Exploring Effective Pressure Injury Prevention Practices in the Paediatric Intensive Care Setting: An Integrative Review

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person except where explicitly defined in the acknowledgments, nor material which to a substantial extent has been submitted for the award of any other degree or diploma or a university or other institution of higher learning.

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Abstract

Pressure injuries are a common health issue affecting patients of all ages across different healthcare settings. Hospital-acquired pressure injuries are an indicator of the quality of healthcare in hospitals and can have physiological and psychological impacts for the individuals affected. Hospitalised children, especially those who are critically unwell, are of particular risk of developing pressure injuries. Pressure injuries have been associated with increased morbidity, mortality, length of stay, risk of infection and costs of treatment. This creates strain on the healthcare system, but more importantly for patients, this impacts their quality of life and delays their recovery journey. Consequently, this can have a significant negative impact psychologically on patients and their families/whānau. Prevention of pressure injuries has been a priority across healthcare settings to tackle the issues associated with pressure injuries. However, pressure injuries still remain a longstanding patient safety issue today and are costly to the healthcare system. Nurses play a vital role in the assessment, prevention and management of pressure injuries. This practice project aimed to explore effective pressure injury prevention practices in paediatric intensive care units (PICU). The integrative review method guided by Whittemore and Knafl's five-stage framework, was used in this project. A total of fourteen studies (all quantitative) were included in this review. Each study was independently and critically appraised using the Mixed Methods Appraisal Tool. The findings of this integrative review highlighted that understanding the risk factors in a PICU patient and up-to-date knowledge about pressure injuries are foundational to prevention. Furthermore, risk assessment tools, education, care bundles and skin champions aid in the implementation of the current recommended prevention strategies. This integrative review provides an overview of the existing literature on the topic and paves the way to understanding what requires further attention and research in the future.

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List of Abbreviations

ACC: Accident Compensation Corporation

ECMO: Extracorporeal Membrane Oxygenation

EPUAP: European Pressure Ulcer Advisory Panel

IHI: Institute for Healthcare Improvement

MMAT: Mixed Methods Appraisal Tool

MOH: Ministry of Health

NICU: Neonatal Intensive Care Unit

NPIAP: National Pressure Injury Advisory Panel

NPUAP: National Pressure Ulcer Advisory Panel

PICU: Paediatric Intensive Care Unit

PPIAP: Pan Pacific Pressure Injury Alliance

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

WHO: World Health Organisation

CHAPTER 1: INTRODUCTION

Background

Pressure injuries have been recognised as a health issue for centuries in the history of medicine. The skin is an effective physical barrier and provides vital protective functions to maintain overall health (Lai-Cheong & McGrath, 2017). As early as 1859, the founder of modern nursing Florence Nightingale introduced repositioning for those patients under her nursing care whose mobility was greatly reduced. Florence Nightingale claimed that pressure injuries were not a result of disease, but poor nursing care (Lyder & Ayello, 2008). The historical methods for the prevention and management of pressure injuries are very similar to those recommended in today's health care guidelines. In the last 10 years research into pressure injuries has dramatically increased and as a result, we have a deeper understanding of the intrinsic and extrinsic factors of pressure injury development (Delmore et al., 2019; Kottner et al., 2010; Murray et al., 2013). With more knowledge and new medical technologies, prevention and treatment strategies for pressure injuries in clinical practice have improved (Lyder & Ayello, 2008; National Pressure Ulcer Advisory Panel [NPUAP] et al., 2014).

Pressure injuries are defined as: "localised injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear'' (NPUAP et al., 2014, p.12). Several terms are used interchangeably to describe pressure injuries, including pressure areas, pressure ulcers, pressure sores, bedsores, and decubitus ulcers (Kottner et al, 2009). The term pressure injuries will be used to describe the phenomena throughout this practice project for consistency. The aetiology of pressure injuries is continuously changing however, in physiological terms, external pressure occludes the blood vessels resulting in surrounding tissues becoming anoxic, which leads to cell death (Mervis & Phillips, 2019). In acutely unwell patients, the tolerance in the amount of high tissue pressure and duration before damage occurs is shortened (Agrawal & Chauhan, 2012). Initially, immobility, friction, shear, or the combination of friction and shear, were thought to be the causes of pressure injuries. However, the development of the injuries is found to be a complex phenomenon caused by both extrinsic and intrinsic factors. Multiple rather than single risk factors contribute to the development of pressure injuries (Murray et al, 2013; Coyer & Tayyib, 2017). Loss of skin fragility decrease blood flow, loss of muscle volume,

nutritional insufficiency are all intrinsic causes of pressure injuries. However, the extrinsic causes, such as immobility and medical device induced pressure are the main contributing factors for developing pressure injuries (Agrawal & Chauhan, 2012).

Medical Device-related Pressure Injuries

Medical devices are almost invariably attached to patients in today's hospital environments and when positioned against the skin or mucosal membranes can lead to pressure injuries development (Murray et al., 2013). These injuries are typically found on the mucous membranes of the respiratory and gastrointestinal tracts where a medical device has been located and do not usually lie over a bony prominence (Coyer et al., 2014). Although the aetiology of immobility-related and medical device-related pressure injuries is different, the mechanism of both injuries involves tissue compression from an external source (National Pressure Ulcer Advisory Panel [NPUAP] et al., 2019). Humidity and heat developing between the device and the skin, changes the microclimate of the skin making it more susceptible to pressure injury (Coyer et al., 2014). Furthermore, often these devices are required to be secured tightly to assure a proper seal. This not only creates pressure on the area of skin but also makes it difficult to inspect the skin beneath (Black et al., 2010). All of these factors increase the risk of medical device-related pressure injuries, and therefore, they are key indicators of patient safety and quality of nursing care in healthcare facilities (Black et al., 2010; Coyer et al., 2014; Murray et al., 2013).

Literature has indicated that medical devices are a leading cause of pressure injuries in the paediatric population (Murray et al., 2013; Schlüer et al., 2014). According to Murray et al. (2013), 36.2% of all pressure injuries in paediatrics are related to medical devices, with most cases associated with the use of oxygen saturation probes. Paediatric patients, especially those who are critically unwell, are often unable to differentiate sensory perceptions of pressure from medical devices. Hence, they are the most vulnerable patient group to develop medical device-related pressure injuries (Schlüer et al., 2009). Furthermore, children who are being treated in the intensive care unit are exposed to an increased risk of pressure injury as the use of medical devices is high in this setting (Delmore et al., 2019). Medical device-related pressure injuries are often seen as adverse reactions and preventable. However, some health care professionals consider the injuries to be inevitable, especially in the area of

intensive care, where the use of medical devices is high (Coyer et al 2014; Tan et al., 2020). The types of medical devices causing pressure injuries are variable. Respiratory equipment, including endotracheal tubes, tracheostomy tubes, and oxygen masks/delivery systems, is often found to be linked to the injuries (Tan et al., 2020 ;Widiati et al., 2017). However, other devices that are commonly used in the intensive care setting, such as oral gastric tubes, nasogastric tubes, orthopaedic braces and collars, urinary catheters, and faecal containment devices, can also be the cause of injuries (Coyer et al., 2014: Widiati et al., 2017).

Assessment and Classification of Pressure Injuries

The foundation of effective medical scientific communication is the use of appropriate and commonly accepted concepts and definitions in healthcare. In the area of pressure injury, accurate documentation when describing an injury using the appropriate classification system is fundamental (Kottner et al., 2010). There are three pressure injury classification systems that are commonly used internationally: The International Pressure Ulcer Classification System, the World Health Organisation International Classification of Diseases, and the National Pressure Ulcer Advisory Panel Classification System (NPUAP et al., 2019). The concepts described by the different pressure injury classification systems are similar overall and there is no evidence that one classification system is more reliable than the other (NPUAP et al., 2014). It is recommended that health professionals are educated on how to best use a pressure injury classification system to improve diagnostic accuracy and reduce misclassification of pressure injuries (NPUAP et al., 2019).

The International Pressure Ulcer Classification is an internationally agreed tool providing a consistent and accurate means to communicate and document the severity of pressure injuries (NPUAP et al., 2014). This classification system is recommended by the New Zealand Ministry of Health, the Health Quality & Safety Commission New Zealand, and the New Zealand Wound Care Society (Accident Compensation Corporation [ACC], 2017). Pressure injury types under this system are classified into six categories: four of which are stages (NPUAP et al., 2014). Stage one is described as intact skin with non-blanchable erythema to the skin. The area may be painful, firmer or softer, warmer or cooler compared to adjacent tissue. Stage two injuries are explained as erythema with the loss of partial thickness of the skin including the epidermis and part of the superficial dermis. These injuries present as a shallow, open wound with a red-pink wound bed, without slough, but may also present as an

intact or open/ruptured serum-filled blister. At stage three, there is full-thickness tissue loss that might involve the exposure of subcutaneous fat, but not the bone, tendon, or muscle. Slough may be present at this stage. A full-thickness injury with exposure of the muscle, tendon, or bone is classified as a stage four injury. The depth of a stage four injury varies by anatomical location. In areas with little subcutaneous tissue, for example, the bridge of the nose, the ear, occiput, and malleolus, full-thickness pressure injuries can be shallow. Full-thickness tissue loss in which the base of the injury is covered by slough (yellow, tan, grey, green, or brown) and/or eschar (tan, brown or black) in the wound bed is classified as unstageable until enough slough and/or eschar is removed to expose the base of the wound. In this condition, the true depth and therefore, category/stage cannot be determined (NPUAP et al., 2014). Figure one shows the various stages of pressure injuries.

Figure 1. International Pressure Ulcer Classification System (NPUAP et al., 2014).

Prevention of Pressure Injuries and Use of Risk Assessment Tools

Pressure injuries can be prevented with the implementation of pressure injury prevention guidelines combined with skincare interventions that target risk factors associated with pressure injury development (Coyer & Tayyib, 2017). The first step toward identifying risk factors is the accurate and timely assessment of the patients at risk (Bernabe, 2012). Identification of those patients most at risk using an assessment tool is useful in facilitating

healthcare professionals' clinical decision making and for planning effective prevention strategies (Grosvenor & Dowling, 2018; Samuriwo, 2010). As an example, an assessment tool measures several factors known to predispose patients to develop pressure injuries. These factors are categorised into subscales with assigned numbers. Scoring each subscale according to the applicability for the patient and then totalling the subscores together gives a patient's overall score. The overall score indicates a patient's risk of developing a pressure injury (Curley et al., 2003; Kottner & Balzer, 2010). Currently, there is a lack of validated data on paediatric pressure injury risk assessment tools. Much of the data used for assessing pressure injury severity and risk in infants, children, and young people have been derived from adult data (Kottner et al. 2013; Willock et al.,2007).

Kottner et al. (2013) report that a total of twelve pressure injury risk assessment scales exist for paediatric/neonates. However, the Glamorgan Risk Assessment Scale and Braden Q Scale are currently the most frequently utilised scales for standardisation of pressure injury risk assessment in the paediatric healthcare setting (Willock et al., 2007; Willock et al., 2016). The Braden Q Scale was adapted from the original adult version which consists of six subscales (mobility, activity, sensory perception, moisture, friction and shear, and nutrition) with a seventh subscale added: tissue perfusion/oxygenation (Noonan et al., 2011). A lower score indicates a higher risk of developing pressure injuries. Preventative interventions are highly recommended for patients with a total score of 16 or less, (Curley et al., 2003). The Glamorgan Risk Assessment Scale was developed solely on paediatric data (Willock et al., 2007). Each score represents a patient risk factor and for each risk factor that applies to the patient, the corresponding score is added to the patient's total score. The generated total score indicates the level of risk a patient is at for developing a pressure injury. The higher the total score, the greater the pressure injury risk (Willock et al, 2007). According to Willock et al. (2016), both the Glamorgan Risk Assessment Scale and Braden Q Scale appear to work well in neonatal and paediatric intensive care and general children's wards.

Introducing an effective prevention measure in a timely manner to those patients identified as being at risk is key to preventing the onset of pressure injuries. Effective prevention measures focus to minimise the risk factors that contribute to the development of pressure injuries (Bernabe, 2012). Substantial research has been done on pressure injuries in adults. However, it is consistently recognised that risk factors for skin breakdown are different in the paediatric

population (Schindler et al., 2011). Risk factors for pressure injuries in the paediatric population include extrinsic factors, such as pressure, friction/shear, and moisture, and intrinsic factors, such as impaired nutrition, obesity, infection, immobility, anaemia, and decreased perfusion (Baharestani & Ratliff, 2007; Schindler et al., 2011). Prevention strategies identified in response to these risk factors include regular skin inspection, skincare regimes that include management of incontinence and moisture, use of skin barrier adhesives and creams, nutrition input, repositioning, support surfaces, and education. (ACC 2017; Bernabe, 2012, NPUAP et al., 2014). The International Pressure Injury Prevention and Treatment Guidelines was created by NPUAP et al., (2019). The intention of this international collaboration was to develop a guideline with evidence-based recommendations for the prevention and treatment of pressure injuries that could be used by health professionals on a global scale. The third edition of the guideline was released in November 2019. The guidelines outline the board range of evidence-based recommendations of practice that exists on pressure injuries. The guideline gives information on the strength of evidence summaries and implementation considerations of each individual recommendation to provide context on the recommendation. This guideline provides a useful guidance to health professionals in assisting their clinical judgment when making decisions on implementing appropriate clinical practice to prevent and manage pressure injuries (NPUAP et al., 2019). In the New Zealand paediatric context, The Pressure Injury Prevention for an Infant, Child, or Young Person Guideline is written by Starship Children's Hospital. This guideline is used to guide nurses' practice in all paediatric areas, including the PICU (Starship, 2020). Unfortunately, this guideline places little emphasis on caring for the PICU patient.

Specialty surfaces have been an important adjunct in the prevention of pressure injuries by aiding in the distribution of pressure, better positioning, and decreasing moisture (Norton et al., 2011). The National Pressure Injury Advisory Panel [NPIAP] (2019), has defined a support surface as a specialised device designed for pressure redistribution or management of tissue loads. There are different types of specialty support surfaces that have been used, including reactive and active support surfaces with properties and technology to adjust load distribution, non-powered or powered surfaces, overlays, and mattresses (NPIAP, 2019). Furthermore, it is recommended to use a combination of different preventive strategies together as a care bundles for their effective outcome (NPUAP et al., 2019) The use of individualised, person-centred care plans employing evidence-based care bundles are

recommended to successfully implement multiple preventive measures (Evans, Barklam, Hone, Ellis & Whitlock, 2013; ACC, 2017). Care bundles are one of the known methods of improving healthcare quality, helping nurses negotiate protocols, care algorithms, and assisting them to decide on priorities in clinical situations (ACC, 2017; Evans et al., 2013). Care bundles have been described as a collection of evidence-based interventions that may be applied targeting a particular condition for a defined patient population and care setting which, when implemented together, result in significantly better outcomes than when implemented individually (Evans et al., 2013). The concept of care bundles was developed by the Institute for Healthcare Improvement (IHI) (Resar et al., 2012). Early evidence on the effectiveness of using care bundles was shown in intensive care through the reduction of ventilation-associated pneumonias and central line infections (Resar et al., 2012).

