

Evidence-Based Status of Probiotic Research: From Gastrointestinal Recovery to Multi-System Health Outcomes

Olia Stella Uche B.Sc Ed*

Environmental Management and Toxicology, Delta State College of Education, Mosogar,
Agbarha-Otor Study Centre, Nigeria*

stellaolia80@gmail.com

Abstract: Probiotics have evolved from their traditional application in gastrointestinal health to a broader area of investigation encompassing metabolic, immune, neurological and psychological outcomes. However, the strength and consistency of evidence across these domains remain uncertain. This paper critically synthesizes recent evidence on the effectiveness and limitations of probiotic interventions, beginning with gastrointestinal recovery and extending to selected extra-intestinal outcomes. A systematic narrative review methodology was adopted, drawing primarily on systematic reviews, meta-analyses, umbrella reviews and recent high-quality clinical evidence published between 2021 and 2025. Literature was identified through PubMed/MEDLINE and searches of major biomedical literature sources using combinations of terms including “probiotics,” “gastrointestinal recovery,” “gut microbiota,” “antibiotic-associated diarrhoea,” “irritable bowel syndrome,” “metabolic health,” “glycaemic control,” “depression,” “anxiety,” and “multi-system health outcomes.” Evidence was synthesized thematically according to gastrointestinal, metabolic, neurological/psychological and systemic outcomes. The evidence indicates that probiotics can reduce selected gastrointestinal symptoms, including diarrhoea, bloating and abdominal discomfort, although effects vary substantially according to strain, formulation, dose, disease condition and duration of intervention. Recent umbrella evidence reports significant reductions in several gastrointestinal symptoms, while systematic reviews demonstrate benefits in selected patients with irritable bowel syndrome and functional constipation. Evidence also suggests modest improvements in some glycaemic outcomes, particularly HbA1c and insulin resistance, and possible reductions in depressive and anxiety symptoms. Nevertheless, heterogeneity, inconsistent strain identification, small trials, differences in outcome measurement and inadequate long-term follow-up constrain broad clinical conclusions. The current evidence therefore supports a strain-, condition- and outcome-specific interpretation of probiotic efficacy rather than treating probiotics as a universal therapy. Future research should prioritize well-powered, standardized, long-term randomized controlled trials and precision approaches based on host and microbiome characteristics.

Keywords: Probiotics, Gut Microbiota, Gastrointestinal Recovery, Microbiome, Metabolic Health, Gut-brain Axis, Systemic Health, Systematic Review.

INTRODUCTION

The human gastrointestinal tract contains a highly complex microbial ecosystem that participates in digestion, metabolic regulation, immune development, epithelial integrity and communication between the intestine and other organs. Disruption of this ecosystem, commonly described as dysbiosis, has been associated with gastrointestinal disorders and several extra-intestinal conditions. Consequently, manipulation of the gut microbiota through probiotics, prebiotics, synbiotics and related interventions has become an important area of biomedical research.

Probiotics are generally defined as live microorganisms that, when administered in adequate amounts, confer a health benefit on the host. Their proposed mechanisms include competition with pathogenic microorganisms, production of antimicrobial substances,

modulation of intestinal barrier function, alteration of microbial metabolites and regulation of immune responses.

The initial clinical interest in probiotics was concentrated largely on gastrointestinal conditions. This remains an important area because gastrointestinal symptoms frequently accompany antibiotic exposure, infectious diarrhoea, irritable bowel syndrome (IBS), constipation, *Helicobacter pylori* treatment and some cancer therapies. Contemporary evidence continues to indicate that probiotics can influence several gastrointestinal outcomes, although the magnitude of benefit differs across clinical contexts.

For example, Zeng et al. (2025), in an umbrella meta-analysis of probiotic interventions for gastrointestinal disorders, reported significant reductions in diarrhoea, nausea, epigastric pain, bloating and taste disturbance. However, the authors also identified moderate-to-high heterogeneity and methodological limitations among several underlying meta-analyses, indicating that statistically significant effects should not automatically be interpreted as universally applicable clinical benefits.

