Medical Science

To Cite:
Sałkowska N, Ochońska I, Borowska O, Magdziak J, Awad S, Mędrek E, Brzozowska N, Wardzyńska B, Zegarska P, Markowska H. The skin microbiome in health and disease – new diagnostic and therapeutic perspectives. *Medical Science* 2026; 30: e138ms3878
doi: https://doi.org/10.54905/dissi.v30i173.e138ms3878

Authors' Affiliation:
[1]University Clinical Center of the Medical University of Warsaw, address Banacha 1a, 02-097 Warsaw, Poland
[2]Independent Public Clinical Hospital named after prof. W. Orłowski CMKP, Czerniakowska 231, 00-416 Warsaw, Poland
[3]Nowodworskie Centrum Medyczne, address Miodowa 2, 05-100 Nowy Dwór Mazowiecki, Poland
[4]Independent Public Healthcare Complex in Wyszków, address Komisji Edukacji Narodowej 1, 07-200 Wyszków, Poland
[5]Grochowski Hospital, address Grenadierów 51/59, 04-073 Warsaw, Poland
[6]Samodzielny Publiczny Wielospecjalistyczny Zakład Opieki Zdrowotnej Ministerstwa Spraw Wewnętrznych i Administracji w Bydgoszczy, address ul. Ks. R. Markwarta 4-6, 85-015 Bydgoszcz, Poland

***Corresponding author:**
Natalia Sałkowska, University Clinical Center of the Medical University of Warsaw, address Banacha 1a, 02-097 Warsaw, Poland, Email nat.kawczynska@gmail.com

Orcid List:

Natalia Sałkowska	0009-0005-2518-3493
Eliza Mędrek	0009-0001-2830-014X
Natalia Brzozowska	0009-0003-6580-1714
Oliwia Borowska	0009-0006-1260-5711
Paulina Zegarska	0000-0001-6727-8128
Barbara Wardzyńska	0009-0002-4521-8911
Jakub Magdziak	0009-0006-0297-7423
Sara Awad	0009-0004-0942-6240
Hanna Markowska	0009-0006-7837-1989
Izabela Ochońska	0009-0007-4645-5771

Peer-Review History
Received: 16 December 2025
Reviewed & Revised: 03/January/2026 to 23/June/2026
Accepted: 07 July 2026
Published: 30 July 2026

Peer-review Method
External peer-review was done through double-blind method.

Medical Science
pISSN 2321–7359; eISSN 2321–7367

DISCOVERY SCIENTIFIC SOCIETY

The skin microbiome in health and disease – new diagnostic and therapeutic perspectives

Natalia Sałkowska[1*], Izabela Ochońska[1], Oliwia Borowska[2], Jakub Magdziak[2], Sara Awad[2], Eliza Mędrek[3], Natalia Brzozowska[3], Barbara Wardzyńska[4], Paulina Zegarska[5], Hanna Markowska[6]

ABSTRACT

The skin microbiome is made up of a complex and ever-changing community of microbes. It recreates a key role in maintaining healthy skin. Problems in this ecosystem, known as dysbiosis, have been linked to a range of inflammatory skin diseases. This review looks at the latest research on the skin microbiome, how it works and its connection to the gut microbiome via the gut-skin axis. It also covers new ways to diagnose and treat it. Results: Healthy skin has certain microbial communities that are specific to the area. These communities are made up of bacteria like *Cutibacterium*, *Staphylococcus*, and *Corynebacterium*. These bacteria help to keep the skin healthy by strengthening the skin's natural defenses and controlling the immune system. Dysbiosis (a problem with the balance of gut bacteria) can make inflammation and skin problems worse. Thanks to improvements in metagenomic and multi-omics technologies, as well as machine algorithms, we can now identify microbes more accurately and spot disease earlier. The gut-skin axis is very important for the development of skin disease and for how well patients respond to treatment. So, to sum things up: The skin microbiome is very important for keeping your skin healthy, and if it doesn't work right, it can lead to skin problems like inflammation. Combining advanced microbial profiling with host-microbe interactions enables personalized diagnostics and targeted therapies. Future longitudinal studies using standardized methodologies are needed to establish causality.

