



Prevention of Pressure Injuries and Nursing Interventions in Critical Care Settings: a Synthesis Without Meta-Analysis (SWiM)

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Purpose: This review aims to update the evidence regarding optimal nursing interventions for mitigating pressure injuries in critical care patients.

Method: A synthesis without a meta-analysis design was used. A systematic review was performed on several databases such as PubMed, SCOPUS, CINAHL, MEDLINE, and Web of Science to find nursing research publications related to pressure injury prevention interventions between January 2007 and May 2023. Data were extracted for each study regarding study aim, study characteristics, intervention details, and finding.

Result: In our comprehensive review, we examined twenty studies encompassing 305,149 patients that investigated nursing interventions for pressure injuries. These studies were categorized into four main groups: (a) the implementation of pressure injury prevention bundles, (b) regular repositioning with supportive surfaces, (c) strategies targeting the prevention of pressure injuries associated with medical devices, and (d) facilitating access to specialized expertise. All the studies demonstrated a reduction in pressure injuries attributed to the implemented interventions. It is crucial to acknowledge, however, that the strength of the evidence varied across the studies, with ratings ranging from moderate to very low. Despite the potential challenges in translating these findings into practice, the consistent trend observed from 2007 to 2023 suggests that adherence to evidence-based nursing care is pivotal. Efforts must be directed towards ensuring the integration of these recommendations into practical healthcare settings.

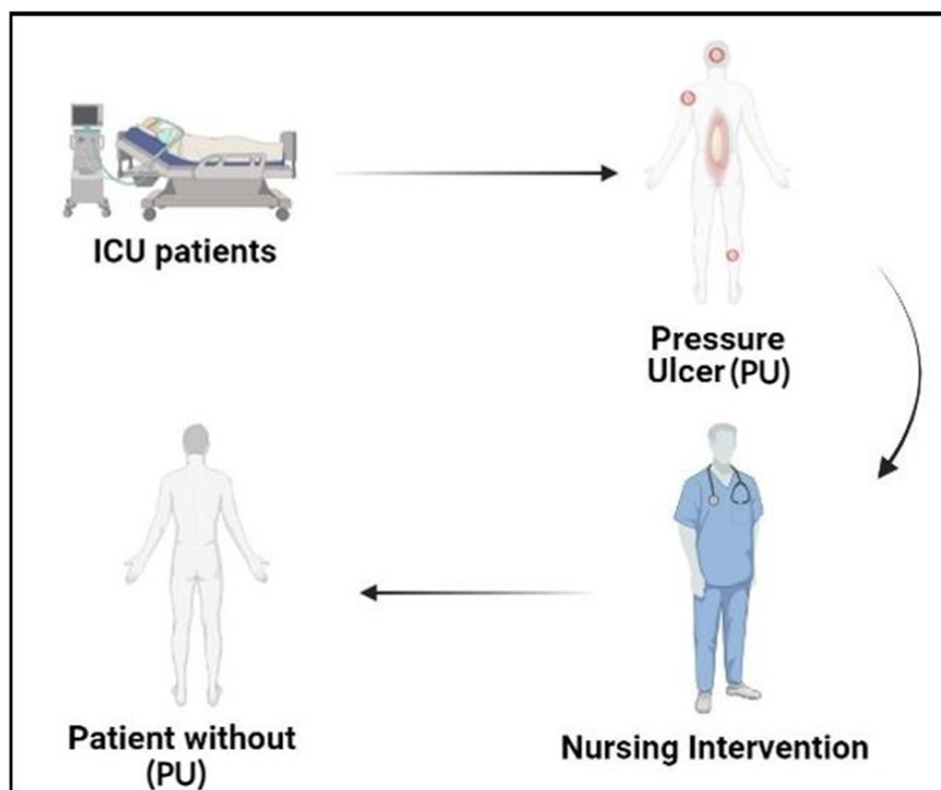
Conclusion: Nurses have the necessary expertise to prevent pressure injuries in critical care units. Every critically ill patient requires interventions to prevent pressure injuries, which makes prevention a complex process. Nurses are responsible for developing and implementing care plans based on evidence to prevent all types of pressure injuries, including those caused by medical devices. The importance of education and training programs for nurses in pressure injury prevention cannot be overstated.

Keywords: nurses, nursing interventions, pressure ulcer, pressure injury, critical care, ICU

Introduction

The European Pressure Ulcer Advisory Panel defines pressure injury (PI)¹ as localized skin or underlying tissue damage caused by pressure, pressure combined with shear, or the use of medical devices. The clinical practice guidelines categorize these injuries into stages I, II, III, IV, unstageable, and deep tissue injury (EPUAP, 2019). These stages help clinicians understand the severity and nature of the injuries. A comprehensive skin assessment conducted by nursing professionals is the basis of the diagnostic framework.² However, the international guidelines list several interventions and practice recommendations for PI prevention (EPUAP, 2019). Based on the five levels of evidence in the guideline, which range from A (more than one high-quality study) to GPS (good practice statement), the strength of evidence regarding nursing interventions related to

Graphical Abstract



PI (pressure injury) prevention in critical care shows an absence of any A level of evidence. Most of the evidence ranges from B2 to C levels, with a good amount of GPS level of evidence.

Therefore, additional support and recommendations are needed to strengthen the evidence for preventing pressure injury formation in critically ill patients who were in higher risk for developing PI due to the complex nature of their health conditions.² Factors such as limited mobility, using ventilators and vasopressor agents, and invasive medical devices have been identified as contributing to PI development in critical care settings.³ Moreover, PIs give rise to serious complications, including severe pain, infections, prolonged hospital stays, psychological distress, delayed recovery, and even mortality (Lin et al, 2020). So, patients with PI in critical care significantly impact comorbidities and negatively affect patient outcomes.⁴ This comprehensive perspective enlightens healthcare practitioners, researchers, and policymakers, fostering a collective understanding crucial for effectively managing and preventing pressure injuries in clinical settings.

