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Exploration of scientific insight of gut-brain axis research trends through computational investigation

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The gut-brain axis, a vital bidirectional communication system between the central nervous system and the gastrointestinal tract, is crucial for maintaining homeostasis. Dysregulation of this axis, influenced by factors like gut microbiota, neurotransmitters, and dietary patterns, is associated with various health conditions. This study presents a comprehensive bibliometric analysis of gut-brain axis (GBA) research. This study utilizes co-word cluster network analysis on 16062 publications from the Web of Science database to understand the thematic evolution of gut-brain axis studies. The top 20 countries, organizations, authors, journals and WoS micro topics were identified along with their publication impact in terms of average citation and h-index, were also analysed using the Bibliometrix-Biblioshiny package in R software. The findings show significant growth in publications that indicates the increasing importance of gut-brain axis research. Thematic analysis reveals a shift from microbiota characterization to metabolic, immune, and neuroinflammatory pathways, emphasizing translational applications such as probiotics and fecal microbiota transplantation (FMT). The increasing focus on neurodegenerative and psychiatric disorders emphasize the interdisciplinary nature of GBA research, spanning neuroscience, microbiology, and immunology.

Keywords: *Gut-brain axis, WoS micro topics, GI tract, Central nervous system, Bibliometrics.*

Introduction

The gut-brain axis (GBA) represents a bidirectional biochemical communication system connecting the central nervous system (CNS) and the gastrointestinal (GI) tract. This system regulates neural (central and enteric), hormonal, and immunological pathways, playing a vital role in maintaining homeostasis [1]. The GBA operates as a complex network that is significant in both health and disease. Signals originating in the GI tract are processed by cortical areas of the brain, generating efferent signals that influence GI functions, including motility, secretion, and immune regulation [2][3][4][5]. This interconnection highlights the intricate association between the brain and the GI tract.

Recent advancements in DNA sequencing have revealed the composition of gut microbiota, with Bacteroidetes and Firmicutes accounting for 90%, while other phyla such as Actinobacteria, Proteobacteria, and Verrucomicrobia make up the remaining 10% [6]. The gut microbiota contributes to the host's immune, metabolic, and neurological systems, with dysbiosis being linked to conditions like inflammatory bowel disease, obesity, and type-II diabetes, although cause-effect relationships remain unclear [7]. The ability of sepsis-induced changes in microbiota to provoke immunosuppression further underscores its clinical relevance [8].

Recent bibliometric analyses have revealed an exponential growth of research in the GBA field, spanning various neuropsychiatric and neurodegenerative disorders. Studies have documented emerging themes such as neuroinflammation, oxidative stress, and microbial-based interventions in conditions like Alzheimer's disease (AD), Parkinson's disease (PD), schizophrenia, and irritable bowel syndrome (IBS). These studies identify influential contributors, institutions, and research trends, underscoring the global interest in gut microbiota's role in neurological and gastrointestinal health. Despite the breadth of research, gaps remain in synthesizing these findings into a unified understanding of the GBA's mechanistic and therapeutic potential.

Literature Review on Gut Brain Axis

Several studies have highlighted neurotransmitters, including dopamine and serotonin, as key regulators of CNS and GI pathophysiology. Dysregulation of these neurotransmitters can lead to diseases like inflammatory bowel disease (IBD) and Parkinson's disease, though catecholamine serum administration shows promise in slowing disease progression [9]. Cognitive states significantly impact the GBA, influencing disorders like irritable bowel syndrome (IBS) [10]. Gut microbiota has also been found to regulate behavioral and temperamental traits [11]. For instance, bacterial infections can induce anxiety-like behavior in mice, while probiotics have been shown to reduce visceral hypersensitivity [12][13][14][15]. Dietary components, including saturated fats and sugars, can alter gut microbiota composition, influencing conditions such as obesity and insulin resistance [16][17]. Short-chain fatty acids (SCFAs), derived from dietary fiber fermentation, regulate neuro-immunoendocrine functions but require further study to elucidate their role in brain physiology and behavior [18]. Emerging evidence links gut microbiota to neurodegenerative diseases. Dysbiosis has been implicated in Parkinson's disease [19][20], Alzheimer's disease (AD) [21][22], and Huntington disease [23]. Alterations in microbial composition, including reduced SCFAs and increased lipopolysaccharide levels, are associated with inflammatory neurodegeneration in AD [24][25]. While some studies suggest protective roles for gut microbiota, tailored diets may hold potential for therapeutic interventions in Alzheimer's disease [26][27]. High-sugar diets have been observed to disrupt gut-brain communication, increasing endotoxin levels and impairing hippocampal-dependent cognitive functions [28][29]. Experimental models support the notion that microbial infections and GI tract alterations affect brain homeostasis.

Literature review on Bibliometric and scientometric analysis on gut-brain axis

The interplay between the gut microbiota and the brain has emerged as a dynamic field of research, with publications spanning diverse neuropsychiatric and neurodegenerative conditions. Bibliometric analyses reveal the rapid growth of this field, underscoring key contributors, influential studies, and emerging research trends. Alzheimer's Disease (AD) and gut microbes have been a focal point, with 1,170 publications highlighting neuroinflammation, oxidative stress, and short-chain fatty acids (SCFAs) as prominent themes. These insights emphasize the need for novel therapeutic strategies targeting the gut-brain axis in AD [30]. Research on the microbiota-gut-brain axis (MGBA) in depression (1999–2019) has grown rapidly, spotlighting cytokines, faecal microbiota transplantation and the microbiota-gut-brain axis as pivotal themes [31]. The MGBA's role in immunomodulation, IBS, and neurodevelopmental disorders has been extensively documented (2009–2018), with animal modelling providing mechanistic insights [32]. Similarly, gut microbiota-neuroscience research (2002–2022) highlights schizophrenia, psychiatric disorders, and inflammation as emerging frontiers, linking microbial composition to neurological health [33]. Investigations into the gut microbiota and schizophrenia (2014–2024) further reinforce microbial-based interventions and the significance of the gut-brain axis in mental health [34].

