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THE EFFECTIVENESS OF PRESSURE INJURY PREVENTION STRATEGIES FOR ADULT PATIENTS IN INTENSIVE CARE UNITS: A SYSTEMATIC REVIEW

Azwimbavhi Tshitereke



WITS
UNIVERSITY

A research dissertation submitted to the

Faculty of Health Sciences, University of the Witwatersrand, Johannesburg

in fulfilment of the requirements for the degree

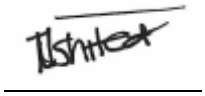
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Master of Science in Nursing

Johannesburg, 2025

DECLARATION

I, Azwimbavhi Tshitereke, declare that this research dissertation is my own work. It is being submitted for the degree of Master of Science (in Nursing) at the University of the Witwatersrand, Johannesburg. It has not previously been submitted for any degree or examination at this or any other university.

Signature 

Date: 6 October 2025

Protocol Number: **W-CBP-220801-01**

DEDICATION

This humble piece of work is devotedly dedicated to my granny Matodzi Tshitereke and my beautiful two daughters Ipfi and Andisa. Thank you so much for everything, words cannot really express my gratitude and hardly describe my appreciation. You have been my source of inspiration, support and strength. My granny taught to be unique, determined, to believe in myself and to always persevere. My kids taught me that the sky is the limit, if you want something bad enough. I am truly honoured to have you in my life. And to other family members, and friends who always keeps me happy and inspired throughout while working in this study.

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To Almighty God for the wisdom, strength, support and knowledge in exploring things, for the guidance in helping surpass all the trials that I encountered and for giving determination to pursue my study, and to make this study possible.

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I would like to express my gratitude to Mr Devind Peters from the University of the Witwatersrand (Medical) for guidance in navigating the library system in search of suitable studies for the systematic review.

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ABSTRACT

Background: Pressure injuries are a common and serious complication in critically ill patients, with a significance impact on patient outcomes and resources. Effective prevention strategies are crucial to minimise their occurrence in intensive care units (ICUs). This systematic review aimed to identify and evaluate the effectiveness of pressure injury prevention strategies in critically ill patients, compare outcomes with standard care, and highlight gaps in the current literature.

Methods: A systematic review included studies published between 2000 to 2024. The search strategy included all the major databases such as: PubMed, CINAHL, LILACS, Web of Science, Scopus, JBI and Cochrane Database of Systematic Reviews. Thirty-three (n=33) quantitative studies were included, covering various interventions such as silicone foam dressings, repositioning protocols, pressure redistribution mattresses, and multi-component prevention programmes. The primary outcome was the incidence of pressure injuries and secondary outcomes included the severity of injuries, patient comfort, and cost-effectiveness.

Results: The review found that silicone foam dressings, regular repositioning, and pressure redistribution devices were the most effective interventions in preventing pressure injuries. Multi-component prevention programs combined several interventions and demonstrated superior effectiveness compared to single interventions. However, there was considerable variability in the outcomes across studies, and many studies lacked long-term follow-up or cost-effectiveness analysis. Few studies incorporated patient-centred outcomes, such as comfort and quality of life.

Conclusions: The study confirmed the effectiveness of several pressure injury prevention strategies, particularly in the ICU setting, but highlighted the need for standardised protocols, consistent implementation, and further research into long-term outcomes and cost-effectiveness. Future research should focus on multi-center, longitudinal studies with standardised outcome measures and the inclusion of patient-centered outcomes.

Keywords: pressure injury prevention strategies, ICU, systematic review, silicone dressing, repositioning, multi-component prevention programmes, patient outcomes, cost-effectiveness. incidence, intensive care, pressure injury/ulcer, the prevalence

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LIST OF ABBREVIATIONS

AHCPR	Agency for Health Care Policy and Research
AHRQ	Agency for Healthcare Research and Quality
APRM	Alternating Pressure Redistribution Mattress
CRS	Continuous Repositioning Schedule
EBP	Evidence Based Practice
EPUAP	European Pressure Ulcer Advisory Panel
ETT	Endotracheal tube
FAME	Feasibility, Appropriateness, Meaningfulness and Effectiveness
HAPI	Hospital Acquired Pressure Injury
HAPU	Hospital Acquired Pressure Ulcer
ICU	Intensive Care Unit
JBI	Joanna Briggs Institute
MDRPI	Medical Device-Related Pressure Injuries
NPUAP	National Pressure Ulcer Advisory Panel
NPIAP	National Pressure Injury Advisory Panel
PI	Pressure Injury
PPPIA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PU	Pressure Ulcer
RAS	Risk Assessment Scale
SCI	Spinal Cord Injury

CHAPTER ONE

OVERVIEW OF THE REVIEW

1.1 INTRODUCTION

Pressure injuries are avoidable and not uncommon occurrences. Patients in intensive care units (ICUs) who are critically ill are at high risk for pressure injury, with reported prevalence rates ranging from 12 to 33% (Lin *et al*., 2020). As this issue has become prevalent, the world's attention in hospitals has been directed to consider best practices for preventable pressure injuries. Pressure ulcer prevention is a crucial indicator of nursing quality, and nurses have a significant role in it (Roberts *et al*., 2016). Since the early 2000s (Keller *et al*., 2002), no systematic review of pressure injury prevention strategies in critically ill patients has been published. This systematic review aimed to determine the efficacy of preventing hospital-acquired pressure injuries in the intensive care unit.

1.2 BACKGROUND

Pressure injury (PI) also known as pressure ulcer, is defined by the National Pressure Ulcer Advisory Panel (NPUAP, 2016) as a localised injury or lesion of the skin and/or underlying tissue, typically over a bony prominence, as a result of pressure (with or without shear and/or friction) or pressure in combination with a microclimate, including moisture and/or temperature. They are devastating and lethal to people of all ages, from the youngest to the oldest, and in all medical speciality areas and types of healthcare facilities. The prevalence of PI differs widely across clinical settings. For instance, in acute care facilities, the reported incidence of PI varies from 0.4% to 38%; in long-term care homes, 2.2% to 39.4%; and in the in-home setting, 0% to 17% (Coyer *et al*., 2017). Also, Chaboyer *et al*. (2018), in an international point prevalence study, found that the incidence of PI in intensive care units (ICU) varies between 0% and 50%.

Moreover, there is a large variability of reported PI prevalence in ICUs from different countries and continents: 49% in Western Europe, 22% in North America and up to 50% in Australia (Chaboyer *et al*., 2018). Hospital-acquired pressure ulcers (HAPIs) are an important problem worldwide in terms of physical and financial costs (Nguyen *et al*., 2015).

Because of their critically ill condition, a high number of comorbidities, high acuity, and unstable haemodynamics and incapacitation. Critically ill patients in adult ICU patients are potentially at a high risk for HAPI. Further, they may receive mechanical ventilation and may become sedated and pharmacologically treated so that there is potential subsidence of peripheral circulation, or they may become comatose (Alberden *et al*., 2017). Despite the increased preventive policies implemented in the last decade, PIs are a public health concern for healthcare facilities worldwide. Pressure ulcers are identified as complex problems and quality indicators for healthcare.

Risk assessment tools or scales are part of the assessment process to identify critically ill patients at risk for pressure injuries in the ICU, which should enhance patient care quality. The National Pressure Ulcer Advisory Panel (NPUAP) and the European Pressure Ulcer Advisory Panel (EPUAP) created prevention guidelines for the prevention of pressure injuries that recommend the use of baseline assessments with a range of risk assessment tools or risk-assessment scales to estimate the level of risk (NPUAP., 2016). These recommendations, however, are based on guidelines to manage mechanical load and pressure redistributing surfaces, correction of nutritional deficiencies, maintaining skin in the best condition possible, and patient education (NPUAP., 2016). Early identification of critically ill patients at risk enables the healthcare team to allocate additional resources towards pressure injury prevention.

Various interventions have been implemented to prevent and treat PIs, with one line of research focusing on reducing the incidence and prevalence of PI in the ICU environment (Coyer *et al*., 2015; Donovan *et al*., 2016). Preventative measures include using support surfaces of ripple mattresses, pillows, and skin-care (Theaker, Kuper & Soni, 2005). It also consists of positioning and repositioning manoeuvres, wound debridement, toileting and surgical closure. These interventions can also include a multitude of wound dressings, biologics, nutritional interventions and education for both the patient and the healthcare provider (Chaboyer *et al*., 2018; Peterson *et al*., 2007). Yet, most of these studies were carried out in small hospitals. The sample sizes were small, and the sorting of PI development and stage was not consistent or reliable.

The first search found several systematic reviews that aimed to compare PI strategies. The results of these reviews tentatively suggest some PI prevention interventions to be used,

support services, and dressing. Nevertheless, no strategy proved superior (Pancorbo-Hidalgo *et al*., 2006). Interestingly, the most recent review regarding PI prevention in the ICU was done over ten years ago (Latimer, Chaboyer & Gillespie, 2016). Moreover, the more recent systematic reviews were in general health care, not intensive care (Chou et al., 2013; Reddy, Gill & Rochon, 2006; Soban *et al*., 2011). Moreover, no original research publications investigating new interventions such as prophylactic dressings, bed linen and devices in intensive care in the last ten years were reported in the previous review (Latimer, Chaboyer & Gillespie, 2016).

The ICU is a dynamic setting with multiple aspects contributing to suboptimal basic care to prevent PIs among the critically ill. These factors are nursing workload, the time cost, relying on technical support, and the critical state of the disease (Lin *et al*.,2020). The NPUAP also indicates that PI can be prevented using interventions of multiple components. Thus, synthesis of the accumulated evidence is facilitated to determine the most effective approach for ICU patients through a systematic review. As a result, the findings of this systematic review should aid in the process of translating the existing clinical evidence which matches the specific ICUs' demand to reduce PI development and for future PI prevention research in ICU.

1.3 PROBLEM STATEMENT

Studies have indicated that pressure injuries are preventable adverse events, but continue to increase in prevalence. Although pressure injuries are commonly encountered in various health settings, critically ill patients have the highest prevalence (Qaseem *et al.,* 2015). This has a negative impact on patient outcomes and leads to longer ICU and hospital stays, increased morbidity, and increased human suffering. Prevention of pressure injuries is an important index to measure nursing quality, in which nurses play an essential role (Roberts *et al.,* 2016). However, no systematic review of published pressure injury prevention strategies focusing on critically ill patients has been published since the early 2000s (Keller *et al.,* 2002; Latimer, Chaboyer & Gillespie, 2016). Further, newer primary studies published since this date warrant a systematic review.

1.4 REVIEW QUESTIONS

The review questions for the study were:

- What pressure injury prevention strategies are currently used in the care of critically ill patients?
- How effective are these strategies, individually or combined, in preventing pressure injuries in ICU patients?
- How do various pressure injury prevention strategies compare to standard care or alternative interventions in reducing the incidence and severity of pressure injuries?
- What are the key evidence gaps and research priorities related to pressure injury prevention in the ICU setting?

1.5 AIM OF THE REVIEW

This review aimed to review and synthesise systematically current evidence on the effectiveness of individual or combined pressure injury prevention strategies in reducing the incidence and severity of pressure injuries among critically ill adult patients in ICUs.

1.6 OBJECTIVES

The objectives of this review were:

- To identify and categorise the pressure injury prevention strategies currently implemented in ICU settings.
- To assess the effectiveness of individual and combined prevention strategies in reducing the incidence and/or severity of pressure injuries in critically ill patients.
- To compare the outcomes of different pressure injury prevention strategies with standard care or alternative interventions.
- To identify gaps in the current literature and provide recommendations for future research and clinical practice in ICU pressure injury prevention.

1.7 SIGNIFICANCE OF THE STUDY

Pressure injuries are common and severe complications in critically ill patients in intensive care units, which complicate the patient's course of illness with high morbidity, increased hospital stay and higher health care costs. Although several measures exist to prevent infection, the complexity of ICU care and the high vulnerability of critically ill patients alike require measures tailored to patient's needs and based on evidence. This systematic review aims to aggregate individual studies to determine an effective individual or multiple pressure injury prevention intervention(s) for the ICU. Findings will provide insight into best practices and may guide the formulation of protocols and policies. Finally, this review will provide gaps in the current state of knowledge and direct future research related to the complex clinical reality found in the ICU to have an impact on patient and pressure injury outcomes.

1.8 DEFINITION OF TERMS

The following definitions were used consistently in this study.

- **Critically ill patient**

It is defined as a patient with a high risk for actual or life-threatening health problems. Critically ill patients with higher acuity levels are viewed as being vulnerable, unstable and complex, requiring vigilant and skilled nursing care in an intensive care unit to prevent complications and restore health where possible (American Association of Critical Care Nurses, 2016; Elliott *et al.,* 2013).

- **Intensive Care Unit (ICU)**

Refer to a specially designated area in the hospital with specialised equipment and skilled personnel for critically ill patients requiring immediate and continuous attention (Oh *et al.,* 2008).

- **Pressure Injury**

A pressure injury is localised damage to the skin and/or underlying soft tissue, usually over a bony prominence or related to a medical or other device. The injury can present as intact skin or an open ulcer and may be painful. The injury occurs because of intense and prolonged pressure or pressure in combination with shear. The tolerance of soft tissue for pressure and shear may also be affected by microclimate, nutrition, perfusion, comorbidities and soft tissue condition (NPUAP, 2016).

- **Pressure Ulcer**

It results from injury to the skin and underlying tissue caused by pressure, shear, friction, and/or a combination of all three (Nijs *et al.,* 2008).

- **Friction**

Refers to the mechanical force of two surfaces moving across each other, causing abrasions or blisters (Melter, 2011).

- **Shearing**

The mechanical force parallel to the skin causes damage to deep tissue (Melter, 2011).

- **Pressure**

Refers to force per unit exerted perpendicular to the plan of interest (NPUAP, 2012).

- **Pressure injury risk assessment scale**

Refer to objective instruments that measure the risk of pressure injury development (Lospitao-Gomez, *et al.*, 2017).

- **Pressure injury prevention strategies**

Refer to a range of strategies such as risk assessment, skin assessment, skincare, nutrition, position and repositioning, education and training, medical devices, care or other strategies designed to manage the risk factors for PI development and reduce the incidence of PIs in ICU (NPUAP; EPUAP & PPPI, 2014).

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1.9 ORGANISATION OF THE THESIS

The thesis is structured into six chapters, each serving a distinct purpose in presenting the systematic review and its findings.

Chapter One: Overview

This first chapter presents an in-depth introduction of the subject of interest. It provides the problem statement, research aim, objectives, and questions and discusses the importance of conducting this systematic review. Moreover, the main terms appearing in the thesis are given explicitly.

Chapter Two: Literature Review:

This chapter critically reviews the current literature on pressure injury prevention and management, specifically in the ICU. This review includes the existing evidence on the frequency of pressure ulcer incidence and the prevalence of using risk assessment tools and staging systems.

Chapter Three: Methodology:

Chapter three sets out the methodological basis of the systematic review. This reflects the history of evidence-based healthcare (EBHC), the contribution of evidence synthesis, and the core principles that are relevant to systematic literature review.

Chapter Four: Systematic review methods:

Chapter four details the precise methodological approach used for the systematic review. It describes the objective and research question of the review, inclusion criteria (population, intervention, comparators, outcomes and study design), search strategy, procedures of study selection, methods for quality appraisal of studies, data extraction, and analysis methods.

Chapter Five: Results:
The results from the systematic search are reported in this chapter (including methodological quality and main features of the included studies). Results from the synthesis of the literature reviewed are also presented.

Chapter Six: Discussion, conclusions and recommendations for practice and research:
This concluding chapter critically discusses review findings in relation to the available evidence and theoretical underpinnings. It describes the implications for practice and future research, identifies the strengths and limitations of the study and offers evidence-based recommendations.

1.10 SUMMARY

Chapter one presented the comprehensive background for the review, which included the problem statement, the study aims, objectives and questions. The significance of the study is described, and key terms used throughout the thesis are defined.

The next chapter presents a greater detail of the literature reviewed for the thesis.

CHAPTER TWO
LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews the current literature on pressure injury prevention and management, in general, and specifically applied to the ICU. The literature review also explores the incidence, prevalence, risk assessment scales and staging systems.

The above evidence and literature were sourced using specialised databases: PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), LILACS, Web of Science, SCOPUS and Cochrane. These databases included the related subjects and journals relevant to the area of inquiry. In addition, Google Scholar was searched for additional literature that was unavailable in the databases. A manual search of pertinent reference lists was also included to make sure no relevant study was missed during the search.

Articles published in English and had the following keywords that were searched (between the years 2000 and 2024): “pressure ulcer” AND “prevention” AND “nursing” AND “intensive care units OR ICU”. When combining search terms, the Boolean term AND was used. In addition, the researcher used some limitations to qualify articles that were ten years old and must be full text, the language was English, and the species was humans.

2.2 OVERVIEW OF PRESSURE INJURIES

2.2.1 Definition

A pressure injury is an area of localised damage to the skin and underlying soft tissue, typically over a bony prominence or related to a medical or other device (NPUAP, 2016). Pressure ulcers are now referred to as pressure injuries (Alderden *et al*., 2017; 2025). According to Edsberg *et al*. (2016), the NPUAP changed the name after determining that the word “ulcer” does not exactly depict the visual appearance of all stages (e.g., stage 1 and deep tissue injury).

2.2.2 Aetiology of Pressure Injuries

Pressure injury aetiology is related to intrinsic and extrinsic factors (Anders et al., 2010) Risk factors for pressure injury development are reported in the literature. However, in general, they fall under the headings of extrinsic or intrinsic factors. Extrinsic factors comprise pressure at the interface or shear, friction and moisture. The intrinsic factors include the nutritional status, age, functional independence, incontinence, circulatory problems and neurological disorders of the patient (Terekeci *et al*., 2009). Other risk factors associated with pressure injury development include gender, body mass index, length of stay, body temperature, C-reactive protein level, oxygenation, blood pressure, oedema, nursing workload, the severity of illness and comorbid medical conditions, such as diabetes (Alderden *et al.,* 2025; Compton *et al*., 2008; Zajac, Schubauer, Simman., 2024).

Nijs *et al*. (2008) conducted a prospective research study to identify risk factors linked to Grade 2 to Grade 4 pressure ulcers after 48 hours following admission in a surgical ICU. Some associated risk factors were positively associated with Stage 2 to 4 pressure injuries, including vascular disease, haemodialysis and mechanical ventilation. In a retrospective correlational design with 347 (n=347) patients in a medical-surgical intensive care unit, Cox (2011) identified further risk factors that emerged as predictors of pressure ulcers, on average controlling for age, length of stay in hospital, mobility, friction/shear, and concurrent norepinephrine infusion and cardiovascular disease all as predictors of pressure ulcer development. Alderden *et al.* (2025) identified length of ICU stay and diabetes as additional potential risk factors. Wilezwesil *et al*. (2012) indicated that bowel management, incontinence, use of support surfaces, corticosteroid use, and hypotension were risk factors significantly associated with pressure ulcer development in a sample of traumatic SCI patients in the ICU.

2.2.3 System for Staging Pressure Injuries

In 2014, the NPUAP, EPUAP and PPPIA developed an International NPUAP/EPUAP pressure classification system. Also, the NPUAP of the United States of America has included two extra stages: unstageable/unclassified and suspected deep tissue injury (Black *et al*., 2007; Cooper, 2013; Anders *et al*., 2010). These phases are described as follows.

- A stage 1 ulcer is the mildest form of sore. It involves intact skin with non-blanchable erythema that is red and localises over bony prominence. The skin that is affected will look red in white people and purple or blue in those with darker skin. The ulcer may hurt or itch. It can also be warm, spongy or rigid (Beekman *et al*., 2014; Black *et al*., 2007; Bhattacharya & Mishra, 2015; Cooper, 2013).
- Stage 2 is partial thickness skin loss involving epidermis, dermis or both. The sore is superficial and clinically resembles an abrasion or blister (Bhattacharya & Mishra, 2015; Cooper, 2013).
- In stage 3, damage includes full thickness skin loss that may reach down to but not through underlying fascia (Black *et al*., 2007; Bhattacharya & Mishra, 2015; Cooper, 2013).
- A stage 4 pressure ulcer is the most advanced stage. The skin is badly damaged, and tissue around it dies (necrosis). In stage 4, pressure sores, severe damage, tissue death and muscle, tendon, and bone are exposed. In this phase, sinus tracts can be related to wound advancement (Black *et al*., 2007; Bhattacharya & Mishra, 2015; Cooper, 2013).
- The unstageable/ Unclassified- Full-thickness skin or tissue loss cannot be assessed not by visual examination because it is entirely obscured by slough (yellow, tan, grey, green, or brown) and/or eschar (tan, brown, or black) in the ulcer bed Black *et al*., 2007, Cooper 2013; Beekman *et al*., 2014).
- The suspected deep tissue injury pressure ulcer is indicated by a purple or maroon local area of discoloured intact skin or a blood-filled blister which is hard to touch (Black *et al*., 2007; Cooper, 2013; Beekman *et al*., 2014).