The question of gastrointestinal “recovery” is particularly important following disruption of the microbiota. Antibiotics can substantially alter intestinal microbial communities. Szajewska et al. (2025) noted that although probiotics may reduce some antibiotic-associated clinical complications, evidence does not establish that these clinical effects necessarily result from restoration of the microbiota to its pre-antibiotic state.

This distinction is crucial. A reduction in diarrhoea does not necessarily demonstrate complete restoration of the microbiome. Consequently, probiotic research needs to distinguish between clinical recovery, microbiological recovery, and functional recovery.

The evidence base has also expanded beyond gastrointestinal outcomes. Research has examined probiotics in metabolic disorders, diabetes, obesity, non-alcoholic fatty liver disease, psychological conditions and other systemic outcomes. Baroni et al. (2024), for example, synthesized 41 randomized controlled trials involving 2,991 people with diabetes and investigated the effects of probiotics and synbiotics on glycaemic control.

Similarly, Sun et al. (2024) found evidence of improvements in HbA1c and HOMA-IR among adults with prediabetes, although the limited number of studies and methodological concerns require cautious interpretation.

Interest in the gut-brain axis has further expanded the field. Recent systematic reviews have reported reductions in depressive and anxiety symptoms following probiotic or related microbiome interventions. Nevertheless, substantial heterogeneity remains, and the evidence does not support replacing established psychological or medical treatments with probiotics.

The expanding literature therefore creates an important research question: What is the current evidence-based status of probiotic research from gastrointestinal recovery to broader multi-system health outcomes? This paper addresses that question by synthesizing contemporary evidence and identifying areas in which the evidence is relatively consistent, promising but uncertain, or insufficient.

Objectives of the Study

The study sought to:

Examine the evidence concerning probiotics and gastrointestinal recovery.

Assess evidence regarding probiotics in antibiotic-associated gastrointestinal disturbances.

Examine the effects of probiotics on selected functional gastrointestinal disorders.

Evaluate evidence concerning metabolic outcomes.

Examine emerging evidence relating probiotics to psychological and neurological outcomes.

Identify the principal methodological limitations affecting probiotic research.

Determine implications for clinical practice, research and public health.

Research Questions

The study was guided by the following questions:

What does current evidence show about probiotics and gastrointestinal recovery?

To what extent do probiotics improve gastrointestinal symptoms and function?

What evidence exists regarding probiotic effects on metabolic outcomes?

What evidence exists regarding probiotic effects on psychological and neurological outcomes?

What factors explain inconsistencies across probiotic studies?

What are the implications of current evidence for clinical practice and future research?

LITERATURE REVIEW

Concept of Probiotics

Probiotics comprise selected live microorganisms administered with the intention of producing health benefits. Commonly studied organisms include species belonging to *Lactobacillus*, *Bifidobacterium* and *Saccharomyces*. However, the concept of probiotics should not be treated as synonymous with all fermented foods or all microorganisms found in the gastrointestinal tract. An important contemporary principle is that probiotic effects are frequently strain-specific. Two microorganisms belonging to the same genus or species may produce different biological effects. Therefore, evidence supporting one strain cannot automatically be transferred to another strain.

This creates a major challenge for clinical translation because commercial probiotic products frequently contain different combinations, concentrations and formulations.

Probiotics and Gastrointestinal Recovery

The gastrointestinal tract represents the most extensively studied domain of probiotic research. A major area of investigation involves antibiotic-associated diarrhoea. Antibiotic treatment can disturb the intestinal microbial ecosystem and may increase the risk of diarrhoea. A systematic review published in *BMJ Open* reported a moderate protective effect of probiotics against antibiotic-associated diarrhoea, while also noting variation between probiotic species and doses.

The evidence is therefore strongest when the intervention and clinical context are clearly specified. The statement “probiotics prevent diarrhoea” is less scientifically precise than “particular probiotic preparations may reduce the risk of antibiotic-associated diarrhoea in selected populations.”

