defined as "a localized injury to the skin and/or underlying tissue, usually over a bony prominence, as a result of pressure or pressure in combination with shear. A number of contributing or confounding factors are also associated with pressure ulcers; the significance of these factors is yet to be elucidated" (EPUAP & NPUAP, 2009; EPUAP, NPUAP, & PPPIA, 2014). Ulcers form when arterioles and capillaries collapse under external pressure, thus decreasing the blood that nourishes the cells. The decreased oxygen and nutrients to these cells leads to tissue hypoxia, causing death of the cells that results in a pressure ulcer (Bryant, 2000). Tissue damage may also occur from shearing forces; however, how shear contributes to

cell death and pressure ulcer development is not well understood. Pressure ulcers can be staged from I to IV depending on the severity of tissue injury and may also be categorized as unstageable or suspected Deep Tissue Injury (sDTI). In some cases, pressure ulcers are found on mucous membranes (mucosal pressure ulcers); these generally develop when there is a history of a medical device pressed against the skin at the location of the pressure ulcer. The NPUAP (2012) does not recommend staging mucosal pressure ulcers because anatomically analogous tissue comparisons or distinctions cannot be made.

Measures of pressure ulcer rates and occurrence include prevalence, incidence, and whether the pressure ulcer was acquired within a health-care facility. Pressure ulcer prevalence is defined as the proportion of individuals in a population experiencing pressure ulcers at a given time (Gordis, 2009). Incidence is the frequency that pressure ulcers appear in a particular population during a specific time period (Gordis, 2009). The number of facility-acquired pressure ulcers is expressed as the proportion of patients without a pressure ulcer on admission who subsequently develop a (new) pressure ulcer during a stay at a health-care facility (Baharestani et al., 2009). The National Database for Nursing Quality Indicators® (NDNQI®; 2012a) measures of pressure ulcers include facility (hospital)-acquired pressure ulcers (NDNQI, 2012a). Estimating the rate of occurrence of new pressure ulcers is thought to provide a reflection of the effectiveness of a pressure ulcer prevention program and patient quality of care (Baharestani et. al., 2009; Bergstrom & Horn, 2011; Kohr & Curley, 2010).

Incidence and Prevalence of Pressure Ulcers Among Children

The prevalence and incidence, or rate of hospital-acquired pressure ulcers (HAPU) among children varies broadly and often reaches that of the adult rate. The prevalence of pressure ulcers among pediatric patients on the general pediatric floor ranges from 4% to 13%,

and the report of cross sectional pressure ulcer incidence among pediatric patients on general pediatric units ranges from 0% to 6% (Baldwin, 2002; Groeneveld et al., 2004; McLane, Bookout, McCord, McCain, & Jefferson, 2004; Van Gilder, Amlung, Harrison, & Myer, 2009; Waterlow, 1997; Willock et al., 2000; Willock & Maylor, 2004). In neonatal intensive care units (NICUs) and pediatric intensive care units (PICUs), the prevalence of pressure ulcers can reach 25% to 27% (Baldwin, 2002; Groeneveld et al., 2004; McLane et al., 2004; Van Gilder et al., 2009; Waterlow, 1997; Willock et al., 2000; Willock & Maylor, 2004). The incidence of pressure ulcers in children on NICUs and PICUs has been reported to be 1% to 7% (Baldwin, 2002; Gallagher, 1997, Waterlow, 1997; Willock, Harris, Harrison, & Poole, 2005; Willock et al., 2000).

Pediatric General Unit Studies Across All Unit Types

Studies of pressure ulcers in the pediatric population have been conducted across all pediatric unit types as well as by specific unit type. Among studies across all pediatric unit types, the prevalence of pressure ulcers was 4% in one study that included 1,064 children aged less than 10 days old to 17 years old in nine pediatric hospitals (McLane et al., 2004). Most of these pressure ulcers occurred in children less than 1 year of age (36%), were Stage I or II pressure ulcers (92%), and were facility-acquired (66%). Slightly higher results were reported by Gallagher (1997) in a study completed in the United Kingdom among pediatric units where a 6.5% prevalence and 7% incidence were observed. Kottner, Wilborn, and Dassen (2010) performed a systematic review of the literature to examine the frequency of pressure ulcers in the pediatric population and reported that the pressure ulcer incidence was 7% overall.

Prevalence estimates varied widely across the reviewed studies, ranging from 0.29% to 28%. A prevalence rate of 13.1% was reported by Groeneveld et al. (2004) among 97 children

admitted to a tertiary care pediatric hospital. In contrast, Baldwin (2002) reported a 0.47% prevalence rate and a 0.29% incidence rate of pressure ulcers from hospital response to a mailed survey with a 25% return rate. Noonan, Quigley, and Curley (2006) also reported a lower prevalence rate of 1.6% in hospitalized children.

Higher rates of pressure ulcer prevalence and incidence have been observed among children with chronic conditions. These patients with chronic conditions were also assessed to be at greater risk for pressure ulcers as they had lower pressure ulcer risk assessment scores indicating higher risk for pressure ulcers. In children with chronic conditions such as Spina Bifida, 944 of 4,533 hospital days (20.8%) could be attributed to loss of skin integrity (Pallija, Mondozzi, & Webb, 1999). Suddaby, Barnett, and Facteau (2005) found a 22% prevalence of skin breakdown among children ages 1 month to 21 years who had episodes of diarrhea and special medical devices close to the skin to which loss of skin integrity could be attributed. However, the terms *skin breakdown* and *pressure ulcers* have been used interchangeably in pediatric research, leading to confusion about reported numbers. McLane et al. (2004) reported a 14.8% prevalence of skin breakdown in pediatric patients, whereas the prevalence of pressure ulcers in those same pediatric patients was 4%. More research to clarify these results is needed.

Pediatric Intensive Care Unit Studies

Overall, studies on pressure ulcers in pediatric intensive care patients report higher prevalence and incidence rates than for other pediatric unit types. In a multisite study of nine PICUs (n = 5,346 patients), the overall pressure ulcer incidence was 10.2% and ranged from 0.8% to 17.5% across sites (Schindler et al., 2011). Curley, Razmus, Roberts, and Wypij (2003) found a 27% incidence of pressure ulcers in a multisite study of three pediatric intensive care units, most of which were Stage I or II pressure ulcers (97%). In another study including

pediatric intensive care patients, the prevalence of pressure ulcers was 8.7% while the rate of HAPU was 3.4 % (McLane et al., 2004).

Pediatric General Unit Studies Including Neonatal Patients

Studies that included neonatal intensive care patients as part of the sample also provided evidence for a higher rate of pressure ulcer occurrence in this population compared to general pediatric units. Schlüer, Cignacco, Miller, and Halfens (2009) conducted a multisite study on pressure ulcer occurrence in four hospitals in Germany and Switzerland with children from birth to 18 years of age; 24% were premature infants from the neonatal intensive care nursery. They found a 27.7% prevalence rate of pressure ulcers. Most pressure ulcers reported were Stage I (84%) and were located on the heels, ankles, or ears. Many were caused by medical equipment such as splints and braces. In contrast, Waterlow (1997) reported a 6% prevalence rate of pressure ulcers in a study of 300 children birth to 18 years of age from pediatric units, including 54 premature infants in the NICUs.

Neonatal Intensive Care Unit Studies

Only one study was found that focused on the incidence of pressure ulcers in neonates admitted to the intensive care nursery. Fujii, Sugama, Okuwa, Sanada, and Mizokami (2010) conducted a study of infants admitted to the neonatal units of seven different Japanese hospitals. Only neonates nursed in incubators were included in the study. A cumulative incidence of pressure ulcers (16%) was reported. Of the 14 pressure ulcers that developed, almost half were located on the nose. The dearth of studies in neonates limits our understanding of pressure ulcers in this population.

Summary of Prevalence and Incidence in Pediatric Studies

The age groups included in pressure ulcer studies have varied. Studies have included premature infants and children up to 18 years of age (Waterlow, 1997); other researchers have focused on more narrow age ranges such as those older than 1 month and younger than 9 years of age (Curley, Razmus, et al., 2003). Pressure ulcer rates by age group have not been reported. Moreover, it is unclear whether pressure ulcer rates among hospitalized children in the United States are similar to pressure ulcer rates among hospitalized children in countries outside the United States such as the United Kingdom, Switzerland, Germany, and Japan.

Studies have also varied by unit type. Some studies have included all pediatric unit types, while others have specifically focused on patients in PICUs. There have been differences conceptually in the definition and classification of pressure ulcers as well as differences in systems to categorize pressure ulcers, resulting in variation in pressure ulcer rate calculations. In addition, there has been a lack of distinction between pressure ulcers and skin breakdown (Kottner, Balzer, Dassen, & Heinze, 2009). Moreover, some researchers included Stage I pressure ulcers in their prevalence and incidence rates for HAPU studies while others excluded Stage I pressure ulcer rates.

Staging and Location of Pressure Ulcers on Children

Pressure ulcers among children occur most often on the occiput and other locations such as the nose, ear, chin, or neck. Their location varies by age, and the likelihood of developing sacral and heel pressure ulcers increases as the child grows older (Kottner et al., 2010). McLane et al. (2004) reported that 31% of all skin breakdown was found on the head, 20% on the sacrum, and 19% on the foot in a study of 1,064 pediatric patients in nine hospitals. The occipital area was the most frequent location of pressure ulcers noted in young children because it is the

heaviest and largest bony prominence. (Amlung, Miller, & Bosley, 2001; Curley, Razmus, et al., 2003; Kottner et al., 2010; Noonan et al., 2006; Razmus, Roberts, & Curley, 2001; Suddaby et al., 2005; Zollo, Gostisha, Berens, Schmidt, & Weigle, 1996). Schlüer et al. (2009) reported many pressure ulcers in children were caused by medical devices. Medical devices are a source of externally applied pressure that causes tissue ischemia. Medical device-related pressure ulcers (MDRPU) are localized tissue injury located below a medical device, mirroring the shape of the medical device (Murray, Noonan, Quigley, & Curley, 2013). Example devices that have been reported to cause pressure ulcers include nasal cannula tubing, braces, splints, oxygen masks, endotracheal tubes, and splints (Baharestani, 2012; Boesch et al., 2012).

Risk Assessment and Pressure Ulcer Prevention

A number of studies have examined pressure ulcer risk in pediatric patients. Some describe pressure ulcer risk assessment instruments for the pediatric or neonatal population while others discuss individual factors that may place the patient at risk for pressure ulcers. Most studies were single-sited and examined the bivariate relationship between patient risk and pressure ulcer development. Few studies have analyzed the multivariate association among patient factors and pediatric pressure ulcers. Moreover, little is known about pressure ulcer prevention in the pediatric population. There is also no evidence as to the impact of unit type, nursing factors, and hospital characteristics on pressure ulcer development among children. A more detailed discussion of pressure ulcer risk and prevention can be found in Chapter 2.

Purpose of the Study

The overall purpose of this study was to determine the prevalence of pressure ulcers and the rate of HAPU among pediatric patients; examine pressure ulcer risk assessment in pediatric patients; determine the frequency of pressure ulcer prevention; and examine patient factors (age,

gender), patient pressure ulcer risk and prevention interventions (general, pressure redistribution surface use, repositioning, moisture management, nutritional support), microsystem factors (unit type and nurse staffing measures), and mesosystem factors (hospital type and characteristics) associated with pressure ulcers in pediatric patients. A secondary analysis of existing 2012 NDNQI data was conducted.

Research Question #1

Health-care outcomes such as pressure ulcers are reported by hospitals to national databases and used as a measure of health-care quality. Patients of all ages are at risk for pressure ulcers, and pressure ulcer occurrence has become a key indicator of patient safety for all patient populations, including infants (Institute for Healthcare Improvement [IHI], 2008; The Joint Commission on Healthcare Quality, 2007; McCannon, Hackbarth, & Griffin, 2007; NPUAP & EPUAP, 2009). However, there is little current information about how these rates vary by unit type. Thus, the first research question for this study was as follows: What was the prevalence of pressure ulcers (both community-acquired and hospital-acquired) and the rate of hospital-acquired pressure ulcers (HAPU) in pediatric patients in the United States in 2012? Subquestions for this research question are listed below:

1a. What was the prevalence of pressure ulcers and rate of HAPU in 2012?

1b. What was the rate of HAPU by age in 2012?

1c. What was the rate of HAPU by gender in 2012?

1d. What was the rate of HAPU by unit type in 2012?

1e. What was the distribution of HAPU by category or stage overall and by unit type in 2012?

Information gained from this study clarified and identified the rate of HAPU among children on different pediatric unit types.

Research Question #2

Pressure ulcer reduction has been a national patient safety goal of the Joint Commission on Health Care Quality (2007) and the American Nurses Association (ANA; 2012). Identifying factors such as how patients are determined to be at risk for pressure ulcer development provides baseline knowledge on which to predicate improvement activities. Understanding factors such as how and what prevention strategies are being used effectively among different pediatric unit types also guides improvement strategies. Compared to research conducted on pressure ulcers in the adult population, the number of studies completed regarding pressure ulcer occurrence in the pediatric population is minimal. Furthermore, evidence of methods used to assess patient pressure ulcer risk and the frequency of those assessments is missing. Therefore, the second research question for this study is as follows: What was the frequency of patient pressure ulcer risk assessment in pediatric patients in the United States in 2012? Subquestions for this research question are listed below:

2a. What was the frequency of patient skin assessment within 24 hours of admission overall and by unit type based on the 2012 data?

2b. What was the frequency of patient pressure ulcer risk assessment within 24 hours of admission overall and by unit type based on the 2012 data?

2c. What was the timing of the last patient pressure ulcer risk assessment overall and by unit type based on the 2012 data?

2d. What methods were used to assess patient pressure ulcer risk overall and by unit type based on the 2012 data?

Information gained from this study identified current practices with pressure risk assessment use and frequency among pediatric patients.

Research Question #3

Prevention interventions play an important role in pressure ulcer prevention. Guidelines for pediatric patients at risk for pressure ulcers and the best interventions to prevent pressure ulcer development have not been established (Schindler et al., 2011). Evidence of the frequency of use of current prevention strategies, such as pressure reduction, support surfaces, repositioning, moisture management, and nutritional support in pediatric units, is scarce. Pressure ulcer interventions have been associated with lower rates of pressure ulcers; however, there is a need to understand which interventions and other factors are more successful in preventing pressure ulcers (Soban, Hempel, Munjas, Miles, & Rubenstien, 2011). For example, in the adult population, patients who received interventions such as a skin risk assessment, pressure ulcer risk assessment, and a risk re-assessment within 24 hours of admission were less likely to develop a pressure ulcer. Some of these interventions were not being applied as frequently as needed (Bergquist-Beringer, Dong, He, & Dunton, 2013). Based on the lack of current evidence concerning pressure ulcers and prevention measures, the following research question was developed: What was the frequency of use of pressure ulcer prevention interventions in pediatric patients in the United States at risk for pressure ulcers based on the 2012 data? Subquestions for this research question are listed below:

3a. What proportion of patients were determined to be at risk for pressure ulcers overall and by unit type based on the 2012 data?

3b. What was the frequency of pressure ulcer prevention interventions used overall and by intervention type based on the 2012 data?

3c. What was the frequency of use of pressure ulcer prevention interventions by unit type based on the 2012 data?

Information gained from this study provided baseline knowledge regarding prevention interventions among infants and children, examined pressure ulcer risk assessment in pediatric patients, and determined the frequency of pressure ulcer prevention.

Research Question #4

Evaluating multiple factors that have an impact on pediatric pressure ulcer development is important to future prevention efforts to reduce the occurrence of HAPU. Currently, there is a lack of endorsed measures for pediatric pressure ulcer prevention as compared to measures to prevent pressure ulcers in adults from key organizations such as the National Quality Forum, the Department of Human Services, or the Center for Medicare and Medicaid Services.

Because of this lack of preventative measures, the fourth research question for this study was developed: What patient factors (age, gender), patient pressure ulcer risk, prevention interventions (general, pressure redistributions surface use, repositioning, moisture management, nutritional support), microsystem factors (unit type and nurse staffing measures), and mesosystem factors (hospital type and characteristics) are associated with HAPU among pediatric patients in the United States for 2012? Subquestions for this research question are listed below:

4a. What was the bivariate association between each independent variable and HAPU based on the 2012 pressure ulcer data?

4b. What patient factors (age, gender), patient pressure ulcer risk, microsystem factors (unit type and nurse staffing measures), and mesosystem factors (hospital

characteristics) were associated with HAPU among all study pediatric patients in hierarchical logistic regression analysis based on the 2012 data?

4c. What patient pressure ulcer risk, prevention interventions (general, pressure redistributions surface use, repositioning, moisture management, nutritional support), microsystem factors (nurse staffing measures), and mesosystem factors (hospital characteristics) are associated with HAPU among pediatric patients who were determined to be *at risk for pressure ulcers* in hierarchical logistic regression analysis based on the 2012 data? (See Table 4.)

The National Quality Forum (NQF, 2011a, 2011b), along with U.S. Human Services, created a Partnership for Patients to prevent pressure ulcers and lower pressure ulcer rates by 40%, primarily utilizing financial incentives as the motivating factor; however, this initiative was created only for those health-care providers working with patients 18 years and older. Significant findings from this study may provide evidence to support inclusion of children ages 0 to 18 years of age in pressure ulcer quality measures. Little is known about the association between prevention interventions and pressure ulcer outcomes. Likewise, the impact of unit type, nursing factors, and hospital characteristics on pressure ulcer rates in the pediatric population is unknown.

Assumptions

This study was based on the following assumptions:

- The identification and staging of pediatric pressure ulcers was performed by health-care professionals who received education and training in pressure ulcer identification as identified in the NDNQI guidelines for Data Collection and Submission on Quarterly Indicators (NDNQI, 2011).

- Data collection of patient pressure ulcer risk and prevention interventions was performed by health-care professionals who have received training on pressure ulcer data collection as identified by the NDNQI (2011) guidelines for Data Collection and Submission of Quarterly Indicators.
- The data entered into the NDNQI was submitted by a health-care professional competent in pressure ulcer data entry as evidenced by completion of a competency test and assessment by the NDNQI team post data entry (NDNQI, 2011).
- Data reported on hospital characteristics to NDNQI by health-care institutions were reported honestly and accurately.

Definitions of Terms

Thirteen key terms have been selected and defined for the purpose of this study. The terms are bolded and listed alphabetically in the paragraphs that follow.

Pressure ulcers are conceptually defined as a localized injury to the skin and underlying tissue, usually over a bony prominence, as a result of pressure or pressure in combination with shear. A number of contributing or confounding factors are also associated with pressure ulcers; the significance of these factors is yet to be elucidated (EPUAP, NPUAP, & PPPIA, 2014). The operational definition is the presence of a pressure ulcer as reported in the NDNQI database: yes or no, total number of pressure ulcers (both community-acquired and hospital-acquired), number of HAPU, and number of pressure ulcers in each category or stage.

Hospital-acquired pressure ulcer (HAPU) is conceptually defined as a new pressure ulcer that developed after admission to a facility (NDNQI, 2012a). The operational definition is the count of HAPU and their category (Stage I, Stage II, Stage III, Stage IV, unstageable, suspected Deep Tissue Injury, and indeterminable) as reported in the NDNQI database.

Pressure ulcer risk assessment is conceptually defined as methods used for identifying patients at risk for pressure ulcer development (Guy, 2007) and the timing of the assessment. Use of a validated instrument is recommended for assessing patient pressure ulcer risk, but the NDNQI does not require facilities to use a particular scale to submit pressure ulcer data. Assessment may reveal other clinical factors that placed patients at risk for pressure ulcer development (e.g., gestational prematurity, existing pressure ulcer, or prolonged surgery). The operational definition is the performance of patient pressure ulcer risk assessment within 24 hours of admission, the timing of the last risk assessment, the method used to assess patient pressure ulcer risk, the scale score, and the determination of risk status as recorded in the NDNQI database.

Pressure ulcer prevention is conceptually defined as the performance of interventions to reduce factors placing the patient at risk for pressure ulcers. The operational definition is the type of pressure ulcer prevention intervention (skin assessment, pressure redistribution surface use, routine repositioning, moisture management, or nutritional support) in use within 24 hours before the NDNQI Pressure Ulcer Survey as recorded in the NDNQI database.

Skin assessment is conceptually defined as the evaluation of the patient's entire skin (from head to toe) with emphasis on bony prominences and other areas at risk for pressure ulcer development where there may be signs or symptoms of tissue injury (NDNQI, 2012a). Patients should be assessed within 24 hours and at least daily thereafter (IHI, n.d.). The operational definition is the performance of skin assessment within 24 hours of admission as documented in the NDNQI database and the performance of a skin assessment during the 24-hour period before the NDNQI Pressure Ulcer Survey as recorded in the NDNQI database.

Pressure redistribution surface is conceptually defined as the use of a special support surface to redistribute pressure on skin and subcutaneous tissue or other parts of the body exposed to pressure. Types of support systems include air, gel, water, or high density foam mattresses; overlays; and padding or positioning devices to protect from pressure (NDNQI, 2012a). The operational definition is pressure redistribution surface use during the 24-hour period before the NDNQI Pressure Ulcer Survey as recorded in the NDNQI database.

Routine repositioning is conceptually defined as the turning or repositioning of patients to reduce the duration and magnitude of tissue pressure. The usual standard of care for patients unable to reposition themselves is routine repositioning every 2 hours while in bed (NDNQI, 2012a). The operational definition is routine repositioning as prescribed during the 24-hour period before the NDNQI Pressure Ulcer Survey as recorded in the NDNQI database.

Nutritional support is conceptually defined as nutrients that can be taken orally (oral intake), provided through a feeding tube (enteral nutrition), or provided intravenously (parenteral nutrition) (NDNQI, 2012a). Nutritional deficiencies decrease the ability of the soft tissue and skin to tolerate pressure. The nutritional status of a patient at risk for pressure ulcers should be assessed. Patients at risk for both pressure ulcers and nutritional deficiencies should receive nutritional support such as macronutrients (carbohydrates, proteins, and fat) and micronutrients (vitamins and minerals). The nutrients can be taken orally (oral intake), provided through a feeding tube (enteral nutrition), or provided intravenously (parenteral nutrition) (NDNQI, 2012a). The operational definition is the provision of nutritional support within the 24-hour period before the NDNQI Pressure Ulcer Survey as recorded in the NDNQI database.

Moisture management is conceptually defined as pressure ulcer interventions that include keeping the patient clean and dry, using absorbent underpads, applying a moisture

barrier, managing urinary and fecal incontinence, and draining wounds (NDNQI, 2012a). The operational definition is moisture management within the 24-hour period before the NDNQI Pressure Ulcer Survey as reported in the NDNQI database.

Conceptually, the **age** of a pediatric inpatient is defined as the amount of time that the child has lived. Pediatric patients range in age from birth to 18 years (NDNQI, 2012a). The operational definition is the age of pediatric inpatients in days, months, or years as reported in the NDNQI database. For neonates, the gestational age in weeks is reported in the NDNQI database.

Gender is conceptually defined as the sex of the individual pediatric inpatient (NDNQI, 2012a). The operational definition is male or female as reported in the NDNQI database.

Clinical microsystems are conceptually defined as a small group of people who work together, such as a clinical unit, to provide direct care for a subpopulation of individuals. Microsystems are a part of a larger system called a mesosystem (Batalden, Godfrey, & Nelson, 2006). A unit is considered eligible to participate in a NDNQI survey if at least 90% of the patients receive a level of care (unit type) specified on the survey or 80% of the patients fall under the specialty of care offered by the clinical microsystem (NDNQI, 2012a). The operational definition is eligible pediatric units that submitted data on pressure ulcers in 2012 as reported in the NDNQI database, including pediatric step down units, medical units, surgical units, medical-surgical units, rehabilitation units, pediatric critical care units (PCCUs), PICUs, neonatal critical care units (NCCUs), and NICUs. The operational definition is nurse staffing measures: registered nurse care hours per patient day (RNHPPD) and percent registered nurse (RN) skill mix, or the proportion of total hours provided by RNs, as reported in the NDNQI database.

Clinical mesosystems are conceptually defined as the relationships and interactions between microsystems. A collection of microsystems works toward a common goal such as health care. Several clinical microsystems, such as acute care units, have a relationship that creates a mesosystem, such as the hospital. These units work together to provide care to hospitalized patients (Batalden et al., 2006). The operational definition is the hospital type (i.e., children's hospital, general acute care hospital) and the characteristics (Magnet status, teaching status, metropolitan status, hospital bed size) as identified in the NDNQI database.

Summary

This chapter presented information about the importance of HAPU in children and provided an overall view of the current state of science for hospitalized children. This chapter also presented concepts and operational definitions to be used for this study. Pressure ulcer prevention is an important health issue for children that has had limited evidence to guide pressure ulcer prevention interventions. This chapter also presented the research questions to be addressed in this study. Due to the paucity of data related to HAPU in children, further research is warranted to guide prevention practices in the pediatric population. The next chapter presents an integrative review of the literature regarding HAPU in children.

Chapter 2

REVIEW OF THE LITERATURE

Pressure ulcer development is considered a preventable occurrence in the hospital and an indicator of nursing care quality and hospital performance. This review of the literature addresses the main concepts related to pressure ulcers in children including findings from previous research studies. More specifically, the review includes discussion on (a) the differences in health care for children and adults; (b) a theoretical framework of pressure ulcers; (c) factors related to pressure ulcer development, including hospital, unit type, and nursing factors; (d) assessment of pressure ulcer risk in children; (e) prevention of pressure ulcers in children; and (f) the limitations and gaps in knowledge of pediatric pressure ulcer research.

Differences in Health Care for Children and Adults

Children's health-care needs are uniquely different from adult health-care needs (National Quality Forum [NQF], 2009). The challenges faced by nurses administering health care to children are identified as differential epidemiology of child health care as compared to adult health care, dependency on caregivers, demographics, and development. The differential epidemiology of pediatric health care refers to the ability to generalize evidence for children relative to other or older age groups. In general, children comprise a healthy age group. Children are also dependent on parents or a caregiver for all aspects of care, including accessing and receiving, paying for, and evaluating health care. Actual care may be dependent on the parent's understanding of the care and communicating care needs as well as providing care in collaboration and cooperation with the child (NQF, 2009).

Sick children are usually cared for at home by their family, and they may be hospitalized for a variety of reasons. A number of children who are discharged from the neonatal intensive

care unit (NICU) return to the hospital for medical needs (Underwood, Danielsen, & Gilbert, 2007). Children in the NICU are susceptible to pneumonia since they were born prematurely with premature lungs and may have been previously dependent on a ventilator to breathe (Morris, Gard, & Kennedy, 2009). Children born with congenital anomalies and those living with chronic illnesses (such as cerebral palsy, muscular dystrophy, or cystic fibrosis) are also frequently hospitalized as are those needing repetitive surgeries (such as repair due to neurologic or cardiac diseases) (Annibale et al., 2012; Mackie, Ionescu-Ittue, Pilote, Rahme, & Marelli, 2008; Murphy, Hoff, Jorgensen, Norlin, & Young, 2006;Yoon et al., 1997). These children are often dependent on medical devices and are possibly less mobile than most children their age.

Children are more likely than adults to live in poverty and belong to a minority group; thus, they are more vulnerable than adults. Adolescents and young adults are less likely than older adults to be insured, and those in poverty are more likely to be on government assisted care such as Medicaid. Living in poverty and belonging to a minority group can have an impact on the development of the child, especially on the development of premature infants (Aber, Bennett, Conley, & Li, 1997; NQF, 2009).

A child's developmental success depends on a variety of physiological, emotional, and cognitive developmental factors; therefore, specific health-care services for one age group, such as premature infants, may be inappropriate for another age group, such as school age children. Furthermore, a child's developmental level influences his or her health-care needs. Valid and reliable tools to assess these needs are important for each level of a child's development as his or her causative factors differ. Reliable tools are a critical first step in addressing the different epidemiology and developmental levels of children as they relate to pressure ulcer development. It is important to base care and clinical practice from pressure ulcers on nationally recognized

standards for children based on empirical evidence, but this information is scarce (Baharestani & Ratliff, 2007). Future development of a theoretical framework that focuses on the health-care needs of children is needed to identify the domains and subdomains of pressure ulcer development based on current evidence. The following paragraphs describe a proposed framework.

Theoretical Framework

A conceptual model of pressure ulcer development guided this discussion of pressure ulcers in the pediatric population. The foundation of the schema of pediatric pressure ulcer development (see Figure 1) is Braden and Bergstrom's conceptual schema depicting factors in the etiology of pressure sores (Bergstrom, Braden, Laguzza, & Holman, 1987). According to this conceptual schema, the critical determinants of pressure ulcer development are the intensity and duration of pressure and tissue tolerance to pressure (Bergstrom et al., 1987). Factors such as mobility, activity, and sensory-perception affect the intensity and duration of pressure. Tissue tolerance to pressure is affected by extrinsic and intrinsic factors. Extrinsic factors include moisture and shear. Intrinsic factors include age, nutrition, and hemodynamic alterations. Within the acute care setting, hospital structures (the mesosystem) and unit processes (the microsystem) may also influence pressure ulcer development. A schema for children that includes the hospital (mesosystem) and unit (microsystem) and also the essential elements of pressure ulcer development is represented in Figure 1.

