Medical Science

To Cite:
Figzał A, Kondratowicz M, Kałamarz K, Żmuda K, Świerczyna M, Czerniachowska M, Kaniewski M, Wojnowska M, Polkowska W, Grabek M. Effects of Probiotics on Gut Health, Immune Response, and Metabolic Processes - Systematic Review. *Medical Science* 2026; 30: e68ms3820
doi:

Authors' Affiliation:
[1]Karol Marcinkowski University Hospital, Zyty 26, 65-046 Zielona Góra, Poland
[2]The Independent Public Hospital No. 4, Lublin, Poland
[3]University Clinical Hospital of Opole al.W.Witosa 26 45-401 Opole, Poland
[4]Ministry of the Interior and Administration Hospital, Północna 42, 91-425 Łódź, Poland
[5]Medical University of Łódź, al. Kościuszki 4, 90-419 Łódź, Poland
[6]Mikolaj Pirogov Provincial Specialist Hospital, Wólczańska 191/195, 90-001 Łódź, Poland
[7]Central Clinical Hospital, Medical University of Łódź, Pomorska 251, 90-213 Łódź, Poland

***Corresponding author:**
Aleksandra Figzał,
Karol Marcinkowski University Hospital, Zyty 26, 65-046 Zielona Góra, Poland, Email: figzal.aleksandra@gmail.com

Contact List:

Aleksandra Figzał -	figzal.aleksandra@gmail.com
Maja Kondratowicz -	mkondratowicz44@gmail.com
Kamila Kałamarz -	kalamarzka@gmail.com
Kinga Żmuda -	kingazmuda99@gmail.com
Maciej Świerczyna–	maciekswierczyna@gmail.com
Maja Czerniachowska -	majaczerniachowska1@gmail.com
Marcin Kaniewski -	mbkan97@gmail.com
Martyna Wojnowska -	martyna.wojnowska98@gmail.com
Wiktoria Polkowska -	polkowskawi@gmail.com
Michał Grabek-	michal.grabek2@gmail.com

ORCID List:

Kamila Kałamarz	0009-0007-3160-8157
Maja Kondratowicz	0009-0003-3931-7216
Aleksandra Figzał	0009-0004-3933-3993
Kinga Żmuda	0009-0007-0948-3642
Maciej Świerczyna	0009-0008-8253-7165
Maja Czerniachowska	0009-0004-8986-1380
Marcin Kaniewski	0009-0006-1445-5577
Martyna Wojnowska	0009-0007-2561-0701
Wiktoria Polkowska	0009-0006-3812-9573
Michał Grabek	0009-0003-7217-4405

Peer-Review History
Received: 01 July 2025
Reviewed & Revised: 25/July/2025 to 16/March/2026
Accepted: 29 March 2026
Published: 09 April 2026

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

Medical Science
pISSN 2321–7359; eISSN 2321–7367

DISCOVERY SCIENTIFIC SOCIETY

Effects of Probiotics on Gut Health, Immune Response, and Metabolic Processes - Systematic Review

Aleksandra Figzał[1]*, Maja Kondratowicz[2], Kamila Kałamarz[1], Kinga Żmuda[3], Maciej Świerczyna[4], Maja Czerniachowska[5], Marcin Kaniewski[2], Martyna Wojnowska[6], Wiktoria Polkowska[7], Michał Grabek[1]

ABSTRACT

Introduction: Probiotics are microorganisms that help the body process nutrients, support the immune system, and maintain the health of the intestinal wall. If this balance is disrupted, a condition called dysbiosis can lead to problems not only in the gut but also throughout the body. *Results*: This review checks out studies published between January 2015 to May 2025, looking at how certain types of bacteria and yeast can help the gut's barrier work better. Research shows that certain types of friendly bacteria can help with some health problems caused by antibiotics, such as diarrhoea, irritable bowel syndrome and inflammatory bowel disease. They can also help control blood sugar levels. There is new evidence to suggest that this could have a positive influence on mental health by adjusting the connection that exists to the brain from the gut. *Conclusion*: Probiotics demonstrate favorable safety profiles with predominantly mild, transient adverse effects. Continued rigorous research and evidence-based clinical guidelines remain essential to optimize therapeutic applications. Personalized probiotic interventions and advanced delivery formulations represent promising areas for future development.

