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Review

Nutritional Support for Prevention and Treatment of Pressure Injuries in Adults: An Integrative Narrative Literature Review

Giovanni Cangelosi[1,†], Francesco Sacchini[2,†], Sara Morales Palomares[3], Marco Sguanci[4], Federico Biondini[5], Stefano Mancin[6,*], Antonella Amendola[7], Gaetano Ferrara[8], Gabriele Caggianelli[9,§], Fabio Petrelli[10,§]

[1]Unit of Diabetology, Asur Marche—Area Vasta 4 Fermo, 63900 Fermo, Italy
[2]Department of Nursing, Polytechnic University of Ancona, 60121 Ancona, Italy
[3]Department of Pharmacy, Health and Nutritional Sciences (DFSSN), University of Calabria, 87036 Rende, Italy
[4]Department of Nursing, A.O. Polyclinic San Martino Hospital, 16132 Genova, Italy
[5]Units of Psychiatry, Ast Fermo, 63900 Fermo, Italy
[6]IRCCS Humanitas Research Hospital via Manzoni 56, 20089 Rozzano, Italy
[7]Department of Health Sciences, Università degli Studi di Milano, 20122 Milan, Italy
[8]Nephrology and Dialysis Unit, Ramazzini Hospital, 41012 Carpi, Italy
[9]Azienda Ospedaliera San Giovanni Addolorata, 00184 Rome, Italy
[10]School of Pharmacy, Polo Medicina Sperimentale e Sanità Pubblica "Stefania Scuri", 62032 Camerino, Italy
*Correspondence: stefano.mancin@humanitas.it (Stefano Mancin)
[†]These authors contributed equally.
[§]These authors contributed equally.

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Abstract

Introduction and Objectives: Pressure injuries (PIs) are a significant issue for international healthcare systems. Particularly common among older adults with reduced mobility, PIs represent a considerable socio-healthcare burden, which deeply impacts the psychological well-being of patients. Malnutrition is one of the main risk factors for the development of PIs, as malnutrition hinders healing and increases the risk of complications. For these reasons, implementing appropriate nutritional interventions, often underestimated in clinical practice, is crucial to manage PIs effectively. This study primarily aimed to identify and synthesize the best scientific evidence on nutritional interventions to prevent, facilitate, or improve the healing of PIs in an adult population. Additionally, both qualitative and quantitative outcomes were analyzed. **Methods**: A narrative literature review was conducted using the PubMed–Medline, Scopus, and Google Scholar databases to potentially include potential studies. The scientific validity of the study was ensured using the Scale for the Assessment of Narrative Review Articles (SANRA) and the pre-registration of the OSF database was performed using the PICOS method, which is employed in numerous studies of this type. Randomized controlled trials (RCTs) published within the last 10 years and in English were included. **Results**: Out of the 1507 records identified, 8 RCTs were included, published between May 2014 and May 2023. One study focused on patient education and self-care in nutrition related to PIs, while the remaining seven focused on intensive nutritional interventions or the administration of dietary supplements to treat PIs directly. Positive therapeutic effects were observed using collagen peptides, vitamin C, and arginine. Furthermore, the topical application of fish oil showed a protective effect. **Conclusions**: This study found that targeted nutritional interventions have a direct positive impact on PIs and an indirect effect on care, reducing complications and the duration of intensive care and healing times for PIs. Future systematic studies are recommended to broaden the understanding of the studied care framework.

Keywords: nutrition; pressure injuries; fragile population; public health

1. Introduction

Pressure injuries (PIs) are localized damage to the skin and 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 as a result of intense and/or prolonged pressure or pressure in combination with shear. Tissue tolerance to pressure and shear may also be influenced by factors such as microclimate, nutrition, perfusion, comorbidities, and the condition of the soft tissue [1,2]. PIs have a significant impact on individuals, communities, and the healthcare system overall [3]. Their prevalence remains alarmingly high, especially among people with chronic diseases, often associated with aging [4–6], with approximately 3 million new cases worldwide each year [7]. According to recent reports, the global burden of PIs continues to rise, particularly in aging populations and those with mobility impairments, making their prevention and treatment a priority in healthcare settings [4,5]. In the United States and Europe, prevalence ranges from 4.6% to 27%,

making PIs the third most costly pathological condition after cancer and cardiovascular diseases [8]. In the United Kingdom, the estimated cost for the management and treatment of PIs ranges from £1.4 to £2.1 billion ($1.75 to $2.63 billion USD) per year, representing 4% of total healthcare expenditure, while in the United States, it reaches $1.6 billion [9]. These costs are expected to increase with the rising incidence of chronic diseases and the growing demand for long-term care. These injuries not only cause physical pain but also result in significant psychological distress, often associated with symptoms such as depression, anxiety, insomnia, and fatigue [10]. In addition, PIs can lead to serious complications, including infections and sepsis, which further contribute to patient morbidity and healthcare costs. Complementary approaches, such as yoga and mindfulness, have been shown to alleviate these symptoms in patients with chronic diseases [11]. Therefore, it is crucial to adopt evidence-based prevention and treatment strategies that address the triggers of PIs and alleviate their complications on a broad scale [12]. One of the main risk factors for the development of PIs is malnutrition [13,14], which includes deficiencies, excesses, or imbalances in energy and/or nutrient intake [15]. Several studies have demonstrated that poor nutritional status is directly associated with delayed wound healing and increased susceptibility to infections in patients with PIs. Malnutrition impairs healing process by prolonging the inflammatory phase, reducing fibroblast proliferation, and altering collagen synthesis [16]. Furthermore, malnutrition is associated with the worsening of the overall clinical picture in several chronic diseases such as cardiovascular diseases, hypertension, diabetes, obesity, dementia, and respiratory conditions [17–20], as well as with weakened immune response, thereby increasing the risk of infections, as demonstrated during the recent COVID-19 pandemic [21]. Despite the growing body of evidence supporting the role of nutrition in PIs prevention and treatment, nutritional strategies remain underutilized in clinical practice. Recent reviews, such as those by Munoz *et al*. [22] and Langer *et al*. [23], have highlighted the effectiveness of targeted nutritional interventions, yet gaps remain in their implementation and integration into standard care. Consequently, managing PIs requires a multidimensional and interdisciplinary approach involving physicians, dietitians, nurses, and other healthcare professionals, integrated within an evidence-based and best-practice framework [24]. Proteins are essential for collagen synthesis, which is vital for skin regeneration. A protein deficiency slows tissue repair and reduces skin resistance to pressure

