International Journal of Health Sciences and Research
[Indexed, Peer-Reviewed Journal]
Volume 15; Issue: 2; February 2025
Website: www.ijhsr.org
Review Article *ISSN: 2249-9571*

The Interplay Between Antibiotics and Probiotics: Implications on Gut Health and Antibiotic Efficacy

Ushika Bhattacharjee[1], Shradha Parvathy Joy[2], Aruna Rajeswari Balaprakash Bhavani[3], Vinay Seetharaman[4]

[1]Department of Medicine, Faculty of Medicine, Tbilisi State Medical University, Georgia
[2]Department of Medicine, Faculty of Medicine, Tbilisi State Medical University, Georgia.
[3]Department of Medicine, Faculty of Medicine, Tbilisi State Medical University, Georgia
[4]University of Georgia School of Health Sciences, Georgia.

Corresponding Author: Ushika Bhattacharjee

DOI: https://doi.org/10.52403/ijhsr.20250225

ABSTRACT

Patients undergoing antibiotic treatment are susceptible to antibiotic-associated diarrhea (AAD), which can lead to complications such as dehydration and longer hospital stays. Research indicates that probiotics can significantly reduce the incidence of *C. difficile*-associated diarrhea by up to 66%. These beneficial microorganisms help restore gut flora balance and enhance the intestinal barrier, making them effective in preventing and treating AAD in both children and adults. Probiotics exert their effects by modulating the immune response and inhibiting pathogen adhesion. Although numerous studies highlight the efficacy of various probiotic strains in managing infections, further standardized clinical trials are essential to validate these results and optimize treatment protocols.

Keywords: AAD, Antibiotic, Probiotic, C. difficile, Gut flora

INTRODUCTION

Probiotics have gained considerable popularity for boosting gut health, especially among the emerging health-conscious community. In recent years, there has been a growing interest in the usage of probiotic bacteria for restoring the gut microbiome and even as alternatives for antibiotics for preventing or treating various infections [1]. Antibiotics are still widely available over the counter in many countries [2], which facilitates improper use for nonbacterial infections and leads to a rise in antibiotic resistance. However, the interactions between probiotics and antibiotics remain an underexplored area. While some studies point out that probiotics can enhance antibiotic efficacy by replenishing normal gut microbiomes and reducing complications or side effects, others raise concerns about potential interference with antibiotic activity, which could negatively impact clinical outcomes. This review aims to investigate the dual nature of probiotics—whether they act as enhancers of antibiotic efficacy or interfere with their therapeutic action—by examining the latest research on microbial interactions, clinical applications, and their implications on antibiotic stewardship.

Antibiotics combat bacterial infections through four main mechanisms: inhibiting cell wall synthesis (e.g., β-lactam antibiotics like penicillins disrupt peptidoglycan synthesis), protein synthesis (e.g., aminoglycosides and tetracyclines target bacterial ribosomal subunits), nucleic acid

synthesis (e.g., fluoroquinolones interfere with DNA gyrase or topoisomerase IV), and metabolic pathways (e.g., sulfonamides and trimethoprim block folic acid synthesis). In contrast, probiotics are live microorganisms that promote health by competing with pathogens for resources, strengthening the gut barrier, modulating immune responses, producing antimicrobial substances, influencing neurotransmitter production through the gut-brain axis, and enhancing digestion while producing short-chain fatty acids that nourish the gut. Together, antibiotics treat infections by directly targeting bacteria, while probiotics help maintain a balanced microbiota and support overall health. [3]

Probiotics are live microorganisms that provide health benefits by promoting a balanced gut microbiota through various mechanisms. They compete with harmful bacteria for space and nutrients, helping to maintain a healthy gut flora. Probiotics also strengthen the intestinal barrier, preventing harmful substances from entering the bloodstream. They modulate immune responses by increasing anti-inflammatory cytokines and enhancing immune cell activity. Additionally, probiotics produce antimicrobial substances such as bacteriocins and organic acids that inhibit pathogen growth. Through the gut-brain axis, they influence neurotransmitter production, impacting mood, behavior, and gut function. Lastly, probiotics improve digestion and nutrient absorption by producing enzymes and beneficial short-chain fatty acids like butyrate, which support gut health. [4]

DISCUSSION

Probiotics and Antibiotics Efficacy: Synergism, Neutrality, or Interference?