Keywords: probiotics; gut microbiota; gastrointestinal disorders; meta-analysis; evidence-based medicine

1. INTRODUCTION

Scientists have discovered a lot more about how probiotics work and how they can be used to treat people. Most recent research examines Lactobacillus, Bifidobacterium, and Saccharomyces strains and how they can help protect the intestinal barrier (Bordalo Tonucci et al., 2017). All these tiny organisms work together to stop harmful bacteria in their tracks, boost the immune system and influence how the body breaks down food. Probiotics are good for the gut and can help stop illness (Pace et al., 2020).

Prebiotics are parts of food that cannot be digested. They help certain good bacteria to grow in a person's gut. A mix of prebiotics and probiotics (synbiotics) can help to restore microbial balance more effectively (Chandrasekaran et al., 2024;

Wang et al., 2021). Microencapsulation stabilises probiotics for storage and digestion. This makes them more effective in the body (Chandrasekaran et al., 2024). Just because probiotics work for some people doesn't mean they'll work for everyone. Factors include: bacteria type; amount taken; genes; gut bacteria composition; diet; lifestyle. These affect the microbes in the gut and the body's ability to fight off disease. It is very important to check the data before using it in the clinic (Su et al., 2020; Salgaço et al., 2019).

Science currently shows that probiotics can help stop and reduce the symptoms of diarrhoea caused by antibiotics and other infectious diseases, like traveller's diarrhoea. These bacteria can help with IBS symptoms, reduce inflammation in people with IBD, and improve blood sugar levels. They can also change the levels of fats in the body, which can help with metabolic syndrome and type 2 diabetes (Kim et al., 2019; Feng et al., 2018). The positive effects on health probably result from changes in the microbes in the gut, better protection of the gut lining, and reduced inflammation. Researchers are looking into how probiotics affect the communication between the gut and brain. The first signs suggest that it could help people who are feeling worried or sad, and people who are finding it hard to remember things. But this is not used very often because there are no standard rules for choosing the types of yeast, how the products are made, how much is used, and how long the treatment should be taken for. We don't have long-term safety data yet, especially for people with weak immune systems.

2. REVIEW METHODS

This review method was based on the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. We searched lots of online databases, like PubMed, Google Scholar, Web of Science, and Scopus, to find relevant research. The researchers looked at publications from January 2015 to May 2025 to include the latest developments and ensure that the research on probiotics was included.

Search Strategy

The search incorporated the following keywords and combinations: Some of the words and phrases that you might come across include "probiotics", "gut microbiota", "inflammatory bowel disease", "irritable bowel syndrome", "metabolic syndrome", "type 2 diabetes", "prebiotics", "synbiotics", and "clinical trials". The search was made more precise using Boolean operators 'AND' and 'OR'.

The review included original research articles, systematic reviews, meta-analyses, and high-quality narrative reviews. These reviews looked at how probiotics affect gut microbiota, metabolism, immune function, and digestive disorders. Our studies looked at people of all ages and focused on gastrointestinal health or metabolic conditions. Studies on animals and in the lab were reviewed to understand how the mechanisms work. Only articles published in peer-reviewed journals were included to make sure the research was accurate and easy to understand.

Exclusion criteria:

- not include studies that did not focus on probiotic interventions or gut microbiota modulation.
- not include non-English publications without available translations.
-not include abstracts without accessible full texts.
-not include case reports with fewer than five subjects.
-not include studies with unclear methodology or diagnostic criteria.

