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Review Article

Probiotics: A Promising Ally in Burn Treatment

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ABSTRACT

Introduction The intricate relationship between the skin and gut microbiota and the systemic immune response highlights the potential of probiotics in managing burn-induced microbiome dysfunctions. This review aims to explore the potential therapeutic benefits of probiotics in burn management and their potential as adjuvant therapy for enhancing treatment results and patient well-being in the burn care context.
Methods: Between 2015 and April 2025, we conducted a comprehensive literature search using the three major databases: PubMed, Scopus, and Web of Science. We included articles written in English. We reviewed both observational and interventional studies.
Results: Probiotics contribute to burn injury management in several ways, from improving clinical outcomes to wound healing and nutrient absorption to immune response modulation. However, their safety remains a matter of concern. Probiotics also decreased hospital stays and enhanced wound healing in pediatric burn patients. Topical probiotics dramatically promoted restoring skin barrier function in burn wounds, decreasing erythema, edema, and hyperpigmentation while stimulating epithelialization and collagen deposition.
Conclusion: Probiotics hold promise for treating burns; qualitative evidence supports their utility in counteracting imbalances in the gut microbiota, enhancing immune function, wound healing, and nutrient absorption. Nevertheless, challenges will include standardization, safety in immunocompromised patients, and variable drug interactions, which may signal a degree of cautious optimism.

1. Introduction

The intricate balance of the human microbiome plays a crucial role in maintaining health and well-being. To keep this balance intact, various strategies have been instituted. For example, probiotics are one such agent. These microorganisms help maintain gut health and beyond when taken in sufficient quantity. The potential health benefits of probiotics vary widely, from promoting digestion to enhancing immunity, thereby demonstrating their multipotent use in preventive and curative health applications [1]. One of the traumatic injuries that a human being can face is burns, characterized by skin damage due to exposure to heat, chemicals, electricity, or radiation. They represent a significant medical challenge due to their complexity and the broad spectrum of complications that can arise during the healing process [2]. Among the first major consequences of burn injury is the disruption to skin barrier function, which is a major insult; the dysbiotic disturbances to the microbiome may directly or indirectly contribute further to impaired wound healing, increased predisposition to infection, and systemic inflammatory responses[3]. The interaction between burns and microbiome dysfunction represents a potential new avenue of therapeutic intervention. Burns can seriously alter microbiome composition and thereby exert a deleterious effect on burn outcomes and recovery [4]. For instance, burns can also possibly help opportunistic pathogens colonize through disruption of the skin barrier, leading to invasiveness of infections of bacteria of the genus Staphylococcus, Pseudomonas, and Acinetobacter, as well as fungal organisms such as Candida Albicans [5]. The interrelationship between skin and gut microbiota with systemic immune response presents the possibilities for probiotic therapy for managing burn-induced microbiome dysfunctions. Thus, probiotic therapy could counteract detrimental effects on wound healing and wound infection secondary to burn due to its ability to modulate the host microbial ecology [6]. This review article seeks to explore the interface between burns and probiotic therapy. Reviewing the current research, this work intends to clarify the implication mechanisms of probiotics in burn recovery as demonstrated in the pediatric population through decreased hospital stay and wound healing outcomes [7], address microbiome dysfunctions, and ultimately contribute to optimizing burn treatment protocols. Through this narrative review, we aim to underscore the importance of integrating probiotic therapy into burn treatment protocols, paving the way for improved patient outcomes and advancing the field of burn care.