The relationship between antibiotics and probiotics is crucial for gut health and clinical interventions. Antibiotics, essential for treating bacterial infections, often disrupt the gut microbiome, leading to complications like antibiotic-associated diarrhea (AAD), *Clostridium difficile* infections, and dysbiosis. Probiotics, such as *Lactobacillus rhamnosus* and *Saccharomyces boulardii*, help mitigate these effects by replenishing beneficial bacteria, enhancing gut barrier function, and modulating immune responses. While studies highlight their efficacy in reducing AAD, the benefits depend on strain specificity, dosage, and timing.

However, concerns persist regarding probiotics' transient effects, limited impact on long-term microbiota diversity, and rare risks of reduced antibiotic efficacy or adverse reactions in immunocompromised individuals. Guidelines, like those from the AGA, recommend selective probiotic use in high-risk populations but discourage routine use in low-risk individuals. Further research needs to be conducted in order to understand its long-term impact, interactions with antibiotics, and role in antibiotic stewardship and resistance prevention.[5]

Probiotics are widely recognized for their therapeutic benefits, particularly in reducing the adverse effects of antibiotics, such as antibiotic-associated diarrhea (AAD). Their ability to combat pathogens through the production of organic acids, bacteriocins, and peptides has shown promise in decreasing the incidence, duration, and severity of AAD, ultimately enhancing patient compliance and reducing the risk of resistance. Studies also highlight that probiotics can reduce infections like respiratory tract illnesses, decreasing the need for additional antibiotics. These synergistic effects underscore the potential of probiotics as an adjunct therapy to antibiotics, promoting better treatment outcomes.[5]

Despite these benefits, concerns about potential interference persist. Certain probiotic strains may stimulate the production of proinflammatory cytokines, altering immune responses and potentially affecting antibiotic efficacy. Moreover, probiotics can influence gut microbial composition and function, raising questions about their impact on immune responses and antibody production. Such interactions are especially concerning for vulnerable populations, like immunocompromised

individuals, where probiotics could pose additional risks. While direct evidence of probiotics interfering with antibiotic action remains limited, these concerns warrant further investigation to clarify their safety and interactions. [6,11,12,13]

On the other hand, probiotics generally maintain neutrality by not promoting antibiotic resistance or harboring transferable resistance genes. Systematic reviews emphasize their role in reducing AAD without hindering antibiotic efficacy. For instance, while strains like *Lactobacillus helveticus* and *Bifidobacterium bifidum* showed limited effectiveness, others such as *Saccharomyces boulardii* have proven more successful in preventing AAD. Furthermore, probiotics may enhance the susceptibility of Gram-negative bacteria to antibiotics, highlighting their role in supporting antimicrobial action. [7,8,9]

Clinical guidelines advocate the selective use of probiotics for high-risk patients, such as those prone to C. difficile infections or severe AAD. Organizations like the American Gastroenterological Association (AGA) recommend strain-specific probiotics tailored to patient needs, particularly for those at higher risk [14][15][16]. However, routine probiotic use in low-risk patients is discouraged due to limited benefits and potential unnecessary costs. This approach helps optimize clinical outcomes while minimizing adverse effects and overprescription risks [17,18].

The evidence also reveals that probiotics exert only temporary effects on gut microbiome composition during antibiotic therapy, with minimal impact on diversity. While commonly used to prevent dysbiosis caused by broad-spectrum antibiotics, probiotics' effectiveness in preserving microbial diversity remains unsubstantiated. Instead, their primary utility lies in preventing specific clinical conditions like diarrhea. This highlights the need for further research to explore the long-term implications of probiotics on microbial diversity and their clinical efficacy [19,20].