Factors Associated with Pressure in Pressure Ulcer Development

Pressure. Pressure is defined as the amount of force applied perpendicular to a surface area. Skin that has been exposed to damaging levels of pressure appear pale from the reduced blood flow and ischemia. If the pressure is not relieved, the blood cells may aggregate and block

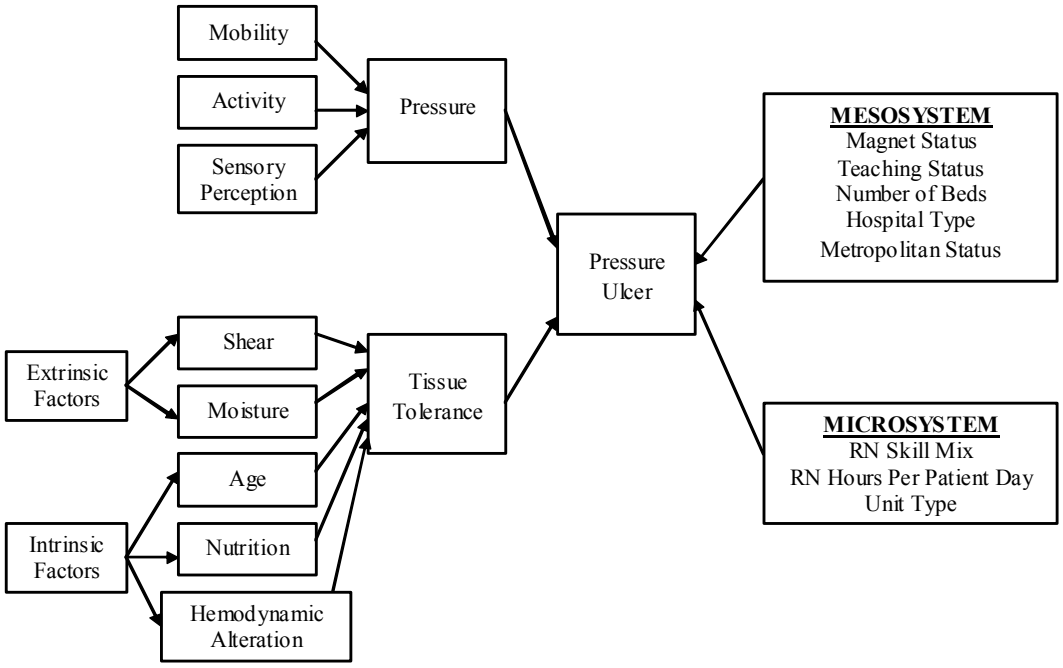

Figure 1. Schema of pediatric pressure ulcer development.

capillaries increasing the ischemia (Takahashi, Black, Dealy, & Gefen, 2010). The capillary walls become damaged causing red blood cells and fluid to leak into the interstitial space (Revis & Geibel, 2012). Continuing tissue anoxia leads to cell death, necrosis, and destruction. Gefen (2008) reviewed research findings from adult, animal, and invitro models and found that pressure ulcers in subdermal tissues over bony prominences most likely develop between the first hour and four to six hours after constant exposure to pressure loads. Pressure from medical devices against the skin may also lead to rapid pressure ulcer development.

Keeping the pressure load less than 32 millimeters of mercury (mm Hg) is thought to be sufficient to prevent the development of pressure ulcers (Shoemake & Stoessel, 2007). A pressure load of more than 32 mmHg places the patient at risk for pressure ulcer; however, the

magnitude of the mechanical load leading to pressure ulcer development is inversely related to the duration of time the load has been applied (Shoemake & Stoessel, 2007). The damaging effects of the magnitude and duration of pressure were initially reported by Kosiak (1959), who found that increased loads for shorter periods of time and decreased loads for longer periods of time led to pressure ulcer development. Reswick and Rogers (1976) extended this research and reported that magnitude and duration are important in pressure ulcer development in that patients' with poor tissue integrity had less tolerance for pressure over a shorter time period. Critically ill patients with hemodynamic instability and comorbid conditions may experience pressure ulcers at lower pressures (Lyder & Ayello, 2008).

Mobility. Immobility is theorized to decrease the individual's ability to change body position and results in increased pressure from exposure to intense and prolonged pressure. Decreased mobility intensifies the risk for increased and prolonged pressure leading to tissue destruction. Immobility can occur during an acute illness, because of disease, or because the patient may be sedated, restrained, require surgery, or may be immobilized by a cast or medical equipment (Baldwin, 2002; Langemo & Brown, 2006). Schindler (2010) found that lower scores on the mobility subscale of the Braden Q Scale for Predicting Pediatric Pressure Ulcer Risk (Braden Q) (Quigley & Curley, 1996) were related to pressure ulcer development.

Muscle tone is flaccid around 28 weeks gestation with primary reflexes becoming progressively stronger into adulthood (Amiel-Tison, 2002). The effect of developmental level on spontaneous movement and its role in pressure ulcer development is not well understood but important in the very young. Spontaneous movement is demonstrated in full-term infants through flexion of all four extremities and turning the head from side to side (Razmus, Lewis, & Wilson, 2008). When an infant or child is sick, spontaneous movement occurs less frequently

because of decreased muscle tone (Corrales & Starr, 2010). Moreover, neither full-term or premature infants are able to move away independently from pressure since their neuromuscular systems may not be well coordinated. If a child is unable to move independently, the child is at risk for increased pressure for an extended period of time leading to pressure ulcers.

In some cases, sick children are physically or pharmacologically immobilized for therapeutic reasons, limiting their ability to change position spontaneously (Manley, 1978). Curley, Razmus, et al. (2003) found that younger pediatric patients who were chemically paralyzed were more likely to develop pressure ulcers. Murdoch (2002) reported spinal immobilization boards, which limited movement, to be associated with pressure ulcers in children. In a study of 1,064 patients in nine hospitals, McLane et al. (2004) determined that immobile patients developed more pressure ulcers. Other conditions or factors limiting mobility that are associated with the development of pressure ulcers in pediatric patients include hypotension, sepsis, medical devices (mechanical ventilation), and critical and terminal illness (Baldwin, 2002; McCord, McElwain, Sachdeva, Schwartz, & Jefferson, 2004). Sometimes medical equipment, such as a ventilator tube, may be placed on a child's skin creating pressure which he or she cannot remove. Schindler (2010) reported that children who required extracorporeal membrane oxygenation (ECMO) have a significantly greater risk for pressure ulcers because of limited movement.

Children are also less mobile after surgery. In a study by Nixon, Brown, and McElvenny (2000), there was an association between decreased mobility on the first postoperative day and pressure ulcers in adult surgical patients. However, there are no reports specific to surgery and immobility in children and an association with pressure ulcer development, which creates a need for more research in this pediatric population.

Children who are more immobile due to chronic disability are also more prone to pressure ulcer development. In children with chronic conditions such as spina bifida, developing a pressure ulcer increased the child's length of hospital stay by 20% (Pallija et al., 1999). After reviewing the literature, Wu, Ahn, Emmons, and Salcido (2009) reported that children with spinal cord injuries such as spina bifida, lap belt injuries, birth injuries, child abuse, juvenile rheumatoid arthritis, Down's syndrome, and cervical spinal cord injury were more likely to experience pressure ulcers from immobility. In addition, chronically ill children may also experience developmental delays due to their disabilities that further impact their mobility. More research is needed in understanding mobility and pressure ulcer development in children.

Activity. Activity refers to a patient's capacity to remove pressure by standing or walking (Braden & Bergstrom, 1987). This ability would also be affected by a child's developmental level or age as well as the level of health. Sicker children are often confined to a bed or chair (Quigley & Curley, 1996). Presently, no studies have specifically identified an association between chair-bound children and pressure ulcer development although it may be inferred from studies in children with spinal cord injuries.

Sensory perception. Senses are needed for survival, growth, and development as well as bodily pleasure. If the senses are altered, this affects a person's ability to function in the environment. Younger children can experience a change in sensory perception even if they are unable to communicate pain or discomfort because their sensory perception is still developing. For example, the premature infant whose neurological system is still maturing may not be able to recognize the sensation of pressure, much less move away from it.

Factors that lessen a child's ability to recognize and relieve the sensation of pressure render the patient vulnerable to pressure ulcer development (Vogel, Hickey, Klaas, & Anderson,

2004). Critically ill children are more likely to experience decreased sensory perception from their illness (McCord et al., 2004). More research is needed to provide evidence regarding these phenomena. A child with a compromised central nervous system may not be aware of the sensation of pressure and may not change position in response to that sensation. Pallija et al. (1999) found that children with alternate insensate perception associated with spina bifida were at risk for pressure ulcers. Sensory perception is further compromised in infants with central neurological impairments because they develop more slowly, leading to decreased mobility and activity (Bertino et al., 2009). Researchers have reported that a lack of awareness of pressure was associated with pressure ulcer development in infants and children who have spinal cord injuries, paralysis, altered cognitive level, and neuromuscular impairment (Okamoto, Lamers, & Shurtleiff, 1983; Zollo et al., 1996). Loss of sensory perception due to spinal cord high paralysis was also associated with pressure ulcers in infants and children (Samaniego, 2003).

Tissue tolerance. Skin tissue is composed of an outer layer epidermis and inner layer dermis. The epidermis provides a barrier physically and chemically helping to regulate temperature and fluid as well as assisting with vitamin D production. The dermis provides the nutrition and support for the epidermis and epidermal appendages, as well as controls thermoregulation, infection, and sensation (Myers, 2012).

The subcutaneous tissue lies below the dermis and consists of fascia and fat which provides cushioning, insulation, and support while also providing a source of energy (Myers, 2012). Compromised dermis, epidermis, and subcutaneous tissue results in loss of thermoregulation, decreased sensation, vitamin D, fluid balance regulation, insulation, and energy support. This also increases the risk of infection due to loss of protection (Myers, 2012).

Tissue tolerance is impacted by a number of extrinsic and intrinsic factors. Extrinsic factors are those that modify the environment at or near the skin surface making it more susceptible to pressure-related injury (Braden & Bergstrom, 1987). Extrinsic factors include exposure to excessive moisture and exposure to shear force. Intrinsic factors are those that adversely affect the architecture of the skin's supporting structures such as muscle, collagen, and elastin (Andersen & Kvorning, 1982; Kosiak, 1959; Krouskop, 1983; Natow, 1983; Seiler & Stähelin, 1999; Williams, 1972); instrinsic factors include age, nutrition, and hemodynamic alterations.

Moisture. Prolonged exposure to moisture from perspiration, urine, and feces and drainage from fistulas and wounds decreases tissue tolerance and leads to an increased risk of pressure ulcers. Water alone may also compromise the skin's barrier with prolonged exposure. Humidity is sometimes used interchangeably with skin moisture and refers to the area of the body that interfaces with the support surface.

Prolonged exposure to moisture diminishes epidural tissue strength. The skin softens, causing it to become more vulnerable to compression from pressure (Black et al., 2011**;** EPUAP & NPUAP, 2009; Junkin & Seleof, 2007). Currently, very few studies with children have reported the relationship between moisture and pressure ulcer development. Chronic fecal and urinary incontinence were cited as a risk factor for pediatric patients in the development of pressure ulcers (Okamoto et al., 1983; Samaniego, 2003). Urine contains ammonia that is toxic to the skin while feces contain bacteria and enzymes that are harmful to the skin; both are inconsistent with the skin pH, leading to decreased tissue tolerance (Black et al., 2011; Junkin & Seleof, 2007). Wet skin caused by incontinence is also conducive to rashes. Children less than 3 years of age are more likely to be developmentally incontinent, and children that are sick

frequently experience developmental regression and incontinence. Increased episodes of diarrhea in a 24-hour period increased the odds for skin break down by 25% (95% CI [1.13, 1.39]) among children ages 0 to17 years of age in four pediatric units including a PICU (Noonan et al., 2006).

Shearing. Shearing can lead to pressure ulcers in children. Shear can occur during repositioning of patients in bed, such as moving a patient up in bed or transferring a patient to another surface or wheelchair (Hanson, Langemo, Anderson, Thompson, & Hunter, 2010). Shearing is a force parallel to the surface of the skin that causes the layers of tissue to slide across other layers, changing their shape; this creates the possibility for blood vessel deformation, occlusion, and tearing as well as physical damage of the tissues (Reger, Ranganathon, Orsted, Ohua, & Gefen, 2010). The perpendicular effect goes deeper into structures such as muscle and subcutaneous tissue, injuring these deeper tissues. The more superficial skin contains collagen and elastic fibers that provide tensile strength (Reichel, 1958), but the looseness of the layers of connective tissue leaves them vulnerable to injury from shear force (Reger et al., 2010). Shearing is considered to be a major contributor to pressure ulcer development (Reger et al., 2010). However, a better understanding of the measurement of shear and how it contributes to pressure ulcers in children is necessary.

Friction involves the rubbing of two surfaces against each other. By itself, friction is not considered a factor in pressure ulcer development (Antokal et al., 2012). However, there are challenges discriminating between shear-induced injuries and friction-induced injuries. Friction may initiate excessive deformation of the superficial tissue through mechanical shear (strain); this increases the skin's vulnerability to pressure injury.

The weight of medical equipment applies pressure perpendicular to the skin but also is known to rub against the skin to deform tissue and produce shear. Indeed, medical devices overlying the skin, such as tubes, drains, probes, and cables, have been shown to cause pressure ulcers in children (Baharestani & Ratliff, 2007; Curley, Quigley, & Lin, 2003; Waterlow, 1997). Kohr and Curley (2010) illuminated the important factor of medical devices related to pressure ulcers. Although the etiology may differ, the effects of medical devices are the same as immobility-associated pressure ulcers. Also, therapies that increase shear and pressure such as the duration of intubation, continuous positive airway pressure, and high frequency ventilation have been associated with pressure ulcer occurrence among infants and children in previous studies (Curley, Quigley, et al., 2003; Dixon & Ratliff, 2005; Fuji et al., 2010; Neidig, Klieber, & Opplinger, 1989; Okamoto et al., 1983; Samaniego, 2003; Schindler et al., 2011; Willock et al., 2000; Zollo et al., 1996). When devices in contact with the skin were altered to reduce shear and pressure, such as elevation of tracheostomy tubes off the skin, there was a significant decrease in the pressure ulcer rate (Boesch et al., 2012). Medical devices that restrict movement yet rub over skin surfaces or apply opposing pressure, such as casts, spinal braces, and cervical collars, have been implicated in pressure ulcer development in children (Matsumura, Makino, & Watanabe, 1995; Powers, 1997; Wukich & Motko, 2004), yet children and infants who are acutely or chronically ill require more technological equipment that increases their risk for pressure and shearing. Information about the different shear characteristics for pediatric patients and their associations with pressure ulcer development may provide useful information for nurses in developing prevention strategies for different pediatric populations and their levels of care.

Age. Immediately after birth, the infant's skin undergoes changes in the stratum corneum, hydration, surface pH, and permeability to water. Neonatal and adult skins differ in

their structure as infants have thinner layers and smaller cells as well as differences in transepidermal water loss absorption and stratum corneum hydration. Similar to the elderly, the very young infants' skin is more fragile because of the lack of subcutaneous fat, leaving the epidermis and dermis directly on top of each other. Preterm infants also have less fat mass than term infants, which translates into less tissue between skin and bone increasing the risk for pressure ulcers (Roggero et al., 2009). There is also a difference in the stratum corneum of infants, making it more vulnerable to pressure. The development of the epidermis from the periderm occurs in the second trimester of pregnancy and approaches completion in the early weeks of the third trimester. At 23 to 26 weeks gestation, the epidermis is poorly developed as it is only a few cell layers thick (Rutter, 1996). Infants born more prematurely also have less skin growth and collagen turnover as opposed to the mature infant, resulting in less collagen III in the soft tissue (Kajantie, Dunkel, Risteli, Pohjavuori, & Andersson, 2001; Risteli & Risteli, 1999).

Studies have reported the association between early age and pressure ulcers (Neidig et al., 1989; Okamoto et al., 1983; Zollo et al., 1996). Although extreme prematurity was cited by Pallija et al. (1999) as a risk factor for pressure ulcer development, no specific gestational age was referenced. Prematurity is also related to decreased movement (Sharp & McLaws, 2005). There is a paucity of literature on pressure ulcers for premature infants, especially the comparison by gestational age.

Nutrition. Nutritional assessment includes evaluation of nutrition, medical data, laboratory data, food, and medication interactions as well as physical examination (Doerner, Posthauer, & Thomas, 2009). Nutrition is important because adequate calories, protein, fluids, vitamins, and minerals are required by the body for maintaining tissue integrity (Makleburst &

Magnun, 1994). Inadequate nutrition places patients at increased risk for pressure ulcer development because of protein and energy deficiencies.

Researchers have described an association between poor nutritional intake and pressure ulcer development in adults (Allman, 1986; Breslow, 1991; Ek, Unosson, Larrson, Von Schneck, & Bjurulf, 1991; NPUAP, 2009; Ferguson, Rimmasch, Voss, Cook, & Bender, 2000; Fuoco, Scivoletto, Pace, Vona, & Catellano, 1997; Gilmore, Robinson, Posthaver, & Raymone, 1995; Guenter et al., 2000; Himes, 1999; Strauss & Margolis, 1996; Thomas, 1997). In a multisite, cross-sectional study in Brazil, researchers found that adult patients who were malnourished were more likely to develop a pressure ulcer (Brito, Genero, & Correla, 2013). More than half of the study patients with pressure ulcers were malnourished, and the severity of their pressure ulcers was directly related to the degree of malnutrition using univariate and multivariate logistic regression. Conditions that increase the risk for inadequate nutrition include eating, chewing, and swallowing problems, leading to a decreased oral intake of fluid and food (Doerner et al., 2009). There are no studies that have evaluated pediatric patients with pressure ulcers and their nutrition.

Optimizing nutritional intake has value, especially in pressure ulcer prevention for children, because it promotes tissue integrity (Ranade & Collins, 2011). As many as 40% of children with special needs may be at risk for pressure ulcers because they often present with lower weight and height, less body mass, and less fat. Inadequate calcium and phosphate can occur with preterm infants who require total parenteral nutrition during their initial weeks of life; this was reported to be directly related to earlier gestational age (Kajantie et al., 2001).

Amino acids are essential and necessary for normal protein growth and balance in premature infants (DeCurtis & Rigo, 2012). Additionally, adequate protein balance is a key

component in healthy, normal inflammatory response (Rodriguez-Key & Alonzi, 2007). Premature infants have limited renal capacity, rendering them unable to metabolize and utilize protein effectively (Sluncheva, 2010). This may place premature and sick children at greater risk for pressure ulcer development because they lack the ability to handle the protein loads recommended for pressure ulcer prevention in adults. More information on nutrition and pressure ulcer development in premature infants and sick children is needed.

Hemodynamic alteration. Oxygen is a component of cell nutrition and is dependent on blood pressure, vascular tone, and capillary closing pressures. Lower arterial blood pressure can result in decreased oxygen transported to the cells of the skin. This decrease in oxygen leaves skin tissue more vulnerable to the effects of pressure, which can lead to pressure ulcers. The child's level of health may also influence tissue tolerance. Sick infants and children may experience severe dysfunction or failure of organ systems. The skin is one of those organ systems susceptible to failure in acute, chronic, and critically ill pediatric patients. Perfusion is measured in the tissue of the skin through capillary refill, color, temperature, and pulse oximetry measures.

In PICU patients 1 month to 8 years of age, a low perfusion score on the Braden Q Scale significantly correlated with pressure ulcers (Curley, Razmus, et al., 2003). Conversely, in a multisite study of 81 neonates, there was no significant difference in oxygen saturation between those neonates that developed pressure ulcers and those that did not (Fujii et al., 2010). Hemodynamic alterations and perfusion are not well studied in the neonatal intensive care population as it relates to pressure ulcer development. Hypotensive episodes during surgery were associated with pressure ulcer development in a study of 416 interoperative adult patients

(Nixon et al., 2000), but further research in this area is needed for a better understanding of the relationship between hemodynamic alterations and pressure ulcers in children.

Skin tissue oxygenation needs can be influenced by body temperature. An increase of body temperature by 1° C increases the oxygen and energy demand by 10% (Scott, Leaper, Clarke, & Kelley, 2001). It has been suggested that a patient with increased body temperature and compromised tissue perfusion may experience tissue damage and ischemia quicker and at a lower intensity during shorter intervals of time as opposed to when the temperature is normal (Clark et al., 2001).

Stress resulting in an inflammatory response may also alter tissue oxygenation, increasing cell vulnerability to pressure. Irreversible injury to tissue was caused by white cells, lipid-derived mediators, and free radicals, as evidenced in studies of pigs (Sharp & McLaws, 2005). It is assumed that the level of health would have an influential role in the type of inflammatory response that could occur in critically ill infants and children as compared to acutely ill children. Inflammatory processes can cause tissue injury; however, the connection to pressure ulcer development remains ambiguous. Understanding this process is further complicated because the inflammatory process is also considered an essential component of wound healing. Research regarding associations with inflammatory responses and pressure ulcers among different pediatric populations would be helpful in designing strategies to prevent pressure ulcers.

Hospital Factors (Mesosystem) and Pressure Ulcers

Hospitals are systems that provide health care (the mesosystem). Each hospital is a component of the macrosystem of health care in the United States. A macrosystem is a group of clinical health-care settings (mesosystems), such as hospitals or health systems. The

macrosystem provides direction for the mesosystems and microsystems through vision and goals. An example of a macrosystem is a U.S. regulatory agency or local communities that influence health care for adults and children. Both are important forces that drive process improvement and performance results in the mesosystems (Batalden et al., 2006).

Hospitals (the mesosystem) can vary in multiple factors such as urban or rural settings, staffed bed size, teaching status, Magnet designation, overall patient population (pediatric versus general), and region. Consequently, process improvement processes may vary between hospitals. The results are quality outcome data that can be represented in measures such as pressure ulcer prevalence and incidence (Batalden et al., 2006). Manojlovic, Antonakos, and Ronis (2010) found that large hospital size was associated with an increase of 1.8 pressure ulcers per 1000 days in eight Midwestern hospitals in addition to other adverse outcomes such as ventilator-associated pneumonia and catheter-related blood stream infections. Likewise, He, Staggs, Bergquist-Beringer, and Dunton (2013) and Choi, Bergquist-Beringer, and Staggs (2013) found that the odds for hospital-acquired pressure ulcers were 18% to 27% higher in hospitals with 300 or more staffed beds compared to hospitals with less than 300 staffed beds.

Many of the NDNQI®-participating hospitals that submit data have pediatric units while others are free-standing children's hospitals that are devoted specifically to the health care of children. Some of these hospitals are Magnet designated while others are not. A study to explore whether Magnet status hospitals had better outcomes when comparing 19 Magnet versus 35 non-Magnet hospitals reported that Magnet hospitals had marginally better outcomes for pressure ulcers ($p = 0.10$) but not for other adverse outcomes (Goode, Blegen, Park, Vaughn, & Spetz, 2011). Choi et al. (2013) and Bergquist-Beringer, Dong, He, and Dunton (2013) also found that Magnet status was associated with lower pressure ulcers overall, while He et al.

(2013) found no association with Magnet status. There is a need for research on hospital characteristics that may influence HAPU in children.

Unit Factors (Microsystem) and Pressure Ulcers

There are numerous types of units within hospitals that care for pediatric patients. Pediatric units that submit pressure ulcer data to the NDNQI include pediatric surgical units, medical units, medical-surgical units, rehabilitation units, pediatric step down units, pediatric intensive care units, and neonatal intensive care units. Each unit is defined as a clinical microsystem that includes groups of people working together to provide direct care for a subpopulation of individuals. These groups of people are dependent on the organizational leadership, mission, values, finances, and image of the mesosystem (hospital).

Most hospitals in the United States establish RN nursing care hours and percent RN skill mix from professional organizations at the national level, but these measurements vary depending on patient acuity and other workload characteristics. The relationship between mesosystem and microsystem is reciprocal, making these too difficult to generalize. However, the more successful the unit microsystem is, the better the hospital mesosystem is anticipated to perform.

The rate of HAPU may be impacted by nursing care hours, percent RN skill mix, and type of pediatric unit. Researchers studied 279 patient care units in 47 acute care hospitals and reported that RN hours and percent RN skill mix increased as the acuity of care increased (Blegen, Vaughn, & Vojir, 2007). The type of unit can represent the acuity of the patient population. In a study by He et al. (2013), the mean HAPU rate was highest for the critical care units (14% for all stages of pressure ulcers and 9.1% excluding Stage I pressure ulcers). The critical care units also had a higher mean total RN hours per patient day (RNHPPD) than other

unit types. The research results revealed a positive association between RNHPPD and HAPU rates, which were attributed to inadequate adjustment for patient acuity. Researchers have noted variability in patient acuity because of the measures within and across facilities. Choi et al. (2013) also reported that higher RNHPPD were associated with higher HAPU rates in critical care units and step down units. Interestingly, a higher percent RN skill mix was associated with lower HAPU rates (*OR* = 0.98, 95% CI [0.97, 0.99]) in this study.

Lower HAPU rates were related to a higher percentage of hours supplied by RNs versus other health-care workers and a higher percentage of RNs with 10 or more years of experience when evaluating data from over 1,000 hospitals contributing to the NDNQI database (Dunton, Gajewski, Klaus, & Pierson, 2007). Conversely, Sovie and Jawad (2001) studied 29 university teaching hospitals of over 300 beds and found that decreasing RN hours and increasing unassisted nurse assistant hours were associated with a lower rate of pressure ulcers in surgical patients in multiple regression modeling. A confounding variable in this study was the implementation of monthly skin prevalence studies, which increased focus on pressure ulcer risk and the impact of the organization and unit culture. Staffing and other variables differ between intensive care units and nonintensive care units. In a study by Blegen et al. (2007), RNHPPD were examined by unit type. Intensive care units had a higher number of registered nursing hours as compared to other units by as much as 10 hours per patient day, suggesting that increased nursing care reflects increased unit acuity. Step down units also have reported a higher number of RN hours as compared to medical/surgical units. Those hospitals that are more complex (are larger, have more technology, higher Medicare case mix, and more medical residents) had more total hours of care by RNs. The number of RN staffing hours increased as

the complexity of care increased, such as in critical care units. However, larger general care units had lower RN hours per patient day and lower percent RN skill mix.

A meta-analysis conducted at the nursing unit level found an increase in failure-to-rescue events from pressure ulcers as the patient severity of illness increased (Seago, Williamson, & Atwood, 2006). Park, Blegen, Spetz, Chapman, and De Groot (2012) reported that unit characteristics such as higher patient turnover increased nursing workloads and were associated with a number of higher adverse outcomes such as pressure ulcers. Similarly, Unruh (2003) found that nurses who increased their average workload by one patient increased the risk for adverse outcomes by 7%. Importantly, a study by Needleman, Buerhaus, Stewart, Zelivinky, and Mattke (2006) provided evidence for the cost effectiveness of increasing the proportion of RN hours to reduce resultant adverse events.

A meta-analysis of studies that focused on staffing and adverse outcomes was conducted by Kane, Shamelyan, Mueller, Duval, and Witt (2007); results revealed that intensive care units with greater percent RN skill mix had significantly lower pressure ulcer incidence unless overtime was increased, in which case it was associated with an increase risk in pressure ulcers. Similarly, Blegen, Goode, and Reed (1998) found that a higher percent RN skill mix was associated with a lower incidence of adverse patient outcomes such as pressure ulcers. In contrast, Lang, Hodge, Olson, Romano, and Kravitz (2004) conducted a meta-analysis of staffing and outcomes and reported no evidence to support an association between staffing and pressure ulcers. Analysis of HAPU by stage and unit reported that critical care units had the highest proportion of unstageable and suspected Deep Tissue Injury (sDTI) and the lowest proportion of Stage I pressure ulcers (Bergquist-Beringer, Gajewski, & Davidson, 2012). However, the association between unit type and pressure ulcers was not significant when comparing general

hospital units versus intensive care units when controlling for support surface, repositioning, immobility, shear forces, and gender (Lahmann, Kottner, Dassen, & Tannen, 2012).

The variable research results related to staffing and pressure ulcer outcomes is probably due to methodological differences. Some researchers have reported pressure ulcers at the hospital level while others have reported pressure ulcers at the unit level, creating systematic differences in measures and methods (Lake & Cheung, 2006). There are no known studies for infants and children regarding nursing information and adverse patient outcomes such as pressure ulcers.

Organizations strive to design staffing to optimize staff, patient, and organizational outcomes. Staffing measures differ for different units, such as adult units versus pediatric units and intensive care units versus general floor units. Individual unit characteristics also may be affected by mesosystem changes such as the type of support surfaces available, frequency of prevalence studies, and other pressure ulcer prevention initiatives that can all affect pressure ulcer risk and rates and help explain disparities (Bergstrom & Horn, 2011). More information is needed in assessing which patient and environmental characteristics are associated with pressure ulcer development in pediatric units since most of what we know is based on adult populations. There are no studies that have evaluated the association between pediatric hospital-acquired and unit-acquired pressure ulcers with nursing staffing characteristics, creating a need for further research.

Prevention of Pressure Ulcers

The goal of pressure ulcer prevention is to determine patients at risk for pressure ulcers and to apply appropriate interventions to ameliorate-identified risk factors to prevent pressure ulcer occurrence. Initial guidelines for pressure ulcer prevention (AHRQ, 1992) were based on

evidence ranging from expert opinion to case studies to randomized controlled trials. These guidelines have since been updated as new evidence has emerged. The most recent guidelines were released by the NPUAP and EPUAP in 2009 and the WOCN in 2010. They were intended for vulnerable populations of all ages. However, most of the evidence has been obtained from studies on adults; there is limited research from studies on children. Without evidence-based knowledge, it is difficult to recommend effective strategies for pressure ulcer prevention in infants and children.

Instruments to Assess Pressure Ulcer Risk in Children

The first step in pressure ulcer prevention is having a policy in place that includes a structured approach to assessing risk for pressure ulcers. Because risk factors for pressure ulcers may be different for children and infants, an assortment of risk assessment instruments (scales) have been developed to enable health-care professionals to identify pediatric patients at risk for pressure ulcers. Determination of patient pressure ulcer risk may also be based on the nurse's clinical judgment from a review of the patient's risk factors. For example, risk factors in children may relate to significant prematurity, critical illness, neurological deficits, or exposure to medical devices not related to immobility (Gray, 2004). Presently, it is unknown if children are being assessed for pressure ulcers based on clinical judgment or an established scale, and there is no evidence that identifies when and how often pediatric patients should be reassessed or are being reassessed for pressure ulcer risk.