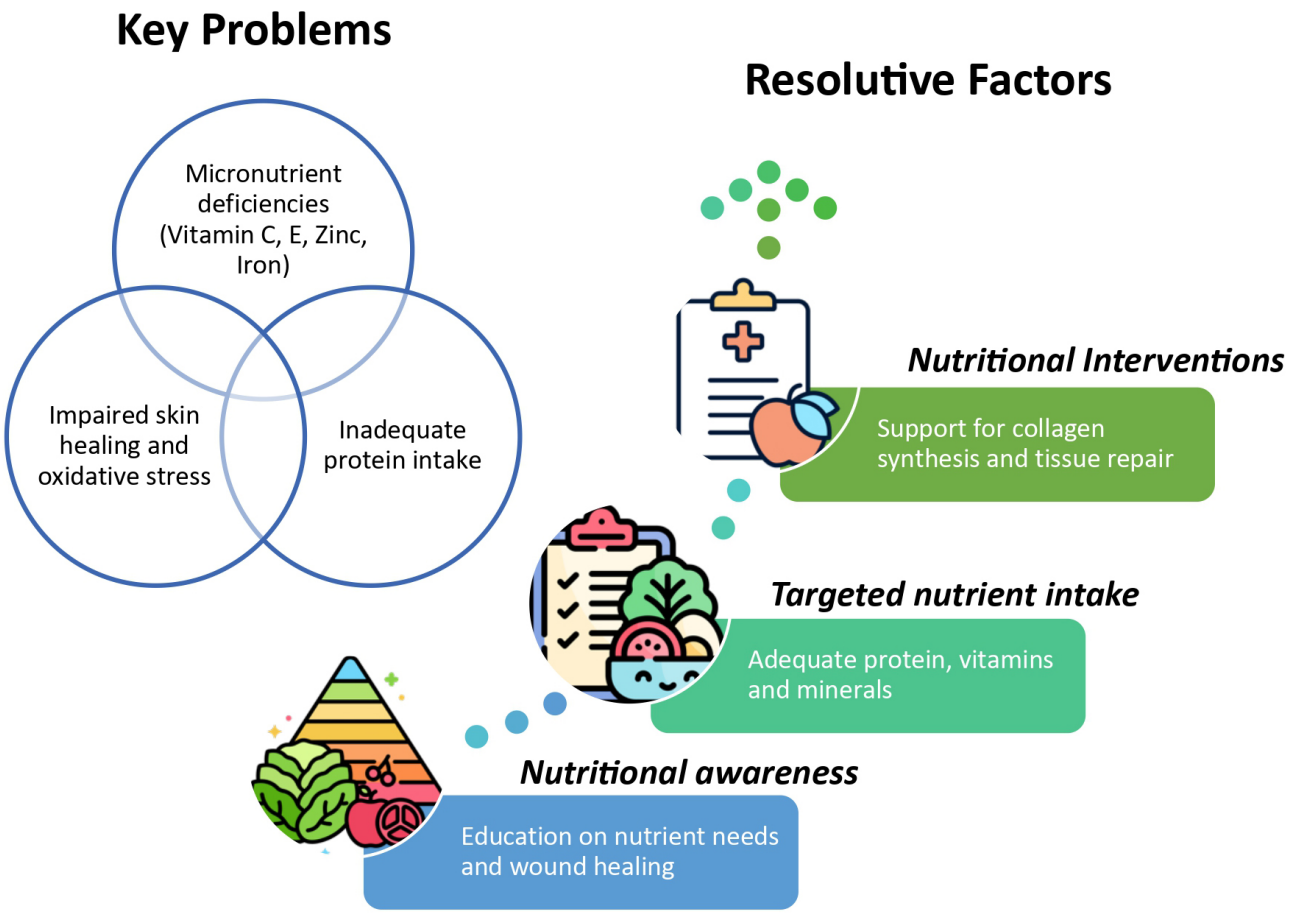

Fig. 1. Summary of vitamins support for pressure injuries (PIs).