2.2.4 Prevalence and Incidence.

Pressure injuries still represent a significant problem for healthcare systems. Elliott, McKinley, and Fox (2008), Shahin, Dassen, and Halfens (2009) and Noie *et al.* (2024) state that pressure ulcers are among the top five adverse patient-care events. Pressure ulcers occur worldwide, with a prevalence of 8.8%-53.2% and an incidence of 7%-71.6% (Moore, 2010). Qaseem *et al*. (2015) reported in the USA, prevalence studies report ranges in acute care settings from 0.4–38%, in long-term care settings 2–24% and in-home care settings 0–17%. Aljezawi *et al.* (2024) revealed a prevalence of 21.8% (including stage 1) and 19.2%

(excluding stage 1) for hospital acquired pressure injuries in their ICU study conducted in Oman. Additionally, pressure injury prevalence in Africa is estimated at between 9.7% and 51.6% (Tayyib, Coyer, & Lewis, 2015).

2.2.5 Consequences of Pressure Injuries

Jiang *et al*. (2014) pressure injuries do cause distress and discourage, reduce the quality of life severely, act as a primary portal for infection, complicate the healing process, increase significantly the nursing time, put an overload on health care institutions and cause the delay of the significant discharge. All of these can result in mortality. Furthermore, pain is another noxious sensory and emotional sensation arising from tissue injury. Gorecki *et al*. (2011) and Kim *et al*. (2016) also found that the pain associated with pressure injury has a neuropathic component, which is the result of a lesion or disease in the somatosensory nervous system, and it is often characterised as sharp, shooting or burning. These authors also indicated that irrespective of the pressure injury, and patients report that the pain is burning-hot across all stages: throbbing in stage 3, tender-stabbing in stage 2 and throbbing-sharp in stage 4.

Cost is yet another devastating consequence of pressure ulcers. Treating each ulcer in the United States can range from $500 to $ 70,000. The estimated annual cost for treating pressure injuries is $1.6 billion to $11 billion. Pressure injury care is expensive, and in 2008, the Centers for Medicare and Medicaid Services implemented a no-pay policy for hospital-acquired pressure injuries, stages 3 and 4, on all Medicare beneficiaries (Qaseem *et al*., 2015; Fulbrook & Anderson, 2016; Fulbrook & Butterworth, 2024). So, hospitals in the program are responsible and will stop getting paid for these scenarios.

Litigation also contributes to the cost of care, particularly long-term care, in which 87% of awards from the judgements and out-of-court settlements against the facility are settled in favour of the plaintiff (Coyer *et al*., 2017). In a U.S. retrospective study of jury awards in pressure injury litigation, jurors returned awards between $5,000 and $82,000, with a median award of around $250,000 (Lyder & Ayello, 2007). In certain countries, such as South Africa, one hears of very little litigation, as most cases are settled out of court. However, it is a good idea for nurses to know how to prevent pressure injuries, so we are not sued for malpractice (Coyer *et al.,* 2017).

2.3 THE CRITICALLY ILL PATIENT

Pressure injuries are more likely to develop in critically ill populations than in general wards (Nowicki *et al.,* 2018). According to Coyer *et al*. (2017), the risk of developing PIs in the ICU is 3.8 times higher than in the general ward, which delays recovery time and increases mortality. Ware and Matthay (2002) and Fulbrook and Anderson (2016) reported that severe illness, comorbidities, reduced mobility and bed rest complications are among the factors that increase the chance of being prone to pressure sore in critical care.

Lospitao-Gomez *et al*. (2017) found that vasopressors, sedation, depressed consciousness, haemodynamic instability and mechanical ventilation were other reasons why ICU patients are at risk. De Almeida Medeiros *et al*. (2018) found that age, certain drugs or therapies, extended ICU stay, extreme body weight such as obese or low body weight, malnutrition, incontinence, oedema, fever, anaemia, lymphopenia, reduced serum albumin, and smoking history are additional risk factors in the trajectory of critical illness.

Other risk factors for pressure injury development include sex, BMI, length of stay, temperature, CRP, oxygenation, blood pressure, oedema, nursing workload, APACHE II (severity of disease) score and comorbidities (Compton *et al*., 2008). In a prospective study, Nijs *et al*. (2008) examined the risk factors for stage 2–4 pressure ulcers within 48 hours of admission in a surgical intensive care unit (ICU). Some risk factors were associated with the development of Stage 2 to 4 pressure ulcers: history of vascular disease, using Dopamine, undergoing haemodialysis, and using mechanical ventilation.

In a retrospective, correlative study on medical-surgical intensive care unit patients (n= 347), Cox (2011) found several risk factors to be associated with pressure ulcer development, such as age, time in hospital, mobility, friction/shear, norepinephrine infusion, and cardiovascular disease were all predictors of pressure ulcer development. Wilezwesil *et al*. (2012) identified that a bowel management programme, incontinence, support surface, steroid therapy and hypotension were associated with the development of pressure injuries in a sample of traumatic spinal cord injured patients in the ICU.

2.4 PREVENTION OF PRESSURE INJURIES

Prevention of pressure injuries includes various aspects, namely, risk assessment, daily skin inspection, relieving pressure, support surfaces, nutritional evaluation and quality assurance.

2.4.1 Risk Assessment

The first step in preventing pressure injuries is the early and accurate identification of high-risk patients. Most healthcare organisations and clinicians accomplish this task by using risk assessment scales.

Table 2.1: Comparison of characteristics of pressure injury risk assessment tools

	Norton score	Waterlow Scale	Braden scale	Jackson & Cubbin Scale
Created year	1962	1985	1987	1991
Speciality	Older people/ Generic	Orthopaedic/ generic	Generic	Intensive care
Risk factors in assessing pressure injury	Physical condition, Mental status, Activity, **Mobility*** **Continence***	Build/weight, Height, Visual skin assessment, **Continence*** **Mobility*** Sex/age, Appetite and special risks in terms of tissue Malnutrition, neurological deficit, medication and surgery/trauma	Sensory perception **Moisture*** Activity **Mobility*** Nutrition Friction/shear	Age Weight Skin condition Mental status **Mobility*** Nutrition Respiration **Continence*** Hygiene Hemodynamic status
Sensitivity (%)	82.83%	75.8 – 100%	38.9 – 100%	83.3%
Specificity (%)	78.20%	10.3 – 38%	26 – 100%	86.1%
Positive predictive value (%)	17.9%	5.3 – 33.3%	4.5 – 100%	48.8%
Negative predictive value (%)	98.8%	65.7 – 100%	50 – 100%	97.7%

Key: * = common risk factors to assess pressure injury

2.4.1.1 The Norton Score

The Norton scale is the most used in the USA and is recommended by the AHCPR. Five risk factors categorise the patients according to the Norton score. These are physical state, mental state, activity, mobility and continence (5 to 20) – the lower the score, the greater the risk (Cooper, 2013; Qaseem *et al*., 2015).

The Norton score's sensitivity, specificity, positive predictive value, and positive predictive value were 82.83%, 78.20%, 17.9%, and 98.9%, respectively (Jiang, 2015). A meta-analysis recently reported the excellent prognostic performance of the Norton scale (RR = 3.69, 95% CI: 2.64-5.16) (Garcia-Fernandez *et al*., 2014). Nevertheless, this risk assessment scale is argued that it is incapable of assessing pressure injury risk in ICU patients, as it does not include other particular risk factors, such as the reduced sensory level and the use of shear, which may further increase the risk of pressure ulcer development (Xue *et al*., 2012). Furthermore, there are few validation studies of the Norton scale, with less data to confirm the reliability and validity of the Norton scale (Pancorbo-Hidalgo *et al*., 2006).

2.4.1.2 The Braden Scale

The Braden scale is another widely established scale used in the United States and Britain. The evaluation considers six factors: per-sensory perception, moisture, mobility, activity, nutrition and friction/shear. Every item is scored from 1 to 3 or 4 (1 indicates an unfavourable condition; 3 or 4 favourable conditions) and, for a maximum total of 23, the lower the score, the worse the prognosis. A score of 16 or lower is associated with a high risk of developing pressure sores (Cooper, 2013; Qaseem *et al*., 2015).

The Braden scale is the most widely researched pressure ulcer risk assessment scale and exhibits a good predictive ability. In the systematic review, the sensitivity of the Braden scale ranged from 38.9% to 100%, the specificity ranged from 26% to 100%, the positive predictive value from 4.5% to 100% and the negative predictive value from 50% to 100%) (Pancorbo-Hidalgo *et al*. 2006). Although the Braden scale is highly practical with moderate sensitivity and specificity, it has the limitation of neglecting the degree of pressure injury (Hu, 2010). It does not evaluate nutritional decrease, metabolic disorders (Hu, 2010) and

malabsorption. In this nutrition, allocated devices are essential to predict pressure injury in ICU patients (Jiang & Liu, 2009).

2.4.1.3 The Waterlow Scale

The Waterlow scale (commonly used and recognised in the UK) assigns risk based on a range of factors, including sex, age, build, appetite, nurse's visual skin assessment, condition, mobility, incontinence, reasons for being at risk of malnutrition, neurological deficit, major surgery or trauma, and drug treatment. The range is from 1–64, and higher scores indicate greater risk (Cooper, 2013; Anders *et al*., 2010; Qaseem *et al*., 2015).

Reported values of sensitivity range from 75.8% to100%, specificity from 10.3% to38%, positive predictive value from5.3% to 33.3% and negative predictive value from 65.7% to100%(Pancorbo-Hidalgo *et al*., 2006). The Waterlow scale score was a good predictor (OR = 2.05, 95% CI 1.11 – 3.76) (Pancorbo -Hidalgo *et al.*, 2006). One of the main disadvantages of the Waterlow assessment is the poor sensitivity and specificity. This high sensitivity and low specificity may increase the risk of false positives since patients might be categorised as at risk for PI by the Waterlow scale test. Yet, in truth, their fate is not endangered at all. Therefore, prevention measures might be implemented for those who do not need them, wasting medical and nursing resources.

2.4.1.4 Jackson and Cubbin Scale

Jackson and Cubbin's risk assessment scale is unique to European critical care units. It estimates the risk of pressure ulceration based on age, weight, skin condition, mental state, mobility, nutrition, respiration, bladder and bowel control, and haemodynamic status. This scale ranges from 9 to 48, with a lower score reflecting a higher risk (Cooper, 2013; Qaseem *et al*., 2015).

Sensitivity, specificity, negative predictive value, and positive predictive values ranged, according to the Jackson and Cubbin scale, from 83.3%, 86.1%, 48.8% and 97.7%, respectively (Pancorbo-Hidalgo *et al*., 2006). In one recent trial, such scales focus on negative predictive value, 78 versus 87%; Positive predictive value, 53 versus 66%; Sensitivity, 17 versus 54%; Specificity, 95 versus 92%; and area under the curve, 0.710

versus 0.793. The Jackson/Cubbin scale had better predictive properties and discrimination performance for pressure injury risk prediction in critically ill trauma-surgical patients than the Braden scale (Higgins *et al*., 2020).

2.4.2 Skin Assessment

An in-depth skin inspection should be included in all risk assessments to evaluate any alterations in skin condition as it plays an essential role in the prevention, categorisation, diagnosis and management of pressure ulcers. The full skin exam should be performed as soon as possible upon admission and every 8 hours thereafter (Tayyib, Coyer & Lewis, 2016). However, the frequency of the assessment level should be individualised and measured around the patient's state. If conditions worsen for the patient, the assessment level should be performed more frequently (The Royal Children's Hospital Melbourne, 2019). Based on these authors, skin assessment is considered a "head-to-toe" assessment. However, high-risk areas over bony prominences (sacrum, heels) should be noted if a break in skin integrity is observed. Therefore, it should be staged per the NPUAP/EPUAP (2014), and size, depth and exudate should be recorded (Tayyib, Coyer & Lewis, 2016).

2.4.3 Preventive Skin Care

Tayyib, Coyer, & Lewis (2016) advocate for patients to be bathed in an appropriate pH agent once daily and skin protected with a padded dressing. These preventative dressings change the load applied to the skin. Similarly, Clarke *et al*. (2014) recommended prophylactic dressings of the sacrum, heels, trochanter, and nose to reduce pressure sore prevalence. These authors suggest using silicone dressings in these areas as a preventive measure (Tayyib *et al*., 2016; Coyer *et al*., 2004; Clarke *et al*., 2014). Furthermore, the NPUAP/EPUAP (2014) also recommends a range of practical protective skin-care measures, such as ensuring that the patient is kept clean and dry using a moisturiser to prevent skin from becoming dry.

2.4.4 Nutrition

Patients at risk of malnutrition should be screened nutritionally, and if they are at nutritional risk, they should be referred for a full nutritional assessment. Tayyib, Coyer, & Lewis (2016)

stated that prevention bundles for pressure injuries included nutritional assessment on admission. The aim is to screen for those patients in danger of experiencing malnourishment, which should be followed up with a complete nutrition assessment. Good nutrition and hydration should be ensured.

Nutrition should be used as support to avoid and compensate for nutritional deficiency. Protein, Vitamin C, Vitamin A and Zinc are key nutrients in preventing and treating pressure injury (The Royal Children's Hospital Melbourne, 2019). Mallah, Nassar and Badir (2015) recommended that the patient management plan incorporate consultation with a dietician to maintain the patient's nutrition and investigate any weight loss. In addition, enteral/ parenteral feeding should be initiated when oral intake is inadequate or not possible , e.g., when an intubated or comatose patient is present (NPUAP/EPUAP, 2014).

2.4.5 Repositioning

Repositioning. This is done to eliminate the pressure exerted on the bony prominences. All PUs at-risk patients are to be repositioned at the shortest possible intervals of time possible unless specified not to do so. According to Tayyib, Coyer, and Lewis (2016), patients should be repositioned after a three-hour interval; Mallah, Nassar, and Badir (2015) suggested that this be done after a two-hour interval or more frequently if indicated. The appropriate time interval should be based on the patient's tissue tolerance, mobility status, and clinical condition because more frequent turning may cause tissue damage. One should also consider the patient's pressure support surfaces, such as pressure redistributing surfaces. If not contradicted, patients should be positioned using the Continuous Repositioning Schedule (CRS). Specifically, CRS 2 recommends regular repositioning, while CRS 3 advises the use of a 30° tilted side-lying position. This means the patient should be rotated between back and each side, maintaining a 30° tilt to reduce pressure on vulnerable areas. Support surfaces are special devices made to redistribute pressure, facilitating pressure from the high-pressure area to the lower-pressure area. Air mattresses should be used for individuals who are critically ill. Once using support surfaces, repositioning should be done frequently. Sheepskin, doughnut-shaped devices and gloves filled with water under the heels must not be used for relieving pressure.

The patient with devices is at elevated risk for the development of PI (Wound, Ostomy and Continence Nurses Society, 2017). Medical devices can cause injury, that "mimics" the device, which may occur in areas of the body with no fat. Such equipment can include cervical collars, orthoses, O2 saturation probes, ECG leads, cables and electrodes, endotracheal tubes, non-invasive masks, and nasal cannulae devices (The Royal Children's Hospital Melbourne, 2019). I) The skin around and under medical devices should be checked every 12 hours each , but more frequently when patients are oedematous (Tayyib, Coyer & Lewis, 2016). Medical devices suspected of causing pressure ulcers should be removed (NPUAP/EPUAP, 2014).

2.5 MEDICAL DEVICE-RELATED PRESSURE INJURIES (MDRPI)

Medical devices commonly used for the treatment and care of critically ill patients can cause pressure injuries in ICUS. The endotracheal tube (ETT) is one of the most common medical devices to cause pressure injuries. The three included studies (Fulbrook & Butterworth, 2024; Cambaz *et al.*, 2024; Kurtgoz *et al.,* 2024) were found to offer critical information on the incidence, risk factors, and nursing awareness of MDRPI, especially as they pertain to ETT in ICUs. Every study adds to the evidence base regarding this clinical problem, but overall, they highlight the pressing requirement for enhanced prevention and education of nurses.

Fulbrook and Butterworth (2024) conducted a large-scale epidemiological study in a single adult ICU in a tertiary general hospital in south-east Queensland, Australia. This investigation, which had 7343 ICU admissions over 4 years, identified 413 ICU episodes of pressure injuries that were acquired, and had the following emphasis: device-related vs non-device-related injuries. Cambaz *et al*. (2024) conducted a prospective study on 146 mechanically ventilated patients with the participation of multiple ICUs (internal, surgical, and anaesthesia) of a training and research hospital in Turkiye. They stated that ETT-related pressure injuries were observed in 80.14% of the patients and that minimum damage occurred in 3–4 days following intubation. Kurtgoz *et al*. (2024) investigated nursing knowledge and practices of MDRPIs in a sample of 143 ICU nurses from adult and neonatal wards of three hospitals in Turkiye. They identified knowledge deficits and perceptions affecting MDRPI control.

All three sources highlight the common rates of device-related PUs and the quickness with which they develop in the ICU. Fulbrook (2024) identified 5.6% of intensive care patients sustained a pressure injury, with device-released ones (4%; including ETTs, contributing to over half of device-related pressure injury) more common than those not associated with devices (2.7%). Cambaz *et al*. (2024) found that 80.14% of intubated patients suffered at least one ETT-associated injury, with the failure of ETT largely discovered after 3–4 days. The two clinical studies also emphasise the mucosal regions, like the lips and mouth, as frequent sites of injury. All studies recognise the importance of nursing care in prevention, such as routine inspection of skin and mucosa, frequent repositioning of ETT and appropriate tube securing. Kurtgoz *et al*. Etikan *et al*.(2024) reported that despite the majority of nurses having experienced MDRPIs, only (63.6%) believed that their knowledge was inadequate with moderate total knowledge score and the recipient mean score for injury staging has shown that there may be educational gaps influencing the prevention and treatment of MDRPI.

The differences between the studies are remarkable in terms of scope, focus and methodology. Fulbrook and Butterworth (2024) utilised a retrospective epidemiological approach to examine a large Australian ICU population (7343 patients). They reported an overall ICU-acquired pressure injury prevalence of 5.6% and a 4.0% incidence of device-related pressure injuries. Cambaz *et al*. (2024), alternatively, investigated prospectively a smaller Turkish ICU sample of 146 intubated patients and established specific risk factors for COVID-19, including high BMI (OR 1.15), amongst its significant associations for heightened risk of injury. In Cambaz *et al*.'s (2024) study, the incidence of injury during the symptom onset period was similarly more immediate, occurring in most cases within 3 to 4 days after intubation.

Meanwhile, Kurtgoz *et al*. (2024) focused on nursing knowledge and self-reported practices, rather than clinical incidence. The study involved 143 ICU nurses and lacked direct patient outcome data. Geographical and healthcare setting differences—Australian compared to Turkish hospitals—are apparent, which may affect prevalence rates and the model of nursing education. Finally, while Fulbrook and Butterworth (2024) and Cambaz *et al*. (2024) dealt with patient outcomes and injury representation, Kurtgoz *et al*. (2024) investigated the educational and working environment affecting the prevention of MDRPI.

Taken together, these studies provide a consistent picture of MDRPIs in ICUs through the integration of epidemiological data, risk factor analysis, and nursing competence in this field. The rate of device-related PI is relatively high, particularly as ETT-related PIs (ranging from 4.0% to more than 80% in intubated patients) and nursing knowledge gaps (63.6% report lack of knowledge), to the extent that these represent an important area for clinical focus.