Instruments to assess pressure ulcer risk in pediatric patients include the Braden Q Scale (Quigley & Curley, 1996), the Neonatal Skin Risk Assessment Scale (NSRAS) (Huffines & Logsdon, 1997), the Glamorgan Scale (Willock, Baharestani, & Anthony, 2009), and the Waterlow Scale (Waterlow, 1997). These pressure ulcer instruments quantify a number of risk

factors using rating scales with combined scores serving as a starting point to determine risk. The Waterlow and Glamorgan Scales are primarily used in the United Kingdom and Europe (Waterlow, 1997, 1998; Willock et al., 2009). The most commonly used scales for children in the United States include the Braden Q Scale (Quigley & Curley, 1996) and the NSRAS (Huffines & Logsdon, 1997). Of these, the Braden Q Scale, the Glamorgan Scale, and the NSRAS have been tested for sensitivity and specificity (Baharestani & Ratliff, 2007).

Braden Q Scale. The Braden Q Scale is an adaptation of the Braden Scale for Predicting Pressure Ulcer Risk. It includes all of the six original Braden subscales (mobility, activity, sensory perception, friction, shear, and nutrition) and adds the additional subscale of tissue perfusion/oxygenation. The addition of the seventh subscale to the model was considered important because it reflects a risk factor relevant to the PICU population. Each subscale can be assigned a score from 1 to 4, with lower values indicating higher risk. All subscale descriptors were modified to fit the pediatric population. Possible scale scores range from a score of 7 (*highest risk*) to 28 (*lowest risk*). A score of 16 or less indicates the patient is at risk for pressure ulcers (Curley, Razmus, et al., 2003; Noonan, Quigley, & Curley, 2011).

The validity of the Braden Q was ascertained in a multisite prospective cohort of 322 pediatric intensive care patients ages 21 days to 8 years on bed rest for at least 24 hours. The sensitivity was 88%, and the specificity was 58% for a critical cutoff score of 16 with a likelihood ratio of 2.11. The positive predictive value was 15%, and the negative predictive value was 98%. Receiver operator characteristic (ROC) curves for each subscale revealed that sensory perception, mobility, and tissue perfusion most contributed to these results (Curley, Razmus, et al., 2003).

NSRAS. The NSRAS was developed to assess risk of skin breakdown in neonates (Huffines & Logsdon, 1997). The NSRAS was modeled after the Braden scale and includes the six subscales of mental status, mobility, activity, nutrition, moisture, and general physical condition (based on gestational age). The subscale descriptions were modified to reflect the neonatal population. Each subscale has a rating of 1 to 4 with a total score range of 6 to 24. The validity and reliability of the NSRAS was tested among 32 neonates between 6 and 40 weeks, with higher scores indicating higher risk. Huffines and Logsdon (1997) reported an inter-rater reliability of 0.97 and stated that content validity was achieved through staff input of the assessment tool for subscales of general physical condition, activity, and nutrition. Using only the subscales of general physical condition, activity, and nutrition, sensitivity was 83%, and the positive predictive value was 50% at a cutoff score of 5. Specificity was 81% with a negative predictive value of 85%. Despite these parameters, Huffines and Logsdon recommended using the scale with all six subscales. The original scale was intended to be scored as lower scores equal higher risk (B. Huffines, personal communication, October 29, 2012). However, this difference in scoring was not communicated in the literature. Further research on the NSRAS is needed to validate the scale in regards to the definitions of the subscales and the recommended cutoff score of 13 for all 6 subscales.

Glamorgan Scale. Children differ in some of the factors that are thought to lead to increased pressure or decreased tissue integrity. The Glamorgan was developed based on a review of the literature and clinician feedback, as well as directly from patient data (Willock et al., 2009). The Glamorgan Scale includes weighted risk factors such as low serum albumin (< 35/dl), immobility, incontinence (inappropriate for age), poor peripheral perfusion (capillary refill > 2 seconds), inadequate nutrition, hemoglobin level (Hg < 9 g/dl), persistent pyrexia

(temperature > 38 degrees C > 4 hours), weight less than the tenth percentile, as well as equipment, objects, or hard surfaces pressing or rubbing on skin. Patients with summated scales of 0 were not considered to be at risk for pressure ulcers; however, patients with scores equal to or greater than 10 were considered at risk, patients with scores equal to or greater than 15 were considered high risk, and patients with scores 20 or greater were considered very high risk.

The validity of the Glamorgan was tested on 336 pediatric patients ages 1 day to 17 years old from 11 hospitals in the United Kingdom. Chi-square analysis of characteristics was conducted, and all items with a *p* value of less than 0.01 were included in the scale. At a score of 15, the Glamorgan was 98.4% sensitive and 67.4% specific under the ROC curve (Willock et al., 2009). Willock et al. (2009) reported a 100% inter-rater reliability of the Glamorgan Scale with the exception of nutrition. Recently, Kottner, Kenzler, and Wilborn (2012) evaluated the inter-rater reliability of the Glamorgan Scale and reported low inter-rater reliability of item and sum scores, indicating that nurses were unable to differentiate between children regarding their pressure ulcer risk. Moreover, some items were insensitive to change; thus, the usefulness of this tool for clinical decision making is unclear.

Interventions to Prevent Pressure Ulcers

The aim of pressure ulcer prevention is to reduce or reverse those factors that cause them. Evidence-based practices recommended by clinical practice guidelines (EPUAP & NPUAP, 2009; IHI, n.d.; Wound Ostomy and Continence Nurses Society, 2010) include patient pressure ulcer risk and skin assessment on admission, routine patient pressure ulcer risk and skin assessment, nutritional support, repositioning for the prevention of pressure ulcers, support surfaces, and moisture management. The evidence is primarily derived from studies with adults, and the interventions target adults. Only recently has attention focused on neonatal and pediatric

populations. The IHI (2008, 2012) published a how-to guide for pressure ulcer prevention in pediatric patients, including recommendations that have been extrapolated from what is known about adult pressure ulcer prevention and have been applied to pediatrics. Recommended practices include conducting a patient pressure ulcer risk assessment and skin assessment on all patients admitted to the hospital and reassessing for risk every 48 hours or when a patient's condition changes. Consistent with those for adults, recommended interventions to prevent pressure ulcers in pediatric patients include daily skin assessments, management of moisture, optimizing nutrition and hydration, and minimizing pressure through repositioning or use of pressure redistribution surfaces (IHI, n.d.).

Pressure redistribution surface use. Adult pressure ulcer studies on the efficacy of support surfaces to reduce pressure ulcers have yielded inconsistent results (Daechsel & Conine, 1985; Guinn, Hudson, & Gallo, 1991; Inman et al., 1999; Jesurum, Joseph, Davis, & Suki, 1996; McInnes, Jammali-Blasi, Bell-Syer, Dumville, & Cullum, 2011; Summer, Curry, Haponik, Nelson, & Elston, 1989). Support surface use was found significant for reducing pressure ulcer incidence for adults in the operating room, when alternative versus standard foam mattresses were used and when using sheepskin (McInnes et al., 2011). Studies have also shown that pressure redistribution surface use can decrease pressure ulcer rates, but it is unknown if one type of support surface is superior to another. For example, there is little difference between constant low pressure devices and alternating pressure devices in reducing pressure ulcers. On review of 41 random control studies, Cullum, McInnes, Bell-Syer, and Legood (2008) even acknowledged that some pressure-reducing devices such as foot waffle heel elevators, some forms of hydrotherapy mattresses, and operating overlays might promote pressure ulcer development.

There is a paucity of studies on pressure redistribution surface use to prevent pressure ulcers in children and neonates. Pediatric patients are often placed on support surfaces designed for adults. However, areas of the body at risk for pressure ulcers in children differ from adults, and there is a lack of evidence-based standards for children in regard to their different pressure points when compared to adult pressure points, rendering the adult surface nontherapeutic for children. Turnage-Carrier, McLane, and Gregurich (2008) reported that standard crib mattresses had high interface pressure, supporting the need for an alternative pressure relief support surface. Among a sample of 54 children ages 6 to 18 years, a foam overlay with a gel-E pillow pressure relief support surface was effective in reducing pressure ulcers as compared to a standard mattress (McLane, Krouskop, McCord, & Fraley, 2002). Similarly, a recent study focused on continuous and reactive low-pressure mattresses specific to pediatric patients found that only one patient developed a pressure ulcer in the pediatric intensive care unit (Garcia-Molina et al., 2012). Garcia-Molina et al. (2012) reported that all standard pressure ulcer prevention measures were used for their patients; however, a confounding variable in this study was that repositioning was not implemented in 19 of the 30 patients because of their clinical instability. In another study of 5,346 pediatric intensive care patients from nine hospitals, use of specialty beds was associated with a lower incidence of pressure ulcers (Schindler et al., 2011). More studies are needed in evaluating support surface use among the pediatric population.

Routine repositioning. The strategy of pressure relief involves patient repositioning and use of transfer aids. Usual practice is to reposition patients every 2 hours, but this frequency rate may be increased or decreased based on patient risk or use of support surfaces (EPUAP & NPUAP, 2009). McLane et al. (2002) reported that children who were not turned every 2 hours had increased pressure ulcer development. In a study among 5,346 pediatric intensive care

patients by Schindler et al. (2011), those patients who were repositioned every 2 to 4 hours using repositioning aids were less likely to develop a pressure ulcer. Although this study was a multisite study from hospitals located in the south, Midwest, and northwest region, no studies were found that examined patient repositioning from a large number of hospitals across the United States.

Repositioning medical equipment to reduce medical device-related pressure ulcers, such as extending the tracheostomy tubing to decrease direct pressure on the skin, was found to significantly decrease tracheostomy-related pressure ulcers in the pediatric intensive care unit (Boesch et al., 2012). Repositioning sick children and infants who have limited activity as a nursing strategy for pressure ulcer prevention needs further clarification through research, especially when considering age and unit type. The frequency of medical device repositioning to alleviate pressure from skin surface also requires further clarification through research.

Moisture management. The purpose of moisture management is to prevent pressure ulcers. Moisture reduction includes prompt cleansing of skin, protecting the skin from moisture, and maintaining skin pH by using non-alkaline agents to cleanse followed by barrier cream (Lund, 1999). Neonates are at risk for absorption of products applied to the skin because of the maturity of their skin, their skin condition, and skin sensitization. Moreover, most products have not been tested on this vulnerable population. Additionally, it is not clear whether barrier creams reduce the risk of pressure ulcer development in pediatric patients (Dealey, 1995; Lund, 1999; Lund et al., 2001; Montoya, 2008; Wound Ostomy and Continence Nurses Society, 2010). The skin of infants less than 37 weeks gestation is at increased risk for infection and water loss (Baharestani & Ratliff, 2007). Interventions to manage moisture, such as use of dry-weave diapers, urinary catheter, and disposable underpads, were consistently associated with lower

pressure ulcer rates in a multisite study of 5,346 pediatric intensive care patients (Schindler et al., 2011). Other than this study, there is limited evidence to suggest that moisture management can reduce pressure ulcers, especially for infants and children**.** Currently, it is unknown how often moisture reduction is being performed across unit types.

Nutritional support. The aim of nutritional support is to prevent pressure ulcer formation by maintaining or restoring tissue integrity. Patients who are at risk for both pressure ulcers and nutritional deficits should be referred to a dietician for dietary evaluation of protein, hydration, calorie, and vitamin requirements. An 80% decrease in risk reduction for pressure ulcers in children was realized when a registered dietician was consulted during the admission process for those at risk (Schindler et al., 2011). Nutrition is not well understood as it relates to prevention of pressure ulcers in pediatric patients, and there are no specific pediatric guidelines for infants and children related to nutrition and pressure ulcer care. As a result, adult criteria are applied to the pediatric population, which may result in inappropriate nutrition management. Further studies examining nutritional interventions and development of pressure ulcers in neonates and children are warranted; also, it is unknown how often at risk patients are receiving appropriate nutritional support.

Routine skin assessment. Routine skin assessment is essential in caring for sick children. Skin assessment is the evaluation of the patient's entire skin (from head to toe), with emphasis on bony prominences and other areas at risk for pressure ulcer development where there may be signs or symptoms of tissue injury (NDNQI, 2012a). Frequent assessment under and around blood pressure cuffs, transcutaneous oxygen probes, continuous positive airway devices, tracheostomies, traction, or tubes is important in prevention of pressure ulcers as pressure ulcers in children can be caused by medical devices and equipment (Baharestani &

Ratliff, 2007). It is important to know how often skin assessments are being accomplished on different pediatric units and neonatal units and the relationship between skin assessments and pressure ulcer development.

Limitations and Gaps in Research on Pressure Ulcers in Children

Skin care is a nursing research priority (Harrison, Wells, Fisher, & Prince, 1996). There have been limited studies in children and neonates on pressure ulcer rates, risk factors and clinical factors, use of instruments to assess for patient pressure ulcer risk, and prevention strategies for the reduction of pressure ulcers. The study of pediatric pressure ulcer development is important and will provide baseline data on current practices for future quality initiatives to reduce pressure ulcers, especially with acutely ill children. There is a need for larger studies in the pediatric patient population that describe pressure ulcer rates and stages. The weaknesses of some of the literature related to prevalence and incidence of pressure ulcers in pediatric patients is confounded with studies that more broadly examine skin breakdown, including pressure ulcers. Furthermore, many of the pediatric pressure ulcer studies were single-site studies with small sample sizes.

Among adults, numerous studies have evaluated the role of gender in adult patients for pressure ulcer development. The results are equivocal. Berlowitz et al. (2001) reported male gender as a significant factor associated with pressure ulcers using logistic regression (*OR* = 1.4, 95 % CI [1.2, 1.6]). Brandeis, Ooi, Hossan, Morris, and Lipsitz (1994) also reported that males were associated with pressure ulcers using logistic regression (*OR* = 1.9, 95% CI [1.2, 3.6]), as did Baumgarten et al. (2004) and Fisher, Wells, and Harrison (2004). Conversely, several studies acknowledged that females were at a greater risk of pressure ulcer development than males. Lindgren, Unosson, Krantz, and Ek (2004) reported that females were more likely to develop

pressure ulcers than males, while Horn et al. (2002) noted that females with longer length of stay (LOS) were more likely to develop a pressure ulcer. Other studies found no difference in pressure ulcer development between genders (Bergstrom, Braden, Kemp, Champagne, & Ruby, 1996; Frankel, Sperry, & Kaplan, 2007). No known research studies to date have explored the relationship between gender and pressure ulcer development in children or infants.

Comparative data for pediatric patients is important for hospitals to improve pressure ulcer care. Researchers who have studied pressure ulcers in children recommend that future studies use age-appropriate criteria to assess pediatric patient pressure ulcer risk (Kottner, Hauss, Schluer, & Dassen, 2013; Noonan et al., 2011), a sample size large enough to allow for subgroup analysis, and differentiation for pressure ulcers among children (Curley, Quigley, et al., 2003). There is limited information regarding the association of prevention strategies in pressure ulcer reduction among the pediatric population.

There is a need for expanded data at both the hospital and unit level. Even though there has been some knowledge gained from previous studies in the NICU or PICU, there is a scarcity of data from pediatric patients on general pediatric units. A larger study would help validate current findings for acutely ill pediatric patients. There are other variables that could be related to pressure ulcers in children that have not been previously explored. The type of hospital (children's hospital, general acute care hospital) and the type of pediatric unit (microsystem) would provide information about differences in pressure ulcer rates between institutional type. The paucity of research suggests a need to study nursing information such as RNHPPD and percent RN skill mix and their relationship to HAPU in children.

Knowledge gained from future research of pressure ulcers is needed, especially for professional organizations specializing in pediatric skin and wound care. Providing new

knowledge in the area of pediatric pressure ulcers can positively influence patient care and interventions for an understudied population. Pressure ulcers rates should be compared across and outside of hospital systems for quality improvement purposes (Noonan et al., 2006). Findings for infants and children will help the Society for Pediatric Nursing, Association for the Advancement of Wound Care, Wound Ostomy Continence Nursing Society, and the EPUAP and NPUAP contribute to pressure ulcer knowledge for younger populations. Governmental agencies and insurance companies will also benefit from this knowledge because both play a major role in reimbursement decisions and the direction of care.

Chapter 3

METHODS

In an effort to create a better understanding of the causes of pediatric pressure ulcers and to improve nursing care for this population, a secondary analysis of existing patient, unit, and hospital demographic data was conducted with the purpose of exploring the variables associated with hospital-acquired pressure ulcers (HAPU) in pediatric patients. The overall purpose of this study was to determine the prevalence of pressure ulcers and rate of HAPU among pediatric patients; examine pressure ulcer risk assessment in pediatric patients; determine the frequency of use of pressure ulcer prevention interventions; and examine patient factors (age, gender), patient pressure ulcer risk and prevention interventions (general, pressure redistributions surface use, repositioning, moisture management, nutritional support), microsystem factors (unit type and nurse staffing measures), and mesosystem factors (hospital type and characteristics) associated with HAPU in pediatric patients using 2012 National Database for Nursing Quality Indicators® (NDNQI®) data. This chapter provides an overview of the research design and methods to address the study purpose. Statistical analyses are described, and protection of human subjects is addressed.

Research Design

This study was a secondary analysis of existing 2012 NDNQI data on patient pressure ulcers, including microsystem factors (unit type and nurse staffing measures) and mesosystem factors (hospital type and characteristics). A descriptive correlational design was used to investigate the relationships between pressure ulcer development, among NDNQI patient, microsystem, and mesosystem data, and the outcomes of pressure ulcer development. Secondary analysis is a time-saving and cost-effective method to examine a large number of patients

(Crossman, 2012). Secondary analysis was particularly appropriate to use for this study as variables to address the research questions were already collected to meet NDNQI goals. Moreover, the questions proposed for this study aligned with questions addressed by the primary data collectors, the NDNQI researchers. Use of a correlational design is an efficient and effective way to observe the relationship among variables (University of New England, 2012). A limitation of secondary analysis is the control over study variables that may not include all variables of interest, and those variables may be defined or categorized differently than the researcher had envisioned. Further, secondary analysis methods generally limit the results to discussion of association rather than causation.

Overview of the National Database for Nursing Quality Indicators (NDNQI)

The NDNQI database is based on a model developed by Donebedian (1988) that asserts that the structure of care affects the processes of care; both, in turn, affect the outcomes of care (NDNQI, 2012b). Unit level data is the foundation of the NDNQI database (NDNQI, 2011). From 1997 to 2000, the ANA conducted a series of pilot studies in the states of Arizona, California, Minnesota, North Dakota, Ohio, Texas, and Virginia to test selected indicators, definitions, data collection, methodology, and instrument development. Data collection on pressure ulcers began in 1998. From 2000 to 2001, data collection was expanded to include information about all HAPU and pressure ulcer risk. Pressure ulcer data were again expanded in 2008 to include suspected Deep Tissue Injury (sDTI), and, in 2009, pediatric pressure ulcer data collection was initiated. Data on pressure ulcer risk and prevention were expanded in 2003, 2007, and 2009, and the survey now includes eight items about pressure ulcer risk and six items about prevention intervention (Bergquist-Beringer, 2011; Bergquist-Beringer et al., 2012). At the

time of this analysis, the NDNQI database was managed by the University of Kansas School of Nursing with participating hospitals growing each year (NDNQI, 2012b).

The value of the NDNQI database is the breadth of the pediatric pressure ulcer data that has been collected at the national level over several years. Moreover, the data are standardized. There is standardization of definitions and data collection procedures, using guidelines as well as training for data collection and entry (NDNQI, 2012b).

Population and Sample

Participation each year in the NDNQI is voluntary. As of November 2012, there were 1,888 hospitals and 18,894 nursing units from across the United States participating in data submission (ANA, 2012). A small number of hospitals outside of the United States also participated in the NDNQI. Data submitted by hospitals on pediatric quality of care revealed that there are different types of hospitals and units submitting data. For this study, only pediatric hospital units from participating U.S. hospitals that submitted data on pressure ulcers during 2012 were included.

Pediatric hospital units eligible to submit data to NDNQI are determined by the hospital NDNQI site coordinator in collaboration with the NDNQI staff. Eligibility was based on acuity level, age, or type of service provided (NDNQI, 2011). A unit was characterized as single acuity if at least 90% of the patients received one level of care. Pediatric unit types eligible to submit pressure ulcer data included pediatric critical care units (PCCUs), pediatric step down units, medical units, surgical units, medical-surgical units, and neonatal critical care units (NICUs Level III and IV). A unit was characterized as a specialty unit if greater than 80% of patient care services were related to the specialty category; specialty units included pediatric rehabilitation units. In the past, most units submitted pressure ulcer data quarterly. For this study, only those

PCCUs, pediatric step down units, medical units, surgical units, and medical-surgical units that submitted pressure ulcer data for three of four quarters in 2012 were analyzed. The sample of pediatric patients included patients from 0 days to 18 years of age from those units that were surveyed for pressure ulcer data during 2012.

Study Variables

Variables of interest for this study included the total number of patient pressure ulcers (both community-acquired and hospital-acquired), the number of HAPU, and the category/stage of HAPU. Other variables of interest included patient skin and pressure ulcer risk assessment on admission, the timing of the last risk assessment, pressure ulcer risk status, pressure ulcer prevention (general), and prevention interventions by type, consisting of pressure redistribution surface use, routine repositioning, moisture management, nutritional support, and routine skin assessment. Hospital characteristics (mesosystem) of interest to this study included hospital type, Magnet® status, teaching status, metropolitan status, bed size, and whether the hospital was a children's hospital or a general care hospital with participating pediatric units. Unit factors (microsystem) of interest included unit type, RN hours per patient day (RNHPPD), and percent RN skill mix. Demographic variables of interest included the age and gender of the patients.

Pressure Ulcer Data

NDNQI data on pressure ulcers, risk for pressure ulcers, and prevention of pressure ulcers was collected on each participating unit during a cross-sectional survey performed on a designated day by trained staff each quarter (Bergquist-Beringer et al., 2012). Participating hospitals followed *NDNQI Guidelines for Data Collection and Submission in Quality Indicators* to collect and report pressure ulcer data (NDNQI, 2012c). A variety of quality control processes

have been established to review the data submission process for errors and discrepancies with extensive quality procedure applications when processing data (NDNQI, 2012c).

If a pressure ulcer was identified, it was categorized or staged according to NPUAP guidelines: Stage I, Stage II, Stage III, Stage IV, unstageable, or suspected Deep Tissue Injury (sDTI) (EPUAP & NPUAP, 2009). The pressure ulcer could also have been classified as indeterminable (NDNQI, 2011; NPUAP, 2009). Indeterminable pressure ulcers included those that could not be staged, specifically mucosal pressure ulcers and pressure ulcers located under non-removable dressings. Mucosal pressure ulcers cannot be staged because the histology of mucous membranes is different from skin. After categorizing or staging the pressure ulcer, it was determined to be community-acquired or hospital-acquired. The determination of HAPU was accomplished by reviewing the patient's medical record. If there was no documentation that the pressure ulcer was present at the site on admission, then it was considered to be hospital-acquired. If there was documentation that the pressure ulcer was present at the site on admission, it was considered to be a community-acquired pressure ulcer.

Training Requirements

Nursing staff were trained in pressure ulcer identification and staging prior to the data collection process by hospital experts to increase the data's accuracy. Initial training included (a) reviewing *NDNQI Guidelines for Data Collection and Submission on Pressure Ulcers*, (b) learning how to perform a skin assessment, and (c) reviewing NPUAP pressure ulcer categories and definitions (NDNQI, 2013). New data collection team leaders and members also received training on pressure ulcer stage appearance that included bedside observation of pressure ulcers by stage, information on other wound types and skin injuries, and information about the differences between community-acquired and hospital-acquired pressure ulcers. The NDNQI

provided an online education program about pressure ulcers that frequently was updated to assist in pressure ulcer training (Bergquist-Beringer & Davidson, 2010). The NDNQI also included training in pressure ulcer data submission as part of the online pressure ulcer education.

One study was conducted to evaluate the NDNQI Pressure Ulcer Training Program to determine whether staff nurses thought the training was effective for pressure ulcer identification and staging (Bergquist-Beringer et al., 2009). Content analysis of the evaluation comments suggested that the training program was effective, whereas reviewer dissatisfaction with content clarity provided direction for revisions to the program. An overwhelming number of positive comments were received about the learning experience. The results of this study suggested that web-based education programs help nurses identify stages of pressure ulcers.

NDNQI Pressure Ulcer Reliability Studies

A number of studies have been performed to establish the reliability of NDNQI data regarding pressure ulcer staging (Gajewski, Hart, Bergquist-Beringer, & Dunton, 2007; Hart, Bergquist, Gajewski, & Dunton, 2006). In one study, researchers developed a web-based criterion referenced test to determine the reliability of nurses identifying pressure ulcer staging from pictures using the NPUAP guidelines for staging and classification (Hart et al., 2006). This web-based test included 24 pictures of pressure ulcers from different sources and stages using scenarios and was administered to 256 raters from 48 hospitals. The overall kappa agreement of wound identification was 0.56 (*SD* = 0.22). According to Kraemer, Periyakoil, and Noda (2002), a kappa value of 0.56 indicated moderate reliability. When data was collapsed to binary variation (pressure ulcer/no pressure ulcer), the kappa value was 0.84 (*SD* = 0.25), indicating near perfect reliability. Overall agreement on staging for pressure ulcers was 0.65 (*SD* = 0.21), reflecting substantial reliability. Agreement was significantly higher (0.72, *SD* = 0.22) when a

description of the wound accompanied the photographs relative to photographs without the description (0.56, *SD* = 0.17). The overall agreement for pressure ulcer source (community-acquired versus hospital-acquired) was 0.80 (*SD* = 0.29).

A follow-up study was conducted for the purpose of determining the inter-rater reliability of pressure ulcer staging from direct observation of wounds and to determine the reliability of pressure ulcer identification, staging, and origin from web-based photographs (Bergquist–Beringer, Gajewski, Dunton, & Klaus, 2011). This study used a convenience sample of 31 hospitals participating in the NDNQI. Participants were asked to stage pressure ulcers using NPUAP staging criteria. The Cohen's kappa was used to compare ratings for pressure ulcer identification, staging, and origin of pressure ulcers. The average *k* coefficient for pressure ulcer staging from direct observation of wounds was 0.60 (*SD* = 0.29) for Stages I through IV and unstageable and 0.61 (*SD* = 0.31) for Stages II through IV including unstageable, reflecting moderate reliability. The average kappa value for pressure ulcer identification (pressure ulcer /not pressure ulcer) was 0.83 (*SD* = 0.21), indicating near perfect agreement. The overall kappa agreement for pressure ulcer origin was 0.79 (*SD* = 0.25). Hierarchical linear modeling provided evidence that nurses certified in wound, ostomy, and/or continence care had significantly higher *k* values for pressure ulcer staging than noncertified nurses ($p = 0.027$). The *k* coefficient was 0.68 (*SD* = 0.25) for certified nurses as compared to 0.57 (*SD* = 0.22) for noncertified nurses. This study provided evidence for moderate to substantial reliability of the NDNQI pressure ulcer indicator.

To further understand the reliability of the pressure ulcer ratings, Gajewski et al. (2007) performed a secondary analysis of data on direct observation of wounds from the previous study (Bergquist-Beringer et al., 2011) using a probit ordinal Bayesian model so that unstageable

ratings could be included in the analyses of pressure ulcer staging (no pressure ulcer, Stage I to IV). The probit model allows for staging of the pressure ulcers to be continuous instead of categorical, thus supporting an understanding of the impact of ordinal data on the analysis. Results suggested that the Bayesian hierarchical model may be the preferred method for inter-rater reliability, especially in studies that include pressure ulcer staging, because it accounts for the uncertain rating of unstageable in the analysis. Bergquist-Beringer et al. (2011) acknowledged that the most important aspect of reliability is knowing the source of error, and the statistical methodology utilized by the NDNQI for pressure ulcer staging was found to be reliable.

Pressure Ulcer Risk and Prevention Data

Pressure ulcer risk and prevention data was collected during the NDNQI survey by chart review. Members of the pressure ulcer data collection team reviewed each patient record to determine if a skin assessment was documented in the patient's chart within 24 hours of admission (yes, no, or pending) and if a pressure ulcer risk assessment was documented in the patient's chart within 24 hours of admission (yes, no, or pending). The method used to assess patient pressure ulcer risk was recorded (Braden Scale, Braden Q Scale, NSRAS, or use of another scale/other clinical factors), and then the score (if applicable) was also recorded. Documentation in the patient record was also reviewed to determine how long before the NDNQI pressure ulcer survey the last risk assessment was performed. The method used to assess patient pressure ulcer risk was recorded along with the score (if applicable). Determination of patient pressure ulcer risk was based on the last pressure ulcer risk assessment (yes, based on risk assessment score; yes, based on other/clinical factors; no) (NDNQI, 2012c).

If the patient was determined to be at risk for pressure ulcers, the members of the pressure ulcer data collection team were asked to review the patient record for documentation on any pressure ulcer prevention performed within the 24 hours before the NDNQI pressure ulcer survey. This was recorded as yes, no, or pending (admitted less than 24 hours prior to survey). Types of pressure ulcer prevention interventions were also recorded. Data collectors reviewed documentation in the patient record for the 24 hours prior to the survey to determine if the following interventions had been performed: patient skin assessment, pressure redistribution surface use, routine repositioning, nutritional support, and moisture management (NDNQI, 2012c).