Critically ill patients commonly experience pressure injuries due to the complex nature of their health conditions.² Factors such as limited mobility, using ventilators and vasopressor agents, and invasive medical devices have been identified as contributing to PI development in critical care settings.³ Moreover, PIs give rise to serious complications, including severe pain, infections, prolonged hospital stays, psychological distress, delayed recovery, and even mortality (Lin et al, 2020). So, patients with PI in critical care significantly impact comorbidities and negatively affect patient outcomes.⁴ Nurses face a substantial challenge in preventing pressure injuries (PIs) while caring for critically ill patients.⁵ To mitigate pressure injuries (PIs), nurses must employ evidence-based interventions, possess a comprehensive understanding of PI prevention, adopt a structured yet personalized approach to address individual patient care requirements, and involve the multidisciplinary team in collaborative efforts toward PI prevention.⁶

Successive editions of international clinical practice guidelines on preventing and treating pressure injuries (PIs) were published in 2009, 2014, and 2019.⁷ However, research has shown that the mere availability of guidelines does not

guarantee the implementation of best practices in care settings,⁸ as these guidelines often need more specific strategies for improving care.^{6,9} Also, presenting the policies is not associated with staff compliance with the required interventions.¹⁰ To enhance the care provided to critically ill patients, various PI prevention programs incorporating multiple interventions, commonly called bundles, have been developed.⁴ Nonetheless, disparities and variations in nursing interventions within these PI prevention bundles and across different practice settings pose challenges to PI prevention efforts.¹¹ Hence, this review aimed to identify and critique the most effective nursing interventions for preventing PIs in critical care unit patients.

Methods

Following the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA),¹² and Synthesis without meta-analysis (SWiM) guidelines,¹³ this systematic review has been conducted.

Information Sources and Search Strategy

To identify relevant studies, a comprehensive search was conducted in PubMed, SCOPUS, CINAHL, MEDLINE, and Web of Science databases for research publications on nursing intervention for pressure ulcer between Jan 1st 2007 and May 31st 2023, using the words nurs* AND “pressure ulcer” (OR) “pressure injury” (OR) “bed sore*” (OR) “decubitus ulcer” (OR) “pressure sore” AND “intensive care” (OR) “critical care” (OR) ICU (OR) “high depend*”. Phrases used for the Medical Subject Heading (MeSH) search included: (“Nurses”[Mesh]) AND “Pressure Ulcer”[Mesh] OR “Pressure injury” [Mesh] OR “bed sore” [Mesh] OR “decubitus ulcer” [Mesh] OR “pressure sore” [Mesh] AND “intensive care” [Mesh] OR “critical care” [Mesh] OR “ICU” [Mesh] OR “high depend*” [Mesh].

Eligibility Criteria and Study Selection

The inclusion criteria were utilized to determine which studies would be incorporated into this review; (a) adult patients (≥ 18 age), (b) studies reported nursing interventions, nurses’ knowledge, nursing skills, attitudes towards PI prevention, (c) critical care/intensive care unit settings, (d) studies reporting nursing interventions randomized controlled trials (RCTs), Quasi-Experimental Studies, cohort (either prospective, retrospective), case-control, Case Series, and cross-sectional, (e) English report publication. The following exclusion criteria were applied: (a) duplicate reports, including repetitive patient information; (b) insufficient data; and (c) reviews and reports.

Three authors, AA, MRW, and HM independently assessed the full texts of the articles and applied the inclusion criteria for filtering by EndNote© X9 software. In cases of disagreement, discussions were held with senior authors ARA until a consensus was reached.

Quality Assessment

Two reviewers (AM and ARA) conducted the quality assessment of the included studies independently, and any discrepancies were resolved through mutual agreement. Various critical appraisal tools, such as the Joanna Briggs Institute (JBI) tools for Quasi-Experimental Studies, Randomized Controlled Trials (RCTs), Cross-Sectional Studies, and Case Series were employed to assess the quality of the studies. Each item was assessed and assigned a score of 1 for “yes” or 0 for “no” or “unclear”. The total score for each study was then converted into a percentage. Based on the JBI critical appraisal tools guidance,¹⁴⁻¹⁶ the authors categorized studies as high (>80% quality score), moderate (50%–80% quality score), or low (<50% quality score). No studies were classified as low-quality (Table 1), and consequently, no studies were excluded based on methodological quality.

Data Extraction

Three authors extracted variables from the information, including the author’s first name, study design, publication year, sample size, country, and more. These variables were stratified based on the main criteria, such as author, country, aim, intervention, and findings.

Table 1 Characteristics of Included Studies and Results

Author, Year	Study Design	Sample Size	Country	Aim	Intervention	Finding	Quality Score
Turmell, M. et al, 2022 ¹⁷	Sequential pretest and posttest.	54	USA	To determine whether using wearable patient sensors to cue nurses about patients' repositioning needs could improve compliance with an every-2-hour repositioning protocol.	<ul style="list-style-type: none"> ● Use of special devices and technology Positioning. 	<ul style="list-style-type: none"> ● In Phase 1: repositioning compliance was 55%, and the mean repositioning interval was 3.8 hours. ● In Phase 2: repositioning protocol compliance increased to 89%, and the mean repositioning interval was 2.3 hours. Nursing staff survey results showed improved teamwork in phase 2. 	80%
Coyer, F. et al, 2021 ²¹	Prospective	740	Australia	To implement targeted evidence-based pressure injury prevention strategies and evaluate their effect through measurement of patient pressure injury observations.	<ul style="list-style-type: none"> ● Skin assessment within 4 hours of admission. ● Moisturizer applied. ● Use of a skin barrier. ● Turns per 24 hours. ● Skin integrity rounds (pre-existing). ● Mandatory training and orientation (pre-existing). ● Prophylactic dressings: Five-layer silicone-bordered foam dressings for the heels and sacrum. ● Work unit guideline for pressure injury prevention. ● PI prevalence feedback. ● PI continuing education. 	<ul style="list-style-type: none"> ● The use of multiple staff-focused and patient-level strategies to successfully reduce PI prevalence rates. ● Use of multilayered PI prevention interventions, coupled with extensive intervention implementation and weekly patient outcome monitoring, ensured our success. ● Increased patient age, scores indicating higher risk for PI development, and mechanical ventilation were significantly associated with PI development. 	75%
Johansen, E. et al, 2020 ¹⁸	Prospective	112	Norway	To investigate the prevalence of moisture associated skin damage and associated factors among Norwegian intensive care patients.	Use of special devices and technology: - <ul style="list-style-type: none"> ● Use of urinary catheters. ● Use of Fecal management system 	<ul style="list-style-type: none"> ● Overall low prevalence of skin breakdown combined with high prevalence of liquid and semi-liquid stools may be explained by the fact that many patients did not have stools, many had urinary catheters, stoma and fecal management systems avoiding that urine and/or feces affected the skin. ● High prevalence of urinary catheters together with fecal management systems, avoiding urine and feces contact with the skin, may also explain the low prevalence of skin breakdown. 	85%
Cao, S. et al, 2022 ¹⁹	Pre & post-quasi	131	China	To examine the effectiveness of implementing the evidence in preventing medical device-related pressure injury (MDRPI) in intensive care patients.	Provide Training and increase knowledge	<ul style="list-style-type: none"> ● Nurses' knowledge scores and evidence compliance significantly improved. ● The incidence of MDRPI in patients decreased from 24.39% to 4.26%. Standardized care and workflows to prevent MDRPI were established. 	82%