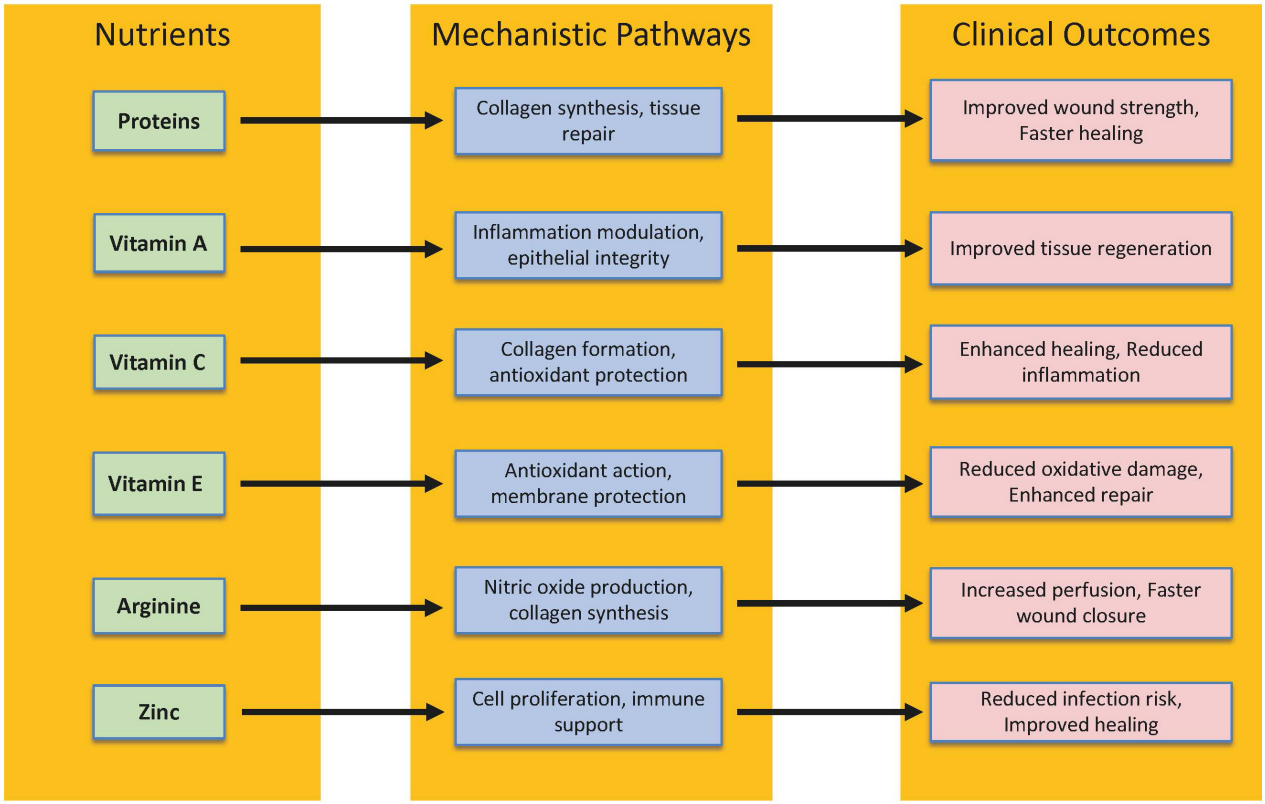

Fig. 2. Nutrient-specific mechanistic pathways for PIs healing.

in chronic care in general [25]. Vitamin C, crucial for collagen synthesis, and vitamin E, with its antioxidant properties, are important for skin protection and healing [26]. Minerals like zinc, which supports cellular regeneration, and iron, essential for oxygen transport, are also key for preventing and treating pressure ulcers [27]. Deficiencies in these nutrients impair collagen synthesis and the body's ability to manage oxidative damage, slowing the healing process (Fig. 1. and Fig. 2.) [25–27]. However, despite the importance of nutrition for patient health and well-being, it is rarely implemented in clinical practice. Healthcare providers report limited nutritional education, highlighting a significant training gap [28]. Nutritional screening and assessment tools, such as the Malnutrition Universal Screening Tool (MUST), should be used for all patients, especially in communities where the prevalence of PIs is higher [29]. Specific nutritional interventions, such as energy-protein support and supplementation with special amino acids like L-arginine, zinc, and antioxidants, have been shown to be effective in improving PIs healing [30]. The primary aim of this study was to identify and integrate the best scientific evidence on nutritional interventions that can prevent, facilitate or accelerate PIs healing in an adult population using a narrative methodology [22,23]. Additionally, qualitative and quantitative outcomes reported in the included studies were analyzed.

2. Materials and Methods

2.1 Study Design

This study employs a narrative review methodology, supported by the Scale for the Assessment of Narrative Review Articles (SANRA) qualitative support for conduction [31] (SANRA checklist; **Supplementary File 1**), aiming to provide a quantitative and qualitative synthesis of the existing literature on the relationship between nutrition and PIs healing in an adult population.

2.2 Research Question Definition

The research questions that guided this narrative review are as follows:

• In adult patients at risk of PIs, do specific nutritional interventions, compared to no intervention or another intervention, reduce the incidence of PIs?

• In adult patients with PIs, is the administration of nutritional supplements, compared to no intervention or another intervention, more effective in improving or healing PIs?

This research was developed using the PICOS framework [32], already established in previous studies [11,21,33], to ensure a structured and scientifically valid approach to the identified topic:

P (Population): Adult patients at risk of or with PIs without a declared primary chronic condition;

I (Intervention): nutritional intervention (nutritional or educational support);

C (Comparison): no nutritional intervention or alternative intervention;

O (Outcome): qualitative and quantitative outcomes;

S (Study Type): Randomized Controlled Trial (RCT).

This review aimed to thoroughly examine the relationships between nutrition and PIs healing to provide solid evidence for clinical and public health practice in managing this complication.

2.3 Inclusion Criteria and Screening

The study included a preliminary registration in the OSF database with the code https://doi.org/10.17605/OSF.IO/NGEZT. The search strategy was conducted using the PubMed-Medline and Scopus databases, aiming to select RCTs published in the last 10 years. After the initial search to identify the total number of records, a blinded screening process was carried out independently by two reviewers (GCan and FS). In case of disagreement between the two, and to reach the necessary consensus for inclusion, a third researcher (SM) was involved in the selection process. EndNote 20 (© 2024 Clarivate, London, UK) [34] was used for bibliographic management of the analyzed records, and specific search strings were applied with Boolean operators (Search Strategy: **Supplementary File 2**). Exclusion criteria: all studies not aligned with the selected review model (e.g., cohort studies), in incomplete editorial formats (such as conferences and editorials), and that did not meet the PICOS framework selected and discussed in point 2.2 of this manuscript.

2.4 Data Synthesis

The selected studies underwent a rigorous two-phase analysis. Initially, they were categorized based on various criteria: first author/period/location, cohort, intervention, bias, and primary outcomes. This categorization ensured a structured approach to synthesizing the identified literature. Subsequently, a comprehensive narrative synthesis was conducted, integrating the results of the selected RCTs and providing an overall perspective on the topic, while also highlighting the unique features and complexities of each included study.

2.5 Risk of Bias and Methodological Quality Assessment

The risk of bias and methodological quality of the studies included in this review were independently assessed by two researchers to ensure a comprehensive and objective evaluation. To achieve this, the researchers utilized the Critical Appraisal Skills Programme (CASP) checklists [35], which are widely recognized tools for assessing the quality of both qualitative and quantitative studies. The use of the CASP checklist allowed for a systematic examination of key elements such as study design, methodology, sample size, data collection processes, and the validity of the conclusions drawn. The assessment aimed to identify potential sources of bias and limitations within the studies, ensuring that the findings presented in the review were based on high-quality, reliable evidence (**Supplementary File 3**).