Practical recommendations include:

- Improved Nurse Education and Training: Develop and provide regular education and training (including targeted MDRPI prevention, staging, and management initiatives) to target specific gaps in knowledge identified within ICU nurses. Such training should involve exposure to risk factors for problematic diagnoses, early recognition, and appropriate interventions.
- Routine Skin and Mucosa Assessment: Promote frequent and regular inspection of skin and mucosa of insertion site for device-related damage, particularly within the first 3–4 days post-device insertion.
- Analysed device management: Preserve good practices on device fixation and repositioning, especially endotracheal tubes and their fixation materials (such as tapes) to reduce pressure and friction that contribute to injury.
- Risk Factor Surveillance: High-risk patients, including those with a high BMI, as it has been shown to increase the risk of MDRPI markedly, should receive targeted preventive measures.
- Policy & Protocol: Adherence to clear clinical guidelines and pre-defined protocols to set a standard of prevention and care of MDRPI cases in the ICU, buttressed by Audits/Quality improvement campaigns in the hospitals.
- Multidisciplinary Approach: Employ a team approach, including nursing leadership, wound care team, and intensivists, to collaborate efforts around MDRPI prevention and patient safety improvements.

Using these strategies, MDRPIs in ICUs can be minimised in both frequency and severity, patient comfort and patient outcomes can be enhanced, and the additional cost of care can be reduced.

2.6 PRESSURE INJURY PREVENTION BUNDLES

Despite many intervention studies designed to prevent PIs in diverse clinical environments, they used one intervention versus standard care. Nevertheless, based on the current evidence, multi-based interventions might be more efficacious to prevent pressure ulcers (Tayyib, Coyer & Lewis, 2015; Rivera *et al.,* 2020).

In a study, for example, Carino *et al*. (2012) designed a HAPU bundle to decrease pressure ulcer occurrence in a Medical-Surgical ICU. The authors selected six interventions for the HAPU bundle: a) skin assessment [daily Braden Scale], b) repositioning, c) nutrition assessment, d) [daily] caloric intake, e) blood glucose measurement and f) support surface utilisation. A 12-month application of the HAPU bundle was conducted with 167 patients in a mixed medical-surgical ICU. The prevalence rate was 12.4% (21/169) before HAPU (HAPU prevalence), but after the implementation of the HAPU bundle, the prevalence rate decreased to 6.1% (11/167). A paired t-test was used, then a significant difference was found (p-value 0.04).

Tayyib, Coyer and Lewis (2015) conducted a multi-centre international study with a two-arm cluster randomised control design to measure the impact on the ICU of a pressure ulcer prevention bundle for the critically ill. The pressure ulcer guideline was based on new guidelines of the European Pressure Ulcer Advisory Panel and NPUAP (2009). The aspects that the researchers analysed were a) risk estimation (Braden Scale), b) skin evaluation, c) skin care, d) nutrition assessment, e) patient's turning, f) special mattress, g) staff training, and h) devices. Results: The cumulative pressure ulcer incidence was statistically different between the intervention (7.14%, 5/70 patients and the control (32.86%, 23/70 patients' group, X^2 -14.46, df=-1, $p<0.001$). The intervention group reported significantly lower Stage 1 and Stage 2 pressure ulcer development (U = 1.976; p=. 002, and U=2.172, p=. 026, respectively). The authors also reported that their results showed a successful PU bundle in their sample. They showed a significant decline in the cumulative incidence for hospital-acquired pressure ulcers and the total number of pressure ulcers per patient.

The effectiveness of a 12-month prevention of hospital-acquired pressure ulcers program in an adult intensive care unit was also studied by Swafford, Culpepper and Dunn (2016). The aim was to halve the incidence of pressure sores. The items considered in their study were:

(a) Braden Scale, (b) skin-care regimen, (c) fluidised positioners, (d) silicone gel adhesive dressing and (e) staff training. In 2011, prior to the implementation of the program, 45 hospital-acquired pressure ulcers were reported in 10% of patients at a total cost of close to 1.7 million dollars. These figures represent a reduction of more than two-thirds (69%) compared to 2011 when 26 hospital-acquired pressure ulcers were reported for 4% of patients. That was more than their 50% goal. These outcomes have also resulted in a projected cost savings of over one million dollars for 2013. This was an excellent decrease in the incidence of pressure ulcers and demonstrated that the pressure ulcer prevention programme had helped to raise awareness and improve nurses' compliance with the pressure ulcer prevention programme, they added

2.7 INTERDISCIPLINARY INTERVENTIONS

Proper management and prevention of pressure ulcers in critically ill patients is best served by a team approach that spans the spectrum of care and involves multiple providers. Collaborative care among the team members, including a nurse, physician, wound care specialist, rehabilitation specialist, and mental health professional, can result in comprehensive and patient-centred care. The crosstalk between both specialities becomes indispensable to ensure this continuum of care for patients at high risk or living with PIs.

- **Role of nursing**

Nursing plays a key role in the prevention and management of PI. The constant bedside monitoring enables regular skin assessment to be achieved, repositioning programmes to be implemented, and dressing review and education to take place around staff and patients/families at the bedside (Cox, 2017). Interventions are coordinated and documented by the critical care nurse, who identifies early signs of tissue damage and ensures the appropriateness of support surfaces and wound care supplies. Their watchful eye and clinical judgement are invaluable in initiating early interventions and avoiding catastrophic injuries (Beeckman *et al*., 2014).

- **Collaboration with physicians**

Pressure injury care physicians are involved in managing pressure injuries by managing underlying medical problems interfering with healing (infection, malnutrition, or hemodynamic insatiability). Their roles are to highlight the systemic therapy, coordinate the diagnostics (diagnostic investigations in suspicion of osteomyelitis and imaging), and, when necessary, advise on the surgical treatment if needed (Brindle *et al*., 2015). Nurse-physician collaboration promotes wound care consistent with the comprehensive medical plan for critically ill patients with multiple complex system diseases.

- **Personal discussions with wound experts**

Wound care specialists can provide expert evaluation and guidance for treating complex or recalcitrant pressure ulcers. These providers often include the enteral wound, ostomy and continence (WOC) certified nurse, other certified nurses and wound care specialists. They will support evidence-based dressing regimens, debridement strategies, and infection management strategies related to the wound (Black *et al*., 2018). They are also engaged in staff education and quality initiatives that promote uniform compliance by healthcare staff with evidence-based pressure injury education (NPIAP, 2019).

- **The role of the rehabilitation services**

Rehabilitation experts (physiotherapists & occupational therapists) are essential to start moving, prevent contractures, and enhance PT in patients with or at risk for PI. They guide individualised repositioning schedules, transfer techniques, and the use of assists to limit pressure exposures (Liu *et al*., 2020). Early mobilisation led by a rehabilitation specialist has been shown to increase tissue perfusion, reduce the complications of immobilisation, and enhance the recovery process of critically ill patients.

- **Counselling and Psychosocial Support**

The psychological impact of pressure injuries is often underestimated, though patients may report anxiety, depression, negative body image, and a sense of powerlessness. In patients

in the ICU, the psychological stresses are more extreme because of the ICU setting and limited interaction. Counselling from psychologists and psychiatric nurses and emotional support, coping and behavioural strategies to reduce emotional suffering and improve quality of life (Gorecki *et al*., 2011). Psychological counselling is added to the treatment, covering emotional and physical care.

2.8 SUMMARY

Pressure ulcers are a major concern in ICUs because of the acutely ill patients with a high risk of their own or due to the interaction between intrinsic and extrinsic factors. These are immobility, mechanical ventilation, vasopressors and sedation, malnutrition, haemodynamic instability, and other comorbidities such as cardiovascular diseases and vasculopathy. Other modifiable risk factors include incontinence, oedema, and abnormal laboratory values (including low albumin). In an ICU environment, numerous patients cannot reposition themselves, are exposed to long periods of contact pressure and experience friction and shear forces from sliding or medical apparatus. As a result, the prevalence and incidence of pressure injuries among ICU patients is significantly higher than among the general patient population. The prevalence figures worldwide can be very broad; anecdotally, they can surpass 70%.

Pressure ulcers are staged according to the international staging system, from I (non-blanch-able erythema) to IV (full-thickness tissue loss), including unstageable ulcers and suspected deep tissue injuries. These injuries can result in significant pain – burning and aching, extended hospital stay, more risk for infection, long recovery time, long-term poor quality of life, and significant financial burden. Pressure injury treatment is costly, and treatment of advanced pressure injuries has health policy implications (e.g., Medicare does not pay hospitals for care related to a Stage 3 or 4 hospital-acquired pressure injury) and legal consequences for healthcare providers that add significant importance for strong prevention efforts, and nurse accountability.

ICU prevention is a complex process. Palliative methods include risk assessment (various validated tools such as the Braden, Waterlow, Norton, Jackson-Cubbin), skin inspection, prophylactic dressing, repositioning, nutrition and pressure relieving surfaces. Most measures used are not specific for critically ill patients, the Jackson-Cubbin scale being one

of the exceptions. Repositioning, nutritional screening, and per-protocol supplementation are key factors in maintaining skin integrity and appropriate medical device management to prevent PI. They have been widely applied, but the results vary with the setting, patients, and adherence to the guidelines.

While numerous RCTs have tested preventive measures for PIs, the latest evidence has leaned more firmly toward multi-component/bundled strategies than single strategy interventions. Bundles combining daily skin assessment, repositioning, nutritional intervention, special mattresses, staff education, and responsible medical devices were proven to significantly reduce the occurrence of pressure ulcers during ICU stay, in a clinically significant way, in other studies. They effectively reduced morbidity and were cost-effective, thus affirming their place in critical care.

A systematic review is warranted as there is heterogeneity in intervention characteristics, patient populations, and clinical endpoints among studies. A high-quality summary of the evidence is required to guide optimal strategies to prevent PI in the critically ill. It can also facilitate standardising the evidence-based ICU protocol, improving patient safety, optimising care, and lowering the costs associated with treating challenged skin.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

This chapter describes the methodological principles for the present study, which follows the JBI approach to evidence-based healthcare. This begins by defining the EBHC principles and the JBI model's unique contribution. Followed by an overview of systematic review methodology for operationalising evidence-based practice within the JBI framework. The chapter concludes with a discussion of how evidence is graded, and recommendations are formulated. While this chapter outlines general methodological principles, the next chapter will discuss the application to the present study.

3.2 EVIDENCE-BASED HEALTH CARE

Evidence-based health care (EBHC) refers to a decision-making process that considers the best available evidence from research, clinical expertise, and patient preferences within the health care system context (Sackett *et al*., 1996). This multi-pronged approach does not allow for decisions to be made in clinical or policy silos. Instead, it allows for consideration of efficacy, applicability, and individual and population-based needs.

There are indeed five steps to EBHC approach: (1) Ask a structured clinical question, (2) Find the best evidence to answer that question, (3) Critically appraise the evidence, (4) Integrate the evidence with clinical expertise, patient preferences and the results of other research, and (5) Evaluate the effectiveness and efficiency in executing steps 1–4 is desirable then do something about the evidence" (Straus *et al*., 2018). This iterative approach enables learning to be applied and adapted in healthcare environments.

Although EBHC emerged from an emphasis on quality evidence derived from RCTs, it has become more inclusive, recognising a variety of study designs and sources of data. This growth indicates a growing appreciation for the complexity of health systems and the role of qualitative, economic, and contextual evidence.

3.3 THE JBI APPROACH TO EBP IN HEALTH CARE

The Joanna Briggs Institute (JBI) provides a comprehensive model for evidence-based care. Unlike more traditional evidence hierarchies, the JBI model acknowledges that different questions demand different evidence. Questions regarding feasibility, acceptability or experience alone may be more satisfactorily explored by qualitative or mixed methods research rather than RCTs alone (Pearson *et al*., 2005).

Central to the approach of JBI is the FAME (Feasibility, Appropriateness, Meaningfulness, and Effectiveness) framework, emphasising the application of evidence in real-world healthcare settings. Such a person-centred and context-sensitive approach guarantees that the evidence is scientifically rigorous and meaningful in practice (Aromataris & Munn, 2020).

In addition, JBI's advocacy of rigorous methods is also evident in its process manual, the Manual for Evidence Synthesis, an extensive compendium which guides a variety of review types such as effectiveness, prevalence, aetiology, qualitative and scoping reviews (Aromataris & Munn, 2020). JBI also offers customised critical appraisal and data extraction tools for each study type to ensure a systematic and transparent evidence review process.

The JBI model also highlights knowledge translation and evidence synthesis as part of a larger dissemination, implementation, and evaluation cycle. Therefore, the JBI model is especially relevant in guiding clinical guidelines, quality improvement programs and policy.

Figure 3.1 displays the JBI model of evidence-based healthcare.



Figure 3.1: JBI model of evidence-based healthcare

3.4 EVIDENCE SYNTHESIS AND SYSTEMATIC REVIEW

The systematic review is regarded as the gold standard in evidence synthesis as it attempts to reduce bias through a transparent and replicable process. Unique characteristics of the JBI systematic review methodology are the incorporation of multiple forms of evidence, the development of detailed protocols and the emphasis on usability.

The process is initiated by the formulation of a protocol whereby the review objectives, eligibility criteria, types of evidence used to identify and appraise, and methods of synthesis are defined. According to the question of a review, the scope of the investigation is established using systems like PICO (Population, Intervention, Comparator, Outcome) or PCC (Population, Concept, Context) (Peters *et al*., 2020).

A comprehensive search is conducted in multiple databases, utilising controlled vocabulary and key terms. Independent double screening occurs for both title/abstract and full text, with disagreement resolved through discussion or third-party adjudication.

The critical appraisal tools for JBI included studies are used (as per design, e.g., randomised trials, cohort studies, and qualitative) for critical appraisal. This enables a more detailed consideration of internal validity and risk of bias. Information is subsequently collected through standardised forms, and appropriate methods pool the result data according to the type of evidence. For instance, quantitative data can be synthesised using meta-analysis; qualitative data can be combined using meta-aggregation, i.e., findings are grouped and then combined into a synthesis as a practical statement (Lockwood *et al*., 2020).

JBI's inclusive methodology enables reviewers to record nuanced phenomena, complex causation, contextual moderators, and factors commonly omitted in narrative reviews. As such, it offers both robust and pragmatic evidence.

3.5 LEVELS OF EVIDENCE AND GRADING OF RECOMMENDATIONS

When evidence is appraised, evaluating its quality and relevance is essential. The approach used to grade the evidence has the potential to rank the quality of evidence (study design) that is the most appropriate for the type of question, whether it is related to effectiveness, experience, diagnosis or prevalence (JBI, 2014).

For example, level 1 evidence of the effectiveness may consist of systematic reviews of RCTs, whereas level 1 evidence of experience may be meta-syntheses of qualitative studies. Low evidence levels (e.g., Level 4 or 5) may involve case series or expert opinions, which are less strong but may have utility depending on the circumstance.

Table 3.1 displays the JBI levels of evidence.

Table 3.1: JBI Levels of evidence

Type of Question	Level 1 (Highest)	Level 2	Level 3	Level 4	Level 5 (lowest level)
Effectiveness / Intervention	Experimental designs (e.g. RCTs).	Quasi-experimental designs (e.g. non-randomised trials, pre-post studies).	Analytical observational studies (e.g. cohort or case control with control group).	Descriptive observational studies (e.g. cross-sectional, case series without control).	Expert opinion, bench research.
Diagnosis	Systematic review of diagnostic studies or high-quality diagnostic RCTs.	Validated diagnostic cohort studies.	Non-validated diagnostic cohort or case-control studies.	Diagnostic case series, diagnostic audit.	Expert opinion.
Prognosis	Systematic review of prospective cohort studies.	Prospective cohort studies.	Retrospective cohort or case-control studies.	Case series or cross-sectional studies.	Expert opinion.
Etiology / Risk	Systematic review of observational or experimental studies.	Cohort or case-control studies.	Non-comparative analytical studies.	Case series.	Expert opinion.
Meaning/experience (qualitative)	Meta-synthesis of qualitative studies (e.g meta-aggregation).	Single qualitative study (e.g. phenomenology, ethnography, grounded theory).	Text and opinion (expert commentary consensus).		

Source: JBI Manual of Evidence Synthesis. https://synthesismanual.jbi.global

JBI provides guidance based on evidence quality, consistency, and clinical relevance for grading the strength of recommendations. Recommendations are usually ranked by a standard value set either:

- Grade A: Strong recommendation – the desirable effects of adherence to the recommendation outweigh the undesirable effects.

- Grade B: Recommendation against: Weak recommendation or condition recommendations --- the balance between strength of evidence and the balance of benefits and harms is unclear, or evidence is of low quality (Aromataris & Munn, 2020).

This grading process supports the evidence user in their decision making while acknowledging that even high-confidence evidence is to be examined in the context of feasibility, patient preferences, and clinical judgment.

3.6 SUMMARY

This chapter outlined the conceptual and methodological foundations for conducting evidence-based research using the Joanna Briggs Institute (JBI) approach. EBHC provides a critical strategy for integrating scientific evidence in health care, and the JBI model offers a flexible, comprehensive and context-related method for synthesising that evidence.

The next chapter presents the research methods used in the systematic review.

CHAPTER FOUR
SYSTEMATIC REVIEW METHODS

4.1 INTRODUCTION

The chapter focuses on the research methodology used in this study. The research design is presented, followed by the research question that guided the review. The chapter also details the review inclusion criteria, search strategy, study selection, appraisal of methodological quality, data extraction and data synthesis.

4.2 RESEARCH DESIGN

A systematic review was conducted using the Joanna Briggs Institute (JBI) methodology for systematic reviews and according to the JBI Manual for performing systematic reviews (Tufanaru *et al.,* 2020).

4.2.1 Review Questions

The following question guided the systematic review:

- What is the effectiveness of individual or combined pressure injury prevention strategies in reducing the incidence and severity of pressure injuries among critically ill adult patients in intensive care units?

4.2.2 Inclusion Criteria

Inclusion criteria in the present systematic review were informed by the PICO (Population, Intervention, Comparison, Outcomes) framework, a structured, evidence-based approach to identifying pertinent studies (Huang et al., 2006).

- Population (P):

Eligible Participants The group of patients to be included were critically ill adult patients, both male and female, 18 years of age and older, who were admitted to a medical or surgical intensive

care unit (ICU) and identified at risk for developing PUs. Pressure injury risk status was determined by an established assessment tool, such as the Braden scale or professional clinical evaluation. Studies with exclusively paediatric, neonatal, or non-ICU patients were not included.

- **Intervention (I):**

The included studies examined interventions to prevent pressure injuries in adult ICUs. These interventions included a variety of strategies (e.g., repositioning interventions [turning or mobility protocols], pressure-redistributing support surfaces [e.g., specialised mattresses or overlays], and prophylactic topical treatments or dressings [e.g., foam, hydrocolloid, or barrier creams]). Studies evaluating multi-component prevention bundles were included as long as pressure injury prevention was central to the intervention.

- **Comparator (C):**

Comparison factors were other pressure injury prevention alternatives, standard/routine care as described by the authors, or no formal prevention strategy. Studies were also included without a control group, but with relevant outcome measures.

- **Outcomes (O):**

The clinical endpoints of interest included PI's occurrence and occurrence rate in ICU patients. Incidence was reported as the percentage of patients who developed new pressure injuries during the study period. In contrast, prevalence was the sum of all patients with a pressure injury at a given time. Secondary outcomes were severity of pressure injuries, categorised by stage according to the NPUAP classification system (NPUAP, 2016); time to the development of a pressure injury following ICU admission; the number of pressure injuries per patient and an adverse event related to the use of the preventive strategies (e.g., skin irritation or discomfort).

- **Types of Studies:**

This review incorporated published and unpublished quantitative studies, including RCTs, quasi-experimental studies, prospective and retrospective cohort designs, case-control studies,

and cross-sectional studies of relevant outcomes. Quality improvement initiatives and grey literature (e.g. theses, dissertations, and institutional reports) were considered if they met the eligibility criteria. A condition was made only to include studies reported in English. Abstracts, opinions, narratives and case reports were excluded from the review.

4.2.3 Search Strategy

The JBI recommended a three-step search approach to search for published and unpublished studies. A preliminary search was performed in PubMed and CINAHL, and the keywords and index terms in the title and abstract were reviewed. A secondary search of all identified words and index terms was performed in all the included databases. This was conducted for each of the participating databases separately. The reference list of all identified studies was also reviewed and screened for additional studies.

Table 4.1: PubMed Search strategy

(((“pressure injury” OR “pressure ulcer” OR “pressure sore”)) AND ((“intensive care unit” OR “critical care”))) AND ((“prevention” OR “intervention” OR “strategies” OR “bundles”))

The text words included in titles and abstracts and the index terms from articles were combined to develop a complete search strategy for PubMed, CINAHL, LILACS, Web of Science, Scopus, and Cochrane. The search strategy will be customised for each database, information source, and all known keywords and index terms. A hand search of the reference list of all the included evidence sources was performed.