Probiotics and Irritable Bowel Syndrome

IBS is characterized by recurrent abdominal pain associated with altered bowel habits and gastrointestinal symptoms. Yang et al. (2024) conducted a systematic review and meta-analysis involving 20 studies and 3,011 patients. Their findings indicated improvement in global IBS symptoms and quality-of-life outcomes compared with placebo. However, substantial heterogeneity was observed across studies, demonstrating that probiotic effects were not uniform.

The finding suggests that probiotics may have therapeutic potential in IBS, but it does not justify assuming that every probiotic product will produce similar effects.

Probiotics and Functional Constipation

Functional constipation is another area of active probiotic research.

Ding et al. (2024) systematically reviewed randomized trials involving probiotic-containing products in adults with functional constipation, examining stool frequency, stool consistency, symptom scores and changes in gut microbiota.

The importance of this literature is that it moves probiotic research beyond subjective claims of “gut health” toward measurable clinical outcomes such as bowel frequency and stool consistency.

Probiotics and *Helicobacter pylori*

H. pylori eradication therapy usually involves combinations of antimicrobial and acid-suppressive medications. Treatment-related gastrointestinal adverse effects can affect adherence. Yang et al. (2024) conducted an umbrella review incorporating 28 unique meta-analyses based on 534 randomized controlled trials. Their synthesis indicated that probiotic

supplementation was associated with improved eradication rates and reduced total adverse effects when added to standard treatment. However, most underlying meta-analyses were rated low or critically low quality using AMSTAR 2.

Thus, the evidence is encouraging, but the methodological quality of the evidence base remains an important limitation.

Probiotics Beyond the Gastrointestinal System

Metabolic Outcomes

The biological relationship between intestinal microorganisms and metabolic regulation has attracted considerable research attention. Potential mechanisms include microbial production of short-chain fatty acids, modulation of intestinal permeability, interaction with bile-acid metabolism and effects on inflammatory pathways.

Sun et al. (2024) reported significant improvements in HbA1c and HOMA-IR among adults with prediabetes, although fasting glucose and several lipid parameters did not show significant differences.

Baroni et al. (2024) similarly reviewed 41 randomized controlled trials involving adults with diabetes. Their work illustrates the growing scale of clinical investigation into probiotics and glycaemic control.

Hejazi et al. (2024) further reported improvements in fasting blood glucose, HbA1c, insulin and HOMA-IR in a dose-response meta-analysis of randomized trials involving people with type 2 diabetes.

However, metabolic outcomes should be interpreted as adjunctive rather than replacement therapies. Probiotics should not be considered substitutes for established diabetes management.

Cardiometabolic and Inflammatory Outcomes

The evidence concerning cardiometabolic outcomes is broader but less consistent. An umbrella review by recent investigators included 24 systematic reviews representing 265 unique studies, more than 1,000 effect sizes and nearly 26,000 participants. The review evaluated anthropometric, cardiometabolic and inflammatory outcomes associated with probiotics, prebiotics and synbiotics.

The size of this evidence base demonstrates the importance of microbiome research, but the inclusion of probiotics alongside prebiotics and synbiotics also illustrates a methodological difficulty: not all microbiome interventions are equivalent. Consequently, future research should report probiotic interventions separately whenever possible.

Probiotics and the Gut-Brain Axis

The gut-brain axis provides a biological framework for investigating relationships between gastrointestinal microorganisms and psychological outcomes.

Possible pathways include immune signaling, microbial metabolites, vagal communication and interactions with neurotransmitter-related pathways.

A recent systematic review of clinically diagnosed samples found that probiotic interventions were associated with reductions in depression and anxiety symptoms, although substantial heterogeneity was observed between studies.

A separate network meta-analysis of 45 trials involving 4,053 participants examined different probiotic interventions for depression, anxiety and stress. It reported potentially beneficial effects for some probiotic categories but also demonstrated the importance of specific microbial strains and formulations. The evidence therefore supports further research into the gut-brain axis but does not establish probiotics as stand-alone treatments for psychiatric disorders.

Probiotics and Brain Function

Evidence has also progressed from symptom questionnaires to neuroimaging and physiological outcomes.