Skin assessment included documentation of a head-to-toe assessment at least daily (IHI, 2012). For infants and pediatric patients, special attention was paid to the occipital area. Skin assessment within the past 24 hours was recorded as yes, no, or documented contraindication (NDNQI, 2012c).

Pressure redistribution is the use of any specialized support surface to redistribute pressure on skin and subcutaneous tissue or other parts of the body exposed to pressure. Types of pressure redistribution strategies used included air, gel, water, foam, low air loss overlays or mattresses, and lateral rotation or air fluidized mattresses for the bed. Response options for this intervention included yes, no, documented contraindication, unnecessary for patient, or patient refused (NDNQI, 2012c).

Routine repositioning involved reducing the pressure duration and magnitude by turning or repositioning patients. Usual hospital practice is that patients be repositioned every two hours or more frequently if their condition warrants it. The patient record was reviewed for documentation of repositioning as prescribed during the 24 hours before the NDNQI pressure

ulcer survey. Response options for this intervention included yes, no, documented, contraindication, unnecessary for patient, or patient refused (NDNQI, 2012c).

Nutritional support for at risk patients whose dietary intake was inadequate included provision of nutritional supplements or enteral or parenteral nutrition. Risk was assessed and needed support identified. Documentation in the patient's chart was reviewed for evidence that nutritional support was provided during the 24 hours before the NDNQI pressure ulcer survey. Response options for this intervention included yes, no, documented contraindication, unnecessary for patient, or patient refused (NDNQI, 2012c).

Moisture management interventions are those activities to keep the patient clean and dry. This included the use of absorbent underpads, application of moisture barrier, a program to manage urinary or fecal incontinence, and management of draining wounds through the use of containment devices such as diapers or briefs. Response options for this intervention included yes, no, documented contraindication, unnecessary for patient, or patient refused (NDNQI, 2012c). A reliability study of the NDNQI data on pressure ulcer risk assessment and prevention was recently conducted but results have not yet been published.

Mesosystem

There were different types of facilities that submitted data on pediatric pressure ulcers to the NDNQI, including free-standing children's hospitals (those that care exclusively for pediatric patients) and other general acute care hospitals. Type of facility and other hospital characteristics such as Magnet status, teaching status, metropolitan status, and bed size were determined during the initial contract process for services with the NDNQI. This information was reviewed quarterly by the hospital site coordinator and the NDNQI.

Magnet status is an award given by the American Nurses' Credentialing Center (ANCC), a division of the American Nurses Association (ANA), to hospitals that meet a set of criteria designed to measure the strength and quality of their nursing. It recognizes health-care organizations for quality patient care, nursing excellence, and innovations in professional nursing practice (ANCC, 2013). A Magnet hospital is one that delivers excellent patient outcomes, that has a high nursing satisfaction, and that has a low nurse turnover rate (Summers, 2012). NDNQI categories for Magnet status are Magnet recognition, Magnet-applicant, intend to apply, no plans to apply, and unsuccessful application. The NDNQI updates Magnet recognition on the ANCC website. Magnet-applicant hospitals must fax their ANCC confirmation letter to the NDNQI (NDNQI, 2012c).

Hospitals self-classified their teaching status, metropolitan status, and bed size for the NDNQI. For teaching status, hospitals identified themselves as an academic medical center, a teaching hospital, or a nonteaching hospital. An academic medical center was defined as a primary clinical site for a university's school of medicine. A teaching hospital was defined as a clinical site for residents or interns. A nonteaching hospital was defined as not a clinical site for interns or residents (NDNQI, 2012c).

Metropolitan status referred to the location of the hospital in a metropolitan area, micropolitan area, or in neither a metropolitan nor a micropolitan area (NDNQI, 2011c). A metropolitan area was a single county or group of adjacent counties that had a core urban area population of 50,000 people or more (NDNQI, 2011c). A micropolitan area was a single county or group of adjacent counties that had a core urban area population of greater than 10,000 people, but less than 50,000 people. A nonmetropolitan area indicated a county that was not a metropolitan or micropolitan county.

Hospital bed size was based on the number of staffed beds and was categorized by less than 100 beds, 100 to199 beds, 200 to 299 beds, 300 to 399 beds, 400 to 499 beds, and greater than 500 beds. Staffed beds included those that were occupied and those that were vacant and available (AHRQ, 2005; NDNQI, 2011c). These included bassinettes, acute rehabilitation beds, and psychiatric beds, whether or not they were reported for those units. Currently, there are no published reliability studies related to NDNQI data on teaching status, staffed bed size, or metropolitan status.

Microsystem

Besides unit type, which was previously described, the microsystem factors relevant to this study included RNHPPD and percent RN skill mix. Both RNHPPD and percent RN skill mix were used in statistical analysis to determine their influence on patient outcomes such as pressure ulcers.

RNHPPD is the number of nursing care hours provided by RNs divided by the total number of patient days. Nursing care hours per patient day measures the supply of nursing personnel regardless of skill level relative to patient workload. The percent RN skill mix is the ratio of RN hours to total nursing care hours.

Nursing care hours. The nursing care hour represents an hour of productive nursing care by nursing staff with direct patient care responsibilities (Kallisch, Friese, Choi, & Rockman, 2011). The NDNQI (2012a) defined nursing care hours as the number of productive hours worked by nursing staff assigned to the unit who have direct patient care responsibilities greater than 50% of the shift. Nursing staff included RNs, licensed practical nurses (LPNs) or licensed vocational nurses (LPN/LVNs), and unlicensed assistive personnel (UAP) hours. Nursing staff assigned to the unit included both hospital and contracted (agency) staff. Productive hours were

those that the nurse worked on the unit, included overtime, but did not include nonproductive time such as vacation days, sick time, education, orientation, or committee time. Total nursing care hours is the sum of RN, LPN or LVN, and UAP hours.

Nursing care hours were submitted monthly for each quarter by unit. The data collection for nursing care hours included selection of the source of reporting hours such as payroll/accounting or staffing system.

Patient days. The NDNQI uses patient days as the denominator in the calculation of nursing hours per patient day (Klaus, Dunton, Gajewski, & Potter, 2012). Conceptually, the number of patient days reflects the demand for nurse staffing and the amount of time patients have to experience an adverse event. Patient days were submitted for each month for a particular quarter. The method of determining patient days was selected monthly by the hospital from a list of options provided by the NDNQI. Methods for determining patient days included (a) midnight census, (b) midnight census along with patient days from short stay patients, (c) patient days from actual patient hours for both inpatient and short stay patients, and (d) patients days from multiple census reports.

NDNQI Reliability Studies on Nursing Care Hours and Patient Days

In 2007, the NDNQI conducted a study on nursing care hours submitted by NDNQI-participating hospitals and reported evidence of high reliability with interclass correlations (ICC) ranging from 0.84 to 0.99 (Dunton et al., 2007). The NDNQI researchers also found that nearly half of the 714 participating hospitals used payroll records to collect nursing hour data, while 70% reported using standardized methods to convert biweekly hours into months (Dunton et al., 2007). A separate study supported the ability of two different raters to obtain similar results (n =

11) when calculating total nursing care hours according to NDNQI guidelines (ICC = 0.76, 0.99) (Klaus et al., 2013).

A study that focused on patient days calculated by 54 hospitals for 260 units reported excellent overall agreement (ICC = 0.96, ranging from 0.958 to 0.974) on the methods the hospitals used to report patient days (Simon, Yankovskyy, Klaus, Gajewski, & Dunton, 2011). Midnight census was the most commonly used method to calculate patient days (Simon et al., 2011). Lake, Sheng, Klaus, and Dunton (2010) discovered evidence of high reliability in terms of hospital compliance with NDNQI guidelines and the ability to produce RNHPPD from raw hours submitted on patient days and nursing care hours.

Data Submission and Management

Hospitals participating in NDNQI submitted data on pressure ulcers, nursing care hours, and patient days electronically into a secure NDNQI website portal. The data was entered into the portal by staff members who were trained on data submission. This training was required prior to staff members having access to the NDNQI pressure ulcer data entry portal (NDNQI, 2011). For data collection on pressure ulcers, the site coordinator oversaw access and qualification of data collectors and renewed access every 3 months. Each hospital had a distinct code used to access the database website. The NDNQI staff oversaw the overall process of unit management and access to the website through the hospital-based coordinator.

Pressure ulcer data submitted to NDNQI underwent a rigorous quality assurance process that included web-based validations during data entry. The data was also reviewed for out of range data, illogical data, incomplete data, and significant changes in trends. If discrepancies were discovered, the data in question was verified by the site coordinator of the hospital. An automatic error report was generated when the individual patient data did not match the number

of patients on the summary data record. This was performed by the NDNQI staff and reported back in the form of an email to the site coordinator, as well as the person who entered the data. An error report was removed when the discrepancy was corrected. If the data were not verified by the site coordinator, then the data were not included in the comparative report released quarterly (Dunton, 2011).

Human Subject Review

Approval for NDNQI activities in 2012 was granted by the University of Kansas Medical Center (KUMC) Institutional Review Board (IRB). Each NDNQI-participating hospital completed a Limited Data Sets use agreement to satisfy HIPPA requirements for participation in research studies. Database access was restricted to authorized NDNQI staff. All hospital data was confidential and not shared in an identifiable manner with any outside entities. Identities or individual patient identifiers, such as names, addresses, or medical record numbers, were not submitted.

Human Subjects Committee approval for this research project was obtained through KUMC IRB. Data for the study was extracted from the NDNQI database by NDNQI staff. This data was de-identified by the NDNQI staff. The researcher did not have access to information that linked hospitals to the data. The researcher submitted this research proposal after completing KUMC Human Subject Protection training, HIPPA training, signing a conflict of interest form, and completing the NDNQI confidentiality form.

Data Analysis

The primary procedures included preparation of the database and data analysis. The extracted file included Quarter 1 through Quarter 4 2012 data on hospital characteristics and nurse staffing measures. The code book of study variables was available from the NDNQI. A

data log was maintained to document the data extraction processes as well as the recoding steps. An analysis file was kept for each set of data analyzed in the data log. The data were evaluated for missing data. An audit trail of the decisions made in managing the data was maintained. Decisions about missing data were addressed during the data analysis process and are reported as they occurred.

Derivation of Study Sample

The 2012 data file received from the NDNQI included data on 42,209 pediatric patients who had been surveyed for pressure ulcers. The sample of this study was restricted to study units that submitted pressure ulcer data for at least three out of the four quarters during 2012 and to patients on these units who were equal to or less than 18 years of age. The final sample size was 39,984 pediatric patients.

Preparation of the Data

Much of the data for this study was categorical data with the exception of RNHPPD and percent RN skill mix. Patient age was recoded to the following age groups: gestational age only, 1 to 30 days, 1 to11 months, 1 to 2 years, 3 to 4 years, 5 to 8 years, and 9 to18 years of age. The category *gestational age only* included those patients for whom only gestational age was reported. These patients were located in the NICUs III and NICUs IV. Data from medical and medical-surgical units were aggregated to create a new unit type called General Pediatric Unit. No pediatric surgical units submitted data. The continuous variables included RNHPPD and percent RN skill mix. All data in 2012 were aggregated for each unit by averaging monthly data for the quarter and then for the year.

Analysis of General Information Data

Descriptive statistics were used to describe the 2012 sample in terms of patients (age, gender), hospitals (facility type, Magnet status, teaching status, metropolitan area, and bed size), and reporting units (by type and nurse staffing measures by unit type). For continuous variables (nurse staffing measures), results were reported as mean and standard deviation. For categorical data (gender, hospital characteristics, etc.), frequencies and distributions were reported. These analyses were performed using SPSS (Statistics for Windows, 2012). Bivariate analyses were performed to examine the association between each independent variable and HAPU using SPSS (IBM Corporation, 2012). Hierarchical logistic regression analysis was performed using SAS (SAS Institute, 2013). The analyses are outlined below.

Data analysis for research question #1. The first research question for the study was as follows: What was the prevalence of pressure ulcers (both community-acquired and hospital-acquired) and the rate of hospital-acquired pressure ulcers (HAPU) in pediatric patients in the United States in 2012? Subquestions for this research question are listed below:

1a. What was the prevalence of pressure ulcers and rate of HAPU in 2012?

1b. What was the rate of HAPU by age in 2012?

1c. What was the rate of HAPU by gender in 2012?

1d. What was the rate of HAPU by unit type in 2012?

1e. What was the distribution of HAPU by category/stage overall and by unit type in 2012?

Pressure ulcer prevalence is defined as the proportion of individuals in a population experiencing pressure ulcers at a given time (Gordis, 2009). For this study, the prevalence of pressure ulcers included patients admitted to the hospital with a pressure ulcer (community

Table 1

Research Question =1: Variables, Level of Measurement, and Data Analysis from NDNQI 2012 Pressure Ulcer Survey

Research Design	Research Question				
	RQ1a	RQ1b	RQ1c	RQ1d	RQ1e
	NDNQI 2012	NDNQI 2012	NDNQI 2012	NDNQI 2012	NDNQI 2012
Variables	Total pressure ulcers and HAPU	Age and HAPU	Gender and HAPU	Pediatric unit type (grouped as general pediatrics, step down, rehabilitation, pediatric critical care, neonatal critical care) and HAPU	HAPU by category stage overall and by unit type
Measure level	Categorical continuous	Categorical continuous	Categorical continuous	Categorical continuous	Categorical
Data analysis	Descriptive frequency and percent	Age: SD, mean, kurtosis, descriptive, skewness HAPU: percent	Gender: descriptive frequency and percent HAPU: percent	Descriptive frequency and percent	Descriptive frequency and percent

RQ = Research Question; NDNQI = National Database of Nursing Quality Indicators; HAPU = Hospital Acquired Pressure Ulcer

acquired) and patients who acquired a pressure ulcer after admission to the hospital. Calculation of pressure ulcer prevalence for 2012 was performed by dividing the total number of patients with a pressure ulcer (both community-acquired and hospital-acquired pressure ulcers) by the number of patients who were surveyed for pressure ulcers during 2012 (see Table 1). This number was then multiplied by 100. Hospital-acquired pressure ulcers are those acquired after admission to the hospital. The rate of HAPU for 2012 was calculated by dividing the total number of patients who acquired a pressure ulcer after admission to the hospital by the total number of patients included in the survey; this number was then multiplied by 100 (NDNQI, 2013). The rate of HAPU, both with and without Stage I and indeterminable pressure ulcers, was evaluated. The rate of Stage III and IV HAPU; the rate of Stages III, IV, and unstageable HAPU; and the rate of Stages III, IV, unstageable, and sDTI HAPU were also evaluated.

The HAPU rate by age category was determined by dividing the number of patients with HAPU within each age category by the total number of patients surveyed in the age category, and multiplying this by 100 (see Table 1). The HAPU rate by gender was determined by dividing the total number of patients with a HAPU according to gender (male or female) by the total number of patients surveyed, and multiplying that by 100. The HAPU rate by unit type was determined by dividing the total number of pediatric patients with a HAPU in each unit type (general pediatric units, pediatric step down units, PCCUs, and NICUs Levels III and IV) by the number of patients surveyed in these unit types, and then multiplying that number by 100. The distribution of all HAPU by category/stage (Stage I, Stage II, Stage III, Stage IV, unstageable, sDTI, and indeterminable) was evaluated. This was determined by dividing the specific number of HAPU in a particular category/stage by the total number of HAPU. The distribution was also evaluated by unit type.

Data analysis for research question #2. The second research question was as follows: What was the frequency of pressure ulcer risk assessment in pediatric patients in the United States in 2012? Subquestions for this research question are listed below:

2a. What was the frequency of patient skin assessment within 24 hours of admission overall and by unit type based on the 2012 data?

2b. What was the frequency of patient pressure ulcer risk assessment within 24 hours of admission overall and by unit type based on the 2012 data?

2c. What was the timing of the last patient pressure ulcer risk assessment overall and by unit type based on the 2012 data?

2d. What methods were used to assess patient pressure ulcer risk overall and by unit type based on the 2012 data?

Descriptive statistics were used to determine the overall frequency of patient skin and pressure ulcer risk assessments performed within 24 hours of admission (yes, no, or pending) and to determine those performed by unit type during 2012. Descriptive statistics were used to describe the timing of the last patient pressure ulcer risk assessment (from 0 to 12 hours, >12 to 24 hours, > 24 to 48 hours, > 48 to 72 hours, > 72 hours to one week, and > than one week) for the year 2012. The frequency of these assessments by unit type was also calculated. Methods used to assess patient pressure ulcer risk (Braden Scale, Norton Scale, Braden Q Scale, NSRAS, or another scale/other clinical factors) were evaluated. Descriptive statistics were used to calculate the overall frequency of use of each scale and frequency by unit type. The range and means of scores were analyzed if an instrument was used to assess patient pressure ulcer risk (see Table 2).

Table 2

Research Question #2 – Variables, Levels of Measurement, and Data Analysis from NDNQI 2012 Pressure Ulcer Survey

Research Design	Research Question			
	RQ 2a	RQ 2b	RQ 2c	RQ 2d
Variables	Patient skin assessment within 24 hours of admission overall and by unit type	Patient pressure ulcer risk within 24 hours of admission overall and by unit type	Patient pressure ulcer reassessment overall and by unit type	Method used to access pressure ulcer risk overall and by unit type
Measure/level	Categorical/ continuous	Categorical/ continuous	Ordinal/ continuous	Categorical/ continuous
Data analysis	Descriptive Frequency and Percent	Descriptive Frequency and Percent	Descriptive Frequency and Percent	Descriptive Frequency and Percent

RQ = Research Question.

Data analysis for research question #3. The third research question was as follows: What was the frequency of use of pressure ulcer prevention interventions in pediatric patients in the United States at risk for pressure ulcers based on the 2012 data? Subquestions for this research question are listed below:

3a. What proportion of patients were determined to be at risk for pressure ulcers overall and by unit type based on the 2012 data?

3b. What was the frequency of pressure ulcer prevention interventions used overall and by intervention type based on the 2012 data?

3c. What was the frequency of use of pressure ulcer prevention interventions by unit type based on the 2012 data?

Descriptive statistics were used to determine the overall proportion of pediatric patients at risk for pressure ulcers (yes based on score, yes based on clinical factors, or no) in 2012. The proportion of pediatric patients determined to be at pressure ulcer risk by unit type (general pediatric units, pediatric step down units, rehabilitation units, PCCUs, and NICUs Levels III and IV) was also calculated. Descriptive statistics were used to identify the proportion of at risk patients who received pressure ulcer prevention. For those patients determined to be at risk for pressure ulcers, the frequency of prevention by intervention was analyzed. Specifically, routine skin assessment, pressure redistribution surface use, routine repositioning, nutritional support, and moisture management were analyzed to determine the overall frequency of use and the frequency of use by unit type (see Table 3).

Table 3

Research Question #3 – Variables, Level of Measurement, and Data Analysis from NDNQI 2012 Pressure Ulcer Survey

Research Design	Research Question		
	RQ 3a	RQ 3b Pediatric patients at risk for pressure ulcers	RQ 3c Pediatric patients at risk for pressure ulcers
Variables	PU risk status overall and by unit type	PU risk status overall and PU prevention by intervention type	PU risk status overall interventions by unit type
Measure/level	Categorical	Categorical	Categorical
Data analysis	Descriptive Frequency and Percent	Descriptive Frequency and Percent	Descriptive Frequency and Percent

RQ = Research Question; PU = Pressure ulcer

Data analysis for research question #4. The fourth research question was as follows: What patient factors (age, gender), patient pressure ulcer risk, prevention interventions (general, pressure redistributions surface use, repositioning, moisture management, nutritional support), microsystem factors (unit type and nurse staffing measures), and mesosystem factors (hospital type and characteristics) are associated with HAPU among pediatric patients in the United States for 2012? Subquestions for this research question are listed below:

4a. What was the bivariate association between each independent variable and HAPU based on the 2012 pressure ulcer data?

4b. What patient factors (age, gender), patient pressure ulcer risk, microsystem factors (unit type and nurse staffing measures), and mesosystem factors (hospital characteristics) were associated with HAPU among all study pediatric patients in hierarchical logistic regression analysis based on the 2012 data?

4c. What patient pressure ulcer risk, prevention interventions (general, pressure redistributions surface use, repositioning, moisture management, nutritional support), microsystem factors (nurse staffing measures), and mesosystem factors (hospital characteristics) are associated with HAPUs among pediatric patients who were determined to be *at risk for pressure ulcers* in hierarchical logistic regression analysis based on the 2012 data? (See Table 4.)

Bivariate analysis. Prior to performing bivariate analysis, the data were evaluated for missing or empty cells using cross tabs and chi-square analysis. Binary logistic analysis was performed to determine the unadjusted relationship between each of the independent variables (patient age, patient gender, skin assessment within 24 hours of admission, patient pressure ulcer risk within 24 hours of admission, admission risk assessment score, timing of last risk

Table 4

Research Question #4 – Variables, Level of Measurement, and Data Analysis from NDNQI 2012 Pressure Ulcer Survey

Research Design	Research Question		
	RQ 4a	RQ 4b All study pediatric patients	RQ 4c Pediatric patients at risk for pressure ulcers
Variables	*Independent:* Patient factors, patient PU risk assessment and patient PU interventions, hospital characteristics, nurse staffing measures, individual unit type	*Independent:* Patient factors (age, gender), skin and patient PU risk assessment, hospital characteristics, nurse staffing measures, unit type	*Independent:* Risk assessment and prevention, nurse staffing measures, hospital characteristics, PU interventions
	Dependent: HAPU	*Dependent:* HAPU	*Dependent:* HAPU
Measure/level	Categorical/ continuous	Categorical/ continuous	Categorical/ continuous
Data analysis	Inferential Bivariate Association	Inferential Hierarchical Logistic regression	Inferential Hierarchicial Logistic regression

RQ = Research Question; PU = Pressure Ulcer; HAPU = Hospital Acquired Pressure Ulcer.

assessment, last risk assessment score, pressure ulcer interventions by type used by unit type, RNHPPD, percent RN skill mix, hospital type, hospital Magnet status, teaching status, metropolitan status, and bed size) and the dependent variable HAPU. Analyzing the measure of association between each independent variable and pressure ulcers increases the understanding of the association. The analysis was conducted using SPSS (IBM, 2012). Unadjusted odds

ratios, 95% confidence intervals (CIs) and *p* values for each variable were included in the analysis. A $p < .05$ was considered significant in determining independent variables associated with HAPU.

Hierarchical logistic regression. Analyses to determine assumptions for hierarchical logistic regression were performed in SPSS. Correlations among the variables were evaluated. The highest correlation of 0.505 was between percent RN skill mix and RNHPPD. There also was a 0.597 correlation between bed size category and pediatric hospital type. To further assess multicollinearity, variance inflation factors (VIF) were evaluated. A VIF greater than 10 indicates a multicollinearity problem (Cohen, Cohen, West, & Aiken, 2013). For this study, all VIF were less than 10, suggesting absence of serious multicollinearity. Cooks analysis revealed all values were less than one, suggesting that there were no outliers in the data.

The data were then evaluated to determine the adjusted relationships between study variables and HAPU. This analysis was performed by hierarchical logistic regression using SAS (SAS Institute, 2012). The advantages of using hierarchical logistic regression are its nesting properties and its ability to share variance across unit and hospital type. The order of entry allows some predictors to be considered before looking at others (IBM Corporation, 2012).

Two main models were created. The first main model included all pediatric patients and was performed to identify factors associated with HAPU among these patients. Variables were entered by level. Level 1 included patient data on age, gender, and patient pressure ulcer risk, such as the timing of last risk assessment, and scale score. Level 2 included microsystem factors (unit type and nurse staffing measures). Level 3 included mesosystem factors (hospital characteristics). Pediatric pressure ulcer rates between free-standing children's hospitals and other general acute care hospitals were compared. Since there was a significant difference in

rates between these hospital types, a variable called hospital type was also included in the regression analysis. The adjusted odds ratios with 95% confidence intervals and *p* values were included in the analysis findings. The significance level for all tests was an α value < 0.05.

The second hierarchical logistic model included only patients who were determined to be at risk for developing pressure ulcers by risk assessment scale or clinical judgment. The second model was used to determine what patient pressure ulcer risk, prevention interventions, microsystem factors, and mesosystem factors were associated with lower HAPU among pediatric patients at risk for pressure ulcers. Variables also were entered by level in this model. Level 1 included patient factors such as skin assessment on admission, patient pressure ulcer risk assessment on admission, frequency of patient pressure ulcer risk assessment, and timing of last patient pressure ulcer risk assessment. Pressure ulcer prevention intervention variables included use of pressure redistribution surfaces, routine positioning, moisture management, nutritional support, and routine skin assessment. Level 2 microsystem factors included nurse staffing measures and unit types. Level 3 mesosystem factors included hospital type and characteristics. Since there was a significant difference in rates between free-standing children's hospitals and general acute care hospital types, the variable called hospital type was also included in the regression analysis. The adjusted odds ratios with 95% confidence intervals and *p* values were included in the analysis.

Conceptually relevant interactions were also evaluated. For example, factors associated with pressure ulcers may vary by unit type; therefore, patient factors, microsystem factors, and mesosystem factors associated with HAPU were analyzed among all pediatric patients and those at risk by unit type.

Summary

This chapter presents an overview of the methods used to analyze HAPU in hospitalized pediatric patients. This secondary analysis answers multiple questions and utilizes multiple methods to create evidence that will provide a better understanding of the individual, unit, and hospital factors associated with children and HAPU. The analysis utilizes descriptive, bivariate, and hierarchical logistic regression for multiple factors and the outcome of HAPU. Chapter 4 will present the findings from the data analysis of HAPU in pediatric patients.

Chapter IV

RESULTS

This chapter presents the analytic findings of data on pediatric pressure ulcers from the National Database for Nursing Quality Indictors® (NDNQI®, 2012a) concerning (a) the prevalence and rate of hospital-acquired pressure ulcers (HAPU) in pediatric patients; (b) the frequency of which pressure ulcer risk assessment is completed on pediatric patients; (c) the frequency of pressure ulcer prevention measures employed for pediatric patients at risk for pressure ulcers; and (d) patient factors (pressure ulcer risk and prevention interventions), microsystem factors (unit type and nursing staffing measures), and mesosystem factors (hospital type and characteristics) associated with HAPU among pediatric patients. Demographic characteristics of the study sample populations are also presented.

Description of Study Sample

The final study sample was comprised of 39,984 children ages 1 day to 18 years of age from 678 different pediatric units in 271 NDNQI-participating U.S. hospitals that submitted pressure ulcer data three out of four quarters during 2012. The demographic characteristics of the study sample are represented in Table 5.

The majority of patients were less than one year of age. Specifically, 27.2% of the patients were ages 1 to 11 months (n = 10,506) and 23.8% of the patients were 1 to 30 days old (n = 9,230). For 6.6% of the patients, only gestational age was reported, suggesting these patients were of early age. Another 20.0% of the patients were 9 to 18 years of age (n = 7,769). Among the sample, 54.5% (n = 17,725) were male, and 44.5% (n = 21,202) were female.

The sample of units included general pediatric units, pediatric critical care units (PCCUs), neonatal intensive care units (NICUs) III, pediatric rehabilitation units, pediatric step

Table 5

Demographic Variables

	Patients		Units		Hospitals	
	n	%	*n*	%	*n*	%
Patient Characteristics						
Age[a]						
Gestational age only	2,571	6.6				
1-30 days	9,230	23.8				
1-11 months	10,506	27.2				
1-2 years	3,641	9.4				
3-4 years	2,089	5.3				
5-8 years	2,888	7.4				
9-18 years	7,769	20.0				
Gender[b]	38,694					
Male	17,725	45.5				
Female	21,202	54.5				
Unit characteristics						
NICU III	16,154	40.5	182	26.8		
General pediatric	15,196	38.0	289	42.6		
PCCU	5,627	14.1	154	22.7		
Pediatric step down	1,650	4.1	38	5.6		
NICU IV	1,163	2.9	9	1.3		
Pediatric rehabilitation	194	0.5	6	0.9		
Hospital characteristics						
Nonpediatric	25,460	63.7			229	84.5
Pediatric	14,524	36.3			42	15.5
Teaching Type						
Academic medical center	17,826	44.6			70	25.8
Teaching	16,155	40.5			120	44.3
Nonteaching	6,003	15.0			81	29.9
Metro Status						
Metropolitan	35,599	99.0			263	97.0
Micropolitan	385	1.0			8	3.0

(continued)

Table 5 (continued)

	Patient		Unit		Hospital	
	n	%	*n*	%	*n*	%
Bed size/category						
<100	1,027	2.6			13	4.8
100-199	7,300	18.3			56	20.7
200-299	6,485	16.2			58	21.4
300-399	6,122	15.3			48	17.7
400-499	5,947	14.9			38	14.0
> 500	13,103	32.8			58	21.4
Magnet® status						
Magnet	23,439	58.6			125	46.1
Non-Magnet	16,545	41.4			146	53.9

[a]Missing data on age = 1,285 (3.2%).
[b]Missing data on gender = 1,057 (2.6%).
PCCU = Pediatric Critical Care Unit; NICU = Neonatal Intensive Care Unit;
Metro = Metropolitan; Micro = Micropolitan.

down units, and neonatal intensive care units (NICUs) IV. The largest number of reporting units were the general pediatric units at 42.6% (*n* = 289), followed by the NICUs III at 26.8% (*n* = 182) and the PCCUs, consisting of 22.7% (*n* = 154) of the units. The NICUs IV and pediatric rehabilitation units made up less than 2% of the reporting units. No data from pediatric surgical units were available for this study. Most of the patient data in this study came from NICUs III (*n* = 16,154 patients) and general pediatric units (*n* = 15,196 patients); the least data were from pediatric rehabilitation units (*n* = 194 patients). The study data are unique in that previous pressure ulcer studies have not focused on neonatal or general pediatric units.

