







Probiotic Therapy in Wound Healing: A Review of Key Evidence on Probiotic-Based Wound Repair

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ABSTRACT

Objective: In recent years, increasing attention has been directed toward the role of the microbiome particularly probiotics in enhancing wound repair. This review aims to critically examine the most relevant scientific evidence regarding the role of probiotics in wound healing and to identify effective strains involved in reducing inflammation, enhancing collagen synthesis, and accelerating tissue regeneration.

Methods: In this narrative review, relevant studies were retrieved from major scientific databases using the keywords “probiotics,” “wound healing,” and “tissue regeneration.” The collected literature was analyzed and categorized based on probiotic strains, mechanisms of action, and reported clinical outcomes. A descriptive and analytical synthesis was then performed.

Results: Available evidence indicates that several *Lactobacillus* species particularly *Lactobacillus rhamnosus*, *L. reuteri*, *L. plantarum*, and *L. casei* demonstrate significant potential in accelerating wound healing through anti-inflammatory effects and enhanced collagen synthesis. In addition, *Bifidobacterium lactis* and *B. breve* have shown beneficial roles in epithelialization and tissue regeneration. Among yeasts, *Saccharomyces cerevisiae* and *S. boulardii* are associated with reduced inflammation and improved structural integrity of repaired tissue. Furthermore, multi-strain probiotic formulations appear to be more effective than single-strain preparations in controlling infection and improving clinical outcomes. Overall, the primary mechanisms involve modulation of the microbiome, inhibition of pathogenic microorganisms, and activation of tissue repair signaling pathways.

Conclusion: Probiotics represent a promising therapeutic strategy in wound management. Current evidence suggests that these microorganisms can support wound healing through restoration of microbial balance, reduction of inflammation, and stimulation of tissue regeneration. Nevertheless, further large-scale clinical trials are required to determine optimal dosing, strain specificity, and long-term safety profiles.

Keywords: Probiotics, wound healing, *Lactobacillus*, *Bifidobacterium*, microbiome, inflammation, tissue regeneration

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Introduction

Wound healing is a dynamic and highly coordinated multistage biological process that encompasses hemostasis, inflammation, proliferation, and tissue remodeling. During this sequence of events, damaged tissues are progressively restored through the concerted activity of cells, growth factors, and the extracellular matrix (1). The quality and rate of this process are influenced by both systemic and environmental factors, and disruption at any stage may result in delayed healing or the development of chronic wounds (2,3).

In addition to intrinsic biological mechanisms, external and behavioral factors such as smoking, alcohol consumption, and poor glycemic control can significantly impair wound repair (4). Appropriate management of open wounds including bleeding control, proper cleansing, antiseptic care, sterile dressing, and adherence to hygiene principles plays a critical role in reducing complications and accelerating tissue regeneration (5).

Adequate nutrition, sufficient oxygen delivery, and tight regulation of inflammatory responses are also fundamental components of effective wound management in clinical practice (6). Deficiencies in key nutrients such as protein, vitamins, and essential trace elements, including zinc and vitamin C, can delay tissue repair and increase susceptibility to infection. Consequently, targeted nutritional support is considered a decisive factor in optimizing wound healing outcomes (7).

In recent years, increasing attention has been directed toward the role of the skin and gut microbiome in tissue repair processes (8). Probiotics, by maintaining microbial balance and inhibiting the growth of pathogenic bacteria, may reduce local inflammation and create a more favorable microenvironment for tissue regeneration (9). These properties have positioned probiotics as promising adjunctive agents in wound management strategies (8,9).

Preclinical studies further suggest that probiotics can stimulate the production of growth factors and

enhance the functional activity of reparative cells (10). These mechanisms contribute to increased cellular proliferation, enhanced collagen synthesis, and improved granulation tissue formation, all of which are essential for effective tissue reconstruction (11).

Moreover, emerging clinical evidence indicates that probiotic supplementation may accelerate the healing of chronic and infected wounds while also reducing scar formation and infection-related complications (12). Nevertheless, well-designed, large-scale randomized controlled trials are still required to determine optimal dosage, administration routes, and long-term safety profiles.

Given the multifaceted role of probiotics in modulating inflammation, controlling infection, and promoting regenerative processes, this review aims to explore their therapeutic mechanisms, summarize current experimental and clinical evidence, and discuss future perspectives in wound management. The ultimate goal is to provide a comprehensive scientific framework for improving clinical strategies in wound care.

Methods

This study was designed as a narrative–integrative review aimed at evaluating the existing evidence on the effects of probiotics in wound healing. Both preclinical (cellular and animal) and human clinical studies were systematically identified, reviewed, and analyzed. The primary objective was to assess the efficacy, safety, and underlying mechanisms of probiotic action in the wound healing process.

Data Sources

Relevant articles were retrieved from major international scientific databases, including PubMed, Scopus, Web of Science, and Google Scholar, as well as national databases such as SID and Magiran.

Time Frame

Studies published between 2010 and 2025 were included to ensure comprehensive coverage of both foundational and recent scientific evidence.

Search Strategy

A structured search strategy was applied using keywords such as “probiotics,” “wound healing,” “Lactobacillus,” “Bifidobacterium,” and “inflammation,” combined with Boolean operators (AND, OR) to refine and optimize the search process.

Inclusion Criteria

Eligible studies included clinical trials, experimental studies, and review articles investigating the role of probiotics in wound healing across human, animal, and cellular models. Only studies with full-text availability and clearly reported wound-healing or tissue-regenerative outcomes were considered.

Exclusion Criteria

Studies unrelated to the topic, lacking full-text access, published as conference abstracts, or exhibiting low methodological quality were excluded from the analysis.

Study Selection Process

Initially, studies were identified through systematic keyword-based searches across the selected databases. Titles and abstracts were then screened for relevance. Subsequently, full-text articles meeting the inclusion criteria were thoroughly assessed for eligibility. Data extraction included study design, probiotic strain, dosage, route of administration, and reported outcomes related to wound healing. The extracted data were then qualitatively synthesized and analyzed.

Results

Based on the extracted data, the included studies comprised a heterogeneous body of evidence, including systematic and narrative reviews, in vitro experimental studies, animal model investigations, and clinical trials. The experimental models ranged from cell cultures and laboratory animals to human patients with various types of acute and chronic wounds.

A wide variety of probiotic strains were evaluated across these studies, most commonly including *Lactobacillus rhamnosus*, *Lactobacillus reuteri*, *Lactobacillus plantarum*, *Lactobacillus casei*, *Lactobacillus acidophilus*, *Bifidobacterium lactis*, and *Bifidobacterium breve*. In addition, several yeast-based probiotics, such as *Saccharomyces boulardii* and *Saccharomyces cerevisiae*, were also investigated. The routes of probiotic administration varied depending on the study design and wound model. These included oral supplementation, topical application, hydrogel-based formulations, ointments, and advanced delivery systems such as nanotechnology-based platforms and bioactive wound dressings. Overall, the findings consistently demonstrated that probiotic interventions were associated with reduced inflammatory responses, enhanced collagen deposition, accelerated epithelialization, inhibition of microbial infection, and improved overall wound healing outcomes.