Keywords: Skin microbiome, Gut-skin axis, Dysbiosis, Inflammatory skin diseases, Microbiome diagnostics, Probiotics, Microbiome therapeutics, Personalized dermatology, Metagenomics, Immune modulation

1. INTRODUCTION

Our skin protects a surface area of 1.8 to 2.5 square meters of the body and acts as a vital barrier to the outside world. As well as protecting us, the skin is home to a diverse community of microorganisms, called the skin microbiome. These include bacteria, fungi, viruses, archaea, and mites. Where on your skin these microbes are found depends on things like how moist it is, the amount of oil (sebum) in your skin, the pH level, and the oxygen levels. When it comes to the tiny organisms that

live on the skin, it is understood that they are a natural part of the human body. Firstly, they help to protect the skin by strengthening its barrier. Another idea is that it controls the immune response. Research has shown that it can stop pathogens from taking hold in different ways, like competing with other microbes and making antimicrobials (Lee & Kim, 2022). New DNA and other sequencing technologies have given us a better understanding of the skin microbiome (Jo et al., 2016). It has been suggested that the skin microbiome can change a lot as we get older and also as a result of the environment (Chen et al., 2023).

There are four main types of bacteria found on human skin: Actinobacteria, Firmicutes, Proteobacteria, and Bacteroidetes. Of the bacteria in these samples, *Cutibacterium*, *Staphylococcus* and *Corynebacterium* are the most common (Lee & Kim, 2022; Carmona-Cruz et al., 2022). Malassezia species are often found in oily areas, and although we have less information about viruses and archaea on the skin, they play important roles (Carmona-Cruz et al., 2022; Chen et al., 2023). Almost all tiny structures, such as hair follicles and glands, create specialized niches that support different microbes (Chen et al., 2023). The skin's microbial community, which includes bacteria, is established at birth and is influenced by the mother and the environment. It typically reaches a stable state during adulthood. The types of microbes on the skin can be affected by things like your age, whether you are male or female, as well as by what you do and don't do to keep yourself clean and what you are exposed to in your environment. Hormonal changes during puberty can have a big effect on the skin, especially in areas where sebum is produced. This could mean there are more bacteria like Cutibacterium acnes (Lee & Kim, 2022). It is important to recognize the valuable role of microbes that live on the skin. The microbes help to keep the skin healthy and support the immune system.

The chemicals produced by these microorganisms can boost skin cell growth, regulate their rate and strengthen junctions. These bacteria can also produce substances that stop harmful organisms from growing while keeping the skin's pH balance. The microbes on the skin can affect the immune system by activating certain cells, producing molecules that control immunity, and changing the number of regulatory T cells (Lee & Kim, 2022). The gut-skin axis is a new idea that says the gut and skin are connected by the immune system, metabolism and the nervous system. Skin problems such as inflammation and dryness may occur when the balance of skin microbes is disturbed (Carmona-Cruz et al., 2022).

If the balance of bacteria on the skin is lost, this can lead to skin problems like eczema, spots, psoriasis, dandruff, and hair loss. The presence of certain types of bacteria in skin conditions like atopic dermatitis and acne may be linked to dysbiosis, which causes imbalances and accelerates harmful bacteria growth. This might be bad for your skin, cause swelling and affect your immune system. Some scientists think that the microbiome may cause immune problems by producing harmful substances and sticky layers that can lead to inflammation and damage (Carmona-Cruz et al., 2022). Some recent studies suggest that the harm caused by a type of microbe often depends on the specific type of microbe. This shows how important it is to correctly identify microbes so that we can develop treatments that work for them (Chen et al., 2023). It is possible that the microbes on the skin could help to diagnose and treat diseases. By looking at the microbes present and how many there are, we may be able to spot signs that could help us predict the start of a disease or see how well a person's treatment is working. For example, scientists have found a possible link between certain skin bacteria and how badly skin reacts to radiation therapy in cancer patients (Hülpüsch et al., 2024).

New treatments that aim to change the skin's microbes, such as probiotics, prebiotics, postbiotics, targeted proteins that kill bacteria, and virus-based treatments, show promise for restoring a healthy balance and easing skin inflammation. These treatments are often less harsh than regular antibiotics. Some new methods even involve applying beneficial gut bacteria to the skin to improve skin health. For instance, consider an adolescent struggling with severe acne, who does not respond to traditional treatments. This condition can be linked to an overgrowth of Cutibacterium acnes, which illustrates how shifts in the microbiome present in real practice. There are new treatments targeting the bacteria C. acnes, which could help patients like this. However, there are still major issues, such as the need to use the same research methods and to better understand how these microbes interact with the human body. New technologies are making treatments that work for each person and target the bacteria on the skin (Chen et al., 2023). This includes ways to better study genes and proteins, as well as computer models and medical studies.