The Effects of Pressure Injuries on Patient Safety and Healthcare Cost

Pressure injuries are classified as a patient safety issue, not a result of the condition of a patient but rather an indicator of poor quality of care in the healthcare system (ACC, 2017; Klynveld Peat Marwick Goerdeler [KPMG], 2016). They are estimated to occur in 1 in 300 people receiving healthcare (World Health Organisation [WHO], 2019). The KPMG report for ACC and the Health Quality & Safety Commission estimated that annually, 55,000 people in New Zealand sustain a pressure injury (KPMG, 2016). In most cases, pressure injuries are preventable and affect patients of all ages (WHO, 2019; Ministry of Health NZ [MOH] 2022). Pressure injuries can prevent a patient's full recovery, as they are linked to increased morbidity and mortality, longer hospital stays, lengthier ongoing healthcare treatments, and, as a result, higher costs of treatment (McCord et al., 2004; Schindler et al., 2011; Willock & Maylor, 2004). While the cost for each pressure injury has been difficult to quantify due to the paucity of research on the topic, it's estimated that the cost of every stage three pressure injury could be around $123,000 in New Zealand, costing the New Zealand healthcare system around $690 million a year (ACC, 2017). Despite being an extensively researched and preventable condition, pressure injuries continue to occur, even in high-standard medical facilities with good nursing care, particularly in the intensive care setting (Curley et al., 2003; Delmore et al., 2019; Krupp & Monfre, 2015). Curley et al. (2003) claim that pressure injuries occur in up to 27% of children in PICU. Auckland District Health Board (ADHB, 2019) reports that pressure injuries make up more than 20% of the serious adverse events at this district health board and 8% of those pressure injuries are within the child

health sector. The report acknowledged that critically ill patients are especially vulnerable to pressure injuries and state its plan to revise its approach to pressure injuries in this patient group, moving from a risk-based approach to a needs-based approach (ADHB, 2019). Similarly, KPMG (2016) and ACC (2017) highlight that there are certain patient populations, for example, premature new-borns, paediatrics, and peri-operative patients that are of higher risk of developing pressure injuries and therefore, reducing the pressure injuries incidence rates within these populations remain as an ongoing priority for New Zealand healthcare system.

All stages of pressure injuries are prone to complications, especially stages three and four. If left untreated, pressure injuries can lead to a wide variety of secondary conditions, which can be life-threatening (Al Aboud & Manna, 2021). Bacterial infections are a major complication of pressure injuries, often leading to osteomyelitis and chronic non-healing wounds. However, infections can also include cellulitis, abscesses, necrotizing fasciitis, gas gangrene, and septicaemia (Al Aboud & Manna, 2021; Redelings et al., 2005). Pressure injuries have also been linked to reduced quality of life and negative psychosocial implications (Jackson et al., 2018; Schindler et al., 2011). This is believed to be due to factors such as increased pain, social exclusion, and limitations on activity and mobility (Jackson et al., 2018; Spilsbury et al., 2007). Negative psychological effects from pressure injuries include feelings of pain and discomfort, changes in body image associated with scarring and/or alopecia, and loss of control and independence (Fox, 2002; Schindler et al., 2011). More importantly, these negative effects reported by patients are not always recognised by nursing staff (Spilsbury et al., 2007).

Nurses' Role in Pressure Injury Prevention

Nurses have an important role in pressure injury prevention in a variety of healthcare settings, given they are the health professionals who spend the most time with patients. Specialised roles, such as skincare champions, have been developed within nursing to improve pressure injury prevention and management (Bergquist-Beringer et al., 2009). These roles have also been helpful to improve the cooperation and working relationships between nurses and other healthcare professionals, including doctors, physiotherapists and dieticians (Bergquist-Beringer et al., 2009). A number of studies have explored the knowledge and attitudes of nurses regarding pressure injury prevention and management (Barakat-Johnson et al., 2018;

Coyer et al., 2019; Samuriwo & Dowding, 2014). The common themes emerging from those studies highlight that nurses experience challenges when managing competing demands in complex clinical settings. Nurses want to implement preventative strategies and provide optimal pressure injury care; however, high patient acuity is reported as a significant barrier to implementing appropriate and timely pressure injury prevention strategies in intensive care (Barakat-Johnson et al., 2018; Coyer et al., 2019). Nurses acknowledge the importance of knowledge and the skill required in providing pressure injury prevention. Furthermore, nurses strongly believe hospitals need to have measures in place that support and enable them to deliver the quality care required in preventing and managing pressure injuries (Barakat-Johnson et al., 2018; Coyer et al., 2019; Samuriwo & Dowding, 2014).

Pressure Injury in the Paediatric Intensive Care Context

With medical technology and knowledge advancement, survival rates of both critically and chronically ill infants and children have improved significantly in recent years. This introduces new challenges for nursing care in the PICU setting, and an increase in the risk of pressure injuries being one of those challenges (Schlüer et al.,2009). The paediatric population has distinctive anatomical, physiological and developmental factors that alter their risk and the presentation of hospital-associated pressure injuries (Baharestani & Ratliff, 2007; Dixon & Ratliff, 2005). Physiologically, body proportions are different in paediatrics compared to adults. Through their infancy into early childhood years, the occiput is the largest bony prominence, making it a site with higher supine pressure than the sacrum. As a result, the ears and occiput are the most prevalent areas for pressure injuries developing in paediatric patients (McCord et al., 2004). Developmentally, neonates, infants, and young children have a limited capacity to communicate discomfort, particularly when critically ill. This limits their ability to communicate the need for repositioning, turning, and convey the discomfort associated with pressure on skin due to medical devices (Dixon & Ratliff, 2005). In the intensive care unit patients are attached to more equipment compared to general paediatric patients. The commonly attached devices, such as respiratory equipment, urinary catheters, sequential compression devices, and multiple intravenous catheters can further increase the risk of developing pressure injuries in intensive care settings (Cooper, 2013). PICU patients are more likely to be haemodynamically unstable with hypovolemia, requiring infusion of vasoactive agents for hypotension, which results in decreased perfusion to extremities (Murray et al.,2013). Fluid and electrolyte disturbances requiring fluid

resuscitation can cause localised or systemic oedema more frequently in the PICU setting. This makes a patient susceptible to developing pressure injuries with even minimal trauma to the skin (Cooper, 2013). Furthermore, PICU patients are likely to be in an unstable medical state, limiting their ability to tolerate movement when being repositioned to relieve pressure (Cooper, 2013; Dixon & Ratliff, 2005; Murray et al.,2013). These factors, as well as the likelihood of increased lengths of stay in hospital, are associated with the increased risk of development of pressure injuries in the PICU patient (Cooper, 2013; McCord et al., 2004; Murray et al., 2013). Overall, research highlights pressure injuries being an issue in the PICU environment; and prevention strategies continue to be a challenge. Hence, addressing this issue should be of priority.

Author's Personal Background and Position in this Practice Project

I have been a registered nurse for six years in the PICU at a tertiary paediatric hospital in New Zealand. The unit is the only PICU in the country, serving all specialities for paediatric patients needing ICU or high dependency level care. As part of the wound care group on the unit, I began looking at how nurses practice skin/wound management on the unit. I became particularly interested in pressure injuries as I noticed the number of safety management reports that were having to be completed on pressure injuries in patients on the unit. Having looked at the available prevention and management practices in the unit, I realised there is a lack of specific guidelines regarding the prevention and management of pressure injuries in PICU. The unit follows a standardised hospital nursing care plan for pressure injury prevention and management, which I noticed that fellow nursing colleagues seldom refer to. Often when a pressure injury does occur, they are unsure of how to manage it, leading to inconsistent management practices. It became evident that PICU needed a deeper exploration on the effectiveness of our current prevention strategy for pressure injuries. Pressure injury prevention is an aspect of nursing care that can be overlooked in a high-intensity environment. However, pressure injuries are indicators of the quality of nursing care and those in intensive care are often at the highest risk for developing injuries. Preventing and managing pressure injuries is a nurse’s responsibility, which includes the assessment and staging of pressure injuries, timely implementation of preventive practices, and management of existing pressure injuries with evidence-based interventions (Nuru et al., 2015). I hope the findings of my practice project will provide evidence to inform future strategies for improving clinical practices in preventing pressure injuries among patients in PICU setting.

Aim

The aim of this practice project is to carry out an integrative review to explore effective pressure injury prevention practices in the paediatric intensive care setting.

Significance of Practice Project

There is a lack of research on pressure injuries in the paediatric population and more so in the paediatric intensive care setting (Curley et al., 2003; Freundlich, 2017). This integrative review identifies existing research on prevention of pressure injuries in PICU setting and highlights gaps in the literature in this area. This integrative review focuses specifically on the prevention aspects of pressure injuries considering that most cases of pressure injuries are preventable; and avoiding pressure injuries before they develop is a high priority for New Zealand's healthcare system (ACC, 2017). Furthermore, the development of pressure injuries is recognised as a patient safety problem as each injury sustained represents a patient harmed while receiving healthcare (ACC, 2017; WHO, 2019). The cost of prevention is significantly lower than the cost of treatment due to the complexity associated with pressure injuries. Investment into improving patient safety will ultimately improve efficiency in healthcare systems and most importantly, result in better patient outcomes (WHO, 2019). Therefore, exploring the literature on prevention strategies rather than on the management is considered to be more valuable to reduce the rate of pressure injuries. It is expected that the findings of this integrative review will provide a basis to develop future strategies and guidelines for preventing pressure injuries in PICU patients, contributing to a decreased burden of pressure injuries in this healthcare specialty.

Structure of the Practice Project

This practice project is presented in four chapters, including this introductory chapter. Chapter Two describes the method used to carry out the integrative review. Chapter Three presents the findings of the integrative review under the common themes emerged from the review. Chapter Four discusses the findings of the integrative review. This chapter also outlines the strengths and limitations of the integrative review and provides recommendations for future research as well as for policy and practice improvement to prevent pressure injuries in paediatric intensive care units.

CHAPTER TWO: METHODS

Introduction

The purpose of this integrative review is to examine and synthesise evidence from the current literature on effective practices for the prevention of pressure injuries in the paediatric intensive care setting. This chapter discusses the rationale for utilising the integrative review method and outlines the steps undertaken to carry out this review. It describes the database search strategies and the exclusion/inclusion criteria for the literature selection process. Furthermore, this chapter discusses the appraisal tool used for quality evaluation of literature included in this review; and finally, it presents the search outcome findings in tabular form.

Design

Robust nursing research has been fundamental to the advancement of evidence-based nursing practice. The wealth of knowledge in nursing care has improved nurses' clinical decision-making ability and consequently, has had direct impact on improved quality of patient care (McCusker & Gunaydin, 2015). Furthermore, nursing research has grounded the development of clinical guidelines and the advancement of health policies in healthcare settings (Mackey & Bassendowski, 2017). The integrative literature review is a non-experimental design that is useful in providing insight into existing practices and defining the scientific evidence on a topic (Cronin & George, 2020). Integrative reviews benefit healthcare practice by summarising past and present empirical and theoretical literature on the topic in focus (Whittemore & Knafl, 2005). The limited literature on the prevention of pressure injuries in the PICU setting was anticipated given the lack of research and inconsistent practices that exist in pressure injury prevention and management in the general paediatric healthcare setting (Bernabe,2012; Delmore et al., 2019; Murray et al., 2013;). An integrative review of the literature focusing on the PICU setting will, therefore, uncover the trends in the research that currently exists, and has the potential to bring about effective changes in nursing practice in this specialised area. Similarly, the findings will identify primary issues in paediatric intensive care and give direction for future research on pressure injury prevention in PICU (Delmore et al., 2019). The integrative review of literature is a comprehensive method with the capability to summarise varied methodologies. An integrative review allows the inclusion of all available literature on the topic, which supports the full exploration and analysis of the topic of focus (Whittemore & Knafl, 2005).

Comparing and contrasting research conducted utilising different methodological approaches provides complementary knowledge from each approach, which contributes to a comprehensive understanding of a topic (Cronin & George, 2020). Quantitative research objectives are useful for identifying the incidence or prevalence of a health issue and the adherence to and effectiveness of new interventions (Carr,1994; McCusker & Gunadin, 2015). Qualitative research, on the other hand, is directed towards understanding what perspectives exist on a particular topic and the differences between individuals' opinions and experiences. Qualitative research serves an important role in the exploratory analysis of a topic (Carr,1994; McCusker & Gunadin, 2015). As a result of the need to combine and summarise diverse methodologies, conducting an integrative review can be challenging and requires following a thorough approach to strengthen the rigor and accuracy of the conclusions (Crossetti, 2012). Summarising a diverse range of literature is achieved through a process of systematic search, categorisation, and thematic analysis of the selected literature. The Whittemore and Knafl (2005) framework for conducting an integrative review is presented in five broad stages: (a) problem formulation, (b) data collection and definitions for the literature search, (c) data evaluation, (d) data analysis, and (e) result presentation and interpretation.

Problem Identification

Infants and young children, particularly those who are critically unwell, have limited capacity to communicate discomfort. A hospitalised child is likely to have limited ability to reposition and turn themselves, and/or convey their discomfort related to the use of medical devices. These factors place critically ill paediatric patients at increased risk of developing pressure injuries (Dixon & Ratliff, 2005). Hence, a comprehensive understanding of paediatric pressure injuries in the intensive care setting is required so that a systematic approach to prevention can be instituted in healthcare settings (Delmore et al., 2019; Schlüer et al., 2009). The development of pressure injuries in patients indicates poor patient care and can lead to long-term physical and psychological effects and increase the length of hospital stays (Curley et al., 2003). Therefore, it is imperative that health professionals understand pressure injury prevention in the PICU setting. There is a high incidence of pressure injuries in ICU patients, despite the implementation of risk assessment tools and preventive nursing practices. This indicates further investigation of the underlying causes of pressure injuries in this healthcare setting is needed (Bernabe, 2012). The findings of this integrative review will inform policy

and practice for developing effective measures to prevent pressure injuries among PICU patients. The knowledge gaps that may be identified through this review will indicate the need for future research and advocacy for policy and practice change in this area.

Literature Search Strategy

An extensive systematic literature search with a two-staged search strategy was used to identify studies that met the inclusion criteria. This involved searching electronic bibliographic databases for published work, and forward and backward citation searching through the reference lists of relevant articles to find further literature related to the topic. Other relevant articles were sourced by manual searching through reference lists of studies. The second stage required the identification of relevant publications to ensure comprehensive coverage of the topic due to the limitations of electronic databases. Limitations exist because of inconsistencies in search terminology resulting in the retrieval of only about 50% of eligible studies (Whittemore & Knafl, 2005). The online databases searched included PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Scopus, Cochrane, and Google Scholar. These databases were chosen as they cover research in nursing, healthcare delivery, and wound care, which are considered relevant to the topic of this integrative review. No country limiters were applied. The key search terms used were pediatric OR paediatric OR children OR child OR infant AND “intensive care unit” OR ICU OR “critical care” AND “pressure injuries” OR “pressure ulcers” OR “pressure sores” OR bedsores OR bed sores OR decubitus. An exclusion and inclusion criteria were established for the literature selection process, as described below. The purpose of inclusion and exclusion criteria is to ensure the database search yields only current, high-quality and credible studies focused on the topic of the integrative review.