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Table 1: Summary of Literature Search Strategy and Selection Criteria

Item	Description
Date of search	Between January 2015 and April 2025
Databases	PubMed, Scopus, Web of Science
Search terms	("probiotic*" OR "lactic acid bacteria" OR "Lactobacillus" OR "Bifidobacterium" OR "Saccharomyces boulardii" OR "Bacillus coagulans" OR "Streptococcus thermophilus" OR "Enterococcus faecium" OR "Escherichia coli Nissle 1917" OR "Clostridium butyricum" OR "Leuconostoc" OR "Pediococcus" OR "Propionibacterium")
	AND ("burn*" OR "thermal injury" OR "burn wound" OR "burn patient*" OR "scald*" OR "fire injury")
	AND ("wound*" OR "wound healing" OR "cutaneous injury" OR "skin injury" OR "ulcer*" OR "tissue repair" OR "lesion*" OR "skin regeneration")
Inclusion criteria	Articles written in English, patients with skin wounds or any degree of skin burns, and using probiotics of any type
Exclusion criteria	Animal studies, articles written in different languages other than English
Selection process	K.J., J.N., L.M., and H.H. conducted the selection of articles. Consensus was reached with discussion among all authors.

2. Methods

We conducted a comprehensive literature search using PubMed, Scopus, and Web of Science databases. The articles retrieved were from January 2015 until April 2025. Our research strategy across the databases included the following Mesh terms: “probiotic” OR “lactic acid bacteria” OR “Lactobacillus” OR “Bifidobacterium” OR “Saccharomyces boulardii and "burn*" OR "thermal injury" OR "burn wound" OR "burn patient" and “wound*" OR "wound healing" OR "cutaneous injury" OR "skin injury". We selected the articles that fit our inclusion criteria: patients above 18 years with skin wounds or burns regardless of the degree, patients using any type of probiotics, and articles that investigated the efficacy and safety of probiotics in patients with burns or wounds. All interventional and observational articles were included. Articles conducted on animals or in vitro were excluded, along with articles written in other than English. Additionally, articles that did not discuss probiotics as an effective treatment for patients with burns or wounds were excluded. The search strategy summary can be found in **(Table 1)**

3. Discussion

The research has proved that probiotics play a significant role not only in the management of burn injury but also in the enhancement of clinical outcomes, accelerating the wound healing process, facilitating the absorption of nutrients, and modulating immune responses. However, the issue of safety is still open. For instance, probiotics have caused a reduction in hospital stays and wound healing in burn children [7]. Moreover, the skin barrier function of topical probiotics, e.g., Lactobacillus rhamnosus and Lactobacillus acidophilus, had been improved by the treatment, which resulted in reduced chemically induced changes of skin (erythema), as well as the subsequent processes: the reduced swelling and darkening of the skin, and the faster regrowth of the epidermis and the introduction of the protein called collagen into the wound [8, 9, 10, 11, 12]. For a patient with burns, the immune system can be given a Probiotic boost by B. fragilis, inducing the production of anti-inflammatory cytokines and reducing inflammation if applied carefully 1[13, 14]. Additionally, Bacillus coagulans GBI-30, 6086 enhances amino acid absorption from milk protein, improving nutrient availability critical for tissue repair in burn recovery [15]. However, safety concerns, such as antibiotic resistance in Butyricicoccus pullicaecorum and the rare risk of Lactobacillus bacteremia in immunocompromised patients, underscore the need for strain-specific selection and careful monitoring to optimize therapeutic outcomes [16, 17, 18, 19].

3.1. Biological and Physiological Responses to Burns

Healing wounds is a very complex process that occurs in tissues and organs of the body. It depends upon an immune-mediated response composed of four key stages: Hemostasis, Inflammation, Tissue Proliferation, and Tissue Remodeling Formation [20]. Any deficiency in one or the other of these processes may harm the body’s ability to heal wounds.

In brief: Hemostasis begins immediately after injury, wherein platelets aggregate and form a clot to prevent further bleeding and release a variety of growth factors such as PDGF and TGF- to begin repair; inflammation soon follows where neutrophils and macrophages phagocytose pathogens and debris while releasing signals to promote repair. During proliferation, fibroblasts are activated to produce collagen III, while keratinocytes undergo re-epithelialization and angiogenesis to form granulation tissue. Remodeling involves the replacement of collagen III with the stronger collagen I, regression of blood vessels, and scar formation, allowing the wound to gradually gain strength over time [20].