3. Results

The search strategy yielded a total of 1507 records from the PubMed-Medline and Scopus databases. After removing 20 duplicates and excluding 1250 articles based on title, 235 articles were selected for abstract screening. Of these, 214 were deemed irrelevant. Subsequently, 23 full-text articles were evaluated for eligibility, and 15 were excluded due to irrelevance or not meeting methodological requirements. As a result, eight RCTs were included in the final narrative review (Fig. 3, Table 1, Table 2 (Ref. [36–43])).

Table 1. Characteristics of included studies.

Characteristic	Frequency (n = 8)	Percentage
Publication year		
2023	2	25.0%
2021	1	12.5%
2017	1	12.5%
2016	2	25.0%
2015	1	12.5%
2014	1	12.5%
Cohort		
EG	355	51.82%
CG	330	48.18%
Quality of studies		
Positive	7	87.5%
Negative	0	0%
Unknowns	1	12.5%

CG, control group; EG, experimental group.

3.1 Characteristics of Included Studies

Of the 8 included RCTs [36–43], three were conducted in Australia [37,40,41], and one each in Iran [36], Brazil [38], Japan [39], Italy [42], and Singapore [43]. A total of 355 subjects were included in the experimental group (EG) and 330 in the control group (CG). The largest experimental cohort included 102 cases, while the smallest had 12. The quality of the study design was high in 7 out of 8 studies, with only one not reaching the same standard.

3.2 Results of Included Studies

3.2.1 Prevention of PIs

The analyzed studies emphasize how the integration of topical and nutritional interventions plays a crucial role in the prevention of PIs, highlighting both clinical efficacy and improvement in patient conditions (Fig. 4.).

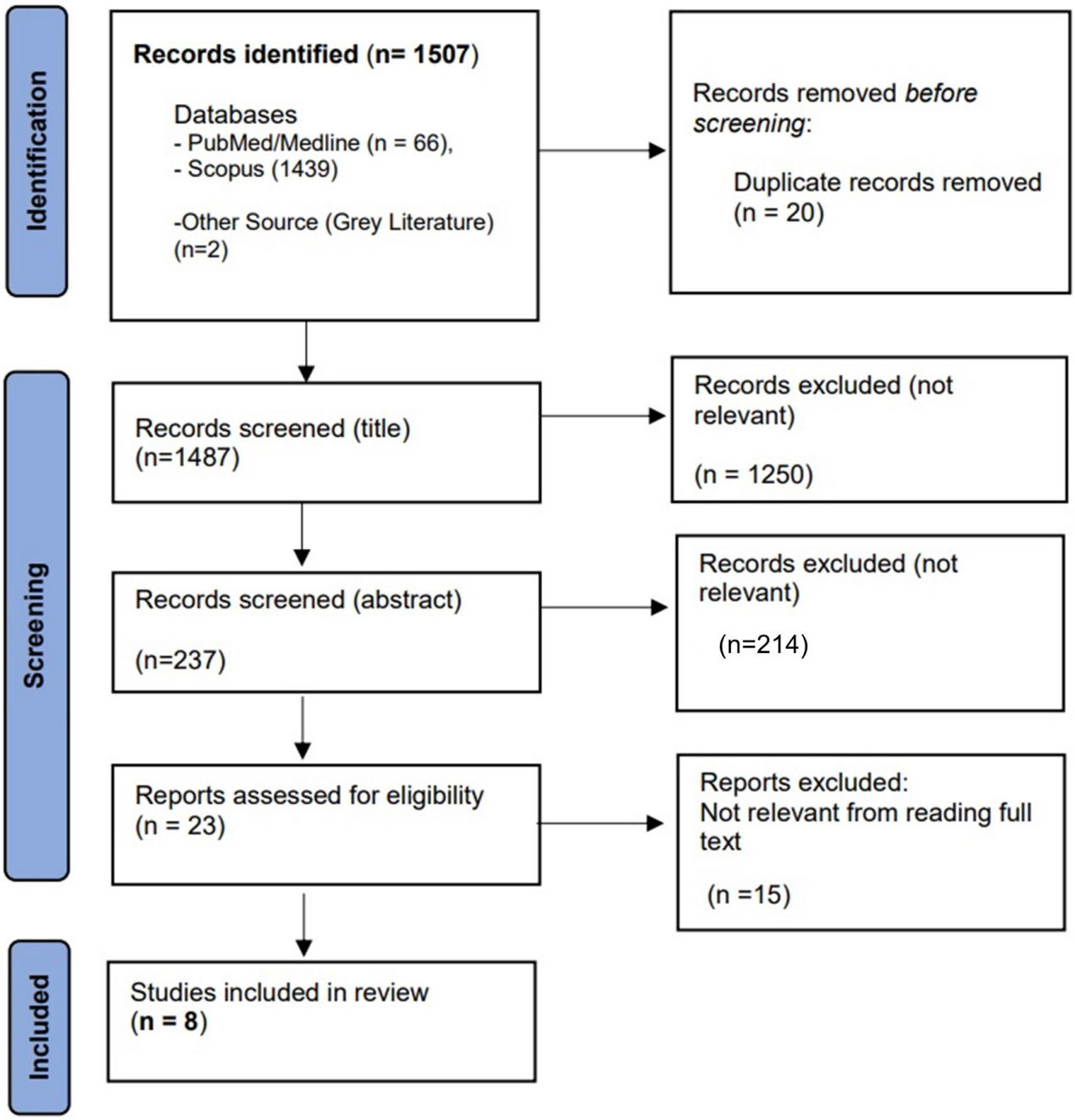

Fig. 3. Prisma flow chart.