Jiang, O. et al, 2020 ²⁰	RCT	1204	China	To compare the effectiveness of two protocols for preventing pressure injuries (PIs) in China's hospitals	Use of special devices and technology Positioning: - <ul style="list-style-type: none"> • The trial group (4- hour repositioning combined with a viscoelastic foam mattress). • Control group (2-hour repositioning combined with a powered air pressure redistribution mattress). • Participants received their respective protocols until they were discharged, died, or for at least 7 days. 	<ul style="list-style-type: none"> • Thirteen patients had single new stage 2 or worse PIs. • Total incidence of PIs was 1.1%. • The difference between the two groups was significant (0.3% vs 1.8%). • Difference between the groups' Braden Scale score median during the intervention was not significant (13 vs 13.5). 	90%
Edsberg, L. et al, 2022 ²¹	Mixed methods	296,014	USA	To evaluate the implementation on of pressure injury (PI) prevention strategies in adult acute care settings.	Bundle (SAFER) bundle: <ul style="list-style-type: none"> • Skin emollients • Assessment of head-to-toe • Floating heels of the bed • Early identification of PIs sources • Repositioning2/Semi-weekly round by the wound, ostomy and continence nurse combined with the bundle implementation 	<ul style="list-style-type: none"> • Compliance to routine repositioning was reported at lower levels between 67% and 84%, respectively. • Heel elevation was reported for over 60% of the patients with severe HAPIs while 31.9% did not receive heel elevation, only 6% were reported as not needing elevation. • The of patients had HOB greater than the 30° at the time of the data collection; compliance with minimizing linen layers (≤ 3) was reported in 76% or more. • Moisture strategies were reportedly used in more than 71% of all patients and 89% for patients with severe HAPIs. • Nutrition support was used for 55% to 82% of the patients and only documented as contraindicated in fewer than 2% of all groups. 	88%
Anderson, M. et al 2015 ²²	Quasi-experimental, pre- and post-intervention study	327	USA	To investigate the effectiveness of the universal PI prevention bundle along with the semi- weekly nurse round	Bundle (SAFER) bundle: <ul style="list-style-type: none"> • Skin emollients • Assessment of head-to-toe • Floating heels of the bed • Early identification of PIs sources • Repositioning2/Semi-weekly round by the wound, ostomy and continence nurse combined with the bundle implementation 	<ul style="list-style-type: none"> • The study intervention led to a significant decrease in the PIs incidence rate from 15.5% to 2.1% ($p = 0.001$). • Statistical significance found in the adherence to heel elevation practice ($p < 0.001$), and repositioning practice, ($p < 0.015$). • The bundle implementation improved the continuity of staff training. • Multidisciplinary approach for the early detection of MDRPIs is effective. • One of the approaches to MDRPI prevention was to standardize securing medical devices. • The impact of the SAFER bundle separate from the semi-weekly rounds was difficult to quantify. • A challenge as to whether semi-weekly rounds caused a change, or the actual impact was begun after applying the bundle. 	97%

(Continued)

Table 1 (Continued).

Author, Year	Study Design	Sample Size	Country	Aim	Intervention	Finding	Quality Score
Barakat, M. et al, 2019 ²³	Experimental design, a post-test study	127	Australia	To evaluate the effectiveness and feasibility of a fluidized positioning device to reduce occipital PI.	Use of special devices and technology Positioning	<ul style="list-style-type: none"> Positioning a fluidized positioner combined with daily skin inspection contributed to decreasing occipital PIs by 87.7% (pre-intervention: 25.4%, post-intervention: 3.13%). Control groups were more prone to occipital PIs than intervention group ($\chi^2(1) = 12.95, p < 0.001$). The severity of PIs decreased in control group including PI stages 3, 4 and unstageable. Intervention group outcomes were PIs stage 2 and 3 only Intervention led to increased awareness of possible occiput. Continuous monitoring is important as skin damage can occur due to incorrect Z flo molding. 	80%
Coyer, F. et al 2015 ²⁴	Experimental design, before and after intervention study	207	Australia	To examine the effectiveness of InSPiRE protocol in reducing PI in critical care	InSPiRE bundle: <ul style="list-style-type: none"> 1/Skin integrity assessment Assessment during admission. Ongoing assessment. 2/Prevention strategies Skin hygiene. Turning frequency schedule. Risk factors elimination. Heel pressure elimination. 3/Force and friction protection. Temperature maintenance. Optimize nutritional status. Mobility formation. 	<ul style="list-style-type: none"> InSPiRE bundle led to a decline in PI incidence ($p = 0.04$). The total number of PI was lower in the intervention group ($n = 24$) compared to control group ($n = 64$) ($p \leq 0.001$). Total number of patients with PI was lower in the intervention group ($n = 9$) compared to the control group ($n = 24$). Patient repositioning every 3 hr in the intervention group resulted in significant finding ($p < 0.001$). Applying heel protectors in the intervention group showed positive outcomes ($p = 0.02$) 	91%