Parkinson's Disease (PD) research reveals a rising trend (2014–2023), with alpha-synuclein and gut microbiota functions garnering attention [35]. A focus on interventional approaches emphasizes the therapeutic potential of targeting gut microbiota [36]. Likewise, SCFAs in central nervous system diseases (2002–2022) emerge as therapeutic hotspots, though large-scale clinical trials are warranted [37]. Irritable bowel syndrome (IBS) research (1994–2024) shows significant contributions from the United States, with serotonin, tryptophan metabolism, and brain-derived neurotrophic factor as focal areas [38]. Gut microbiota and pain research (2002–2021) further highlight SCFAs and the brain-gut axis as key directions [39].

Hypothesis and objectives

Despite these numerous domain-specific insights, the lack of a comprehensive analysis that synthesizes gut-brain axis research trends as a whole is a notable gap in the literature. While individual studies highlight distinct aspects like disease mechanisms and interventions, an integrated framework analyzing overarching trends, interconnections, and translational pathways across conditions remains underexplored. Such an analysis could provide a unified roadmap to accelerate progress in this promising field. This study aims to examine the top contributors and their impact in this field of research and progression of themes in gut-brain axis research using co-word cluster network analysis based on 16062 publications retrieved from the Web of Science database. Additionally, this study also aims to identify the active and emerging research themes in successive 5-year periods through analysing WoS micro topics and top 30 keywords.

Methodology

Generation of the search string and collection of publication data

The search string was constructed by combining several phrases linked to gut-brain axis related research to retrieved publication data. The publication data were retrieved using the following search string "TS = (((gut* OR gastrointestin*) AND (microbio* OR microbial*)) AND ("central nervous system" OR brain OR neuro* OR CNS))", from WoS Core Collection, which was once owned by Thomson Reuters and is currently controlled by Clarivate Analytics. About 16062 of total global research publications have been retrieved on 28th February, 2025 for the period of last 15 years (2010-2024) from WoS.

Analysis of Bibliometric parameters

All publication data were exported from WoS in plain text format. The biblioshiny for bibliometrix software was used to extract and analyse the number of publications and citation impact of the leading countries, organizations, author, leading journals and WoS micro topics involved in this field of research. For the purpose of analysis, the data were taken into Excel format. Year wise growth and citation impact of the publications were analysed and represented graphically using R software packages.

Conceptual structure analysis of the most relevant themes vis-à-vis topics

The factorial analysis was performed using multiple correspondence analysis (MCA) on the keywords of the total publication dataset. The automatic clustering algorithm was applied and the number of terms were restricted to 100. The correlated keywords have been represented as figure with an intention to identify independent latent keywords. Keywords close to the centre have received immense attention in recent years. The results were analysed based on their relative position in the two-dimensional space; words with more similar in distribution appear closer in the map (Aria and Cuccurullo, 2017). The prime goal of this factorial analysis was to identify the themes of the "gut-brain axis" research.

Topic trends and analysis at successive periods

A multi-step approach was employed for analysing research trends in the gut-brain axis. First, the topic trend analysis was performed with Bibliometrix-Biblioshiny of R software to study the year wise shifting of the top 5 themes towards the understanding about their origin and fate. Alongside, the publication contribution and citation impact of the top 20 WoS micro topics were assessed by analysing the number of publications, average citations per paper, and h-index. These metrics helped to identify influential research areas. A period-wise distribution analysis was carried out by categorizing publications into three timeframes: 2010–2014, 2015–2019, and 2020–2024. This allowed for the identification of temporal growth patterns within WoS micro topics and their relative prominence over the years. A keyword co-occurrence analysis was conducted using VOSviewer to uncover relationships between key topics. The top 30 keywords from the network dataset were extracted based on the occurrence frequency during successive periods to understand significant research themes and emerging trends at successive periods. These keywords were then visualized through R software packages.

Results and Discussion

Year-wise growth of publications and citation impact

According to the Web of Science Core Collection database, 16062 publications were published in various journals worldwide between 2010 and 2024. Figure 1 illustrates the number of publications, mean total citation (TC) per article and mean TC received per year at successive years (2010-2024). The number of publications has exponentially increased throughout the years, with a compound annual growth rate of 33.94%. The average total citations per article exhibit fluctuations in the early years, followed by a gradual decrease as expanding the citation window results in increased citations for articles. However, the mean total citations per year remain relatively stable, indicating the enduring relevance and significance of the subject throughout the study period.

Publication contribution and citation impact of the top 20 countries

Globally, "Gut-Brain axis" research involves 134 countries. The leading 20 countries, as shown in Figure 2, are determined by their number of publications and average citation per publication (ACPP) which highlights the highest contributors and noteworthy publications among these countries. It was found that the top 20 nations published near about 83.17 % of total publications. Among which China found to be appeared at the top position with 4827 publications, followed by USA (4296) and Italy (1128). The first 20 countries have an average of 923.55 publications, with only three countries having more than the group average. The group average of ACPP is near about 55.08 and only 9 countries found to be