Sadeghi SS *et al*. [36] conducted a clinical study involving 102 patients admitted to the Intensive Care Unit at Besat Hospital (Iran), assigned to either the control group (CG) (N = 31), the placebo group (N = 37), or the experimental group (EG) (N = 34). Baseline data were collected on demographics, clinical variables, level of consciousness, Braden scale, and nutritional status. The intervention group received topical fish oil (2 cc) applied to the sacrum daily for 5 days, while the placebo group received soybean oil, and the CG received routine care. Daily assessments of the incidence of PIs were conducted for 6 days. Results showed a significantly lower incidence of PIs in the fish oil group compared to the control group (p = 0.023), demonstrating the preventive efficacy of topical fish oil. Similarly, the pilot study by Roberts S *et al*. [41] evaluated the effectiveness of nutritional education in the prevention of PIs. Patients participated in nutritional self-care sessions and were interviewed about the acceptability of the intervention. The survey was conducted on 80 at-risk patients in 3 hospital wards in Queensland, Australia, with a 3-day intervention. The EG (n = 39) showed an improvement of 27% and 42% in energy and protein requirements, compared to marginal improvements (1% and 18%) observed in the CG (n = 41). Recruitment and retention rates were high (81.6% and 87.5

Table 2. Summary of included studies.

Author/Period/Location	Sample	Main intervention	Main biases	Main results
Sadeghi SS *et al.* [36] 2023/Iran	34 EG, 31 CG, 37 Placebo group	Topical use of fish oil to prevent wounds	Unclear randomization	Higher risk of PIs in CG vs EG and placebo; EG 2.7 times lower ($p = 0.023$); placebo 11.9 times lower ($p = 0.132$)
Banks MD *et al.* [37] 2023/Australia	42 intensive intervention, 43 supplements 46 CG	Intensive nutritional intervention or with supplements of Arg, VIT-C, and Zinc	Reduced sample, knowledge of the intervention known to patients	91% enriched diet; only 26.7% and 33.6% meet energy/protein requirements; variations in PUSH score (-2.9 ± 3.2) and reduction in PIs area (-0.75 cm^2) in EG
Mehl AA *et al.* [38] 2021/Brazil	15 EG, 15 CG	Specialized ONS in EG; standard ONS in CG	Heterogeneous sample, short duration (4 weeks)	Difference in percentage reduction of wound area: CG 34.0% $\pm$ 32.1 vs EG 28.4% $\pm$ 32.0. Weekly growth of wound edge in EG: 1.85 mm (diabetics), 3.0 mm (non-diabetics). Average reduction of the area of PIs: EG 15%, CG worsening by 1.8%
Yamanaka H *et al.* [39] 2017/Japan	22 CP, 22 Arg, 22 CG	Standard care, with supplementation of CP or Arg	Reduced sample, stringent inclusion/exclusion criteria	Improvement in DESIGN-R score for the CP group (10.9 $\pm$ 4.5) vs CG (15.2 $\pm$ 6.5) after 2 weeks; significant improvement in final scores for the CP group (8.6 $\pm$ 6.2) vs CG (13.9 $\pm$ 7.9) after 4 weeks
Banks MD *et al.* [40] 2016/Australia	25 EG, 25 CG	Intensive nutritional care in EG; standard care in CG	Assignment of notes to patients and nurses, reduced sample	High correlation between intensive care and improvements in PUSH scores and in the area of PIs
Robert S *et al.* [41] 2016/Australia	39 EG, 41 CG	Education and participation in nutritional self-care	Exclusion of patients with cognitive deficits or illiteracy; knowledge of nutritional monitoring in the CG	Satisfaction of: recruitment rates (81.6%), number of subjects who completed the study (87.5%) and number of subjects who performed at least part of the intervention (100%); energy/protein needs improved by 27% and 42% in EG vs 1% and 18% in CG; no negative feedback
Cereda E *et al.* [42] 2015/Italy	101 EG, 99 CG	Nutritional formula with Arg, zinc, antioxidants in EG; standard formula in CG	Exclusion of normonutrient patients; inclusion only of patients who can drink ONS	Reduction of PIs size by 60.9% in EG vs 45.2% in CG; complete healing better at 4 weeks in EG (16.9%) vs CG (9.7%)
Wong A *et al.* [43] 2014/Singapore	12 EG, 14 CG	Mixture with amino acids in EG; placebo in CG	Heterogeneity of PIs, short study (2 weeks), small sample	Reduction of wound area by 37.5% in CG vs 27.5% in EG; decrease in PUSH scores from 12.25 $\pm$ 0.72 to 10.81 $\pm$ 0.95 in EG after 1 week vs 10.63 $\pm$ 1.06 in CG after 2 weeks; significant improvement of vital tissues in EG (+43%) vs CG (25.9%)

EG, experimental group; CG, control group; ONS, Oral Nutritional Supplements; PIs, Pressure Injuries; PUSH, Pressure Ulcers Scale for Healing; CP, collagen peptide; VIT-C, Vitamin C; Arg, Arginine; DESIGN-R, Depth, Exudate, Size, Inflammation/Infection, Granulation Tissue, Necrotic Tissue – rating score; *p*, *p* value.