Screening

The first database search found 2,145 relevant references. After removing duplicates, 1,307 studies were left for screening. Reviewers checked the titles and summaries of the studies to see how they related to the effects of probiotics on gut health and related diseases. During the screening process, 908 articles were not included because they did not meet the necessary standards. After that, we checked the full texts of the remaining 399 articles to see if they met the requirements. In the end, 142 top-quality publications met all the requirements to be included in the final summary. We searched four online databases — PubMed, Google Scholar, Web of Science, and Scopus — and found a total of 2,145 records. After removing 838 copies of the same entry, 1,307 different records were sent to the screening phase. Titles and summaries that met the set standards were chosen. At this stage, 908 records were judged irrelevant and excluded. The rest of the articles were found and checked to see if they met the requirements. Of all the studies, 257 were not included in the end for the following reasons: they did not focus enough on probiotic treatments or gut bacteria, they were in a language other than English and could not be translated, they were only published as short summaries, they were not available in full, they only had case reports with less than five people in them, or the way they were done was unclear.

In total, 142 studies met all the inclusion criteria and were included in the final analysis. Together, they show the current best evidence about how probiotics affect the composition of gut microbiota, gastrointestinal disorders, and metabolic outcomes.The study selection process is illustrated in the flow diagram (Figure 1), developed in accordance with PRISMA guidelines.