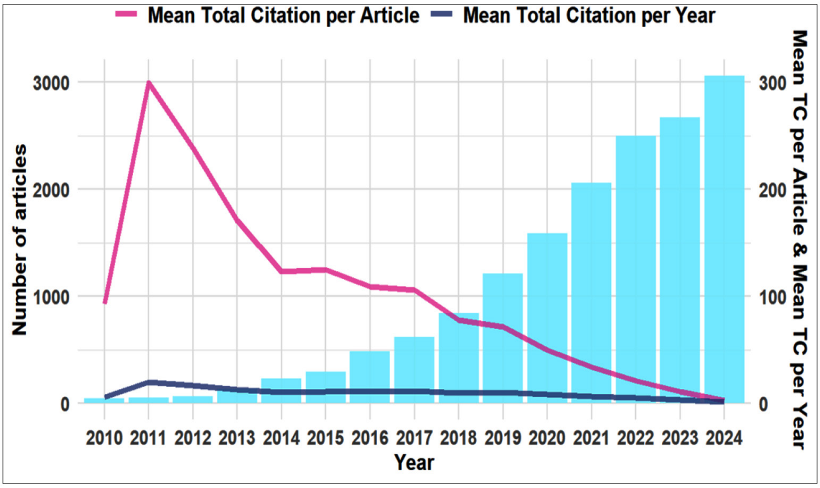

Figure 1

Year-wise Number of publications, mean total citation per articles, and mean total citation per year.

appeared above this value. Figure 2, on the other hand, shows that a country's largest number of publications has the lowest ACPP. Despite having the second top number of publications (4294), the United States had less ACPP (52.95) in contrast Ireland has the highest ACPP 110.82 which has only 505 publications.

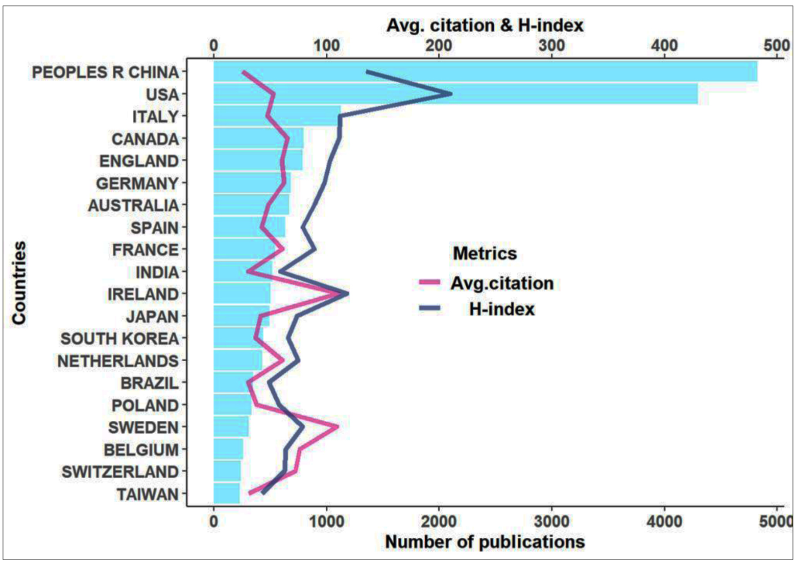

Figure 2

Number of publications, average citations per article and h-index of the top 20 countries

European and North American countries, including Italy, Canada, England, and Germany, also contribute significantly to the field. These nations not only have a high number of publications but also maintain strong h-index values and citation rates, suggesting that their research is both extensive and impactful. Emerging Asian contributors such as India, Japan, and South Korea are also making notable progress in gut-brain axis research. However, their relatively lower citation impact and h-index suggest that while they are producing more research, they need to focus on enhancing quality and influence. Smaller European countries, including the Netherlands, Sweden, Belgium, and Switzerland, exhibit a different trend. Despite having lower publication counts, their research is of high quality, as indicated by relatively high average citations and h-index values. This suggests that their studies are well-regarded and widely cited within the scientific community.

Publication contribution and citation impact of the top 20 Institutions

The top 20 institutes contributed more than 30 % of the total publications in gut-brain axis research. The publication contribution and citation impact of the top 20 institutions highlighted the dominance of North American and European institutions in this emerging interdisciplinary field (Figure 3). The University of California System leads with 577 publications (3.59% of the total) that reflects its strong research focus on microbiome-host interactions, neuroinflammation, and the role of gut microbiota in neurological disorders. Notably, Harvard University (338, 2.10%), Harvard Medical School (243, 1.51%), and Harvard Medical Affiliates (256, 1.59%) demonstrated substantial contributions, likely encompassing studies on the gut microbiome's influence on mental health,

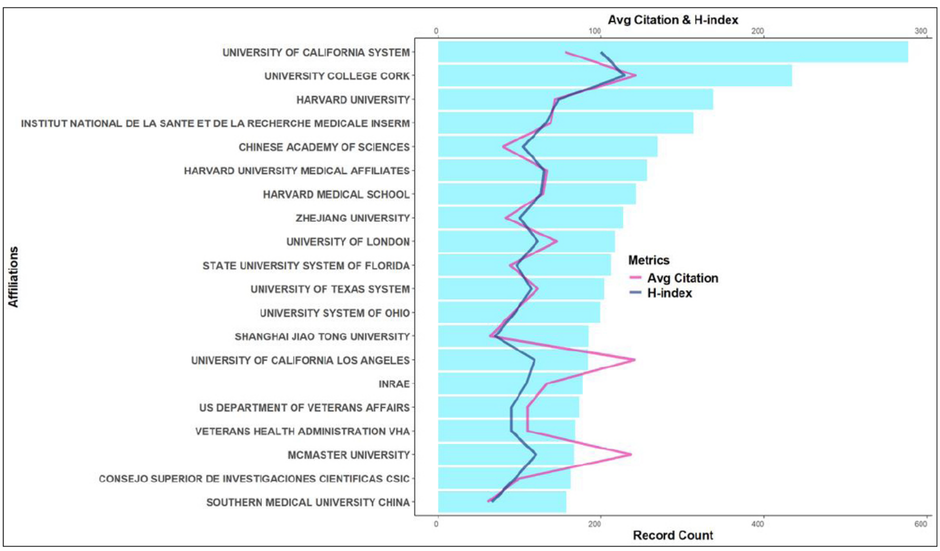

Figure 3

Number of publications, average citations per article and h-index of the top 20 organizations

neurodegenerative diseases, and psychiatric disorders. University College Cork (434, 2.70%), with the highest h-index (114) and average citation per paper (120.95), stands out as a global leader in gut-brain axis research, particularly in relation to probiotics, psychobiotics, and microbiome-based therapeutic interventions.