3.1.1. Inflammatory and Immune response

Beyond the initial tissue damage, burns trigger a systematic inflammatory response. This response can be categorized into two phases: acute inflammation, crucial for healing, and chronic inflammation, which can lead to scarring if not properly managed. Effective inflammation management is essential to prevent complications like systemic inflammatory response syndrome (SIRS), multiple organ failure, and excessive scar formation [20].

3.1.2. Pain and sensory impact

Burns are also associated with significant pain, which varies based on factors like age, overall health, the cause of the burn, and its depth [21].

3.1.3. Metabolic response and nutritional needs

Metabolic rates increase greatly in major burns; thus, maintaining adequate nutrition is necessary to prevent muscle loss and promote wound healing. Accordingly, burn nutrition entails a well-balanced, closely monitored diet heavy in carbohydrates [22]. Finally, burn wound healing is a complex and slow process relying on the activity of the immune system. It progresses through three stages: inflammation, formation of tissues, and remodeling, with the risk of scarring along with these stages [23].

3.2. Mechanisms of Action of Probiotics in Burn Wound Healing

3.2.1. Burn-Induced Gut and Systemic Dysregulation

Severe burns produce extensive damage in the body, which triggers inflammation and affects multiple physiological systems and functions during their occurrence [24]. Severe burns have shown clear evidence of producing major gut microbiota changes and internal environment shifts. This demonstrates that the gut is a fundamental target site during acute infection, affecting patients from early to middle stages [25, 26, 27]. The modifications in microbial composition and increased intestinal permeability create essential changes that activate broad inflammation that affects immune functions across different organ systems since the gut microbiota serves as a crucial immune response controller during burn recovery, leading to multiple organ failure and severe critical illness outcomes [24, 25]. The gut serves as the central system in response to burn injuries because alterations in gastrointestinal conditions affect patient outcomes through increased complications, while a large burn can lead to extensive systemic inflammation, which develops into multiple organ failure, sepsis, and systemic inflammatory response syndrome (SIRS) [6, 24, 25, 28].

3.2.2. Gut Microbiome Composition and Burn Effects

Firmicutes, Bacteroidetes, Actinobacteria, and Verrucomicrobia, constitute the principal phyla of bacteria that make up the microbiome in a healthy gut [29]. The body relies on good bacteria to generate short-chain fatty acids (SCFAs), which form tight junctions to protect barriers. SCFAs perform a dual function by generating an anti-inflammatory response, which boosts immune cell tolerance in the gut, thus maintaining intestinal equilibrium [30]. Burn injuries cause damaged tissues to release cytokines and chemokines alongside danger-associated molecular patterns (DAMPs), which spread to the gut and various other tissues [26, 31]. The altered fecal microbiome worsens barrier dysfunction [27, 32], which triggers the intestinal epithelial barrier's breakdown, enabling bacteria and their byproducts to move into the lymphatic system and blood circulation [26, 33]. A burn injury causes a marked reduction in the microbiome's total number of bacterial types, which results in decreased levels of beneficial bacteria such as Bacteroidaceae, Bifidobacterium, and Ruminococcaceae [25]. Conversely, there's an increase in the potentially harmful bacterial family Enterobacteriaceae following a burn [34]. For example, invasive strains, such as Klebsiella species found outside their typical locations, can prompt dendritic cells to engulf pathogens and release inflammatory cytokines (IL-6, IL-12, and TNF). This process is strongly connected with the shift toward a Th1-type immune response [35].

3.2.3. Probiotic Role in Mitigating Gut Damage

The gut microbiota and the intestinal barrier permeability get altered due to burns and the underscored alterations in the microbiome composition. From here, probiotics play an important role in managing and reversing these damages [36]. The main research focus of recent years has centered on microbial ecosystem management, epithelial barrier protection, and immune system homeostasis [36].