Darvall, J. et al, 2018 ²⁵	Prospective	2259	Australia	To evaluate the impact of the 3 hr repositioning compared to 5 hr on reducing PI.	<p>The nurses should position ICU patients according to this sequence:</p> <ul style="list-style-type: none"> • Supine then left side-lying, then right. • Side-lying <ul style="list-style-type: none"> - 2- 30° elevation of the bed head. - Placing pillows under and between bony prominence areas. - Changing the turning frequency for critically ill patients from 5 hourly to 3 hourly. <p>5-Care included involved other interventions such as:</p> <ul style="list-style-type: none"> • Risk assessment. • Skin integrity checks • Nutrition • Contenance management plans • Allied health involvement • Physiotherapy • Early mobilization • Use of pressure- relieving mattresses • Applying prophylactic dressing to sacrum and heel 	<ul style="list-style-type: none"> • The turning protocol led to a decrease in PI incidence and was significantly different between groups ($p = 0.028$). • The total number of PI were higher in pre-intervention [53 vs 28 PI ($p < 0.001$)]. • The number of PI occurring in recumbent positions were higher in pre-intervention group [36 vs 8 PIs in recumbent positions ($p < 0.001$)]. • Risk adjustment based on the APACHE III score, age and intubation duration were carried out and the findings were: <ul style="list-style-type: none"> • Significant reduction noted in risk of developing PIs by 49% ($p = 0.041$). • The rate of PI in recumbent positions fell from 62.5% (pre-intervention)–25.0% (post-intervention) ($p = 0.011$) 	85%
De laet, E. et al, 2007 ²⁶	Prospective	399	Netherlands	To explain the impact of prevention and treatment of PI guidelines on both the incidence and time of onset.	The intervention was based on developing a prevention program from different sources. An expert nurse was responsible for creating a network and introduced the employees with the new guidelines	<ul style="list-style-type: none"> • The program developed resulted in a decrease in PIs II–IV incidence density from 54 patients in 1000 days (Baseline) to 46 patients in 1000 days (Period 2) and to 32 patients in 1000 days (Period 3) ($p = 0.012$). A significant decrease in PI incidence across the study periods ($p = 0.04$): <ul style="list-style-type: none"> • 43% in the baseline, 37% in the 2nd period, 28% in the 3rd period • The PI free time increased after the intervention from 12 to 19 days ($p = 0.01$). • Staff use of equipment changed during the intervention. Frequency of using PI mattresses increased to 40% in the 2nd period and 60% in the 3rd period ($p = 0.003$) 	96%
Gray-Siracusa and Schrier 2011 ²⁷	Quasi-experimental, pre- and post-intervention study	1199	USA	To design an evidence-based PI prevention bundle based and determine its effectiveness on reducing PI.	<ul style="list-style-type: none"> • Risk assessment every 12 hrs. • Repositioning every 2 hr. • Minimal head of bed elevation. • Heel elevation. • Nutrition assessment on admission and daily nutritional assessment. • Skin health and assessment 7/Sacral area cleansing and moisturizing 	<ul style="list-style-type: none"> • The incidence of PIs declined following the intervention and stayed at a lower level following comparison with the quarterly hospital report (6% Pre-intervention and 0% post-intervention) Stages 1, 2 and 3 have been reported during the study, and there were no reported cases for stage 4 • Stage 1 decreased from 1.98% to 0.93% • Stage 2 decreased from 3.96% to 1.87% Stage 3 decreased from 0.99% to 0% 	82%

(Continued)

Table I (Continued).

Author, Year	Study Design	Sample Size	Country	Aim	Intervention	Finding	Quality Score
Manzano, F. et al, 2014 ²⁸	Pragmatic, open-label randomized clinical trial	329	Spain	To compare the efficacy of repositioning every 2 or 4 hr to prevent the PI in patients under mechanical ventilation.	<p>The patients were divided to two groups:</p> <ul style="list-style-type: none"> • The intervention group received repositioning every 2 hr. • Control group received repositioning every 4 hr. 	<p>The intervention showed limited impact on decreasing PIs incidence rate in the intervention group compared to the control group PIs developed more in the control group (13.4% n = 22/164) compared to the intervention group (10.3% n = 17/165) but no statistical significant found, HR 0.89, CI (0.46–1.71, 95%).</p> <ul style="list-style-type: none"> • MDRPIs occurred more in the intervention group (47.9%, n = 79/165) compared to the control group (36.6%, n = 60/164) (p = 0.02). • The nurses' workload in the intervention group increased (21 min/day) compared to the control group (11 min/day) (p < 0.001). • Several adverse events occurred more in the intervention group but were not statistically significant. • Unplanned extubating (Intervention 11.5% n = 19/165, Control 6.7% n = 11/164). • Endotracheal intubation obstruction (Intervention 36.4% n = 60/165, Control 30.5% n = 50/164). • Loss of medical devices (Intervention 9.1% n = 15/165, Control 7.3% n = 12/164). • Reintubation (Intervention 7.3% n = 12/165, Control 4.3% n = 7/164). • Respiratory instability (Intervention 77% n = 127/165, Control 70.1% n = 115/164) • Hemodynamic instability (Intervention 55.8% n = 92/165, Control 47.6% n = 78/164). • Ventilator-associated pneumonia (Intervention 18.3% n = 31/165, Control 12.8% n = 21/164). 	84%

Mendonça, P. et al 2018 ²⁹	A cross-sectional	104	Brazil	To identify the interventions recommended by critical care nurses for the prevention of PI	Assessing the prescribed nursing action to prevent PIs in ICUs such as: <ul style="list-style-type: none"> • Change of position. • Application of hydrocolloid dressing on the sacral region. • Use of emollients for skin hydration. • Comfort cushions. • External hygiene of perineum area. • Change orotracheal catheter and/or mesenteric catheter fixation device. • Air mattress. • Skin Inspection. • Dry and clean perineum. • Rotate oximeter sensor. • Observation of positioning and fixation of orotracheal catheter • Bed headboard raised to 30° 	<ul style="list-style-type: none"> • Some nursing actions were associated with preventing PIs • Repositioning (p = 0.005). • External hygiene (p < 0.001). • Several actions have not been carried out by nursing staff and resulted in PI development. • Application of hydrocolloid dressing on the sacral region (p < 0.001). • Change the orotracheal catheter and/or mesenteric catheter fixation device (p < 0.001). • Skin Inspection (p < 0.001). • Dry and clean perineum (p < 0.001). • Rotate oximeter sensor (p < 0.001). • Observation of positioning and fixation of the orotracheal catheter (p < 0.001). • Bed headboard raised to 30° (p = 0.043) <p>Hypothermia (p = 0.029) and oedema (p = 0.012) were found to be significant risk factors for developing PIs.</p>	75%
Otero, D. et al, 2017 ³⁰	RCT	152	Spain	To evaluate four methods for prevention of facial PI related to the use of non-invasive mechanical ventilation techniques critical care.	The patients were allocated into four groups to receive different therapeutic strategies as the following: <ul style="list-style-type: none"> • Group A: Direct mask. • Group B: Adhesive thin dressing. • Group C: Adhesive foam dressing. • Group D: hyper-oxygenated fatty acids (HOFA) 	The use of HOFA led to reduction in FPU compared to the direct mask (p = 0.055), thin adhesive dressing (p = 0.03) and foam dressing (p < 0.001) Almost 49% of the total number developed facial PIs during this trial, mostly in the nasal bridge (72 patients), and the cheekbones (12 patients) Stage I PIs over the nasal bridge occurred in the HOFA group. Stage I, II, and III of nasal bridge facial PIs were reported in the other three groups Patient on vasoactive medications had more facial PIs than those who did not receive (54.8% vs 47.5%) (p = 0.452)	85%
Rodríguez, C. et al, 2019 ³¹	Retrospective	55	Spain	To determine the PI incidence and the most cases in critical care.	<ul style="list-style-type: none"> • Position changes every 3 hrs. for those at moderate or high risk. • Placing patient in sitting position early morning and afternoon. • Provide hyper-oxygenated fatty acids (HOFA) over pressure areas. • Using neutral soap during skin wash in the morning and urea cream for hydration in the evening. • Provide support surfaces (powered and non-powered). Powered surfaces are given to high or moderate risk, and the non-powered to those with a low risk 	PI incidence was 6.78%, with a predominance of grade II (n = 29, 52.7%), grade I (n = 24, 44%), and then grade III and IV (n = 2, 1.8%) Only one PI of stage III and one of stage IV were identified Sacral and heels were the most affected structures Using support surfaces find helpful in preventing PIs	71%