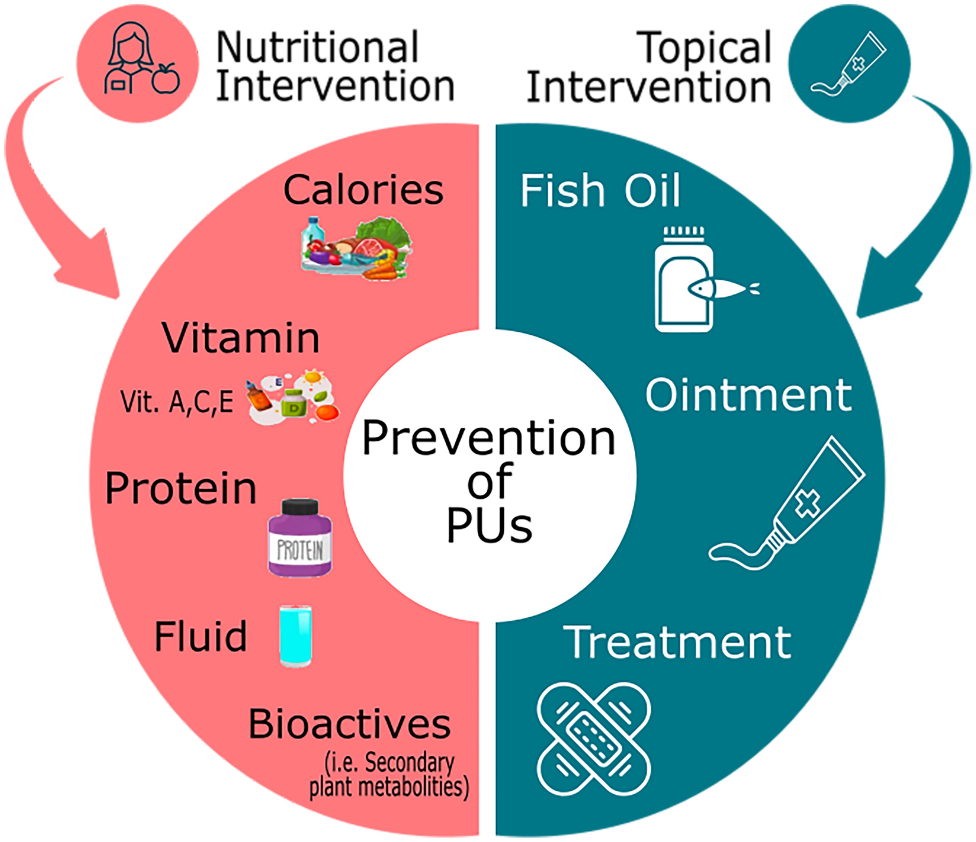

Fig. 4. Preventive nutritional interventions for PIs.

%, respectively), and 100% of participants took part in at least part of the intervention. No negative feedback was reported.

3.2.2 Care of PIs

Studies on the management of PIs highlight how specific nutritional interventions and personalized care programs can significantly improve healing processes. Various strategies have been explored, ranging from intensive nutritional regimens to enriched supplementation, all showing promising outcomes.

In 2023, Banks MD *et al.* [37] conducted a multicenter study at public and private hospitals in Australia. A total of 131 malnourished adult patients with PIs were recruited, followed for 14 days, and assigned to three groups: CG (n = 46) with standard nutrition, intensive nutritional intervention conducted by nutritionists and dietitians (n = 42), and enriched supplements with trace elements such as Arginine (Arg), Vitamin C (VIT-C), and Zinc (n = 43). The majority (91%) received an enriched diet, but the estimated energy/protein requirements were met by only 26.7% and 33.6%, respectively. There were changes in the Pressure Ulcers Scale for Healing (PUSH) score in the intensive experimental group (–2.9 $\pm$ 3.2) with an overall variation in the area of the PIs (–0.75 cm^2), demonstrating the potential benefits of nutritional interventions for wound healing. Despite this, no statistically significant differences were found between the groups due to the low adherence (56%) of the participants. Supporting this evidence, the study by Mehl AA *et al.* (2021) [38] explored the impact of a specialized oral supplement in an outpatient wound care center in Curitiba, Paraná, Brazil. Thirty adult patients with difficult wounds were recruited. In the experimental group (EG) (n = 15), the intervention involved the administration of a specialized oral nutritional supplement (ONS) and the evaluation of its effects on wound healing. In the CG (n = 15), a standard ONS was administered. The patients were monitored for 4 consecutive weeks. After 1 month, the percentage reduction in wound surface area was significant in both groups (34.0 $\pm$ 32.1 in the CG compared to 28.4 $\pm$ 32.0 in the experimental group). The EG also showed a significantly greater average weekly growth of the wound edge in patients with diabetes compared to those without chronic complications (3.0 mm and 1.85 mm, respectively). Between the first and second week in the EG, there was a performance peak (average rate of area reduction of 15%), while in the CG, there was a deterioration of 1.8%. Further confirmations come from the multicenter study by Yamanaka H *et al.* (2017) [39], conducted in 22 hospitals in Japan, which evaluated the effectiveness of the collagen peptide and Arg supplement. Sixty-six patients with PIs were randomized into three groups: CG (n = 22) which in-

volved standard care, with collagen peptide supplement (n = 22), and with Arg supplement (n = 22) provided in the form of a drink (125 mL). The effects on the healing of PIs were analyzed for 4 weeks, and already after 2 weeks of treatment, the total scores of the Depth, Exudate, Size, Inflammation/Infection, Granulation Tissue, Necrotic Tissue - rating score (DESIGN-R) of the group with collagen peptide supplement (10.9 $\pm$ 4.5) were significantly lower than those in the CG (15.2 $\pm$ 6.5) during the same period. There was no difference in scores in the Arg group compared to those in the CG. After 4 weeks, the final scores of the group supplemented with collagen peptides (8.6 $\pm$ 6.2) were significantly lower than the CG group (13.9 $\pm$ 7.9). These results are consistent with the pilot study by Banks MD *et al.* (2016) [40], which examined the effect of intensive nutritional care in an Australian regional hospital. The objective was to assess the feasibility of data collection on recruitment, retention, intervention delivery, and outcome measurement. Fifty adult patients with PIs were randomized to receive intensive nutritional care in the EG (n = 25) or standard care in the CG (n = 25). Day 15 was deemed suitable for outcome analysis. Early discharges reduced the number of participants (n = 31), necessitating a post-discharge follow-up. PUSH scores and changes in the area of PIs were strongly associated with intensive nutritional care, thus justifying its use. Given the small sample size, no significant differences were found in the healing of PIs. Further supporting this, the multicenter study by Cereda E *et al.* (2015) [42] demonstrated the effectiveness of enriched nutritional formulas administered in Italian long-term care and home care facilities. Two different oral hypercaloric/protein nutritional formulas were administered to 200 patients for 8 weeks. The EG (n = 101) differed from the CG (n = 99) by the addition of Arg, zinc, and antioxidants in the nutritional formula. The EG achieved better results compared to the CG, with an average reduction in PI size of 60.9% and 45.2%, respectively. Furthermore, the EG showed a significant effect on complete healing at 4 weeks (16.9% in the EG compared to 9.7% in the CG). Finally, Wong A *et al.* (2014) [43] examined the effect of an amino acid mixture on patients with PIs at Changi General Hospital, Singapore. Twenty-six patients with PIs were randomized into two groups: CG (n = 14) which involved a placebo mixture supplement and EG (n = 12) with an amino acid mixture. The duration of the study was 2 weeks. In the CG, the wound area was reduced by 37.5% compared to 27.5% in the EG. In the EG, the PUSH scores significantly decreased after just 1 week (from 12.25 $\pm$ 0.72 to 10.81 $\pm$ 0.95), whereas in the CG, this occurred only after 2 weeks (10.63 $\pm$ 1.06). However, the differences in scores between the two groups were not significant. A notable finding of the study was the significant improvement in the proportion of viable tissues from baseline to the planned follow-up in the EG (+43.1%) compared to the CG (25.9%).

