

Future research should focus on long-term follow-up studies and multi-omics joint research to clarify the causal relationship between intestinal microbiota disorders and the occurrence and development of Parkinson's disease. At the same time, reliable and non-invasive biomarkers should be identified for the early diagnosis and monitoring of the disease. The assessment of the gut microbiota should be integrated into the entire process of risk prediction, early intervention and personalized treatment of Parkinson's disease. The focus of the research should shift from "observing phenomena" to "active intervention", integrating the latest research achievements of artificial intelligence and systems biology. Relying on the collaboration of multiple disciplines such as neurology, gastroenterology, microbiology, and nutrition, more precise and effective targeted treatment methods for the gut-brain axis have been developed at present.

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### Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

### References

- Alam M., Abbas K., Mustafa M., Usmani N., and Habib S., 2024, Microbiome-based therapies for Parkinson's disease, *Frontiers in Nutrition*, 11: 1496616.  
<https://doi.org/10.3389/fnut.2024.1496616>
- Bakshi I., Dey S., Raut A., Katta S., and Sharma P., 2024, Exploring the gut-brain axis: a comprehensive review of interactions between the gut microbiota and the central nervous system, *International Journal For Multidisciplinary Research*, 6(3): 1.  
<https://doi.org/10.36948/ijfmr.2024.v06i03.19563>
- Ben-Shlomo Y., Darweesh S., Llibre-Guerra J., Marras C., Luciano M., and Tanner C., 2024, The epidemiology of Parkinson's disease, *The Lancet*, 403: 283-292  
[https://doi.org/10.1016/s0140-6736\(23\)01419-8](https://doi.org/10.1016/s0140-6736(23)01419-8)
- Bertollo A., Santos C., Bagatini M., and Ignácio Z., 2025, Hypothalamus-pituitary-adrenal and gut-brain axes in biological interaction pathway of the depression, *Frontiers in Neuroscience*, 19: 1541075.  
<https://doi.org/10.3389/fnins.2025.1541075>
- Chiang H., and Lin C., 2025, Management of gastrointestinal symptoms in Parkinson's disease, *Journal of Central Nervous System Disease*, 17: 11795735251370014.  
<https://doi.org/10.1177/11795735251370014>
- Derkinderen P., Cossais F., Kulcsárová K., Škorvánek M., Sellier-Montaigne L., Coron E., Leclair-Visonneau L., Cerri S., Pellegrini C., and Rolli-Derkinderen M., 2025, How leaky is the gut in Parkinson's disease?, *eBioMedicine*, 117: 105796.  
<https://doi.org/10.1016/j.ebiom.2025.105796>
- Dodiya H., Forsyth C., Voigt R., Engen P., Patel J., Shaikh M., Green S., Naqib A., Roy A., Kordower J., Pahan K., Shannon K., and Keshavarzian A., 2020, Chronic stress-induced gut dysfunction exacerbates Parkinson's disease phenotype and pathology in a rotenone-induced mouse model of Parkinson's disease, *Neurobiology of Disease*, 135: 104352.  
<https://doi.org/10.1016/j.nbd.2018.12.012>
- Guo M., Gao H., Wang Y., and Xiang Y., 2025, Exploring the role of gut microbiota in Parkinson's disease: insights from fecal microbiota transplantation, *Frontiers in Neuroscience*, 19: 1574512.  
<https://doi.org/10.3389/fnins.2025.1574512>
- Hattori N., and Yamashiro Y., 2021, The gut-brain axis, *Annals of Nutrition and Metabolism*, 77: 1-3.  
<https://doi.org/10.1159/000512226>
- Heinzel S., Aho V., Suenkel U., Von Thaler A., Schulte C., Deuschle C., Paulin L., Hantunen S., Brockmann K., Eschweiler G., Maetzler W., Berg D., Auvinen P., and Scheperjans F., 2021, Gut microbiome signatures of risk and prodromal markers of Parkinson's disease, *Annals of Neurology*, 90(3): E1-E2.  
<https://doi.org/10.1002/ana.26128>
- Hill A., Wade-Martins R., and Burnet P., 2021, What is our understanding of the influence of gut microbiota on the pathophysiology of Parkinson's disease?, *Frontiers in Neuroscience*, 15: 708587.  
<https://doi.org/10.3389/fnins.2021.708587>
- Jones J., Rahmani E., Garcia E., and Jacobs J., 2020, Gastrointestinal symptoms are predictive of trajectories of cognitive functioning in de novo Parkinson's disease, *Parkinsonism and Related Disorders*, 72: 7-12.  
<https://doi.org/10.1016/j.parkreldis.2020.01.009>
- Khalaf N., Badr M., and Nasef M., 2025, Assessment of prodromal gastrointestinal manifestations in idiopathic Parkinson's disease, *The Open Biomarkers Journal*, 15: e18753183382955.  
<https://doi.org/10.2174/0118753183382955250509055110>