(Continued)

Table 1 (Continued).

Author, Year	Study Design	Sample Size	Country	Aim	Intervention	Finding	Quality Score
Rogenski and Kurcgant 2012 ³²	Prospective	18	Brazil	To assess the impact of PI prevention protocol among critically ill patients	<ul style="list-style-type: none"> ● Risk assessment: Prevention measures to be applied when Braden score is ≤ 16. ● Daily skin assessment and frequent positioning changing. ● Reducing trochanters positioning (lateral position, pillows and cushions were recommended). ● 30-degree head of the bed elevation. ● Nutritional support (especially if Braden score is equal or lower than 11). ● Heels elevation. ● Applying incontinence, perspiration, or drainage of fluids prevention measures. ● Skin hygiene. ● During and after bath: Avoid using hot water and excessive friction. ● Gentle bath agent (glycerin soap). ● Gentle emollient immediately after bathing. ● Avoid using tape on fragile skin. ● Use a skin protector. ● Do not massage areas with hyperemia. ● Avoid massage on bony prominences. ● Avoid using Donut ring pads. ● When seated, reposition every hour. ● Use pressure reducing cushion on seating chair. ● Observe weight distribution, postural alignment, and stability if a wheelchair is used. ● Pressure relief every 15 min for wheelchair users. ● Patient and family education 	The procedure led to a 23% decrease in the ICU incidence of PIs the areas affected were calcaneus (42.1%), sacral region (36.8%), buttocks (15.8%) and trochanter (10.5%) The most-reported stage was stage II (64%) Moisture, sensorial perception and mobility have been found the most crucial influences that increase ordecrease PIs development	98%
Swafford, N. et al 2016 ³³	RCT	1458	USA	To reduce the incidence of hospital-acquired pressure ulcers in an intensive care unit.	<ul style="list-style-type: none"> ● PI risk assessment. ● Applying a skincare protocol. ● Fluidized repositions. ● The use of silicone gel adhesive dressings and dressing underneath cervical collars. 	<ul style="list-style-type: none"> ● The prevention program led to a decrease in the incidence of PIs in ICU from 10% (n = 45/461) in 2011–3% (n = 17/563) in 2013 (69% cumulative incidence reduction). ● MDRPIs reduced from (9/461 in 2011) – (2/563 in 2013) ● Staff education was a central factor in achieving the program efficiency, leading to lower PI incidence rates 	80%

Tayyib, N. et al 2015 ³⁴	RCT	140	Saudi Arabia	To evaluate the effect of a prevention bundle on the reduction of PI in critical care	<ul style="list-style-type: none"> ● PI risk assessment. ● Skin assessment must be within 4 hrs of admission and then every 8 hr. ● Daily bed bath with pH balanced cleaning agent and skin moisturizer. ● Clinical nutritionist involvement. ● A three hourly turning schedule using a 'turn clock'. ● 20-degree elevation for the end of the bed. ● Daily mobility if not contraindicated. ● Transfer and lift patients using draw sheets. ● Documentation of position. ● Air mattress. ● Frequent training on Braden scale and prevention bundle elements. ● Assessing skin for possible medical devices-related injuries every 12 hrs. 	The bundle caused a decrease in the cumulative incidence among the intervention group (total of 12 PIs, n = 5 patients) compared to the control group (total of 37 PIs, n = 23 patients) (p < 0.001) Sacrum, and heels were the most affected anatomical structure and reported more in the control group • Sacrum (n = 14 in the control group vs n = 5 in the intervention group) • Heels (n = 10 in the control group vs n = 3 in the intervention group) Bundle impact was evident in the intervention group by recording a lower rate of stages I (n = 6/5 vs 19/23, p = 0.002) and II (n = 5/5 vs 13/23, p = 0.026). No reported injuries for stages III, and IV MDRPIs were prevalent in the control group compared to the intervention group Using heel protectors in the intervention group resulted in lower heel PI (p < 0.001) Delayed development of PI in the intervention group was associated with bundle implementation (17%, n = 12 PIs in the intervention group vs 52.8, n = 37 PIs in the control group)	80%
Yimalzer, T., Bulut, H., 2019 ³⁵	RCT	120	Turkey	To determine the impact of an algorithm on preventing PI.	<p>The study has four phases:</p> <ul style="list-style-type: none"> ● Pre-algorithm data collection. ● Training program initiated in critical care units includes distribution of booklets and establishes practicing the algorithm. ● Frequent monitoring by researchers on the progress of applying the algorithm, required documentation. Tool evaluating carried out by nurses after 3 months of starting the algorithm. ● Comparing the incidence rate pre-and -post the algorithm, and then, algorithm evaluation. 	The algorithm helped to decrease the incidence of PI in the post-intervention group from (93.7% n=59) - (49.1% n=28) (p<0.001). The incidence rate decreased from 46.10 per 1000 patient-days in the pre-intervention group to 9.21 per 1,000 patient-days in the post-intervention group (p<0.001). Almost 27% found that the proposed algorithm is hard to follow and complicated. The post intervention group reported stages I, II and III versus stage I, III and IV in the pre-intervention group.	97%

Abbreviations: RCT, Randomized controlled trials; PI, Pressure Injury; MDRPI, Medical Device-Related Pressure Injury; PIs, Pressure Injuries; HAPIs, Hospital Acquired Pressure Injuries; HOB, Head Of Bed; MDRPIs, Medical Device-Related Pressure, Injuries; InSPIRE protocol, an interventional patient skin integrity protocol named (InSPIRE); ICU, Intensive care unit; hrs, hours; APACHE III, Acute Physiology and Chronic Health Evaluation; HOFA, Hyper-Oxygenated Fatty Acids, FPU, Facial Pressure Injuries.