The review included studies published in English between January 2000 and January 2024. All databases were searched from their inception to January 2024, including PubMed, CINAHL, LILACS, Web of Science, Scopus, and Cochrane. A librarian/information scientist was contacted to assist in searching all literature in all relevant databases and to enable the identification of unpublished/grey literature in multiple databases. (ProQuest Dissertation, Theses and Google Scholar were also searched for unpublished studies. The role of NPUAP, EPUAP, and PPPIA was sought from appropriate organisations, as well as manuals and guidelines.

4.2.4 Study Selection

After the search, references were collected and entered the Mendeley reference manager software, and duplicated references were deleted. The titles and abstracts of studies obtained were screened by two reviewers (AT and SS) for eligibility for inclusion in this review. Relevant studies extracted in full were retrieved, and citation details were found in JBI SUMARI. The full texts of citations meeting the inclusion criteria were independently reviewed in more detail by two reviewers. Reasons for excluding papers that did not fulfil the inclusion criteria were recorded and presented in the systematic review. Any disputes between reviewers during each selection stage were settled through discussion or by a third reviewer (EK). The search retrieval and inclusion into the review process were fully described in the resulting systematic review and displayed in a Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram (Moher et al., 2009) (see **Appendix A**).

4.2.5 Assessment of Methodological Quality

The selected studies were critically appraised by two independent reviewers according to the JBI critical appraisal tool for the type of study (see **Appendices B to F for the JBI critical appraisal checklist**). Authors of articles were contacted if necessary to get any missing or additional information for clarification. All differences were settled by discussion or with a third reviewer. Results of the critical appraisal were presented narratively and in a table. Data extraction and synthesis (where appropriate) were completed on all studies, regardless of methodological quality.

4.2.6 Data Extraction

Studies were extracted using a standardised data extraction tool (**Appendix G of the JBI extraction tool)**. The information captured comprised individual population characteristics, study methodology, interventions, and outcomes. Disagreements with the reviewer were resolved by discussion or by a third reviewer. Corresponding authors of papers were also contacted in case missing, or additional data were needed.

4.2.7 Data Synthesis

A meta-analysis was intended for this systematic review but could not be performed because of too much heterogeneity between the included studies. There was substantial variance among the studies in four important dimensions: (i) The population characteristics: age, clinical conditions, and severity of illness in ICU patients varied. (ii) Types of interventions: The studies assessed a broad spectrum of prevention strategies such as repositioning, support surfaces, prophylactic dressings, and care bundles, with disparate protocols and intensity. (iii) Results: Pressure injury outcomes were defined, measured, and reported in various ways (e.g., incidence vs. prevalence, timing of measurement and the staging systems used); thus, it was not possible to directly compare studies. (iv) Design of studies: The inclusion of randomised controlled trials and observational studies, as well as the associated variation in methodology and bias. These differences were the reason that the data could not be statistically combined, which may have resulted in either spurious or non-interpretable findings. Instead, a narrative synthesis was performed to synthesise and compare study findings. It was possible to achieve a methodical and clear analysis of evidence consistent with best practice in systematic review methodology when heterogeneity impeded meta-analysis.

4.3 ETHICAL CONSIDERATIONS

The following ethical issues were taken into consideration.

- Protocols were submitted to the University Postgraduate Committee in the School of Therapeutic Sciences for approval to conduct the study.
- An ethics waiver was obtained from the Human Research Ethics Committee of the University of Witwatersrand (Clearance Number: **W-CBP-220801-01)**

4.4 SUMMARY

This chapter outlined the systematic review method in the study, which included the review eligibility criteria, search strategy, study selection process, how the studies would be critically appraised, and data extraction and data synthesis methods. The next chapter presents the results of the systematic review.

CHAPTER FIVE

RESULTS

5.1 INTRODUCTION

In chapter five, the findings of the systematic review conducted to evaluate the effectiveness of pressure injury prevention strategies in reducing the incidence of hospital-acquired pressure injuries in adult ICU patients are provided. A detailed description of the search results, the study selection process, and the methodological quality assessment are presented, followed by the characteristics of the included studies. Finally, a narrative synthesis of the results organised by outcome is provided.

5.2 DESCRIPTION OF STUDIES

5.2.1 Description of Search Results

The initial search was undertaken in June 2020 and identified a total of 781 (n-781) potentially relevant citations using the search strategies developed for each database, plus 7 (n=7) records identified through other sources. The search was updated in January 2021 and limited to December 2024, which identified 346 (n=346) potentially relevant citations. Between the two search dates, a total of 1132 (n=1132) records were identified. Of the 1132 (n=1132) citations, 676 (n=676) were excluded as duplicates. Of the remaining citations, 411 (n=411) were excluded after examination of the title and abstract. A full text review of 45 (n=45) papers were conducted, 10 (n=10) were immediately removed for not fulfilling the inclusion criteria. Two independent reviewers then assessed the remaining 35 (n=35) studies. Three (n=3) studies were removed after methodological quality assessment. The methodological quality of the remaining studies was assessed, and 34 (n=34) studies were subsequently included in this review.

5.2.2 Description of Search Results and Study Selection Process

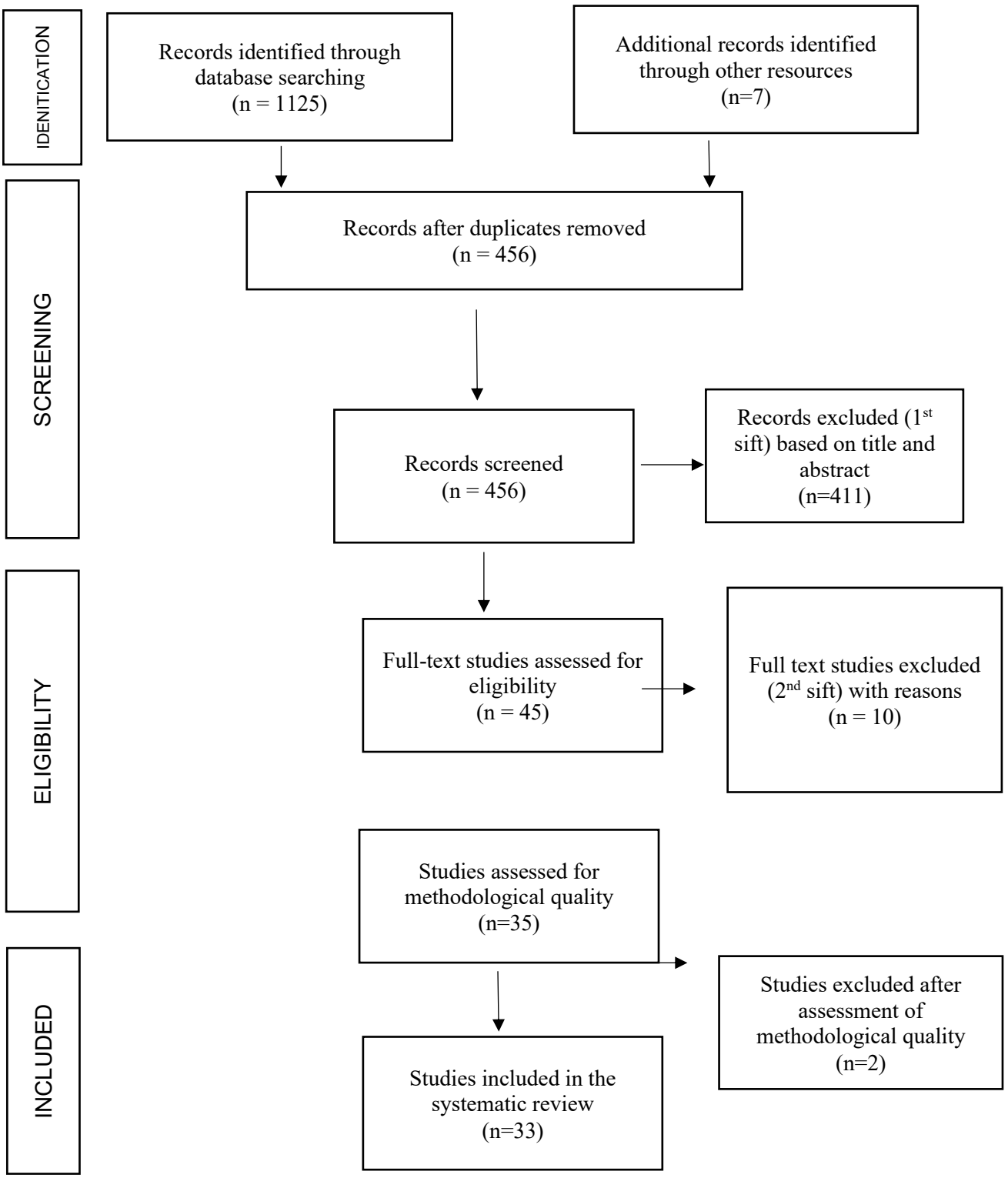


Figure 5.1: PRISMA flow diagram of search outcome

5.2.3 List of Included Studies in the Final Review

After quality assessment, 33 (n=33) articles were found eligible for inclusion in the review and presented in **Table 5.1.**

Table 5.1: List of included studies in chronological order (n=33)

Code	Author (year)	Country	Title	Journal
#1	Forni *et al*. (2022)	Italy	*"Effectiveness of a multi-layer silicone-adhesive polyurethane foam dressing as prevention for sacral pressure ulcers in at-risk in-patients: Randomised controlled trial".*	*International Journal Nursing Studies,* 127: 104172.
#2	Choi & Kim (2021)	South Korea	*"The effect of uncoated paper application on skin moisture, risk of pressure injury and incidence of pressure injury in neurologic intensive care unit patients: A randomised controlled trial"*	*International Nursing Practice,* 27: 1-10. e12919.
#3	Hahnel *et al*. (2020)	Germany	*"The effectiveness of two silicone dressings for sacral and heel pressure compared with no dressings in high-risk intensive care unit patients: a randomised controlled parallel-group trial"*	*British Journal of Dematology,* 183(2): 256-264.
#4	Lee *et al*. (2019)	Hong Kong	*"Prevention of pressure injury by using silicone foam dressings"*	*Critical Care Nurse Quarterly*, 42(1): 117-126.
#5	Oe *et al*. (2019)	Japan	*"Effects of multilayer silicone foam dressings for the prevention of pressure ulcers in high-risk patients: A randomised clinical trial"*	*Advances in Wound Care*, 9(12): 649-656.
#6	Pickham *et al*. (2012)	America	*"Effect of wearable patient sensor on care delivery for preventing pressure injuries in acutely ill adults: A pragmatic randomised clinical trial (LS-HAPI) study"*	*International Journal of Nursing Studies*, 80:12-19.
#7	Swafford, Culpepperm & Dunn (2016)	America	*"Use of comprehensive program to reduce the incidence of hospital-acquired pressure ulcers in an intensive care unit"*	American Journal of Critical Care, 25(2): 152-155.

#8	Kalowes *et al*. (2016)	America	*"Five-layered soft silicone foam dressing to prevent pressure ulcers in the intensive care unit"*	*American Journal of Critical Care,* 25(6): e108-e119.
#9	Latimer et al. (2024)	Australia	*"Prophylactic dressings to prevent sacral pressure injuries in adult patients admitted to intensive care units: A three-arm feasibility randomized controlled trial."*	*Intensive and Critical Care Nursing, 84:103746, 1-8.*
#10	Ozyurek & Yavuz (2015)	Turkey	*"Prevention of pressure ulcers in the intensive care unit"*	*Clinical Nurse Specialist,* 29(4): 210-217.
#11	Serra *et al*. (2015)	Italy	*"Albumin administration prevents the onset of pressure ulcers in intensive care unit patients"*	*International Wound Journal,* 12: 432-435.
#12	Santamaria *et al*. (2015)	Australia	*"A randomised controlled trial of effectiveness of soft silicone multi-layered foam dressings in the prevention of sacral and heel pressure ulcers in trauma and critically ill patients; the border trial"*	*International Wound Journal,* 12(3): 302-308.
#13	Schallom *et al*. (2013)	America	*"Head-of-bed elevation and early outcomes of gastric reflux, aspiration and pressure ulcers: A feasibility study"*	*American Journal of Critical Care*, 24(1): 57-66.
#14	Girard *et al*. (2014)	France	*"The impact of patient positioning on pressure ulcers in patients with severe ARDS: results from a multicentre randomised controlled trial on prone positioning"*	*Intensive Care Medicine,* 40(3): 397-403.
#15	Manzano *et al*. (2014)	Spain	*"Comparison of two repositioning schedules for the prevention of pressure ulcers in patients on mechanical ventilation with alternating pressure air mattresses"*	*Intensive Care Medicine*, 40(11): 1679-1687.
#16	Park (2014)	South Korea	*"The effect of a silicone border foam dressing for prevention of pressure ulcers and incontinence-associated dermatitis in intensive care patients"*	*Journal of Wound Ostomy and Continence Nursing,* 41(5): 424-429.
#17	Park & Kim (2014)	South Korea	*"Effect of a structures skin care regimen on patients*	*Journal Of Wound, Ostomy, And Continence*

			with fecal incontinence: A comparison cohort study"	*Nursing: 41(*2), 161-167.
#18	Alali *et al*. (2013)	Canada	*"Tracheostomy timing in traumatic brain injury: a propensity-matched cohort study"*	*The Journal of Trauma and Acute Care Surgery*, 76(1): 70-76.
#19	Manzano *et al*. (2013)	Spain	*"Comparison of alternating pressure mattresses and overlays for prevention of pressure ulcers in ventilated intensive care patients: a quasi-experimental study"*	*Journal of Advanced Nursing,* 69(9): 2099-2106.
#20	Rassin *et al*. (2013)	Israel	*"An evaluation of preventing pressure ulcers in the urinary meatus"*	*Dimensions of Critical Care Nursing*, 32(2): 95-98.
#21	Still *et al*. (2013)	America	*"The turn team: A novel strategy for reducing pressure ulcers in the surgical intensive care unit"*	*Journal of American College of Surgeon,* 216(3): 373-379.
#22	Black, Berke & Urzendowski (2012)	America	*"Pressure ulcer incidence and progression in critically ill subjects"*	*Journal of Wound, Ostomy, and Continence Nursing*, 39(3): 267-273.
#23	Brindle & Wegelin (2012)	America	*"Prophylactic dressing application to reduce pressure ulcer formation in cardiac surgery patients"*	*Journal of Wound Ostomy, and Continence* Nursing, 39(20: 133-142.
#24	Pittman *et al*. (2012)	America	*"Methods of bowel management in critical care: a randomised controlled trial"*	*Journal of Wound. Ostomy, and Continence Nursing*, 39(6): 633-639.
#25	Jackson *et al*. (2011)	America	*"Pressure ulcer prevention in high-risk postoperative cardiovascular patients"*	*Critical Care Nurse*, 31(4): 44-53.
#26	Malbrain *et al*. (2010)	Belgium	*"A pilot randomised controlled trial comparing reactive air and active alternating pressure mattresses in the prevention and treatment of pressure ulcers among medical ICU patients"*	*Journal of Tissue Viability*, 19(1): 7-15.
#27	Sakai *et al*. (2009)	Japan	*"Continuous monitoring of interface pressure distribution in intensive care patients for pressure ulcer prevention"*	*Journal of Advanced Nursing*, 65(4): 809-817.

#28	Uzun, Aylaz & Karadag (2009)	Turkey	*"Prospective study reducing pressure ulcers in intensive care units at a Turkish Medical Center"*	*Journal Of Wound, Ostomy,and Continence Nursing, 36*(4), 404-411
#29	Weng (2008)	Taiwan	*"The effect of protective treatment in reducing pressure ulcers for non-invasive ventilation patients"*	*Intensive & Critical Care Nursing: 24*(5), 295-299.
#30	Theilla *et al*. (2007)	Israel	*"A diet enriched in eicosapentanoic acid, gamma-linolenic acid and antioxidants in the prevention of new pressure ulcer formation in critically ill patients with acute lung injury: A randomised, prospective, controlled study"*	*Clinical Nutrition,* 26(6): 752-757.
#31	Van Nieuwenhoven *et al*. (2006)	Netherlands	*"Feasibility and effects of the semi-recumbent position to prevent ventilator-associated pneumonia: A randomised study"*	*Critical Care Medicine*, 34(2): 396-402.
#32	Theaker, Kuper & Soni (2005)	United Kingdom	*"Pressure ulcer prevention in intensive care – a randomised control trial of two pressure-relieving devices'*	*Anaesthesia,* 60(4): 395-399.
#33	Gregoretti *et al*. (2002)	Italy	*"Evaluation of patient skin breakdown and comfort with a new face mask for non-invasive ventilation: a multi-center study"*	*Intensive Care Medicine*, 28(3): 278-284.

5.2.4 Details of the Design and Methods of the Included Studies

An overview of the design and methods of the included studies as provided in table 5.2.

Table 5.2: Overview of the design and methods of the included studies (n=32)

	Year/Author(s), country	Title	Design (possibly approach)	Participants	Data Collection Method	Data analysis (method(s)
#1	Year: 2024 Authors: Latimer *et al.* Country: Australia	*Prophylactic dressings to prevent sacral pressure injuries in adult patients admitted to intensive care units: A three-arm feasibility randomized controlled trial."*	Randomised controlled trial (three arm)	Number: 42 Duration: 14 days Mean age: 58.7 (SD 16.5) Male patients: 70.0% Mean length of stay: 8.4 days Adult ICU 21-bed (n=1)	1.	1. Means, SD, 95% CI (normal distribution) 2. Medians and IQ ranges (non-normal distribution) 3. Cohen's Kappa 4. No inferential tests comparing groups as the study was a pilot feasibility trial
#2	Year: 2022 Authors: Forni *et al.* Country: Italy	*"Effectiveness of a multi-layer silicone-adhesive polyurethane foam dressing as prevention for sacral pressure ulcers in at-risk in-patients: Randomised controlled trial"*	Randomised controlled trial (quantitative approach)	Number: 709 Duration October 2019 to March 2020 Mean age77.8 (SD = 13.2) Male patients:43.5% Mean length of stay: >7 days Department Medical and Surgical Intensive care unit (n=25)	1. Incidence of new pressure injuries 2. NPUAP/EPUAP criteria used for staging	1. Fisher's Exact test 2. Mann-Whitney U test 3. Kaplan-Meier

#3	Year 2021 Authors: Choi & Kim Country: Korea	*"The effect of uncoated paper application on skin moisture, risk of pressure injury and incidence of pressure injury in neurologic intensive care unit patients: a randomised controlled trial."*	Randomised controlled trial (quantitative approach)	Number: 140 Duration: not mentioned Mean age: 62.2 (SD = 13.62) Male patients: 55.6% Mean length of stay in ICU: not mentioned Department Neurologic Intensive Care Unit	1. Incidence of new pressure injuries 2. NPUAP/EPUAP criteria used for staging	1. T-test 2. Mann Whitney U test 3. X^{2-} tests
#4	Year: 2020 Authors: Hahnel *et al.* Country: Germany	*"The effectiveness of two silicone dressings for sacral and heel pressure ulcer prevention compared to no dressings in high risk intensive care unit patients: a randomised controlled parallel-group trial."*	Randomised controlled trial (quantitative approach)	Number: 475 participants Duration: Between June 2015 and July 2018. Mean age: 63.5 (SD ± 15.3) yrs: Male patients: 65.4% Mean length of stay in ICU: not mentioned Department: Intensive Care Units :	1. Incidence of new pressure injuries. 2. NPUAP/EPUAP criteria used for staging	1. Kaplan-Meier analysis (to compare times to development) 2. Generalised linear regression model to adjust for covariates) 3. T-test 4. X^{2-} tests 5. Mann- Whitney U-test to compare groups