Inclusion and Exclusion Criteria

Only articles published within a time range of ten years (2010-2020) were included to reflect current research on the topic. Nursing approaches toward wound care, particularly when addressing pressure injury prevention and treatment, have developed in the last ten years (Delmore et al., 2019). Advancements have been made in standardised approaches in hospitals to risk assessment, the use of evidence-based guidelines, prevention strategies, medical equipment, and device design, and wound treatments specific to the paediatric

population (Delmore et al., 2019; Murray et al., 2013). The literature search was limited to English language primary research publications only. Only studies related to pressure injuries in paediatric and neonatal patients in paediatric intensive care units were included. A number of paediatric intensive care units also provide care to neonatal patients and high dependency cardiac surgical patients. Therefore, literature on paediatric intensive care with neonatal and paediatric high dependency care combined units were included. Review articles, clinical reports, editorial articles, and discussion papers were excluded. Studies with a focus on neonatal intensive care units, paediatric wards, and adult intensive care units were also excluded. This is due to the differences in the clinical aspects and treatment courses for PICU patients in comparison to neonates and adults. Although practices in neonatal intensive care resemble those routinely used in paediatric intensive care settings, several clinical aspects are unique to each respective sector and cannot be easily translated from one to the other (Biban & Spaggiari, 2011). Furthermore, newborns in neonatal intensive care acquire a different array of diseases requiring treatment compared to young infants, toddlers, and other age groups in the paediatric population (Biban & Spaggiari, 2011). As the focus of this review is on pressure injury prevention, literature focusing on the management of existing pressure injuries was excluded.

Search Outcome

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flowchart (Moher et al., 2009) is used to illustrate the database search process for the literature selection for this integrative review. During the initial database search, 414 studies were found. Additionally, reference lists from the identified studies were reviewed for possible studies may not retrieved by the database searches. Two studies were discovered through this method. Duplicate studies were discarded with 164 studies remaining to be screened. Based on the inclusion/exclusion criteria discussed earlier, 130 articles were excluded. The remaining 34 articles were screened by reviewing the title and abstract for relevance which resulted in a further 20 being excluded. These excluded articles were related to adult ICU only or both paediatric and adult ICU, or abstract and skim reading of the research indicated that they were not primary research articles, or they were unrelated to pressure injury prevention. Full-text versions of each of these studies were obtained and reviewed thoroughly to determine if each of these studies met the inclusion criteria. A total of

fourteen studies met the inclusion criteria and were included in the review. All 14 relevant studies included in this review utilised a quantitative method.

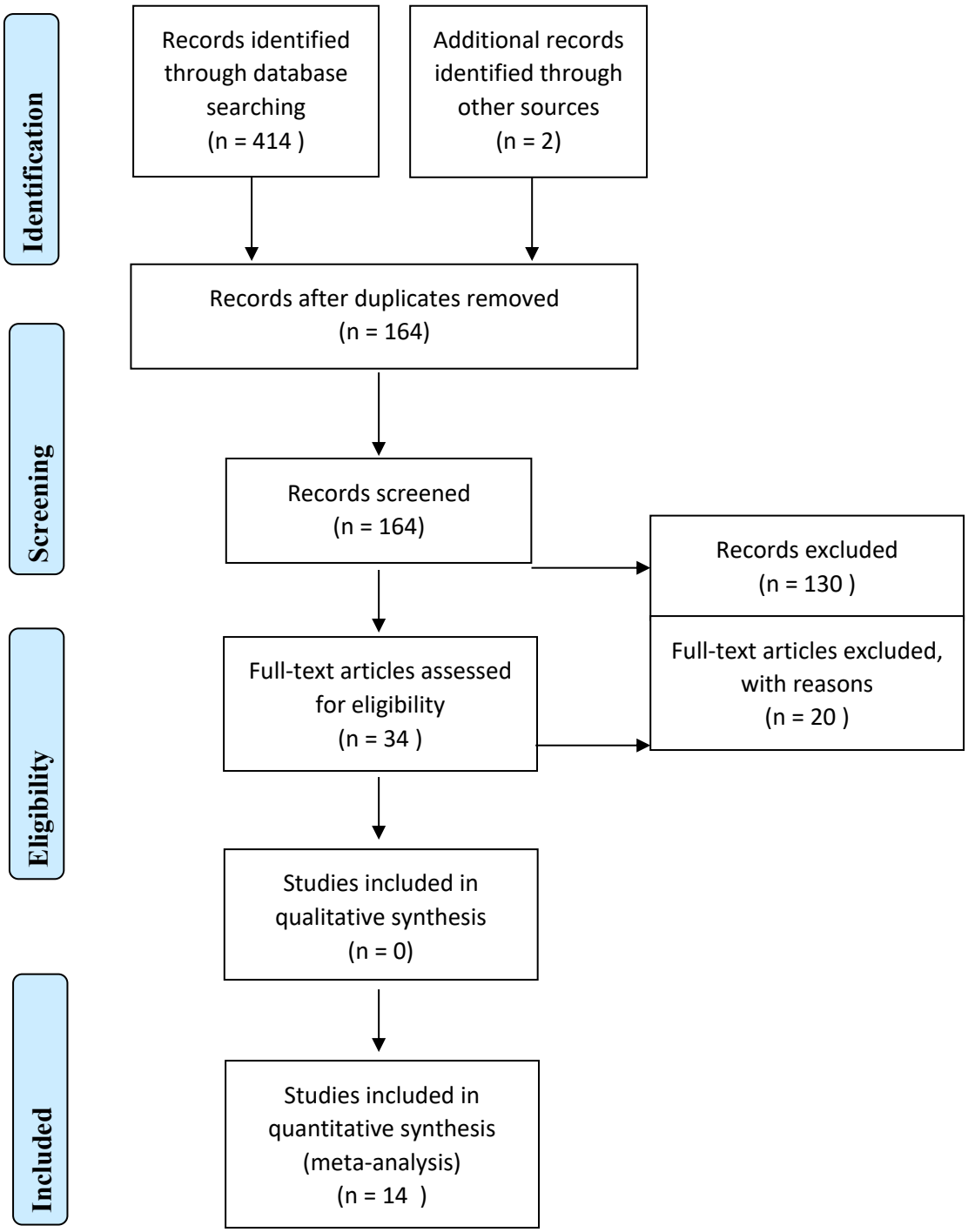

Figure 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart (Moher et al., 2009)

Quality Appraisal

With the inclusion of diverse sources of data from both experimental and non-experimental research in the integrative review method, the Mixed Methods Appraisal Tool (MMAT) version 18 was utilised for quality appraisal of the articles included in this review. This tool was chosen because it is designed for systematic reviews that include qualitative, quantitative, and mixed methods. The Mixed Methods Appraisal Tool is efficient as it allows the use of one uniformly formatted tool to appraise the most common types of empirical studies, while accommodating the distinct characteristics that are specific to each research methodology (Hong et al., 2018).

The MMAT comprises a checklist of screening questions. For each study, the appropriate checklist is selected based of the study's methodology (Table 1, Table 2 and Table 3). The responses to each checklist question are "Yes", "No" or "Can't tell". The responses are used to give an indication of overall quality of the study. Exclusion is generally discouraged in the MMAT (Hong et al., 2018). Instead, these findings are accounted for in the results and discussion section of the integrative review. No studies in this integrative review were excluded due to low methodological quality. Those studies included that were appraised as having a lower quality methodology were noted and were given less significance in the conclusion drawing process. Each study included in this integrative review was independently critiqued by the student researcher and a second reviewer (the research supervisor).

Data Extraction and Analysis

Following the study selection process, the chosen studies were all read in full thoroughly. Comparisons between the chosen studies were made and themes were identified. Following the steps of Whittemore & Knafl (2005), findings were classified based on shared characteristics: authors, year and place of publication, research aim, sample size, methodology, results, and recommendations. Following on, the data extracted were condensed into a summary in the form of a table. This enabled the grouping of similar findings, the establishment of links between articles, and the identification of recurring themes. The tabulation of the data facilitated the comparison of findings and research objectives between articles.

Braun and Clarke's (2006) method of thematic analysis is used for identifying themes in this integrative review. The phases of the thematic analysis process include:

1. Familiarisation with the data: reading and re-reading and noting down initial ideas.
2. Generation of initial codes: coding interesting features of the data and collating data by code.
3. Searching for themes: collating codes into possible themes, gathering all data relevant to each possible theme, and identifying relationships between codes, themes, and different levels of the themes (such as main overarching themes and sub-themes within them.
4. Reviewing themes: checking if the themes are appropriate in relation to the coded extracts (Level 1) and the entire data set (level 2) and generating a thematic "map" of the analysis.
5. Defining and naming themes: ongoing analysis to refine the specifics of each theme and the generation of clear definitions and names for each theme.
6. Producing the report: the final opportunity for analysis, selection of extract examples, the final analysis of selected extracts, the relation of the analysis back to the research question and literature, and the production of a scholarly report of the analysis.

This thorough process of data analysis allows for flexibility in interpreting data and improves the approachability of large data sets through the categorisation of themes at different levels, such as main overarching themes and sub-themes within main themes (Braun & Clarke, 2006).

Table 1 Quantitative non- randomised studies MMAT. Appraisal of included articles

Quantitative Non-randomised yes: ✓ No: X Can't tell: CT	**S1. Are there clear quantitative research questions?**	**S2. Do the collected data address the research question?**	**3.1. Are the participants representative of the target population?**	**3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?**	**3.3. Is there complete outcome data?**	**3.4. Are the confounders accounted for in the design and analysis?**	**3.5. During the study period, is the intervention administered (or does exposure occur) as intended?**	**Comments**
Vocci et al., 2017	✓	✓	✓	✓ Pearson's correlation enabled verification between the variables of the outcome.	✓	✓ Exclusion criteria: patients with less than 24 hours of hospitalisation, mental illness or with existing pressure injuries.	✓	Cohort Study

Quantitative Non-randomised yes: ✓ No: X Can't tell: CT	**S1. Are there clear quantitative research questions?**	**S2. Do the collected data address the research question?**	**3.1. Are the participants representative of the target population?**	**3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?**	**3.3. Is there complete outcome data?**	**3.4. Are the confounders accounted for in the design and analysis?**	**3.5. During the study period, is the intervention administered (or does exposure occur) as intended?**	**Comments**
Kulik et al., 2017	✓	✓	✓	✓ Data recorded relevant to nursing assessment and management based on pre-defined targeted data statements and algorithm.	✓	✓ Nursing feedback regarding diversions was recorded and analysed. Skin assessments completed by nurses 81-86.6% of the time. Inclusion and exclusion criteria	✓	Quality improvement approach
Aprea et al., 2018	✓	✓	✓	✓	✓ Over 80%. 15% lost-to-follow-up	✓ Exclusion criteria	✓	Uncontrolled before and after study

Table 2 Quantitative randomised controlled studies MMAT. Appraisal of included articles

Quantitative randomised controlled trials **yes: ✓** **No: X** **Can't tell: CT**	**S1. Are there clear quantitative research questions?**	**S2. Do the collected data address the research question?**	**2.1. Is randomisation appropriately performed?**	**2.2. Are the groups comparable at baseline?**	**2.3. Are there complete outcome data?**	**2.4. Are outcome assessors blinded to the intervention provided?**	**2.5 Did the participants adhere to the assigned intervention?**	**Comments**
Bargos-Munarriz et al., 2020	✓	✓	✓ Consecutive sampling. Six-month pre (control group) and post (intervention group) implementation periods.	✓ Intervention group (bundle implementation) VS control group (nonstandard care)	✓	CT Outcome data entered by nurses onto IT platform which is reviewed by the lead research nurse.	✓	Quasi-experimental before and after study
Schindler et al., 2013	✓	✓	✓	✓ Control group (group in a prior study before the pressure injury prevention guide is implemented) VS Prospective intervention group	✓	✓	✓	Prospective-quasi-experimental
Rowe et al., 2018	✓	✓	✓	✓	✓	CT	✓	Quality Improvement Project

Quantitative randomised controlled trials **yes: ✓** **No: X** **Can't tell:** **CT**	**S1. Are there clear quantitative research questions?**	**S2. Do the collected data address the research question?**	**2.1. Is randomisation appropriately performed?**	**2.2. Are the groups comparable at baseline?**	**2.3. Are there complete outcome data?**	**2.4. Are outcome assessors blinded to the intervention provided?**	**2.5 Did the participants adhere to the assigned intervention?**	**Comments**
				Historical data used as the control group.				
Uysal et al., 2019	✓	✓	✓.	✓ Control group (group in a prior study before the pressure injury prevention guide is implemented) VS Prospective intervention group	✓ Retrospective data from the controlled group compared with outcome data of the study period.	X	✓	Pre and post intervention study
Visscher et al., 2013	✓	✓	✓ Injury rates measured during an initial period of rapid-cycle tests of change and compared to injury rates after	✓ Measurement of patient characteristics with and without pressure injuries, characteristics of pressure injuries pre and	✓	✓ Collected quarterly from a medical review of records.	✓	Quality improvement project Prospective Study

Quantitative randomised controlled trials **yes: ✓** **No: X** **Can't tell: CT**	**S1. Are there clear quantitative research questions?**	**S2. Do the collected data address the research question?**	**2.1. Is randomisation appropriately performed?**	**2.2. Are the groups comparable at baseline?**	**2.3. Are there complete outcome data?**	**2.4. Are outcome assessors blinded to the intervention provided?**	**2.5 Did the participants adhere to the assigned intervention?**	**Comments**
			interevention implementation	post intervention.				
Kriesberg et al., 2018	✓	✓	✓ Preintervention period comparison with 6-month post intervention period	✓ Average of 66 patients per month during preintervention period. Average of 59 patients per month during post intervention period.	✓	✓ Collected via electronic medical record review.	**CT** Mentions adherence data shared among nursing staff during study, however doesn't not report figures.	Quality improvement project Prospective Study
Cummins et al., 2019	✓	✓	✓ All patients admitted to the PICU during a 6-week intervention time period	✓	✓	CT	✓	Quality improvement project

Table 3 Quantitative descriptive studies MMAT. Appraisal of included articles

Quantitative Descriptive yes: ✓ No: X Can't tell: CT	**S1.Are there clear quantitative research questions?**	**S2. Do the collected data address the research question?**	**4.1 Is the sampling strategy relevant to address the quantitative research question?**	**4.2. Is the sample representative of the population understudy?**	**4.3 Are measurements appropriate (clear origin, or validity known or standard instrument)**	**4.4 Is there an acceptable response rate (60% or above)**	**4.5. Is there clear mention of ethical approval process in the article?**	**Comments**
Smith et al., 2019	✓	✓	✓ Convenience	✓	✓ Chi-Square Test Mood's Median test. Spearman's Correlation Co-Efficient Statistical significance value set at p< 0.05	✓	✓	Prospective Cohort

Quantitative Descriptive yes: ✓ No: X Can't tell: CT	**S1.Are there clear quantitative research questions?**	**S2. Do the collected data address the research question?**	**4.1 Is the sampling strategy relevant to address the quantitative research question?**	**4.2. Is the sample representative of the population understudy?**	**4.3 Are measurements appropriate (clear origin, or validity known or standard instrument)**	**4.4 Is there an acceptable response rate (60% or above)**	**4.5. Is there clear mention of ethical approval process in the article?**	**Comments**
Schindler et al., 2011	✓	✓	✓ Data collected through retrospective chart review on every PICU patient during the study duration in the 9 participating sites.	✓	✓ X^2 analysis Multiple logistic Regression T tests Mann-Whitney tests. SAS version 9.1 SPSS 14.0	✓	✓	Retrospective, Multisite study
García-Molina et al., 2012	✓	✓	✓	✓	✓ IBM SPSS statistics 19 data base. Cumulative incidence using a Z-test for difference in proportions	✓	✓	Observational, Prospective, Longitudinal study

Quantitative Descriptive **yes: ✓** **No: X** **Can't tell: CT**	**S1.Are there clear quantitative research questions?**	**S2. Do the collected data address the research question?**	**4.1 Is the sampling strategy relevant to address the quantitative research question?**	**4.2. Is the sample representative of the population understudy?**	**4.3 Are measurements appropriate (clear origin, or validity known or standard instrument)**	**4.4 Is there an acceptable response rate (60% or above)**	**4.5. Is there clear mention of ethical approval process in the article?**	**Comments**
Kim et al., 2019	✓	✓	✓ Convenience	✓ Skin initially examined by first-line staff; occurrences of medical adhesive pressure injuries confirmed by wound care specialist	✓ .SPSS software version 20.0 Chi-Sqaured test	✓	✓	Prospective observational study

CHAPTER THREE: RESULTS

Introduction

This integrative review explores the current evidence-based practice regarding effective measures for preventing pressure injuries in the paediatric intensive care (PICU) setting. Firstly, this chapter describes the general characteristics of 14 articles included in this review. Subsequently, it presents the findings under the common themes that emerged from the review of the articles.