A detailed summary of the included studies, including study design, probiotic strains, intervention methods, and key findings, is presented in Table 1.

As shown in Figure 1a, *Lactobacillus plantarum* (n=10, 17.9%) and *L. rhamnosus* (n=9, 16.1%) were the most frequently investigated probiotic strains, followed by *L. reuteri* (n=8, 14.3%). Multi-strain formulations accounted for 7 studies (12.5%). The distribution of study designs (Figure 1b) showed that animal-only studies were the most prevalent (n=22, 39.3%), followed by combined in vitro and animal studies (n=15, 26.8%). Clinical trials and RCTs accounted for 7 studies (12.5%), while review articles (n=6, 10.7%) and in vitro-

only studies (n=4, 7.1%) constituted the remaining proportion. Two additional studies (3.6%) were classified as case reports or other designs.

Table 1: Preclinical and clinical studies investigating the effects of probiotics on wound healing

Study type	Model / experimental condition	Probiotic used	Application / formulation	Key findings	Ref.
Systematic review	Humans and animals (mice, rats, surgical wounds)	Various probiotics	Oral / topical / nanotechnology-based systems	↑ Re-epithelialization, ↑ angiogenesis, accelerated wound healing, no adverse effects	[13]
In vitro + animal	Gingival MSCs and oral wounds in mice	<i>Lactobacillus reuteri</i> extract	Interaction with <i>P. gingivalis</i>	↑ MSC proliferation/migration, ↑ osteogenic differentiation, NLRP3 inflammasome inhibition	[14]
In vitro + animal	Infected full-thickness wounds in mice	<i>Lactobacillus rhamnosus</i> (hydrogel $\leq 10^7$ CFU/mL)	Injectable hydrogel	↓ <i>P. aeruginosa</i> infection, ↓ inflammation, ↑ collagen deposition, ↑ epithelial regeneration	[15]
Animal	Subcutaneous wounds in Wistar rats	Probiotic strain VITSAMJ1	Topical gel	Improved wound healing, antibacterial activity against <i>S. aureus</i>	[16]
In vitro + biomaterials	MSCs with GelNB-GelSH hydrogel	<i>L. reuteri</i>	Hydrogel dressing	Maintained probiotic activity, >90% antibacterial effect, accelerated infected wound healing	[17]
Narrative review	Chronic wounds	Live biotherapeutic products	Oral/topical	Antimicrobial activity, biofilm inhibition, immune modulation, ↓ scarring	[18]
In vitro	Human skin ECM	Multiple strains (<i>B. lactis</i> , <i>L. acidophilus</i> , <i>L. plantarum</i> , <i>S. boulardii</i>)	Mono-/multi-strain (10^2 – 10^4 CFU/mL)	↑ growth factors, ↑ collagen I/III, ↑ fibronectin; multi-strain > single-strain	[19]
Narrative review	Wound microbiota	Commensals and pathogens	Microbiota modulation	Immune regulation and improved tissue regeneration	[20]
In vitro + animal	Skin wounds in mice	<i>L. paracasei</i> TYM202	Hydrogel dressing	↓ inflammation, ↑ angiogenesis, ↑ collagen deposition	[21]

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Narrative review	Skin wounds	<i>Various probiotics</i>	Topical formulations	Immune modulation, ↑ growth factors, accelerated tissue repair	[22]
In vitro	Skin wounds	<i>L. plantarum-derived AgNPs</i>	Nanoparticles	Antibacterial, antioxidant, ~96% wound closure	[23]
Narrative review	Skin and intestinal wounds	<i>Multiple probiotics</i>	Oral/topical	Gut-skin axis modulation, fibroblast migration, immune regulation	[24]
Integrated review	Cellular, animal, clinical	<i>Multiple Lactobacillus spp.</i>	Various	↓ infection, ↑ healing, reduced complications	[25]
In vitro + animal	Hydrogel system	<i>L. reuteri@FeTA</i>	Injectable hydrogel	Sustained lactic acid release, angiogenesis enhancement	[26]
Pilot clinical trial	Diabetic wounds (n=20)	<i>Multi-strain probiotic</i>	Oral	↑ quality of life, ↓ pathogens, improved healing	[27]
Crossover clinical trial	Oral mucosal wounds (n=10)	<i>L. reuteri</i>	Oral tablets/oil	Faster healing trend (non-significant)	[28]
Animal	Burn wounds in mice	<i>Saccharomyces cerevisiae</i>	Hydrogel scaffold	↑ epithelialization, ↑ collagen, ↓ scar size	[29]
Animal	Full-thickness wounds	<i>L. reuteri</i>	Topical ointment	↑ collagen, ↓ inflammation, ↓ MPO activity	[30]
RCT	Episiotomy wounds	<i>L. casei 431</i>	Oral	Significant improvement (P = 0.03)	[31]
In vitro + ex vivo	Skin biofilm model	<i>Multi-lactobacilli</i>	Hydrocolloid dressing	Biofilm eradication, enhanced migration	[32]
Animal	MRSA wounds	<i>Probiotic microneedle patch</i>	Single application	Long-term antibacterial effect, sustained healing	[33]
Animal	S. aureus wounds	<i>LGG + BB-12</i>	Topical	↓ inflammation, ↑ M2 macrophages	[34]

Animal	Diabetic wounds	<i>L. bulgaricus & L. plantarum</i>	Topical	Immune regulation, improved healing	[35]
Animal	Oral mucosal wounds	<i>S. salivarius K12 + L. reuteri</i>	Topical	↑ collagen, ↑ angiogenesis	[36]
Animal	Diabetic wounds	<i>L. reuteri + L. plantarum</i>	Topical	Reduced inflammation, enhanced regeneration	[37]
Animal	<i>P. aeruginosa</i> wounds	<i>L. rhamnosus GG</i>	Topical	↓ microbial load, ↑ collagen	[38]
In vitro + animal	Hydrogel system	<i>L. acidophilus</i>	Injectable hydrogel	Sustained antibacterial effect	[39]
Preclinical	Diabetic foot ulcers	<i>L. reuteri + H₂ nanoparticles</i>	Active gel	Reduced ROS, accelerated healing	[40]
In vitro + animal	Gingival wounds	<i>L. reuteri</i>	Topical extract	↑ migration, osteogenic differentiation	[41]
Animal	Skin wounds	<i>L. rhamnosus</i>	Oral	↓ inflammation, ↑ angiogenesis	[42]
Clinical	Equine wounds	<i>Probiotic mixture</i>	Topical dressing	Accelerated healing	[43]
In vitro	Fibroblasts	<i>L. plantarum EPS</i>	Extract	↑ migration and proliferation	[44]
Animal	Infected wounds	<i>Bacillus subtilis</i>	Hydrogel	98.3% closure, ↑ collagen	[45]
In vitro + animal	Infected wounds	<i>L. casei</i>	SF/SA scaffold	Anti-inflammatory, scarless healing	[46]
Animal	Skin wounds	<i>Lactobacillus + B. subtilis</i>	Nanogel	Improved histological healing	[47]
Animal	Infected wounds	<i>Lactobacillus EVs</i>	Microneedle patch	↓ microbes, ↑ angiogenesis	[48]
Animal	Full-thickness wounds	<i>Probiotic mixture</i>	Topical	Accelerated all healing phases	[49]
Animal	Skin wounds	<i>L. plantarum</i>	Topical	↓ inflammation, ↑ fibroblasts	[50]