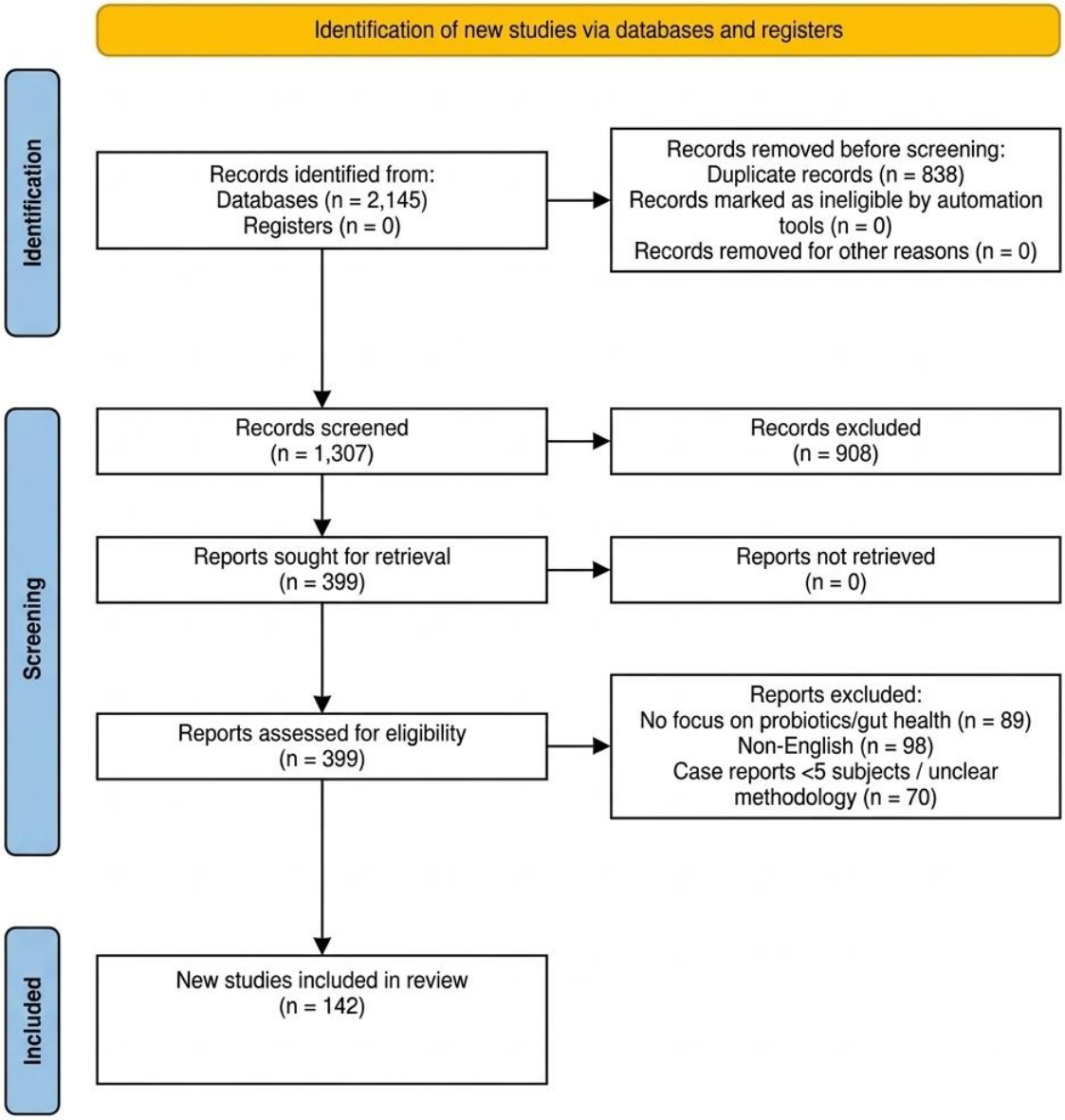

Figure 1. Flow diagram of the study selection process

3. RESULTS & DISCUSSION

Probiotics are a group of microorganisms that, when given in the right amounts, can make a noticeable difference to the health of the person. The genera that are written about most in medical literature are Lactobacillus, Bifidobacterium, and Saccharomyces. Each of these has its own way of spreading and working in the body. In recent years, however, scientists have become increasingly interested in two species that have recently been discovered — *Akkermansia muciniphila* and *Faecalibacterium prausnitzii*. These have been found to have a connection in scientific studies with the health of the gut barrier and the immune system in the gut.

Probiotics protect us in a number of ways. First, they compete directly with harmful organisms for places to attach to the intestinal epithelium, while also releasing chemicals that kill bacteria and reduce the acidity of the local area to restrict the growth of pathogens (Bordalo Tonucci et al., 2017). Secondly, at the structural level, probiotic strains encourage the production of tight junction proteins such as occludin and claudin. These proteins make the epithelial barrier more effective and reduce the permeability of harmful

substances and endotoxins (Wang et al., 2021). Thirdly, probiotics influence the immune system by affecting special cells in the gut, which in turn affects the balance of different types of immune cells, helping to keep things under control. Fourth, when the non-digestible dietary fibres are fermented, the probiotic bacteria make short-chain fatty acids (SCFAs), like butyrate, propionate, and acetate. Butyrate is the main energy source for colonocytes (the cells that line the colon), supports regeneration of the epithelial cells, and has effects on glucose homeostasis (the balance of glucose in the blood) and adipose tissue metabolism (the tissue that stores fatty acids) (Pace et al., 2020).

A decrease in the variety of microbes, along with an increase in harmful bacteria, is a key part of what causes many stomach and intestinal problems. Dysbiosis disrupts the balance of bacteria in the gut, creating conditions that can lead to infection, chronic inflammation, and impaired mucosal healing. Probiotic supplementation has been shown to reverse these changes, increasing the number of beneficial species and reducing the number of harmful ones (Chandrasekaran et al., 2024). Some types of bacteria, like Bifidobacterium and Lactobacillus, have been shown to help people with irritable bowel syndrome (IBS) and inflammatory bowel disease (IBD) feel better (Zhang et al., 2021).

One study found that eight weeks of taking probiotics every day increased the amount of a type of bacteria called *Faecalibacterium prausnitzii* in the intestines by 30%. This increase was linked to a decrease in certain substances found in the faeces and markers of intestinal inflammation seen during a test of the intestines (Szajewska et al., 2023). This finding is particularly important because *F. prausnitzii* is one of the most common butyrate-producing bacteria in the healthy human colon, and it has been seen that there is less of it in patients with active Crohn's disease.