Characteristics of the Articles

A total of fourteen articles were included in this integrative review, all of which utilised the quantitative study method. Half of the studies (n=7) utilised the quantitative randomised controlled trial method (Bargos-Munarriz et al., 2020; Cummins et al., 2019; Kriesberg et al., 2018; Rowe et al., 2018; Schindler et al., 2013; Uysal et al., 2020; Visscher et al.,2013). Four studies used a quantitative descriptive approach (García-Molina et al., 2012; Kim et al.,2019; Schindler et al., 2011; Smith et al., 2019) and three studies used a quantitative non-randomised method (Aprea et al.,2018; Kulik et al.,2017; Vocci et al.,2017).

Half of the studies (n=7) included in this review were conducted in the United States (Cummins et al., 2019; Kriesberg et al., 2018; Kulik et al., 2018; Rowe et al., 2018; Schindler et al., 2011; Schindler et al., 2013; Visscher et al.2013). The remaining studies were conducted in various countries including Spain (Bargos-Munarriz et al., 2020; García-Molina et al., 2012), Brazil (Vocci et al.,2017), Turkey (Uysal et al., 2020), Argentina (Aprea et al., 2018), South Korea (Kim et al., 2019) and Ireland (Smith et al., 2019). All studies included in this review were carried out in a single PICU within the respective countries except one (Schindler et al., 2011), which was conducted in nine different PICUs across the Southern, Midwest, and Northwest regions of the United States.

Table 4. A summary of articles included in this integrative review

Author(s) **Country**	**Sample size/Participant information**	**Study Aim**	**Methodology/ Methods**	**Key findings**	**Limitations**
Schindler et al., 2011 United States	N= 5346 9 PICUs across the Southern, Midwest, and Northwest regions of the United States, from March 2006 through December 2007	To determine the incidence of pressure ulcers in critically ill children, to compare the characteristics of patients in whom pressure injuries do and do not develop, and to identify prevention strategies associated with less frequent development of pressure injuries.	Quantitative Descriptive	The overall incidence among critically ill infants and children is greater than 10%. Greatest risk: those more than 2 years old, in PICU for 4 days or longer, non-invasive /invasive ventilation, or extracorpeal membrane ventilation. Preventive interventions: Speciality beds, foam overlays, gel pads, dry weave diapers, urinary catheters, body lotion, nutrition consultation, repositioning 2-4 hours, blankets roll, foam wedges, pillow and draw sheets	Distribution of its sample between participating sites. Several sites could not participate because of a lack of resources. Actual number of patients enrolled at each site varied in accordance with resources available to screen and enrol children at the site. This situation may have introduced a bias based on intrinsic differences in institutions related to the sizes of the institutions.
García-Molina et al., 2012 Spain	N= 30 13 (43.3%) girls and 17 (56.7%) boys.	To assess the effect of two paediatric-specific, continuous, and reactive low-pressure	Quantitative Descriptive	The low-pressure mattress had a positive impact:	Small sample size Limited number of support surfaces, and absence of a

Author(s) Country	Sample size/Participant information	Study Aim	Methodology/ Methods	Key findings	Limitations
	Most patients were 1 month to 3 years old (73.3%)	mattresses on the incidence of pressure injuries.	Prospective longitudinal study	Incidence of injuries not related to medical device was low (3.3%), much lower than the rate of similar injuries in a previously conducted study (20%) at the same facility. No adverse safety-related events occurred, and the surfaces were believed to be particularly beneficial for patients who cannot be repositioned (facilitated maintenance of patient's clinical stability)	prospective control group limits to ability to draw definitive conclusions.
Schindler et al., 2013 United States	N=399 Infants, 0 to 3 months of age	To determine whether a pressure ulcer prevention bundle is associated with a significant reduction in pressure injury development in infants in PICU	Quantitative randomised controlled trials Quasi-experimental design	Care bundle associated with injury incidence drop from 18.8- 6.8 %. Remains unclear why incidences can't reach 0 % Nurses received education. Use of skin champions. Paediatric risk assessments were	Small sample, replication is needed to support generalisability of these findings.

Author(s) Country	Sample size/Participant information	Study Aim	Methodology/ Methods	Key findings	Limitations
				completed every 24 hours (Braden Q scale). Bundle components included: correct support surface, repositioning, incontinence management, nutrition and education.	
Visscher et al., 2013 United States	N=1425 over 54,351 patient-days in the PICU and NICU.	To establish a quality improvement collaborative leadership team, measure pressure injury rates during an initial period of rapid-cycle tests of change, develop a quality improvement bundle, and evaluate the pressure injury rates after the quality improvement implementation	Quantitative randomised controlled Prospective study	Bundle effective in decreasing rates of injuries. Unappreciated number of paediatric pressure injuries associated with medical devices. Heightened awareness, early detection, and identification of strategies to mitigate device-related injury are necessary to further reduce pressure injury rates.	
Vocci et al., 2017 Brazil	N= 21	To apply the Braden Q Scale to verify the risk for the paediatric patient developing	Quantitative Non-randomised	The use of the scale may not reduce the incidence of pressure injuries, but focuses, on	Small sample study

Author(s) Country	Sample size/Participant information	Study Aim	Methodology/ Methods	Key findings	Limitations
		pressure injuries, correlate important variables for their development and estimate their incidence.	Cohort study	the need to evaluate the skin of critically ill patients during the care process. Prevention protocols, including risk assessment in order to incorporate specific interventions into the nursing planning of patients with greater risks are essential.	
Aprea et al.,2018 Argentina	N= 152 74 in the pre-intervention period and 78 in the post-intervention period. All children older than 1 month admitted to the PICU during the period between March and September 2014 and the period between May and September 2016.	To assess the impact of a healthcare quality improvement intervention on the development of pressure injuries at a PICU.	Quantitative Non-randomised Before and after study	Injury location most common in the lower occipital region, followed by the lateral malleolar and the upper occipital regions. Bundle of measures was implemented to reduce the incidence of pressure injury, which included staff training, identification of patients at risk, and pressure relief by using anti bedsore mattresses and polymer gel positioners. After the	Study carried out in a single site. It should not be ruled out that the change in the staff's behaviour during the second part of the research was due to their awareness of being actively observed (Hawthorne effect). There is no certainty that the results are associated with the implemented intervention, given the lack of a control group.

Author(s) Country	Sample size/Participant information	Study Aim	Methodology/ Methods	Key findings	Limitations
				implementation, pressure injury incidence reduced significantly in the postintervention period.	The study periods did not match accurately, although both corresponded to the winter months. Study does not assess the persistence of the benefit observed in the study over time.
Kriesberg et al., 2018 United States	N= 2545 Pre intervention n= 2186 (January 2014 to September 2016, an average of 66 patients per month admitted to the unit) Post intervention n= 359 (October 2016 to March 2017, an average of 59 patients per month admitted to the unit). Majority of patients were either less than 3 months or between 3 and 18 years of age.	To develop and implement an evidence-based protocol in the paediatric cardiac care unit. Paediatric patients were monitored for pressure injury development for 6 months following protocol implementation.	Quantitative randomised controlled	Development and use of a standardized pressure injury prevention protocol reduced the incidence, prevalence, and severity of hospital associated pressure injuries in the cardiac PICU.	During the preintervention period, pressure injuries, and severity, began to decline prior to formal education, training, and implementation. It is not uncommon in quality improvement work and may be attributed to increased awareness. The pre intervention data collection was longer in duration than the post intervention time period. Authors felt that period was necessary to

Author(s) Country	Sample size/Participant information	Study Aim	Methodology/ Methods	Key findings	Limitations
					demonstrate the incidence and severity of pressure injuries prior to the increased awareness associated with the initiation of protocol development.
Kulik et al., 2018 United States	N= 674	To develop a standardised clinical assessment and management plan (SCAMP) to describe the development of pressure injury in paediatric cardiac surgical patients and evaluate prevention strategies.	Quantitative Non-randomised	The implementation of a preventative pressure injury SCAMP or practice bundle for patients decreased the incidence and severity of pressure injury development. Majority of pressure injuries were medical device-related (70%) or immobility related (30%). The Braden Q subscales that were more frequently scored as 1 or 2 in patients who developed pressure injuries were mobility, activity, perception and nutrition.	Data relied on self-reporting. These data were recorded on paper, adding an additional data burden to an already busy workload for the nurses, leading to missing data. Not all patients who met inclusion criteria were included. Only 77% of the expected forms returned and analysed. An 'all or non'approach was used to evaluate whether nursing staff followed the intervention. Halo effect during the intervention and data collection period.

Author(s) **Country**	**Sample size/Participant information**	**Study Aim**	**Methodology/ Methods**	**Key findings**	**Limitations**
					Nursing staff were aware that data were collected about compliance, which may have affected their actions.
Rowe et al., 2018 United States	N=161	To explore the implementation of a nurse-driven pathway to reduce incidence of hospital-acquired pressure injuries in the PICU and increase usage of pressure injury bundle compliance and pressure injury prevention strategies.	Quantitative randomised controlled	Significant increase in bundle compliance for pressure injury prevention (from 45% to 75%) and a decrease in reported injuries. Clear, easy to use, nurse-driven clinical pathways, give nurses the ability to implement pressure injury prevention strategies without relying oninterdisciplinary partners for guidance. A focus on pathways to mitigate risk factors for injury development instead of on the overall risk score can prevent pressure injuries in a greater number of patients; including	Conducted in a single PICU. Further testing is needed to ensure it is generalised to all patient populations

Author(s) Country	Sample size/Participant information	Study Aim	Methodology/ Methods	Key findings	Limitations
				those not identified as high risk.	
Cummins et al., 2019 United States	Nurses: N= 80 (51 pre-test and 29 post-test) Patients: N= 757 (Pre intervention N= 197, Postintervention N= 560) All patients admitted to PICU preintervention time period was May 7, 2017 - May 13 2017. Postintervention period June 5, 2017- June 30, 2017	To implement evidence-based paediatric pressure injury prevention strategies to decrease the incidence of pressure injuries by reducing the rate from 8% to 6% during a 6-week period.	Quantitative randomised controlled Quality improvement project	Pressure injury incidence decreased from 8% to 3%. Three evidence-based strategies: Education: educating nurses on risk factors and prevention strategies. Patient repositioning: every 2 hours Nutrition: nutrition input for patients with a Braden Q score of less than 16. Following education for nurses, turning compliance for PICU patients at high risk of developing pressure injuries increased from 36% to 67%. The ordering of nutrition consultations for patients with a Braden Q scale risk score of 16 or less	Single cohort Short time frame The sample size is not large enough to generalize the findings to the entire PICU staff. The incidence rate should be interpreted with caution since several structure changes were implemented in January 2017 to better support pressure injury prevention efforts on the unit and the incidence rate had already been dropping rapidly since January 2017 (50% decrease).

Author(s) Country	Sample size/Participant information	Study Aim	Methodology/ Methods	Key findings	Limitations
				improved from 7% to 100%	
Kim et al., 2019 South Korea	N= 60	To identify the purpose, type and site of medical adhesives used for patient care and to measure the incidence of medical adhesive-related skin injury (MARSI)	Quantitative Descriptive Prospective Observational study	MARSI is common among critically ill children, and especially in patients requiring long-term use of medical adhesives for central venous catheters or surgical wound dressings, and when medical adhesives placed in high-moisture areas such as near an endotracheal tube. Importance of regular skin inspection. Frequent but gentle replacements of medical adhesives for prolonged used of adhesives in critically ill children.	Data collection in a single facility Comparatively small sample size Exclusion of measurement of MARSI under adhesive electrodes.
Smith et al., 2019 Ireland	N= 77	To determine the incidence and risk factors for pressure injuries in a PICU. Use the information	Quantitative Descriptive Prospective cohort study	Incidence of pressure ulcers was 11.7%, with facial and scalp area the most common anatomical areas	Single centre study did not include any cardiac patients.

Author(s) Country	Sample size/Participant information	Study Aim	Methodology/ Methods	Key findings	Limitations
		gathered to develop preventive pressure ulcer care bundles.		affected. Medical devices appeared to be the prime causative factor. Demonstrated the need for paediatric-specific care bundles and accurate identification of a patient's risk and where they need additional support. The Braden Q Scale does not account for medical devices and could not be recommended for use in the PICU.	Overall sample size less than 100 patients. Only 9 developed a pressure injury, limiting the ability to validate risk factors. Most injuries were graded as stage one and therefore our findings may not be applicable for stages two and higher.
Bargos-Munarriz et al., 2020 Spain	N= 110 (50 control group and 60 intervention group). Paediatric patients up to 14 years old.	Evaluate a care bundle prevention strategy implemented to reduce incidence and severity of positioning-related pressure injuries. Evaluate compliance with preventive recommendations.	Quantitative randomised controlled Quasi-experimental before and after study with consecutive sampling.	Care bundle for prevention can be an effective solution, The total number of injuries reduced by 21-43%. Stage 3 and 4 injuries were eliminated in the intervention group. The care bundle recommendations with	Limited sample obtained during the six-month study period. Quasi experimental design without random assignment .

Author(s) Country	Sample size/Participant information	Study Aim	Methodology/ Methods	Key findings	Limitations
				the highest level of adhesion recorded were skin inspection, application of hyper oxygenated fatty acid creams and use of a special support surface. The main risk factor found was the prone position.	
Uysal et al 2020 Turkey	N=184	Determine the effectiveness of a pressure injury prevention guide used in PICU on the occurrence of pressure injuries	Quantitative randomised controlled a pre-post intervention study with a control group and a prospective intervention group.	Prevention guide components: Risk assessment - Braden Q used daily Skin examination - before each shift change Position changes - 2 hourly Nutrition - nutritional status patterns assessed, weight loss and dehydration monitored, adequate nutrition provided. The risk of pressure injuries was reduced with pressure injuries occurring in 9.4% of the control	Nurses collected the data and therefore, cannot attest to the inter reliability of the data collectors. Single cohort study therefore results cannot be generalised.