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Animal	Ischemic wounds	<i>NO-producing probiotics</i>	Patch	2.52× faster healing	[51]
Animal	MRSA wounds	<i>L. paracasei</i>	Nanofiber scaffold	M2 polarization, antibacterial effect	[52]
Animal	Skin wounds	<i>L. plantarum + curcumin</i>	Sponge dressing	↓ TNF-α, ↑ VEGF	[53]
Animal	Skin wounds	<i>P. pentosaceus</i>	Hydrogel + phycocyanin	↓ oxidative stress, ↑ epithelialization	[54]
Preclinical	Skin wounds	<i>L. delbrueckii</i>	Spray	↓ fibrosis and scarring	[55]
Animal	Fish wounds	<i>Shewanella putrefaciens</i>	Oral	↑ antioxidant activity	[56]
Animal	Diabetic wounds	<i>L. plantarum LC38</i>	Oral	Accelerated closure	[57]
Pilot clinical	Oral wounds	<i>L. reuteri</i>	Oral/topical	No significant effect	[58]
Animal	MRSA wounds	<i>L. fermentum</i>	Microgel	87.4% infection reduction	[59]
In vitro	Epithelial cells	<i>E. coli Nissle 1917 (EGF+)</i>	Genetic engineering	Enhanced migration	[60]
Clinical + review	Surgical patients	<i>Various probiotics</i>	Oral	Mixed outcomes	[61]
In vitro	Cell culture	<i>P. pentosaceus AF2</i>	Metabolites	Antibacterial and regenerative effects	[62]
Animal	MRSA wounds	<i>E. coli Nissle</i>	Alginate hydrogel	Faster healing	[63]
Animal	Skin wounds	<i>Multi-strain LAB/Bifidobacteria</i>	Topical	Stage-dependent improvement	[64]
In vitro + animal	Skin wounds	<i>L. plantarum MTCC 2621</i>	Gel	IL-6/IL-10 modulation	[65]

Animal	Diabetic wounds	<i>Heat-killed L. chungangensis</i>	Postbiotic	Reduced inflammation	[66]
Animal	Skin wounds	<i>L. acidophilus / L. plantarum</i>	Oral	↑ collagen, ↑ tensile strength	[67]
In vitro + animal	Skin wounds	<i>EVs of L. rhamnosus GG</i>	Injectable/topical	↑ re-epithelialization, ↑ angiogenesis	[68]

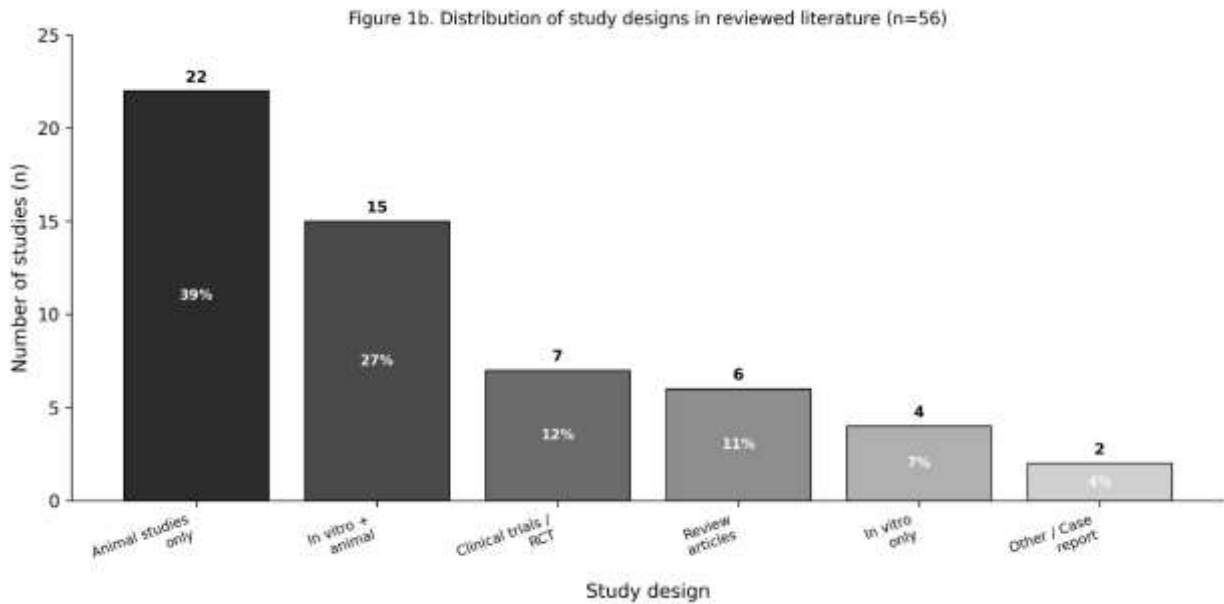
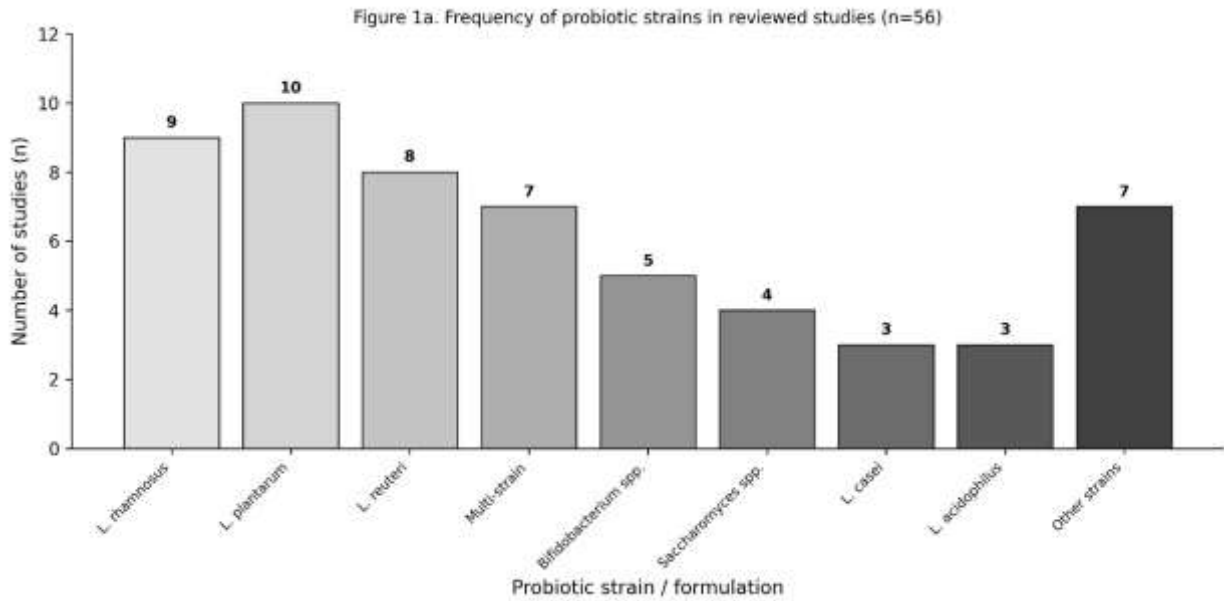