Akkermansia muciniphila is a type of bacteria that lives in the intestinal mucus layer. It has been shown to play a key role in maintaining gut barrier function and metabolic health. High levels of this species have been linked to obesity, insulin resistance and ongoing low-grade inflammation in the body. This suggests that it could be a useful marker for diagnosing metabolic diseases and a target for treatment. It can help to renew the mucus layer and strengthen the tight junctions in the gut. This makes it a good candidate for a probiotic that could be used in the future.

AAD is one of the medical conditions for which probiotics are most commonly prescribed (Table 1). Information from 35 trials (4,800 people) showed that probiotics reduced the number of AAD cases by 42% (RR 0.58; 95% CI: 0.50–0.67). Of all the types of bacteria and yeast that were tested, *Lactobacillus rhamnosus* GG and *Saccharomyces boulardii* were the most effective at protecting patients. The suggested process involves stopping the commensal microbiota from being killed off by antibiotics, which limits the space available for Clostridioides difficile and other harmful bacteria to live.

In both children and adults, probiotic supplementation shortened acute infectious diarrhoea by an average of 24 hours compared to placebo or standard care (Su et al., 2020). Although a day's reduction might seem small, it is very important for public health, especially in places with limited healthcare resources. It is particularly important for young children, as long-term diarrhoea can lead to dehydration and malnutrition, which can be fatal. The effect was most obvious in cases of viral gastroenteritis, with the evidence pointing most strongly to *Lactobacillus rhamnosus* GG.

Table 1. Summary of selected meta-analyses on probiotics in gastrointestinal disorders

CONDITION	NUMBER OF STUDIES	KEY PROBIOTIC STRAINS	MAIN OUTCOMES	RELATIVE RISK (95% CI) / EFFECT SIZE
Antibiotic-Associated Diarrhea (AAD)	35	*L. rhamnosus* GG, *S. boulardii*	Reduced incidence of AAD	RR 0.58 (0.50–0.67)
Infectious Diarrhea	20	Various *Lactobacillus* and *Bifidobacterium* spp.	Shortened diarrhea duration	Mean reduction 24h ($p<0.001$)
Irritable Bowel Syndrome	15	Multi-strain probiotics	Symptom improvement:	Effect size 0.45 (SMD)

			pain, bloating	
Ulcerative Colitis (Maintenance)	12	*E. coli* Nissle 1917, VSL#3	Increased remission rates	RR 1.28 (1.10–1.48)

IBS is a complicated condition that has many causes (Table 1). It is linked to changes in the bacteria in the gut, the body being more sensitive to pain, and long-lasting swelling of the mucosa. In several well-designed studies, probiotics made up of different strains of bacteria helped people with IBS by reducing their symptoms, like stomach pain, bloating, and having stools that were hard or loose. About 60% of the people in the probiotic groups had a positive response, compared to about 30% in the placebo groups (Pace et al., 2020). This is more than we would expect to see naturally, so it seems like the treatment really is working. The results of the study (SMD 0.45) are similar to those achieved with other well-known treatments, such as antispasmodics, and they don't have the same negative side effects.

Probiotics can be especially useful in managing ulcerative colitis by helping to keep symptoms under control. Several trials have shown that *Escherichia coli* Nissle 1917 and the multi-strain formulation VSL#3 are just as good as mesalamine, the standard first-line maintenance therapy, in preventing relapses, over follow-up periods of 12 months (RR 1.28; 95% CI: 1.10–1.48) (Zhang et al., 2021). This probably happens by suppressing NF-κB-mediated inflammation, restoring mucosal IgA to normal, and eliminating the harmful bacteria that contribute to UC. These findings have helped to include certain types of friendly bacteria in international guidelines for treating people with mild to moderate UC.