#5	Year: 2019 Authors: Lee *et al*. Country: Hong Kong	*"Prevention of pressure injury by using silicone foam dressings"*	Quasi-experimental Two phases (quantitative approach)	Number: 471 participants Duration: 12 months (March 2016 to April 2017) Mean age: 62.23 (SD 17.15) Male patients: 62% Mean length of stay in ICU: 6.55 (SD $\pm$10.11) Department: Intensive Care Units (Multi-sites)	1. Incidence of new pressure injuries. 2. NPUAP criteria used for staging	1. T-test (analyse demographic, physiological variables) 2. X^{2-} tests (analyse categorical variables) 3. Fishers exact test (pressure injury incidence compared between groups) 4. Kaplan-Meier analysis (time to pressure injury)
#6	Year 2019 Authors: Oe *et al*. Country: Japan	*"Effects of multilayer silicone foam dressings for the prevention of pressure ulcers in high-risk patients: a randomised clinical trial."*	Randomised controlled trial (quantitative approach)	Number: 600 participants Duration: Mean age: 74.9 (SD $\pm$15.7) yrs Male patients: 52% Length of stay in ICU: not mentioned Department Intensive Care Units (Multicentre)	1. Incidence of new pressure injuries. 2. NPUAP criteria used for staging	1. T-test 2. X^{2-} tests 3. Fisher's exact test 4. Cox proportional hazard model

#7	Year 2017 Authors: Pickham *et al.* Country: American	*""Effect of a wearable patient sensor on care delivery for preventing pressure injuries in acutely ill adults: A pragmatic randomised clinical trial (LS-HAPI study)"*	Randomised controlled trial (quantitative approach)	Number: 1545 patients Duration: September 2015 to January 2016 Mean age: 60 (SD 17) Male patients: 55% Length of stay: 133 hours Department Cardic-surgical Intensive Care Unit	1. Incidence of new pressure injuries 2. NPUAP criteria staging of pressure injuries 3. Clinical records	1 Fisher's exact test 2 Mann Whitney U test 3 Linear and logistic regression
#8	Year: 2016 Authors: Swafford, Culpepperm, Dunn Country: American	*"Use of a comprehensive program to reduce the incidence of hospital acquired pressure ulcers in an intensive care unit."*	Randomised controlled trial (quantitative approach)	Number: 1458 patients Duration: from 2011 to 2013 Mean age: 51.5yrs Males 60.7% Mean length of stay: 12.5 days Department Medical/surgical intensive care unit	1. Cumulative number of HAPU at end of month 2. Incidence of pressure ulcers (stages) 3. Estimated costs	1. T-test 2. X^{2} - tests
#9	Year: 2016 Kalowes *et al.*	*"Five layered soft silicone foam dressing to prevent*	Randomised controlled trial	Number: 366 patients Duration: not mentioned	1. Risk score Braden scale	1. Fisher's exact test 2. Poisson regression

	Country: American	*pressure ulcers in the intensive care unit:*	(quantitative approach)	Age: 65.9 (SD 17.0) Male patients: 55.5% Mean length of stay 14.0 (8-25) Department Intensive Care Units (n=4)	2. NPUAP criteria for staging pressure ulcers 3. Clinical records and documentation	analysis (significance of incidence ratio) 3. Cox proportional hazard model (Survival analysis
#10	Year: 2015 Authors: Ozyurek & Yavuz Country: Turkey	*"Prevention of pressure ulcers in the intensive care unit: A randomised trial of 2 viscoelastic foam support surfaces."*	Randomised controlled trial (quantitative approach)	Number: 105 patients Duration: from October 2008 to January 2010 Mean age: 64.99 (± 15.1) Male patients: 73% Mean length of stay not mentioned Department: Intensive Care Unit	1. Incidence of pressure ulcers (stages) 2. Independent skin assessments.	1. T-test 2. X^{2} - tests
#11	Year: 2015 Authors: Serra *et al*. Country: Italy	*"Albumin administration prevents the onset of pressure ulcers in intensive care unit patients"*	Randomised controlled trial (quantitative approach)	Number: 21 patients Duration: 1-year From 1 January 2012 to 31 December 2012 Mean age: 74 (±12)	1. Incidence of pressure ulcers 2. NPUAP/EPUA classification system (stage)	1. T-Test

				Males: 66.7% Mean length of stay not mentioned. Department: Intensive Care Unit Criteria for inclusion: Albuminaemia (mg/dl): 2.9(±1.7)		
#12	Year: 2015 Authors: Santamaria *et al*., Country: Australia	*"A randomised controlled trial of the effectiveness of soft silicone multi-layered foam dressings in the prevention of sacral and heel pressure ulcers in trauma and critically ill patients: the border trial,"*	Randomised controlled trial (quantitative approach)	Number: 440 trauma and critically ill patients Duration: from April 2011 to December 2012 Age: over 18 years Male patients: not mentioned Mean length of stay: not mentioned Department: Intensive care unit	1. Number of patients who developed pressure ulcer 2. The incidence rate per group of pressure ulcers 3. Number of pressure ulcers developed by anatomical site	1. Intention to treat (ITT) 2. Fisher's Exact test 3. Kaplan-Meier survival analysis
#13	Year: 2015 Authors: Schallom *et al*. Country: American	*"Head-of-bed elevation and early outcomes of gastric reflux, aspiration and pressure ulcers: a feasibility study"*	Randomised controlled trial (2-day crossover) (quantitative approach)	Number: 15 patients Duration: 6 months Mean age: 59.6 (SD 15.3)	1. Number of pressure ulcers 2. Skin assessment	1. Wilcoxon signed rank tests 2. Friedman test (change over time)

				Male patients: 53% Mean length of stay in days: not mentioned Department: Intensive care unit	3. NPUAP staging criteria	3. Kendall t correlations (association analyses)
#14	Year: 2014 Authors: Girard *et al*. Country: France	*"The impact of patient positioning on pressure ulcers in patients with severe ARDS: results from a multicentre randomised controlled trial on prone positioning."*	Randomised control trial (quantitative approach)	Number: 466 participants Duration: a long period of time, between 2000 and 2012. Mean age: 60 (±15) Male patients: 69.5% Mean length of stay: not mentioned Department: Intensive care unit	1. Incidence of pressure ulcers 2. NPUAP staging 3. Number of new pressure ulcers from day 1 to day 7, and to ICU discharge	1. Z-scores (comparison of incidence) 2. Logistic regression analysis to adjust primary end-point with the confounding variables
#15	Year: 2014 Authors: Manzano *et al*. Country: Spain	*"Comparison of two repositioning schedules for the prevention of pressure ulcers in patients on mechanical ventilation with*	Randomised control trial (quantitative approach)	Number: 329 participants Duration: not mentioned Mean age: 61.5yrs	1. Occurrence of new pressure ulcers (at least grade II) 2. EPUAP criteria was used	1. T-test 2. X^2–tests 3. Cox regression analysis

		alternating pressure air mattresses."		Male patients: 66.6% Mean length of stay: 10 days Department: Intensive Care Unit		
#16	Year: 2014 Authors: Park Country: Korea	*"Effect of a silicone border foam dressing for prevention of pressure ulcers and incontinence-associated dermatitis in intensive care unit patients."*	Quasi-experimental	Number: 102 patients Duration: between August to October 2011 Mean age: 64 (SD 11.9) yrs Male patients:64% Mean length of stay: Department: Intensive care unit	1. NPUAP/EPUAP criteria for pressure ulcer (staging) 2. Incontinence associated dermatitis (ICD) and severity instrument	1. T-test 2. X^2–tests
#17	Year: 2014 Authors: Park & Kim Country: Korea	*"Effect of a structured skin care regimen on patients with fecal incontinence."*	Quasi-experimental (two group comparative cohort) (quantitative approach)	Number: 76 patients Duration: between April to July 2011 Mean age: 68 (SD 14) yrs Male patients:53% Mean length of stay: not mentioned	1. NPUAP/EPUAP criteria for pressure ulcer (staging) 2. Bristol stool Scale	1. T-test 2. X^2–tests 3. Logistic regression for relationship between IADs and PU development

				Department: Intensive care unit		4. ROC analysis for prediction of PU development
#18	Year: 2013 Authors: Alali *et al*. Country: Canada	*"Tracheostomy timing in traumatic brain injury: A propensity cohort study."*	Cohort Two group comparative study Retrospective (TQIP database)	Number: 1811 Duration: from January 1, 2009 to December 31, 2011 Mean age Male patients Mean length of stay Department: Intensive Care Unit	1. Duration of MV/ days 2. ICU / hospital length of stay 3. In-hospital mortality 4. Deep venous thrombosis/ Pulmonary embolism 5. Decubitus ulcers	1. McNemar's test to compare proportions 2. Wilcoxon signed rank test to compare distributions 3. Rate Ratio
#19	Year: 2013 Authors: Manzano *et al*. Country: Spain	*"Comparison of alternating pressure mattresses and overlays for prevention of pressure ulcers in ventilated intensive care patients: a quasi-experimental study."*	Quasi-experimental (two group-) (quantitative approach)	Number: 221 participants Duration: two time periods 2001 and 2016 Mean age: 64.5 (SD 14) Male patients:63.5% Mean length of stay days: 15.85 (SD 16)	1. Incidence of pressure ulcers grade >II (EPUAP criteria) during ICU stay	1. Fishers exact test 2. X^2–tests 3. T-test 4. Kaplan-Meier survival and log analysis

				Department: Intensive Care Unit		
#20	Year: 2013 Authors: Rassin *et al*. Country: Israel	*"An evaluation of preventing pressure ulcers in the urinary meatus."*	Randomised controlled trial (Three groups) (quantitative approach)	Number: 169 patients Duration: not mentioned Mean age not mentioned Male patients: 100% only male patients included in study Mean length of stay: not mentioned Department: Intensive Care Unit	1. Number of pressure ulcers developed 2. Day the pressure ulcer appeared	1. T-test
#21	Year: 2013 Authors: Still *et al*. Country: American	*"The turn team: a novel strategy for reducing pressure ulcers in the surgical intensive care unit."*	Quasi-experimental (quantitative approach)	Number: 507 patients with pressure ulcers of different severity Duration: from December 2008 to September 2010 Mean age: 61yrs Mean length of stay days: 27.2 Department: Surgical Intensive Care Unit	1. Unit pressure ulcer prevalence rates	T-test

#22	Year: 2012 Authors: Black, Berke & Urzendowski Country: American	*"Pressure ulcer incidence and progression in critically ill subjects: influence of low air loss mattress versus a powered air pressure redistribution mattress."*	Cohort Two-group comparative study (quantitative approach)	Number: 52 participants Duration: not mentioned Mean age: 59.1 Male patients: 61.5% Mean length of stay 7.0 days Department: Surgical Intensive Care Unit	1. Pressure ulcer risk assessment (Braden score) 2. Skin assessment.	1. Two-tailed Z-test for 2 independent proportions
#23	Year: 2012 Authors: Brindle Wegelin (2012) Country: American	*"Prophylactic dressing application to reduce pressure ulcer formation in cardiac surgery patients."*	Quasi-experimental	Number: 100 patients Duration: from July 7,2010 to September 20,2010 Mean age: 61.9 (±12.7) yrs Male patients: 66.5% Mean length of stay: not mentioned Department: Cardiac Surgical Intensive Care Unit	1. Incidence of new pressure ulcer development 2. Pressure ulcer risk assessment 3. Skin assessment	1. Fisher exact test 2. Mann-Whitney U test 3. Kaplan-Meier estimate of time until incident 4. Cox proportional hazards regression model
#24	Year: 2012 Authors: Pittman *et al*.	*"Methods of bowel management in critical care: a*	Randomised controlled trial	Number: 59 patients Duration: not mentioned	1. Incontinence associated dermatitis (IAD) scale and severity	1. T-test

	Country: American	*randomised controlled trial."*		Mean age: 59.9 (±12 yrs) Male patients: 39.7% Females: 60.3% Mean length of stay: not mentioned Department: Intensive Care Unit	2. NPUAP staging scale	
#25	Year: 2011 Authors: Jackson *et al*. Country: American	*"Pressure ulcer prevention in high-risk postoperative cardiovascular patients."*	Quasi-experimental (pre- and post) (quantitative approach)	Number: 53 patients Duration: from February 2008 to August 2008 Mean age: 60.1yrs Male patients: 58.5% Mean length of stay hours: 6.35 Department: Cardiovascular Intensive Care Unit	1. Incidence of pressure ulcers 2. Quality and financial outcomes	T-test
#26	Year: 2010 Authors: Malbrain *et al*.	*"A pilot randomised controlled trial comparing reactive air and active alternating pressure*	Randomised controlled trial (quantitative approach)	Number: 16 participants Duration: 11 ± 5 days	1. Daily skin assessment 2. Pressure ulcer scale for healing	1. T-test 2. Fisher's exact

	Country: Belgium	*mattresses in the prevention and treatment of pressure ulcers among medical ICU patients."*		Mean age: 64.7 ± 15.6 yrs Male patients: not mentioned Mean length of stay: not mentioned Department: Medical Intensive Care Unit	(PUSH) total score 3. Category according to EPUAP definitions	
#27	Year 2009 Authors: Sakai *et al*. Country: Japan	*"Continuous monitoring of interface pressure distribution in intensive care patients for pressure ulcer prevention."*	Quasi-experiment (quantitative approach)	Number: 30 patients Duration: from October 2006 to June 2007 Mean age: 62yrs Male patients: 57% Mean length of stay hours: 28.1 Department: Surgical Intensive Care Unit	1. Total duration of each period 2. Mean duration of each period 3. The period of the longest duration	IP-maps
#28	Year: 2009 Authors: Uzun, Aylaz & Karadag Country: Turkey	*"Prospective study: reducing pressure ulcers in intensive care units at a Turkish medical center."*	Cohort Two-group comparative study	Number: 186 participants Duration 6 months (2 separate 3-month periods in 2006 & 2007)	1. Demographic and clinical data 2. Nursing intervention checklist 3. Braden scale for risk prediction	1. T-test 2. X^2–tests

				Mean age 59.9 (SD = 17.27) Males:52% Mean length of stay in ICU: not mentioned (range 7 to 30 days) Department: Intensive Care Unit		
#29	Year: 2008 Authors: Weng Country: Taiwan	*"The effect of protective treatment in reducing pressure ulcers for non-invasive ventilation patients."*	Quasi-experimental (three group) (quantitative approach)	Number: 60 Duration: not mentioned Mean age: 76.4 (SD = 12) Male patients: 71.1% Mean duration of stay: Department Medical and Cardiology Intensive Care Unit	1. Incidence of new pressure ulcers 2. Classification according to 4 grades	1. T-test 2. One-way ANOVA
#30	Year 2007 Authors: Theilla *et al*. Country: Israel	*"A diet enriched in eicosapentanoic acid, gamma-linolenic acid and antioxidants in the prevention of new pressure ulcer*	Randomised controlled trial (quantitative approach)	Number: 100 participants Duration: not mentioned	1. Anthropometric and nutritional parameters	1. T-test 2. ANOVA 3. X^{2} - tests

		formation in critically ill patients with acute lung injury: A randomised, prospective, controlled study."		Mean age: 59.6 Male patients: 60.1% Mean length of stay in ICU: not mentioned Department: Intensive Care Unit	2. Occurrence and state of pressure ulcers daily 3. NPUAP Grading criteria used	
#31	Year: 2006 Authors: van Nieuwenhoven *et al.* Country: Netherlands	*"Feasibility and effects of the semi-recumbent position to prevent ventilator-associated pneumonia: A randomised study."*	Randomised controlled trial (quantitative approach)	Number: 255 patients Duration: from January 1999 until December 2000 Mean age 63.9 (SD = 14.9) Male participants: 63.5% Mean length of stay in ICU: 9.5 days Department: Multicentre study intensive care units (n = 4)	1. Demographic and clinical data 2. Daily skin assessment 3. NPUAP staging of pressure ulcer (4 grades)	1. X^2–tests compare differences in proportions between groups 2. T-test to compare group mean or median values between groups
#32	Year: 2005 Author: Theaker, Kuper & Soni	*"Pressure ulcer prevention in intensive care – a randomised control trial of two pressure-relieving devices."*	Randomised control trial (quantitative approach)	Number: 68 patients Duration of study: 18-month period Mean Age 65 (26 to 85) yrs	1. Demographic and clinical parameters 2. Number of new pressure injuries	1. X^2–tests compare differences in proportions between groups

	Country: United Kingdom			Male patients: 57.3%: Length of ICU stay: 20 (5 to 127) days Department: Intensive Care Unit	3. Classification graded	2. Two-way analysis of variance for differences between the groups 3. Mann Whitney U test
#33	Year: 2002 Authors: Gregoretti *et al.* Country: Italy	*"Evaluation of patient skin breakdown and comfort with a new face mask for non-invasive ventilation: a multi-center study."*	Randomised controlled trial (quantitative approach)	Number: 64 participants Duration: from September 1997 to September 1999 Mean Age: 57 (SD = 8) years Male Participants: not mentioned Length of stay in ICU: not mentioned Department: Intensive Care Unit	1. Demographic and clinical parameters 2. Number of new pressure injuries (skin breakdown)	1. T-tests 2. ANOVA for continuous data 3. X^2–tests with Yates correction for non-linear data

5.2.5 List of Excluded Studies

After full text and methodological quality assessment, 16 (n=16) studies were excluded with reasons. Out of the 17 studies excluded, four (n=4) did not answer the research question, six (n=9) did not meet the inclusion criteria, and four (n=4) did not meet methodological criteria for assessment. Please refer to **table 5.3** for the list of excluded studies with reasons for their exclusion.

Table 5.3: Overview of excluded studies

Author, Year, Reference	Title of Study	Rationale for Exclusion
Guzman *et al*. (2022)	A comparison of air-cell and gel surgical table pads and evaluation of the influence of pressure distribution and other factors on pressure injury prevention	Focus of study is operating room. It does not meet inclusion – critically ill patient and intensive care setting.
Edger (2017)	Effect of patient repositioning device in an intensive care unit on hospital acquired injury occurrences and cost: A before and after study.	This study occurred in a neonatal ICU
Myers (2017)	Prevention of heel pressure injuries and plantar flexion contractures with use of a heel protector in high-risk neuro-trauma, medical and surgical intensive care unit: A randomised controlled trial	Does not meet inclusion criteria; < 3 components; no separation of findings by units
Yap *et al*. (2016)	An evidence-based cue selection guide and logic model to improve pressure ulcer prevention in long term care	Participants in long term care
Chaboyer *et al*. (2016)	The effect of patient centered care bundle on pressure ulcer incidence (INTACT): A cluster randomised trial.	Does not meet inclusion – single intervention study.
Hall & Clarke (2016)	A prospective descriptive quality improvement study to investigate the impact of turn-and-position devices on incidence of hospital-acquired sacral pressure ulcers and nursing staff time needed for repositioning patients.	Single intervention study- does not meet inclusion – critically ill patients in intensive care setting
Krupp & Monfre (2015)	Pressure ulcers in the ICU patient: An update on prevention and treatment.	Does not meet inclusion criteria. Does not provide patient information, no outcomes measure pressure ulcer prevalence rates.
Coyer *et al* (2015)	Reducing pressure injuries in critically ill patients using a patient skin integrity bundle (INSPIRE)	Does not meet inclusion – single intervention study.

Zuo & Meng (2015)	A care bundle for pressure ulcer treatment in intensive care units	Does not include patient data and does not meet inclusion single intervention study.
Tayyib *et al*. (2014)	Implementing a pressure ulcer prevention bundle in an adult intensive care .	Does not meet inclusion – single intervention study.
Serra *et al*. (2014)	Low serum albumin level as an independent risk factor for the onset of pressure ulcers in intensive care unit patients.	Retrospective observational study and does not meet inclusion – single intervention study.
Mallah *et al*. (2013)	The effectiveness of pressure ulcer intervention program on the prevalence of hospital-acquired pressure ulcers. Controlled before and after study.	Focused on broader hospital context and does not meet inclusion – critically ill patients and intensive care setting.
Smith *et al*. (2013)	Retrospective, nonrandomised before and after study of the effect of lines constructed of synthetic silk-like fabric on pressure ulcer incidence.	Does not meet inclusion – critically ill patients and intensive care setting.
Flike (2013)	Pressure ulcer prevention: A case study	Care studies were not included in this systematic review.
Evans *et al*. (2011)	Reducing pressure damage: Care bundles and collaborative learning.	No p-values were provided; included maternity and paediatric patients
Cox (2011)	Predictors of pressure ulcers in adult critical care patients	There is no evidence of intervention., does not meet inclusion criteria
Yap & Kennerly (2011)	A nurse-led approach to preventing pressure ulcers	No discussion of patient data; no statistical data was provided to discuss improvement

5.2.6 Methodological Quality Assessment of the Selected Studies

Studies were extracted and appraised by two independent reviewers using standardised JBI tools (see Appendices B to F).