Of the 271 hospitals, 15.5% (*n* = 42) were pediatric specialty hospitals, and 84.5% (*n* = 229) were general acute care (nonpediatric) hospitals with pediatric units. The majority of hospitals were teaching hospitals (44.3%; *n* = 120), 29.9% (*n* = 81) were nonteaching hospitals,

and 25.8 % (*n* = 70) were academic medical centers. Among the hospitals that submitted pressure ulcer data, 53.1% (*n* = 144) had greater than 300 beds. Ninety-seven percent of the hospitals were from metropolitan areas, with 3% from micropolitan areas. The majority of hospitals were non-Magnet hospitals (53.9%; *n* = 146).

Prevalence and Rate of HAPU in Pediatric Patients

The overall prevalence of pressure ulcers in hospitalized children ages 1 day to 18 years was 1.4% (*n* = 575 patients). The rate of HAPU was 1.1%; specifically, 441 of 39,984 children developed a pressure ulcer after admission to the hospital.

The rate of pressure ulcers, excluding Stage I pressure ulcers, was 0.67%. Only 0.06% of the pressure ulcers were located under a nonremovable dressing or were unable to be staged across unit types. When the number of both mucosal pressure ulcers under a nonremovable dressing and Stage I pressure ulcers were excluded, the HAPU rate was 0.60%. The rate of Stage III and IV HAPU was 0.06%. The rate of Stage III, IV, and unstageable HAPU was 0.19%; the rate of Stage III, IV, and sDTI was slightly higher at 0.36%. The rate of Stage III, IV, unstageable, and sDTI HAPU was 0.44%.

Rate of HAPU by Age, Gender, and Unit Type

The HAPU rate was highest among patients who were 9 to18 years of age (1.65%) and was next highest among those 5 to 8 years of age (1.37%). For patients 1 to 30 days of age, the rate of HAPU was only 0.72%. The rate of HAPU among males was 1.06%, and the rate among female patients was 1.14%. The HAPU rate was highest on the pediatric rehabilitation units (4.63%) and pediatric critical care units (3.74%) and lowest on the NICUs III (0.64%) and general pediatrics units (0.57%) (see Table 6).

Table 6

Number of Patients With and Without HAPU by Age, Gender, and Unit Type

	Patients without HAPU (*n* = 39,543)	Patients with HAPU (*n* = 441)	Overall rate of HAPU (%)
Patient characteristics			
Age[a]			
Gestational only	2,551	20	0.78
1-30 days	9,164	66	0.72
1-11 months	10,393	113	1.13
1-2 years	3,594	47	1.26
3-4 years	2,068	21	1.00
5-8 years	2,849	39	1.37
> 8 years	7,641	128	1.65
Gender[b]			
Male	17,538	187	1.06
Female	20,960	242	1.14
Unit characteristics			
Unit Type			
PCCU	5,416	211	3.74
NICU III	16,050	104	0.64
General pediatric	15,109	87	0.57
Pediatric stepdown	1,633	17	1.03
NICU IV	1,150	13	1.11
Pediatric rehabilitation	185	9	4.63

[a]Missing data on age = 1,285 (3.2%).
[b]Missing data on gender = 1,057 (2.6%).
HAPU= Hospital Acquired Pressure Ulcer; PCCU = Pediatric Critical Care Unit; NICU = Neonatal Intensive Care Unit.

Distribution of HAPU by Category/Stage Overall

The 441 patients with a HAPU had a total of 601 HAPUs. The majority of patients (78.0%) had just one pressure ulcer, but the average was 1.36 HAPU per patient. Most of the 601 HAPUs were Stage I (35.6 %) or Stage II (30.0%) pressure ulcers (see Table 7). Suspected

Table 7

Distribution of HAPU by Category/Stage

	Number of HAPU	Percentage (%) of all HAPU
Stage		
Stage I	214	35.6
Stage II	180	30.0
Stage III	24	4.0
Stage IV	4	0.6
sDTI	86	14.3
Unstageable	61	10.1
Indeterminable	32	5.3

HAPU = Hospital Acquired Pressure Ulcer; sDTI = Suspected Deep Tissue Injury.

Deep Tissue Injury (sDTI; 14.3%) was the next highest reported category/stage of HAPU. The proportion of all HAPU that were unstageable pressure ulcers was 10.1% while Stage III, Stage IV, and indeterminable pressure ulcers occurred less frequently.

Distribution of HAPU by Category/Stage and Unit Type

The distribution of HAPU by unit type is displayed in Table 8. In general, Stage I and Stage II pressure ulcers predominated across the unit types. The highest rates of Stage I HAPU were reported by the PCCUs (1.6 %) and the pediatric rehabilitation units (1.5 %). It was notable that the pediatric rehabilitation unit patients had a greater number of Stage III, unstageable, and indeterminable pressure ulcers than most of the other unit types. It was unexpected that the PCCUs had fewer patients with Stage IV and unstageable pressure ulcers but had a higher number of sDTIs. Another unanticipated finding was that the NICU III and NICU IV patients had a higher proportion of unstageable pressure ulcers compared to patients on other units, such as PCCUs, which may be related to the lack of subcutaneous fat under the very

Table 8

Distribution of HAPU by Category/Stage According to Unit Type (n = 601 Pressure Ulcers)

	Stage I		Stage II		Stage III		Stage IV		Unstageable		sDTI		Indeterminable		Total
	n of HAPU	% HAPU for the unit	*n* of HAPU	% HAPU for the unit	*n* of HAPU	% HAPU for the unit	*n* of HAPU	% HAPU for the unit	*n* of HAPU	% HAPU for the unit	*n* of HAPU	% HAPU for the unit	*n* of HAPU	% HAPU for the unit	
Unit															
General pediatric	39	34.5	37	32.7	3	2.7	2	1.8	11	9.7	16	14.2	5	4.4	113
PCCU	121	38.6	91	29.1	13	4.2	1	0.3	19	6.1	52	16.6	16	5.1	313
NICU III	41	32.8	30	24.0	7	5.6	0	0.0	25	20.0	15	12.0	7	5.6	125
Rehabilitation	5	35.7	6	42.8	1	7.1	0	0.0	1	7.1	0	0.0	1	7.1	14
Pediatric stepdown	3	13.0	13	56.5	0	0.0	1	4.4	3	13.0	2	8.7	1	4.3	23
NICU IV	5	38.5	3	23.0	0	0.0	0	0.0	2	15.3	2	15.4	1	7.7	13

HAPU = Hospital Acquired Pressure Ulcer; sDTI = Suspected Deep Tissue Injury; PCCU = Pediatric Critical Care Unit; NICU = Neonatal Intensive Care Unit.

young infants' skin, leaving the epidermis and dermis directly on top of each other. Preterm infants also have less fat mass than term infants, resulting in less tissue between skin and bone increasing the risk for pressure ulcers (Roggero et al., 2009). Likewise, it was surprising to see that the pediatric step down patients had a higher proportion of Stage IV pressure ulcers when compared to the other unit type patients.

Frequency of Pressure Ulcer Risk Assessment in Pediatric Patients

Skin assessment within 24 hours of admission overall and by unit type. Skin assessment on admission was performed for the majority of study patients (*n* = 36,464; 96.7%) within 24 hours of admission to the hospital; however, a small number of patients *(n* = 969, 2.6%) did not receive a skin assessment on admission. Additionally, 0.7% (*n* = 249) of patients' skin assessments were pending as the patient had just been admitted within the past 24 hours, and the admission assessment had not yet been completed.

Skin assessment on admission by unit type showed like distribution except for the pediatric rehabilitation unit. On this unit, 5.7% of patients had not received a skin assessment within 24 hours of admission (see Table 9). On all other units, more than 96% of patients received a skin assessment on admission.

Pressure ulcer risk assessment on admission. Most of the patients (*n* = 33,644; 89.2%) received a pressure ulcer risk assessment within 24 hours of admission while 10.0% (*n* = 3,755) did not. For 0.8% of patients (*n* = 322), the risk assessment was pending as the patient had just been admitted within the past 24 hours, and the admission assessment had not yet been completed.

The highest proportions of pediatric pressure ulcer risk assessment on admission were for patients in the pediatric rehabilitation units at 98.4%, followed by the patients in the general

Table 9

Skin Assessment on Admission by Unit Type (n = 37,682)[a]

	Yes		No		Pending	
	n	Percentage	*n*	Percentage	*n*	Percentage
Unit type						
General pediatric	13,711	96.8	350	2.5	105	0.7
PCCU	5,179	97.4	79	1.5	58	1.1
NICU III	14,751	99.2	45	0.3	69	0.5
Pediatric rehabilitation	183	94.3	11	5.7	0	0.0
Pediatric step down	1,523	97.0	32	2.0	15	1.0
NICU IV	1,117	96.2	42	3.6	2	0.2

[a]2,302 patients were missing data (5.8%).
NICU = Neonatal Intensive Care Unit; PCCU = Pediatric Critical Care Unit.

pediatric care units (94.6%) and the pediatric step down units (93.1%). The NICUs III had the lowest number of patients receiving a pressure ulcer risk assessment within 24 hours of admission at 81.0% (see Table 10).

Time since last pressure ulcer risk assessment prior to survey overall and by unit type. Overall, the majority of patients (*n* = 35,367; 89.2%) had received a pressure ulcer risk assessment within the 24-hour period before the pressure ulcer survey. For another 4.5% of the patients, a pressure ulcer risk assessment was completed more than 24 hours before the survey while 6.3% of the patients (*n* = 2,483) were never assessed for pressure ulcer risk (see Table 11).

By unit type, the highest number of patients that had received a pressure ulcer risk assessment less than 24 hours prior to the survey were in the NICUs IV (98.4%). Only 83.5% of patients in the NICUs III had received a pressure ulcer risk assessment within the 24 hours

Table 10

Pressure Ulcer Risk Assessment on Admission by Unit Type (n = 37,721)[a]

	Yes		No		Pending	
	n	Percentage	*n*	Percentage	*n*	Percentage
Unit type						
General pediatric	13,712	95.0	588	4.1	142	0.9
PCCU	5,084	94.6	226	4.2	63	1.2
NICU III	12,192	81.0	2,758	18.3	97	0.6
Pediatric rehabilitation	123	98.4	2	1.6	0	0.0
Pediatric step down	1,462	93.1	90	5.7	19	1.2
NICU IV	1,071	92.1	91	7.8	1	0.1

[a]2,263 patients with missing data (5.6%). 754 patients with missing data from pediatric general care units (4.9%); 254 patients with missing data from PCCUs (4.5%); 1,107 patients with missing data from NICUs III (6.8%); 69 patients with missing data from pediatric rehabilitation units (35.5%); 79 patients with missing data from pediatric step down units (4.8%); 0 patients with missing data from NICUs IV.
PCUU = Pediatric Critical Care Unit; NICU = Neonatal Intensive Care Unit.

Table 11

Time Since Last Pressure Ulcer Risk Assessment Prior to the Pressure Ulcer Survey (n = 39,657)[a]

	Time since last assessment	
	n	Percentage
Time		
> 0-12 hours	30,508	77.0
> 12 to 24 hours	4,859	12.2
> 24 to 48 hours	796	2.0
> 48 to 72 hours	156	0.4
> 72 hours to 1 week	175	0.4
> 1 week	680	1.7
Never assessed	2,483	6.3

[a]327 patients with missing data (0.8%).

before the survey, which is surprising since the NICUs IV had the highest percentage. Patients in the general pediatrics units, PCCUs, pediatric rehabilitation units, and pediatric step down units received a pressure ulcer risk assessment within 24 hours of the survey between 93.5% and 95.9% of the time.

Method used to assess pressure ulcer risk on admission and prior to the pressure ulcer survey. Overall, most patients (72.7 %) were assessed for pressure ulcer risk assessment on admission by means of a scale, such as the Braden Scale, Braden Q Scale, or NSRAS. For 27% to 28% of the patients, pressure ulcer risk was assessed on admission using a different scale or by clinical judgment. Among the scales, the Braden Q was the scale most frequently used to assess patient pressure ulcer risk on admission (52.4%) and was also the scale most frequently used to assess patient pressure ulcer risk prior to survey (51.1%) (see Table 12). For 10% to 11% of patients, the Braden Scale was used to assess pressure ulcer risk. The NSRAS was used 9.4% of the time for patient pressure ulcer risk on admission and was used 9.7% of the time to assess patient pressure ulcer risk before the pressure ulcer survey (see Table 12).

Method used to assess pressure ulcer risk by unit type. The method used to assess pressure ulcer risk on admission and before the survey varied by unit type (see Tables 13 and 14). Consistent with overall scale use, the Braden Q Scale was the most used scale to assess pediatric pressure ulcer risk. The Braden Q Scale was used most often to assess patient pressure ulcer risk in the general pediatrics units, pediatric step down units, PCCUs, and pediatric rehabilitation units. The Braden Scale was more frequently used on pediatric rehabilitation units to assess patient pressure ulcer risk. The NSRAS was used most to assess pressure ulcer risk assessment in NICU III patients (25%). However, the majority of the NICU III and IV patients were assessed for pressure ulcer risk using another scale or clinical judgment.

Table 12

Method Used to Assess Pressure Ulcer Risk on Admission (n = 33,644)[a] and Prior to the Pressure Ulcer Survey (n =37,178)[b]

	Method to assess risk on admission		Method to assess risk prior to survey	
	n	Percentage	*n*	Percentage
Scale				
Braden	3,676	10.9	3,820	10.3
Braden Q	17,635	52.4	19,010	51.1
NSRAS	3,156	9.4	3,589	9.7
Other scale/clinical factors	9,177	27.3	10,759	28.9

[a]6,340 patients with missing data (15.8%).
[b]2,806 patients with missing data (7.0%).
NSRAS = Neonatal Skin Risk Assessment.

Table 13

Method Used to Assess Pressure Ulcer Risk on Admission by Unit Type (n = 33,644)[a]

	Braden		NSRAS		Braden Q		Other Scale/Method	
	n	Percentage	*n*	Percentage	*n*	Percentage	*n*	Percentage
Unit Type								
General pediatric	2,398	17.5	53	0.4	10,332	75.4	929	6.8
PCCU	621	12.2	32	0.6	4,131	81.3	300	5.9
NICU III	290	2.4	3,066	25.1	1,549	12.7	7,287	59.8
Pediatric rehabilitation	54	43.9	0	0.0	69	56.1	0	0
Pediatric stepdown	140	9.6	3	0.2	1,250	85.5	69	4.7
NICU IV	173	16.2	2	0.2	304	28.4	592	55.3
Total	3,676		3,156		17,635		9,177	

[a]6,340 patients with missing data (15.9%).
PCCU = Pediatric Critical Care Unit; NICU = Neonatal Critical Care Unit.

Table 14

Method Used to Assess Pressure Ulcer Risk Prior to Pressure Ulcer Survey by Unit Type (n = 37,170)[a]

	Braden		NSRAS		Braden Q		Other Scale/Method	
	n	Percentage	*n*	Percentage	*n*	Percentage	*n*	Percentage
Unit Type								
General pediatric	2,448	16.6	42	0.3	10,930	74.2	1,320	6.3
PCCU	661	12.0	30	0.5	4,505	81.7	319	5.8
NICU III	315	2.2	3,467	24.8	1,899	13.6	8,315	59.4
Pediatric rehabilitation	61	32.6	0	0.0	73	39.0	53	28.3
Pediatric stepdown	162	10.3	3	0.2	1,293	82.4	112	7.1
NICU IV	173	14.9	38	3.3	310	26.7	641	55.2
Total	3,820		3,580		19,010		10,760	

[a]2,814 patients with missing data (7.0%).
PCCU = Pediatric Critical Care Unit; NICU = Neonatal Critical Care Unit.

Pressure Ulcer Risk Status

Among the 39,984 study patients, data on pressure ulcer risk status was available for 37,077 patients (90%). Of the 37,077 patients, 30.2% (*n* = 11,203) were determined to be at risk for a pressure ulcer based on the last pressure ulcer risk assessment prior to the survey (see Table 15).

Table 15

Methods Used to Assess Pressure Ulcer Risk Status (n = 37,077)[a]

	At risk	*n* = Method Used	Percentage
Based on risk assessment scale	Yes	5,524	14.9
Based on clinical factors/other	Yes	5,679	15.3
Not at risk	No	25,874	69.8

[a]2,907 patients with missing data (7.3%).

Of the 11,203 patients at risk, 49.3% of patients (*n* = 5,524) were considered at risk based on a risk assessment scale score, and 50.1% of patients (*n* = 5,679) were considered at risk based on clinical factors or other scales.

Pressure ulcer risk status by unit type. The percentage of patients determined to be at risk for pressure ulcers varied by unit type. The NICUs III had the highest proportion of at risk patients with 45.5% (*n* = 6,337) of the patients determined to be at risk for pressure ulcers. In the PCCUs, 44.6% (*n* = 2,154) of patients were at risk for pressure ulcers. Among pediatric rehabilitation units, 27.6% of patients were determined to be at risk. Somewhat similarly, 22.5% of NICU IV patients were determined to be at risk. Only 18.1% of pediatric step down unit patients and 12.3 % of patients on general pediatric units were found to be at risk.

Pressure Ulcer Prevention in Pediatric Patients

Frequency of prevention overall and by intervention type. Of the 11,203 pediatric patients at risk for pressure ulcers, 95.8% (*n* = 10,741) received some kind of pressure ulcer prevention in the 24 hours prior to the survey. The type of intervention received varied among at risk patients (see Table 16).

Most at risk patients received a skin risk assessment within the 24 hours prior to the NDNQI pressure ulcer survey (99.2%); 0.6% did not receive a skin assessment. For 18 patients (0.2%), this intervention was contraindicated for reasons that were not known to the survey. At risk patients received repositioning 89.5% of the time; 4.3% of at risk patients did not receive repositioning as prescribed. For another 0.7% of the at risk patients, repositioning was contraindicated, and, for 5.5% of patients, repositioning was considered unnecessary. Approximately 0.1% of the at risk patients refused the repositioning intervention.

At risk patients received nutritional support 88.6% of the time, but nutritional support was not provided for 4.8% of the patients. At risk patients did not receive nutritional support because it was contraindicated for 1.2% of the patients (*n* = 118) and unnecessary for another 5.3% of the patients, implying the intervention was not indicated based on the patients' risk factors.

Other interventions used to prevent pressure ulcers included the use of a pressure redistribution surface and moisture management. Seventy percent (70.7%) of at risk patients received a pressure redistribution surface while another 13.6% did not receive a pressure redistribution surface. For 15.4% of the patients, pressure redistribution surface was considered unnecessary. There were no or very few patients for whom a pressure redistribution surface was considered contraindicated or was refused (0% to 0.3%). Moisture was managed for 84.6% of

Table 16

Frequency of Prevention Interventions for At Risk Patients by Intervention Type[a]

Intervention Type	Frequency by Response Option (%)				
	Yes *n* (%)	No *n* (%)	Contraindicated *n* (%)	Unnecessary *n* (%)	Refused *n* (%)
Redistribution surface use[b]	6,743 (70.7%)	1,299 (13.6%)	31 (0.3%)	1,465 (15.4%)	4 (0%)
Repositioning as prescribed[c]	8,762 (89.5%)	419 (4.3%)	68 (0.7%)	540 (5.5%)	5 (0.1%)
Nutritional support[d]	8,598 (88.6%)	467 (4.8%)	118 (1.2%)	515 (5.3%)	2 (0%)
Moisture management[e]	8,177 (84.6%)	513 (5.4%)	21 (0.2%)	954 (9.9%)	3 (0%)
Skin assessment[f]	9,582 (99.2%)	62 (0.6%)	18 (0.2%)		

[a] *n* = 10,741 at risk patients who had received pressure ulcer prevention interventions; 462 at risk patients did not receive pressure ulcer prevention interventions (4.1%).
[b] 1,661 patients missing data for redistribution surface use (14.8%).
[c] 1,409 patients missing data for repositioning as prescribed (12.6%).
[d] 1,503 patients missing data for nutritional support (13.4%).
[e] 1,535 patients missing data for moisture management (13.7%).
[f] 1,541 patients missing data for skin assessment (13.8%).
Contraindicated = documented contraindicated; Unnecessary = documented unnecessary for the patient; Refused = documented patient refused.

patients (n = 8,177), but for another 5.4% of patients, moisture was not managed. Moisture management was considered unnecessary for 9.9% of the at risk patients, and there were minimal patients for whom moisture management was contraindicated or the patient refused (0% to 0.2%).

Pressure ulcer prevention by unit (microsystem). Pressure ulcer prevention interventions varied by unit type. Skin assessment was the most frequently employed intervention across units (see Table 17). Repositioning was also used to prevent pressure ulcers in at risk patients and used more often in units where the patient was less mobile, such as in PCCUs and NICUs. Moisture was managed more often in units with younger patients who were developmentally incontinent where moisture management was a routine part of care. There was greater variability in pressure redistribution surface use and nutritional support among the unit types. A pressure redistribution surface was used most often for patients in pediatric rehabilitation units and PCCUs relative to all units. Neonatal patients received the most nutritional support. Patients in the pediatric rehabilitation units had fewer interventions to prevent pressure ulcers.

Pressure redistribution surface by unit type (microsystem). The use of redistribution surfaces for the prevention of pressure ulcers was highest among patients at risk in the pediatric rehabilitation units (95.0%) and the pediatric critical care units (85.0%). Use of pressure redistribution surface rates was lowest among at risk patients in the general care pediatric units (61.0%). Pressure redistribution surface was not used as frequently for patients in the NICUs IV (79.0%), NICUs III (67.0%), or the pediatric step down units (75.2%). Coincidentally, in units where there was less use of a pressure redistribution surface, there were higher numbers of patients for whom it was considered unnecessary (NICUs IV = 8.7%, NICUs III = 16.7%, and

Table 17

Frequency of Prevention Interventions for At Risk Patients by Intervention Type and Unit

Intervention Type	Frequency by response option (%)				
	Yes	No	Contraindicated	Unnecessary	Refused
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Redistribution surface					
General pediatric unit	870 (61%)	181 (12.7%)	2 (0.1%)	37 (2.6%)	3 (0.2%)
PCCU	1,769 (85%)	183 (8.8%)	2 (0.1%)	127 (6.1%)	1 (0.9%)
NICU III	3,696 (67%)	867 (15.7%)	24 (0.4%)	918 (16.7%)	0 (0%)
Pediatric rehabilitation unit	36 (95%)	2 (5.3%)	0 (0%)	0 (0%)	0 (0%)
Pediatric step down unit	171 (75.2%)	38 (16.1%)	0 (0%)	27 (11.4%)	0 (0%)
NICU IV	200 (79%)	28 (11.1%)	3 (1.2%)	22 (8.7%)	0 (0%)
Repositioning as prescribed					
General pediatric unit	965 (67%)	106 (7.4%)	5 (0.3%)	361 (25.1%)	3 (0.2%)
PCCU	1,832 (86.6%)	119 (5.6%)	54 (2.6%)	109 (5.2%)	2 (0.1%)
NICU III	5,488 (96.3%)	173 (3%)	8 (0.1%)	28 (0.5%)	0 (0%)
Pediatric rehabilitation unit	33 (89.2%)	1 (2.7%)	0 (0%)	3 (8.1%)	0 (0%)
Pediatric step down unit	193 (76.3%)	20 (7.9%)	1 (0.4%)	39 (15.4%)	0 (0%)
NICU IV	251 (100%)	0 (0%)	0 (0%)		

(continued)

Table 17 (continued)

Intervention Type	Frequency by response option (%)				
	Yes	No	Contraindicated	Unnecessary	Refused
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Nutritional support					
General pediatric unit	984 (68.3%)	134 (9.3%)	22 (1.5%)	299 (20.7%)	2 (0.15)
PCCU	1,742 (83.3%)	153 (7.3%)	91 (4.4%)	105 (5%)	0 (0%)
NICU III	5,407 (96.0%)	146 (2.6%)	3 (0.1%)	79 (1.4%)	0 (0%)
Pediatric rehabilitation unit	37 (100.0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Pediatric step down unit	192 (78.7%)	19 (7.8%)	1 (0.4%)	32 (13.1%)	0 (0%)
NICU IV	236 (93.7%)	15 (6%)	1 (0.4%)	0 (0%)	0 (0%)
Moisture management					
General pediatric unit	1,009 (70.7%)	97 (6.8%)	3 (0.2%)	316 (22.1%)	3 (0.2%)
PCCU	1,711 (83.2%)	111 (5.4%)	6 (0.3%)	228 (11.14%)	0 (0%)
NICU III	5,016 (88.8%)	265 (4.7%)	11 (0.2%)	356 (6.3%)	0 (0%)
Pediatric rehabilitation unit	35 (92.1%)	12 (5%)	1 (0.4%)	2 (5.3%)	0 (0%)
Pediatric step down unit	187 (77.3%)	12 (5%)	1 (0.4%)	42 (17.4%)	0 (0%)
NICU IV	219 (85.5%)	27 (10.5%)	0 (0%)	10 (3.9%)	0 (0%)

(continued)

Table 17 (continued)

Intervention Type	Frequency by response option (%)				
	Yes	No	Contraindicated	Unnecessary	Refused
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Skin assessment					
General pediatric unit	1,400 (99%)	25 (1.7%)	10 (0.7%)		
PCCU	2,036 (99%)	19 (0.9%)	1 (0.05%)		
NICU III	5,605 (99.6%)	15 (0.26%)	7 (0.02%)		
Pediatric rehabilitation unit	38 (95%)	2 (5%)	0 (0%)		
Pediatric step down unit	249 (99.6%)	1 (0.4%)	0 (0%)		
NICU IV	254 (100%)	0 (0%)	0 (0%)		

Contraindicated = documented contraindicated; Unnecessary = documented unnecessary for the patient; Refused = documented patient refused; PCCU = Pediatric Critical Care Unit; NICU = Neonatal Intensive Care Unit.

pediatric step down units = 11.4%). Nevertheless, 5.3% to 16.1% of patients in these units did not receive a pressure redistribution surface (see Table 17).

Repositioning as prescribed by unit type (microsystem). All of the at risk patients were repositioned as prescribed in the NICUs IV (100%), and nearly all of the patients in the NICUs III (96.3%) were repositioned as prescribed. Patients at risk in less acute care units, such as the general pediatric units (67.0%) and step down units (76.3%), were less often repositioned as prescribed. However, repositioning as prescribed was determined to be unnecessary for 25.1% of patients on the general pediatrics units and 15.4% of the patients on the pediatric step down units. Conversely, for a small number of patients from PCCUs (2.6%), repositioning as prescribed was contraindicated; the reason for this was not available. Patients from the general pediatric and step down units had the highest number of patients (7.4% to 7.9%) who did not receive repositioning as an intervention (see Table 17).

Nutritional support by unit (microsystem). All of the patients at risk for pressure ulcers in the pediatric rehabilitation unit received nutritional support. Most of the patients on the NICUs III (96.0%) and NICUs IV (93.7%) received nutritional support. Fewer patients on the general pediatric units (68.3 %) and pediatric step down units (78.7%) received nutritional support. However, nutritional support was determined to be unnecessary for 20.7% of the at risk patients on the general pediatric units and for 13.1% on the pediatric step down units. Nine percent of at risk patients in general pediatric units did not receive needed nutritional support (see Table 17).

Moisture management by unit (microsystem). Moisture management was used most often for patients at risk in the infant populations of the NICUs III (88.8%) and the NICUs IV (85.5%), as well as for patients in pediatric rehabilitation units (92.1%). Consistent with other

pressure ulcer interventions across unit types, moisture was managed less often for at risk patients in general pediatric units (70.7%) and pediatric step down units (77.3%). For a substantial number of patients in the general pediatric units (22.1%), the PCCUs (11.14%), and the pediatric step down units (17.4 %), moisture management was determined to be unnecessary. There were also a very few patients for whom moisture management was considered contraindicated. General pediatric units and NICUs IV had the greatest number of patients that did not receive moisture management (6.8% and 10.5%, respectively) (see Table 17).

Routine skin assessment by unit type (microsystem). Routine skin assessment was performed on all of the NICU IV patients at risk for pressure ulcers and for 99.6% (n = 5,605) of the patients in the NICUs III within the 24-hour period before the survey. Routine skin assessment was also performed for most of the at risk patients in the pediatric step down units (99.6%; n = 249) and PCCUs (99.0%; n = 2,036). The majority of patients from the general pediatric units (99.0%) and pediatric rehabilitation units (95.0%) also received routine skin assessment less than 24 hours prior to the survey (see Table 17).

Analysis of Independent Variables and HAPU for All Pediatric Patients

Bivariate analyses were performed to determine the unadjusted relationship between each of the independent variables and HAPU (yes, no). Independent variables included patient age, patient gender, skin assessment within 24 hours of admission, patient pressure ulcer risk assessment within 24 hours of admission, patient pressure ulcer risk assessment score, timing of last patient risk assessment score prior to survey, pressure interventions (pressure redistribution surface, repositioning, nutritional support, moisture management, and routine skin assessment), unit type, RN hours per patient day, percent RN skill mix, hospital type, Magnet status, teaching status, metropolitan status, and bed size.

Patient Level Data

Patient age, patient pressure ulcer risk assessment within 24 hours of admit, timing of the last patient pressure ulcer risk assessment, and select pressure ulcer risk assessment scale scores were significantly associated with HAPU in bivariate analysis. Patients ages 9 to18 years had a higher number of HAPU than expected, whereas those ages 1 to 30 days had a lower number than expected ($\chi^2 = 38.619$, $p < .001$) (see Table 18). Interestingly, more HAPU were observed than expected among patients assessed for pressure ulcer risk on admission; the rate of HAPU was less than expected for patients who were not assessed for pressure ulcer risk on admission ($\chi^2 = 9.23$, $p = .002$). Likewise, those who were assessed for pressure ulcer risk within the 24-hour period before the survey had more HAPU than those who were assessed longer than 24 hours before the survey ($\chi^2 = 8.24$, $p = .004$).