European institutions such as INSERM (313, 1.95%) and the University of London (217, 1.35%) also show significant research influence, likely focusing on translational studies linking gut microbiota with neurodevelopmental disorders and neuroimmune signalling. Chinese institutions, including Zhejiang University (227, 1.41%) and Shanghai Jiao Tong University (185, 1.15%), contribute notably to the publication count but have relatively lower citation impacts, suggesting that while they are producing substantial research, their global reach and influence are still developing. Meanwhile, McMaster University (167, 1.04%), with a high average citation rate (118.26), reflects its strong impact in microbiome research, particularly in understanding gut-mediated mechanisms in neuropsychiatric conditions.

Publication contribution and citation impact of the top 20 Authors

The analysis of the top 20 authors contributing to GBA research reveals the dominance of key scientists with substantial publication records and citation impacts. John F. Cryan (h-index: 105, NP: 297, ACPP: 157.66) and Timothy G. Dinan (h-index: 99, NP: 206, ACPP: 201.19) are the most influential figures in the field, reflecting their pioneering work on the MGBA, psychobiotics, and the role of gut microbiota in neuropsychiatric and stress-related

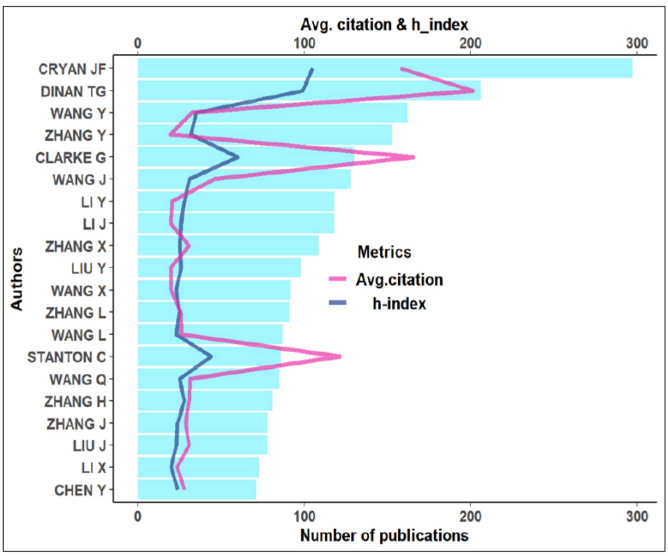

Figure 4

Number of publications, average citations per article and h-index of the top 20 Authors

disorders. Their exceptionally high average citations per paper (ACPP) suggest that their research is not only prolific but also widely recognized and impactful (Figure 4).

Similarly, Gerard Clarke (h-index: 60, NP: 130, ACPP: 165.42) and Catherine Stanton (h-index: 44, NP: 86, ACPP: 121.53) also demonstrate strong research influence, likely focusing on gut microbiome modulation and neuroinflammation in brain health. Other significant contributors, such as Wang Y (h-index: 35, NP: 162, ACPP: 32.51) and Zhang Y (h-index: 32, NP: 153, ACPP: 19.43), indicate an increasing contribution of researchers from China though their citation impact remains comparatively lower than Western counterparts, reflecting potential differences in research visibility and global collaboration.

The presence of multiple researchers from China such as Wang J, Zhang X, Wang L, and Liu Y suggests an expanding contribution from China in gut-brain axis research, particularly in molecular mechanisms, gut microbiota diversity, and metabolic interactions influencing neurological conditions. While their individual ACPP values (ranging between 19-46) are lower than Cryan, Dinan, Clarke and Stanton, and their growing research output indicates an increasing role in shaping future advancements.

Publication contribution and citation impact of the top 20 journals

Figure 5 illustrates the contributions and citation impact of the top 20 journals of "Gut-Brain Axis" research in terms of publications, total citations, and h-index. Only seven journals have been found to be appeared with more than 100 publications. The analysis highlights the diverse and interdisciplinary nature of this field, encompassing nutrition, neuroscience, microbiology, immunology, and pharmacology. Among them, "Nutrients" leads in publication volume (NP: 545, h-index: 66, ACPP: 30.94), indicating a strong research focus on the role of diet and nutrition in microbiota-gut-brain interactions. Similarly, the "International Journal of Molecular Sciences" (NP: 440, h-index: 51, ACPP: 25.56) suggests a molecular and mechanistic approach to GBA research, emphasizing pathways linking gut microbiota to brain function.

Journals with high average citations per paper (ACPP) include Brain, Behavior, and Immunity (ACPP: 70.07) and "Neurogastroenterology & Motility" (ACPP: 64.54), reflecting the impact of immunological and gastrointestinal aspects of the gut-brain axis in shaping scientific discourse. "Scientific Reports" (ACPP: 44.57, NP: 308) and "PLOS ONE" (ACPP: 51.96, NP: 152), both open-access multidisciplinary journals, play a crucial role in disseminating GBA-related findings across broad scientific communities.