Author(s) Country	Sample size/Participant information	Study Aim	Methodology/ Methods	Key findings	Limitations
				nontreatment group and 3.6% of the intervention treatment group. Pressure injuries onset occurred later during the patient's admission when the prevention guide was used.	

Common Findings

Six common themes emerged from the findings of this integrative review regarding effective measures for preventing pressure injuries in the PICU setting. They include identification of patients at risk using a risk assessment tool, implementation of a prevention bundle, education on pressure injuries, skin champions, risk factors in the PICU patient, and preventative skincare measures in clinical practice.

Identification of Patients at Risk Using a Risk Assessment Tool

The use of a pressure injury risk-assessment tool has been shown to be effective in identifying patients at risk and timely implementing prevention strategies for these patients (Bernabe, 2012). Eight out of fourteen studies (Aprea et al., 2018; Bargos-Munarriz et al., 2020; Kriesburg et al., 2018; Kulik et al., 2018; Schindler et al., 2011; Smith et al., 2019; Uysal et al., 2020; Visscher et al., 2013) included in this review used a risk assessment tool. While various risk assessment tool exists, all eight studies mentioned the use of the Braden Q Assessment Scale. One study (Bargos-Munarriz et al., 2020) mentioned the use of the Neonatal Skin Risk Assessment Scale in addition to the Braden Q Scale.

The Braden Q Scale was the most used tool across the studies included in this review. All eight studies that mentioned the use of a risk assessment tool, utilised the Braden Q Scale at the time of patient admission and then daily to identify the level of risk a patient was at for developing a pressure injury. All nurses who took part in the study by Schindler et al. (2011), completed education on the Braden Q Scale scoring before the study began. Although the hospitals were already using the Braden Q Scale, education was provided to ensure the nurses reviewed the risk assessment tool and that it would be utilised properly in their practice. During the study, the nursing staff used the scale to assess the skin of each patient at the time of admission and then every 24 hours throughout the PICU stay. A high Braden Q score indicated a low risk of developing a pressure injury while a low score indicated a high risk of pressure injury development. Similarly, Smith et al. (2019), reported that all patients with a risk of developing a pressure injury were assessed during each shift by two nurses using the Braden Q Scale. Any divergence in the assessment findings between the two would be assessed for reasons for the discrepancies. Contrary to the expected outcome, none of the patients who developed a pressure injury were categorised as being at a high or severe risk of developing a pressure injury using the risk assessment tool. The findings of this study (Smith

et al., 2019) show the median Braden Q score on admission was lower for those who developed a pressure injury than those who did not. Furthermore, the Braden Q Scale was criticised by the authors for not accounting for medical devices, given that this study identified medical devices to be a significant causative factor for pressure injuries. Based on these results, Smith et al. (2019) concluded that the Braden Q Scale could not be recommended for PICUs. This view is supported by a recent study in Spain, where Bargos-Munarriz et al. (2020) also critiqued the Braden Q Score for not being applicable to cover the variety of age groups of patients in the PICU environment. Instead, one of two assessment tools was utilised in their study, dependent on the patient's age. The Neonatal Skin Risk Assessment Scale was used for neonates up to one month and the Braden Q Scale for those between one month and 14 years. Either assessment was done every 24 hours for at-risk patients and every 72 hours for patients not at risk. However, if the patient showed any significant clinical changes a repeat assessment was performed. Furthermore, Bargos-Munarriz et al. (2020) claimed the Braden Q Scale not accounting for medical devices. Smith et al. (2019) also mentioned that all patients with medical devices to be classified as at risk for pressure injuries, regardless of their score from the assessment tool. As a result, these patients received more frequent skin assessments. In contrast, Vocci et al. (2017) indicate that the application of the Braden Q Scale in the PICU setting was effective by showing how the Braden Q Scale variables and estimates correlate with the pressure injury rates in their study. 76.7 % of the patients in PICU were identified as high risk according to the Braden Q Scale and of those patients, 19% developed pressure injuries during their stay in PICU. Associations between the time of hospitalisation and the Braden Q score were noted, with a longer hospitalisation time correlating to a lower score indicating higher risk of developing a pressure injury.

While the use of the Braden Q Scale may not contribute directly to reducing the incidence of pressure injuries, it does bring focus on the need to evaluate the skin of critically ill patients (Vocci et al., 2017). This was demonstrated in other studies where a patient's Braden Q score was utilised to make decisions on which elements of a pressure injury prevention bundle a patient would receive while in PICU (Cummins et al.,2019; Kriesberg et al., 2018; Vissher et al., 2013). A quality improvement project conducted by Cummins et al. (2019) focused on increasing nursing compliance by turning PICU patients every two hours and instituting the routine ordering of nutrition consultations on all PICU patients with a Braden Q Scale risk

score of less than 16. Similarly, patients with a Braden Q score less than 16 in the study by Kriesberg et al. (2018) received increasingly more preventive interventions compared to other patients. Overall, a lower risk assessment score equated with more elements of the bundle and increasingly comprehensive preventive measures being used.

Implementation of a Preventive Care Bundle

A care bundle is a group of evidence-based interventions suggested for implementation with patients as appropriate for the purpose of cementing clinical practice components into healthcare environments to improve clinical outcomes (Resar et al., 2012). Seven of the studies (Aprea et al, 2018; Bargos-Munarriz et al.,2020; Kulik et al., 2018; Rowe et al., 2018; Schindler et al., 2013; Uysal et al., 2020; Visscher et al., 2013) included in this review used a bundle of care approach as a strategy to decrease pressure injury rates in the PICU environment. A preventive care bundle is shown to reduce rates of pressure injuries in PICU. For example, Visscher et al. (2013) evaluated the rates after introducing a pressure injury quality improvement bundle and showed a 50% reduction in pressure injury rates in PICU. This finding is supported by Schindler et al. (2013) who also reported that the implementation of the pressure injury prevention bundle resulted in a significant decrease in pressure injury incidence from 18.8 % to 6.8%. Similarly, in another study, Aprea et al. (2018) reported a noticeable reduction in the incidence of pressure injuries from 50.6% pre-intervention to 23.98% post-intervention in a skincare bundle quality improvement project. Furthermore, care bundles were shown to be effective for further reducing pressure injuries in PICUs with relatively low baseline rates. In the study by Uysal et al. (2020), rates of pressure injuries in the controlled group were 9.4% compared to 3.6% among the intervention group that used a care bundle. In contrast, Rowe et al. (2018) reported that bundle compliance and the use of the risk assessment scales were consistently below 90% and preventing pressure injuries continued to be a challenge in the PICU environment. Hence, they explored the use of a nurse-driven pathway to assist nurses in implementing interventions based on the individual categories within the risk assessment tool (subscales) instead. The pathway included interventions to reduce risk in each of the categories outlined in the Braden Q Scale. The use of the nurse-led pathway showed improved bundle compliance rates and decreased pressure injuries, with a 57% and a 66% increase in staff compliance with the prevention bundle. This finding is supported by Kulik et al. (2018), who examined the effectiveness of a

standardised cardiac PICU pressure injury prevention plan using a pathway algorithm compared to the standard bundle of care approach. The pathway was assessment, prevention, and management focused while also allowing for clinical variability between PICU patients. This pathway allowed diversions from the standard plan and an opportunity for nurses to gain understanding through the decision-making process. Following the implementation of this pathway pressure injury incidence rates decreased from 6% to 4.4%. Furthermore, Schindler et al. (2013) discuss why the rates of pressure injuries in their study remain at 6.8% post introduction of bundle care with targeted nursing interventions. While it remains unclear why the incidence stays above zero, it could be due to deviation in prescribed nursing care and suboptimal effectiveness of the intervention (Schindler et al., 2013).

Care bundles aid in the consideration of all the health factors involved when planning pressure injury prevention care for patients at risk of developing pressure injuries. Ideally, a bundle of care should be a set of three to five evidence-based practices used together (Resar et al., 2012). An existing bundle called the SSKIN (surface, skin inspection, keep moving, incontinence, nutrition) care bundle was evaluated and modified for the context of the PICU environment in the study by Smith et al. (2019). A PICU patient's degree of mobility was found to be the most common risk factor with facial and scalp areas being particularly susceptible to pressure injuries. Based on these findings, the SSKIN care bundle was modified with key changes being regular skin inspections in the facial and scalp areas, use and correct management of pressure distributing devices, and ensuring no excessive use of adhesives. In another similar study by Visscher et al. (2013), data on pressure injury rates during an initial period was used to construct a bundle of care. This process assisted in identifying the characteristics of the pressure injuries that occurred, such as anatomical location, suspected cause, and pressure injury stage. As a result, five key evidence-based practice components were identified as being important for prevention, including skin assessments, skin care, care indirectly related to skin (pain control, nutrition, hydration), products related to pressure, and patient/family involvement. These key components underline the importance of close monitoring and early detection of compromised skin conditions due to pressure and excess moisture. Kriesberg et al. (2018) carried out the same processes prior to implementing a skincare bundle quality improvement project in the PICU. They claimed this process enables potential barriers and new knowledge to be identified and allows for refinements in the bundle. In an earlier study, Schindler et al. (2013) designed a

skincare bundle using the findings from two studies. The first study only explored nursing interventions associated with lower pressure injury incidence (Schindler et al., 2011). The second study built on the findings of the previous study (Schindler et al., 2011) by using the same participants as the control group (Schindler et al., 2013). The results from the 2011 study were used in their 2013 study to design a skincare bundle comprising five components: ensuring patients were on the correct support surface to decrease tissue interface pressure, frequent repositioning, incontinence management, appropriate nutrition, and education.

Education on Pressure Injuries

Several studies included in this review highlight the importance of educating nursing staff in preventing pressure injuries in the PICU setting (Aprea et al., 2018; Cummings et al., 2019; Schindler et al., 2013; Visscher et al., 2013). One of the primary focus areas reported by Cummings et al. (2019) was to educate PICU nurses on the risk factors for paediatric pressure injury and evidence-based prevention strategies to increase compliance with the pressure injury guidelines of the unit. This pressure injury education content covered risk factors for paediatric patients, reinforced proper documentation, and highlighted the importance of turning patients every two hours and obtaining nutrition consultations for patients with Braden Q scores less than 16 (Cummings et al., 2019). The average pre-test score on the PICU pressure injury education assessment was 61.6%, revealing PICU nurses lacked knowledge about pressure injury causation (13.7%), paediatric pressure injury causation (29.4%), patient outcomes associated with pressure injuries (23.5%), paediatric pressure injury occurrence time frame (39.2%), and Braden Q scale risk assessment (2%). There was a noticeable increase in the average post-test score (79.5%), which indicated the education session significantly enhanced PICU nurses' knowledge about paediatric pressure injuries (Cummins et al., 2019).

Four studies included in this review used education as part of their bundle of measures in their quality improvement project for PICU pressure injuries (Aprea et al., 2018; Rowe et al., 2018; Smith et al., 2019; Visscher et al., 2013). In two of these studies, nursing staff were required to attend study sessions on skincare prevention practices prior to implementation of the skincare bundle (Rowe et al., 2018; Smith et al., 2019). These sessions ensured the bundle implementation was standardised and carried out correctly by the nurses involved. Likewise,

in the study by Aprea et al. (2018), nurses were required to complete training modules and demonstrate competency prior to implementing prevention interventions as a skincare bundle for patients on the unit. Importantly, after the nurses participated in this study had completed the training modules, there was a noticeable decrease in pressure injury rates even before the period of bundle interventions began on the unit. As Aprea and colleagues (2018) explained, the effects may reflect increased awareness of pressure injuries with PICU staff attention focused on early indicators of compromised skin and the implementation of some of the bundle elements.

In an earlier study, the role of education was extended beyond healthcare professionals to the families of the patients (Visscher et al., 2013). The integration of patient/family involvement and education for families, such as brochures regarding pressure injuries and skin assessment, were made a part of the bundle of care initiative. This raised awareness and integrated families into the pressure injury prevention process while also promoting greater attention to individual patient needs. Furthermore, nurses actively engaged families in skin assessments, discussed observations with them, and had them involved in the skin care of their child. No direct measured outcomes were reported as a result of focusing on family education and engagement about pressure injuries alone. However, the extension of responsibility for pressure injury prevention care beyond nurses alone seemed to contribute towards the success of the care bundle and resulted in a 50% reduction in pressure injury rates on the unit (Visscher et al., 2013).

Role of Skin Care Champions

Four articles included in this review explore the use of skin care champions and their role in pressure injury quality improvement projects (Kriesburg et al. 2018; Schindler et al., 2013; Smith et al., 2019; Visscher et al., 2013). Champions within a PICU are registered nurses who are knowledgeable and leaders in a specific area, such as skin care (Bergquist-Beringer et al., 2009). These skin care champions serve as resources for all other unit staff in providing pressure injury care for patients, especially those with complex skin care needs, and assist with compliance with the prevention care bundle (Kriesburg et al. 2018; Schindler et al., 2013; Smith et al., 2019; Visscher et al., 2013). All four studies reported that the skin care champions received additional education and attended regular meetings for skincare updates.

In addition, Visscher et al. (2013) report that several skincare champions in their study underwent training to become wound care professionals certified by the National Alliance of Wound Care.

According to Schindler et al., (2013) and Visssher et al., (2013), skin care champions can proactively identify and avoid potential adverse clinical outcomes of pressure injury. In the study by Schindler et al., (2013), each skin care champion was assigned six-bed spaces for which they were responsible for conducting weekly skin rounds and ensuring preventative pressure injury measures were taking place. When a pressure injury was identified, the skin care champion implemented an appropriate treatment plan and discussed the plan with the patient nurse. Similarly, in the study by Visscher et al. (2013), skin champions consulted one-on-one with the nurse when a potential pressure injury was identified. The skin champion would help develop skin care and wound care plans for identified patients and reinforce the skin assessment procedures. While not discussed in detail, it was noted skin care champions were responsible for conducting and participating in weekly collaborative skin rounds with other multidisciplinary healthcare teams on the unit (Visscher et al., 2013). This collaborative approach was reported as an incentive for changes to the system in the unit regarding who should be responsible and involved in preventing and managing pressure injuries on the unit.

The use of dedicated skin care champions was shown to be effective for pressure injury prevention in the PICU environment across all four studies included in this review (Kriesberg et al. 2018; Schindler et al., 2013; Smith et al., 2019; Visscher et al., 2013). Schindler et al. (2013) highlighted that although the implementation of skin care bundle interventions itself was important, skin care champions reinforced the practice change and implementation of the interventions in nurses' daily practice. Furthermore, the skin care champions not only facilitated peer-to-peer education about appropriate interventions but also provided rapid-cycle feedback to nurses. Fundamentally, this helped nurses to improve their practice in pressure injury prevention and sustain these practice changes over time (Schindler et al., 2013; Visscher et al., 2013).