In conclusion, probiotics demonstrate a synergistic potential in enhancing antibiotic therapy by mitigating adverse effects like AAD and reducing infection rates. However, their neutral or minimal impact on gut microbiome diversity and possible interference with immune responses underscore the need for caution in their use. Strain-specific probiotics should be considered for high-risk patients, while routine use in low-risk populations is unnecessary. Ongoing research and standardized clinical trials are essential to further elucidate their role in antibiotic stewardship and long-term health outcomes. [10]

CONCLUSION

Probiotics have demonstrated considerable potential in reducing the incidence and severity of antibiotic-associated diarrhea (AAD), particularly in preventing *C. difficile* infections. Restoring the balance of gut flora and enhancing the intestinal barrier, probiotics can modulate immune responses and inhibit pathogen adhesion, making them a valuable adjunct to antibiotic therapy. While numerous studies support the efficacy of probiotics in managing infections, few studies discuss the possibility of adverse effects on antibiotic efficacy due to shifts in immune modulation. Further standardized clinical trials remain essential to validate these findings and optimize their use in clinical practice. With their ability to reduce the duration and severity of AAD and possibly prevent further infections, probiotics offer a promising strategy for improving patient outcomes and reducing the risk of antibiotic resistance.

Declaration by Authors

Ethical Approval: Not Applicable

Acknowledgement: Generative AI was used for language purposes only.

Source of Funding: None

Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

1. Ouwehand, A. C., Forssten, S., Hibberd, A. A., Lyra, A., & Stahl, B. (2016). Probiotic approach to prevent antibiotic resistance. Annals of Medicine, 48(4), 246–255. https://doi.org/10.3109/07853890.2016.1161232
2. Kirsten Gravningen, Nigel Field, Hege Salvesen Blix, Anne Mette Asfeldt, Lars Småbrekke. Non-prescription purchase of antibiotics during travel abroad among a general adult population in Norway: Findings from the seventh Tromsø Study doi: 10.1371/journal.pone.0228792
3. Halawa, E. M., Fadel, M., Al-Rabia, M. W., Behairy, A., Nouh, N. A., Abdo, M., Olga, R., Fericean, L., Atwa, A. M., El-Nablaway, M., & Abdeen, A. (2024). Antibiotic action and resistance: updated review of mechanisms, spread, influencing factors, and alternative approaches for combating resistance. Frontiers in Pharmacology, 14. https://doi.org/10.3389/fphar.2023.1305294
4. Latif A, Shehzad A, Niazi S, Zahid A, Ashraf W, Iqbal MW, Rehman A, Riaz T, Aadil RM, Khan IM, Özogul F, Rocha JM, Esatbeyoglu T, Korma SA. Probiotics: mechanism of action, health benefits and their application in food industries. Front Microbiol. 2023 Aug 17; 14:1216674. doi: 10.3389/fmicb.2023.1216674. Erratum in: Front Microbiol. 2024 Feb 14; 15:1378225. doi: 10.3389/fmicb.2024.1378225. PMID: 37664108; PMCID: PMC10470842.
5. Lee, J. H., Kim, J., & Kim, G. (2023). Synergistic Effects of a Probiotic Culture Extract and Antimicrobial Combinations against Multidrug-Resistant Acinetobacter baumannii. *Medicina*, *59*(5), 947. https://doi.org/10.3390/medicina5905094
6. Reid, G. (2006). Probiotics to prevent the need for, and augment the use of, antibiotics. *Canadian Journal of Infectious Diseases and Medical Microbiology*, *17*(5), 291–295. https://doi.org/10.1155/2006/934626
7. Ouwehand, A. C., Forssten, S., Hibberd, A. A., Lyra, A., & Stahl, B. (2016). Probiotic approach to prevent antibiotic resistance. *Annals of Medicine*, *48*(4), 246–255. https://doi.org/10.3109/07853890.2016.1161232
8. Goodman, C., Keating, G., Georgousopoulou, E., Hespe, C., & Levett, K. (2021). Probiotics for the prevention of antibiotic-associated diarrhoea: a systematic review and meta-analysis. *BMJ Open*, *11*(8), e043054. https://doi.org/10.1136/bmjopen-2020-043054
9. Alakomi, H., Paananen, A., Suihko, M., Helander, I. M., & Saarela, M. (2006). Weakening effect of cell permeabilized on Gram-Negative bacteria causing biodeterioration. *Applied and Environmental Microbiology*, *72*(7), 4695–4703. https://doi.org/10.1128/aem.00142-06
10. Horosheva, T. V., Vodyanoy, V., & Sorokulova, I. (2014). Efficacy of Bacillus probiotics in prevention of antibiotic-associated diarrhoea: a randomized, double-blind, placebo-controlled clinical trial. *JMM Case Reports*, *1*(3). https://doi.org/10.1099/jmmcr.0.004036
11. Mousa, W. K., Mousa, S., Ghemrawi, R., Obaid, D., Sarfraz, M., Chehadeh, F., & Husband, S. (2023). Probiotics Modulate Host Immune Response and Interact with the Gut Microbiota: Shaping Their Composition and Mediating Antibiotic Resistance. *International Journal of Molecular Sciences*, 24(18), 13783. https://doi.org/10.3390/ijms241813783
12. Éliás, A. J., Barna, V., Patoni, C., Demeter, D., Veres, D. S., Bunduc, S., Erőss, B., Hegyi, P., Földvári-Nagy, L., & Lenti, K. (2023). Probiotic supplementation during antibiotic treatment is unjustified in maintaining the gut microbiome diversity: a systematic review and meta-analysis. *BMC Medicine*, 21(1). https://doi.org/10.1186/s12916-023-02961-0
13. Lozupone, C. A., Stombaugh, J. I., Gordon, J. I., Jansson, J. K., & Knight, R. (2012). Diversity, stability and resilience of the human gut microbiota. Nature, 489(7415), 220–230. https://doi.org/10.1038/nature11550
14. Kriss, M., Hazleton, K. Z., Nusbacher, N. M., Martin, C. G., & Lozupone, C. A. (2018). Low diversity gut microbiota dysbiosis: drivers, functional implications and recovery. *Current Opinion in Microbiology*, 44, 34–40. https://doi.org/10.1016/j.mib.2018.07.003
15. Guarner, F., Sanders, M. E., Szajewska, H., Cohen, H., Eliakim, R., Herrera-deGuise, C., Karakan, T., Merenstein, D., Piscoya, A., Ramakrishna, B., Salminen, S., & Melberg, J. (2024). World Gastroenterology Organisation Global Guidelines: Probiotics and Prebiotics. *Journal of Clinical*