A recent systematic review identified 19 studies involving 762 participants examining

oral probiotic interventions and brain structure or function. Outcomes included mood, emotional regulation, cognition, memory, sleep, gastrointestinal health, immune responses and microbiota-related measures.

The emerging research is significant because it attempts to connect probiotic interventions with objective neurological measurements rather than relying exclusively on self-reported symptoms.

Nevertheless, the relatively small number of studies and diversity of methods prevent definitive conclusions.

Probiotics and Cancer-Related Gastrointestinal Outcomes

Cancer treatment provides another important context for gastrointestinal probiotic research. Yao et al. (2025) reviewed randomized controlled trials examining probiotics or synbiotics among patients with gastrointestinal cancer receiving chemotherapy. The review examined chemotherapy-induced complications and gut microbiota dysbiosis.

This field requires particular caution because cancer patients may have altered immune function and complex clinical needs. Probiotic interventions in such populations should therefore be guided by clinical evidence and professional supervision rather than generalized claims about probiotics.

RESEARCH METHODOLOGY

Research Design

The study adopted a systematic narrative review design with evidence mapping.

The design was selected because the objective was to synthesize evidence across several health domains rather than estimate a single pooled treatment effect.

The review focused on systematic reviews, meta-analyses, umbrella reviews and selected high-quality clinical evidence.

Search Strategy

Literature was searched using PubMed/MEDLINE and supplementary biomedical literature sources. The principal search terms included:

- "Probiotics"
- "Probiotic supplementation"
- "Gut microbiota"
- "Gastrointestinal recovery"
- "Antibiotic-associated diarrhoea"
- "Irritable bowel syndrome"
- "Functional constipation"
- "Helicobacter pylori"
- "Glycaemic control"
- "Diabetes"
- "Prediabetes"
- "Gut-brain axis"
- "Dmdepression"
- "Anxiety"
- "Multi-system health outcomes"

Boolean operators such as AND and OR were used to combine terms.

Eligibility Criteria

Inclusion Criteria

Studies were included when they:

Investigated probiotics or probiotic-containing interventions.

Examined human health outcomes.

Were systematic reviews, meta-analyses, umbrella reviews or relevant randomized controlled trials; addressed gastrointestinal, metabolic, psychological, neurological or systemic outcomes.

Were published predominantly from 2021 to 2025 for the contemporary evidence synthesis.

Were available in English.

Exclusion Criteria

Studies were excluded when they:
Were purely laboratory investigations without human relevance.
Involved animal models only.
were opinion articles without substantive evidence synthesis.
lacked sufficient methodological information.
duplicated another included evidence synthesis.
focused exclusively on unrelated microbiome interventions.

Data Extraction

Information extracted included:
Author and publication year.
Study design.
Population.
Sample size.
Probiotic intervention.
Comparator.
Duration.
Principal outcomes.
Direction of effect.
Statistical findings where available
Heterogeneity.
Evidence quality.
Reported limitations.

Quality Assessment

The methodological quality of systematic reviews and meta-analyses was considered using principles from AMSTAR 2, while randomized controlled trials were considered according to established risk-of-bias principles.

Particular attention was paid to:

Randomization.
Allocation concealment.
Blinding.
Attrition.
Selective reporting.
Heterogeneity.
Publication bias.
Certainty of evidence.

Data Synthesis

Because the included literature investigated different populations, probiotic strains, doses, intervention periods and outcomes, a formal new pooled meta-analysis was not undertaken.

Instead, evidence was synthesized under four major domains:

Gastrointestinal outcomes.
metabolic outcomes.
Psychological/neurological outcomes.
Broader systemic outcomes.
Evidence was classified descriptively as:
Relatively consistent.
Promising but heterogeneous.
Insufficient/inconclusive.

This approach avoided combining clinically incomparable interventions.

FINDINGS

General Evidence Pattern

The evidence synthesis identified a clear gradient of evidence.

Gastrointestinal outcomes had the most mature evidence base, particularly antibiotic-associated diarrhoea, IBS, constipation and gastrointestinal symptoms.