Risk Factors in the PICU Patient

Six of the studies included in this review identified common risk factors for developing pressure injuries in PICU and it is encouraged that these factors are considered when planning pressure injury prevention and management strategies for patients (Aprea et al., 2018; Kulik et al., 2018; Schindler et al., 2011; Schindler et al., 2013; Smith et al., 2019; Uysal et al., 2020). Long duration of PICU stay and being clinically unstable were notable risk factors in these studies. According to Schindler et al. (2011), patients with the greatest risk for developing pressure injuries were those who were older than two years; were in the intensive care unit for four days or longer; and require mechanical ventilation, non-invasive ventilation, or extracorporeal membrane oxygenation. This finding is supported by a later study (Schindler et al., 2013), which also showed that patients who developed a pressure injury were found to have a significantly higher risk of mortality when compared with patients who did not develop a pressure injury. Patients who developed a pressure injury had a significantly longer length of stay when compared with patients who did not develop a pressure injury. Similar findings are also evident in a study by Aprea et al. (2018), where events and procedures associated with high mortality (mechanical ventilation, inotropic support, extracorporeal membrane oxygenation, cardiorespiratory arrest) were identified as risk factors for pressure injury development in PCU patients. Furthermore, Smith et al. (2019) found that skin exposure to moisture, which is commonly associated with pressure injury development, was the least common cause, whereas a patient's declining mobility was identified as the most common risk factor. While the authors did not specifically state this in this study (Smith et al.,2019), declining mobility can be a sign of an increase in the patient's risk of mortality. This would suggest a decrease in mobility indicates an increasingly unstable PICU patient with at higher risk of developing a pressure injury.

The six studies included in this integrative review highlighted that there are several locations on the body which are more prone to developing a pressure injury in the PICU patient. The hip, lower back, neck, and occipital regions were found to be the most common regions for developing a pressure injury (Aprea et al., 2018; Kulik et al., 2018; Schindler et al., 2011; Schindler et al., 2013; Smith et al., 2019; Uysal et al., 2020). Uysal et al. (2020) found that 33.3. % of PICU pressure injuries occur on the coccyx, 33.3% in the occipital region,16.7% on the left ear, and 16.7% on the side of the hip. Uysal et al. (2020) and Schindler et al., (2013) had relatively consistent findings, with the most common location for pressure injuries

being the hip and neck followed by the occipital regions of the body, whereas the finding of the study by Schindler et al. (2011) was inconclusive on the most common locations for pressure injuries. Nonetheless, pressure injuries located in the buttocks, neck, perinium, occiput, sacrum, shoulders, and forehead combined made up half of all pressure injuries in PICU (Schindler et al.,2011). In contrast, Smith et al., (2019) found that the majority (77.8%) of pressure injuries on the facial and scalp areas were caused by medical devices for airway support.

Medical interventions themselves were found to be associated with pressure injury development in four of the studies included in this integrative review (Kim et al., 2019; Kulik et al., 2018; Smith et al.,2019; Visscher et al., 2013). Smith et al. (2019) identified medical devices as one of the main causative factors for developing pressure injuries in PICU patients. This is supported by the findings of Visscher et al., (2013), where after three months of a skin care bundle having been initiated, data continued to show that pressure injuries occurred at multiple body sites. More than 50% of these were associated with medical devices, including facemasks for non-invasive positive pressure ventilation. The findings were consistent with those of Kulik et al. (2018), who showed that 70% of pressure injuries were related to the use of a medical device. Kim et al. (2019) demonstrated that for every 100 patients with a medical adhesive used, 8.5 cases of pressure injuries occurred as a direct result of the adhesives. Of the pressure injury cases that occurred, the majority were from skin stripping (60.0%) or tension injuries (22.9%). It was found that medical adhesives were commonly used to secure medical devices including endotracheal tubes, indwelling catheters, nasal cannula, and central venous catheters. Furthermore, those patients requiring long-term use of adhesives such as central line dressings or adhesives in high moisture areas such as near an endotracheal tube were at particular risk (Kim et al., 2019). These findings are supported by Smith et al., (2019), who commented that not all skin adhesives used on patients in their study were clinically justified. As adhesives have the potential to leave skin vulnerable to pressure injuries, it is suggested that nursing staff should ensure that there is no excessive use of adhesives.

Preventative Skin Care Measures

Various pressure injury preventative measures in the PICU setting were described in eleven out of fourteen studies included in this review (Aprea et al.,2018; Cummins et al., 2019; García-Molina et al., 2012; Kriesberg et al., 2018; Kulik et al., 2017; Rowe et al., 2018; Schindler et al., 2011; Schindler et al.; 2013, Smith et al., 2019; Visscher et al., 2013; Uysal et al., 2019). Regular head-to-toe skin assessments at least once a day, particularly on admission, were described in nine of the studies (Aprea et al.,2018, Kriesberg et al., 2018, Rowe et al., 2018, Schindler et al., 2011, Schindler et al., 2013, Smith et al.,2019, Visscher et al., 2013 & Uysal et al., 2019). However, Uysal et al. (2020) recommends a patient's skin be examined more frequently, ideally before each shift change. This recommendation was supported by Rowe et al., (2018) who state that although skin should be examined at least every 24 hours, once every twelve-hour shift is recommended best practice. Moreover, both Uysal et al. (2020) and Visscher et al. (2013) mention the importance of examining skin specifically for temperature, erythema, oedema, and areas of non-blanchable skin. Particular attention to the bony prominences, especially the facial and scalp regions, during head-to-toe skin examinations is suggested by Kriesberg et al. (2018) and Smith et al. (2019). While both Smith et al. (2019) and Aprea et al. (2018) advise regular examining areas at the highest risk under medical devices such as tracheostomy tubes and under braces or orthoses.

Frequent repositioning of patients to eliminate pressure is recommended as a preventive measure in the eleven studies included in this review. The frequency of turning varied, with the majority of studies (n=7) recommending patient repositioning every two hours (Aprea et al., 2018; Cummins et al., 2019; Kriesberg et al., 2018, Kulik et al., 2018.; Rowe et al., 2018; Schindler et al., 2011; Schindler et al., 2013) and two studies suggesting repositioning every two to four hours (Garcia-Molina et al., 2012; Visscher et al., 2013). Details on how a patient should be repositioned varied among studies. Rowe et al. (2018) comment that a patient should not be positioned on non-blanchable red areas of the body. Furthermore, if a patient is haemodynamically unstable, only small tilts and repositioning of limbs and head may be tolerated. Positioning the head of the patient to relieve pressure in the occipital and scalp region was also recognised as important. Adjusting the head of the bed to 15 degrees (Kriesberg et al., 2018) and 30 degrees (Kulik et al., 2018 & Rowe et al., 2018) were recommended in three studies unless medically contraindicated.

Various resources to aid in patient repositioning were recommended in the studies. Hospital linen emerged as a useful tool with three studies indicating the use of draw sheets when repositioning to avoid shear and friction to the skin (Aprea et al.2018; Rowe et al., 2018; Schindler et al., 2011), while two studies suggest the use of pillows and rolled blankets to maintain patients' positions (Rowe et al. 2018; Schindler et al., 2011). Six of the eleven studies that discussed repositioning mention the use of polymer gel positioners to assist with pressure distribution when positioning a patient (Aprea et al., 2018; Kriesberg et al., 2018; Kulik et al., 2018; Schindler et al., 2011; Schindler et al., 2013; Uysal et al., 2020). Although none of these studies mentions specifically how and when polymer gel positioners should be used on a patient, Schindler et al. (2013) indicate using them in the positioning and padding of bony prominences will be where they are most effective. Particular attention to relieving pressure on the heels were indicated in three studies through floating heels off beds using the gel positioners (Kulik et al., 2018; Rowe et al., 2018) or applying a pressure protecting adhesive or gel positioner to the heel as a protector (Uysal et al., 2020).

The use of speciality beds with pressure relieving mattresses was described in varying detail in eight studies (Aprea et al., 2018; Bargos-Munarriz et al., 2020; Garcia-Molina et al., 2012; Kriesberg et al., 2018; Kulik et al., 2018; Rowe et al., 2018; Schindler et al., 2011; Schindler et al., 2013). While most studies provided limited detail about the criteria for the use of speciality beds, overall, higher acuity was more indicative of the use. According to Kulik et al. (2018), if a patient is going for surgery or reoperation for more than four hours of the time the patient should be in a bed with a low air loss mattress overlay. Rowe et al. (2018) recommend a specialty pressure relieving bed for patients with a Braden Q score of < 3 considered at increased risk for developing a pressure injury. When examining patients with pressure injuries, Garcia-Molina et al. (2012) found that 63.3% of the patients at the time had repositioning schedules outside the ward's guidelines due to the patient being clinically unstable. More importantly, Garcia-Molina et al. (2012) suggested this issue could be resolved with the use of a continuous and reactive low-pressure mattress, as it reduces the need for regular repositioning compared to a standard hospital mattress. As a result, this reduces inconsistent repositioning regimes, by providing a solution to conflicting opinions between healthcare workers wanting to make positional changes on patients and others who do not.

The majority of studies (n=9) indicated monitoring and optimising nutrition as an effective measure in preventing pressure injuries (Cummings et al., 2019; Kriesberg et al., 2018; Kulik et al., 2018; Rowe et al., 2018; Schindler et al., 2011; Schindler et al., 2013; Smith et al., 2019; Visscher et al., 2013; Uysal et al., 2020). According to Uysal et al. (2020), monitoring for weight loss, dehydration, and nutritional intake are important when considering nutrition as a component of the prevention of pressure injuries in the PICU setting. This is supported by a multi-region study conducted by Schindler et al. (2011), that the areas with the lowest rates of pressure injuries had used protective nursing strategies such as nutrition consultations. The link between nutrition and pressure injury development in PICU was further consolidated in their later study (Schindler et al., 2013), which found infants who did develop pressure injuries required nutrition consultation significantly more frequently than those infants who did not develop a pressure injury. Both Kulik et al. (2018) and Rowe et al. (2018) indicate that completing a patient nutrition screen on admission and assessing the need for a dietitian for all patients while in PICU was effective in pressure injury prevention. In contrast, some studies indicated that consideration of the nutritional component was worthwhile only in patients at increased risk of pressure injury development (Cummings et al., 2019; Schindler et al.,2013; Visscher et al., 2013). In the study by Cummings et al. (2019), ordering nutrition consultations and optimising nutrition is only suggested for patients with a Braden Q score <16 (patient of moderate risk). This finding was further supported both by Schindler et al. (2013) and Visscher et al. (2013), who also only utilised optimising nutrition and nutrition consults as pressure injury preventive strategies for patients classified as moderate to high risk of developing a pressure injury.

Protecting the skin with regular incontinence management to prevent pressure injuries was highlighted in half (n=7) of the studies included in this review (Aprea et al., 2018; Kriesberg et al., 2018; Kulik et al., 2018; Schindler et al., 2011; Schindler et al., 2013; Smith et al., 2019 & Visscher et al., 2018). Damp skin is associated with the development of rashes and fragile skin that tends to break down easily. Thus, maintaining clean, dry skin is essential for preventing pressure injuries (Schindler et al., 2013). Kulik et al. (2018) recommend changing diapers as frequently as every two hours for patients to maintain clean, dry skin. Two studies (Schindler et al., 2013; Smith et al.,2019) recommend applying a skin barrier cream to the diaper area in between changes. However, while skin should be kept clean and moisturised, Schindler et al., (2013) advise minimising bathing. Furthermore, as suggested by Aprea et al.

(2018) and Schindler et al. (2013), any products used for cleaning the skin should be mild non-drying cleansers.

CHAPTER FOUR: DISCUSSION

Introduction

This integrative review explores and analyses the literature on pressure injury prevention measures in the paediatric intensive care unit (PICU) setting. Fourteen studies were found relevant to the topic and are included in this review. As stated in the previous chapter, the comprehensive analysis of the studies identified six common themes; which include identification of patients at risk using a risk assessment tool, implementation of a prevention bundle, education about pressure injuries, skin champions, risk factors in the PICU patient, and preventative skin care measures in clinical practice. The aim of this chapter is to critically discuss the common findings of this integrative review in relation to the literature and to provide recommendations for policy and practice for the effective prevention of pressure injuries in the PICU. Finally, limitations of this integrative review and suggestions for future research are presented in this chapter.

Critical Discussion of the Key Findings

Effectiveness of Risk Assessment Tools

The use of a risk assessment tool emerged as a catalyst for implementing appropriate and timely pressure injury prevention strategies in the PICU. The findings of this integrative review suggest that the Braden Q scale is the preferred risk assessment tool used in the PICU environment. These findings are consistent with an earlier systematic review by Kottner et al. (2013), who also state that while at least 12 paediatric pressure ulcer risk assessment scales exist, the ones most employed in the paediatric field are the Braden Q and Glamorgan scales. The Braden Q scale is used in many countries including Australia and the USA, while the Glamorgan scale is used in the UK, Germany, New Zealand, Australia, and Saudi Arabia (Kottner et al., 2013). This is reflected in the articles included in this integrative review, with the majority reporting the use of the Braden Q risk assessment tool in the country where the study took place.

While the integrative review results indicate the Braden Q scale is widely used in PICU, there is contrasting evidence on its performance in PICU. For example, the systematic review by Kottner et al. (2013) claims that although assessment tools are widely used in paediatric hospital settings, there is little indication of assessment tools being used in paediatric intensive care. One of the studies included in this review (Smith et al., 2019) found none of

the patients who developed a pressure injury were assessed as being at a high or severe risk of pressure injury development according to their Braden Q score. Importantly, the most common indicator for developing a pressure injury was the patient's degree of mobility, (Smith et al., 2019). This finding indicates that the Braden Q score may not be as effective as the literature suggests, particularly in the PICU setting. Findings of other comparative research point to the Braden Q tool being flawed due to its lack of ability to assess skin breakdown caused by pressure from a medical device (Anthony et al., 2010; Liao et al., 2018; Willock et al., 2016). This is evident in a study where the Glamorgan scale is argued to be superior in the PICU setting compared to the Braden Q scale (Anthony et al., 2010). These authors did note however that the Glamorgan scale does not specifically test for the respiratory device-related pressure injuries that are common in the PICU environment. These claims by Anthony et al. (2010) appear to be consistent with the findings of this integrative review. Several studies included in this review found patients who had multiple medical devices in place were more likely to develop pressure injuries in PICU (Aprea et al., 2018; Schindler et al., 2011; Schindler et al., 2013; Smith et al., 2019)**.** It's interesting to find the Braden Q scale being widely used in the studies included in the integrative review despite the indications of the scale being flawed. This finding perhaps suggests there is insufficient quality evidence available for the effectiveness of these tools in relation to outcomes for paediatric patients. This is of concern because without sufficient quality evidence, health professionals may be resistant to the use of these tools. However, there has been some recent literature that has claimed to address the the Braden Q scale's lack of focus on medical devices. Improvements have been evident with the Braden QD scale being developed after a revision of the Braden Q tool (Puspitasari et al., 2020). The main revision has been adding a subscale to measure whether patients' medical devices can be repositioned or the skin under the device can be protected (Curley et al., 2018). A retrospective study comparing the Braden Q and the Braden QD scale in assessing risk during non-invasive ventilation indicates that a Braden QD score is more accurate in identifying paediatric subjects at risk (Curley et al., 2018). This is supported by a recent study in Indonesia that indicates the Braden QD Scale is a valid and reliable tool that is applicable to assess pressure injury risk in PICU patients with immobility and medical devices (Puspitasari et al., 2020). While these findings showing the success of the Braden QD scale in PICU is preliminary, they do seem promising. Future studies will likely see more use of this risk assessment scale which will demonstrate the effectiveness of the scale.