3.2.4. General Benefits and Historical Use of Probiotics

Probiotics contribute to a healthy gut by introducing beneficial bacteria that support the digestive system and boost the immune system [37, 38, 39]. This was noticed long ago when people noticed an increase in life expectancy and decreased frequency of illness when ingesting yogurt and some mixes of bacteria. As understanding gut microbes deepens, probiotics, which are live microorganisms consumed effectively, have emerged to promote host health [39]. Probiotics also help prevent pathogens' growth by competing for nutrients indispensable for properly developing and multiplying these pathogenic microorganisms. Research studies have established that Lactobacillus rhamnosus GG and Lactobacillus plantarum probiotic strains suppress the adhesion of pathogenic Escherichia coli to intestinal epithelial cells through various mechanisms. These include competition for binding sites on epithelial cells, co-aggregation with pathogens, and production of surface adhesins and extracellular proteins antagonistic to the pathogen adhesion [13, 14, 38].

3.2.5. Probiotic Metabolites and Gut Barrier Enhancement

Probiotics have been proven to produce metabolites that are helpful for the host and aid in strengthening the gut lining and controlling mucosal immune activity [36]. Metabolites such as secreted proteins, organic acids, indole, bacteriocins, hydrogen peroxide (H2O2), and nitric oxide (NO) are released through the action of probiotics, enhance the integrity and protective function of the gut barrier through mechanisms including increased mucus production, heightened antimicrobial activity, and strengthened cellular connections [40]. In addition, the surface parts of probiotics such as flagella, pili, surface layer proteins (SLPs), capsular polysaccharides (CPS), and lipopolysaccharides also play a role. They act by creating microbial-associated molecular patterns (MAMPs), communicating with special receptors on intestinal epithelial cells (IEC), and initiating a cellular signaling pathway that promotes the release of inflammation-fighting molecules such as cytokines and chemokines, ultimately enhancing the function and health of the gut lining [40].

3.2.6. Immunomodulatory Actions of Probiotics

New research shows that live probiotics in the gut and the substances they produce can interact with various immune cell types, supplying them with enhanced immunomodulatory properties [36]. Specifically, the production of IgA within the gut is stimulated by probiotics, contributing to an elevated number of IgA+ cells in the intestinal mucosa and promoting a robust IgA cycle. This process contributes to developing the humoral immune system and enhancing mucosal immune surveillance beyond the gastrointestinal tract [36, 41]. Furthermore, probiotics influence immune responses through a well-defined regulatory mechanism by binding to pattern recognition receptors (PRRs) such as Toll-like receptors (TLRs), NOD-like receptors (NLRs), Dendritic Cell-Specific Intercellular adhesion molecule (DC-SIGN), and C-Type Lectin receptors (CLRs), triggering downstream signaling pathways mediated by adaptor proteins associated with nuclear factor-kappa B (NF-B) and mitogen-activated protein kinase (MAPK) pathways [40]. This consequently turns on genes encoding cytokines, chemokines, and antimicrobial peptides [40]. Probiotics, however, have a complex effect on the immune system because they modulate immune responses, trigger them, and preserve immunological homeostasis. For example, certain probiotic species like Bacteroides fragilis induce immune tolerance by producing Polysaccharide A (PSA), a key capsular antigen that directly regulates host immunity. PSA is detected by Toll-like receptor 2 (TLR2) of gut mucosa-residing dendritic cells to activate the signaling pathway to produce more regulatory CD4+ T cells (Tregs) [42]. These Tregs secrete anti-inflammatory cytokines such as IL-10 and Transforming Growth Factor-beta (TGF-) that exert their function to inhibit pro-inflammatory Th17 and Th1 responses and thus ensure intestinal immune homeostasis and prevent excessive immune activation [35].