The positive effects of probiotics on the body go beyond just the gut. There is growing evidence that certain types of bacteria can have a significant impact on metabolic health, particularly in people with type 2 diabetes, metabolic syndrome, and obesity. In these groups, probiotic use has been linked to better insulin sensitivity, lower blood sugar levels, and better cholesterol and fat levels, including lower LDL cholesterol and triglycerides and higher HDL cholesterol (Bordalo Tonucci et al., 2017; Abenavoli et al., 2019).

These improvements in the body's ability to use energy seem to be caused by a number of different processes. Restoring the gut barrier can stop lipopolysaccharide (LPS) from getting into the blood from the intestinal lumen. LPS is a structural component of gram-negative bacterial cell walls. High levels of a substance in the body called LPS can trigger a reaction in certain cells, which contributes to the ongoing low-grade inflammation that is characteristic of metabolic syndrome. By limiting this translocation, probiotics reduce a key cause of metabolic inflammation (Salgaço et al., 2019). At the same time, increased production of short-chain fatty acids (SCFAs), especially propionate and butyrate, causes the release of glucagon-like peptide-1 (GLP-1) and peptide YY (PYY) from special cells in the gut. These help to produce insulin, reduce appetite and improve how the body uses glucose. Butyrate also acts as a histone deacetylase inhibitor, which controls how genes are expressed in the liver and fat tissue, telling the body to burn fat instead of storing it (Salgaço et al., 2019).

Some studies have shown that a mix of different types of bacteria, like *Lactobacillus acidophilus*, *L. casei*, and *Bifidobacterium lactis*, have had the most consistent metabolic effects in trials where patients are randomly divided into groups. But the way these bacteria are chosen, how much is used, and how long they are used for are not all the same in the research papers (Abenavoli et al., 2019). The role of Akkermansia muciniphila as a new type of metabolic probiotic is interesting scientists. Research has shown that taking pasteurised A. muciniphila can reduce insulin resistance, decrease belly fat and lower inflammation in people with insulin resistance. Other studies have now shown the same results (Chandrasekaran et al., 2024).

The immune system in the gut has to keep telling the difference between good and bad microbes, as well as real pathogens. This depends a lot on the types and activity of the bacteria in the gut. Probiotics help with this process by interacting directly with the gut, which triggers a reaction in the immune system that affects more than just the mucosal surface.

At the cellular level, good bacteria help T cells to become regulatory T cells (Tregs). These cells inhibit the immune system from becoming overly active by producing IL-10 and TGF-β (Kim et al., 2019). This change in the rules is especially important in autoimmune and allergic conditions, such as atopic dermatitis, allergic rhinitis, and asthma, where a response from the immune system called Th2 dominance causes the disease. Studies on people have shown that taking probiotics can reduce symptoms and lower certain antibodies in the blood, but the results are different for each person depending on the type of probiotics and the person's age (Kim et al., 2019).

Probiotics also help to produce a special antibody called secretory IgA (sIgA) at the surface of the gut. This helps to protect against

harmful bacteria in the food we eat without causing inflammation throughout the body. Research has shown that people who take probiotics are less likely to get upper respiratory infections, and if they do, the symptoms won't last as long. This suggests that probiotics might help to protect the immune system in the lungs and intestines, which is known as the "gut-lung axis" (Wang et al., 2021). Even though there are some good signs, we still don't fully understand how probiotics change the immune system. At the moment, we don't have enough evidence to suggest specific probiotics for immune-related health problems other than in the gut (Szajewska et al., 2023).

Probiotics are usually well tolerated by most patients. The most common reported side effects are mild, short-lived, and gastrointestinal in nature — usually bloating, wind, or loose stools during the first one to two weeks of supplementation, after which symptoms usually get better without treatment (Szajewska et al., 2023). These reactions probably show short-term changes in how fermentation works as the gut microbiota gets used to new microbes.