Figure 1: Probiotic strains and study designs in the reviewed literature (n=56 studies). a, Frequency of probiotic strains across included studies. *L. plantarum* (n=10), *L. rhamnosus* (n=9), and *L. reuteri* (n=8) were the most frequently investigated. b, Distribution of study designs. Animal-only studies (n=22, 39.3%) and in vitro/animal combined studies (n=15, 26.8%) dominated the evidence base

Table 1: Summary of probiotic strains identified in 56 reviewed studies. Values indicate number of studies (percentage). Lactobacillus species were most frequent (58.9%). See main text for detailed reference list.

Strain/Formulation	Studies (n)	Percentage	Reference numbers (from table 1)
<i>L. Plantarum</i>	10	17.9%	19,35,37,44,50,53,57,65+2 others
<i>L.rhamnosus</i>	9	16.1%	15,17,34,38,42,48,64, 68,+1 other
<i>L.reuteri</i>	8	14.3%	14,17,26,28,30,36,41,58
Multi-Strain	7	12.5%	19,27,34,49,64 + 2 others
<i>Bifidobacterium spp.</i>	5	8.9%	19,34,64 +2 others
<i>Saccharomyces spp.</i>	4	7.1%	19,29 + 2 others
<i>L. casei</i>	3	5.4%	31,46 + 1 other
<i>L. acidophilus</i>	3	5.4%	19,39,67
Other strains	7	12.5%	Various (single appearance)
TOTAL	56	100%	-

Table 1 Frequency of probiotic strains and formulations in the reviewed literature (n=56 studies). The table presents the number and percentage of studies investigating each probiotic strain or multi-strain formulation, along with corresponding reference numbers from the included publications. Lactobacillus species collectively accounted for 33 studies (58.9%), with *L. plantarum* (n=10, 17.9%), *L.*

rhamnosus (n=9, 16.1%), and *L. reuteri* (n=8, 14.3%) being the most prevalent. Multi-strain formulations were evaluated in 7 studies (12.5%). "Other strains" includes *L. casei*, *L. acidophilus*, *P. pentosaceus*, *B. subtilis*, *E. coli* Nissle 1917, *L. bulgaricus*, *L. paracasei*, *L. fermentum*, *L. delbrueckii*, and *L. chungangensis*, each appearing once.

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Discussion

The findings of this review indicate that probiotics represent a promising and multifaceted therapeutic strategy in wound management. Evidence synthesized from in vitro studies, animal models, and clinical trials suggests that these microorganisms can accelerate wound repair through multiple complementary mechanisms, including modulation of inflammatory responses, inhibition of pathogenic microbial growth, enhancement of epithelial barrier integrity, and stimulation of tissue regeneration. Collectively, these effects reflect a complex and dynamic interaction between probiotics, the host immune system, and the wound microbiome, ultimately contributing to improved healing outcomes (69).

One of the most consistent observations across the included studies is the prominent role of Lactobacillus species particularly Lactobacillus rhamnosus, L. reuteri, and L. plantarum in reducing inflammation and promoting collagen synthesis (70). These strains have been shown to downregulate pro-inflammatory cytokines such as TNF- α and IL-6 while enhancing anti-inflammatory mediators, thereby creating a microenvironment that supports fibroblast and keratinocyte function (71). In addition, the polarization of macrophages toward the M2 reparative phenotype appears to be a key mechanism underlying accelerated tissue repair during the proliferative phase (72). These findings are consistent with previous evidence emphasizing that a tightly regulated inflammatory response is essential for optimal wound healing.

Another important aspect is the antimicrobial potential of probiotics, which plays a crucial role in the management of infected wounds. Numerous strains included in this review demonstrated inhibitory effects against major wound pathogens, including *Staphylococcus aureus* and *Pseudomonas aeruginosa*, primarily through the production of antimicrobial metabolites such as lactic acid, hydrogen peroxide, and bacteriocins (73). Furthermore, their ability to disrupt biofilm formation an important contributor to chronic wound persistence is particularly significant. This effect has been especially pronounced in studies utilizing probiotic-loaded hydrogels and bioactive wound dressings, which enable simultaneous antimicrobial action and tissue regeneration at the wound site (74).

An additional key finding is the potential superiority of multi-strain probiotic formulations compared with single-strain interventions. Evidence suggests that probiotic combinations may exert synergistic effects, leading to broader immunomodulatory activity, enhanced growth factor expression, and more effective restoration of microbial homeostasis. Nevertheless, the optimal composition, strain ratios, and dosing strategies remain unclear and warrant further systematic investigation.

From a clinical perspective, although several trials have reported encouraging outcomes in chronic, diabetic, and surgical wounds, the overall evidence remains limited by small sample sizes, heterogeneity in study design, variability in formulations and dosing regimens, and relatively short follow-up periods. These limitations reduce the generalizability and strength of current clinical conclusions. Moreover, the absence of standardized probiotic preparations with defined stability, viability, and bioavailability profiles remains a major barrier to clinical translation (75).

From a technological standpoint, recent advances in drug delivery systems such as nanoparticles, hydrogels, nanofibers, and bioengineered wound dressings have opened new avenues for probiotic-based therapies. These platforms improve probiotic stability, enable controlled release, and enhance bacterial survival within the wound microenvironment, thereby increasing therapeutic efficacy. In particular, such systems may serve as promising adjuncts or alternatives to conventional antibiotic therapy in infected and chronic wounds (76).

Despite these promising findings, safety considerations must also be addressed. Although probiotics are generally regarded as safe, there remains a potential risk of opportunistic infection, particularly in immunocompromised or critically ill patients (77-82).

Therefore, rigorous safety evaluation is essential, especially for long-term use and high-risk clinical populations.

Conclusion

Overall, this review demonstrates that probiotics hold considerable promise as adjunctive therapeutic agents in wound management. However, translation of these findings into routine clinical practice requires well-designed randomized controlled trials, standardization of probiotic strains and dosages, and long-term safety assessments. Furthermore, a deeper understanding of probiotic–host–microbiome interactions may facilitate the development of more targeted and effective therapeutic strategies for wound healing in the future.