3.3. Probiotic Impact on Wound Healing and Skin Regeneration

3.3.1. The Gut-Skin Connection in Burns

The skin microbiome, which consists of bacteria, fungi, and viruses, plays a role in maintaining health and immune responses. It has an impact on skin conditions [43]. The interactions between the microbiome and the immune system are crucial for wound healing, highlighting the importance of species in determining outcomes [44]. The diversity of microorganisms on the skin protects against pathogens, supports immunity, and influences the development of skin issues and chronic wounds [45]. Furthermore, the gut microbiota has a remarkable influence on skin health, where it emphasizes its role in shaping the skin microbiome's dynamics and managing skin conditions [46]. Probiotics have been widely used as topical and oral methods to treat numerous dermatological conditions [47]. Probiotics are promising to reduce wrinkles by suppressing the synthesis of matrix metalloproteinase-1 (MMP-1) and antioxidant action, which minimizes collagen breakdown. Moreover, probiotics enhance the skin's shininess by suppressing the synthesis of melanin and inhibiting the activities of tyrosinase, TYRP-1, and TYRP-2. They also provide proper hydration by strengthening the skin barrier and minimizing the trans-epidermal water loss (TEWL), promote anti-aging by inhibiting collagen cleavage and breakdown, and eliminate body odors via cutting down the strains associated with odor production [47, 48]. Participants who received a high concentration of topical probiotic formula showed considerable improvement in the severity of wrinkle depth and hyperpigmentation on the forehead and glabella [8]. Moreover, experimental evidence suggests that Lactobacillus rhamnosus (LR) can significantly enhance the skin barrier, qualifying it as a moisturizing skincare product [9]. Also, lactobacillus acidophilus IDCC 3302 protects the skin epidermis from UV-induced photodamage by enhancing the skin's antioxidant capacity, increasing hydration cytokines, and inhibiting the synthesis of MMPs by suppressing the MAPK loop [10]. Furthermore, applying topical probiotics decreased erythema and edema associated with CO2 laser therapy, alleviated skin sensitivity in individuals with reactive skin, and enhanced ceramide levels and skin hydration [11]. Various Lactobacillus species, such as Lactobacillus coryneform and Lactobacillus rossiae, have shown a potential to manufacture vitamin B12, accelerating wound healing. Additionally, Lactobacillus reuteri and Lactobacillus acidophilus enhance the absorption of dietary vitamins D and E, which are immensely important for wound healing [49]. In summary, probiotics taken via the oral route have three significant benefits. First, it influences the central nervous system, aiding in faster tissue regeneration. Second, it enhances the immune system by increasing lymphocyte recruitment. Lastly, it improves nutrient absorption [43, 44] **(Figure 1)**.

Probiotics promote burn wound healing by restoring gut microbiota balance disrupted by burns, counteracting dysbiosis with strains like Lactobacillus to inhibit pathogenic Escherichia coli adhesion. They enhance gut integrity through metabolites like SCFAs, strengthening epithelial barriers to prevent bacterial translocation and reduce systemic inflammation. Bacteroides fragilis modulates immunity by inducing Tregs and anti-inflammatory cytokines (IL-10, TGF-) via PSA and TLR2 signaling.

3.4. Potential challenges and limitations in probiotic treatment for burn wounds

3.4.1. Standardization Issues

The lack of standardized varieties and dosages can prevent the utilization of probiotics for treating burn wounds. Without well-defined protocols for selecting and administering probiotic strains and doses, there is a risk of obtaining unreliable results, ultimately diminishing the therapeutic effectiveness of such treatment [50]. Determining the right probiotic dose for healing burn wounds is critical but can be complex. The severity of the burn, the patient's immunological condition, and the delivery route can all impact how successful probiotic therapy is [50, 51].