The rate of HAPU among patients who were identified to be at risk for pressure ulcers was significantly higher than the rate of HAPU among those who were not at risk for HAPU ($p < .002$). The mean Braden score on admission for patients with HAPU was 16.4 ($SD = 4.52$), whereas the mean score for those without a HAPU was 19.58 ($SD = 3.81$; see Table 19). This difference was statistically significant ($t = 5.209$, $p = 0.029$). Similarly, the mean Braden Q score on admission for patients with a HAPU was 19.42 ($SD = 4.84$) on average while the mean score for patients with no HAPU was 23.38 ($SD = 4.24$); however, a score of 19 does not indicate risk. This difference was statistically significant ($t = 14.2$, $p < .001$). Likewise, the NSRAS mean score on admission was significantly lower for patients with HAPU (13.24) relative to the mean score of patients without HAPU (mean = 16.07, $t = -2.709$, $p = .007$). The cut off score for the NSRAS is 13; therefore, both scale scores indicated a risk for pressure ulcer. Contrary to the

Table 18

Categorical Variables Associated with HAPU for All Pediatric Patients (n = 39,984)

	HAPU				*p*-value	
	Patients with HAPU (*n*)	Percentage	Patients without HAPU (*n*)	Percentage	χ^2	Fisher's
Age[a]					< 0.001**	
Gestational only	20	4.6	2,551	6.7		
1-30 days	66	15.2	9,164	23.9		
1-11 months	113	26.0	10,393	77.2		
1-2 years	47	10.8	3,599	9.4		
3-4 years	21	4.8	2,068	5.4		
5-8 years	39	9.0	2,849	7.4		
9-18 years	128	29.5	7,641	20.0		
Gender[b]						0.222
Male	187	43.6	17,538	45.6		
Female	242	56.4	20,960	54.4		
Skin assessment on admission (n = 37,682)[c]					0.47	
Yes	409	97.4	36,055	96.8		
No	11	2.6	1,207	3.2		

(continued)

Table 18 (continued)

	HAPU				*p*-value	
	Patients with HAPU (*n*)	Percentage	Patients without HAPU (*n*)	Percentage	χ^2	Fisher's
Unit type					< 0.001**	
General pediatric	87	19.7	15,109	38.2		
PCCU	211	47.8	5,416	13.7		
NICU III	104	23.6	16,050	40.6		
Pediatric rehabilitation	9	2.0	185	0.5		
Pediatric step down	17	3.9	1,683	4.1		
NICU IV	13	2.9	1,150	2.9		
Hospital type					< 0.001**	
Nonpediatric	186	42.2	25,274	63.9		
Pediatric	255	58.8	14,269	36.1		
Teaching status					< 0.001**	
Academic medical	247	56.0	17,579	44.5		
Teaching status	169	38.8	15,986	40.4		
Nonteaching status	25	5.7	3,978	15.1		

(continued)

Table 18 (continued)

	HAPU				*p*-value	
	Patients with HAPU (*n*)	Percentage	Patients without HAPU (*n*)	Percentage	χ^2	Fisher's
Metro status						0.073
Yes	440	99.8	39,159	99		
No (micro)	1	0.2	384	1		
Magnet					<0.001**	
Yes	142	32.2	23,140	58.5		
No	299	67.8	16,403	41.5		
Bed category					0.449	
< 300	171	38.8	14,641	37		
> 300	270	61.2	24,902	63		

[a]Missing data on age = 1,285 (3.2%).
[b]Missing data on gender = 1,057 patients (2.6%).
[c]Missing data on skin assessment = 2,302 patients (5.8%).
[d]Missing data on risk assessment admit = 2,263 patients (5.6%).
[e]Missing data timing on risk assessment = 767 patients (1.9%).
[f]Missing data on pressure ulcer last assessment prior to survey = 2,907 patients (7.2%).
PCCU = Pediatric Critical Care Unit; NICU = Neonatal Intensive Care Unit; Metro = Metropolitan; Micro = Micropolitan.
*Significant $p < .05$.
**Significant $p < .001$.

Table 19
Risk Assessment Scale Score Associated with HAPU for All Pediatric Patients

Scales	Scores				
	N	Mean	*SD*	*t*	*p*
Braden score on admission	3,044				
Yes HAPU	41	16.4	4.52	5.209	0.029*
No HAPU	3,003	19.58	3.81		
Braden Q score on admission	16,878				
Yes HAPU	236	19.42	4.84		
No HAPU	16,642	23.38	4.24	14.2	< 0.001**
NSARS score on admission	2,616				
Yes HAPU	15	13.24	4.305	- 2.709	0.007*
No HAPU	2,601	16.07	3.55		
Braden score on last assessment prior to pressure ulcer survey	2,858				
Yes HAPU	40	14.95	3.86		
No HAPU	2,818	19.57	3.7	7.827	< 0.001**
Braden Q score on last assessment prior to pressure ulcer survey	17,015				
Yes HAPU	238	19.73	3.84		
No HAPU	1,677	23.86	3.85	16.449	< 0.001**
NSRAS score on last assessment prior to pressure ulcer survey	2,794				
Yes HAPU	17	13.00	3.85		
No HAPU	2,777	9.93	3.77	-3.86	< 0.001**

NSRAS = Neonatal Skin Risk Assessment Scale.
*Significant $p < .05$. **Significant $p < .001$.

Braden and Braden Q Scales, a higher score on the NSRAS Scale indicates a higher risk for HAPU.

Patients with a HAPU had significantly different mean pressure ulcer risk assessment scores on their last pressure ulcer risk assessment prior to the NDNQI pressure ulcer survey compared to patients that did not have a HAPU. The mean Braden score on last assessment prior to the survey for patients with a HAPU was statistically lower at 14.95 (*SD* = 3.86) when compared to the mean score for patients without a HAPU (mean = 19.57, *SD* = 3.7, $t = 7.827$, $p < .001$). The mean Braden Q score on last assessment prior to the survey was also significantly lower at 19.73 (*SD* = 3.84) for patients with a HAPU as compared to the mean score for patients without a HAPU (mean = 23.86, $t = 16.449$, $p < .001$) although a score greater than 19 does not indicate risk. The mean NSRAS score on last assessment prior to the survey for patients with a HAPU was significantly higher at 13.00 (*SD* = 3.77), relative to the mean score for patients without a HAPU (mean = 9.93, $t = -3.86$, $p < .001$). (The NSRAS scale has higher scores for higher risk). There were no significant differences between admission and last pressure ulcer risk assessment prior to the survey for mean scores for the Braden or the Braden Q Scales; however, there was a statistically significant difference for mean NSRAS scores that requires further exploration.

Microsystem Factors

Patients on the PCCUs and the pediatric rehabilitation units had significantly more HAPU than patients on the general pediatric units and NICUs ($\chi^2 = 454.14$, $p < .001$) (see Table 18). Overall, the mean RNHPPD for patients with HAPU was 14.98 (*SD* = 5.06), which was significantly different than the mean RNHPPD for patients without HAPU (mean = 11.68, *SD* = 3.69, $t = -17.542.26$, $p < 0.001$) (see Table 20). By unit type, the mean RNHPPD was higher for

patients with HAPU as compared to those without HAPU, but this difference in RN hours was not significant except for pediatric step down unit patients. Specifically, on general pediatric units, the mean RNHPPD for patients with HAPU was 9.35 (*SD* = 1.41) while the mean

Table 20

RN Hours Per Patient Day by Unit Type

Unit	Number of patients	RN hours per patient day			
	n	Mean	*SD*	*t*	*p*
General Pediatric					
Yes HAPU	87	9.35	1.41	-2.83	0.231
No HAPU	15,109	8.8	1.75		
PCCU					
Yes HAPU	211	19.26	3.09	-0.89	0.464
No HAPU	5,416	19.08	3.3		
NICU III					
Yes HAPU	104	12.33	2.34	-2.15	0.058
No HAPU	16,050	11.92	1.93		
Pediatric rehabilitation					
Yes HAPU	9	6.87	3.4	-0.462	0.062
No HAPU	185	6.42	2.8		
Pediatric step down					
Yes HAPU	6	11.82	3.38	-1.38	0.017*
No HAPU	256	11.19	1.84		
NICU IV					
Yes HAPU	13	13.7	2.29	-1.875	0.184
No HAPU	1,150	12.7	1.89		

RN = Registered Nurse; HAPU = Hospital Acquired Pressure Ulcers; PCCU = Pediatric Critical Care Unit; NICU = Neonatal Intensive Care Unit.
*Significant $p < .05$.
**Significant $p < .001$.

RNHPPD for patients without HAPU was 8.8 (*SD* = 1.75, *t* = -2.8, *p* = 0.23). There was little difference in the mean RNHPPD on PCCUs for patients with HAPU (mean = 19.26, SD=3.09, *t* = -0.89) relative to the RNHPPD for those without HAPU (mean = 19.08, *SD* = 3.3, *t* = -0.89, *p* = 0.464). Likewise, the mean RNHPPD in the NICUs III, NICUs IV, and pediatric rehabilitation units were nonsignificantly higher for patients with HAPU as compared to patients without HAPU. However, the mean RNHPPD on pediatric step down units was significantly higher for patients with HAPU (mean = 11.82, *SD* = 3.3) relative to patients without HAPU (mean = 11.19, *SD* = 1.8, *t* = -1.38, *p* = 0.017).

Overall, the mean percent RN skill mix for patients with HAPU was 0.90 (*SD* = 0.09), which was statistically significantly greater than the mean percent RN skill mix for patients without HAPU, but the difference was numerically small (mean = 0.88, *SD* = 0.10, *t* = -4.01, *p* <.001). By unit type, the only significant variable was the mean percent RN skill mix on general pediatric units for patients with HAPU at 0.81 (*SD* = 0.07) while the mean percent RN skill mix for patients without HAPU was 0.80 (*SD* = 0.09) (see Table 21). Although this difference was statistically significant, it was numerically small (*t* = -0.62, *p* = .003). There was no significant difference in the mean percent RN skill mix for patients with HAPU compared to mean percent RN skill mix for patients without HAPU on the PCCUs, NICUs III, pediatric rehabilitation units, pediatric step down units, and NICUs IV.

Mesosystem Factors

The bivariate relationship between HAPU and mesosystem factors, such as hospital type, Magnet status, teaching status, metropolitan status, and bed category, were also evaluated (see Table 18). As previously mentioned, most of the hospitals in the hospital sample were

nonpediatric hospitals. Analysis of pediatric hospital type revealed that pediatric hospitals had more patients with HAPU than expected, whereas nonpediatric hospitals had fewer patients with

Table 21

Percent RN Skill Mix by Unit Type

Unit	Number of patients	Percent RN skill mix			
	n	Mean	*SD*	*t*	*p*
General Pediatric					
Yes HAPU	87	0.81	0.07	-0.62	0.003*
No HAPU	15,109	0.80	0.09		
PCCU					
Yes HAPU	211	0.94	0.05	-0.231	0.07
No HAPU	5,416	0.94	0.05		
NICU III					
Yes HAPU	104	0.95	0.05	-0.28	0.298
No HAPU	16,050	0.95	0.04		
Pediatric rehabilitation					
Yes HAPU	9	0.60	0.09	0.89	0.526
No HAPU	185	0.62	0.07		
Pediatric step down					
Yes HAPU	13	0.83	0.08	0.453	0.523
No HAPU	1150	0.84	0.1		
NICU IV					
Yes HAPU	56	0.94	0.01	1.97	0.344
No HAPU	1,759	0.94	0.01		

RN = Registered Nurse; HAPU = Hospital Acquired Pressure Ulcers; PCCU = Pediatric Critical Care Unit; NICU = Neonatal Intensive Care Unit.
*Significant $p < .05$.
**Significant $p < .001$.

HAPU ($\chi^2 = 89.10$, $p < .001$) than expected. Teaching status was also significantly associated with HAPU ($\chi^2 = 39.47$, $p < 0.001$) as was Magnet status ($\chi^2 = 15.49$, $p < 0.001$). Metropolitan status and bed size greater than or less than 300 were not significantly associated with HAPU in this analysis.

Hierarchical Logistic Regression

The adjusted relationship between study variables and HAPU was examined using hierarchical logistic regression (SAS Institute, 2012). Two main models were fit. The first model included all pediatric patients and was performed to identify factors associated with HAPU among these patients. The second model included patients at risk for pressure ulcers in order to explore the current pressure ulcer prevention practices being used and if those prevention measures are associated with HAPU.

Hierarchical Logistic Regression Analysis of All Pediatric Patients – Main Model #1

In the first main model, variables were entered in the model by level, with patient level data first, unit level data second, and hospital level data third. Patient level data included gender, age, skin assessment on admission, risk assessment on admission, timing of last risk assessment, and patient at risk for pressure ulcers on last risk assessment prior to survey. Unit level data included unit type, the annual RN hours per patient day, and annual percent RN skill mix. Hospital data included hospital teaching status, metropolitan status, Magnet status, and bed size. The independent variable was the presence of patient HAPU (yes or no). Because there were significant differences in the HAPU rate by hospital type, this variable was also included in the analysis. The final main model #1 included 34,020 patients and 398 HAPU (see Table 22).

For patient level data, there was no significant association between HAPU and gender, skin assessment on admission, patient pressure ulcer risk assessment on admission, and patient

Table 22

Factors Associated with HAPU – Main Model #1

Measure	Patient Level				Unit Level Added				Hospital Level Added			
	ß Estimate	*OR*	95% CI	*p-value*	ß Estimate	*OR*	95% CI	*p-value*	ß Estimate	*OR*	95% CI	*p-value*
Patient level												
Age												
Gestational age only												
1-30 days	0.35	1.42	(0.73, 2.76)	0.3	0.01	1.01	(0.54, 1.9)	0.97	-0.07	0.93	(0.48, 1.7)	0.82
1-11 months	0.64	1.8	(0.99, 3.59)	0.05	0.02	1.02	(0.54, 1.96)	0.95	-0.1	0.9	(0.46, 1.7)	0.76
1-2 years	0.73	2.08	(1.04, 4.15)	0.04*	-0.10	0.9	(0.43, 1.9)	0.78	-0.21	0.81	(0.38, 1.7)	0.58
3-4 years	0.68	1.97	(0.93, 4.20)	0.08	-0.16	0.85	(0.38, 1.9)	0.7	-0.29	0.75	(0.33, 1.6)	0.49
5-8 years	0.88	2.41	(1.19, 4.89)	0.01*	0.09	1.09	(0.51, 2.32)	0.83	-0.04	0.96	(0.44, 2.08)	0.93
9-18 years	1.06	2.89	(1.52, 5.48)	0.001*	0.27	1.3	(0.65, 2.63)	0.46	0.15	1.17	(0.57, 2.3)	0.67
Gender male	0.07	1.07	(0.87, 1.31)	0.54	0.06	1.06	(0.86, 1.3)	0.59	0.06	1.06	(0.86, 1.29)	0.6
Skin risk assessment on admit	0.62	1.87	(0.86, 4.05)	0.12	0.56	1.76	(0.81, 3.8)	0.15	0.59	1.81	(0.83, 3.9)	0.14
Pressure ulcer risk assessment	-0.06	0.95	(0.54, 1.67)	0.85	0.03	1.03	(0.59, 1.8)	0.92	0.04	1.04	(0.59, 1.8)	0.89
Timing of last PU risk assessment	0.12	1.13	(0.67, 1.92)	0.65	0.11	1.12	(0.67, 1.87)	0.66	0.14	1.15	(0.68, 1.9)	0.6
At risk on last assessment	2.24	9.42	(7.28, 12.17)	<001**	2.05	7.8	(6.0, 10.2)	<.001**	2.04	7.71	(5.9, 10.0)	<.001**
Unit level												
Percent RN skill mix					0.66	1.94	(0.22, 17.35)	0.55	0.98	2.67	(0.28, 24.8)	0.43
RNHPPD					0.01	1	(0.95, 1.07)	0.83	-0.03	0.97	(0.91, 1.03)	0.39
Unit type												
General pediatrics												
PCCU					0.95	2.59	(1.28, 5.26)	0.009*	1.21	3.36	(1.5, 7.1)	.002*
NICU III					-0.49	0.61	(0.34, 1.11)	0.11	-0.36	0.7	(0.37, 1.2)	0.24
Pediatric rehabilitation					1.39	4.05	(1.21, 13.55)	0.02*	1.48	4.41	(1.3, 14.7)	.02*
Pediatric step down					0.23	1.27	(0.65, 2.45)	0.49	0.21	1.24	(0.63, 2.39)	0.53
NICU IV					0.48	1.61	(0.65, 4.0)	0.3	0.49	1.63	(0.66, 4.03)	0.3

(continued)

Table 22 (continued)

Measure	Patient Level				Unit Level Added				Hospital Level Added			
	ß Estimate	*OR*	95% CI	*p-value*	ß Estimate	*OR*	95% CI	*p-value*	ß Estimate	*OR*	95% CI	*p-value*
Hospital level												
Hospital type									0.98	2.67	(1.5, 4.76)	.001*
Teaching status												
Academic medical center												
Teaching									-0.10	0.9	(0.59, 1.3)	0.63
Nonteaching									-0.58	0.56	(0.29, 1.07)	0.08
Metropolitan status									-0.44	0.64	(0.06, 6.5)	0.71
Magnet status									0.08	1.09	(0.73, 1.5)	0.67
Bed size (< 300 or > 300)									0.58	1.79	(0.99, 3.2)	0.05

Model includes 34,020 pediatric patients, 398 HAPU, 2 LL = 31,774.13.
PCCU = Pediatric Critical Care Unit; NICU = Neonatal Intensive Care Unit; RN = Registered Nurse; *OR* = Odds Ratio; CI = Confidence Interval.
*Significant $p < .05$.
**Significant $p < .001$.

pressure ulcer risk assessment within 24 hours of the survey. The odds for a patient to develop a HAPU were 9.42 times higher among patients who were identified as being at risk for pressure ulcers on last assessment when compared to patients not at risk for pressure ulcers on last assessment (*OR* = 9.42, 95% CI [7.28, 12.17], $p < .001$). This relationship remained significant when unit level and hospital level data were added to the model. (*OR* = 7.71, 95% CI [5.9, 10.0], $p < .001$). Patients ages 1 to 2 years had two times higher odds for a HAPU (*OR* = 2.08, 95% CI [1.04, 4.15], $p = .04$) relative to newborns for whom gestational age was reported. Patients ages 5 to 8 years had 2.41 times higher odds for a HAPU (*OR* = 2.41, 95% CI [1.19, 4.89], $p =. 01$) and patients ages 9 to18 years had 2.89 times higher odds for a HAPU (*OR* = 2.89, 95% CI [1.52, 5.48], $p = .001$) when compared to newborns for whom gestational age was reported (see Table 22).

When unit level data was added into the model, the association between age and HAPU was attenuated to nonsignificance. The odds for a HAPU among patients in the PCCU were 2.59 times higher than for patients in the general pediatric units (*OR* = 2.59, 95% CI [1.28, 5.26], $p = .009$). The odds for a HAPU among pediatric rehabilitation patients were also higher (*OR* = 4.05, 95% CI [1.21, 13.55], $p = .02$) relative to general pediatric patients. This significance remained stable when the hospital level data were added to the hierarchical logistic analysis. No other unit types were significantly associated with HAPU in hierarchical logistic regression.

The only hospital level variable associated with HAPU rates in hierarchical logistic regression was pediatric hospital type. Specifically, the odds for a HAPU were 2.67 times greater among patients in pediatric hospitals as compared to general acute care hospitals with pediatric units (*OR* = 2.67, 95% CI [1.50, 4.76], $p = .001$). Hospital characteristics such as

teaching status, Magnet status, metropolitan status, or bed size were not significantly associated with HAPU after controlling for all other variables.

Hierarchical logistic regression analysis of all pediatric patients by unit type. Because processes and outcomes can vary by unit type, the relationship between study variables and HAPU were examined in hierarchical logistic regression analysis by unit type. The analyses by unit type included removing variables with cell sizes that were not large enough to meet assumptions necessary for logistic regression and merging cells that were clinically appropriate (see Table 23).

General pediatric units. For general pediatrics units, all of the variables in the main model were included in the unit analysis except for metropolitan status, which was excluded because of small or nonexistent cell sizes. Among general pediatric patients, the odds of HAPU were 10 times higher for those patients identified to be at pressure ulcer risk compared to those patients not at risk for HAPU (OR = 11.86, 95% CI [7.32, 19.21], $p < .001$), and this remained stable when unit and hospital level variables were entered into the analysis (see Table 23). No other patient level data (i.e., age, gender, skin assessment on admission, risk assessment on admission, timing of last risk assessment prior to survey), unit level data (i.e., RNHPPD, percent RN skill mix), or hospital level data (i.e., hospital type, teaching status, Magnet status, bed size, or bed category) were associated with HAPU in the hierarchical logistic regression analysis.

Pediatric critical care units. All of the variables in the main model were included in the unit analysis for the PCCUs with the exception of metropolitan status, which was excluded because of small cell size. Those PCCU patients who were assessed to be at risk on last assessment had 4.65 times higher odds for a HAPU (OR = 4.65, 95% CI [3.25, 6.63], $p < .001$) relative to PCCU patients not determined to be at risk for pressure ulcers on last assessment.

Table 23

Pediatric Variables Associated with HAPU by Unit Type

Unit Measure	Model level patient ß Estimate	*OR*	95% CI	*p-value*	Model level unit ß Estimate	*OR*	95% CI	*p-value*	Model level hospital ß Estimate	*OR*	95% CI	*p-value*
General pediatric[a]												
Patient level factors												
At risk on assessment	2.47	11.86	(7.32, 19.21)	<.001**	2.45	11.62	(7.14, 18.91)	<.001**	2.4	10.94	(6.66, 17.97)	<.001**
PCCU[b]												
Patient level factors												
At risk on assessment	1.54	4.65	(3.25, 6.63)	<.001**	1.54	4.67	(3.3, 6.67)	<.001**	1.53	4.62	(3.22, 6.61)	<.001**
Hospital factors												
Hospital type									0.96	2.6	(1.42, 4.78)	.002*
NICU III[c]												
Patient level factors												
At risk on assessment	2.5	12.59	(6.27, 25.27)	<.001**	2.52	12.43	(6.2, 24.94)	<.001**	2.6	13.52	(6.55, 27.88)	<.001**
Hospital factors												
Teaching status												
Academic medical Teaching									-0.21	0.81	(0.38, 1.75)	0.58
Nonteaching									-1.39	0.25	(0.07, 0.92)	0.04*
Pediatric rehabilitation[d]												
Patient level factors												
At risk on assessment	1.65	5.3	(1.12, 24.49)	0.04*	1.57	4.79	(1.0, 23.0)	0.05	1.52	4.56	(0.94, 22.27)	0.06

(continued)

Table 23 (continued)

Unit Measure	Model level patient ß Estimate	*OR*	95% CI	*p-value*	Model level unit ß Estimate	*OR*	95% CI	*p-value*	Model level hospital ß Estimate	*OR*	95% CI	*p-value*
Pediatric step down[e]												
Patient level factors												
At risk on assessment	2.26	9.57	(0.003, 26,311)	0.17	2.3	9.96	(2.63, 37.75)	<.001**	2.47	11.79	(2.74, 50.76)	0.001*
NICU IV[f]												
Patient level factors												
At risk on assessment	1.96	7.1	(1.3, 38.75)	0.02*	2	7.46	(1.28, 43.64)	0.03*	2.3	10.01	(1.65, 60.67)	0.01*

[a] $n = 13,458$, EAPU 79.
[b] $n = 5,028$, EAPU 197.
[c] $n = 12,771$, EAPU 92.
[d] $n = 178$, EAPU 9.
[e] $n = 1,489$, EAPU 13.
[f] $n = 1,154$, EAPU 13.

PCCU = Pediatric Critical Care Unit; NICU = Neonatal Intensive Care Unit; *OR* = Odds Ratio; CI = Confidence Interval.
*$p < .05$ = statistical significance.
**$p < .001$ = statistical significance.

This association was consistent when unit and hospital level data were added to the analysis (see Table 23). The odds for a HAPU were 2.6 times higher for patients in pediatric hospital types when compared to patients from general acute care hospital types with pediatric units (*OR* = 2.6, 95% CI [1.42, 4.78], *p* =.002). No other patient level data (i.e., age, gender, skin assessment on admission, risk assessment on admission, or timing of last risk assessment prior to survey), unit level data (i.e., RNHPPD or percent RN skill mix), or hospital level data variables (i.e., hospital type, teaching status, Magnet status, bed size, or bed category) were associated with HAPU in hierarchical logistic regression analysis.

NICUs III. For NICUs III, all of the variables in the main model were included in the analysis. Similar to PCCUs, the odds for a HAPU were 12 to 13 times higher for NICU III patients assessed to be at risk for pressure ulcers on last assessment compared to patients not determined to be at risk for pressure ulcers (*OR* = 12.59, 95% CI [6.27, 25.27], *p* < .001). This remained stable when adding unit and hospital level data (see Table 23). Among NICU patients in nonteaching hospitals, the odds for a HAPU were 75% lower relative to NICU patients in academic centers (*OR* = .25, 95% CI [0.07, 0.92], *p* = .04). No other patient level data (i.e., age, gender, skin assessment on admission, risk assessment on admission, or timing of last risk assessment prior to survey), unit level data (i.e., RNHPPD or percent RN skill mix), or hospital level data (i.e., hospital type, metropolitan status, Magnet status, bed size, or bed category) were associated with HAPU in hierarchical logistic regression analysis.

Pediatric rehabilitation units. Variables excluded from the modeling of study variables and HAPU in pediatric rehabilitation units included age, skin assessment on admission, risk assessment on admission, metropolitan status, teaching status, and Magnet status. These variables were excluded from the analysis because of small or nonexistent cell sizes. Patients in

pediatric rehabilitation units had 5.3 times higher odds for a HAPU if they were assessed to be at risk for pressure ulcers on their last risk assessment prior to the survey relative to patients who were not at risk for pressure ulcers on last risk assessment (*OR* = 5.3, 95% CI [1.12, 24.49], *p* = .04). No other patient level data (i.e., gender, skin assessment, or pressure ulcer risk assessment), unit level data (i.e., RNHPPD or percent RN skill mix), or hospital level data (hospital type, bed size, or bed category) were associated with HAPU in this analysis (see Table 23).

Pediatric step down units. Hierarchical logistic regression modeling of patients in the pediatric step down units excluded data on age, timing of last risk assessment, and metropolitan status due to small cell sizes. In pediatric step down units, the odds for a HAPU were 9.96 times higher for patients at risk for pressure ulcers on their last assessment compared to patients not at risk for pressure ulcers on their last assessment at the unit level (*OR* = 9.96, 95% CI [2.63, 37.75], *p* = < .001). These odds increased to 11.79 when controlling for unit and hospital level data. No other patient level data (i.e., gender, skin assessment, or pressure risk assessment), unit level data (i.e., RNHPPD or percent RN skill mix), or hospital level data (i.e., hospital type, teaching status, Magnet status, bed size, or bed category) were associated with HAPU in the hierarchical logistic regression analysis (see Table 23).

NICUs IV. For NICUs IV patients, the regression model excluded data on age, timing of risk assessment, bed category, and metropolitan status because of small cell sizes. Patients in the NICUs IV had 7.1 times greater odds for a HAPU if they were determined to be at risk on their last pressure ulcer risk assessment relative to patients who were not determined to be at risk for pressure ulcers on last assessment (*OR* = 7.1, 95% CI [1.3, 38.75], *p* = .02) (see Table 23). These odds increased to 10.01 when controlling for unit and hospital level data. No other patient level data (i.e., gender, skin assessment, or pressure risk assessment), unit level data (RNHPPD or

percent RN skill mix), or hospital level data (i.e., hospital type, teaching status, Magnet status, bed size, or bed category) were associated with HAPU in hierarchical logistic regression analysis.

Hierarchical Logistic Regression Analysis of Patients at Risk for HAPU – Main Model # 2

There were 11,203 pediatric patients (*n* = 270 HAPU) at risk for pressure ulcers. Variables were entered in the model by level, with patient level data first, unit level data second, and hospital level data third. Patient level data included skin assessment on admission, patient pressure ulcer risk assessment on admission, timing of patient pressure ulcer risk assessment, use of pressure redistribution surface, repositioning, nutritional support, moisture management, and routine skin assessment. Unit level variables entered into the model included unit type, RNHPPD, and percent RN skill mix; hospital level variables included pediatric hospital type, teaching status, Magnet status, metropolitan status, and bed size. The dependent variable was the presence of patient HAPU (yes or no). The model included 9,111 patients at risk for HAPU and 270 HAPU.