Microbiome-centric journals like "Frontiers in Microbiology" (NP: 264, ACPP: 27.13), "Gut Microbes" (NP: 187, ACPP: 36.82), and "Frontiers in Cellular and Infection Microbiology" (NP: 179, ACPP: 33.11) emphasize the microbial dimension of gut-brain communication, underlining the growing recognition of microbial metabolites and host-microbe interactions in brain health and neurodegenerative disorders. Meanwhile, "Frontiers in Neuroscience" (NP: 221, ACPP: 25.25), "Molecular Psychiatry" and "Frontiers in Aging Neuroscience" (NP: 114, ACPP: 36.96) contribute insights into the neurological implications of gut microbiota, particularly in neurodegenerative and psychiatric diseases.

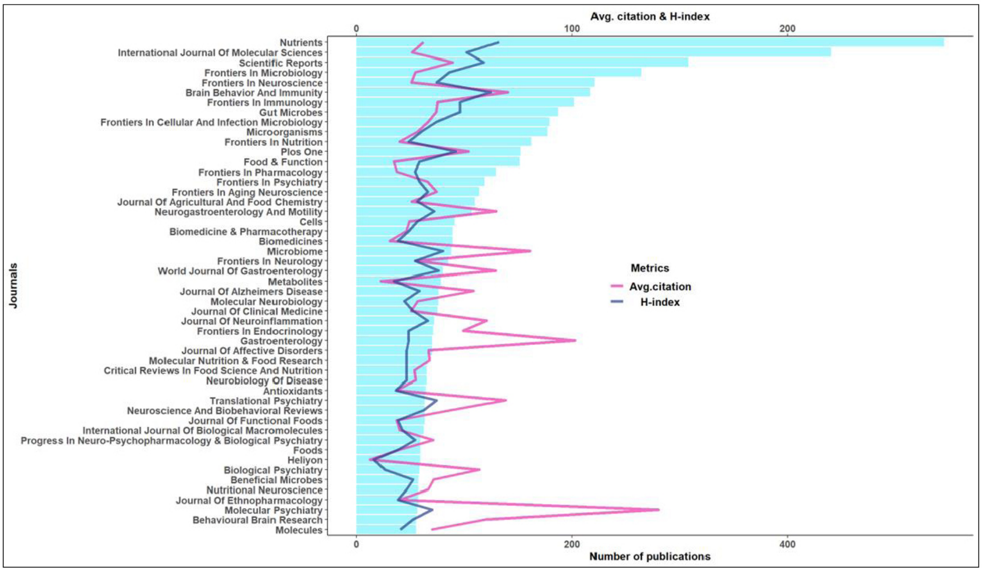

Figure 5

Number of publications, average citations per article and h-index of the top 20 journals.

The presence of pharmacology-focused journals like “Frontiers in Pharmacology” (NP: 129, ACPP: 18.47) and “Biomedicine & Pharmacotherapy” (NP: 89, ACPP: 22.90) suggests active exploration of therapeutic strategies targeting the gut-brain axis, including psychobiotics and microbiota-based interventions. Furthermore, “Neurogastroenterology and Motility” (NP: 107, ACPP: 64.54) reinforces the critical role of the enteric nervous system in gut-brain communication.

Publication contribution and citation impact of the top 20 WoS Micro topics

The publication contribution and citation impact of the top 20 Web of Science (WoS) microtopics related to gut-brain axis research indicate a strong research focus on “Gut Microbiota,” which leads significantly with 8,103 publications, an average citation of 54.32, and the highest h-index of 270 (Figure 6). This reflects its central role in gut-brain interactions and its high academic influence. “Irritable Bowel Syndrome” and “Parkinson’s Disease” follow with 544 and 371 publications, respectively, with notable citation impacts (37.01 and 32.34) and h-indices of 69 and 59, highlighting their relevance in gut-brain studies. Other critical topics, such as “Microglia,” “Alzheimer’s Disease,” and “Autism,” show moderate publication counts (ranging from 168 to 189) but maintain strong citation metrics, demonstrating their emerging importance in neuroinflammatory and neurodegenerative contexts. “Antioxidant Activity” stands out with the highest average citation (72.97), suggesting a growing interest in oxidative stress in gut-brain research. Topics like “Microplastics” (53.42) and “Lactic Acid Bacteria” (46.74) also show high citation impact despite having fewer publications, reflecting their niche but influential role. Overall, this

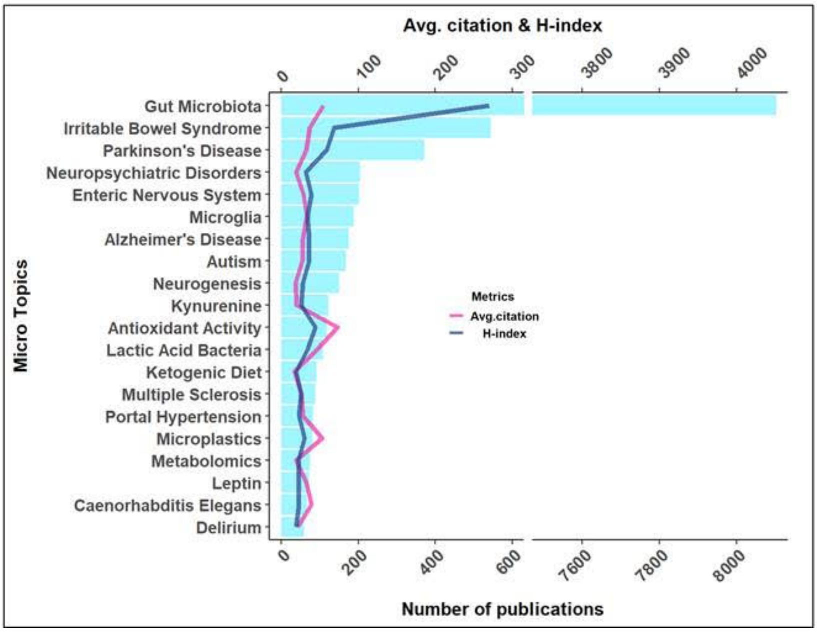

Figure 6

Number of publications, average citations and h-index of the top 20 WoS micro topic of Gut-brain axis research

analysis highlights the growing interdisciplinary nature of gut-brain axis research, integrating microbiology, neurology, and immunology, with key areas of investigation focusing on neurodegeneration, mental health disorders, and metabolic influences.