3.4.2. Implementation barriers

In addition, to have any good benefits, probiotic strains must withstand the severe circumstances of the burn site. Probiotics' viability and survival are impacted by factors such as pH, temperature, and interactions with other bacteria in the wound [51]. However, additional investigation is required to understand the mechanism of action, optimum strain, cost-effectiveness, and optimal dose and duration of therapy for probiotics in burn patients [50, 51, 52]. Additionally, until now, there are no specific guidelines to follow in conducting trials (in vivo and in vitro) to assess possible probiotic strain toxicity and side effects [18]. Not only do probiotics influence the immune system in burn patients, but research also implies that they result in beneficial effects such as a decreased mortality rate and shorter hospital stays [53].

3.4.3. Safety concerns

Bacteremia, fungemia, septicemia, pneumonia, and abdominal abscesses are some of the hazards associated with probiotics. As a result, it is critical to properly assess the risk-benefit ratio before using probiotics in this population [12, 19]. One clinical trial showed that a probiotic containing Butyricicoccus pullicaecorum strain had several antibiotic resistance genes and carries the risk of horizontal transfer [18].

Probiotic therapy's role should be understood from managing the burn injuries perspective. Research, including that by Moghadam et al., shows that when probiotics are used together with antibiotics like tetracycline, they can synergistically combat antimicrobial-resistant strains of Pseudomonas aeruginosa found in burn wounds, potentially enhancing the effectiveness of treatments [19]. Nonetheless, the outcome of such interactions can be unpredictable, with the potential for antagonistic effects that might diminish the overall effectiveness of the treatments [19]. On the other hand, other studies have concluded that the direct application of probiotics on burned surfaces, like Lactobacillus plantarum and Saccharomyces cerevisiae, could control the inflammation, speed up epithelialization, and enhance collagen deposition on the burn wound surface [12]. However, the promise offered to burn patients with probiotics is partially hampered by the interference with gut flora and the gut environment, a prerequisite for the absorption of orally administered medications.

3.4.4. Challenges in immuno-compromised people

Further, the administration of probiotics in immunocompromised burn patients carries risks. It demands careful selection and control of the strains used so that infection is not enhanced, as noted by Mayes et al. [52]. Several cases of Lactobacillus bacteremia have been documented, and they are linked to probiotic use in immunocompromised patients [16, 17]. The risk of bacteremia is particularly relevant in patients undergoing hematopoietic cell transplants. Moreover, some studies have shown that probiotics