2. REVIEW METHODS

The objective of this review was to provide a comprehensive examination of the role of the skin microbiome in health and disease. The investigation focused on the following key areas: microbial community composition, dysbiosis, the gut-skin axis, emerging microbiome-based therapeutic strategies, and advances in microbiome diagnostics. The review was prepared and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Search Strategy

A thorough, methodical approach was adopted: the following databases were searched: PubMed/MEDLINE, Google Scholar, and Web of Science. The search covered publications up to the end of December 2024. The following list shows the keywords and logical operators that were used in the search: "skin microbiome" OR "skin microbiota" OR "cutaneous microbiome"

- "dysbiosis" AND "skin"
- "gut-skin axis"
- "atopic dermatitis" AND "microbiome"
- "acne" AND "microbiota"
- "psoriasis" AND "microbiome"
- "metagenomics" AND "skin"
- "16S rRNA sequencing" AND "skin"
- "probiotics" AND "skin disease"
- "microbiome therapeutics" AND "dermatology"

All records rescued from the three databases were exported to a reference management system and merged into a single dataset before the screening process began, as shown in Table 1.

Inclusion/Exclusion

Table 1. Inclusion/exclusion criteria in study selection.

Criterion	Inclusion	Exclusion
Language	English only	Non-English publications
Publication type	Original research articles, systematic reviews, narrative reviews	Conference abstracts, editorials, letters, opinion papers without primary data
Topic	Skin microbiome in health or disease; dysbiosis; gut-skin axis; microbiome diagnostics; microbiome-based therapeutics	Studies unrelated to skin microbiome or gut-skin axis
Population	Human subjects or validated in vitro / ex vivo skin models	Animal studies with no direct relevance to human skin outcomes
Full-text availability	Full-text accessible	Records without accessible full text or insufficient methodological detail
Publication period	January 2019 – December 2024	Publications outside the defined time range
Duplicate content	Single unique publications	Duplicate content from overlapping publications

Reasons for full-text exclusion

Of the 59 full-text reports assessed for eligibility, 47 were excluded for the following reasons (Table 2):

Table 2. Reasons for exclusion at the full-text assessment stage (n = 47).

Reason for exclusion	n
Conference abstract, editorial, or letter without primary scientific data	14
Topic unrelated to skin microbiome or gut-skin axis	13
Insufficient methodological detail or no accessible full text	10
Animal study with no direct relevance to human skin outcomes	7
Duplicate content or overlapping publication	3
Total excluded	47

In the end, 12 studies were included in the study and are used as a reference for this text. The selection procedure is shown in the PRISMA flow diagram (Figure 1).

Analytical Methods Used in Included Studies

The 12 included studies employed a range of methodological approaches relevant to skin microbiome research. These included:

- Metagenomic sequencing – enabling whole-genome characterization of microbial communities present on the skin surface and within skin structures, without the need for prior cultivation
- 16S rRNA gene profiling – allowing identification and classification of bacterial taxa across different body sites and disease states, based on variable regions of the 16S ribosomal RNA gene
- Machine learning algorithms – applied to large microbiome datasets to identify microbial signatures predictive of disease onset or treatment response
- In vitro and ex vivo models – including people sweat media cultures and air-liquid interface skin models, used to study host-microbe interactions under controlled laboratory conditions
- Stratified participant grouping – research groups subdivided study populations by age, sex, skin type, body site, and disease severity to examine microbial diversity, community structure, and functional gene activity across subgroups

These methods help to identify microbial markers associated with disease, assess microbiome-targeted therapies, and develop personalized diagnostic tools for inflammatory skin conditions.