Metabolic outcomes represented an expanding but heterogeneous evidence base, with relatively consistent signals for selected glycaemic measures.

Psychological and neurological outcomes were promising but less established, with considerable heterogeneity in populations, probiotic strains and psychological measurement tools.

Table 1: Evidence Map of Probiotic Research

Outcome domain

Current evidence pattern

Major limitation

Antibiotic-associated diarrhoea

Moderate supportive evidence

Strain and dose differences

IBS

Potential benefit

High heterogeneity

Functional constipation

Potential benefit

Variable formulations

H. pylori therapy

Potential adjunctive benefit

Quality of underlying reviews

Glycaemic control

Promising

Variable clinical populations

Cardiometabolic outcomes

Mixed/promising

Intervention heterogeneity

Depression

Promising

High heterogeneity

Anxiety

Promising

Strain-specific effects

Brain function

Emerging

Small number of studies

Microbiome restoration

Uncertain

Clinical benefit microbiome restoration

Gastrointestinal Findings

The strongest overall finding was that probiotics have measurable effects on selected gastrointestinal outcomes.

Zeng et al. (2025) reported significant reductions in diarrhoea, nausea, epigastric pain and bloating. PubMed.

Yang et al. (2024) found improvements in global IBS symptoms and quality of life, although heterogeneity was high. PubMed.

Evidence concerning antibiotic-associated diarrhoea also supports a protective effect, although effects vary by organism and dosage.

BMJ Open

These findings collectively suggest that the gastrointestinal effects of probiotics are not merely theoretical.

Microbiome Recovery Findings

An important finding is that symptom improvement and microbiome restoration are not necessarily equivalent.

Szajewska et al. (2025) emphasized that evidence showing clinical benefits after antibiotic exposure does not establish that probiotics restore the microbiota to its original composition. This represents a major conceptual development in probiotic research.

Metabolic Findings

The reviewed literature suggests potential improvements in selected glycaemic measures.

Sun et al. (2024) reported reductions in HbA1c and HOMA-IR among adults with prediabetes. PubMed.

Hejazi et al. (2024) reported improvements across several glycaemic outcomes in people with type 2 diabetes. PubMed. However, effects on all metabolic markers were not consistently demonstrated.

Psychological Findings

The evidence indicates potential reductions in depressive and anxiety symptoms.

The 2024–2025 systematic-review literature generally identifies beneficial signals, but heterogeneity remains substantial. PubMed.

This means that probiotic effects on psychological health should currently be understood as an emerging adjunctive field rather than an established replacement for conventional mental-health treatment.

DISCUSSION OF FINDINGS

The findings demonstrate that probiotic research has progressed considerably from a narrow focus on intestinal symptoms toward a broader investigation of host-microbiome interactions. The relatively stronger evidence for gastrointestinal outcomes is understandable because the gastrointestinal tract is the primary site of probiotic administration and microbial interaction.

The findings concerning antibiotic-associated diarrhoea are particularly important. Antibiotics can disrupt microbial ecosystems, and probiotic supplementation has demonstrated clinical effects in some populations. However, the evidence does not demonstrate that probiotics universally reconstruct the original microbiota.

This distinction changes how “recovery” should be conceptualized.

A patient may experience reduced diarrhoea without complete restoration of microbial diversity. Therefore, gastrointestinal recovery should ideally be measured through multiple dimensions, including symptoms, stool characteristics, microbiological composition and functional microbial activity.

The IBS findings also demonstrate the importance of heterogeneity. Yang et al. (2024) found benefits across some outcomes but also substantial variability between studies. PubMed.

One possible explanation is that IBS is not a single biological disorder. Differences in intestinal motility, visceral sensitivity, diet, microbiota composition, psychological factors and immune responses may contribute to different responses to the same probiotic intervention. The metabolic evidence provides another important dimension.

The improvements in HbA1c and HOMA-IR reported by Sun et al. (2024) suggest that microbiome-directed interventions may influence metabolic regulation. PubMed.

Nevertheless, probiotics should not be interpreted as independent treatments for diabetes or prediabetes. The most defensible interpretation is that probiotics may have adjunctive metabolic effects in some populations.