Statements and Declarations

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Competing interests

The authors have no competing interests to declare that are relevant to the content of this article.

Ethics approval

This study was performed in line with the principles of the Declaration of Helsinki.

Consent to participate

Informed consent was obtained from all individual participants included in the study.

Author contributions

XX: Conceptualization, the original draft writing, investigation, writing including reviewing and editing and investigation and formal analysis; XX: Conceptualization, supervision, and project administration; XX and XX Conceptualization, the original draft writing, investigation, writing including reviewing and editing.

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References

- Gonzalez AC, Costa TF, Andrade ZD, Medrado AR. Wound healing-A literature review. *Anais brasileiros de dermatologia*. 2016;91:614-20. doi: 10.1590/abd1806-4841.20164741.
- Guo SA, DiPietro LA. Factors affecting wound healing. *Journal of dental research*. 2010 Mar;89(3):219-29. doi: 10.1177/0022034509359125.
- Kirsner RS, Eaglstein WH. The wound healing process. *Dermatologic clinics*. 1993 Oct 1;11(4):629-40.
- Li J, Chen J, Kirsner R. Pathophysiology of acute wound healing. *Clinics in dermatology*. 2007 Jan 1;25(1):9-18. doi: 10.1016/j.clindermatol.2006.09.007.
- Young A, McNaught CE. The physiology of wound healing. *Surgery (Oxford)*. 2011 Oct 1;29(10):475-9. doi: 10.1016/s0196-0644(88)80351-2.
- Wild T, Rahbarnia A, Kellner M, Sobotka L, Eberlein T. Basics in nutrition and wound healing. *Nutrition*. 2010 Sep 1;26(9):862-6. doi: 10.1016/j.nut.2010.05.008.
- Ghaly P, Iliopoulos J, Ahmad M. The role of nutrition in wound healing: an overview. *British Journal of nursing*. 2021 Mar 11;30(5):S38-42. doi: 10.12968/bjon.2021.30.5.S38.
- Bădăluță VA, Curuțiu C, Dițu LM, Holban AM, Lazăr V. Probiotics in wound healing. *International journal of molecular sciences*. 2024 Jan;25(11):5723. <https://doi.org/10.3390/ijms25115723>
- Umekar M, Chaudhary AA, Manghani M, Shidhaye S, Khajone P, Mahore J, Rudayni HA, Trivedi R. Probiotics in nanotechnology-driven wound healing: From mechanistic insight to clinical promise. *Pharmaceutics*. 2025 Jun 21;17(7):805.
- Çelo E, Dama A, Hasho S, Deda L. Topical Probiotics in Diabetic Wound Healing: Emerging Therapeutic Strategies. *International Journal of Molecular Sciences*. 2026 Mar 20;27(6):2826. <https://doi.org/10.3390/ijms27062826>
- Oryan A, Jalili M, Kamali A, Nikahval B. The concurrent use of probiotic microorganism and collagen hydrogel/scaffold enhances burn wound healing: An in vivo evaluation. *Burns*. 2018 Nov 1;44(7):1775-86. doi: 10.1016/j.burns.2018.05.016.
- Jiali DO, Xuejing WA, Geyan BA, Dong WA. Research progress on the mechanisms of probiotics promoting wound healing. *Sheng Wu Yi Xue Gong Cheng Xue Za Zhi= Journal of Biomedical Engineering*. 2024 Jun 25;41(3):635.
- Bekiaridou A, Karlafti E, Oikonomou IM, Ioannidis A, Papavramidis TS. Probiotics and their effect on surgical wound healing: a systematic review and new insights into the role of nanotechnology. *Nutrients*. 2021 Nov 26;13(12):4265. doi: 10.3390/nu13124265.
- Han N, Jia L, Guo L, Su Y, Luo Z, Du J, Mei S, Liu Y. Balanced oral pathogenic bacteria and probiotics promoted wound healing via maintaining mesenchymal stem cell homeostasis. *Stem cell research & therapy*. 2020 Feb 14;11(1):61.
- Mei L, Zhang D, Shao H, Hao Y, Zhang T, Zheng W, Ji Y, Ling P, Lu Y, Zhou Q. Injectable and self-healing probiotics-loaded hydrogel for promoting superbacteria-infected wound healing. *ACS applied materials & interfaces*. 2022 Apr 26;14(18):20538-50. doi: 10.1021/acsami.1c23713.
- Sinha A, Sagar S, Osborne WJ. Probiotic bacteria in wound healing; an in-vivo study. *Iranian Journal of Biotechnology*. 2019 Dec 1;17(4):e2188. doi: 10.30498/IJB.2019.85188
- Sun Y, Liu M, Tang X, Zhou Y, Zhang J, Yang B. Culture-delivery live probiotics dressing for accelerated infected wound healing. *ACS Applied Materials & Interfaces*. 2023 Nov 10;15(46):53283-96.
- Kaistha SD, Deshpande N. Traditional probiotics, next-generation probiotics and engineered live biotherapeutic products in chronic wound healing. *InWound healing research: current trends and future directions 2021 Jul 21 (pp. 247-284)*. Singapore: Springer Singapore.
- Tarapatzi G, Filidou E, Kandilogiannakis L, Spathakis M, Gaitanidou M, Arvanitidis K, Drygiannakis I, Valatas V, Kotzampassi K, Manolopoulos VG, Kolios G. The probiotic strains bifid obacterium lactis, lactobacillus acidophilus, lactiplantibacillus plantarum and saccharomyces boulardii regulate wound healing and chemokine responses in human intestinal subepithelial myofibroblasts. *Pharmaceutics*. 2022 Oct 20;15(10):1293. doi: 10.3390/ph15101293.
- Zielińska M, Pawłowska A, Orzeł A, Sulej L, Muzyka-Placzyńska K, Baran A, Filipecka-Tyczka D, Pawłowska P, Nowińska A, Bogusławska J, Scholz A. Wound microbiota and its impact on wound healing. *International journal of molecular sciences*. 2023 Dec 10;24(24):17318. doi: 10.3390/ijms242417318.
- Xu H, Li Y, Song J, Zhou L, Wu K, Lu X, Zhai X, Wan Z, Gao J. Highly active probiotic hydrogels matrixed on bacterial EPS accelerate wound healing via maintaining stable skin microbiota and reducing inflammation. *Bioactive materials*. 2024 May 1;35:31-44. <https://doi.org/10.1016/j.bioactmat.2024.01.011>
- Yin Z, Qiu Y, Han Y, Li K. Topical probiotics in wound care: a review of effects, mechanisms, and applications. *Interdisciplinary Nursing Research*. 2024 Jun 1;3(2):63-71.
- Vijayakumar G, Kim HJ, Rangarajulu SK. In vitro antibacterial and wound healing activities evoked by silver nanoparticles synthesized through probiotic bacteria. *Antibiotics*. 2023 Jan 10;12(1):141.
- Lukic J, Chen V, Strahinic I, Begovic J, Lev-Tov H, Davis SC, Tomic-Canic M, Pastar I. Probiotics or pro-healers: the role of beneficial bacteria in tissue repair. *Wound Repair and Regeneration*. 2017 Nov;25(6):912-22. doi: 10.1111/wrr.12607.
- Fijan S, Frauwallner A, Langerholc T, Krebs B, ter Haar JA, Heschl A, Mičetić Turk D, Rogelj I. Efficacy of using probiotics with antagonistic activity against pathogens of wound infections: an integrative review of literature. *BioMed research international*. 2019;2019(1):7585486.
- Zhou C, Zou Y, Xu R, Han X, Xiang Z, Guo H, Li X, Liang J, Zhang X, Fan Y, Sun Y. Metal-phenolic self-assembly shielded probiotics in hydrogel reinforced wound