Gastroenterology, 58(6), 533–553. https://doi.org/10.1097/mcg.0000000000002002

16. Oh, B., Kim, B., Kim, J. W., Kim, J. S., Koh, S., Kim, B. G., Lee, K. L., & Chun, J. (2015). The Effect of Probiotics on Gut Microbiota during the Helicobacter pylori Eradication: Randomized Controlled Trial. Helicobacter, 21(3), 165–174. https://doi.org/10.1111/hel.12270
17. Kakiuchi, T., Mizoe, A., Yamamoto, K., Imamura, I., Hashiguchi, K., Kawakubo, H., Yamaguchi, D., Fujioka, Y., Nakayama, A., Okuda, M., & Matsuo, M. (2020). Effect of probiotics during vonoprazan-containing triple therapy on gut microbiota in Helicobacter pylori infection: A randomized controlled trial. Helicobacter, 25(3). https://doi.org/10.1111/hel.12690
18. De Wolfe, T. J., Eggers, S., Barker, A. K., Kates, A. E., Dill-McFarland, K. A., Suen, G., & Safdar, N. (2018). Oral probiotic combination of Lactobacillus and Bifidobacterium alters the gastrointestinal microbiota during antibiotic treatment for Clostridium difficile infection. PLoS ONE, 13(9), e0204253. https://doi.org/10.1371/journal.pone.0204253
19. Forssten, S., Evans, M., Wilson, D., & Ouwehand, A. C. (2014). Influence of a probiotic mixture on antibiotic induced microbiota disturbances. World Journal of Gastroenterology, 20(33), 11878. https://doi.org/10.3748/wjg.v20.i33.11878
20. Hegyi, P., Erőss, B., Izbéki, F., Párniczky, A., & Szentesi, A. (2021). Accelerating the translational medicine cycle: the Academia Europaea pilot. Nature Medicine, 27(8), 1317–1319. https://doi.org/10.1038/s41591-021-01458-8

How to cite this article: Ushika Bhattacharjee, Shradha Parvathy Joy, Aruna Rajeswari Balaprakash Bhavani, Vinay Seetharaman. The interplay between antibiotics and probiotics: implications on gut health and antibiotic efficacy. *Int J Health Sci Res.* 2025; 15(2):189-193. DOI: *https://doi.org/10.52403/ijhsr.20250225*

******