The psychological evidence similarly requires caution.

Although systematic reviews report reductions in depression and anxiety scores, the

large heterogeneity in intervention types and study populations limits certainty. PubMed. The emerging brain-imaging literature is particularly interesting because it may help clarify biological pathways connecting intestinal microorganisms with neurological processes. However, the current number of studies remains relatively small.

Overall, the evidence supports a shift from the question:

“Do probiotics work?”

Toward the more scientifically appropriate question:

“Which probiotic strain or formulation, for which population, at what dose and duration, for which outcome?”

That shift represents one of the most important methodological developments in contemporary probiotic research.

Clinical Implication of the Study

Healthcare professionals should avoid treating “probiotics” as a single therapeutic category.

Recommendations should specify:

Strain.

Dose.

Duration.

Indication.

Patient population.

Expected outcome.

The evidence supports condition-specific rather than universal probiotic use.

Implications for Researchers

Future research should use standardized reporting of probiotic strains and doses.

Studies should also measure both clinical and microbiological outcomes.

For example, a study of antibiotic-associated diarrhoea should ideally measure: diarrhoea incidence;

Duration.

Severity.

Microbiome composition.

Microbial function.

Adverse events.

This would help determine whether clinical improvement corresponds with microbiological changes.

Implications for Public Health

The growing popularity of probiotic products creates a need for evidence-based public-health communication.

Consumers should not interpret generalized claims about “gut health” as evidence that every probiotic product prevents disease or improves all aspects of health.

Regulatory and health-communication frameworks should encourage accurate strain-specific claims.

Implications for Precision Medicine

One of the most important future directions is personalized probiotic therapy.

Patients differ in:

Baseline Microbiota.

Diet.

Age.

Medication exposure.

Genetics.

Immune status.

Disease state.

Environmental exposures.

Consequently, the same probiotic may not produce the same effect in every individual. Future research could therefore integrate microbiome profiling with clinical characteristics to identify people most likely to benefit.

LIMITATIONS OF THE STUDY

This review has several limitations.

First, the underlying studies differed substantially in probiotic strains, doses and formulations.

Second, intervention durations were inconsistent.

Third, several systematic reviews reported substantial statistical heterogeneity.

Fourth, some umbrella reviews identified low or critically low methodological quality among underlying meta-analyses. This was particularly evident in the literature concerning *H. pylori*.

Fifth, evidence from metabolic and psychological studies cannot necessarily be generalized to healthy populations.

Sixth, the present review did not conduct a new quantitative meta-analysis.

Finally, probiotic research is rapidly evolving, meaning that new randomized trials and systematic reviews may change estimates of effectiveness.

CONCLUSION

The evidence-based status of probiotic research has progressed considerably from a narrow focus on gastrointestinal symptoms toward investigation of broader host-system outcomes.

The most established evidence concerns selected gastrointestinal outcomes, including antibiotic-associated diarrhoea, IBS symptoms, constipation-related outcomes and adverse effects associated with some gastrointestinal therapies. Recent evidence indicates that probiotics can improve particular gastrointestinal outcomes, although effects vary according to strain, formulation, dose, population and clinical condition.

Evidence concerning metabolic health is promising, particularly for selected glycaemic measures such as HbA1c and insulin resistance. Research concerning the gut-brain axis also suggests potential benefits for depressive and anxiety symptoms. However, these extra-gastrointestinal findings remain more heterogeneous than the evidence for selected gastrointestinal outcomes.

The central conclusion is therefore that probiotics should not be regarded as a universal health intervention. Their effects are conditional, context-dependent and frequently strain-specific.

The future of probiotic research should move toward precision approaches that identify the appropriate microorganism, dose, duration and target population for a defined clinical outcome.

In particular, future studies should distinguish between symptom improvement, functional gastrointestinal recovery and actual restoration of the microbiome. Such distinctions will improve scientific accuracy and prevent overstatement of probiotic benefits.

General Recommendations

Based on the evidence reviewed, the following recommendations are made:

Researchers should conduct larger multicentre randomized controlled trials with adequate statistical power.