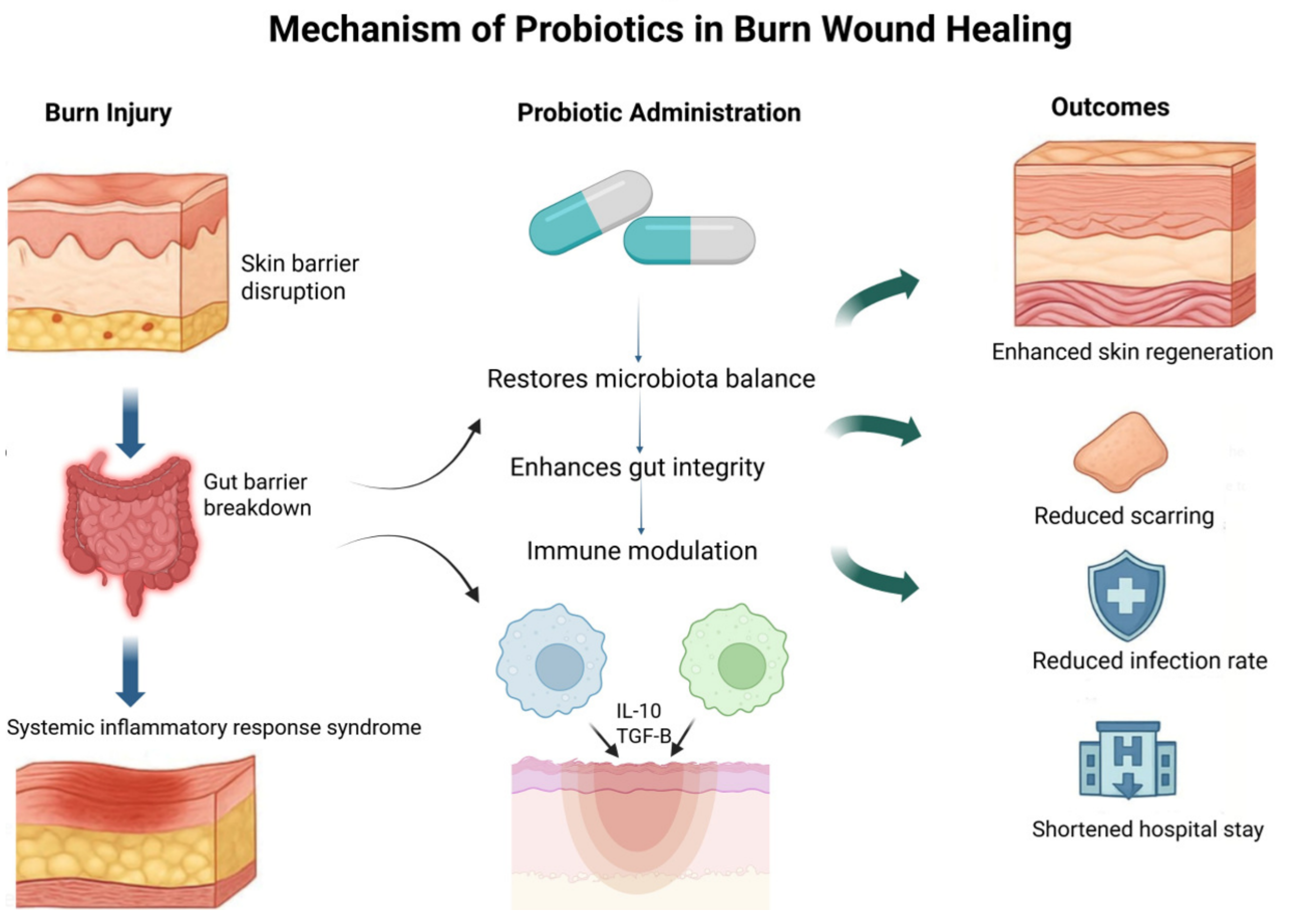

Figure 1: Mechanism of action of probiotics in wound and burn management.

can induce many infections and, subsequently, severe sepsis, especially if administered incorrectly (intravenously) in immunocompromised patients [54]. Additionally, some probiotic strains, like enterococci, have virulent traits and antibiotic resistance, making them dangerous for the vulnerable population [55]. It's crucial to note that probiotics differ in effect in immuno-compromised people and healthy individuals of different ages and physical statuses. Thus, more clinical trials and studies are needed to tackle these differences [18].

3.5. Probiotics and Nutrition: Synergistic Effects on Burn Recovery

Probiotics can aid nutrient absorption, which is crucial for tissue repair and overall health during recovery [56]. While nutrients are essential for burn recovery, their absorption and utilization by the body may depend on the presence and activity of beneficial bacteria in the gut: probiotics [11, 57].

Probiotics function as essential microorganisms in maintaining host functions and physiological balance, which includes decreasing harmful bacteria while supporting immune modulation and infection prevention, as well as gastrointestinal enhancement and bacterial translocation reduction after thermal shock [11, 56, 57]. Probiotics' immune system modulation abilities work through two distinct mechanisms, which include direct enhancement of macrophage function and natural killer cell activity and lysozyme performance and T lymphocyte response and indirect improvement of gut epithelial barrier function together with mucus secretion changes and bacterial competition effects [39, 58].

A research team investigated with 30 healthy participants how the probiotic Bacillus coagulans GBI-30, 6086 (BC30) affects protein absorption in milk. The research lasted two weeks, during which participants consumed 25 grams of milk protein with or without the probiotic. Participants who took the BC30 strain demonstrated increased levels of important amino acids within their blood, including arginine, isoleucine, and methionine. The outcomes demonstrated that particular amino acids reached the bloodstream at an accelerated pace, which suggested better digestive processing and absorption [15].