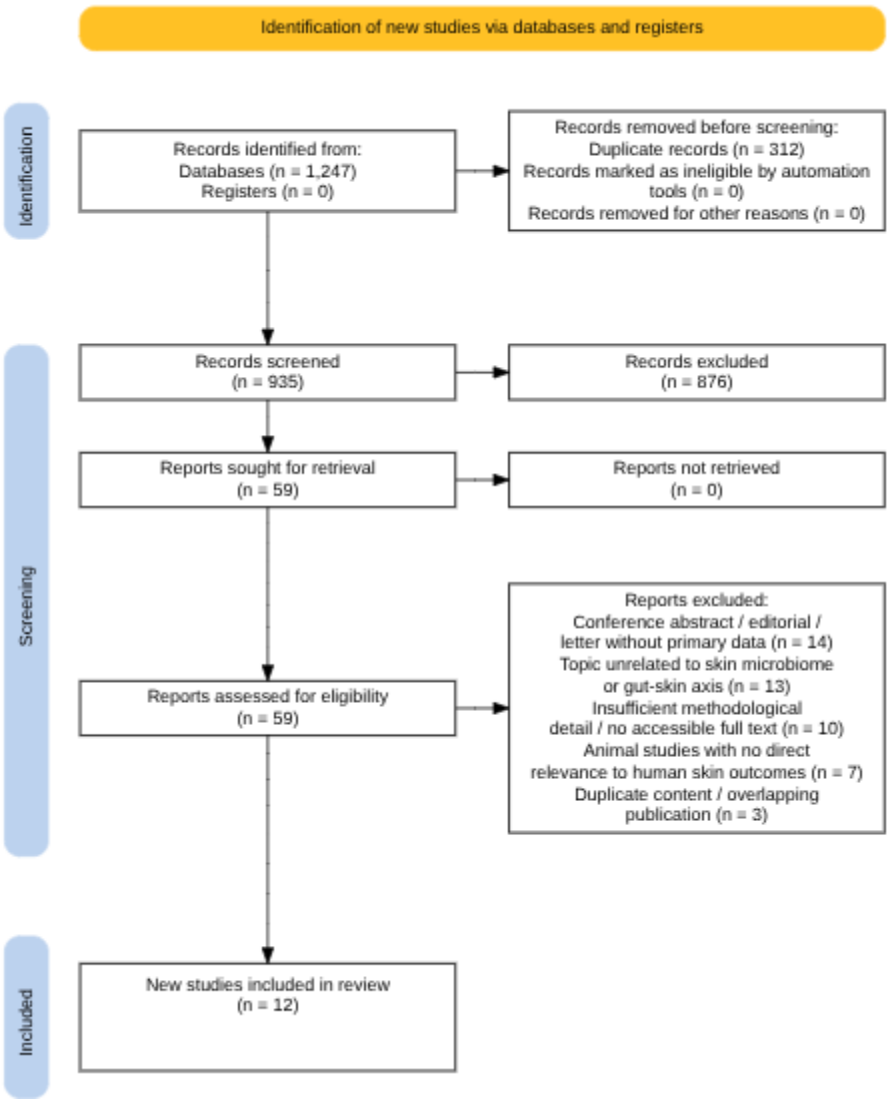

Figure 1. PRISMA flow diagram of study selection.

A total of 1,247 records were identified through database searching (PubMed/MEDLINE, Scopus, Web of Science). After removal of 312 duplicate records, 935 records were screened by title and abstract. Fifty-nine full-text reports were assessed for eligibility, of which 47 were excluded with reasons. Twelve studies were eventually included in the review.

3. RESULTS

The gut-skin axis is a new idea that describes the connection between the bacteria in your gut and your skin health (Sun et al., 2023; Jiang et al., 2022; Galvan et al., 2024). Recent research shows that the bacteria in our guts (our microbiome) have a big impact on skin problems like eczema, acne, and rosacea. The chemicals they produce and the signals they send to our immune system (Mahmud et al., 2022; Mann et al., 2020; De Pessemier et al., 2021).

Gut microbes produce chemicals to simulate the skin's barrier, inflammation, and immune response. A problem with the bacteria in your gut can lead to swelling and skin problems, making skin diseases worse. However, some types of bacteria in the gut can help protect the body by increasing the number of regulatory T cells and reducing inflammation through signals between the gut and skin (Mahmud et al., 2022). There's a connection between Th17-mediated skin inflammation in psoriasis and atopic dermatitis and imbalances in the bacteria in your gut. Probiotics can restore immune balance and improve symptoms (Mann et al., 2020).

New studies use a variety of scientific methods to understand how gut microbes affect the skin, which could lead to new ways to treat skin problems. Research is being done into using probiotics, prebiotics and postbiotics to improve the health of bacteria in the gut and skin, which can help to reduce inflammation, strengthen the skin's barrier and control the immune system (Mahmud et al., 2022). Another suggested treatment is a procedure based on transferring healthy bacteria from a donor to a recipient as a therapy for skin diseases (Mann et al., 2020; Yu et al., 2025).