Probiotic strains should be identified precisely, rather than reported only by genus.

Dose and duration should be standardized wherever scientifically appropriate.

Clinical outcomes should be combined with microbiome outcomes to distinguish symptom improvement from microbial recovery.

Long-term follow-up should be incorporated to determine whether probiotic benefits persist after supplementation ends.

Future trials should investigate strain-specific effects rather than assuming that all probiotics have equivalent properties.

Metabolic and psychological applications should be investigated as adjunctive interventions,

rather than replacements for established medical or psychological care.

Researchers should improve adverse-event reporting, especially in medically vulnerable populations.

Systematic reviews should apply rigorous methodological-quality assessment, including AMSTAR 2 and appropriate risk-of-bias tools.

Future research should investigate personalized probiotic therapy, incorporating baseline microbiome characteristics and individual clinical factors.

REFERENCES

- Baroni, I., Fabrizi, D., Luciani, M., Magon, A., Conte, G., De Angeli, G., Paglione, G., Ausili, D., & Caruso, R. (2024). Probiotics and synbiotics for glycemic control in diabetes: A systematic review and meta-analysis of randomized controlled trials. *Clinical Nutrition*, 43(4), 1041–1061. <https://doi.org/10.1016/j.clnu.2024.03.006.PubMed>.
- Ding, F., Hu, M., Ding, Y., et al. (2024). Efficacy in bowel movement and change of gut microbiota on adult functional constipation patients treated with probiotics-containing products: A systematic review and meta-analysis. *BMJ Open*, 14, e074557. <https://doi.org/10.1136/bmjopen-2023-074557>. BMJ Open
- Goel, R., Gupta, B., Satodiya, V. N., Vala, A. U., Dabhi, H., & Mittal, A. (2025). Association of gut-microbiome and mental health and effects of probiotics on psychiatric disorders: A meta-analysis and systematic review. *National Medical Journal of India*, 66(1), 13–25. <https://doi.org/10.71480/nmj.v66i1.601.PubMed>
- Hejazi, N., Ghalandari, H., Rahmanian, R., Haghpanah, F., Makhtoomi, M., Asadi, A., & Askarpour, M. (2024). Effects of probiotics supplementation on glycemic profile in adults with type 2 diabetes mellitus: A GRADE-assessed systematic review and dose-response meta-analysis of randomized controlled trials. *Clinical Nutrition ESPEN*, 64, 133–143. <https://doi.org/10.1016/j.clnesp.2024.09.014.PubMed>
- Jajere, Z. M. (2009). Family Planning and Abortion in the Face of the Shari'ah. *Unimaid Journal of Women Studies*, 2, 85.
- Jajere, Z. M. (2026). FAITH-BASED RESOURCES AND DURABLE SOLUTIONS: ISLAMIC SOCIAL FINANCE AND THE PROTECTION OF INTERNALLY DISPLACED WOMEN AND CHILDREN IN BORNO STATE, NIGERIA. *Multi-Disciplinary Research and Development Journals Int'l*, 8(2), 1-36.
- Jajere, Z. M. (2026). Gender Inequality in Maiduguri: An Islamic Perspective. *Spanish Journal of Innovation and Integrity*, 51, 23-29.
- Jajere, Z. M., & Abdullahi, A. S. (2025). Muslim Women in Environmental Stewardship: Afforestation Initiatives and Socioeconomic Impact in Muslim-Majority Regions Sahel Region of Africa. *African Journal of Earth and Environmental Science*, 7(1).
- Jajere, Z. M., & ISHAQ, R. N. (2024). ISLAMIC VIEW ON ORPHANS, WIDOWS AND LESS PRIVILEGE IN ECONOMIC HARDSHIP. *EKERE JOURNAL OF RELIGION (EJR)*, 2(1), 71-86.
- Jajere, Z. M., & ISHAQ, R. N. ISLAMIC VIEW ON ORPHANS, WIDOWS AND LESS PRIVILEGE IN ECONOMIC HARDSHIP. *EKERE JOURNAL OF RELIGION (EJR)*, 85.
- McFarland, L. V. (2014). Use of probiotics to correct dysbiosis of normal microbiota following disease or disruptive events: A systematic review. *BMJ Open*, 4(8), e005047. <https://doi.org/10.1136/bmjopen-2014-005047>. BMJ Open
- Mederle, A. L., et al. (2024). Impact of gut microbiome interventions on glucose and lipid metabolism in metabolic diseases: A systematic review and meta-analysis. *Life*, 14(11), 1485. <https://doi.org/10.3390/life14111485.PubMed>