- healing with antibiotic treatment. *Materials horizons*. 2023;10(8):3114-23. <https://doi.org/10.1039/D3MH00033H>
27. Stuermer EK, Bang C, Giessler A, Smeets R, Janke TM, Seki FD, Debus ES, Franke A, Augustin M. Effect of oral multispecies probiotic on wound healing, periodontitis and quality of life on patients with diabetes. *Journal of wound care*. 2024 Jun 2;33(6):394-407. doi: 10.12968/jowc.2023.0302.
 28. Twetman S, Keller MK, Lee L, Yucel-Lindberg T, Pedersen AL. Effect of probiotic lozenges containing *Lactobacillus reuteri* on oral wound healing: a pilot study. *Beneficial Microbes*. 2018 Sep 14;9(5):691-6. doi: 10.3920/BM2018.0003.
 29. Oryan A, Jalili M, Kamali A, Nikahval B. The concurrent use of probiotic microorganism and collagen hydrogel/scaffold enhances burn wound healing: An in vivo evaluation. *Burns*. 2018 Nov 1;44(7):1775-86. doi: 10.1016/j.burns.2018.05.016.
 30. Khodaii Z, Afrasiabi S, Hashemi SA, Ardeshiryajimi A, Natanzi MM. Accelerated wound healing process in rat by probiotic *Lactobacillus reuteri* derived ointment. *Journal of basic and clinical physiology and pharmacology*. 2019 May 27;30(3):20180150. doi: 10.1515/jbcpp-2018-0150.
 31. Abdollahpour D, Homayouni-Rad A, Nourizadeh R, Hakimi S, Mehrabi E. The effect of probiotic supplementation on episiotomy wound healing among primiparous women: a triple-blind randomized clinical trial. *BMC Complementary Medicine and Therapies*. 2023 May 5;23(1):149.
 32. Li Z, Zhang S, Zuber F, Altenried S, Jaklenec A, Langer R, Ren Q. Topical application of *Lactobacilli* successfully eradicates *Pseudomonas aeruginosa* biofilms and promotes wound healing in chronic wounds. *Microbes and infection*. 2023 Nov 1;25(8):105176. doi: 10.1016/j.micinf.2023.105176.
 33. Jin Y, Lu Y, Jiang X, Wang M, Yuan Y, Zeng Y, Guo L, Li W. Accelerated infected wound healing by probiotic-based living microneedles with long-acting antibacterial effect. *Bioactive Materials*. 2024 Aug 1;38:292-304. doi: 10.1016/j.bioactmat.2024.05.008.
 34. Yin Z, Wang Y, Feng X, Liu C, Guan X, Liu S, Long Z, Miao Z, He F, Cheng R, Han Y. *Lactobacillus rhamnosus* GG and *Bifidobacterium animalis* subsp. *lactis* BB-12 promote infected wound healing via regulation of the wound microenvironment. *Microbial biotechnology*. 2024 Oct;17(10):e70031.
 35. Mohtashami M, Mohamadi M, Azimi-Nezhad M, Saeidi J, Nia FF, Ghasemi A. *Lactobacillus bulgaricus* and *Lactobacillus plantarum* improve diabetic wound healing through modulating inflammatory factors. *Biotechnology and applied biochemistry*. 2021 Dec;68(6):1421-31.
 36. Ananda N, Ariawan D, Juniantito V, Julia V, Yunial A, Januarti RD, Irfan I, Bachtiar EW. Effects of the probiotics on the proliferation phase in oral wound healing: In vivo study. *Dental and Medical Problems*. 2025;62(4):681-90. doi: 10.17219/dmp/195282.
 37. Kuhn T, Aljohmani A, Frank N, Zielke L, Mehanny M, Laschke MW, Koch M, Hoppstädter J, Kiemer AK, Yildiz D, Fuhrmann G. A cell-free, biomimetic hydrogel based on probiotic membrane vesicles ameliorates wound healing. *Journal of controlled release*. 2024 Jan 1;365:969-80. doi: 10.1016/j.jconrel.2023.12.011.
 38. Tsiouris CG, Kelesi M, Vasilopoulos G, Kalemikerakis I, Papageorgiou EG. The efficacy of probiotics as pharmacological treatment of cutaneous wounds: Meta-analysis of animal studies. *European Journal of Pharmaceutical Sciences*. 2017 Jun 15;104:230-9. doi: 10.1016/j.ejps.2017.04.002.
 39. Wang Y, Shi L, Lu J, Wang F, Zhou Z, Wang Y, Du X, Qin D, Chen F, Shao D, Gao Y. Probiotic active gel promotes diabetic wound healing through continuous local glucose consumption and antioxidant. *Journal of Nanobiotechnology*. 2025 Jan 30;23(1):62. doi: 10.1186/s12951-025-03115-5.
 40. Wang Y, Shi L, Lu J, Wang F, Zhou Z, Wang Y, Du X, Qin D, Chen F, Shao D, Gao Y. Probiotic active gel promotes diabetic wound healing through continuous local glucose consumption and antioxidant. *Journal of Nanobiotechnology*. 2025 Jan 30;23(1):62. doi: 10.1186/s12951-025-03115-5.
 41. Han N, Jia L, Su Y, Du J, Guo L, Luo Z, Liu Y. *Lactobacillus reuteri* extracts promoted wound healing via PI3K/AKT/ β -catenin/TGF β 1 pathway. *Stem cell research & therapy*. 2019 Aug 7;10(1):243.
 42. Moreira CF, Cassini-Vieira P, Canesso MC, Felipetto M, Teixeira MM, Nicoli JR, Martins FS, Barcelos LS. *Lactobacillus rhamnosus* CGMCC 1.3724 (LPR) improves skin wound healing and reduces scar formation in mice. *Probiotics and antimicrobial proteins*. 2021 Jun;13(3):709-19.
 43. Wilmink JM, Ladefoged S, Jongbloets A, Vernooij JC. The evaluation of the effect of probiotics on the healing of equine distal limb wounds. *PloS one*. 2020 Jul 29;15(7):e0236761. <https://doi.org/10.1371/journal.pone.0236761>
 44. Zaghoul EH, Ibrahim MI. Production and characterization of exopolysaccharide from newly isolated marine probiotic *Lactiplantibacillus plantarum* EI6 with in vitro wound healing activity. *Frontiers in Microbiology*. 2022 May 13;13:903363. doi: 10.3389/fmicb.2022.903363.
 45. Wu Q, Lu Z, Wang L, Peng S, Wang Z, Qiu Y, Liao Z, Wang Y, Qin X. Konjac glucomannan/xanthan gum hydrogels loaded with metal-phenolic networks encapsulated probiotic to promote infected wound healing. *Carbohydrate Polymers*. 2025 Apr 1;353:123243. doi: 10.1016/j.carbpol.2025.123243.
 46. Dou Z, Li B, Wu L, Qiu T, Wang X, Zhang X, Shen Y, Lu M, Yang Y. Probiotic-functionalized silk fibroin/sodium alginate scaffolds with endoplasmic reticulum stress-relieving properties for promoted scarless wound healing. *ACS Applied Materials & Interfaces*. 2023 Jan 26;15(5):6297-311.
 47. Ashoori Y, Mohkam M, Heidari R, Abootalebi SN, Mousavi SM, Hashemi SA, Golkar N, Gholami A. Development and in vivo characterization of probiotic