Serious adverse events are rare and only happen in certain high-risk groups. Some people with weak immune systems, including those having chemotherapy, people with HIV, and babies with short bowel syndrome, have had problems with bacteria or fungus in their blood because of probiotic organisms. These organisms can also get into the blood of patients with central venous catheters, which are tubes put into a vein to help with chemotherapy or other treatments (Pace et al., 2020). Some patients with heart problems have also had a type of heart infection called *Lactobacillus endocarditis*. These findings show how important it is to do a very careful check-up before starting probiotic therapy in people who are at high risk, and to make sure that the probiotics are safe for all the different types of bacteria, especially for new types like *A. muciniphila* and *F. prausnitzii* that we don't have as much information about yet (Chandrasekaran et al., 2024).

The rules about what counts as a probiotic can be very different from one place to another. In most places, probiotics are seen as a type of food supplement, but in a few countries they are also used as a medicine. This means that the rules about how to check their quality can be different from one place to another. Problems with how cells are counted, contamination with other strains, and incorrect labelling of storage conditions are ongoing challenges. These problems can affect how reliable the results are and patient safety (Su et al., 2020).

Despite the good work documented in this review, there are still some important problems. The field still does not agree on the best ways to select strains, the most effective dosing ranges, and the minimum treatment durations for specific clinical indications. Most of the trials so far have been short-term, conducted with groups of people who are quite similar, and have used different methods to measure outcomes. This makes it impossible to apply the results to the wider population or compare them with other studies.

The idea of using personalised probiotic therapy, where the type of probiotic bacteria used is chosen based on the individual's microbiome, genetics, health history, and diet, is a really exciting area of research (Chandrasekaran et al., 2024). Thanks to advances in metagenomics and metabolomics, it is now possible to study each patient's gut ecosystem in enough detail to predict how well they will respond to specific treatments for their microbes. Combining probiotics with specific prebiotics has been shown to have a better effect on the gut than probiotics alone, and this combination should be studied more in bigger trials (Zhang et al., 2021).

Technology used for deliveries is also improving all the time. There are different ways to protect probiotics (good bacteria) so that they can survive on their travels through the stomach and small intestine. One way is to put them in tiny capsules. These capsules protect the bacteria and help them to be released just in the right place at the end of the small intestine. It is thought that this is where many of the bacteria's beneficial effects occur. In addition, there are genetically engineered probiotic strains that can produce therapeutic molecules (such as anti-inflammatory cytokines or antimicrobial peptides) right where they are needed. This represents a longer-term goal that links conventional probiotic therapy and the development of biopharmaceuticals (Chandrasekaran et al., 2024).

4. CONCLUSION

The evidence we have seen here shows that probiotics can be important in keeping the gut healthy and managing problems with the stomach and metabolism. Lactobacillus, Bifidobacterium, and Saccharomyces act together to reduce the risk of AAD, ease IBS symptoms, and better the outcome of IBD. It also has other health benefits, such as helping people with obesity and type 2 diabetes become more sensitive to insulin and better control their cholesterol. Some other early studies also suggest that it could have effects on the gut–brain axis and mental health. We need to do more research before we can update the guidelines. The safety data are good for the general population, but it's still important to be careful for those at high risk.

Future research should focus on standardizing strain selection criteria, characterizing mechanistic pathways, and long-term safety surveillance. Combining probiotics and prebiotics (synbiotics) might work better than using them separately. Probiotics show great promise as a preventative and therapeutic tool for gastrointestinal and systemic diseases.

Acknowledgments
We thank all participants who contributed to the studies included in this systematic review. We also acknowledge the support of our institution and colleagues who guided manuscript preparation.

Authors' Contributions
Aleksandra Figzał - Conceptualization, review and editing, investigation, methodology
Maja Kondratowicz- Methodology, investigation, visualization, supervision
Kamila Kałamarz- Conceptualization, visualization, resources
Kinga Żmuda- Review, data curation, investigation
Maciej Świerczyna- Resources, writing- rough preparation, data curation
Maja Czerniachowska- Visualization, data curation, investigation
Marcin Kaniewski- Review, visualization, formal analis
Martyna Wojnowska- Supervision, writing- rough preparation, data curation
Wiktoria Polkowska- Review and editing, formal analis, supervision
Michał Grabek- Resources, writing- rough preparation, formal analis
Project administration- Aleksandra Figzał

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 are present in the paper.