PCA analysis

The factorial analysis through principal component analysis of keywords in gut-brain axis (GBA) research reveals five distinct clusters, each representing key interdisciplinary themes that integrate neuroscience, immunology, microbiology, and psychology (Figure 7). These clusters illustrate the complex interactions between gut microbiota, metabolic health, neuroinflammation, and mental well-being, shedding light on emerging therapeutic strategies. The green cluster focuses on metabolism, oxidative stress, and neurodegenerative diseases, emphasizing conditions like Alzheimer's disease and obesity. Keywords such as "oxidative stress" and "in vitro" indicate that studies in this cluster frequently use experimental models, including cell cultures and rodents, to explore molecular mechanisms of neurodegeneration and metabolic dysfunction. The red cluster highlights gut microbiota's role in inflammation and systemic health, with keywords like "microbiota," "gut," and "inflammatory." It emphasizes the microbiome's influence on immune responses and chronic inflammatory conditions such as inflammatory bowel disease (IBD) and neurodegeneration. This research informs therapeutic developments, including probiotics

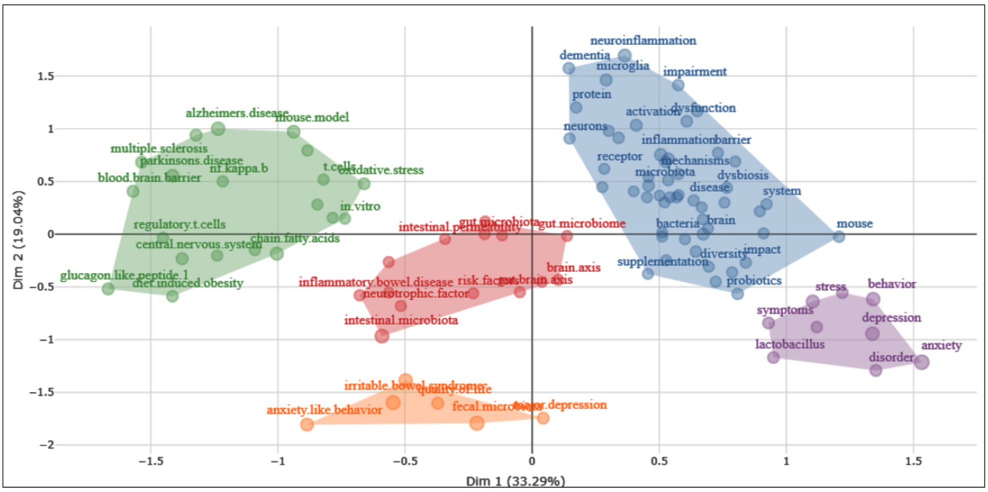

Figure 7

Factorial analysis of conceptual structure map-method: MCA of high-frequency keywords

and microbiome-targeted treatments. The orange cluster examines the relationship between gastrointestinal disorders and mental health. Keywords such as “irritable bowel syndrome” and “anxiety-like behavior” suggest a focus on the bidirectional influence of gut health on stress, anxiety, and depression, aiming to develop holistic interventions. The blue cluster focuses on neuroinflammation, cognition, and aging, with keywords like “memory” and “mouse,” emphasizing preclinical studies investigating inflammation-driven cognitive decline and dementia. Finally, the purple cluster explores psychological health, stress, and behavior, with keywords such as “depression” and “anxiety,” examining hormonal and physiological responses to chronic stress and potential therapeutic approaches.

Topic trends analysis

The Figure 8 presents a timeline visualization of the emergence and growth of key terms related to gut-brain axis research over the past decade. The y-axis lists various terms associated with gut-brain interactions, while the x-axis represents the years from 2010 to 2024. Each term is accompanied by a horizontal line, indicating its presence in scientific literature over time, with blue dots representing key points of increased research activity. The size of each bubble directly correlates with the frequency of the respective keyword. The figure highlights the progressive expansion of gut-brain axis research, with an increasing number of terms gaining prominence in recent years. Early research focused on foundational topics such as “infectious disease,” “gradient gel electrophoresis,” and “lactobacillus,” with limited publication activity before 2015. From 2016 onward, the emergence of newer terms like “gut microbiota,” “behaviour,” “anxiety,” “intestinal