- lysate-treated chitosan nanogel as a novel biocompatible formulation for wound healing. *BioMed Research International*. 2020;2020(1):8868618.
48. Qi F, Xu Y, Zheng B, Li Y, Zhang J, Liu Z, Wang X, Zhou Z, Zeng D, Lu F, Zhang C. The core-shell microneedle with probiotic extracellular vesicles for infected wound healing and microbial homeostasis restoration. *Small*. 2024 Nov;20(46):2401551. doi: 10.1002/sml.202401551.
 49. Moysidis M, Stavrou G, Cheva A, Deka IA, Tsetis JK, Birba V, Kapoukranidou D, Ioannidis A, Tsaousi G, Kotzampassi K. The 3-D configuration of excisional skin wound healing after topical probiotic application. *Injury*. 2022 Apr 1;53(4):1385-93.
 50. Heydari Nasrabadi M, Tajabadi Ebrahimi M, Dehghan Banadaki SH, Kajousangi T, Zahedi F. Study of cutaneous wound healing in rats treated with *Lactobacillus plantarum* on days 1, 3, 7, 14 and 21. *Afr. J. Pharm. Pharmacol.* 2011 Dec 8;5(21):2395-401.
 51. Jones M, Ganopolsky JG, Labbé A, Gilardino M, Wahl C, Martoni C, Prakash S. Novel nitric oxide producing probiotic wound healing patch: preparation and in vivo analysis in a New Zealand white rabbit model of ischaemic and infected wounds. *International wound journal*. 2012 Jun;9(3):330-43. doi: 10.1111/j.1742-481X.2011.00889.x.
 52. Huang B, Xiao F, Chen Z, Hu T, Qiu R, Wang W, You W, Su X, Hu W, Wang Z. Coaxial electrospun nanofiber accelerates infected wound healing via engineered probiotic biofilm. *International journal of biological macromolecules*. 2024 Nov 1;279:135100.
 53. Sandhu SK, Raut J, Kumar S, Singh M, Ahmed B, Singh J, Rana V, Rishi P, Ganesh N, Dua K, Kaur IP. Nanocurcumin and viable *Lactobacillus plantarum* based sponge dressing for skin wound healing. *International Journal of Pharmaceutics*. 2023 Aug 25;643:123187. doi: 10.1016/j.ijpharm.2023.123187.
 54. Negm El-Dein A, Soliman TN, Ezzat A, Abd El-Fattah MA, Aly HF, Younis EA, Flefil NS. Innovative hydrogel formulation combining phycocyanin and probiotic for enhancing skin regeneration and accelerated wound healing: A preclinical investigation in wistar rats. *Probiotics and Antimicrobial Proteins*. 2025 Jul 12:1-9. doi: 10.1007/s12602-025-10635-x.
 55. Han F, Wang W, Shen K, Wang P, Wang Y, Han S, Hu D, Guan H, Wu G. A novel *Lactobacillus delbrueckii*-based topical spray promotes wound healing and inhibits dermal fibrosis: A probiotic biomaterial for integrated scar management. *Chemical Engineering Journal*. 2025 Oct 17:169786.
 56. Chen Z, Ceballos-Francisco D, Guardiola FA, Esteban MÁ. Dietary administration of the probiotic *Shewanella putrefaciens* to experimentally wounded gilthead seabream (*Sparus aurata* L.) facilitates the skin wound healing. *Scientific Reports*. 2020 Jul 3;10(1):11029. doi: 10.1038/s41598-020-68024-z.
 57. Chouikhi A, Ktari N, Bardaa S, Hzami A, Ben Slima S, Trabelsi I, Asehraou A, Ben Salah R. A novel probiotic strain, *Lactiplantibacillus plantarum* LC38, isolated from Tunisian camel milk promoting wound healing in Wistar diabetic rats. *Archives of microbiology*. 2022 Jan;204(1):24.
 58. Twetman S, Pedersen AM, Yucel-Lindberg T. Probiotic supplements containing *Lactobacillus reuteri* does not affect the levels of matrix metalloproteinases and interferons in oral wound healing. *BMC research notes*. 2018 Oct 25;11(1):759. doi: 10.1186/s13104-018-3873-9.
 59. Hua C, Yang F, Jia X, Lu Y, Li X, Zhao P, Xing M, Lyu G. Multi-compartmented microgels delivering human derived probiotics and deferroxamine for multidrug-resistant infection and healing. *Chemical Engineering Journal*. 2024 Mar 1;483:148432.
 60. Choi HJ, Ahn JH, Park SH, Do KH, Kim J, Moon Y. Enhanced wound healing by recombinant *Escherichia coli* Nissle 1917 via human epidermal growth factor receptor in human intestinal epithelial cells: therapeutic implication using recombinant probiotics. *Infection and immunity*. 2012 Mar;80(3):1079-87. doi: 10.1128/IAI.05820-11.
 61. Rahma CT, Wulandari Y. Effect of probiotic supplementation on wound healing in postoperative patients. *World Nutrition Journal*. 2023 Aug 31;7(01):85-93.
 62. Ugras S, Fidan A, Yoldas PA. Probiotic potential and wound-healing activity of *Pediococcus pentosaceus* strain AF2 isolated from *Herniaria glabra* L. which is traditionally used to make yogurt. *Archives of Microbiology*. 2024 Mar;206(3):115. doi: 10.1007/s00203-024-03831-w.
 63. Cui Y, Yu W, Feng X, Gao N, Chen H, Wang K, Ren W, Liu Y, Li J. Alginate-based injectable probiotic/squid ink composite hydrogels for accelerated wound healing of MRSA infected abscess through photothermally synergized probiotic therapy. *International Journal of Biological Macromolecules*. 2024 Nov 1;279:135302.
 64. Panagiotou D, Filidou E, Gaitanidou M, Tarapatzi G, Spathakis M, Kandilogiannakis L, Stavrou G, Arvanitidis K, Tsetis JK, Gionga P, Shrewsbury AD. Role of *Lactiplantibacillus plantarum* UBLP-40, *Lactobacillus rhamnosus* UBLR-58 and *Bifidobacterium longum* UBBL-64 in the Wound Healing Process of the Excisional Skin. *Nutrients*. 2023 Apr 10;15(8):1822. doi: 10.3390/nu15081822.
 65. Dubey AK, Podia M, Priyanka, Raut S, Singh S, Pinnaka AK, Khatri N. Insight into the beneficial role of *Lactiplantibacillus plantarum* supernatant against bacterial infections, oxidative stress, and wound healing in A549 cells and BALB/c mice. *Frontiers in pharmacology*. 2021 Nov 4;12:728614.
 66. Nam Y, Kim J, Baek J, Kim W. Improvement of cutaneous wound healing via topical application of heat-killed *Lactococcus chungangensis* CAU 1447 on diabetic mice. *Nutrients*. 2021 Jul 31;13(8):2666. doi: 10.3390/nu13082666.
 67. Gudadappanavar AM, Hombal PR, Timashetti SS, Javali SB. Influence of *Lactobacillus acidophilus* and *Lactobacillus plantarum* on wound healing in male Wistar rats-an experimental study. *International*