The analysis of patient level data revealed that the odds for a HAPU were 2.63 times higher among patients who received a skin assessment on admission compared to those who did not receive a skin assessment on admission (*OR* = 2.63, 95% CI [1.09, 6.34], *p* = .03) (see Table 24). This relationship was attenuated to nonsignificance when unit and hospital level variables were entered into the analysis. Interestingly, patients for whom a pressure redistribution surface was not in use had 55% lower odds for a HAPU as compared to those who did receive a pressure ulcer redistribution surface (*OR* = .45, 95% CI [0.27, 0.73], *p* = .002). Patients at risk for pressure ulcers, who did not receive a pressure redistribution surface because it was contraindicated, unnecessary, or the patient refused pressure redistribution, had 66% lower odds

Table 24

Pediatric Patients at Risk for HAPU

Measure	Model level patient				Model level unit				Model level hospital			
	ß Estimate	*OR*	95% CI	*p*-value	ß Estimate	*OR*	95% CI	*p*-value	ß Estimate	*OR*	95% CI	*p*-value
Patient level factors												
Skin assessment admission	0.97	2.63	(1.09, 6.34)	0.03*	0.83	2.28	(0.95, 5.4)	0.06	0.82	2.28	(0.95, 5.47)	0.07
Risk assessment admission	0.05	1.05	(0.52, 2.09)	0.9	0.11	1.12	(0.57, 2.2)	0.74	0.13	1.14	(0.58, 2.26)	0.7
Timing last risk assessment	-0.15	0.86	(0.41, 1.83)	0.7	-0.12	0.89	(0.44, 1.79)	0.74	-0.13	0.88	(0.43, 1.8)	0.73
Pressure redistribution surface use												
No pressure redistribution	-0.81	0.45	(0.27, 0.73)	0.002*	-0.66	0.52	(0.32, 0.84)	0.008*	-0.69	0.5	(0.31, 0.82)	0.006*
Contraindicated, Unnecessary or refused	-1.07	0.34	(0.20, 0.59)	<0.001**	-0.88	0.42	(0.24, 0.71)	0.002*	-0.89	0.41	(0.24, 0.71)	0.002*
Repositioned as prescribed												
No repositioning as prescribed	0.32	1.38	(0.75, 2.6)	0.3	0.27	1.3	(0.73, 2.33)	0.37	0.24	1.28	(0.71, 2.29)	0.41
Repositioning contraindicated, Unnecessary or refused	0.31	1.37	(0.74, 2.54)	0.32	0.07	1.07	(0.58, 1.98)	0.82	0.09	1.1	(0.60, 2.02)	0.76
Nutritional support												
No nutrition	-0.87	0.42	(0.19, 0.94)	0.03*	-0.96	0.38	(0.17, 0.85)	0.02*	-0.96	0.39	(0.17, 0.85)	0.02*
Contraindicated, Unnecessary or refused	-0.8	0.45	(0.24, 0.86)	0.015*	-0.89	0.41	(0.23, 0.77)	0.006*	-0.92	0.4	(0.21, 0.75)	0.004*
Moisture management												
No moisture management	-0.58	0.56	(0.25, 1.27)	0.16	-0.66	0.52	(0.23, 1.15)	0.11	-0.6	0.55	(0.24, 1.22)	0.14
Contraindicated, Unnecessary or refused	-0.43	0.65	(0.39, 1.09)	0.11	-0.38	0.69	(0.42, 1.14)	0.15	-0.35	0.7	(0.42, 1.17)	0.18
Skin assessment prevention												
No skin assessment prevention	0.27	1.31	(0.27, 6.27)	0.74	0.16	1.18	(0.25, 5.6)	0.84	0.16	1.17	(0.25, 5.58)	0.85
Contraindicated, Unnecessary or refused	1.29	3.63	(0.46, 28.65)	0.22	1.5	4.47	(0.62, 32.08)	0.14	1.55	4.71	(0.61, 36.2)	0.14

(continued)

Table 24 (continued)

Measure	Model level patient				Model level unit				Model level hospital			
	ß Estimate	*OR*	95% CI	*p*-value	ß Estimate	*OR*	95% CI	*p*-value	ß Estimate	*OR*	95% CI	*p*-value
Unit level factors												
Percent RN skill mix					0.93	2.53	(0.15, 43.9)	0.52	1.12	3.05	(0.17, 54.8)	0.45
RNHPPD					0.01	1.01	(0.94, 1.09)	0.81	-0.02	0.98	(0.90, 1.07)	0.63
Unit type												
General pediatrics												
PCCU					0.35	1.42	(0.55, 3.67)	0.47	0.61	1.83	(0.68, 4.98)	0.23
NICU III					-0.99	0.37	(0.19, 0.75)	0.006*	-0.82	0.44	(0.21, 0.91)	0.03*
Pediatric rehabilitation					1.04	2.84	(0.70, 11.5)	0.14	1.06	2.9	(0.73, 11.5)	0.13
Pediatric stepdown					0.15	1.16	(0.49, 2.75)	0.74	0.13	1.14	(0.48, 2.7)	0.77
NICU IV					-0.44	0.65	(0.17, 2.44)	0.52	-0.43	0.65	(0.17, 2.44)	0.52
Hospital level factors												
Hospital type pediatric									0.66	1.93	(0.94, 3.9)	0.07
Teaching status												
Academic medical center												
Teaching									0.02	1.02	(0.59, 1.77)	0.94
Nonteaching									-0.8	0.45	(0.19, 1.06)	0.07
Magnet status									-0.11	0.9	(0.08, 10.3)	0.93
Metropolitan status									0.06	1.06	(0.65, 1.73)	0.82
Bed size (< 300 or > 300)									0.25	1.29	(0.62, 2.66)	0.49

Model included 9,111 patients and 270 HAPU; 2 LL = 60,985.11.
PCCU = Pediatric Critical Care Unit; NICU = Neonatal Intensive Care Unit; RNHPPD = RN hours per patient per day; RN Percent = Percent RN skill mix; *OR* = Odds Ratio; CI = Confidence Interval.
*$p < .05$ = statistical significance.
**$p < .001$ = statistical significance.

for a HAPU (*OR* = .34, 95% CI [0.20, 0.59], $p < .001$) relative to patients who received a pressure redistribution surface. The same was true for nutritional support; specifically, patients who did not receive nutritional support had 58% lower odds for a HAPU than those patients who did not receive nutritional support because it was contraindicated, unnecessary, or the patient refused. Patients who did not receive nutritional support had 55% lower odds for a HAPU compared to patients who received nutritional support (*OR* = .45, 95% CI [0.24, 0.86], $p = .015$) (see Table 24). These relationships changed little when unit level and hospital level data were entered into the analysis. No other patient factors were significantly associated with HAPU in patient level analysis.

Analysis of unit level data found that patients in NICUs III had lower odds for a HAPU when compared to general pediatric patients (*OR* = 0.37, 95% CI [0.19, 0.75], $p = .006$). This remained consistent when hospital level data were entered into the analysis. No other unit level variables, such as RNHPPD or percent RN skill mix, were significantly associated with HAPU. Hospital type, teaching status, Magnet status, metropolitan status, and bed size were not significantly associated with HAPU in hierarchical regression analysis (see Table 24).

Hierarchical logistic regression for HAPU among pediatric patients at pressure ulcer risk by unit type. Because the processes and outcomes might have differed by unit type, the relationship between study variables and HAPU were examined in hierarchical regression analysis by unit type. Hierarchical regression by unit type included removing independent variables with cell sizes that were not large enough to meet the assumptions necessary for logistic regression and merging cells that were clinically appropriate.

General pediatric units. For general pediatric units, main model variables included in the unit level analysis were skin assessment on admission, patient pressure ulcer risk assessment

on admission, timing of patient pressure ulcer risk assessment, use of pressure redistribution surface, repositioning, nutritional support, and moisture management. Unit level data entered into the model included RNHPPD and percent RN skill mix; hospital level data included pediatric hospital type, teaching status, Magnet status, and bed size. The analysis excluded skin assessment and metropolitan status due to small cell size. In general pediatric units, patients for whom pressure redistribution surface use was contraindicated, unnecessary, or the patient refused had 80% lower odds for a HAPU compared to patients who received a redistribution surface (*OR* = 0.20, 95% CI [0.06, 0.67], *p* = .01); this association remained consistent when unit level and hospital level data were entered into the analysis. No other significant associations were observed between HAPU and patient level data (i.e., skin assessment on admission, patient pressure ulcer risk assessment on admission, timing of patient pressure ulcer risk assessment, repositioning, nutritional support, moisture management, and routine skin assessment). No other significant associations were observed between HAPU and unit level data (i.e., RNHPPD, and percent RN skill mix), and no other significant associations were observed between HAPU and hospital level data (i.e., pediatric hospital type, teaching status, Magnet status, and bed size) (see Table 25).

PCCUs. For PCCUs, the variables in the main model included in the unit analysis were patient level skin assessment on admission, patient pressure ulcer risk assessment on admission, timing of patient pressure ulcer risk assessment, use of pressure redistribution surface, repositioning, and moisture management. Nutritional support and routine skin assessment were excluded in the unit analysis because of small cell size. Unit level data entered into the model included RNHPPD and percent RN skill mix; hospital level data included pediatric hospital type,

Table 25

Pediatric Patients at Risk for HAPU by Unit Type

Unit Measure	Model level patient ß Estimate	*OR*	95% CI	*p*-value	Model level unit ß Estimate	*OR*	95% CI	*p*-value	Model level hospital ß Estimate	*OR*	95% CI	*p*-value
General pediatric[a]												
Patient level factors												
Pressure redistribution surface use												
No pressure redistribution	-0.83	0.44	(0.13, 1.51)	0.19	-0.82	0.44	(0.13, 1.53)	0.2	-0.83	0.44	(0.12, 1.55)	0.20
Contraindicated, Unnecessary, or refused	-1.63	0.2	(0.06, 0.67)	0.01*	-1.64	0.2	(0.06, 0.69)	0.01*	-1.73	0.18	(0.05, 0.64)	0.008*
PCCU[b]												
Patient level factors												
Nutritional support												
No nutrition	-1.34	0.26	(0.08, 0.86)	0.03*	-1.35	0.26	(0.08, 0.85)	0.03*	-1.36	0.26	(0.08, 0.85)	0.03*
Contraindicated, Unnecessary, or refused	-1.15	0.32	(0.12, 0.83)	0.02*	-1.15	0.32	(0.12, 0.83)	0.02*	-1.16	0.32	(0.12, 0.82)	0.02*
Pressure redistribution surface												
No pressure redistribution	-1.57	0.21	(0.06-0.68)	0.01*	-1.59	0.2	(0.06-0.67)	0.01*	-1.53	0.22	(0.07-0.72)	0.01*

(continued)

Table 25 (continued)

Pediatric Patients at Risk for HAPU by Unit Type

Unit Measure	Model level patient ß Estimate	*OR*	95% CI	*p*-value	Model level unit ß Estimate	*OR*	95% CI	*p*-value	Model level hospital ß Estimate	*OR*	95% CI	*p*-value
NICU III[c]												
Patient Level Factors												
Pressure redistribution surface use												
No pressure redistribution	-0.01	0.99	(0.52, 1.91)	0.98	0.04	1.04	(0.54, 2.02)	0.90	-0.004	1.0	(0.5, 1.98)	0.99
Contraindicated, Unnecessary, or refused	-0.94	0.39	(0.17, 0.93)	0.04*	-0.92	0.40	(0.17, 0.96)	0.04*	-0.97	0.38	(0.16, 0.92)	0.03*
Unit level factors												
Annual RNHPPD					0.16	1.18	(1.01, 1.38)	0.04*	0.17	1.18	(0.99, 1.41)	0.07

[a] n = 1,404, HAPU 41.
[b] n = 1,974, HAPU 137.
[c] n = 5,330, HAPU 79.
PCCU = Pediatric Critical Care Unit; NICU = Neonatal Intensive Care Unit; RNHPPD = RN hours per patient per day; RN Percent = Percent RN skill mix; *OR* = Odds Ratio; CI = Confidence Interval.
*$p < .05$ = statistical significance.
**$p < .001$ = statistical significance.

teaching status, Magnet status, and bed size. Metropolitan status was excluded in the unit analysis because of small cell size. Patients in PCCUs for whom a pressure redistribution surface was not in use had 78% lower odds for a HAPU compared to patients using a pressure redistribution surface (*OR* = 0.22, 95% CI [0.07, 0.72], *p* = .01) after controlling for all other variables in the model. Similarly, patients who did not receive nutritional support had 74% lower odds for a HAPU compared to those patients who did receive nutritional support (*OR* = 0.26, 95% CI [0.08, 0.85], *p* = .03). The odds for a HAPU were also 68% lower among PCCU patients for whom nutritional support was contraindicated, unnecessary, or the patient refused compared to those patients who did receive nutritional support (*OR* = 0.32, 95% CI [0.12, 0.82], *p* = .02). No other patient, unit, or hospital level data were significantly associated with HAPU in PCCUs.

NICUs III. For NICUs III, patient level variables included most of the main model variables of skin assessment on admission, patient pressure ulcer risk assessment on admission, timing of patient pressure ulcer risk assessment, use of pressure redistribution surface, repositioning, and moisture management. Nutritional support and routine skin assessment were excluded in the unit analysis because of small cell size. Unit level variables entered into the model included RNHPPD and percent RN skill mix; hospital level variables included pediatric hospital type, teaching status, Magnet status, metropolitan status, and bed size. In the NICUs III, patients for whom a pressure redistribution surface was contraindicated, unnecessary, or refused had 62% lower odds for a HAPU when compared to patients for whom a pressure redistribution surface was in use after controlling for all other variables (*OR* = 0.38, 95% CI [0.16, 0.92], *p* = .03) (see Table 25) after controlling for other variables in the model. Higher RN hours per

patient day increased the odds for a HAPU by 18% (*OR* = 1.18, 95% CI [1.01, 1.38], *p* = .04), but this relationship was attenuated to nonsignificance when hospital level data were entered into the model. No other significant associations between HAPU and patient level variables, unit level variables, or hospital level variables were observed.

Pediatric rehabilitation units, pediatric step down units, and NICUs IV. Modeling for pediatric rehabilitation units did not include patient level variables due to small cell size but did include unit level data of RNHPPD and percent RN skill mix as well as hospital level data of pediatric hospital type and bed size. Regression analysis for the pediatric step down units included skin assessment on admission, patient pressure ulcer risk assessment on admission, repositioning, nutritional support and moisture management, RNHPPD, and pediatric hospital type. Modeling of the data from the pediatric step down units excluded timing of last risk assessment, pressure redistribution use, routine skin assessment, percent RN skill mix, teaching status, Magnet status, metropolitan status, and bed size due to small cell size. Regression analysis of NICUs IV data included skin assessment on admit, patient pressure ulcer risk assessment on admit, RNHPPD, and pediatric hospital type, and excluded all other variables in the unit analysis due to small cell size. None of the patient level data of skin assessment on admission, patient pressure ulcer risk assessment on admission, timing of patient pressure risk assessment, repositioning, or moisture management were significantly associated with HAPU on pediatric rehabilitation units, pediatric step down units, and NICU IV units. Nor were the unit level data (RNHPPD or percent RN skill mix) or hospital level data (pediatric hospital type, teaching status, Magnet status, metropolitan status, or bed size) significantly associated with HAPU on these unit types in their unit analyses.

Summary

This chapter presented the results of a secondary analysis of pressure ulcers in pediatric patients. The results provide a detailed description of demographic characteristics of the study population, as well as the rate of HAPU in pediatric patients. This chapter also describes the frequency of patient pressure ulcer risk assessment and prevention interventions in the pediatric population. Bivariate and hierarchical logistic regression analysis reveals select patient, microsystem, and mesosystem factors that are associated with HAPU in pediatric patients. The next chapter identifies factors associated with HAPU as they relate to the research questions. Strengths and limitations, as well as recommendations for future studies, are explored.

Chapter V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

This chapter discusses findings relative to the study and how the results may contribute to the knowledge of pressure ulcers in children. The study investigated the rate of hospital-acquired pressure ulcers (HAPU) in hospitalized pediatric patients during 2012 and the frequency of patient pressure ulcer risk assessment and prevention interventions among NDNQI®-participating hospital pediatric units across the United States.

Significance of the Study

Relatively few studies have examined pressure ulcers in pediatric patients. Among them, most focused on the prevalence of pressure ulcers, most were single-hospital or small studies, and most reported rates across the pediatric population. To our knowledge, this is the first pediatric study to investigate HAPU and patient factors such as age and gender, unit level factors (RN hours, percent RN skill mix, and unit type), and hospital factors and their association with HAPU in pediatric patients. The large sample size of this study allowed for consideration of these variables in bivariate and multivariate analysis. This is also the first study to report the proportion of pediatric patients at risk for HAPU, provide a description of pressure ulcer prevention interventions, and evaluate their association with HAPU.

Discussion of the Results

Prevalence and Rate of HAPU

This study found a 1.4% overall prevalence of pressure ulcers and a 1.1% rate of HAPU among pediatric patients. The 1.1% rate of HAPU in this study was higher than the 0.29% rate of HAPU among pediatric patients found by Baldwin (2002). However, the results were much lower than the 7.0% to 7.4% rates among pediatric patients reported by Gallagher (1997),

Kottner et al. (2009), and Willock et al. (2000) respectively, and the 6.0% rate of HAPU by Noonan et al. (2006), the 5.6% rate reported by Waterlow (1997) and the 3.4% rate reported by McLane et al. (2004). This study was a larger study among pediatric patients across multiple pediatric unit types and hospitals compared to previous studies; therefore, the 1.1% HAPU rate is a better reflection of HAPU among pediatric patients across unit types and by unit types.

In this study, the lowest HAPU rates were for those children whose age was reported as gestational age or 1 to 30 days of age (0.72% to 0.78%). Patients less than 1 year of age comprised 57.6% of the sample, but the rate of HAPU was only 0.9% for this age group overall. In contrast, a previous study on pressure ulcers reported that most pressure ulcers occurred in children less than one year of age (McLane et al., 2004). There were no significant differences in HAPU rates by gender. This finding is consistent with those by Curley, Razmus, et al. (2003) and Schindler et al. (2011) that found no significant differences in HAPU by gender in pediatric patients.

By unit type, HAPU rates were higher in PCCUs and pediatric rehabilitation units. The 3.74% rate of HAPU in the PCCUs was higher than the 1.6% rate of HAPU for all pediatric patients reported by Noonan et al. (2006) and the 3.4% rate of HAPU for all pediatric patients reported by McLane et al. (2004). However, the 3.74% HAPU rate for PCCUs was less than the HAPU rate of 10.2% among PCCU patients reported by Schindler et al. (2011) and the HAPU rate of 27% among PCCU patients reported by Curley, Razmus, et al. (2003). There has been a decrease in reported HAPU among adult patients since the Centers for Medicare and Medicaid (2008) implemented a policy of nonpayment for hospital-acquired pressure care (Centers for Medicare and Medicaid, 2014). In addition, there has been a decline in PCCU patients, but the reason for the dramatic decline in HAPU rates from 10.2% during 2006 to 2007 (Schindler et al.,

2011) to the 3.7% in 2012 among PCCU patients as determined by this study deserves further investigation.

This study found a 0.64% and 1.11% rate of HAPU among NICUs III and NICUs IV patients, respectively, which was much lower than the 16% cumulative HAPU rate among NICU patients reported by Fujii et al. (2010). Differences may be because the overall number of neonates in the Fuji et al. study was small (n = 81) and restricted to those patients in an incubator whose parents provided consent to participate in the study. No previous studies have reported the rate of HAPU among pediatric step down units or pediatric rehabilitation units, which was 4.3% and 7.1%, respectively, in this study.

In this study, the proportion of Stage I and Stage II pressure ulcers was 65.6%. In other studies, the proportion of Stage I and Stage II HAPU was higher. Specifically, Curley, Razmus, et al. (2003) found that the proportion of patients with Stage I and Stage II HAPU was 97%, with the remaining 3% being Stage III HAPU. Similarly, Schindler et al. (2010) noted that the proportion of patients with Stage I (63.6%) and Stage II (32.07%) HAPU represented 96.3% of all the HAPU when combined. Prevalence studies on pressure ulcers in children have also reported that most pressure ulcers are Stage I or Stage II (Amlung et al., 2001; Barczak, Barnett, Jarczynski, & Bosley, 1997; Groeneveld et al., 2004; Meehan, 1994). More recently, Schluer, Schols, Halfens, and Rudd (2014) found 84% of pressure ulcers among pediatric patients were Stage I. It is noteworthy that the 65% proportion of patients with Stage I and II HAPU in this study is consistent with a recent study on adult HAPU by Bergquist-Beringer et al. (2013), in which the proportion of patients with Stage I and II HAPU was 68% to 69%.

The small proportion of patients with Stage III and IV HAPU is consistent with other HAPU studies (Bergquist-Beringer et al., 2013; Curley, Razmus, et al., 2003; Schindler et al.,

2009; VanGilder, Lachencruch, Harrison, & Meyer, 2013). In this study, the proportion of Stage III HAPU was 4.0%, and the proportion of Stage IV HAPU was 0.6%, totaling 4.6% of all the HAPU. The proportion of patients with Stage III HAPU was higher in the NICUs III (5.6%) and pediatric rehabilitation units (7.1%) while patients in the other unit types such as NICUs IV and pediatric step down units had no Stage III pressure ulcers. The patients from the pediatric step down units had the highest proportion of Stage IV HAPU at 4.4%, while the patients from the general pediatric units had the second highest proportion of Stage IV HAPU at 1.8%. The small number of Stage III and Stage IV pressure ulcers is important because the Centers for Medicare and Medicaid does not reimburse for the extra cost of treating hospital-acquired Stage III and IV HAPU (Centers for Medicare and Medicaid Services, 2008).

This is one of the few studies reporting sDTI in children. SDTI was added to the pressure ulcer classification system in 2007 and is defined as a pressure-related damage to the soft tissue under intact skin (NDNQI, 2015). These injuries have the potential for rapid deterioration (NPUAP, 2014). Interestingly, 14.3% of all HAPU in this study were sDTI. VanGilder, MacFarlane, Harrison, Lauchenbruch, and Meyer (2010) documented an increasing proportion of sDTI pressure ulcers among adults from 3% to 9% over a 3-year period from 2006 to 2009 but did not report the frequency of sDTI in children. The proportion of sDTI in this study overall are consistent with adult studies of sDTI such as the 12.1% to12.4% reported by Bergquist-Beringer et al. (2013) and lower than the 20% for critical care patients in 2012 reported by VanGilder et al. (2013). Previous pediatric studies on pressure ulcers were conducted prior to sDTI becoming a category/stage of pressure ulcer; therefore, there are no pediatric studies with which to compare these results. The proportion of unstageable HAPU among children in this study was 10.1%. The result is consistent with those results found by Bergquist-Beringer et al. (2013), who

identified the proportion of unstageable HAPU among adults was 10.3% to 10.9%. SDTI and unstageable HAPU are considered full thickness tissue injuries, as are Stage III and Stage IV HAPU. The total of Stage III, IV, sDTI, and unstageable HAPU comprised 29% of the HAPU in this study. As mentioned by VanGilder et al. (2009) and Bergquist-Beringer et al. (2013), adverse reporting of just Stage III and IV HAPU without other full thickness HAPU such as sDTI and unstageable HAPU would suggest that the rate of full thickness pressure ulcers is underreported.

The proportion of mucosal pressure ulcers or pressure ulcers under a non-removable dressing was 5.3%. This is much higher than the 1.6% rate among adults reported by Bergquist-Beringer et al. (2013). The reason for the 5.3% is unclear, but it is possible that this could be related to mucosal pressure ulcers and the use of medical devices, where use may be higher in children than in adults. A recent meta-analysis by Newnam et al. (2013) determined that rates of skin injury caused by medical devices, such as treatment for neonates using nasal continuous positive airway pressure (NCPAP), were 20% to 60%; these rates were associated with smaller infant size, gestational age, and duration of therapy. Further research regarding location of pressure ulcers and whether medical devices were associated with HAPU is warranted in both children and adults.

Pressure Ulcer Risk Assessment

Frequency of skin assessment. The NPUAP (2009, 2014) guidelines recommended that a skin assessment be included in the patient pressure ulcer risk assessment for all facility types, but no known studies have evaluated the frequency of skin assessment among pediatric patients. Findings from this study suggest that a skin assessment was performed within 24 hours of pediatric patient admission (96.7% of the time on average) across unit types. This is higher than

the 92.9% reported across critical care, step down, medical, surgical, and medical-surgical adult units (Bergquist-Beringer et al., 2013).

Pressure ulcer risk assessment. Based on the study results, 89.2% of all pediatric patients received a pressure ulcer risk assessment within 24 hours of admission. That pediatric patients received a risk assessment is consistent with the IHI (2008, 2012) guideline recommendations that a pressure ulcer risk assessment should be performed on all patients upon admission to the hospital. Although still high, the pressure ulcer risk assessment on admission was lowest for patients in the NICUs III (81.0%) and the NICUs IV (92.1%). The lower proportion of neonates (92.1%) that were assessed for pressure ulcer risk in NICUs is a little concerning given the 1.11% rate of HAPUs in the NICUs IV.

Time since last patient pressure ulcer risk assessment is intended to estimate the frequency of reassessment (NDNQI, 2012c). Most of the patients (89.2%) in this study received a pressure ulcer risk assessment less than 24 hours prior to the NDNQI pressure ulcer survey; 4.5% received a pressure ulcer risk assessment more than 24 hours prior to survey, and 6.3% were never assessed for pressure ulcer risk. Results suggest compliance with guideline recommendations that patients in the acute care setting be reassessed for risk daily (IHI, 2008, 2012). No previous studies have reported the timing of pressure ulcer risk assessment in pediatric patients.

NPUAP (2009, 2014) guidelines recommend that patients be assessed for pressure ulcer risk status using a structured approach that is based on the use of clinical judgment and informed by knowledge of relevant risk factors. This is the first known study to report the method by which pressure ulcer risk is assessed in pediatric patients. Of those patients assessed, about half of the patients (49.3%) were assessed using a pressure ulcer risk assessment scale, and the other

half (50.1%) were assessed using clinical judgment or "other scale." The Braden Q Scale was used most frequently to assess pressure ulcer risk in the general pediatric units, PCCUs, and pediatric step down units. This scale has been validated for pediatric patients ages 1 month to 8 years but encouraged for use in all pediatric populations (Noonan et al., 2011). In this study, the Braden Scale was used to assess pressure ulcer risk about 10% of the time on units and more so where one would expect older patients such as general pediatric units and pediatric rehabilitation units. This is different than the frequency of scale use in the adult population, where 90% of the patients were assessed for risk using the Braden Scale (Bergquist-Beringer et al., 2013). The NSRAS was primarily used in the NICUs III to assess pressure ulcer risk and used less often in the NICUs IV; only 25% of the neonatal patients were assessed for risk using the NSRAS while the majority of the neonatal patients were assessed using "other" or "multiple scales." Use of "other" or "multiple scales" suggests that nurses may be assessing pressure ulcer risk using clinical judgment or a different type of scale in the neonatal population. Further research is needed to understand the role of pressure ulcer risk assessment in the neonatal population and what factors are considered when determining pressure ulcer risk. Among the sample of pediatric patients, 30.2% (n = 11,203) were determined to be at risk for pressure ulcers based on the last risk assessment. This study's proportion of pediatric patients determined to be at risk for pressure ulcers was much higher than the 6% of hospitalized pediatric patients reported to be at risk by Noonan et al. (2006). The difference may be related to dissimilarities in sample size, unit types, and number of hospitals included in the study. In the current study, the proportion of pediatric patients determined to be at risk for pressure ulcers was somewhat lower than the reported 39.7% proportion of adult acute care patients found by Bergquist-Beringer et al. (2013) to be at pressure ulcer risk.

NICUs III had the lowest proportion of patients assessed for pressure ulcer risk on admission, but they had the highest proportion of patients determined to be at risk for pressure ulcers at 45.5% (n = 6,337). Interestingly, the lowest proportion of patients at risk (22.5%) was on the NICUs IV while the highest proportion of patients at risk was on the NICUs III (44.5%). This difference may be due to how nurses assessed patients for pressure ulcer risk in each unit. The majority of the NICU III patients were assessed for risk on admission by other scale/clinical judgment (59.85%), followed by the Braden Q (28.0%), the NSRAS (25.1%), and the Braden (14.9%). The majority of NICU IV patients were also assessed risk on admission by other scale/clinical judgment (55.3%), but there was less use of the Braden Q (12.7%), the Braden (2.0%), and the NSRAS (0.2%). It is not clear whether the differences in the proportion of pressure ulcer risk between NICU III and IV is due to the method or scales used for this assessment. For example, the Braden Scale and Braden Q Scale have not been validated in neonate patients. It also unclear what clinical factors were used in determining risk among neonatal patients. More information is needed on how nurses judge pressure ulcer risk in neonatal patients. It is also possible that patients at risk for pressure ulcers may have receive a higher degree of nursing surveillance in the prevention of pressure ulcers in the NICUs III.

Frequency of Pressure Ulcer Prevention

Most of the pediatric patients at risk for a pressure ulcer received at least one type of pressure ulcer prevention intervention (95.8%). Pressure ulcer interventions in this study included pressure redistribution surface use, repositioning as prescribed, moisture management, nutritional support, and routine skin assessment. The frequency of pressure ulcer prevention interventions used for pediatric patients in the 24 hours prior to the survey was higher in the higher acuity units such as neonatal units, PCCUs, and pediatric step down units where mobility

might have been a factor. This study noted that missing data for pressure ulcer prevention interventions was 15%, which is higher than the recorded 7% to 13% of missing data for pressure ulcer prevention interventions in a previous study by Bergquist-Beringer et al. (2013).

For 70.7% of the pediatric patients at risk for pressure ulcers, a pressure redistribution surface was applied. This is lower than the 81.8% of adult patients for whom a pressure redistribution surface was in use as reported by Bergquist-Beringer et al. (2013). Pressure redistribution surfaces were used more often in the pediatric rehabilitation units and PCCUs relative to the other pediatric units, which may be related to acuity level in those patient populations. The NPUAP (2009, 2014) guidelines recommend use of a pressure redistribution surface compatible with the care setting and individual patient size and weight. It is not clear whether the pressure redistribution surfaces used in the PCCUs or pediatric rehabilitation units were designed for pediatric or adult patients or whether there was access to "pediatric" redistribution surfaces. It is also unknown which types of support surfaces were being used to prevent HAPU in younger populations and which types of pressure redistribution surfaces actually decrease HAPU. More study is needed to create a better understanding of the use of pressure redistribution surfaces in pediatric patients.