The findings of this integrative review highlight the flaws in the existing Braden Q scale and recommend further research to develop a tool that will be appropriate for the PICU environment. Coincidently, when there is a lack of connection between risk assessment, care planning, and preventive care provision, assessments will likely be ineffective. This is evident in the findings of the studies conducted by both Uysal et al. (2020) and Apera et al. (2018), where daily risk assessments using the Braden Q scale on patients were implemented, but guidance on the subsequent prevention measures based on the outcome of the assessment was missing. Some emerging literature shows that while a risk assessment tool provides nurses with an indication of a patient's risk of a skin injury, it may not necessarily result in care planning and provision of appropriate preventive interventions (Johansen et al., 2014; Samuriwo & Dowding, 2014). A qualitative study conducted in Norway and Ireland found that regardless of whether a risk assessment is undertaken using clinical judgment or formal structured risk assessment, the identified risk factors of patients and appropriate preventative initiatives made by nurses were similar (Johansen et al., 2014). This claim is further supported in a systematic review by Samuriwo and Dowding (2014) with findings that assessment tools were not being routinely used to identify pressure injury risk by nurses. Instead, they rely on their own knowledge and experience rather than research evidence to decide on preventative measures (Samuriwo & Dowding, 2014). The experience of nurses with risk assessment tools gives perspective on the need to continuously re-develop existing risk assessment scales to improve practice. Future research on the practices of risk assessments may, instead, need to be re-evaluated on how a risk assessment tool can provide structured preventive care guidance for nurses.

Understanding Risk Factors of the PICU Patient

One of the main findings that emerged from this integrative review is the identification of recurring characteristics of patients who developed pressure injuries in the PICU. Understanding the added risk factors for the PICU patient developing pressure injuries is fundamental to prevention and should be acknowledged when assessing patients (NPUAP et al., 2019). Several studies included in the review reveal that patients with a higher risk of mortality and longer lengths of hospital stay and those requiring mechanical ventilation, non-invasive ventilation, extracorporeal membrane oxygenation, higher numbers of medical devices and/or medical adhesives, have an increased chance of developing pressure injuries (Aprea et al., 2018; Kulik et al., 2018; Schindler et al., 2011; Schindler et al., 2013; Smith et

al., 2019; Uysal et al., 2020). These findings are consistent with those outlined in earlier studies (Curley et al., 2003; McCord et al., 2004; Schindler et al., 2007). For example, a 2004 case control study in the United States compared groups of PICU patients with and without pressure injuries (McCord et al., 2004). For patients in PICU, oedema, weight loss, limited repositioning, use of specialty beds in the turning mode, positive-end expiratory pressure respiratory support, and longer PICU admission stays were associated with increased risks of developing pressure injuries (McCord et al., 2004). These findings are supported by Schindler et al. (2007), who also reported that PICU patients with skin breakdown were younger, with a higher risk of mortality, and were more likely to have required mechanical ventilatory support and longer hospital stays. The risk factors in PICU identified in this integrative review unfortunately have limited reinforcement in the Prevention and Treatment of Pressure Ulcers/Injuries: Quick Reference Guide (NPUAP et al., 2019). As an internationally recognised and recommended pressure injury framework for all health professionals across tertiary healthcare settings, the guide does not include PICU risks specifically. However, it does mention that additional risk factors in critically ill individuals should be considered, including duration of critical care stay, mechanical ventilation, use of vasopressors, perfusion, and oxygenation. Furthermore, the guide suggests that the presence of medical devices is a particular risk in the neonatal and paediatric population (NPUAP et al., 2019). Given the above-mentioned factors that place PICU patients at risk, more distinct recognition of these factors in practice guidelines would be beneficial. Literature has shown that these risk factors are seemingly not being captured and adequately translated into the current risk assessment tools or prevention practices used in the PICU. More awareness of the risk factors gives the potential for earlier identification of patients at risk, prompt preventative interventions, and consistent practice among nurses.

The pressure injury risk factors identified in the literature included in this review also indicate that there are some similarities across adult and paediatric intensive care environments. In the study by Aprea et al. (2018), events and procedures associated with high mortality (such as mechanical ventilation, inotropic support, extracorporeal membrane oxygenation, and cardiorespiratory arrest) were identified as risk factors for pressure injury development in PICU patients; and these findings also reflected those in adult medical intensive care units. For example, risk factors such as the need for hemodynamic support with vasopressor administration, sedation, mechanical ventilation, and an increased length of stay were the

most significant to pressure injury development in the adult intensive care setting (Serrano et al., 2017). This finding is further supported by the findings of a systematic (Alderden et al., 2017) that reported old age, mobility/activity, perfusion, and vasopressor infusion as being the most common risk factors. On the other hand, a study conducted in Japan examining seven neonatal intensive care units indicated that 50% of pressure injuries located on the nose were associated with endotracheal intubation usage (Fujii et al., 2010). These results resemble the findings of studies included in this integrative review, revealing up to 70% of the pressure injury occurrences in PICU are related to the use of a medical device (Kulik et al., 2018), with 77.8% of the pressure injuries in the facial and scalp area being due to a form of airway support (Smith et al., 2019). Overall, neonatal and adult intensive care environments seem to have some common risk factors to those found in PICU. Being aware of patterns that exist may be beneficial in understanding which preventative strategies are beneficial across all intensive care environments.

It is evident that a PICU patient's risk of developing pressure injuries is complex and multifactorial, and the findings of this integrative review add to the growing body of literature highlighting risk factors in this vulnerable patient population. While pressure injuries are largely preventable, there has been an argument as to whether certain patient risk factors that lead to pressure injuries are avoidable. No single prevention strategy has been shown to be consistently reliable in reducing pressure injury incidence rates to zero (NPUAP at al., 2014). Many known factors remain non-modifiable during care in hospital, especially when managing a life-threatening condition must take precedence over skin-preservation interventions. According to Edsberg et al. (2014), various factors can be the cause, including hemodynamic instability, the impact of head-of-bed elevation when medically necessary, septic shock, body oedema, burns, immobility, medical devices, spinal cord injury, and terminal illness. More importantly, the prevention of pressure injuries from medical devices is potentially more complicated as a device may be an essential component of treatment in the intensive care environment. Unavoidable pressure injuries may occur in situations where it would be medically contraindicated to reposition a medical device or sight skin integrity, manage moisture, or apply a prophylactic dressing in the surrounding skin area (Edsberg et al., 2014). The European Pressure Ulcer Advisory Panel also supports these claims stating certain risk factors in situations increase the likelihood of an unavoidable pressure injury. This includes critically ill neonates and children, highlighting the impact of their illness severity and duration of intensive care stay, making it particularly challenging to avoid

pressure injuries in this population (NPUAP et al., 2019). As suggested by Edsbreg et al. (2014) pressure injury formation is a complex combination of pathophysiologic processes and arguably may not be avoided even with excellent interprofessional prevention and treatment measures. Therefore, further research is needed to evaluate the risk conferred by variables in the PICU environment

Importance of Education in Pressure Injury Prevention

One of the main findings of this integrative review is the impact of education to prevent pressure injuries. The findings indicate that providing education on pressure injury to nurses supports preventive practices being effectively carried out in PICU (Aprea et al., 2018; Cummins et al., 2019; Rowe et al., 2018; Smith et al., 2019; Visscher et al., 2013). Consistent with the findings of this integrative review, findings of studies in other intensive care environments affirm the significance of education for pressure injury prevention. For example, a study by Coyer et al. (2019) in an Australian intensive care reported education to be foundational to pressure injury prevention. Nurses having a satisfactory level of knowledge and ongoing education for consistency of practice is highlighted as essential for nurses delivering pressure injury prevention measures. In terms of education shortfalls, pressure injury knowledge not being given priority during orientation and the lack of knowledge on available prevention equipment were the key hindrances reported by nurses (Coyer et al., 2019). A study included in the integrative review by Cummins et al. (2019), shows that PICU nurses lacked knowledge in certain areas of pressure injury, particularly in the causation of pressure injuries. Education sessions significantly enhance PICU nurses' knowledge of paediatric pressure injury (Cummins et al., 2019). Nurses should have current evidence-based knowledge about pressure injuries to take an active part in preventive interventions. Specifically, education is needed on skin assessment, risk assessment, staging, and prevention strategies (Källman & Suserud, 2009). Similar concerns on the limited pressure injury knowledge among nurses were highlighted in a more recent multicentre study in Iran revealing nurses' knowledge of pressure injuries to be poor (Khojastehfar et al., 2020). No significant correlation was found between levels of knowledge and the application of adequate preventive measures. However, nurses with greater knowledge about pressure injuries generally had a more positive attitude towards preventive measures and used better practices. This finding suggests a lack of education is a possible explanation for negative attitudes of nurses, suboptimal care, and poor compliance with pressure injury clinical

guidelines (Khojastehfar et al., 2020). As highlighted by Beeckman et al. (2011), nurses' level of knowledge has the potential to affect their decisions on which and how patients should receive preventive interventions. This finding, while preliminary, indicates nurses' limited education about pressure injuries could affect nursing care for pressure injuries. In practice, this would potentially translate into nurses considering pressure injury prevention as a low priority and ignoring its importance.

While the results of this integrative review indicate education to be beneficial for promoting preventative practices for pressure injuries, some other studies have shown contrasting evidence claiming that a higher level of knowledge about pressure injuries does not necessarily equal better practice (Beeckman et al., 2011; Drake et al., 2012; Tweed & Tweed, 2008). This position is supported by the finding of a cross-sectional multicentre study performed in fourteen Belgian hospitals (Beeckman et al., 2011). At the beginning of the study, less than a quarter of nurses had the desired level of knowledge on pressure injury prevention. This was of concern to the authors as they predicted a link to poor practice. Interestingly, the results show while nurses' attendance at additional training on pressure injury prevention resulted in higher knowledge scores, this did not significantly correlate with higher rates in the application of preventive measures (Beeckman et al., 2011). An earlier study conducted in a New Zealand ICU by Tweed and Tweed (2008) offers some possible explanations for these results by showing that nurses' knowledge levels on pressure injuries declined back to baseline over time despite initial improvement with educational programs. More importantly, high levels of knowledge of pressure injury prevention were also found to not necessarily be reflected in clinical practice. As Tweed and Tweed (2008) explain, while reasons for pressure injuries are likely multifactorial in the intensive care environment; prevention and management of pressure injuries may not be perceived as a high priority. This might be because the complex illnesses and life-threatening situations of ICU patients often take priority. Findings of nurses failing to apply pressure injury knowledge in clinical practice was also evident in a survey carried out at a paediatric hospital in the United States (Drake et al.,2012). Nurses in this study reported that despite having adequate knowledge of general pressure injury prevention they struggled to integrate individualised interventions into the patient care plan. Ultimately, how education is utilised as a tool is important, as nurses with higher levels of knowledge may not necessarily perceive the need to act more effectively in practice. As Drake et al. (2012) suggest, education alone is unlikely to change the prevalence of pressure injury in the paediatric setting. Instead, nurses require education on

individualised interventions and access to comprehensive, user-friendly resources. Furthermore, acceptable performance requires not only knowledge but also frequent reinforcement to prevent knowledge decay.

The Role of Skin Care Champions

Several studies included in this integrative review identified the use of skin champions as being an effective strategy in pressure injury prevention in PICU setting. (Kriesburg et al., 2018; Schindler et al., 2013; Smith et al., 2019; Visscher et al., 2013). Skin champions are not only advisors on the use of resources (like prevention products and devices) but also serve as mentors and educators for other staff in the unit (Bergquist-Beringer et al., 2009; Niederhauser et al., 2012; Pasek et al., 2008; Rodgers et al., 2014). Overall, there appears to be compiling literature to support the use of nurses as unit-based skin care champions in facilitating pressure injury prevention (Sullivan & Schoelles, 2013). The use of unit-based champions has been supported in guidelines as a component of a comprehensive pressure injury prevention strategy. For example, skin champions are included in evidence-based practice guidelines published by international professional pressure expert organisations such as the National Pressure Ulcer Advisory Panel and the Wound Ostomy Continence Nursing Society (Creehan, 2015). According to Creehan (2015), champions are not a new phenomenon as this model has been used to target the prevention of other hospital-acquired injuries. The use of a unit-based champion model has been successful in various nurse-initiated interventions such as fall prevention, pain management, diabetes education, and stroke awareness in tertiary care. Consistent with the findings of this review, which demonstrate the effectiveness of skin champions in preventing pressure injuries in PICU, skin champions have been effective in other similar environments. A NICU study conducted in the United States (Nist et al., 2016) introduced an interdisciplinary skin team to identify skin injuries and implement skin interventions through weekly skin rounds on the unit. After the initiation of skin champion coordinated skin rounds, the baseline incidence of pressure injury saw an increase. It was suggested that the increase in pressure injury numbers was a result of improved detection and reporting of pressure injuries, which then resulted in earlier interventions. As Nist et al., (2016) concluded, standard nursing assessments alone without the support of a designated trained skin team potentially result in underreporting of pressure injury incidence.

The findings of this integrative review highlight that although the use of skin care champions is one component of a comprehensive pressure injury prevention strategy, it brings evidence-based prevention initiatives into practice (Kriesburg et al. 2018; Schindler et al.,2013; Smith et al., 2019; Visscher et al., 2013). Champions are found to assist in mobilising staff responsible for pressure injury care in patients and increasing unit accountability for providing safe and effective care (Schindler et al., 2013; Visscher et al., 2018). These findings share similarities with those reported in other areas of hospital healthcare. For example, in a systematic review by Sullivan et al. (2013), the involvement of a multidisciplinary team with designated skin champions as leaders in pressure injury efforts was highlighted as a key component to successful prevention. The systematic review showed that skin champions provided leadership and support to ensure nurses received orientation and education around pressure injury at the point of care. This encourages consistency of practice by nurses, while also giving the opportunity for champions to assess the actions of their colleagues and feedback to committee meetings on potential improvements (Sullivan et al., 2013).

A strategy that has effectively improved clinical practice should prove to be sustainable not only in the short term. There has been evidence to suggest the use of skin champions is sustainable in the paediatric environment and effective long term. In an extensive study conducted in the United States (Luton et al., 2018), an evidence-based skin champion program was found to reduce rates of pressure injury in a large urban paediatric hospital. Over a five-year period (2013-2017) the skin champion quality improvement program achieved an 85% reduction in the rate of reportable pressure injuries as well as an increase in nurse compliance with the prevention bundle (Luton et al., 2018). During the program, weekly skin rounds discussing patients identified as high-risk on the unit and monthly skin champion meetings were held to review the units' compliance to the program and pressure injury rates. These scheduled rounds and meetings were identified as key components that effectively contributed to the success and sustainability of the skin care program. Together, this initiative facilitated standardisation and evaluation of practice as well as opened the lines of communication between nurses and unit management (Luton et al., 2018). The findings of the studies included in this integrative review and other literature suggest that the skin champions model is an effective strategy for preventing pressure injuries across all hospital settings. To encourage the use of the skin champions model in PICU, further studies focusing

on how the skin champion role affects pressure injury rates and effective practices in PICU will be beneficial.