Result

Study Selection

Having searched five bibliographic databases, this review returned 14,030 citations. We subsequently removed 1,318 duplicates. Additionally, we excluded 12,609 records by evaluating their titles and abstracts against the criteria outlined in Figure 1.

Among the remaining 103 references, 83 publications were excluded during the full-text screening process. Despite performing backward and forward reference list checks, the number of studies remained at 20, indicating no change. These 20 studies, which met our inclusion criteria, form the final synthesis.

Study Characteristics

A total of 20 studies were included in this review, consisting of 3 quasi-experimental study, 8 randomized controlled trials (RCTs), 1 cross-sectional study, 1 Sequential pretest and post-test, 1 retrospective, 1 mixed method, and 5 prospective studies. The cumulative sample size encompassed 305,149 patients who received treatment in critical care units across 9 countries (5 studies USA, 3 Australia, 3 Spain, 2 China, 2 Brazil, 1 Saudi Arabia, 1 turkey, 1 Netherland, and 1 Norway). All studies^{17–36} were conducted in critical care settings between 2007 and 2023, with a focus on adult patients. Detailed information for all studies can be found in Table 1.

Most of the studies do describe the demographic characteristics and severity of illness for all patients included in the studies, with ages ranging from 24 to 92 years old. Additionally, several studies did not specify the length of stay in the intensive care unit (ICU). One study excluded patients who developed a pressure injury within 24 hours of admission,²⁴ while another excluded patients with a longer stay than 48 hours in the ICU.²⁶ Another study excluded patients who

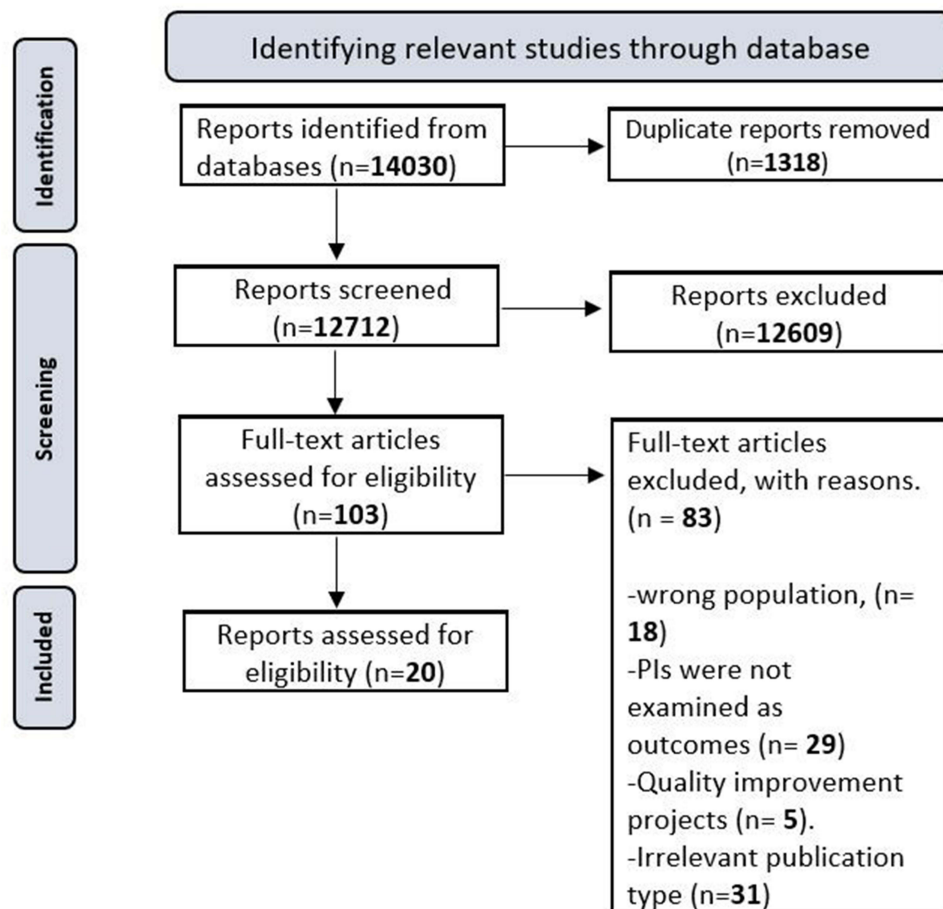


Figure 1 PRISMA diagram of literature search.

stayed in the ICU for less than 48 hours,¹⁹ and one study included patients with an expected length of stay of at least 7 days and excluded those with pressure injuries upon admission.²⁰

Primary Outcomes

The primary outcome measure in all the included studies was the development of pressure injuries (PIs). Of the 20 studies, 18 directly reported a reduction in the incidence of PIs^{21–36}, while one study demonstrated an indirect improvement by enhancing compliance with nursing interventions.¹⁷ Regarding Medical Device-Related Pressure Injuries (MDRPI), eight studies examined this outcome and observed a decrease in the incidence of MDRPIs.^{22–24,28,30,33,34,36}

In 17 studies, the assessment of pressure injuries was conducted by critical care nurses at the respective study sites.^{20,22–28,31,32,34–36} Among these, 11 studies reported that critical care unit nurses received training on identifying and staging pressure injuries within their facilities.^{24,26–28,31,32,34,35} Additionally, two studies provided training on measuring outcomes related to pressure injuries. In 7 studies, the assessments focused on identifying the initial presence of a pressure injury within 48 hours of admission. This included one study that assessed for pressure injuries at the time of admission,²² two studies that conducted assessments within 4 hours,^{20,24} one study within 8 hours,³⁵ and three studies that assessed during the first 48 hours of admission.^{26,32,36}

In four studies,^{21,22,25,31} data regarding the presence of a pressure injury was extracted from electronic datasets. However, none of the studies provided information on how the presence of a pressure injury at or following discharge from the critical care unit was assessed.