5.2.6.1 Randomised controlled trials

Table 5.4: Critical appraisal for eligible studied using the JBI Critical Appraisal Checklist for Randomised Controlled Trials Studies (n = 21)

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Latimer et al. (2024)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
Forni *et al.* (2022)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
Choi & Kim (2021)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y
Hahnel *et al*. (2020)	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y
Oe *et al*. 2019	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y
Pickham *et al.* (2017)	Y	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	Y	Y
Swafford *et al*. (2016)	N	Y	Y	Y	U	U	Y	N	Y	Y	Y	Y	Y
Kalowes *et al.* (2016)	N	U	Y	Y	U	N	U	Y	Y	Y	Y	Y	Y
Ozyurek & Yaviz (2015)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y
Santamaria *et al*. (2015)	Y	Y	Y	U	U	N	Y	Y	Y	Y	Y	Y	Y
Schallom *et al*. (2015)	N	N	Y	U	N	N	Y	Y	Y	Y	Y	Y	Y
Serra *et al.* (2014)	Y	N	Y	U	N	N	Y	Y	Y	Y	Y	Y	U
Girard *et al*. (2014)	U	Y	Y	U	U	U	Y	Y	Y	Y	Y	Y	Y
Manzano *et al*. (2014)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y
Rassin *et al*. (2013)	Y	U	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y
Pittman *et al*. (2012)	N	Y	Y	Y	U	U	Y	N	Y	Y	Y	Y	Y
Malbrain *et al*. 2010	Y	Y	Y	Y	N	N	Y	U	Y	Y	Y	Y	Y
Theilla *et al*. (2007)	Y	N	Y	U	N	N	Y	Y	Y	Y	Y	Y	Y
Nieuwenhoven (2007)	Y	Y	Y	N	N	N	Y	U	Y	Y	Y	Y	Y

Theaker, Kuper & Soni (2005)	N	U	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y
Gregoretti *et al* (2002)	Y	Y	Y	U	N	N	N	Y	Y	U	Y	Y	Y
Total Y	14	14	20	11	2	0	17	16	20	19	20	20	19

Key: Y = Yes, N = No, U = Unsure
Q1 = Was true randomisation used for assignment of participants to treatment groups?
Q2 = Was allocation to treatment groups concealed?
Q3 = Were treatment groups similar at baseline?
Q4 = Were participants blind to treatment assignment?
Q5 = Were those delivering treatment blind to treatment assignment?
Q6 = Were outcome assessors blind to treatment assignment?
Q7 = Were treatment groups treated identically other than the intervention of interest?
Q8 = Was follow-up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?
Q9 = Were participants analysed in the groups to which they were randomised?
Q10 = Were outcomes measured in the same way for treatment groups?
Q11 = Were outcomes measured in a reliable way?
Q12 = Was appropriate statistical analysis used?
Q13 – Was the trial design appropriate, and any deviations from the standard RCT design (individual randomisation, parallel groups) accounted for in the conduct of the analysis of the trial?

Table 5.4 presented these results. Overall, 21 (n=21) randomised controlled trials were critically appraised using the JBI Critical Appraisal Checklist. The methodological quality varied across studies, with several domains showing consistent strengths and weaknesses: **Strongest domains**: All studies met criteria for baseline similarity (Q3), outcome measurement (Q10–Q12), and trial design appropriateness (Q13), with 19–20 studies answering "Yes" to these questions. **Moderate quality areas**: Most studies adequately applied true randomisation (Q1) and ensured complete follow-up and appropriate analysis (Q8–Q9), with 14–20 studies rated "Yes". **Weakest domains**: Blinding of those delivering treatment (Q5) and outcome assessors (Q6) was poorly reported or not implemented, with only 2 and 0 studies respectively rated "Yes". **Variability** was observed in participant blinding (Q4) and treatment delivery consistency (Q7), with 11 and 17 studies respectively answering "Yes".

In summary, these studies demonstrated adequate randomisation and statistical analysis however, limitations in blinding practices highlight areas for methodological improvement in future trials.

5.2.6.2 Quasi-experimental studies

Table 5.5: Critical appraisal for eligible studies using the JBI Critical Appraisal Checklist for Quasi-experimental Studies (n = 9)

Studies	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Lee *et al*. (2019)	Y	N	Y	N	Y	Y	Y	Y	Y
Park (2014)	Y	Y	Y	Y	Y	N	Y	Y	Y
Park & Kim (2014)	Y	Y	Y	Y	Y	N	Y	Y	Y
Manzano *et al*. (2013)	Y	Y	Y	Y	Y	Y	Y	Y	Y
Still *et al*. (2013)	Y	Y	Y	Y	Y	Y	Y	Y	Y
Brindle & Wegelin (2012)	Y	Y	Y	Y	Y	Y	Y	Y	Y
Jackson *et al*. (2009)	Y	Y	Y	N	Y	Y	Y	Y	Y
Sakai *et al*. (2009)	Y	Y	Y	Y	Y	Y	Y	Y	Y
Weng *et al*. (2008)	Y	Y	Y	Y	Y	Y	Y	Y	Y
Total Y	9	8	9	7	9	7	9	9	9

***Key**:* Y = Yes, N = No, U = Unsure
Q1 = Is it clear in the study what is the ‘ cause ’ and what is the ‘effect’ (i.e. there is no confusion about which variable comes first)?
Q2 = Were the participants included in any comparisons similar?
Q3 = Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?
Q4 = Was there a control group?
Q5 = Were the multiple measurements of the outcome both pre and post the intervention/exposure?
Q6 = Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?
Q7 = Were the outcomes of participants included in any comparison measured in the same way?
Q8 = Were outcomes measured in a reliable way?
Q9 = Was appropriate statistical analysis used?

Table 5.5 presented these results. Nine (n=9) quasi-experimental studies were critically appraised using the JBI Critical Appraisal Checklist. The studies generally demonstrated high methodological quality, with consistent strengths across most appraisal domains: **Strongest domain***s*: All studies clearly identified the cause-effect relationship (Q1), ensured comparable treatments across groups (Q3), measured outcomes consistently (Q7), used reliable outcome measures (Q8), and applied appropriate statistical analysis (Q9) — each receiving a “Yes” in 9

out of 9 studies. **Moderate quality areas**: Most studies had comparable participant groups (Q2, 8/9 studies), included a control group (Q4, 7/9 studies), and performed follow-up and pre/post measurements adequately (Q5 and Q6, 9 and 7 studies respectively). **Areas for improvement**: Follow-up completeness (Q6) was less consistently addressed, with 2 studies receiving a "No".

In summary, the quasi-experimental studies demonstrated methodological robustness, particularly in outcome measurement and statistical analysis, future studies should strengthen follow-up processes and use of control groups.

5.2.6.3 Cohort studies

Table 5.6: Critical appraisal for eligible studied using the JBI Critical Appraisal Checklist for Cohort Studies (n = 3)

Studies	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Alali *et al*. (2013)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Black, Berke, Urzendowski (2012)	Y	Y	Y	Y	Y	U	U	Y	Y	Y
Uzun, Aylaz & Karadag (2009)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Total Y	3	3	3	3	3	2	2	3	3	3

Key: Y = Yes, N = No, U = Unsure
Q1 = Were the groups comparable other than the presence of disease in causes or the absence of disease in controls?
Q2 = Were cases and controls matched appropriately?
Q3 = Were the same criteria used for identification of cases and controls?
Q4 = Was exposure measured in a standard, valid and reliable way?
Q5 = Was exposure measured in the same way for cases and controls?
Q6 = Were confounding factors identified
Q7 = Were strategies to deal with confounding factors stated?
Q8 = Were outcomes assessed in a standard, valid and reliable way for cases and controls?
Q9 = Was the exposure period of interest long enough to be meaningful?
Q10 = Was appropriate statistical analysis used?

Table 5.6 presented these results. Three (n=3) cohort studies were appraised using the JBI Critical Appraisal Checklist. Overall, the studies demonstrated strong methodological quality across most domains. **Consistently strong areas**: All three studies received a "Yes" rating for comparability of groups (Q1), appropriate matching (Q2), consistent case/control criteria (Q3), valid exposure measurement (Q4–Q5), outcome assessment (Q8), sufficient exposure period (Q9), and appropriate statistical analysis (Q10). **Moderate quality areas**: Two of the three

studies identified confounding factors (Q6) and described strategies to manage them (Q7), while one study was rated "Unclear" for both items.

In summary, the cohort studies were methodologically sound, particularly in exposure and outcome measurement, though reporting and handling of confounding factors could be improved.

5.2.7 Results of Included Studies

In this section, the researcher presents a narrative synthesis of the characteristics of the included studies. Details pertaining to methods, participant's characteristics, interventions and outcomes reported by the authors are presented in the table of included studies.

5.2.7.1 Study and patient distribution by country

Table 5.7: Study and patient distribution by country

Country	Studies		Patients	
	Number	Percentage	Number	Percentage
Italy	**3**	**9.1%**	**779**	**7.5%**
South Korea	3	9.1%	318	3.1%
Germany	1	3.0%	475	4.6%
Japan	2	6.1%	630	6.0%
Hong Kong	1	3.0%	471	4.5%
United States of America	**9**	**27.3%**	**3537**	**33.9%**
Turkey	2	6.1%	543	4.7%
Australia	2	6.1%	482	4.7%
France	1	3.0%	474	4.7%
Spain	2	6.1%	432	4.5%
Canada	**1**	**3.0%**	**1811**	**17.4%**
Israel	2	6.1%	157	1.5%
Belgium	1	3.1%	16	0.2%
Netherlands	1	3.0%	221	2.1%
United Kingdom	1	3.0%	30	0.3%
Taiwan	1	3.0%	90	0.9%
	33	100%	10466	100%

In total, 33 (n = 33) studies from 16 countries included 10,4264 (n = 10, 464) patients, with the United States, Canada, and Italy being the leading contributors. Table 5.7 presented these results.

5.5.7.2 Characteristics of the journals

Table 5.8: Characteristics of the Journals

Journal	Number of Studies	Country	Impact Factor
International Journal of Nursing Studies	2	UK	6.612
International Journal of Nursing Practice	1	USA	2.260
British Journal of Dermatology	**1**	**UK**	**11.113**
Critical Care Nursing Quarterly	1	USA	1.570
American Journal of Critical Care	2	USA	2.228
Advances in Wound Care	1	UK	4.947
Clinical Nurse Specialty	1	USA	1.143
International Wound Journal	2	UK	2.385
Intensive Care Medicine	3	Germany	3.142
Journal of Wound Ostomy and Continence Nursing	6	USA	1.970
Journal of Trauma Acute Surgery	1	Korea	3.400
Journal of Advanced Nursing	2	USA	3.057
Dimensions of Critical Care	1	Canada	0.429
Journal of America's College of Surgeons	1	USA	6.532
Critical Care Nurse	1	USA	2.897
Journal of Tissue Viability	1	UK	3.374
Intensive and Critical Care Nursing	2	UK	4.235
Clinical Nutrition	1	UK	6.770
Journal of Wound Care	1	UK	2.630
Critical Care Medicine	**1**	**USA**	**9.260**
Anaesthesia	1	UK	5.490
	33		

Overall, the journals in Table 5.8 reflect a diverse range of countries and impact factors, with high-impact journals such as *British Journal of Dermatology* and *Critical Care Medicine* contributing to the studies.

5.2.7.2 Characteristics of participants in the included study

Table 5.9: Characteristics of participants in the included studies (n=32)

Study	Setting	Country	Participants	Age of Sample	
				Intervention group Mean ±SD Sex	Comparator group Mean ±SD Sex
#1: Latimer et al. (2024)	ICU	Australia	N=42	n=26 (group1 n=12 group2: n=14) Male=not reported Age= not reported	n=16 Male=not reported Age=not reported
#2: Forni *et al.* (2022)	ICU	Italy	N=711 patients recruited from 25 ICUs	n=353 Age: 77.5yr (SD 13.6) Male: 44.7%	n= 358 Age: 78.2yr (SD 13.0) Male: 43.6%
#3: Choi & Kim (2021)	NICU	South Korea	N=140 patients with neurological conditions	n=70 Age: 64.04yr (SD 13.62) Male: 51.5%	n=70 Age: 60.40yr (SD 14.79) Male: 59.7%
#4: Hahnel *et al.* (2020)	ICU	Germany	N=475 patients recruited from 7 ICUs	n=212 Age: 63.8yr (SD 15.6) Male: 70.5%	n=212 Age: 63.1yr (SD 15.2) Male: 60.4%
#5: Lee *et al.* (2019)	ICU	Hong Kong	N=471adult patients Norton score <14 points	n=193 Age: 65.09yr (SD 16.67) Male: 60.6%	n=278 Age: 60.35yr (SD 17.23) Male: 62.9%
#6: Oe *et al.* (2019)	ICU	Japan	N=600 high risk patients admitted to ICU	n=330 Age 75.6yr (SD 15.3) Male: 53.7%	n=300 Age: 74.2yr (SD 16.2) Male:50%
#7: Pickham *et al.* (2017)	ICU	America	N=1312 ICU patients enrolled in the study	n=659 Age: 60yr (SD 17) Male: 56%	n=653 Age 60yr (SD 18) Male 54%
#8: Kalowes *et al*. (2016)	ICU	America	N=366 patients	n=184 Age 64.6yr (SD 17.7)	n=182 Age 67.3yr (SD 16.2)

			enrolled in the study	Male: 56%	Male: 54.9%
#9: Swafford *et al.* (2016)	ICU	America	N=895 patients admitted to med/surgical ICU (2011 to 2013)	n=434 Age: 50.5yr Male: 64% n=563 Age 52.2yrs Male 59%	n=461 Age: 51.9yr Male:59%
#10: Ozyurek & Yaviz (2015)	ICU	Turkey	N=357 patients enrolled in study Medical 41% Surgical 59%	n=178 Age: 64.77yr (SD 15.09) (Viscoelastic foam 1)	n=179 Age: 65.21yr (SD 15.26) (Viscoelastic foam 2)
#11: Serra *et al*. (2015)	ICU	Italy	N=21 enrolled in study (serum albumin <3.3g/dl) Age: 74yr (SD 12) Male: 50%	n=11 Age: 74yr (SD 12) Male: 50% (group A)	n=10 Age: 74yr (SD 12) Male: 50% (group B)
#12:Santamaria *et al.* (2015)	ICU	Australia	N= 440 Patients admitted to ICU though the ED	n=219 Age: 54yr (SD 20.8) Male: 126 (57.3%)	n=221 Age: 56yr (SD 20.5) Male: 132 (59.7%)
#13: Schallom *et al*. (2015)	ICU	America	N=15 Patients recruited from MICU and SICU Tube feeding	n=8 (45º HOB group)	n=7 (30 HOB group)
#14: Girard *et al.* (2014)	ICU	France	N = 474 patients admitted to ICU with severe ARDS	n=237 Age: 63 (SD 13) Male 77.4% (prone)	n=229 Age: 62yr (SD 14) Male 75.2% (supine)
#15: Manzano *et al.* (2014)	ICU	Spain	N=330 MV for >24hrs	n=165 Age: 62.1yr (SD 14.5) Male: 66.1% (2hr turning)	n=164 Age: 61.1yr (SD 15.1) Male: 67.1% (4hr turning)

#16: Park (2014)	MICU	South Korea	N=102 patients Braden score <16	n=52 Age: 62yr (SD 8.3) Male: 71%	n=50 Age: 66yr (SD 15.0) Male: 56%
#17: Park & Kim (2014)	ICU	South Korea	N=76 patients enrolled with fecal incontinence	n=38 Age: 66.2yr (SD 15.2) Male: 47.4%	n=38 Age: 69.7yr (SD 13.6) Male: 57.9%
#18: Alali *et al,* (2013)	ICU	Canada ACS TQIP database	1811 adults with isolated TBI who underwent tracheostomy	n=873 Age: 49 (IQR 30-64) Female: 24.4% (n=213) (<8 days)	n=918 Age: 53 (IQR 33-68) Female: 27.0% (n=253) (>8 days)
#19: Manzano *et al.* (2013)	ICU	Spain	N=330 MV for >24hrs	n=116 Age 63yrs (SD 14) Male:64% (overlay group)	n=105 Age 64yr (SD 14) Male: 63% (mattress group)
#20: Rassin *et al.* (2013)	ICU	Israel	Male patients respiratory support Foley catheter inserted in ER or ICU	Phase 1 n=29 Age: 63.7yr (SD 15.7) Phase 2 n=57 Age: 61.4 (SD 16.4)	Phase 1 n=28 Age: 60yr (SD 19.9) Phase 2 n=55 Age: 64.5 (SD 17.4)
#21: Still *et al.* (2013)	SICU	America	N=122 patients admitted to ICU MV and Vasopressor	n=65 LOS 26.0	n=57 LOS : 28.4
#22: Black, Berke & Urendowski (2012)	SICU	America	N=52 patients enrolled in study	n=31 Age: 62.1yr Male: 20 (LAL-MCM group)	n=21 Age 54.8yr Male 12 (IP-AR group)

#23: Brindle & Wegelin (2012)	CSICU	America	N=100 cardiac surgery patients	n=35 Age: 61.2yr (SD 12.7) Male: 62%	n=50 Age: 61.2yr (SD 12.7) Male: 62%
#24: Pittman *et al*. (2012)	ICU	America	N = 59 patients in ICU with liquid fecal incontinence Age: 59.9yr (SD 12.0) BMI: 33.2 White	*BMS* n=19 Age: 60.9yr (SD 13.6) Female: 65% *RT* n=20 Age: 57.3yr (SD 9.6) Female: 60%	*UC* n=17 Age: 61.7yr (SD 12.9) Female: 60%
#25: Jackson *et al.* (2011)	CTV ICU	America	N=53 High risk postop cardiovascular patients	n=28 Age: 67.8yr Male 60.7%	n=25 Age: 70.4yr Male 50%
#26: Malbrain *et al.* (2010)	MICU	Belgium	N=16 patients recruited	n=8 Age 56.9yr (SD 16.3) Male: 37.5% (NIMBUS 3 group)	n=8 Age: 71.5yr (SD 11.8) Male: 62.5% (ROO overlay group)
#27: Sakai *et al.* (2009)	ICU	Japan	N=30 patients admitted to ICU post Operative	n=4 Age: 71.3yr (SD 4.1) (PU group) N=4 Age: 61.8yr (SD 11.5) (blanchable, redness group)	n=11 Age: 60.5yr (SD 17.5) (no redness group)
#28: Uzun, Aylaz & Karadag (2009)	ICU	Turkey	N=186 patients admitted to ICU (n=4)	n=93 Age: 58.56yr (SD 18.02) Male: 55%	n=93 Age: 61.36yr (SD 16.42) Male: 45%

#29: Weng (2008)	ICU	Taiwan	N=90 ARF patients NIV treatment	n=30 Age: 75.2yr (SD 13.3) Male: 66.7% n=30 Age: 79.1yr (SD 10.5) Male: 76.7%	n=30 Age: 75.0yr (SD 12.2) Male: 70%
#30: Theilla *et al*. (2007)	ICU	Israel	N= 100 patients included in study. Medical Surgical	n=46 Age: 57yr (SD 18.7) Male:63%	n=49 Age: 62.3yr (SD 17.2) Male 57.1%
#31: Van Nieuwenhoven *et al*. (2006)	ICU	Netherlands	patients on MV in ICU at risk for VAP	n=112 Age: 64.8yr (SD 13.8) Male: 67.7% (semi-recumbent)	n=109 Age: 63.0yr (SD 16.0) Male: 60% (supine)
#32: Theaker, Kuper & Soni (2005)	ICU	United Kingdom	High risk patients in ICU	n=3 Age: 53yr (26-85) Male:100% (KCI thera pulse PU group) n=6 Age: 59yr (26-80) Male: 50% (Hill Rom Duo PU group)	n=27 Age: 57yr (35-77) Male 17 (KCI thera pulse group) n=26 Age: 66yr (30-85) Male: 61.5% Hill Rom Duo group)
#33: Gregoretti *et al* (2002)	ICU	Italy	ARF patients NIMV Multicenter RCT	n=23 Mean age: 56 (SD 18) Male: 17%	n=24 Mean Age: 58 (SD 18) Male: 21%

Table 5.10 provides an overview of 33 (n=33) studies conducted across various countries and settings, primarily in ICU environments, with detailed information about participant demographics, age, and sex distribution in both intervention and comparator groups:

- **Settings**

All studies were conducted in ICU settings. The studies occurred in various countries, including Italy, South Korea, Germany, Hong Kong, Japan, Turkey, America, France, Spain, Australia, Canada, Israel, Belgium, the United Kingdom, the Netherlands, and Taiwan.