In this study, 90% of the pediatric population was repositioned as prescribed, which is higher than in the study by Bergquist-Beringer et al. (2013) where 82% of the patients were repositioned as prescribed. To prevent pressure ulcers, the NPUAP (2009, 2014) guidelines recommended repositioning (turning) patients regardless of the type of support surface in use unless it is contraindicated. Patients were most frequently repositioned as prescribed in the neonatal units. This is logical as infants are not able to reposition themselves by rolling over or turning to their sides. Rolling over is a developmental task that is achieved during the first year

of life; therefore, infants would need nursing assistance with repositioning. For 5.5% of pediatric patients, it was determined that the intervention was unnecessary for the patient. Repositioning may have been unnecessary for less critical pediatric patients who could reposition themselves because they were developmentally or physically able to do so. Interestingly, for 15.4% of the patients in the step down units, repositioning was "unnecessary for the patient," yet HAPU rates were still 1%.

Moisture management is designed to maintain a patient's tissue integrity. In this study, moisture was managed for 84.6% of the at risk patients. This is higher than the 65% of adult patients receiving moisture management reported by Bergquist-Beringer et al. (2013). The difference in moisture management use may be associated with the large proportion of pediatric patients who were developmentally or situationally incontinent in this study. Moisture was managed most often among patients in neonatal and pediatric rehabilitation units. Although the NPUAP (2009, 2014) guidelines recommend keeping the skin clean and dry while also protecting the skin from excessive moisture, no study has examined the use of moisture management as a pressure ulcer prevention intervention in unit types outside of PCCUs or with a larger sample. More study is needed to determine what type of moisture management is being used to prevent pressure ulcers among at risk pediatric patients.

Close to 90% of the pediatric patients at risk for HAPU received nutritional support, which is substantially higher than what was reported in the adult population (56.3%) by Bergquist-Beringer et al. (2013). The frequency of nutritional support was highest for the neonatal population, suggesting that this is a standard of care for neonatal patients and newborns in most units, due to the inability of these patients to feed themselves independently and often due to their low birth weight. In addition to neonatal patients, many rehabilitation patients at risk

for pressure ulcers received nutritional support but fewer general pediatric and pediatric step down patients received this support. Findings may be because patients in general pediatric units and pediatric step down units were able to feed themselves independently. Indeed, this was reflected in the 5.3% for whom the intervention was determined to be unnecessary for the patient. Included in the NPUAP (2009, 2014) guidelines was a recommendation for an individualized plan of nutritional support for those patients identified at risk for pressure ulcers. However, there are no known studies that have evaluated nutritional support as a preventive pressure ulcer nursing intervention for pediatric patients. Future research could evaluate how nutritional support is integrated into the prevention of pressure ulcers for different pediatric populations.

Hierarchical Logistic Regression

All pediatric patients and factors associated with HAPU – Main Model # 1.

Hierarchical logistic regression modeling of all patient (n = 34,020) factors (age, gender, skin assessments, and patient pressure ulcer risk assessments), unit factors (unit type, RNHPPD, and percent RN skill mix), and hospital factors (hospital type, Magnet status, teaching status, and bed size) associated with HAPU revealed that patients who were determined to be at risk for HAPU on last assessment, patients on pediatric critical care and pediatric rehabilitation units, and patients in pediatric hospitals were more likely to acquire a pressure ulcer after controlling for all other variables in the analysis.

In the final model, the odds for a patient to develop a HAPU were 7.71 times higher if the patient was determined to be at risk for pressure ulcers compared to patients who were not at risk for pressure ulcers. This is consistent with a previous study among PCCU patients that was

performed to validate the Braden Q Scale and that found those determined to be at risk for pressure ulcers developed more pressure ulcers (Curley, Razmus, et al., 2003).

There was no association between patient pressure ulcer risk assessment within 24 hours of admission or the timing of patient pressure ulcer risk assessment prior to the pressure ulcer survey and HAPU in this study. These findings differ from the findings of Bergquist-Beringer et al. (2013), where adults were 28% less likely to acquire a pressure ulcer if they were assessed for pressure ulcer risk on admission and 15% less likely to acquire a pressure ulcer if they were re-assessed within 24 hours prior to the pressure ulcer survey.

When modeling patient level data only, age was associated with HAPUs. Patients ages 1 to 2 years had 2.08 times higher odds for a HAPU compared to newborns for whom gestational age was reported. In addition, patients ages 5 to 8 years had 2.41 times higher odds and patients ages 9 to 18 years had 2.89 times higher odds for a HAPU relative to newborns for whom gestational age was reported. However, when unit level data was added to the model, this association was attenuated to nonsignificance, which most likely indicated an interaction between age and pediatric unit types. Indeed, after controlling for all other variables in the model, patients on PCCUs had 3.36 higher odds for a HAPU relative to general pediatric unit patients, and patients on pediatric rehabilitation units had 4.41 times higher odds for a HAPU. It is possible that more children ages 5 to 8 and 9 to 18 years of ages were patients on these units. This may also be attributed to patients having more risk factors related to complex illness, neurological deficits, exposure to medical devices, or limited mobility.

Interestingly, the odds for a HAPU for patients in pediatric hospitals were 2.67 times higher relative to patients in nonpediatric hospitals. The association between pediatric hospital patients and HAPU may be because pediatric patients with more complex and critical problems

were generally referred to pediatric hospitals where there are more resources for complex care of ill children. The majority of children with complex diseases are associated with children's hospitals because the subspecialists that provide care for these children are employed by the 200 children's hospitals in the United States. Children's hospitals are also the locations for most interventions for children with complex health-care needs (Miller, 2013).

None of the other hospital characteristics such as teaching status, Magnet status, or bed size were associated with HAPU when controlling for all variables in hierarchical logistic regression. Results from this study on hospital factors and HAPU differ from a recent study of at risk adult patients in which HAPU was less likely to occur in patients at Magnet status and Magnet-applicant hospitals (Bergquist-Beringer et al., 2013). Likewise, Choi et al. (2013) found that Magnet status was associated with lower pressure ulcers overall among 2,397 nursing units in 409 U.S. acute care hospitals using a Random-intercept logistic regression analysis. In this study, relationships between nurse staffing measures and unit acquired pressure ulcer (UAPU) occurrences were examined in eight models, each with one or more staffing measures as predictors. In another recent study, Magnet-designated hospitals showed lower unit-acquired pressure ulcers than non-Magnet hospitals (Park, Boyle, Bergquist-Beringer, Staggs, & Dunton, 2014). Magnet status hospitals had better outcomes when comparing 19 Magnet versus 35 non-Magnet hospitals for pressure ulcers ($p = 0.10$) (Goode et al., 2011). However, He et al. (2013) found no association between Magnet status and HAPU.

This study's findings are also different from adult studies for hospital bed size. HAPU were more likely to occur in patients at larger hospitals and academic hospitals (Bergquist-Beringer et al. 2013). Likewise, Manojlovic, Antonakos, and Ronis (2010) reported that larger hospital size was associated with an increase of 1.8 pressure ulcers per 1,000 days. Similarly, He

et al. (2013) and Choi et al. (2013) found that the odds for a HAPU were 18% to 27% higher in hospitals with greater than 300 or more staffed beds relative to hospitals less than 300 staffed beds. In contrast, hospital size was not associated with unit-acquired pressure ulcer occurrence (Park et al., 2014).

All pediatric patients and factors associated with HAPU by unit type. Hierarchical regression analysis of factors associated with HAPU among at risk patients by unit type revealed that patients on general pediatric units, PCCUs, NICUs III, pediatric step down units, and NICUs IV had 4.62 to 13.52 times higher odds for a HAPU after controlling for other variables in the model. This result provides support for the practice of pressure ulcer risk assessment in pediatric patients. Among PCCU patients, the odds for a HAPU were 2.6 times higher for patients who were treated in a pediatric hospital. Although many hospitals provide pediatric care, pediatric critical care is not available at all hospitals; consequently, complex pediatric patients are often transferred to a pediatric hospital for a higher level of care. The most critically ill pediatric patients are cared for in pediatric hospitals compared to nonpediatric hospitals (Miller, 2014). Of note, NICU III patients at nonteaching hospitals had 75% lower odds for a HAPU as compared to those patients at academic medical centers. A nonteaching hospital is not a clinical site for interns or residents, suggesting that this type of hospital has a lower acuity level of NICU III patients relative to academic medical centers or pediatric hospitals (American Hospital Association [AHA], 2009).

Patients at risk for pressure ulcers and factors associated with HAPU – Main Model #2. Hierarchical logistic regression analysis of patients at risk for HAPU found no association between those who received the pressure ulcer prevention intervention and lower HAPU in the final model. In the model with patient level data on prevention interventions, only those at risk

for pressure ulcers who received a skin assessment on admission had 2.63 times higher odds for a HAPU as compared to patients who did not receive a skin assessment on admission. This was attenuated to nonsignificance when unit level data was added to the model. The result may indicate that pediatric patients at risk are more likely to receive a skin assessment within 24 hours of admission across all units. This finding was not consistent with a recent study where adult patients (across all units) who received a skin assessment were 27% less likely to acquire a HAPU (Bergquist-Beringer et al., 2013).

There was an unexpected association between pressure redistribution surface use and HAPU among pediatric patients in this study. Pediatric patients who did not receive a pressure redistribution surface had 50% lower odds for a HAPU as compared to those who did receive a pressure redistribution surface when controlling for all variables in the model. This finding is different than those of previous studies that noted an association between lower HAPU and the use of pressure redistribution surfaces in postoperative and pediatric critical care patients (Huang, Chen, & Xy, 2013; Schindler et al., 2011). Also, in this study, patients who did not receive a pressure redistribution surface because it was contraindicated, unnecessary, or the patient refused pressure redistribution had 59% lower odds for a HAPU compared to patients who received pressure redistribution surface after controlling for all other variables in the model. It could be that nurses were able to identify when the surface was not needed but that there may also be confusion as to when to mark *no* versus *unnecessary* on charts during data collection. Nurses and patients would benefit from further review of how to determine when to use a pressure redistribution surface for pediatric patients and whether all pediatric patients have access to pediatric pressure redistribution surfaces. Further research is needed to understand why 29% of the at risk patients did not receive a pressure redistribution surface and when its use

would be considered unnecessary, contraindicated, or refused. More education for nurses may be needed to determine when to document no for pressure redistribution surface relative to when a pressure redistribution surface is unnecessary, contraindicated, or refused.

There was no association between repositioning as prescribed and HAPU in this study. However, a relatively recent study of PCCU patients found decreased development of pressure ulcers when the patients were repositioned every 2 to 4 hours and received use of blanket rolls, foam wedges, and draw sheets to assist with repositioning (Schindler et al., 2011). An earlier study by McLane et al. (2002) reported that children who were not turned every 2 hours had increased pressure ulcer development. Repositioning medical equipment, such as tracheostomy tubing, was found to significantly decrease tracheostomy-related pressure ulcers in the pediatric intensive care unit (Boesch et al., 2012). The difference between results may be attributed to different study methods. Schindler et al. (2011) and Boesch et al. (2012) evaluated repositioning prospectively to reduce HAPUs among PCCU patients. In contrast, this study data was collected cross-sectionally with retrospective review of admission data to determine pressure ulcer presence on admission. In adults, there was a 15% decrease in HAPU when patients were repositioned as prescribed to prevent pressure ulcers (Bergquist-Beringer et al., 2013). Further study is warranted to provide a better understanding of the role of repositioning and pressure ulcer prevention in pediatric patients.

Patients who did not receive nutritional support because it was contraindicated, unnecessary, or the patient refused had 60% lower odds for a HAPU compared to patients who did receive nutritional support after controlling for all other variables in the model. This indicates that nurses could discriminate between those patients who needed nutritional support and those who did not. Also, at risk pediatric patients who did not receive nutritional support

had 61% lower odds for a HAPU relative to patients who received nutritional support after controlling for all other variables in the model. These findings align with those by Bergquist-Beringer et al. (2013) who reported that there was a significant association between adult patients who received nutritional support and higher HAPU. It is unclear whether nutritional support may be a routine intervention in pediatric patients and less related to use in patients at risk for pressure ulcer prevention. There are no known studies that have evaluated nutritional support specifically as a pressure ulcer prevention intervention in pediatric patients. Further study is needed for a full understanding of the role of nutritional support in pressure ulcer prevention for pediatric patients.

There was no association between moisture management as prescribed and HAPU in this study. This is unexpected because previous studies have reported the increased odds for skin breakdown among children up to 17 years of age on different pediatric units by 25% (Noonan et al., 2006), and chronic fecal and urinary incontinence were cited as a risk factor for pediatric patients in the development of pressure ulcers (Okamoto et al., 1983; Samaniego, 2003). This finding is inconsistent with those by Schindler et al. (2011) where PCCU patients who received moisture management had decreased HAPU. The difference may be attributed to Schindler's study being a prospective study that provided temporal evaluation of the intervention as compared to the cross sectional nature of this study. Also, contrary to this study's findings, moisture management was positively associated with HAPU in a study of adult acute care patients (Bergquist-Beringer et al., 2013). Further investigation is needed to understand this phenomenon. Moisture management has not been studied as a pressure ulcer intervention for pediatric patients outside of the PCCUs.

Patients in the NICUs III had 56% lower odds for a HAPU than patients in general pediatric units, but no other unit (microsystem) or hospital (mesosystem) factors were associated with HAPU in the regression analysis. The NICU III had the highest percentage of patients at risk for pressure ulcers at 45%. This is interesting given the general pediatric rate of HAPU was 0.57, and the NICU III HAPU rate was 0.64 and should be explored further. It is possible that more attention was given to pressure ulcer prevention in the NICUs III. There was no association between RNHPPD or percent RN skill mix and HAPU in at risk pediatric patients. This is consistent with the results of the study by Bergquist-Beringer et al. (2013) but differed from the results found by He et al. (2013), Dunton et al. (2007), and Parks et al. (2014), where a higher number of RNHPPD and an increased percent RN skill mix were associated with HAPU in adults.

Patients at risk for pressure ulcers and factors associated with HAPU by unit type. In general pediatric units, the odds for a HAPU were 82% lower if a pressure redistribution surface was contraindicated, unnecessary, or refused relative to those patients who received a pressure redistribution surface after controlling for all other variables in the model. Results are consistent with the analysis across unit types (Main Model #2). NICU III patients for whom a pressure redistribution surface was contraindicated, unnecessary, or refused had 62% lower odds for a HAPU. PCCU patients had 78% lower odds for a HAPU if they did not receive a pressure redistribution surface relative to those who did receive a pressure redistribution surface. The type of pressure redistribution surfaces used in pediatric units is not submitted to the NDNQI database. The lower odds for a HAPU when pressure redistribution surfaces were not applied needs further study to evaluate if the support surfaces are appropriately sized for pediatric patients especially in the general pediatrics, PCCUs, and NICUs III.

Patients in PCCUs were less likely to have a HAPU when nutritional support was not provided. PCCU patients had 74% lower odds for a HAPU if they did not receive nutritional support and 68% lower odds for a HAPU if nutritional support was contraindicated, unnecessary, or refused relative to those who did receive nutritional support after controlling for all of the variables in the model. Results suggest that nurses were able to discern when nutritional support was unnecessary for a patient. The reason for lower odds of a HAPU among patients who did not receive nutritional support is unclear. Nurses would benefit from further review of why there were lower HAPU rates for these patients. In the NICUs III, when RNHPPD was added to the model, results showed patient odds for a HAPU increased by 18%; however, this result was attenuated to nonsignificance when hospital level data was entered. Previous NDNQI adult studies have identified differences in RNHPPD and the relationship with HAPU. Specifically, an increase in RNHPPD was associated with higher HAPU rates in adults in the studies by He et al. (2013) and Dunton et al. (2007). Conversely, Parks et al. (2014) reported a higher number of RNHPPD and also an increased percent RN skill mix associated with lower HAPU in adults, while Bergquist-Beringer et al. (2013) found no association between RNHPPD and HAPU. The lack of association of RNHPPD and percent RN skill mix by unit type in this study may be attributed to the small number of HAPU by unit type. Further investigation regarding the association between RNHPPD and percent RN skill mix among hospital types is warranted.

Among patients in pediatric rehabilitation units, pediatric step down units, and NICUs IV, there was no association between patient, microsystem, or mesosystem factors and HAPU. This may be because the number of HAPU was small relative to the number of patient variables in the hierarchical regression analysis, limiting power to determine the association.

Strengths and Limitations of the Study

This study used NDNQI pediatric data on pressure ulcers from hospitals across the United States. Study strengths included the large sample size that permitted examination of patient factors such as age, gender, patient pressure ulcer risk, and pressure ulcer prevention interventions, and their association with HAPU in pediatric patients. This study provided important information about unit and hospital factors associated with HAPU. The size of the dataset provided sufficient power to conduct hierarchical logistic regression on patient, microsystem, and mesosystem factors and their associations with HAPU in children in overall modeling. Based on the generally accepted rule of 10 patients with HAPU per variable, 270 patients would be necessary for adequate power, and there were 398 patients with pressure ulcers in the first model (VanVoorhes & Morga, 2007). In the second model, there were 270 patients with pressure ulcers, and 220 would be necessary for adequate power.

There were limitations to this study. In the hierarchical analysis by unit type, there was a small number of HAPU, a small number in variable cells among patients at risk, and some units types were small (NICU IV and pediatric rehabilitation) which reduced the number of independent variables that could be included in the hierarchical logistic regression by unit type and may have limited the power to detect a significant association. With the exception of the prevalence and several pediatric incidence studies, there are few studies to which findings such as age, unit type, patient risk status, pressure ulcer interventions, and hospital type and their associations with HAPU could be compared.

Two hundred seventy-one NDNQI hospitals participated in this study. Of these, 35% of were Magnet hospitals. Magnet hospitals only represent 7% of the registered hospitals in the United States. Therefore, the results from this study cannot be generalized to other acute care

pediatric units or hospitals in the United States (American Hospital Association, 2015). In addition, the data were limited to what was submitted to the NDNQI; therefore, some of the factors such as race, length of stay, the location of HAPU, and the category/stage of HAPU were not obtained in this study nor were the prevalence and incidence or the number of and location of medical device-related HAPU available for analysis. It is possible that some of the prevention interventions were begun after a pressure ulcer was discovered. In addition, reporting of pressure ulcer prevention intervention data was voluntary, resulting in instances of missing data. Therefore, not all of the pressure ulcer prevention interventions were available for analysis by the NDNQI, limiting the generalizability of this study. The NDNQI evaluates data cross-sectionally, which limited evaluation of the factors to association as opposed to causation of HAPU. NDNQI provides detailed data collection guideline directions for data collection on pressure ulcer data but guidelines might not have been followed. Although the data were thoroughly evaluated for errors by the NDNQI, there was still a possibility of errors in the data that were submitted to the database.

Theoretical Framework

The theoretical framework for this study was based on Braden and Bergstrom's Conceptual Schema Depicting Factors in the Etiology of Pressure Sores (Bergstrom et al., 1987) but tailored to include mesosystem (Magnet status, teaching status, number of beds, hospital type, and metropolitan status) and microsystem (percent RN skill mix, RNHPPD, and unit type) concepts (see Figure 2). Results from this study suggest that age is a risk factor for HAPU among pediatric patients because, in unadjusted analysis (see Table 22), more children ages 5 to 8 years and 9 to 18 years developed a pressure ulcer than expected. However, the interaction

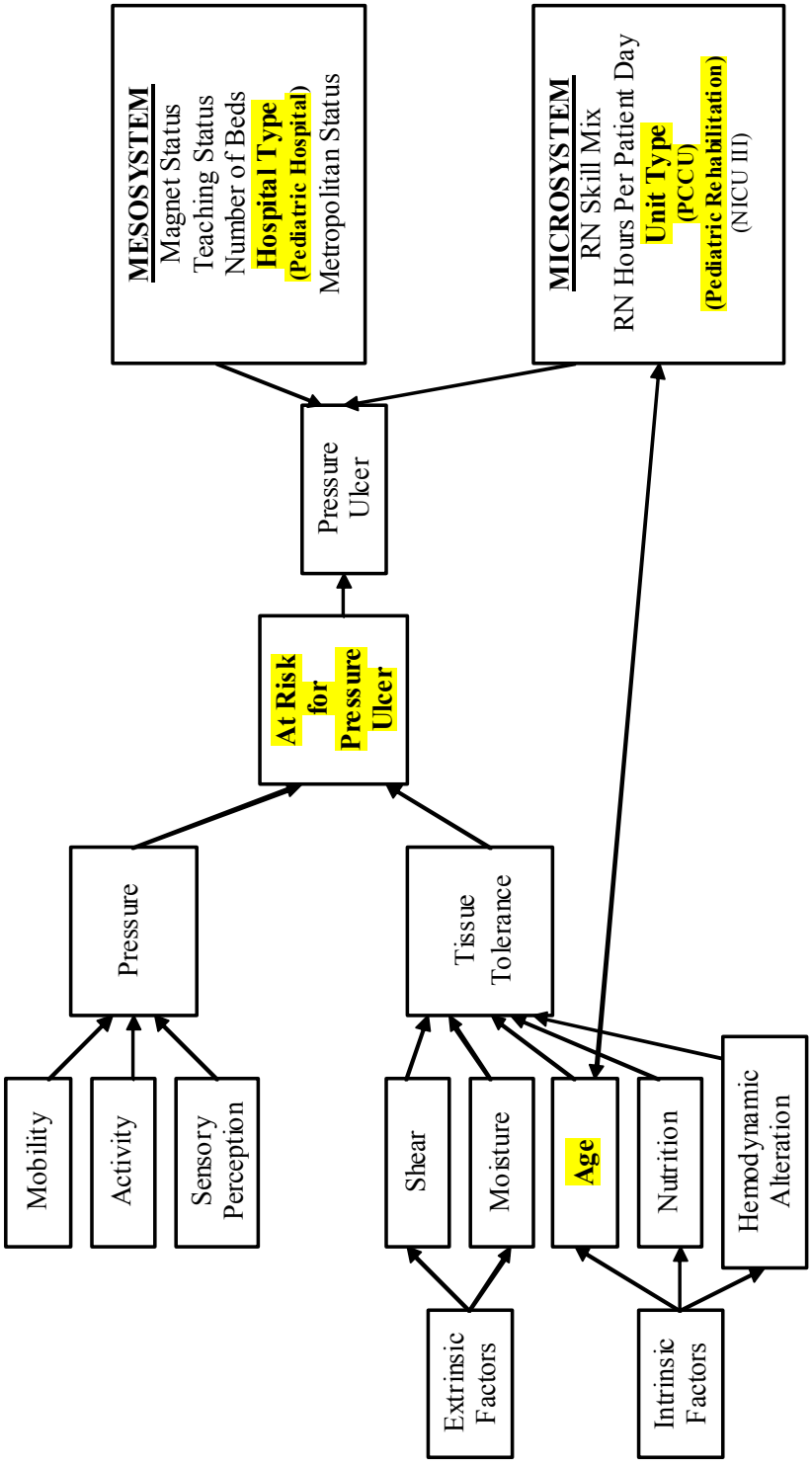

Figure 2. Revised Braden and Bergstrom's conceptual schema depicting factors in the etiology of pressure ulcers in pediatric patients.

effect between age and unit attenuated this result. Patients in pediatric rehabilitation units were 4.41 times more likely to have a HAPU, and patients in PCCUs were 3.36 times more likely to have a HAPU. When examined by unit, age was not associated with HAPU. Also, higher HAPU among patients in these units could also be related to patient factors such as acuity level. The odds for HAPU were higher in pediatric hospital types relative to nonpediatric hospital types, which may also be related to the higher acuity of patients in pediatric specialty hospitals. This was also reflected in the greater likelihood for HAPU for PCCU patients from pediatric hospitals. There was no association between pediatric HAPU and other hospital characteristics that included academic medical, teaching, and nonteaching hospitals; Magnet status; number of beds of the hospital; or metropolitan status. Concepts positively associated with HAPU are highlighted and bolded in the theoretical framework.

Recommendations for Future Research

This study was able to describe patient, microsystem, and mesosystem factors and their relationship with HAPU. This study should be repeated in non-NDNQI hospitals and in hospitals outside of the United States. More research is needed to better understand how patient, microsystem, and mesosystem factors are related to HAPU in children. The significant association between the patient identification of risk for pressure ulcers and HAPU provides support for the use of pediatric patient pressure ulcer risk assessment. Future studies should assess the validity of the Braden Q Scale across age groups with the goal of standardizing risk assessment in this population. Additional studies are needed to examine the clinical factors that place neonates at risk for pressure ulcer.

More work is needed to identify strategies to prevent pressure ulcers in pediatric patients. The availability of pediatric redistribution surfaces is unknown. Nurses and patients would

benefit from further exploration of the process by which patients receive a pressure redistribution surface. Another area for future study would be to delineate how nutritional support and moisture management are used to prevent pressure ulcers among different pediatric patients. Guidelines for pediatric pressure ulcer prevention can be updated based on this information. Although this study did not involve medical devices and HAPU, more knowledge is needed regarding medical devices and their association with pediatric patients and HAPU.

Nursing Implications

There are limited studies on pressure ulcer prevention in children, but results provide support for the performance of patient pressure ulcer risk assessment, daily skin assessment, and reassessment of risk among children from 1 day through 18 years of age (Pressure ulcers: Quick reference guide; (EPUAP, NPUAP, & PPPIA, 2014). Patient ages vary on the different types of pediatric units. Nurses should be educated on risk factors for pressure ulcers among pediatric patients, such as those that lead to prolonged pressure (activity, mobility, and sensory perception), tissue integrity (moisture, nutrition, age, shear, and hemodynamic alteration), microsystem factors (PCCU and pediatric rehabilitation units), and mesosystem factors (pediatric hospital type) to prevent HAPU. Nurses can partner with patients and family members through education on prevention practices so that family are actively involved in a plan for interventions specific for the child and application.

Nursing leaders can develop protocols, policies, and procedures at the unit level for assessing patient pressure ulcer risk based on age and clinical factors. Nursing leaders can also ensure resources are in place for pressure ulcer prevention for nutritional support and pressure redistribution surfaces appropriate for their patients' sizes and developmental levels. Policy and

procedures may include interventions to prevent mucosal and device-related pressure ulcers, such as repositioning equipment in contact with the pediatric patient at routine intervals.

Cues for pressure ulcer documentation may be incorporated in the electronic health record to trigger interventions based on patient pressure ulcer risk or flow diagrams to guide nurses in pressure ulcer prevention intervention plans of care. This plan of care can be shared with the patient, family, and caregivers to remind them of the importance of pressure ulcer prevention strategies such as positioning, transferring, and turning techniques to minimize shear injuries in pediatric patient care (EPUAP, NPUAP, & PPPIA , 2014).

Nurses can conduct prevalence and incidence on all pediatric patients and monitor pressure ulcers in all pediatric unit types. Staff can be involved in the process through monitoring of pressure ulcer prevention processes and HAPU outcomes on a routine basis (monthly or quarterly). Skin champions on pediatric units can be utilized to champion pressure ulcer prevention and to be a resource for other staff on the nursing unit. If a skin committee is not in place for pediatric patients, one could be developed. If pediatric units are part of an adult hospital, those units can have pediatric representation on their hospital skin committee.

Conclusions

Like adults, acutely ill children develop pressure ulcers. This study found a 1.1% rate of HAPU among pediatric patients ages 1 day to 18 years of age in U.S. acute care hospitals. Most pediatric HAPU were determined to be Stage I or Stage II, but 24% were determined to be unstageable or sDTI HAPU. More information regarding the location of pressure ulcers and their association with medical devices is necessary.

Approximately 30% of the pediatric patients in this study were at risk for pressure ulcers. At risk status increased the odds for a HAPU by 4.62 to 13.52 times across unit types. Findings

provide support for pressure ulcer guidelines that recommend pressure ulcer risk be assessed in pediatric patients, but more research is needed to evaluate methods use to assess risk in NICUs.

Study results identified microsystem and mesosystem factors associated with HAPU among hospitalized children. Patients from PCCUs and pediatric rehabilitation units had 3.36 and 4.41 times higher odds for a HAPU, respectively. Patients from pediatric hospitals had 2.67 times higher odds for a HAPU, and PCCU patients from pediatric hospital types had higher odds for a HAPU compared to patients from nonpediatric hospitals. Pressure redistribution use, repositioning as prescribed, moisture management, and nutritional support were not associated with lower HAPU after controlling for other model variables. Research is needed to understand what pressure redistribution surfaces are in use by unit type. More information about the role of nutritional support and moisture management in the prevention of pressure ulcers is also needed among pediatric patients. Findings expand the theoretical framework on risk factors for pressure ulcers to include unit type (PCCU and pediatric rehabilitation) and pediatric hospital type for pediatric patients.

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Appendix A

University of Kansas Medical Center Human Research Protection Program Approval

The University of Kansas Medical Center

Human Research Protection Program

December 12, 2013

Project Title:	Pressure Ulcers and Prevention among Pediatric Patients and Factors Associated with Their Occurrence in Acute Care Hospitals
Investigators:	Sandra Bergquist-Beringer, PHD, RN Ivy Razmus, MSN, RN, PhD Student
Department:	School of Nursing
Determination:	Not human subjects research

Dear Investigator:

Thank you for your submission. This letter certifies that the above referenced project has been evaluated by the KUMC Human Research Protection Program (HRPP).

Your project involves the secondary analysis of data that is held by the National Database for Nursing Quality Indicators. Because the data were collected by the contributing hospitals for benchmarking purposes and they are being provided to you in a way that does not allow for individual identification, your project does not constitute human subjects research. Your project does not require review or oversight by the Human Subjects Committee.

Please note that if you revise your activities to interact directly with human subjects, or to obtain identifiable data, you should contact our office immediately. If this were to occur, the HRPP would re-evaluate your project's regulatory status. Please feel free to contact our office with any questions.

Very truly yours,

Karen Blackwell

Karen Blackwell, MS, CIP
Director, Human Research Protection Program

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