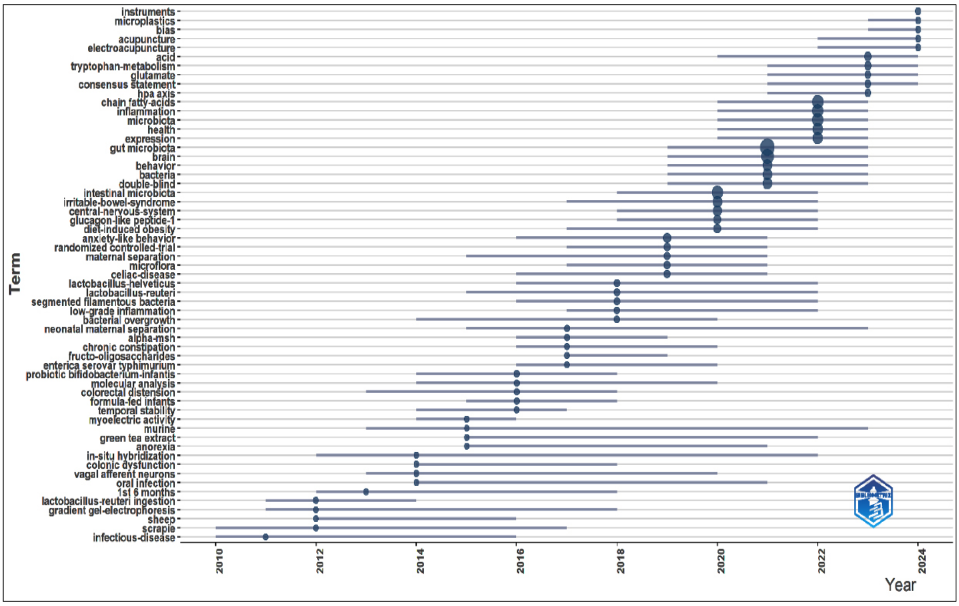

Figure 8

Year-wise topic trends of gut-brain axis research during 2010-2024.

microbiota," and "inflammation" suggests a shift towards investigating the microbiome's role in neurological and psychological functions.

A striking trend is observed in the past five years (2020–2024), where multiple terms show concentrated bursts of research activity, as indicated by dense clusters of blue dots. Notably, terms like "microplastics," "tryptophan metabolism," "consensus statement," "chain fatty acids," "inflammatory," and "microglia" have seen a surge in publications, reflecting an increased focus on metabolic pathways, immune responses, and environmental influences on gut-brain interactions. Additionally, the presence of terms like "randomized controlled trial" and "probiotic bifidobacterium" signifies growing interest in clinical applications, including microbiome-based therapeutics for neuropsychiatric and neurodegenerative disorders. The figure highlights the evolving landscape of gut-brain axis research, driven by technological advancements and an increasing recognition of the microbiome's critical role in neurological and psychological health.

Period-wise distribution of to 20 WoS micro topics

The exponential growth in gut-brain axis (GBA) research across the top 20 Web of Science (WoS) micro topics over successive periods (2010–2014, 2015–2019, and 2020–2024) signifies a paradigm shift in scientific exploration (Figure 9). "Gut Microbiota" has seen the most significant increase, rising from 238 publications in 2010–2014 to 1,986 in 2015–2019, and surging to 6,685 in 2020–2024. This trend underscores its central role in gut-brain interactions, with the microbiome increasingly recognized as a key modulator of brain

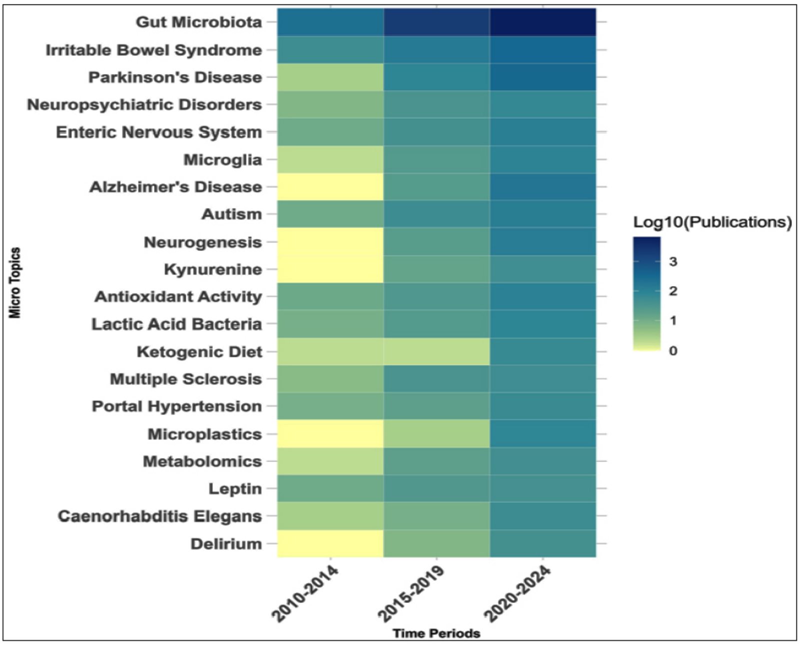

Figure 9

Number of publications on the top 20 WoS micro topic of Gut-brain axis research at successive periods

function, behavior, and neurodegenerative diseases. The growing focus on neurodegenerative diseases is evident in the dramatic rise in studies on "Irritable Bowel Syndrome" and "Parkinson's Disease." Parkinson's research, which had just 2 publications in 2010–2014, surged to 333 in 2020–2024, reflecting intensified interest in the gut as an early marker and therapeutic target for neurological disorders. Similarly, "Alzheimer's Disease" research, nearly absent before 2015, expanded significantly (173 publications in 2020–2024), emphasizing neuroinflammation and oxidative stress in cognitive decline. A notable shift towards mechanistic studies is reflected in the increasing focus on "Microglia," "Neurogenesis," and "Microplastics," highlighting cellular and environmental influences on brain health. Rising interest in "Kynurenine" and "Metabolomics" points to an expanding focus on biochemical pathways linking gut microbiota to neurotransmission and neuropsychiatric disorders. The kynurenine pathway, crucial for neuroinflammation and neurotransmitter balance, is gaining prominence due to its implications in depression, schizophrenia, and neurodegenerative diseases.