3.6. Clinical evidence from studies

Perai MC et al. (2009) suggested that according to a randomized control trial, a group of 80 burn patients with varying degrees of injury, Lactobacillus plantarum probiotics were capable of treatment of the burns and burns complication "infection" by comparison with silver sulphadiazine (SD-Ag). This was accomplished by affecting and killing the microorganisms in the wound, thus promoting healthy tissue [59]. The research conducted by Mayes T et al. in 2015 examined the safety of probiotics in 20 acutely burned children through probiotic and placebo treatment twice daily. The probiotics group in Mayes' study displayed a reduced wound healing period, while control group patients required an excision/graft procedure [52]. In a study by El-Ghazely MH and colleagues 2016, a randomized double-blinded clinical trial examined probiotic effectiveness in 40 thermally injured pediatric patients by creating two groups that received control or probiotic treatment. The research discovered that patients in the probiotics group experienced lower diarrhea episodes, reduced infection rates, and shorter hospital stays, leading to improved pediatric outcomes, from decreased hospitalization periods to faster wound recovery times [7]. These findings suggest that probiotics contribute to tissue healing in burned patients and decrease the financial and economic crisis by preventing infection. Various research reports present clinical data demonstrating probiotics as an effective treatment approach for burn wound management. During the treatment of a 47-year-old patient who had sustained 54% deep-dermal and full-thickness flame burns colonized with extremely drug-resistant (XDR) metallo--lactamase (MBL VIM) Pseudomonas aeruginosa, his wounds developed non-healing and breakdown [18]. A daily intake of Yakult drink containing Lactobacillus casei Shirota produced notable alterations in wound cultures in two weeks, which converted P. aeruginosa strains from multi-drug resistant to multi-drug sensitive [18]. The administration of probiotics directly connects to enhanced bacterial susceptibility because the modified antibiotic sensitivity pattern remained effective until the patient left the facility. The administration of probiotics leads to changes in the gut microflora, which subsequently affects how bacteria colonize wounds. Lactobacillus plantarum is a promising antibacterial and healing agent that could serve as a topical treatment for burn wounds [18].

4. Conclusions

In conclusion, probiotics should be considered in the treatment protocols for burns. They offer a unique and promising approach to burn treatment by showing fascinating capabilities in accelerating wound healing, enhancing skin regeneration, and fixing burn-induced microbiome dysfunctions. Probiotics could become a valuable tool in burn care by addressing gut dysbiosis and potentially enhancing healing and immune function. Aside from the benefits, further research is needed to optimize probiotic use in this setting, but the potential benefits are undeniable. Is it safe to prescribe probiotics for immuno-compromised patients? Should a standardized probiotic strain with a specific dosage be administered? Additional research is needed to address the current questions for optimal use. However, probiotics have a holistic approach to treating burn injuries, as per the review above. Hence, this paradigm shifts in burn treatments using probiotics or helpful bacteria is opening new doors for research.

The `table` environment is handy for marking up tabular material. If users want to use multirow.sty, array.sty, etc., to fine control/enhance the tables, they are welcome to load any package of their choice and cas-dc.cls will work in combination with all loaded packages.

Conflicts of Interest

The authors declare that they have no competing interests that could have influenced the objectivity or outcome of this investigation.

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KJ conceptualized and validated the study; JN developed the methodology and wrote the main draft; JT, AA, RS, MS, LG, and ND wrote the main draft; ND generated the image; LM conceptualized, validated, and wrote the main draft; HH supervised the project, reviewed and edited the manuscript, and wrote the main draft. All authors reviewed and approved the final manuscript.

Data Availability Statement:

This review article does not contain any new primary data. All information discussed is derived from previously published sources and publicly available databases, as cited in the manuscript.

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