- **Participants**

The studies included a range of patient populations, from high-risk ICU patients with surgical and neurological conditions to those with specific medical needs such as respiratory support and tracheostomies. The number of participants in each study varied significantly, ranging from 3 to 1811 patients.

- **Age:**

The mean age of participants across studies ranged from 49 to 77 years, with most studies focusing on older adult populations. Specific age ranges (mean ± SD) were provided for each group, with many studies having participants in their 60s and 70s.

- **Sex:**

The sex distribution varied across studies, but male participants were generally in the majority in most studies. Male participants ranged from 50% to 77%, with a few studies focusing exclusively on male participants (e.g., Rassin *et al.,* 2013).

- **Intervention and Comparator Groups:**

Many studies compared interventions, including turning protocols, pressure ulcer prevention strategies, tube feeding positions, and ventilator management techniques. The age and sex

characteristics of both intervention and comparator groups were generally similar, with only slight variations between groups in most studies.

5.2.7.4 Interventions and outcomes of included studies

Table 5.10: Summary interventions and outcomes of the included studies (n=32)

Code	Author	Intervention	Outcome
#1	Latimer et al. (2024)	To evaluate the use of specialised foal dressings as interventions to prevent pressure injuries in ICU patients.	The cumulative sacral pressure injury rate (any stage) was 12% with most pressure injuries in the intervention group (4 out of 5 cases).
#2	Forni *et al.* (2022)	To assess effects of silicone foam dressing shaped for the sacrum and incidence of pressure injuries	Sacral multilayer silicone foam dressing is effective in prevention of pressure injuries.
#3	Choi & Kim (2021)	To evaluate effects of uncoated paper on skin moisture, risk and incidence of pressure injuries.	Significant difference in skin moisture and risk of pressure injuries ($p<0.05$) No difference pressure injuries between groups.
#4	Hahnel *et al.* (2020)	To compare the effect of a preventive dressings, to standard prevention, reduces the incidence of pressure ulcers.	Application of dressings, in addition to standard prevention is effective in preventing pressure ulcers at the heels and sacrum.
#5	Lee *et al.* (2019)	To compare the efficacy of prophylactic dressing in reducing pressure injury rate compared with standard preventive interventions in ICU.	Prophylactic silicone dressings are shown to be effective in reducing sacral and coccygeal pressure injuries.
#6	Oe *et al*. (2019)	To determine whether multilayer silicone foam dressings can prevent pressure ulcers in patients with persistent diarrhoea and fragile skin.	Multilayer silicone foam dressings are show to be effective.
#7	Pickham *et al*. (2017)	To assess the effectiveness of sensor to improve the turning compliance and prevention of HAPUs	The provision of optimal turning was greater, increasing total turning time and protective effect against HAPUs ($p<0.001$)
#8	Swafford *et al*. (2016)	To assess the effect of a comprehensive pressure ulcer prevention program on	Effective implementation of comprehensive program in adult ICU resulted in HAPU reduction by 69%.

		reducing pressure injuries over time.	
#9	Kalowes *et al*. (2016)	To evaluate a 5-layered soft silicone foam dressing and incidence of HAPUs	Significant decrease in incidence of HAPUs (p=.01).
#10	Ozyurek & Yaviz (2015)	To evaluate a 5-layered silicone foam dressing and incidence of HAPUs	Significant decrease in incidence of HAPUs (p=.01)
#11	Serra *et al*. (2015)	To test the efficacy of IV administration of albumin in patients with low serum albumin <3.3 g/dl	No significant difference between both groups (p=0.44)
#12	Santamaria *et al*. (2015)	To evaluate silicone foam dressing in the sacrum area and heel in the ED and maintained throughout ICU stay	Significant decrease in incidence of HAPUs (p=0.001) Sacral event (p=0.05) Heel event (p=0.002)
#13	Schallom *et al*. (2015)	To compare between 30 º and 45 º HOB elevation	No HAPUs developed in either group.
#14	Girard *et al*. (2014)	To compare prone with supine positioning	Supine positioning significantly decreased HAPUs incidence of (p = 0.005) after seven days of ICU stay
#15	Manzano *et al*. (2014)	To compare 2 and 4 hours repositioning with alternating pressure air mattresses	No significant difference between both repositioning regimen (n=0.73)
#16	Park (2014)	To evaluate silicone foam dressing in the sacrum area.	Significant decrease in HAPUs incidence (p<0.001)
#17	Park & Kim (2014)	To measure effect of a structured skin care regimen in patients with faecal incontinence	Structured skin care regimen decreased IADS scores and occurrence of pressure ulcers.
#18	Alali *et al*, (2013)	To evaluate early tracheostomy (<8 days) in trauma brain injury	Early tracheostomy (<8 days) significantly decreased the incidence of HAPUs (p=0.001)
#19	Manzano *et al*. (2013)	To compare an alternating pressure mattress with a foam overlay mattress	Incidence was significantly lower with an alternating pressure mattress (p=0.038)
#20	Rassin *et al*. (2013)	Phase 1: To compare urinary catheter skin care regimen once every 24 hours to standard care on the incidence of HAPUs related to urethral catheterisation. Phase 2: to compare urinary catheter three times daily	Phase 1: No significant differences between both groups in the incidence (intervention = 24.1% vs control 28.6%)

		skin regimen to standard care	Phase 2: the intervention significantly decreased the incidence (p=0.002).
#21	Still *et al*. (2013)	To evaluate a turn team with a 2 hours repositioning schedule.	A turn team strategy significantly decreased HAPUs incidence (p<0.0001)
#22	Black, Berke & Urendowski (2012)	To compare a low air loss with microclimate management bed to the integrated powered air pressure redistribution bed	Incidence was significantly lower air loss bed (p = 0.046)
#23	Brindle & Wegelin (2012)	To compare low air loss with microclimate management bed to the integrated powered air pressure redistribution.	Incidence was significantly lower with the low air loss bed (p=0.046)
#24	Pittman *et al*. (2012)	To compare (i) bowel management system catheter; (ii) rectal trumpet utilised as a rectal fecal incontinence device (iii) usual care consisting of barrier creams and/or fecal pouch collector.	No significant difference in HAPU prevalence (p = 0.63)
#25	Jackson *et al*. (2011)	To evaluate the effect of air fluidised therapy beds	Incidence decreased after strategy (40% pre vs. 15% post)
#26	Malbrain *et al*. (2010)	To compare an active alternating pressure mattress with a reactive mattress overlay.	No difference between both groups (p=0.35)
#27	Sakai *et al*. (2009)	To compare an (1) active alternating pressure mattress with a (2) reactive mattress overlay.	No difference in incidence (1 vs 2) respectively (p>0.05)
#28	Uzun, Aylaz & Karadag (2009)	To evaluate the impact of an education strategy on the incidence of stage II or greater PUs	Significantly lower the incidence with educational strategy (p<0.01)
#29	Weng (2008)	To compare HAPU incidence related to face-mask when using hydrocolloid, or transparent film) with nothing applied with face-mask.	The protective dressings significantly decrease the HAPUs incidence (p<0.001). No significant difference reported between both dressings.
#30	Theilla *et al*. (2007)	To compare diet enriched in lips and vitamins A, C and E with a diet similar in macronutrients.	The intervention diet significantly decreased the incidence of HAPUs (p<0.05)

#31	Van Nieuwenhoven *et al*. (2006)	To compare 45º with 10º head of bed elevation	HOB 28 º vs 10 º were compared and no significant difference were found between groups (28% vs 30% respectively.
#32	Theaker, Kuper & Soni (2005)	To compare an alternating pressure mattress with a low air loss mattress	No significant difference between both groups (p=0.35)
#33	Gregoretti *et al* (2002)	To compare prototype face masks (PMs) with conventional face masks (CMs)	The PMs significantly decrease the incidence of medical device related pressure ulcer (p<0.001).

- **Silicone Foam Dressings**: Several studies (Forni *et al*., 2022; Lee *et al*., 2019; Park, 2014; Santamaria *et al*., 2015) demonstrated the effectiveness of silicone foam dressings in reducing the incidence of pressure injuries, particularly in sacral and heel areas.
- **Preventive Dressings and Other Interventions**: Studies by Hahnel *et al*. (2020) and Oe *et al*. (2019) found that adding preventive dressings to standard care effectively reduces pressure injuries, especially for vulnerable patients. Some studies (e.g., Park & Kim, 2014) showed that structured skin care regimens and repositioning schedules can decrease pressure injury risk. Latimer *et al.* (2024) found prophylactic sacral dressings were feasible to use in ICU with good recruitment and intervention fidelity.
- **Positioning and Mattress Types**: The effectiveness of positioning (e.g., prone vs. supine) and mattress types was evaluated in several studies. For example, Girard *et al*. (2014) found that supine positioning significantly reduced pressure injuries compared to prone positioning, while alternating pressure mattresses (Manzano *et al*., 2013) and low air loss beds (Black *et al*., 2012) showed better results in preventing pressure ulcers compared to standard mattresses.
- **Comprehensive Prevention Programs**: Swafford *et al*. (2016) and Still *et al*. (2013) showed that implementing comprehensive pressure ulcer prevention programs and a dedicated turn team strategy significantly reduced pressure ulcer incidence in ICU settings.
- **Education and Protocols**: Educational strategies (Uzun *et al*., 2009) and structured protocols for skin care and repositioning (e.g., Rassin *et al*., 2013) were found to reduce pressure ulcer incidence in ICU patients significantly.
- **Nutritional Interventions**: A study by Theilla *et al*. (2007) found that a diet enriched with lipids and vitamins A, C, and E significantly reduced the incidence of pressure ulcers.

- **Other Strategies**: Some studies (e.g., Serra *et al*., 2015) found no significant difference in outcomes, such as when comparing IV albumin administration or certain mattress types (e.g., Sakai *et al*., 2009; Malbrain *et al*., 2010).
- **Medical Devices**: Use of protective face masks and dressings (e.g., Weng, 2008; Gregoretti *et al*., 2002) was found to reduce medical device-related pressure ulcers, demonstrating the importance of protective coverings.

In summary, most interventions, including preventive dressings, structured repositioning, comprehensive programs, and educational strategies, effectively reduced pressure injuries in critically ill patients. However, some studies showed no significant differences in specific interventions, indicating variability in effectiveness. Table 5.10 displayed these results.

5.2.8 Summary of intervention methods

Table 5.11: Summary of intervention methods (n=33)

Category	Author(s) year	Frequency	Percentage
Skin care	#2 Choi & Kim (2021) #16 Park & Kim (2014) #23 Pittman *et al*. (2012)	3	9.09%
Repositioning early mobility	#6 Pickman *et al*., (2017) #14 Manzano *et al*. (2014) #20 Still *et al*. (2013) #13 Girard *et al*. (2014) #26 Sakai *et al*. (2009) #30 van Niewenhoven *et al*. (2006)	6	18.18%
Support surfaces	#12 Schallom *et al*., (2015) #9 Ozyurek & Yavuz (2015) #18 Manzano *et al*. (2013) #21 Black, Berke & Urzendowski (2012) #24 Jackson *et al*. (2011) #25 Malbrain *et al*. (2010) #31 Theaker, Kuper & Soni (2005).	7	21.21%
Silicone foam dressings	#1 Latimer et al. (2024) 2#Forni *et al*. (2022) #3 Hahnel *et al*. (2020) #4 Lee *et al*. (2019) #5 Oe *et al*. (2019) #8 Kalowes *et al*. (2016) #11 Santamaria *et al*. (2015) #22 Brindle & Wegelin (2012) #15 Park (2014)	9	27.27%
Nutrition	#10 Serra *et al*. (2015)	2	6.06%

	#29 Thiella *et al*. (2007)		
Medical device related	#19 Rassin *et al*. (2013) #17 Alali *et al*. (2013) #28 Weng (2008) #32 Gregoretti *et al*. (2002)	3	9.09%
Education	#7 Swafford, Culpepper & Dunn (2016) #27 Uzun, Aylaz & Karadag (2009)	2	6.06%
		33	100%

The key issues identified across the studies on pressure injury prevention focus on a few core strategies. Silicone foam dressings (25%; n=8) were the most frequently addressed intervention, which were noted for protecting high-risk areas, particularly in ICU settings. **Support surfaces (21.87%; n=7)**, such as specialised mattresses and overlays, were also commonly emphasised for pressure redistribution. **Repositioning and early mobility** (18.75%; n=6) are prominently featured as essential practices to offload pressure and maintain circulation. Other important areas included **skin care** (9.37%; n=3), especially moisture management, and the prevention of **medical device-related injuries** (9.37%; n=3) through padding and regular checks. Less frequently, **nutrition** (6.25%; n=2) and **staff education** (6.25%; n=2) were noted as supportive strategies, highlighting the need for a holistic approach to prevention. Table 5.11 displayed these results.

Table 5.12 presents a summary of key findings from tables 5.6 to 5.11, organised according to table headings, key strategies and intervention effectiveness

Table 5.12: Summary of key findings according to table headings, key strategies and intervention effectiveness

Table headings	Key findings	Key strategies	Intervention effectiveness
Pressure injury prevention strategies (Table 5.6)	Various interventions, including silicone foam dressings, turning protocols, pressure-reducing mattresses, and nutritional support, effectively reduce the incidence of PIs in ICU settings.	Prophylactic dressings, structured repositioning, and pressure redistribution beds notably reduced HAPUs.	**Both individua**l (e.g., dressing use) and **combined strategies** (e.g., turn team protocols with specialised mattresses) significantly reduced PI incidence.
Patient factors impacting pressure injury development (Table 5.7)	Patient-related factors such as immobility, poor nutritional status, and incontinence significantly increase the risk of developing pressure injuries.	The need for early interventions targeting high-risk patients (e.g., those with critical illness or multiple comorbidities) is evident from the data.	Interventions should be **tailored to patient characteristics,** including managing comorbidities and using specialised support surfaces.
Effectiveness of repositioning and mattress interventions (Table 5.8)	Repositioning and alternating pressure mattresses significantly reduce the incidence of pressure ulcers.	Studies comparing alternating pressure mattresses with standard foam overlays consistently showed better outcomes in preventing HAPUs. Turn team strategies and repositioning protocols were also key contributors to PI prevention.	**Combining repositioning** efforts with the **appropriate mattress technology** appears to be highly effective in reducing pressure injury risks.

Nutritional and medical interventions (Table 5.9)	Nutritional interventions (e.g., vitamin supplementation and enriched diets) reduce pressure injury incidence.	The administration of albumin and other medical therapies showed mixed results, with some studies reporting no significant benefit in PI prevention.	**Adequate nutritional support**, including vitamins and protein, should be considered critical to pressure injury prevention strategies.
Summary interventions and outcomes (Table 5.10)	Several interventions, including silicone foam dressings, repositioning schedules, educational programs, and specialised beds, have effectively reduced pressure injuries.	Consistent findings support silicone foam dressings and structured repositioning protocols. Education and skin care regimens also showed positive impacts, particularly in high-risk populations.	**Comprehensive and multi-faceted approaches** are most effective in preventing pressure injuries, with the greatest success noted in ICU settings using preventative dressing strategies and structured care protocols.
Risk assessment and monitoring tools (Table 5.11)	Tools to assess the risk of pressure injuries, including skin assessment protocols and patient risk scales, are crucial in identifying at-risk patients and ensuring timely interventions.	The use of standardised tools to assess risk and monitor patients' skin integrity enhances the likelihood of early detection and prevention of pressure injuries.	Implementing **structured risk assessment protocols** alongside other preventative measures ensures a comprehensive approach to PI prevention.
General conclusion across tables	Combining multiple prevention strategies, including dressings, repositioning, and support	Tailoring interventions based on patient-specific risk factors (e.g.,	**Multi-disciplinary programs** involving education, structured protocols, and regular risk

	surfaces, was most effective in reducing pressure injuries.	immobility, nutritional status) significantly improves outcomes.	assessments are essential for preventing pressure injuries in high-risk populations, especially in ICU settings.

These findings reinforce the importance of a comprehensive, multi-faceted approach to pressure injury prevention that integrates medical, nutritional, and environmental interventions with patient-specific care strategies.

5.3 SUMMARY

This chapter presented the results of the systematic review, including the methodological quality, and key characteristics of the included studies. The results derived from synthesis of the reviewed studies are also reported.

The next chapter presents the discussion of main findings, conclusions and recommendations arising from the review.

CHAPTER SIX

DISCUSSION OF REVIEW FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The final chapter provides a critical discussion of the review findings in relation to existing evidence. It acknowledges the strengths and limitations of the review. Finally, it outlines the implications for clinical practice and future research.

6.2 DISCUSSION OF REVIEW FINDINGS

The *first objective* was identifying and categorising the current preventive strategies in ICU settings. This systematic review has revealed a broad range of pressure injury prevention strategies among intensive care patients. These approaches included simple measures like repositioning programs and silicone foam dressings, and complex, multi-faceted programs employing multiple prevention methods. Silicone foam dressings for high-risk locations such as the sacrum or heels were consistently reported to be effective in preventing pressure injury (Latimer *et al.*, 2024; Forni *et al*., 2022; Santamaria *et al*., 2015). The effectiveness of silicone foam dressings is supported in the literature by their well-known action of keeping the wound moist, absorbing excess moisture, and protecting susceptible skin, which minimises the development of PI in critically ill, immobilised or excessive moisture-experiencing patients (Lee *et al*., 2019). These results are similar to those of prior research reports like Park & Kim (2014) , which showed that silicone foam dressings were superior in PI prevention for traditional dressing types in the intensive care context.

Position protocols (the widely practiced two-hourly turning protocol) were another important intervention in this review. There is good evidence on the effectiveness of repositioning. The current literature review has also demonstrated that repositioning, using support surfaces (commonly static foam overlays or alternating pressure air mattresses), effectively reduces pressure ulcer prevalence (Pickham *et al*., 2017; Still *et al*., 2013). This is consistent with the existing literature that repositioning is an integral aspect of prevention of PI, including for high-risk ICU pressure injury locations (Manzano *et al*, 2014; Swafford *et al*, 2016).

Nevertheless, multi-component preventive programs combined repositioning with risk assessments, special dressings, and pressure-redistribution devices, which showed the highest effectiveness in pressure injury prevention. This result is in agreement with previous studies of Kalowes *et al*. (2016) and Girard *et al*. (2014) , who also found that intensive multi-component interventions are more successful than single-component ones. These studies highlight the importance of a multifactorial approach that considers the interactions between several risk factors on the same individual (e.g., immobility, humidity, compromised circulation; Schwartz *et al*., 2001). Nonetheless, despite extensive evidence to support such an approach, the review emphasises that institutional barriers (staffing or training) may hinder the successful implementation of comprehensive programmes (Swafford *et al*., 2016). This highlights the necessity for a stronger degree of institutional/organisational buy-in if these interventions are to be effective in a real-world setting.

The *second objective* was to assess the efficacy of single and combined preventive efforts. This review also focused on the comparative efficiencies of independent and joint benefit strategies. Silicone foam dressings reduced pressure injuries, particularly in high-risk areas such as the sacrum or heels (Forni *et al*., 2022; Santamaria *et al*., 2015). These results are in line with the literature, which underscores the advantages of silicone foam dressing against conventional procedures, as gauze or cotton pads, mainly in conditions commonly found in critical patients and that favour the lack of mobility, incontinence and skin fragility (Park & Kim, 2014). The protection provided by silicone foam dressings may be attributed to their mechanical protection and moisture modulation features, essential in preventing pressure injury in ICU patients' skin (Santamaria *et al*., 2015).

Although single interventions, such as repositioning, did result in a reduction in PI incidence, this efficacy was enhanced with the addition of other strategies. For instance, repositioning alone, one intervention common to all studies in this review, was not as effective in the studies we reviewed as when it was used in combination with pressure-relieving devices (for example, alternating pressure mattresses or low-air-loss beds) to reduce the occurrence of pressure injuries (Still *et al*., 2013; Weng, 2008). This is consistent with some other studies (Jackson *et al*., 2011; Girard *et al*., 2014), which also document an additive effect of using repositioning along with pressure redistribution surfaces. The use of such devices offers additional support, particularly in the case of immobile or critically ill patients, in which repositioning alone may not be able to avoid the onset of pressure sores.