4. Discussion

The review highlighted the crucial role of nutrition in the management of PIs among adults, emphasizing that targeted nutritional strategies can significantly enhance the healing process. These approaches not only support tissue repair but also help reduce the pain and discomfort associated with PIs, ultimately improving patients' quality of life [44,45]. Despite the growing body of evidence supporting the efficacy of nutritional interventions, their implementation in routine clinical practice remains inconsistent. Barriers such as limited awareness among healthcare professionals, inadequate training, and limited integration into clinical guidelines hinder the widespread adoption of these strategies. The emerging data confirm that adequate nutritional interventions can positively impact tissue repair, reducing complications and accelerating recovery. Furthermore, several international studies have demonstrated the effectiveness of these interventions in the management of other common chronic conditions, including type 2 diabetes, cancer, respiratory, hepatic, allergic, neurodegenerative, and kidney diseases [46–54]. This suggests that a broader application of nutritional strategies in chronic disease management could also enhance PI prevention and treatment. Conversely, poor nutrition can promote the development of such conditions. For example, it has been documented that a high consumption of ultra-processed foods increases the risk of developing diabetes by 31% [55]. A key aspect identified is the importance of nutritional education. Although educational programs have been shown to be well-received by patients, improving awareness regarding the prevention of PIs [41], previous studies [53] indicate that nutritional knowledge remains limited, even when patients benefit from specific professional consultations. Munoz *et al.* [22] and Langer *et al.* [23] emphasized that while nutritional interventions show clear benefits, their success largely depends on patient adherence and healthcare provider engagement. Therefore, educational strategies should not only target patients but also be incorporated into training programs for nurses and clinicians to ensure better long-term implementation. Consequently, it is essential to implement integrated educational strategies, also through digital platforms and social media, to enhance nutritional literacy a promote healthier behaviors [56–58]. The active participation of the patient, promoting greater awareness of the link between nutrition and health, represents a fundamental lever to improve therapeutic compliance and clinical outcomes [59]. In this context, the adoption of artificial intelligence (AI) could amplify the effectiveness of nutritional strategies, offering personalized recommendations based on the specific needs of the patient. However, its use raises legal and ethical issues, requiring careful regulation, which is already common practice in numerous branches of medicine for chronic diseases [60–62]. Recent advancements in AI-driven nutritional guidance have demonstrated potential in optimizing dietary interventions for chronic wound healing.

Implementing AI-based decision-support systems in hospitals and long-term care facilities could enhance the precision of nutritional plans and improve patient outcomes [57–59]. Nevertheless, further research is needed to validate the effectiveness of these approaches specifically in the context of PIs. Another decisive element that emerged from the review concerns the effectiveness of specific nutritional interventions compared to standard care. Recent studies [63–65] confirm that the use of nutritional supplements, including formulas enriched with proteins, micronutrients, and antioxidants, plays a fundamental role in improving clinical outcomes. For example, specialized ONS containing energy, proteins, and vitamins have been shown to accelerate the healing process of PIs, with noticeable improvements observed as early as two weeks from the start of treatment [38]. Moreover, the use of these supplements in community settings is associated with a significant reduction in complications, such as infections, post-operative problems, and insufficient healing [66]. However, it is important to note that not all studies have demonstrated a direct causal link between micronutrient supplementation and PI prevention. Several studies have reported variable responses, highlighting the need for personalized approaches that consider individual patient factors such as comorbidities, baseline nutritional status, and severity of PIs [67,68]. The use of arginine, zinc, and other micronutrients has been widely studied and has proven promising in promoting wound repair [36–40,42,43]. Arginine, for example, stimulates the synthesis of proline and nitric oxide, both essential for tissue repair, while zinc plays a key role in maintaining immune function [69]. To strengthen the proposed mechanisms and reduce the excessive reliance on correlational data, it is essential to integrate translational evidence, such as *in vitro* collagen synthesis assays, which can provide more concrete and direct evidence of the biological pathways involved [70,71]. Furthermore, it is crucial to understand the underlying biological mechanisms that link nutrient status and intake to pressure ulcer healing. Specific nutrients, such as arginine and zinc, play a direct role in the biological processes involved in tissue repair. Arginine, for instance, stimulates the synthesis of proline and nitric oxide [72], two molecules essential for wound healing. Zinc is critical for supporting immune function and regulating cellular metabolism [73]. Additionally, vitamins, particularly vitamin C and vitamin A, are vital for collagen synthesis and for modulating the inflammatory response [74]. Although previous studies, have already demonstrated the positive effects of nutritional interventions in PIs management [22,23] this review adds value by offering a comprehensive synthesis of recent clinical evidence with a particular focus on implementation challenges and future research directions. Unlike earlier systematic reviews that primarily assessed efficacy, this study highlights the barriers preventing nutritional strategies from becoming standard practice in PIs care. Furthermore, it discusses the importance of interdisciplinary collaboration and emerging technologies, such as AI and digital health tools, in optimizing nutritional interventions. By emphasizing these aspects, our work contributes to bridging the gap between research findings and real-world clinical application. However, some studies [67–71,75] have not demonstrated a direct causal link between the intake of these micronutrients and the prevention of PIs, suggesting the need for further studies to clarify these associations. A more standardized approach to nutritional supplementation is also required to define optimal dosages and administration protocols tailored to PIs patients. Future trials should focus on defining the most effective combinations of nutrients and evaluating their long-term effects. In addition to nutritional interventions, educational modalities play a critical role in the management of PIs particularly in community setting [76–78]. Patient education on self-care practices, including proper nutrition, skin care, and repositioning techniques, is essential for preventing and managing PIs effectively [79,80] Studies have shown that well-structured educational programs can empower patients to actively engage in their care, improving compliance with nutritional strategies and reducing the risk of complications [81,82]. Healthcare professionals, specially nurse, are key in delivering this education, ensuring that patients are equipped with the necessary knowledge to optimize their healing process and overall well-being [76–82].