Secondary Outcomes

Several included studies utilized various risk assessment tools to identify patients at a higher risk of developing pressure injuries. Among these tools, the Braden scale was the most frequently employed, appearing in 11 studies.^{19–22,27–29,32–35}

Additionally, alongside the risk assessment tools, some studies collected data on the severity of illness. The Sequential Organ Failure Assessment (SOFA) score was used in two studies,^{24,34} while the Acute Physiology and Chronic Health Evaluation (APACHE III) score was employed in one study.²⁵ Two studies incorporated the SOFA and APACHE III scores, and another two utilized a combination of the SOFA and APACHE II scores.³⁶

Interventions

Use of Comprehensive PI Prevention Strategy

A total of 11 studies implemented comprehensive bundles to prevent and manage pressure injuries (PIs) in critical care patients, and all of them demonstrated improvement in PI prevention and management.^{20–22,24,26,27,29,33–36} The interventions in these 11 studies were comprehensive, with certain interventions being commonly implemented among the strategies. These included skin assessment, risk and nutrition assessment, skin hygiene and moisturizing, heel elevation, repositioning, and nursing education and training. Furthermore, additional interventions were included in some studies as part of their comprehensive strategies. These interventions encompassed the application of prophylactic dressing and support surface, minimizing linen layers, head elevation, change of orotracheal catheter and/or nasogastric catheter fixation device, rotation of pulse-oximeter sensor, temperature monitoring, use of fluidized positioners and application of gel adhesive dressings. Two studies listed multiple interventions but did not describe them as PI prevention “bundles”.^{31,32} Although both studies reported decreased incidence of PIs related to their interventions, they did not provide statistical analysis or a rationale for their chosen interventions. Among these comprehensive strategies and bundles, the interventions could be categorized into the following categories: (a) training and education, (b) assessment prevention and protection against pressure forces. Two studies explicitly framed their interventions within these categories,^{24,27} reporting decreased incidence of PIs.

Repositioning

In addition to being included as part of a comprehensive bundle and strategy in multiple studies,^{20–22,24,26,27,29,33–36} one study focused specifically on the repositioning intervention as the main intervention. This study aimed to assess the impact of different repositioning intervals on reducing the incidence and occurrence of PIs.

The study compared a repositioning interval of every 2 hours in the intervention group with a 4-hour interval in the control group. Although no statistically significant difference was observed, the study found that the incidence of PIs was higher in the control group (13.4%) compared to the intervention group (10.3%).²⁸

Use of Special Devices and Technology

A total of 8 studies acknowledged the utilization of various technologies and devices as part of interventions to prevent pressure injuries (PIs).^{17,18,20,23,25,28,30,36} One study specifically incorporated alternating-pressure air mattresses as an element of their inclusion criteria.²⁸ Additionally, two studies integrated special devices and technology within their bundle of interventions to prevent PIs. These included prophylactic dressings such as five-layer silicone-bordered foam dressings for the heels and sacrum,^{25,36} as well as the implementation of pressure-relieving mattresses.²⁵ Furthermore, one study indirectly mentioned the beneficial impact of special devices, such as Foley catheters and fecal management systems, on preventing PIs in critical care patients, which could explain the low prevalence of skin breakdown observed.¹⁸

Finally, four studies highlighted the utilization of special technology and devices as primary interventions in their respective research papers.^{17,20,23,30} These interventions included the use of wearable sensors to prompt critical care patient repositioning,¹⁷ the implementation of pressure-redistribution mattresses with different intervals,²⁰ the use of a fluidized positioner to reduce occipital pressure injuries,²³ and the application of hyper-oxygenated fatty acids (HOFA) to prevent facial pressure injuries in non-invasive mechanical ventilation patients.³⁰

Provide Training, Increase Knowledge and Skills, and Expertise

Pressure injury assessment was conducted by critical care nurses in 13 studies, as documented within each respective study.^{20,22–28,31,32,34–36} Among these studies, 9 of them involved critical care unit nurses receiving training on identifying and staging pressure injuries in their facilities.^{24–28,31,32,34,35} Additionally, two studies offered training specifically related to measuring outcomes associated with pressure injuries.^{22,24}

Five studies emphasized the crucial role of knowledgeable and highly skilled nurses in preventing pressure injuries, highlighting them as expert practitioners in implementing nursing interventions for PI prevention.^{22,25,26,35,36} One study explicitly reported a significant improvement in nurses' knowledge scores and compliance, resulting in a substantial decrease in device-related pressure injuries from 24.39% to 4.26%.

Furthermore, the findings of the remaining four papers^{22,25,26,35} suggest that having trained and knowledgeable nurses to provide assistance and guidance in practice contributes to lower incidences of pressure injuries. Some PI preventive strategies mentioned in the literature involved the active involvement of highly skilled nurses and the provision of specialized training, which facilitated the implementation of effective nursing interventions.²⁵

Discussion

This systematic review of various studies focused on preventing pressure injuries (PIs) in critical care patients to determine the most effective PIs prevention. The results provide valuable insights into PI prevention. From the United States in the west to China in the east, passing through Australia, Spain, Brazil, and so on, nurses over the globe report their concerns about the need for pressure injury prevention. Also, the review shows general agreements on the interventions for pressure injury prevention during their stay in critical care units, including skin assessment, offloading, repositioning, and skin care. However, these studies also have different representations for these interventions; in some reports, the researchers adopt the term “Bundle” to refer to the set of interventions and create an acronym to refer to these interventions,^{20–22,24,26,27,29,33–36} while others stick to the direct terminology of these each intervention. The review shows a general agreement about how PIs prevention had to occur and the importance of these interventions with different levels of the significant impact of these interventions on PI prevention.

On the other hand, the reports show wide variations in how these interventions had been followed, monitored, measured, or assured. For instance, assessing skin conditions formulates a general agreement between the studies. However, there must be a standard on when this must be done, whether immediately, after four hours,²¹ eight hours³⁵ or 48 hours.^{26,32,36} This was also observed among the tool adopted for skin risk assessment; Braden was the most utilized assessment tool,^{19–22,27–29,32–35} but other tools also adopted for evaluating the general patient's conditions such as

Sequential Organ Failure Assessment (SOFA),^{24,34} or Acute Physiology and Chronic Health Evaluation (APACHE III) which both initially created for other than PIs purpose²³ but formulated in the review as actual applications, which refers for disagreements between experts about the best assessment tool.