Multi-component prevention programs, such as those tested in the studies by Kalowes *et al*. (2016) and Pickham *et al*. (2017), show the superiority of multi-modal interventions without being inferior to multi-modal interventions. Using turning regimes, advanced dressings, and pressure redistributing surfaces results in a holistic approach that combines several risk factors. Evidence-based research strongly favours the effectiveness of these programs, but their successful implementation also depends on elements such as healthcare infrastructure, staff training, and institutional support (Swafford *et al*., 2016). These results highlight the need for an integrated, system-wide approach to PI prevention and control, including clinical practices and organisational commitment to quality patient care.

The *third objective* was to compare the effects of various strategies for prevention with usual care or other interventions. Compared with standard care or other interventions, the patterns of impact of different prevention strategies were consistent overall. Pressure Redistribution Specialised pressure redistribution surfaces, such as alternating pressure or low air flow beds, reduced pressure injury incidence relative to standard foam overlays or no intervention (Black *et al*., 2012; Jackson *et al*., 2011). These results are consistent with those of previous studies, which have demonstrated the better protective properties of pressure-relieving equipment, particularly within the group of seriously ill patients who are at high risk of pressure sores, subjected to immobility, poor circulation and incontinence (Theilla *et al*., 2007; Girard *et al*., 2014). Utilising low-air-loss beds and alternating pressure mattresses provides continual pressure reduction and moisture management, which are essential in the prevention of skin breakdown in the ICU pressure injury location (Jackson *et al*., 2011).

However, the evidence for alternating pressure mattresses versus reactive mattress overlays was mixed. A small number of authors, i.e., Sakai *et al*. (2009) and Malbrain *et al*. (2010), reported no significant difference in pressure sores between these two categories of mattresses. These results indicate that although alternating pressure mattresses provide the advantages of a more uniform redistribution of pressure, the effectiveness of pressure-relieving surfaces could depend on patient-related parameters, including comorbidities, nutritional status and overall clinical condition. Furthermore, the cost and resource availability are other factors that may determine the use of the devices as mentioned earlier in various clinical settings, particularly in resource-deprived centres (Weng *et al*., 2008).

The analysis also showed that multi-faceted prevention strategies, such as repositioning, specific dressings, and pressure redistribution surfaces, were more effective than single interventions. This result corresponds with the literature, which has proven that global prevention programs are more efficient than isolated ones in decreasing the incidence of pressure injury (Swafford *et al*., 2016; Kalowes *et al*., 2016). These findings strengthen the concept that a multi-dimensional, multiple-factorial model of care is the most successful in critically ill pressure injuries.

The *fourth objective* was to identify gaps in the literature and recommendations for further research and clinical practice. There are still some limitations in the strength of evidence presented in this review. First, there is limited long-term research on the usability of pressure ulcer prevention strategies. Most of the studies in this systematic review only report on short-term outcomes, typically measuring the prevalence of pressure wounds on admission and during the hospital stay. Few studies address the long-term effect of these measures with regard to the recurrence of pressure wounds or on randomised patients post-discharge (Uzun, Aylaz, & Karadag, 2009).

Second, the efficacy of pressure injury prevention strategies continue to be under-researched. Although the health benefits of interventions such as silicone foam dressings and pressure redistribution mattresses have been established (Jackson *et al*., 2011), the economic impact of such strategies is not so clear, particularly in resource-poor settings. Cost-effectiveness analyses should be included in future studies to inform healthcare providers on the feasibility of interventions in relation to clinical and economic components.

Finally, patient-related outcomes, such as comfort, quality of life, and patient preferences, are frequently ignored in pressure injury prevention research. These results are particularly relevant for interventions that may be applied for extended periods in critically ill patients. Prospective studies should incorporate patient-centered outcomes to better understand the benefits and potential barriers to pressure injury prevention (Weng, 2008).

This review has provided good evidence to support several pressure injury prevention strategies, including silicone foam dressings, repositioning policies and pressure redistribution surfaces, especially when combined. According to such programmes, multi-faceted interventions seem to be the most effective approach to preventing infections in these patients. Nonetheless, many

knowledge gaps in the literature require further exploration in future studies, such as a paucity of long-term research, cost-effectiveness and patient-reported outcomes. The results of this review demonstrate the need for a holistic and personalised strategy in pressure injury prevention for the critically ill patient to achieve optimal outcomes.

6.3 LIMITATIONS OF THE STUDY

The limitations of this review include substantial heterogeneity of study designs, sample sizes, interventions, outcome measures and settings, and the inability to compare between and generalise from FPIs. Most studies were small-scale, single-centred, included no blinding or randomisation, and reported poorly, which impacted internal validity. There was also little long-term follow-up, making it complex to determine the sustainability of the interventions' effectiveness. Results varied because some studies prioritised incidence, others severity or proxy measures, making it challenging to assess efficacy. The results might not apply to the scarce, resource-limited, intermediate care ICU, where advanced prevention technologies are unavailable. Moreover, there were few patient-centred outcomes relating to comfort and quality of life. Lastly, the possible publication bias may overestimate the intervention's efficacy. Nevertheless, improving pressure injury prevention in critically ill patients may be considered a priority.

6.4 RECOMMENDATIONS FROM THE REVIEW

6.4.1 Implications for Clinical Practice

Several key strategies that can improve the prevention of pressure injuries in the critically ill patient should receive greater clinical focus:

- The first is that ICUs would adopt standardised, multi-component prevention protocols as part of their routine care. Such protocols could include a mix of evidence-based treatment modalities, such as frequent repositioning/turning, skin care, synthetic or silicone foam dressings, and pressure-redistribution surfaces. A systemised patient-centred approach utilising a combinative regimen rather than single interventions is superior and promotes uniformity of care.
- Second, staff development and training should be provided continuously. Clinicians and nurses require current knowledge and the skills to undertake risk identification,

conduct timely skin assessments, and implement preventive interventions with intrusive technology. Routine in-service training will reinforce the best practice and facilitate the early identification of and timely response to high-risk patients.

- Third, the daily clinical workflow should incorporate standardised, validated risk assessment tools such as the Braden Scale. These instruments enable the early detection of patients at risk of developing PIs and allow timely and targeted early intervention.
- Ultimately, cost should be considered in low-resource countries, already hampered by technological differences. Even the most mundane interventions, such as regular turning schedules and simple foam mattresses, may be helpful when applied correctly and consistently.

6.4.2 Implications for Further Research

To develop the body of evidence supporting pressure injury prevention among critically ill patients, several research priorities need to be addressed in future research.

- First, there is an urgent requirement for prospective cohort studies with a long follow-up time. Most studies considered short-term follow-up, and it was impossible to conclude the persistence of the effects over time. The long-term benefits and feasibility of preventive strategies must be considered, particularly for patients with extended ICU duration of stay or recovering from critical illness.
- Second, there is a need for more standardisation of outcome measures and methods. Consistency in how terms are defined, judged, and measured should be the goal of future research, specifically concerning the incidence, severity, and healing of pressure ulcers. This will improve comparability between studies and allow for firmer, generalisable conclusions.
- Furthermore, cost-effectiveness analyses are critical, especially for resource allocation in low and middle-income countries. Assessment of the economic value of various interventions will guide interventions to have the best clinical impact to cost ratio and guarantee that prevention activities are efficient and sustainable.
- Finally, clinical trials should also be multinational and multicentre. Studying across different healthcare contexts can potentially create universal standards that can be

adaptable to differences in resources, patient populations or health system capabilities, thereby enhancing the relevance and utility of the evidence produced.

6.5 CONCLUSIONS

This review evaluated the effectiveness of different interventions to prevent pressure injuries in the critically ill, classified existing interventions in the area, compared their efficacy to standard care provided to similar patients, and noted deficiencies in the evidence base. The findings suggest that interventions with silicone foam dressings, structured repositioning schedules, pressure redistribution surfaces and multi-component prevention programmes can substantially decrease PI incidence in ICUs. Of these, prophylactic dressing, regular repositioning, and special mattresses or overlays were the three most consistently effective interventions. However, the review also noted a substantial heterogeneity of the interventions studied and how the outcomes were measured. This heterogeneity restricts cross-study comparisons and highlights the importance of homogenised prevention protocols and their uniform performance across clinical scenarios. Notably, there is still a lack of long-term and cost-benefit data, given that it has been studied mainly in the short-term follow-up. This lack of coherence impedes our ability to grasp the sustained impact of prevention strategies during prolonged ICU stays and after weaning off MV. Finally, the review reiterates the importance of the patient perspective, including patient-centred outcomes such as comfort, quality of life, and patient preferences, which are frequently neglected in favour of clinical end-points. Training and continuing education of healthcare workers was also identified as key factor for successful uptake and implementation of preventive practices.

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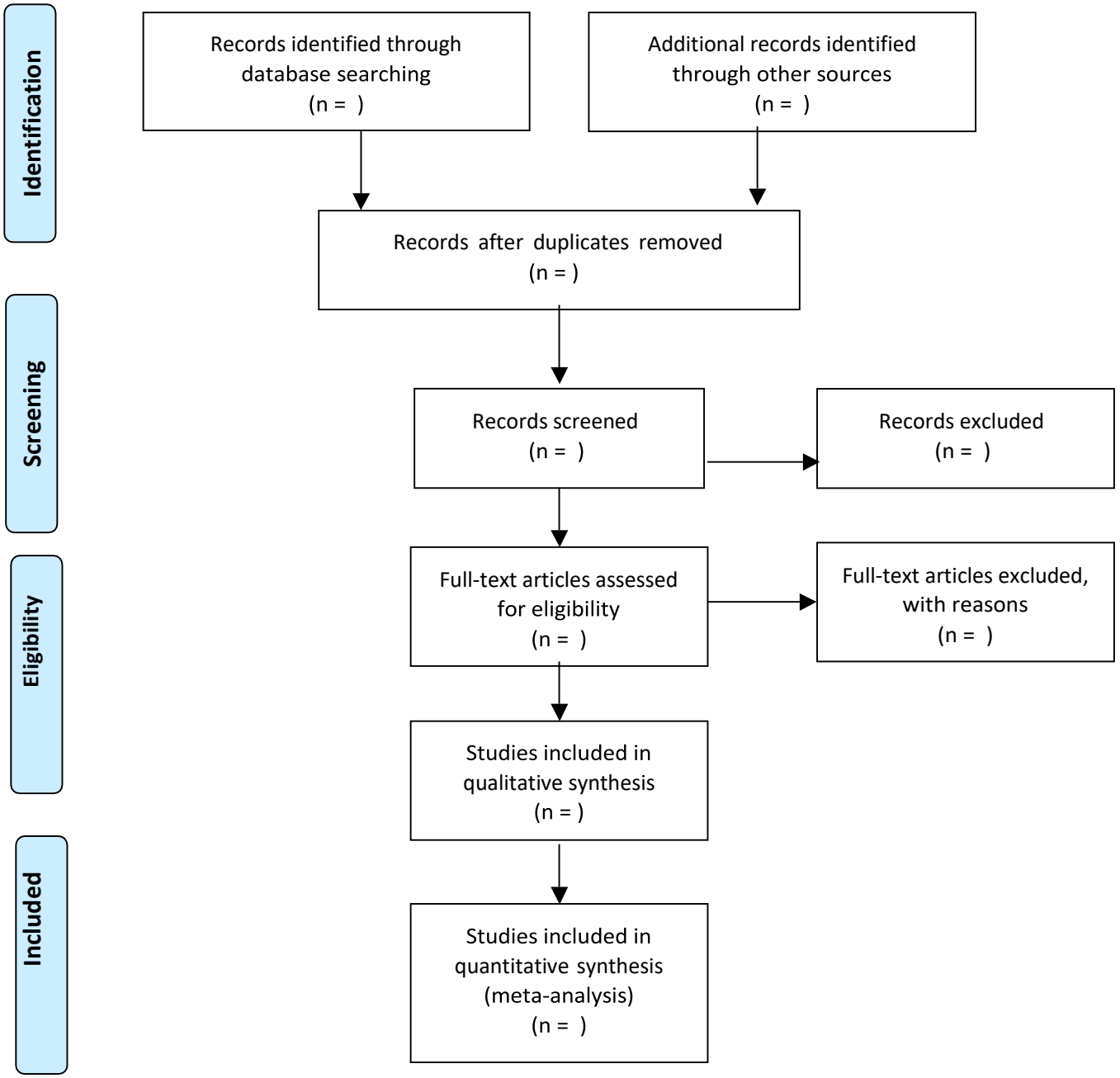
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PRISMA 2009 Flow Diagram



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta- *A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

APPENDIX B

JBI CRITICAL APPRAISAL CHECKLIST FOR RANDOMISED CONTROLLED TRIALS

Reviewer _____

Date_____

Author_____ Year_____ Record Number_____

	Yes	No	Unclear	NA
1. Was true randomisation used for assignment of participants to treatment groups?	□	□	□	□
2. Was allocation to treatment groups concealed?	□	□	□	□
3. Were treatment groups similar at the baseline?	□	□	□	□
4. Were participants blind to treatment assignment?	□	□	□	□
5. Were those delivering treatment blind to treatment assignment?	□	□	□	□
6. Were outcomes assessors blind to treatment assignment?	□	□	□	□
7. Were treatment groups treated identically other than the intervention of interest?	□	□	□	□
8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately	□	□	□	□
9. Were participants analysed in the groups to which they were randomised?	□	□	□	□
10. Were outcomes measured in the same way for treatment groups?	□	□	□	□
11. Were outcomes measured in a reliable way?	□	□	□	□
12. Was appropriate statistical analysis used?	□	□	□	□
13. Was the trial design appropriate, and any deviations from the standard RCT design (individual randomisation, parallel groups) accounted for in the conduct and analysis of the trial?	□	□	□	□

Overall appraisal: Include □ Exclude □ Seek further info □

Comments (Including reason for exclusion)

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_____
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APPENDIX C

JBI CRITICAL APPRAISAL CHECKLIST FOR QUASI-EXPERIMENTAL STUDIES

Reviewer_____

Date_____

Author_____ Year_____ Record Number_____

	Yes	No	Unclear	Not applicable
1. Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?	□	□	□	□
2. Were the participants included in any comparisons similar?	□	□	□	□
3. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	□	□	□	□
4. Was there a control group?	□	□	□	□
5. Were there multiple measurements of the outcome both pre and post the intervention/exposure?	□	□	□	□
6. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?	□	□	□	□
7. Were the outcomes of participants included in any comparisons measured in the same way?	□	□	□	□
8. Were outcomes measured in a reliable way?	□	□	□	□
9. Was appropriate statistical analysis used?	□	□	□	□

Overall appraisal: Include □ Exclude □ Seek further info □

Comments (Including reason for exclusion)

APPENDIX D

JBI CRITICAL APPRAISAL CHECKLIST FOR COHORT STUDIES

Reviewer_____

Date_____

Author_____ Year_____ Record Number_____

	Yes	No	Unclear	N/A
1. Were the two groups similar and recruited from the same population?	☐	☐	☐	☐
2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?	☐	☐	☐	☐
3. Was the exposure measured in a valid and reliable way?	☐	☐	☐	☐
4. Were confounding factors identified?	☐	☐	☐	☐
5. Were strategies to deal with confounding factors stated?	☐	☐	☐	☐
6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	☐	☐	☐	☐
7. Were the outcomes measured in a valid and reliable way?	☐	☐	☐	☐
8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?	☐	☐	☐	☐
9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	☐	☐	☐	☐
10. Were strategies to address incomplete follow up utilised?	☐	☐	☐	☐
11. Was appropriate statistical analysis used?	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Comments (Including reason for exclusion)

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APPENDIX E

JBI CRITICAL APPRAISAL CHECKLIST FOR ANALYTICAL CROSS SECTIONAL STUDIES

Reviewer_____

Date_____

Author_____ Year_____ Record Number_____

	Yes	No	Unclear	Not applicable
1. Were the criteria for inclusion in the sample clearly defined?	□	□	□	□
2. Were the study subjects and the setting described in detail?	□	□	□	□
3. Was the exposure measured in a valid and reliable way?	□	□	□	□
4. Were objective, standard criteria used for measurement of the condition?	□	□	□	□
5. Were confounding factors identified?	□	□	□	□
6. Were strategies to deal with confounding factors stated?	□	□	□	□
7. Were the outcomes measured in a valid and reliable way?	□	□	□	□
8. Was appropriate statistical analysis used?	□	□	□	□

Overall appraisal: Include □ Exclude □ Seek further info □

Comments (Including reason for exclusion)

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APPENDIX F

JBI CRITICAL APPRAISAL CHECKLIST FOR CASE CONTROL STUDIES

Reviewer_____

Date_____

Author_____Year_____ Record Number_____

	Yes	No	Unclear	N/A
1. Were the groups comparable other than the presence of disease in cases or the absence of disease in controls?	☐	☐	☐	☐
2. Were cases and controls matched appropriately?	☐	☐	☐	☐
3. Were the same criteria used for identification of cases and controls?	☐	☐	☐	☐
4. Was exposure measured in a standard, valid and reliable way?	☐	☐	☐	☐
5. Was exposure measured in the same way for cases and controls?	☐	☐	☐	☐
6. Were confounding factors identified?	☐	☐	☐	☐
7. Were strategies to deal with confounding factors stated?	☐	☐	☐	☐
8. Were outcomes assessed in a standard, valid and reliable way for cases and controls?	☐	☐	☐	☐
9. Was the exposure period of interest long enough to be meaningful?	☐	☐	☐	☐
10. Was appropriate statistical analysis used?	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Comments (Including reason for exclusion)

_____

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DATA EXTRACTION TOOLS

JBI-MAStARI Data Extraction Form Experimental/Observational Studies

Reviewer _____ Date _____
Author _____ Year _____
Journal _____ Record Number _____

Study Method RCT ☐ Quasi-RCT ☐ Longitudinal ☐
Retrospective ☐ Observational ☐ Other ☐

Participants

Setting _____
Population _____
Sample size _____
Intervention 1 _____ Intervention 2 _____ Intervention 3 _____

Interventions
Intervention 1: _____
_____
Intervention 2: _____
_____
Intervention 3: _____
_____

Clinical outcome measures

Outcome Description	Scale/measure

Study results
Dichotomous data

Outcome	Intervention ( ) number/total number	Intervention ( ) number/total number

Continuous data

Outcome	Intervention ( ) mean & SD (number)	Intervention ( ) mean & SD (number)

Authors' conclusions: _____
_____
Comments: _____
_____

APPENDIX H

ETHICAL WAIVER

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Human Research Ethics Committee (Medical)

Research Office Secretariat:
Faculty of Health Sciences, Phillip Tobias Health Sciences Building, 3rd Floor, Office 301/2/4, 29 Princess of Wales Terrace, Parktown, 2193
Private Bag 3, Wits 2050
Office email: HREC-Medical.ResearchOffice@wits.ac.za
Website: https://www.wits.ac.za/research/researcher-support/research-ethics/ethics-committees/

Ref: W-CBP-220801-01 01/08/2022

TO WHOM IT MAY CONCERN:

Waiver:	This certifies that the following research does not require clearance from the Human Research Ethics Committee (Medical)
Investigator:	Mrs Azwimbavhi Tshitereke (Student No.: 338113)
Supervisor:	Prof Shelley Schmollgruber
Department:	Nursing Education
Project title:	*The effectiveness of pressure injury prevention strategies for adult patients in intensive care units: a systematic review*
Reason:	Review of information in the public domain. No human participants will be involved in the study.

Dr CB Penny

Co-Chairperson: Human Research Ethics Committee (Medical)

Copy – HREC (Medical) Secretariat: Ms Zanele Ndlovu, Ms Mapula Ramaila and Mr Rhulani Mkansi

APPENDIX I

APPROVAL OF TITLE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

30 September 2022
Person No: 338113
PAG

Mrs A Tshitereke
23 Swempie Crescent Street
Liefde En Vrede,
Mulbarton
2190
South Africa

Dear Mrs Azwimbavhi Tshitereke

Master of Science in Nursing: Approval of Title

We have pleasure in advising that your proposal entitled *The effectiveness of pressure injury prevention strategies for adult patients in Intensive Care Units: A systematic review* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

100 1922 2022