The primary studies included in this review are summarized in Table 3, which outlines their design, population, biomarkers assessed, and key findings.

Table 3. Summary of studies included in the review on the skin microbiome and the gut-skin axis

Author, year	Study type / focus	Key findings
Lee & Kim, 2022	Review — skin barrier and microbiome	The microbiome strengthens the skin barrier and regulates the skin's immune response
Chen et al., 2023	Review — microbiome profiling in skin disease	New sequencing technologies and computational models enable personalized therapies
Carmona-Cruz et al., 2022	Review — skin microbiome in selected dermatoses	Dysbiosis accelerates pathogenic bacterial growth, contributing to inflammation
Mahmud et al., 2022	Review — gut-skin axis, therapeutics	Gut metabolites affect skin barrier, inflammation, and immune response; probiotics/prebiotics/postbiotics reduce inflammation
Mann et al., 2020	Review — gut microbiome and skin health	Signals and chemicals from the gut influence inflammatory skin diseases (eczema, acne, rosacea)

4. DISCUSSION

Current research shows that the skin's microbial community and the connection between the gut and skin are very important for maintaining skin health and controlling skin inflammation (Table 3). Healthy skin is covered in different types of bacteria, especially *Cutibacterium*, *Staphylococcus*, and *Corynebacterium*. All of these groups help control the immune system (Mahmud et al., 2022; Mann et al., 2020). Some of the natural substances produced by bacteria and other tiny living things have a positive effect on our skin. They reduce inflammation and keep the skin healthy (Lee & Kim, 2022; Mahmud et al., 2022). Healthy skin has different types of bacteria in different areas, mostly *Cutibacterium*, *Staphylococcus*, and *Corynebacterium*. All of these groups help control the immune system (Mann et al., 2020).

It's interesting that some natural substances produced by microbes can actually have a positive effect on the skin, reducing inflammation and balancing it (Lee & Kim, 2022; Mahmud et al., 2022). So, if there is a disruption in the microbial balance in your body, it can lead to skin problems (Mahmud et al., 2022; Carmona-Cruz et al., 2022). The connection between the gut and the skin is also significant because gut microbes can affect the whole body's immune system and the skin's barrier by producing certain chemicals and signals (Mann et al., 2020; Mahmud et al., 2022). Changes in the gut microbiota have also been associated with skin disorders, including psoriasis and rosacea. It looks like keeping skin healthy is good for the whole body, according to these studies by Mahmud et al., (2022). New tools can now predict skin disease flare-ups using microbial indicators. This means that doctors can now use a person's unique microbial profile for prevention and treatment (Mahmud et al., 2022). Before they are given their treatment, patients with cancer who have low levels of protective bacteria on their skin are more likely to have severe skin reactions when they have radiation therapy. This information can help doctors prevent these problems. Changing the microbiome with probiotics, prebiotics, postbiotics, and microbe transplants has been shown to help restore balance and lower skin inflammation (Mahmud et al., 2022). You can try putting certain helpful bacteria on your skin, which make germ-fighting substances. This can reduce the number of harmful germs and reduce swelling, offering another option.

Fixing gut microbe imbalances with diet changes, probiotics, and gut microbe transplants also looks promising for improving both overall and skin health by balancing the immune system, which is key in skin inflammation. However, there are still big challenges. The microbiome is complex and changes frequently. This makes proving cause-and-effect difficult (Mahmud et al., 2022). We need to conduct more studies to better understand microbes (Mann et al., 2020). New technologies might change skin care in the future. Combining microbiome changes with current treatments could be a solution. A more comprehensive approach to strengthening the skin's barrier and regulating the immune system may help people with long-term skin inflammation when other treatments are ineffective (Mahmud et al., 2022). In short, the way the skin's microbes and the gut-skin connection work together is a key focus in skin research and treatment. Learning more about these microbial communities and how they interact with the immune system will help create new, personalized ways to manage skin diseases and keep skin healthy.