- Journal of Applied and Basic Medical Research. 2017 Oct 1;7(4):233-8.
68. Wang J, Li X, Zhao X, Yuan S, Dou H, Cheng T, Huang T, Lv Z, Tu Y, Shi Y, Ding X. Lactobacillus rhamnosus GG-derived extracellular vesicles promote wound healing via miR-21-5p-mediated re-epithelization and angiogenesis. *Journal of nanobiotechnology*. 2024 Oct 19;22(1):644. doi: 10.1186/s12951-024-02893-8.
 69. Umekar M, Chaudhary AA, Manghani M, Shidhaye S, Khajone P, Mahore J, Rudayni HA, Trivedi R. Probiotics in nanotechnology-driven wound healing: From mechanistic insight to clinical promise. *Pharmaceutics*. 2025 Jun 21;17(7):805. <https://doi.org/10.3390/pharmaceutics17070805>
 70. Zolfaghari SI, Khorasgani MR, Noorbakhshnia M. The effects of lactobacilli (*L. rhamnosus*, *L. reuteri*, *L. Plantarum*) on LPS-induced memory impairment and changes in CaMKII- α and TNF- α genes expression in the hippocampus of rat. *Physiology & behavior*. 2021 Feb 1;229:113224. doi: 10.1016/j.physbeh.2020.113224.
 71. Peran L, Sierra S, Comalada M, Lara-Villoslada F, Bailón E, Nieto A, Concha A, Olivares M, Zarzuelo A, Xaus J, Gálvez J. A comparative study of the preventative effects exerted by two probiotics, *Lactobacillus reuteri* and *Lactobacillus fermentum*, in the trinitrobenzenesulfonic acid model of rat colitis. *British Journal of Nutrition*. 2007 Jan;97(1):96-103. doi: 10.1017/S0007114507257770.
 72. Liu Y, Fatheree NY, Mangalat N, Rhoads JM. Human-derived probiotic *Lactobacillus reuteri* strains differentially reduce intestinal inflammation. *American Journal of Physiology-Gastrointestinal and Liver Physiology*. 2010 Nov 1.
 73. Fijan S, Kocbek P, Steyer A, Vodičar PM, Strauss M. The antimicrobial effect of various single-strain and multi-strain probiotics, dietary supplements or other beneficial microbes against common clinical wound pathogens. *Microorganisms*. 2022 Dec 19;10(12):2518. doi: 10.3390/microorganisms10122518.
 74. Tao S, Zhang S, Wei K, Maniura-Weber K, Li Z, Ren Q. An injectable living hydrogel with embedded probiotics as a novel strategy for combating multifaceted pathogen wound infections. *Advanced Healthcare Materials*. 2024 Oct;13(27):2400921. doi: 10.1002/adhm.202400921.
 75. Gao Y, Wang X, Xue C, Wei Z. Latest developments in food-grade delivery systems for probiotics: A systematic review. *Critical Reviews in Food Science and Nutrition*. 2023 Aug 7;63(20):4371-88. doi: 10.1080/10408398.2021.2001640.
 76. Gheorghita R, Anchidin-Norocel L, Filip R, Dimian M, Covasa M. Applications of biopolymers for drugs and probiotics delivery. *Polymers*. 2021 Aug 15;13(16):2729. doi: [10.3390/polym13162729](https://doi.org/10.3390/polym13162729)
 77. Mikawlawng K, Kumar S, Bhatnagar K. Drug interactions, safety and efficacy of probiotics. *Asian J. Med. Health*. 2016 Jan 10;1:1-8. doi: [10.9734/AJMAH/2016/29244](https://doi.org/10.9734/AJMAH/2016/29244)
 78. Salminen S, von Wright A, Morelli L, Marteau P, Brassart D, de Vos WM, Fondén R, Saxelin M, Collins K, Mogensen G, Birkeland SE. Demonstration of safety of probiotics— a review. *International journal of food microbiology*. 1998 Oct 20;44(1-2):93-106. doi: 10.1016/s0168-1605(98)00128-7.
 79. Abdullah, D., Poddar, S., Dewi, N. P., Pratama, Y. E. Effectiveness of *Lactobacillus plantarum* from Dadiah Payakumbuh yoghurt as Immunomodulator in hypertension. *Caspian Journal of Environmental Sciences*, 2023; 21(2): 439-443. doi: 10.22124/cjes.2023.6538
 80. Alabdallah, Z. A., Nikishov, A. A., Jhonn Lenon, C. J., Ortiz Manzano, M. L. Influence of using probiotic on the productivity and morphometry of the organs in the visceral cavity of broiler chicks. *Caspian Journal of Environmental Sciences*, 2023; 21(2): 431-437. doi: 10.22124/cjes.2023.6537
 81. Dewi, N. P., Poddar, S., Abdullah, D., Pratama, Y. E. Evaluation of *Pediococcus acidilactici* from Dadiah Bukitinggi (dairy food) as an insulin promotor by bioinformatics. *Caspian Journal of Environmental Sciences*, 2023; 21(3): 595-602. doi: 10.22124/cjes.2023.6938
 82. Orynbayeva, Z., Tungushbayeva, Z., Nurlybayeva, K., Abikenova, F., Jankiewicz, U., Seilkhan, A., Koibasova, L., Kurmanbay, U. Correction of liver changes caused by alcohol rates with probiotics. *Caspian Journal of Environmental Sciences*, 2024; 22(4): 993-998. doi: 10.22124/cjes.2024.8123