The Impact of Care Bundles on Preventing Pressure Injuries

The benefit of including a bundle of care as an integral part of pressure injury prevention is an important finding of this integrative review. According to NPUAP et al., (2019), the use of care bundles can alleviate hospital-acquired conditions. It has, therefore, been a quality improvement strategy that is gaining increasing recognition in pressure injury care. The use of care bundles has been recognised and supported in pressure injury care guidelines. According to The Prevention and Treatment of Pressure Ulcers: Quick Reference Guide (NPUAP et al., 2019), structured and multi-faceted approaches to pressure injury prevention such as care bundles are recommended across all areas of healthcare, including intensive care and paediatric environments. Care bundle is not a new concept. In 2001 the Institute for Healthcare Improvement developed the "bundle" concept as an initiative to improve critical care processes and health outcomes (Resar et al., 2012). The main goal of this concept is to facilitate the implementation of a bundle of three to five relatively independent evidence-based interventions. Chosen interventions are those accepted by clinicians as care that should be applied as part of usual practice for a defined patient population and care setting (Resar et al., 2012). The use of this approach has shown to prevent some serious adverse clinical outcomes such as ventilator-associated pneumonia and central line-associated infections and has a growing body of published evidence in medical journals. Thus, the bundle concept has been applied in other clinical areas, including sepsis, which has also led to reported improvements in outcomes (Resar et al., 2012).

This integrative review highlights the effectiveness of pressure injury care bundles involving five main components including skin assessment, direct skin patient care (patient positioning, pressure of device on skin, moisture on skin), indirect skin patient care (nutrition, hydration, optimal pain control), use of products (support surfaces, repositioning devices) and patient and family involvement (Schindler et al., 2013; Smith et al., 2019; Visscher et al., 2013). Whether a skin care bundle should strictly consist of specifically five components has been questioned in the literature. In the adult intensive care population, a systematic review by Lin et al. (2019) found that the effectiveness of care bundles in pressure injury prevention did not

seem to have a relationship with the number of components or complexity of their implementation. The authors comment that including interventions designed to suit the nature of a unit and individual patient characteristics may be more important for meaningful outcomes.

The findings of this integrative review as well as the findings in other literature across paediatric and adult settings suggest that a five-component approach to care bundles in PICU is an effective pressure injury prevention/management strategy. For example, in a large study by Frank et al. (2017) across 33 paediatric hospitals in the United States, the application of a five-element pressure injury prevention bundle showed a significant reduction in stage three and four pressure injuries. There was also a statistically significant increase in reports of stage two injuries and deep tissue injuries. These trends were believed to reflect improved detection of pressure injury at an earlier stage of injury, and thus reduced the progression to more severe injuries. More importantly, Frank et al., (2017) did not find a linear relationship between compliance with individual bundle elements and clinical outcomes. These findings suggest that it is not necessarily specific interventions, but rather grouped interventions that make the difference in successful pressure injury prevention. These findings are further supported by the findings of an extensive six-year study that explored the relationship between paediatric pressure injuries rates and a five-factor prevention bundle implemented in paediatric hospitals (Singh et al., 2018). This study showed a 57% decrease in pressure incidence as a result of the bundle of care, however, indicated none of the five factors addressed in the prevention bundle had a stronger correlation with pressure injury occurrences (Singh et al.,2018). These results are consistent with the findings of another study included in the integrative review (Visscher et al., 2013), which state that the use of a skin care bundle is effective in reducing 50% of PICU pressure injury rates. Similarly, in an Australian study (Coyer et al., 2015) the impact of a five-element care bundle on pressure injuries in adult ICU show on average, the severity of pressure injuries decreased and pressure injury onset time increased in addition to reducing injury incidence. Overall, the literature provides consolidating evidence to support the use of care bundles, not only in PICU but across adult and paediatric settings. This is promising and may contribute to a growing body of evidence that suggests that the use of care bundles can be a valuable initiative in preventing pressure injuries in PICU. While a five-element bundle approach has

been proven effective, it would be informative to explore which specific combination of bundle elements is the most applicable in the PICU environment.

Effectiveness of Preventative Skin Care Practices

Decisions about appropriate pressure injury prevention strategies are often made by nurses and ideally, these strategies and or recommendations are based on high-quality evidence (NPUAP et al., 2019). The findings of this integrative review suggest some common pressure injury prevention strategies such as skin assessment, use of skin barrier products, patient repositioning, and use of support surfaces. Similar findings are also reported from a more recent study (Pasek et al., 2021) that explored the use of a prevention bundle protocol for patients receiving extracorporeal membrane oxygenation (ECMO) in PICU. The key pressure injury prevention practices of the study included placing prophylactic foam dressings beneath ECMO cannulas, performing head-to-toe assessment, protecting the occiput and bony prominences, the use of the Braden QD score, repositioning medical devices, nutrition, repositioning patients every two hours and the use of air mattresses (Pasek et al., 2021). There is currently no research to support the use of each strategy individually in PICU and there is a lack of paediatric practice guidelines. However, the reoccurring findings in this integrative review about skin care practices in PICU seem consistent with the recommendations in the international clinical practice guidelines in adults (NPUAP et al., 2019). The lack of robust research on pressure injury prevention practice is also reported by Grosvenor and Dowling (2018), in their research into neonatal intensive care prevention practice options. This has resulted in variations in practice among health professionals. As in paediatrics, ethical issues arise in conducting research with neonates and premature infants. Consequently, the lack of neonatal guidelines in this area means policies and guidelines based on adult skin are often adapted and used for neonates.

PICU skin care practices highlighted in the findings of this integrative review are also reported in other literature on adult and neonatal intensive care. For example, according to Thorpe (2015) and Cooper (2013), the recommended preventive strategies in the adult intensive care units include a combination of the use of a risk assessment tool, suitable high-specification mattresses, prophylactic dressings, two hourly medical device and patient repositioning, barrier cream use in incontinence management and nutrition planning. More specifically, Copper (2013) recommends speciality mattresses be provided particularly to

those patients on vasoactive medications and/or unable to be repositioned every two hours. A study exploring neonatal pressure injury prevention nursing practices in the United States (Razmus & Keep, 2021) reports similar preventative strategies. In this study, 78% of nurses reported using a risk assessment scale, 69% reported using a rolled blanket or small soft objects as pressure redistribution surfaces and 15% reported the use of different types of positioners, such as fluidised positioners, as pressure redistribution surfaces. In addition, petroleum-based products and ostomy powders were recommended for incontinence and moisture management. There appears to be a pattern of prevention strategies in pressure injuries practice with overlaps between the PICU, adult ICU, and NICU settings. This could be due to the similar nature of an intensive care environment; as a result, some practices may serve well across a variety of different intensive care settings.

The results of this integrative review indicate that a variety of preventative strategies have been applied in the PICU setting which decreased the prevalence of pressure injuries post-intervention. However, they lacked the ability to demonstrate their sustainability in PICU or their ability to eliminate pressure injury rates entirely. In the study by Schindler et al. (2013), substantial efforts with a bundle of preventative measures were able to lower paediatric pressure injury rates of 18.8 % in a PICU. Interestingly, despite these efforts to reduce the prevalence of pressure injuries, the rate continued to be significant at 6.8%. Some literature provides explanation for this and challenges the universal applicability of clinical prevention strategies by exploring the experiences and attitudes of nurses towards pressure injury prevention (Coyer et al., 2018; Samuriwo, 2010; Waugh, 2014). A Swedish study (Samuriwo, 2010) reported that although nurses gave high value to pressure injury prevention, environmental factors and lack of time were reported to hinder prevention practice. Similar attitudes of nurses towards pressure injuries were reported by Waugh (2014) highlights that despite nurses having positive attitudes and adequate knowledge, there was still inadequate performance in pressure injury prevention. This finding is concerning because adequate knowledge and positive attitudes are commonly seen as strengths enabling nurses to carry out recommended preventive measures. Waugh (2014) revealed pressure injury prevention was a low priority for nurses and they were interested in other aspects of patient care such as treatment of disease. The commonly reported perceived barriers to providing pressure injury prevention are lack of access to equipment, adequate staffing, time, knowledge, established routines, and continuity of care. An Australian exploratory study (Coyer et al., 2018) with 204 adult intensive care nurses reported high patient acuity as a significant barrier to

implementing prevention practices. Pressure injury prevention was reported by nurses as a priority in the care of patients. However, patient acuity impacted on implementing appropriate prevention strategies particularly when haemodynamic instability, frequent procedures or where issues with cervical spine clearance were evident. Particularly, the presence of various medical devices such as arterial lines, central lines, indwelling catheters, and chest drains increased the level of difficulty of regularly repositioning intensive care patients (Coyer et al., 2018). Overall, the literature has provided limited but valuable insight into the importance of understanding barriers in the application of prevention measures in the intensive care unit. Perceived barriers and attitudes to pressure injury prevention should be examined to help nurse leaders towards developing strategies to change nurses' behaviours and practice.

Strengths and Limitations

Selection of the integrative review method enabled a comprehensive understanding of the identified issue in healthcare. This method allowed for the evaluation of a broad range of sources of scientific evidence, the identification of gaps in current research and the need for future research. The integrative review method allowed for the inclusion of literature from diverse sources bridging related areas of work and assisting in the identification of central issues in the topic of focus. The review unfortunately did not include any studies from New Zealand which could have been appropriate in a New Zealand context. Only articles in English were included, excluding non-English language research literature which may have been valuable contributions to this integrative review. Another limitation common to the studies included in this review relates to the way the impacts of specific nursing interventions on outcomes were analysed. Before and after designs were used in most of the quality improvement studies and therefore, the credibility of research evidence was generally low. Additionally, we did not assess the risk of bias in the studies but instead assessed the quality of reporting. Furthermore, because each hospital utilised different evidence-based nursing interventions, the study results are limited to broad categories of risk factors and nursing interventions. Thus, caution should be taken with the interpretation of the findings of each study.

Recommendations and Implications for Research, Policy and Practices

The findings of this integrative review identified several skin injury prevention strategies and risk factors specific to the PICU environment. It has been recognised consistently that differences in the risk factors, anatomical sites, and consequences of skin breakdown in PICU patients need to be accounted for (Baharestani & Ratliff, 2007). Overall, there is a lack of robust research and systematic preventive intervention focused on this population. Many authors express frustration over the lack of research on skin breakdown in PICU patients. These findings may encourage future researchers to further explore the role and effectiveness of standardisation in the preventive interventions. Specifically, the use of standardised assessment and risk assessment tools, care bundles, skin champions, and education in the PICU are areas for exploration. In addition, the experiences and barriers for nurses may also be contributing factors to pressure injuries in PICU. Further exploration into the barriers to the implementation of pressure injury prevention practices and measurement of the effectiveness of the current guidelines and practices may aid in improving existing practices.

It is evident from this integrative review that health professionals as a group would benefit from the availability of a framework to guide the standardisation of practices aimed at improving pressure injury prevention in the PICU environment. According to the findings of this review, guidelines and policies should include interventions such as the formation of a skin care team, the use of a risk assessment tool, bundles of care, and evidence-based prevention strategies. Several frameworks related to pressure injury prevention and management have been developed in healthcare to guide the practice of implementing change to achieve better healthcare outcomes. The Prevention and Treatment of Pressure Ulcers/Injuries is a collaboratively produced international guideline first in 2009 to assist healthcare professionals in making consistent practice decisions for preventing pressure injuries. The guideline reflects the most recent evidence on the development and prevention of pressure injuries (NPUAP et al., 2019). This guideline is significant in New Zealand pressure injury prevention practice considering its use in the development of the Guiding Principles for Pressure Injury Prevention and Management in New Zealand guideline for New Zealand healthcare professionals and organisations (ACC, 2017). Both the Prevention and Treatment of Pressure Ulcers/Injuries guideline, and the Guiding principles for pressure injury prevention and management in New Zealand lack guidance in caring for paediatric or critically ill patients. Currently in New Zealand, The Pressure Injury Prevention for an Infant,

Child, or Young Person Guideline produced by Starship Children's Hospital, is the only one that exists on paediatric pressure injuries. While the guideline includes perioperative and community bundles of care, none exist for the PICU setting (Starship, 2020). This guideline highlights that nursing care for critically ill neonates and children should be planned around patient stability and tolerance. For example, smaller positional changes for pressure injury prevention may be more appropriate where theres instability of the child's clinical condition. There is, unfortunately, no elaboration of the interventions within the guideline. The relatively low quality of the existing guidelines for the PICU population indicates the need for further research in this area. Health professionals as a group would benefit from the availability of a framework to guide their practice that is specifically aimed at improving pressure injury prevention and management in the PICU environment. Furthermore, ongoing education and training opportunities for health professionals involved in the assessment and prevention of pressure injuries in PICU must be supported. The results of this integrative review demonstrate the use of skin champions and education are effective measures in preventing pressure injuries. Continuing participation in pressure injury-related education beyond the undergraduate level is vital to enable nurses to keep up with the most current and effective prevention methods for pressure injuries.

Conclusion

Pressure injuries have been an ongoing nursing concern and remain a prominent patient safety issue in hospitals. PICU patients are among the population of hospital patients at the greatest risk of developing a pressure injury. The large numbers of equipment or treatment required to support a patient admitted to the PICU, make pressure injury prevention increasingly complex. Balancing optimising lifesaving treatment and reducing patients' risk of iatrogenic injuries like pressure injuries can be a big challenge for PICU nurses. This practice project aimed to explore effective practices to prevent pressure injuries in the PICU setting. The integrative review method guided by Whittemore and Knafl's five-stage framework was utilised, with fourteen articles identified as being relevant for inclusion in this integrative review. The quality of each study was appraised using the Mixed Method Appraisal Tool. The findings of this review reveal that understanding the risk factors for a PICU patient and utilising an appropriate risk assessment tool to promptly identify those at risk are important preventive strategies for nurses. The common findings of the studies included in this review suggest that a wide range of prevention strategies are used in the PICU setting, including regular skin assessment, use of skin barrier products, repositioning, and use of support surfaces. What may be most valuable is utilising the strategy of clustering preventive interventions into a care bundle. Nurses with current knowledge and a good understanding of pressure injuries are pivotal to prevention. Incorporating skin champions in PICU was identified as a useful way to provide expert recommendations and knowledge to PICU nurses in the clinical setting, while also increasing nurses' compliance with preventative measures.

This integrative review adds to the current literature showing that PICU pressure injury prevention is suboptimal but is an important issue needing further attention and research to reduce incidence. Furthermore, it is recommended a PICU-focused framework be developed and implemented to standardise the practices of nurses and other health professionals for preventing pressure injuries. Such a framework may contribute toward the effective, safe, and consistent assessment and clinical practice of pressure injury prevention in this vulnerable population. The consequences of skin breakdown in the PICU population are costly, both for the patient and the healthcare system. Ultimately, it impacts negatively on a PICU patient's recovery and prolongs their hospital stay. While barriers to prevention practice do exist, reducing pressure injuries in PICU patients is an important and achievable goal.

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