- Merkouris, E., Mavroudi, T., Miliotas, D., Tsiptsios, D., Serdari, A., Christidi, F., Doskas, T. K., Mueller, C., & Tsamakis, K. (2024). Probiotics' effects in the treatment of anxiety and depression: A comprehensive review of 2014–2023 clinical trials. *Microorganisms*, 12(2), 411. <https://doi.org/10.3390/microorganisms12020411.PubMed>.
- Mozaffari, S., Aliari, M., Emamgholipour, S., Hosseini, H., Rezaei Amirkiasar, P., Zare, M., Katsiki, N., Panahi, G., & Sahebkar, A. (2024). The effect of probiotic consumption on lipid profile, glycemic index, inflammatory markers, and liver function in NAFLD patients: A systematic review and meta-analysis of randomized controlled trials. *Journal of Diabetes and Its Complications*, 38(8), 108780. <https://doi.org/10.1016/j.jdiacomp.2024.108780.PubMed>
- Pandey, R. P., Gunjan, G., Himanshu, H., Mukherjee, R., & Chang, C.-M. (2024). Nanocarrier-mediated probiotic delivery: A systematic meta-analysis assessing the biological effects. *Scientific Reports*, 14, 631. <https://doi.org/10.1038/s41598-023-50972-x.Nature>.
- Sun, C., Liu, Q., Ye, X., Li, R., Meng, M., & Han, X. (2024). The role of probiotics in managing glucose homeostasis in adults with prediabetes: A systematic review and meta-analysis. *Journal of Diabetes Research*, 2024, 5996218. <https://doi.org/10.1155/2024/5996218.PubMed>.
- Szajewska, H., Scott, K. P., de Meij, T., Forslund-Startceva, S. K., Knight, R., Koren, O., Little, P., Johnston, B. C., Łukasik, J., Suez, J., Tancredi, D. J., & Sanders, M. E. (2025). Antibiotic-perturbed microbiota and the role of probiotics. *Nature Reviews Gastroenterology & Hepatology*, 22, 155–172.
- Yang, R., Jiang, J., Ouyang, J., Zhao, Y., & Xi, B. (2024). Efficacy and safety of probiotics in irritable bowel syndrome: A systematic review and meta-analysis. *Clinical Nutrition ESPEN*, 60, 362–372. <https://doi.org/10.1016/j.clnesp.2024.02.025.PubMed>.
- Yang, Z., Zhou, Y., Han, Z., He, K., Zhang, Y., Wu, D., & Chen, H. (2024). The effects of probiotics supplementation on *Helicobacter pylori* standard treatment: An umbrella review of systematic reviews with meta-analyses. *Scientific Reports*, 14, 10069. <https://doi.org/10.1038/s41598-024-59399-4>.
- Yao, B., Wei, W., & Zhang, H. (2025). Efficacy of probiotics or synbiotics supplementation on chemotherapy-induced complications and gut microbiota dysbiosis in gastrointestinal cancer: A systematic review and meta-analysis. *European Journal of Clinical Nutrition*, 79, 616–626. <https://doi.org/10.1038/s41430-024-01542-5>.
- Zeng, Q., Li, P., Wu, H., Zhuang, Y., Zhang, Y., Asemani, S., Jamilian, P., Jamali, M., & Yu, H. (2025). Probiotics and gastrointestinal disorders: An umbrella meta-analysis of therapeutic efficacy. *European Journal of Medical Research*, 30, 515. <https://doi.org/10.1186/s40001-025-02788-w.PubMed>.