Furthermore, the literature shows that time is essential to PI development. PIs occur during the long duration of pressure on the organs. So, prevention strategies must be monitored over time to prevent injury. However, there were no agreements on the aspects of time in offloading the pressure. For instance, the frequency of conducting the repositioning appears as a disagreement point. The studies report a variation in performing the repositioning from two, three, or even every five hours.^{17,28} Although the results did not show statistically significant differences in PI incidence with the changes in the repositioning frequencies, studies indicated a trend toward reduced PIs with more frequent repositioning intervals. Therefore, this suggests further research to establish agreeable tools for evaluating the complaint and standardize the measurements of nursing performance for repositioning after assessing the significant impact of these changes on PIs incidences. However, the challenges of repositioning continued time; instead, they also manifested in the term applied. Repositioning appears as not having the same reflection term between the studies; even though majorities adopt the term repositioning, other studies use the positioning, turn, or turning with a lack of assurance if these terms refer to the same actions performed by nurses or a different set of actions.

Expert practitioners' involvement and specialized training provision were associated with lower incidences of PIs. This systematic review provides valuable insights into the continuous need of nurses (all over the globe) to receive education and training in Pi prevention, and this is common among all varieties of nurses in different cultures. However, the studies need more comprehensive descriptions of what these educational programs include and what learning theories are applied to these changes. This makes comparing these educational activities as one "thing" inapplicable.

It is essential to note a gap in the literature about pressure injury prevention interventions. While the studies have explained the immediate impacts of these interventions, they have yet to explore their long-term effects and sustained compliance. The scope of these studies mainly covers the aftermath of the interventions, leaving the long-term impact and adherence to these preventive measures unexplored. For instance, studies have been about repositioning to prevent patient pressure injuries. These studies have shown how vital repositioning can be, but researchers may need to look at the bigger picture of how nurses approach pressure injury prevention in general. It is essential to understand how long these changes in behavior will last beyond just the initial implementation of the intervention. Although some studies have shown how vital repositioning is for critically ill patients—something widely accepted by the scientific community—there are still issues with low compliance. The initial studies showed low compliance with repositioning, but there has yet to be much analysis on why this is the case. Other studies from the same country, conducted a few years later, still reported low to moderate compliance. This suggests that more work needs to be done to improve compliance with pressure injury prevention methods like repositioning. This is the required intervention in the future among the scientific community.

The question arises about how to ensure sustained compliance among healthcare practitioners. While the efficacy of pressure injury prevention interventions is acknowledged, there needs to be more insight into the dynamics governing the enduring adherence to these measures across diverse healthcare settings. It is crucial to ensure compliance for a comprehensive understanding of the landscape of pressure injury prevention. It was observed that the studies had a common initial condition regarding their country of origin. They all had low-quality adoption of interventions, which improved after specific recommendations were given. However, subsequently, they reverted to the initial condition of low quality, which is an indication of the inability of these studies to find their way into the actual nursing practice. For example, the studies conducted in the USA, Anderson 2015 and Edsberg 2022 are related to nursing care for PI management. The authors note the initial conditions in the nursing units were similar. That means the recommendation from Anderson's study after seven years did not find a practical application for nursing care, which makes Edsberg's study conduct the study and document that the stays of nursing care could be more satisfactory. This means that despite similarities in the initial conditions, the recommendations from different studies did not impact nursing care, which needs further exploration on the nature of the compliance of the PI management and its applicability in the actual clinical conditions for a long-term practice.

Pressure injury prevention is multifaceted, and it is necessary to consider not only how these interventions occur but also how they endure over time within the healthcare facilities. Future research must transcend the temporal constraints of existing studies and delve into the intricate fabric of sustained compliance and the pragmatic shifts in nurses' approaches to pressure

injury prevention beyond the immediate implementation phase. Such holistic exploration is essential for refining evidence-based practices and fortifying the resilience of pressure injury prevention protocols across diverse healthcare contexts.

In summary, the studies add valuable information about the PIs prevention adopted in critical care: assessing the skin condition at regular intervals, providing regular offloading for the pressure over the patient's body tissues, and dressing for prevention. However, there is a need to build a more substantial consensus among experts in PIs prevention strategies in evaluating the benefits of these interventions and ensuring compliance with the performance. The current review concludes with scattered information about the impact of these interventions with difficulties in comparing these results due to differences in the measurements applied for the prevention applications and changes in the methods of evaluating its effect on pressure injury prevention. A pressure injury panel of experts and stakeholders is asked to organize these efforts toward unifying the ways of PIs prevention evaluation in a similar way of creating a PI staging system. At that time, nurses can detect the impact of these interventions and methods of evaluating the Pi prevention performance.

Strength and Limitation

Nurses equipped with appropriate knowledge and skills can prevent pressure injuries (PIs) in critically ill patients. PI prevention strategies must be grounded in evidence and empower nurses to utilize their decision-making abilities. To enhance the efficiency of care, intervention bundles should be designed within a framework that prioritizes evidence-based practices.

Continuing education plays a vital role in enabling nurses to identify strengths and weaknesses in their practice and promote compliance with best practices.

It is important to note that the studies included in this review displayed varying levels of methodological quality, particularly concerning their sampling methods, measurement validity, and statistical analyses. As a result of the heterogeneity observed in the interventions and study designs, conducting a meta-analysis was not feasible. These considerations should be considered when interpreting the results of the review. Secondly, it is worth mentioning that a few studies were omitted from our analyses due to insufficient or ambiguous information. Additionally, it is important to recognize that the search and inclusion process focused on the most current and up-to-date evidence available in the published literature.

Conclusion

This systematic review encompasses all nursing interventions documented in the literature for preventing pressure injuries (PIs) in critical care settings. Our study offers valuable guidance regarding the utilization of evidence-based PI prevention bundles, regular repositioning, the prevention of medical device-related pressure injuries (MDRPis), and the role of education in enhancing PI outcomes. It is crucial to incorporate basic PI prevention interventions into the routine care schedule for critically ill patients, with a specific emphasis on mitigating MDRPis. The implementation of PI prevention interventions resulted in a notable decrease in both the frequency and severity of PIs across all the studies included in this review. To enhance the outcomes of critically ill patients, it is imperative to adopt evidence-based PI prevention bundles. Furthermore, nurses must receive comprehensive education, clinical practice and fully comprehend their pivotal role in PI prevention.

Data Sharing Statement

All data analyzed during this study are included in this article, and further inquiries can be directed to the corresponding author.

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Disclosure

All authors declare there is no conflict of interest for this work.

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