5. CONCLUSION

The skin microbiome is vital for skin barrier integrity, immune regulation and protection against pathogens. However, too few beneficial gut bacteria and too many harmful ones can lead to skin problems. The gut-skin axis shows how microbes in the gut can affect skin health, offering new ways to treat disease. Advances in sequencing, bioinformatics, and microbial network analysis have revealed diagnostic microbial signatures and early disease biomarkers. This means that we can now make a diagnosis and come up with targeted interventions. These strategies can also limit antibiotic use and resistance. Standardization of methodologies, establishment of causality, and implementation of well-designed clinical trials remain key challenges. But microbiome-based diagnostics and treatments are a new area for dermatology, opening up possibilities for new, personalized ways of treating people that look at the skin and the body's microbes together to improve health.

Acknowledgments

There are no acknowledgments to disclose.

Authors' Contributions

Natalia Sałkowska - Conceptualization; writing - rough preparation; supervision
Eliza Mędrek - Writing - rough preparation
Oliwia Borowska - Writing - rough preparation
Jakub Magdziak - Writing - rough preparation
Sara Awad - Writing - rough preparation
Natalia Brzozowska - Writing - rough preparation
Paulina Zegarska - Writing - rough preparation
Barbara Wardzyńska - Writing - review and editing
Hanna Markowska - Writing – review and editing
Izabela Ochońska - Writing – review and editing

Informed consent
Not applicable.

Ethical approval
Not applicable. This article does not contain any studies with human participants or animals performed by any of the authors.

Funding
This research did not receive any external funding like specific grant from funding agencies in the public, commercial, or nonprofit sectors.

Conflict of interest
The authors declare that they have no conflicts of interest, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Data and materials availability
All data associated with this study will be available based on the reasonable request to corresponding author.

REFERENCES

1. Carmona-Cruz S, Orozco-Covarrubias L, Sáez-de-Ocariz M. The human skin microbiome in selected cutaneous diseases. Front Cell Infect Microbiol 2022;12:834135.
2. Chen Y, Knight R, Gallo RL. Evolving approaches to profiling the microbiome in skin disease. Front Immunol 2023;14:1151527.
3. De Pessemier B, Grine L, Debaere M, Maes A, Paetzold B, Callewaert C. Gut-skin axis: current knowledge of the interrelationship between microbial dysbiosis and skin conditions. Microorganisms 2021;9:353.
4. Galvan A, Sala A, Fantini V, Crippa S, Sitia G. Recreating human skin in vitro: should the microbiota be taken into account? Int J Mol Sci 2024;25(2):1165.
5. Hülpüsch C, Neumann AU, Reiger M, Fischer JC, de Tomassi A, Hammel G, et al. Association of skin microbiome dynamics with radiodermatitis in patients with breast cancer. JAMA Oncol 2024.
6. Jiang Z, Li J, Kong N, Kim JH, Kim BS, Lee MJ, Park YM, Lee SY, Hong SJ, Sul JH. Accurate diagnosis of atopic dermatitis by combining transcriptome and microbiota data with supervised machine learning. Sci Rep 2022;12:290.
7. Jo JH, Kennedy EA, Kong HH. Bacterial 16S ribosomal RNA gene sequencing in cutaneous research. J Invest Dermatol 2016;136(3):e23-e27.
8. Lee HJ, Kim M. Skin barrier function and the microbiome. Int J Mol Sci 2022;23(21):13071.
9. Mahmud MR, Akter S, Tamanna SK, Mazumder L, Esti IZ, Banerjee S, Akter S, Hasan MR, Acharjee M, Hossain MS, Pirttilä AM. Impact of gut microbiome on skin health: gut-skin axis observed through the lenses of therapeutics and skin diseases. Gut Microbes 2022;14(1):2096995.
10. Mann EA, Bae E, Kostyuchek D, Chung HJ, McGee JS. The gut microbiome: human health and inflammatory skin diseases. Ann Dermatol 2020;32(4):265-272.
11. Sun T, Niu X, He Q, Chen F, Qi RQ. Artificial Intelligence in microbiomes analysis: A review of applications in dermatology. Front Microbiol 2023;14:1112010.
12. Liu X, Luo Y, Chen X, Wu M, Xu X, Tian J, Gao Y, Zhu J, Wang Z, Zhou Y, Zhang Y, Wang X, Li W, Lu Q, Yao X. Fecal microbiota transplantation against moderate-to-severe atopic dermatitis: a randomized, double-blind controlled explorer trial. Allergy 2025;80(5):1377-1388.