REFERENCES

1. Abenavoli L, Scarpellini E, Colica C, Boccuto L, Salehi B, Sharifi-Rad J, Aiello V, Romano B, De Lorenzo A, Izzo AA, Capasso R. Gut microbiota and obesity: a role for probiotics. Nutrients 2019;11(11):2690. doi: 10.3390/nu11112690.
2. Bordalo Tonucci L, Dos Santos KMO, De Luces Fortes Ferreira CL, Ribeiro SMR, De Oliveira LL, Martino HSD. Gut microbiota and probiotics: the focus on diabetes mellitus. Crit Rev Food Sci Nutr 2017;57(11):2296-2309. doi: 10.1080/10408398.2015.1042380.
3. Chandrasekaran P, Weiskirchen S, Weiskirchen R. Effects of probiotics on gut microbiota: an overview. Int J Mol Sci 2024;25(11):6022. doi: 10.3390/ijms25116022.
4. Feng P, Ye Z, Kakade A, Virk AK, Li X, Liu P. A review on gut remediation of selected environmental contaminants: possible roles of probiotics and gut microbiota. Nutrients 2018;11(1):22. doi: 10.3390/nu11010022.
5. Kim SK, Guevarra RB, Kim YT, Kwon J, Kim H, Cho JH, Kim HB, Lee JK. Role of probiotics in human gut microbiome-

associated diseases. J Microbiol Biotechnol 2019;29(9):1335-1340. doi: 10.4014/jmb.1906.06064.
6. Pace F, Pace M, Quartarone G. Probiotics in digestive diseases: focus on Lactobacillus GG. Minerva Gastroenterol Dietol 2020;61(4):273-292. doi: 10.23736/S1121-421X.15.02184-5.
7. Salgaço MK, Oliveira LGS, Costa GN, Bianchi F, Sivieri K. Relationship between gut microbiota, probiotics, and type 2 diabetes mellitus. Appl Microbiol Biotechnol 2019;103(23):9229-9238. doi: 10.1007/s00253-019-10156-y.
8. Su GL, Ko CW, Bercik P, Falck-Ytter Y, Sultan S, Weizman AV, Morgan RL. AGA clinical practice guidelines on the role of probiotics in the management of gastrointestinal disorders. Gastroenterol 2020;159(2):697-705. doi: 10.1053/j.gastro.2020.05.059.
9. Szajewska H, Berni Canani R, Domellöf M, Guarino A, Hojsak I, Indrio F, Lo Vecchio A, Mihatsch WA, Mosca A, Orel R, Salvatore S, Shamir R, Vandenplas Y, Van den Akker CHP, Van Goudoever JB, Weizman Z; ESPGHAN Special Interest Group on Gut Microbiota and Modifications. Probiotics for the management of pediatric gastrointestinal disorders: position paper of the ESPGHAN special interest group on gut microbiota and modifications. J Pediatr Gastroenterol Nutr 2023;76(2):232-247. doi: 10.1097/MPG.0000000000003633.
10. Wang X, Zhang P, Zhang X. Probiotics regulate gut microbiota: an effective method to improve immunity. Molecules 2021;26(19):6076. doi: 10.3390/molecules26196076.
11. Zhang XF, Guan XX, Tang YJ, Sun JF, Wang XK, Wang WD, Fan JM. Clinical effects and gut microbiota change of using probiotics, prebiotics, or synbiotics in inflammatory bowel disease: a systematic review and meta-analysis. Eur J Nutr 2021;60(5):2855-2875. doi: 10.1007/s00394-021-02503-5.