4.1 Future Research Perspectives

There are several promising directions for future research in the field of nutrition applied to the management of PIs. For instance, AI and technological support in healthcare could be leveraged to generate personalized nutritional recommendations. These technologies enable continuous and real-time monitoring of patient needs. Moreover, the advancement of digital nutrition platforms and social media opens new perspectives for developing more effective methods of food promotion. Nutritional mobile apps, already successfully used in other conditions such as chronic kidney disease, also show promise in the prevention of PIs [83]. Additionally, future research should explore the cost-effectiveness of large-scale nutritional interventions for PI prevention. Economic analyses comparing standard wound care with nutrition-focused strategies could provide valuable insights for policymakers and healthcare administrators. Studies have confirmed the effectiveness of these supports in improving patients' motivation, self-efficacy, knowledge, and attitudes, enhancing the therapeutic education offered by healthcare professionals between clinical and social care [84]. Another important research direction involves evaluating the impact of interdisciplinary collaboration in PI care. Integrating dietitians into wound care teams could improve the identification of malnutrition-related risks and ensure timely nutritional interventions. Interdisciplinary collaboration between nursing and engineering disciplines is crucial for the development of these inno-

vative solutions, which not only improve patient outcomes but also transform healthcare practice [85]. Finally, future studies should investigate the potential benefits of specific dietary patterns, such as the Mediterranean or high-protein diets, in PI prevention and treatment. These approaches, which have shown promising results in other chronic conditions, could offer alternative, patient-friendly strategies for PI management. It is essential to evaluate the long-term effectiveness of such nutritional interventions to understand their impact on patients' quality of life and healthcare costs. These advancements in research and implementation of healthcare technologies allow for the improvement of therapeutic and preventive strategies, fostering a future of excellence in global healthcare.

4.2 Limitations

This review presents some limitations that affect its interpretation. Firstly, many of the included studies have small sample sizes, which reduce the statistical power and robustness of the results. Furthermore, the heterogeneity among patient groups, resulting from different comorbidities, makes direct comparison between studies difficult. Factors such as short follow-up durations, often caused by early patient discharge, also limit the ability to assess the long-term effectiveness of interventions. Another critical limitation is the marked heterogeneity in the demographics and clinical profiles of the included populations. The analyzed studies involved diverse groups, including critically ill patients, individuals with diabetes, and elderly people with varying degrees of frailty. For instance, Cereda *et al*. [42] did not stratify patients based on diabetes status, which may have influenced wound healing outcomes. This variability hinders the generalizability of the results and underscores and underscores the need for future trials to adopt more standardized inclusion criteria and stratification methods to improve comparability across studies. Additionally, the methodological quality of the included studies was moderate, as reflected in the SANRA score score of 10 out of 12. A major concern was the lack of blinding in most randomized controlled trials (7 out of 8), as highlighted in the CASP Checklist (**Supplementary File 3**). This limitation raises concerns about potential bias in outcome assessment, especially when relying on subjective measures such as wound healing scores. Furthermore, many studies failed to report key statistical indicators, such as confidence intervals, which weakens the reliability of the findings and limits the generalizability of results. Another important limitation concerns the incomplete reporting of critical parameters in some studies, such as the exact dosage, duration, and administration details of interventions like fish oil. These omissions make it difficult to replicate the interventions or apply them in clinical practice. Despite these limitations, the main strength of this review lies in its rigorous and well-structured methodological approach, which ensures a high level of validity for a narrative review. Future research should adhere to more robust methodological and reporting standards, such as the CONSORT guidelines, to improve transparency, reproducibility, and clinical applicability.

5. Conclusions

This study provides an in-depth overview of the importance of nutritional interventions in the management of PIs in adults, an aspect often underestimated in routine clinical practice. Nutritional education has proven essential in improving patient engagement and promoting informed dietary choices, while nutritional supplements, aimed at tissue repair, have shown a significant positive impact on wound healing. The implementation of these strategies not only optimizes clinical outcomes but also contributes to the overall improvement of patient well-being, promoting more effective integration within care pathways. However, the collected data suggest the need for further research, especially regarding larger sample sizes and the analysis of the long-term effectiveness of nutritional interventions. Future studies should also explore the benefits derived from specific dietary patterns and evaluate the impact of nutritional education by healthcare providers, particularly nurses, on clinical outcomes. Moreover, it would be valuable to assess the effectiveness of these interventions in high-risk populations, such as individuals in community or long-term care settings, to determine their preventive impact in vulnerable groups.

Availability of Data and Materials

The datasets used and analyzed during the current study are available from Giovanni Cangelosi on reasonable request.

Author Contributions

GCan, AA, GCag and FS designed the research study. GCan, FS, SM, SMP and MS performed the research. FB and SMP provided help and advice. GF and FB analyzed the data. GCag, FS, SM, SMP, AA, FB and FP wrote the manuscript. GCag FB, SMP, AA and FP supervision. GCan, AA, GCag, SM and FP responsability and direction. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Not applicable.

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Conflict of Interest

The authors declare no conflict of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/IJVNR36342.

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