Top 30 keywords in Gut-brain axis research during successive periods

The analysis of the top 30 keywords related to Gut-Brain Axis research using VoS Viewer highlights a significant shift in scientific focus over the past decade (Figure 10). The term "gut microbiota" emerged as the most frequently occurring keyword, with a total of

15,167 links and 3,256 occurrences, demonstrating its central role in understanding gut-brain interactions. The increasing occurrence of this term from 115 (2010–2014) to 2,296 (2020–2024) indicates a growing research interest in how gut microbial composition influences brain function and behavior. Similarly, the keyword "brain" exhibited a parallel growth pattern, with its total links increasing from 217 in the early period to 7,626 in the most recent period, highlighting a strengthened scientific emphasis on gut-brain connectivity.

The research landscape has also expanded toward metabolic and immune pathways influencing brain health. The rising occurrences of keywords such as "chain fatty-acids" (total links: 8,247) and "inflammation" (7,815) underscore the increasing recognition of metabolic byproducts and immune signaling in gut-brain communication. Additionally, "oxidative stress" exhibited a notable rise in linkages (total: 4,622), suggesting a growing body of research on its role in neuroinflammation and cognitive dysfunction. Another major trend is the increasing focus on mental health and neurodegenerative disorders, as evidenced by the growing occurrences of "depression" (692), "anxiety" (649), "Alzheimer's disease" (682), and "Parkinson's disease" (627). These trends indicate that gut microbiota research is expanding beyond fundamental microbiology into clinical neuroscience, with a strong emphasis on psychiatric and neurodegenerative disorders.

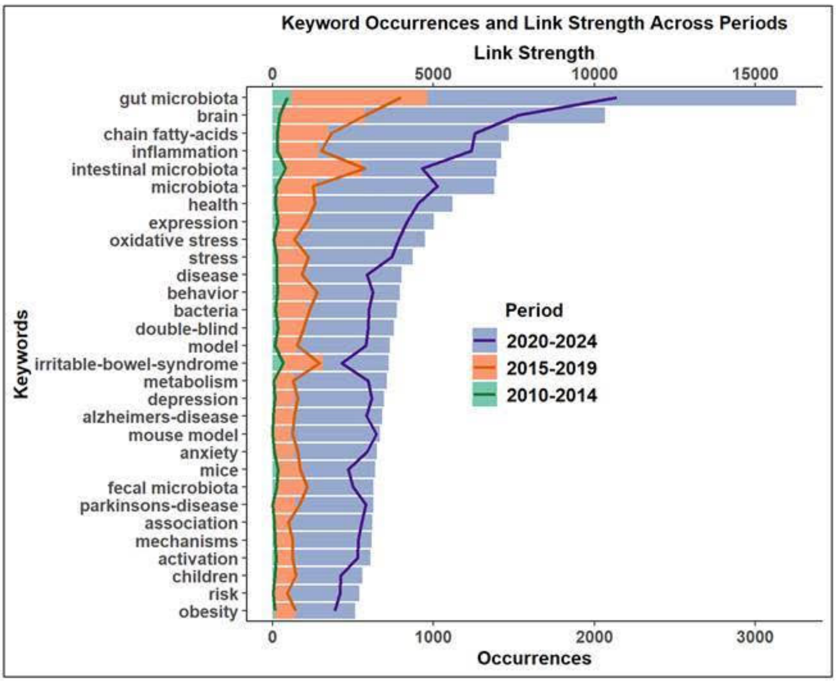

Figure 10

Occurrence frequency and link strengths of the top 30 keywords of Gut-brain axis research at successive periods

The methodological approaches in Gut-Brain Axis research have also evolved significantly. The increasing prevalence of “mouse model” (3,850 links) and “mice” (3,370 links) suggests that animal models continue to play a crucial role in elucidating mechanistic insights into microbiota-brain interactions. Simultaneously, the rise in occurrences of “double-blind” (754) points to a growing number of clinical trials evaluating the therapeutic potential of microbiome-based interventions. Furthermore, the keyword “fecal microbiota” (3,648 links) has gained prominence, reflecting the increasing interest in fecal microbiota transplantation (FMT) as a potential treatment for neurological and psychiatric conditions.

Conclusion

This study provides an in-depth bibliometric analysis of gut-brain axis research, highlighting global contributions, influential institutions, leading authors, prominent journals and WoS micro topics. The findings reveal a substantial rise in research output, with China and the USA leading in publications, while European nations exhibit high citation impact. Institutions like the University of California and University College Cork play pivotal roles, with researchers such as Cryan and Dinan being key contributors. The interdisciplinary nature of this field spans neuroscience, microbiology, nutrition, and pharmacology, as reflected in journal rankings. The bibliometric analysis of the top 20 Web of Science (WoS) micro topics reveals “Gut Microbiota” as the leading theme. Emerging topics like “Microglia,” “Kynurenine,” and “Metabolomics” highlight growing interest in neuroinflammatory and metabolic pathways. The analysis reflects a transition from foundational studies to mechanistic insights and translational applications, focusing on neurodegeneration, mental health, and gut-derived metabolites’ influence on brain functions.

Principal component analysis (PCA) reveals that gut-brain axis research is categorized into five key clusters: oxidative stress & metabolic dysfunction, gut microbiota & immune modulation, gastrointestinal disorders & mental health, neuroinflammation & cognitive decline and stress-related disorders. These clusters highlight the interdisciplinary nature of the field, bridging neuroscience, immunology, microbiology, and psychology to explore the complex mechanisms underlying brain-gut interactions.

The topic trends analysis highlighted that the early studies primarily focused on the characterization of gut microbiota, whereas recent research (2020–2024) emphasizes pathways such as tryptophan metabolism, short-chain fatty acids, and neuroinflammation. Environmental factors like microplastics also represent emerging areas of interest. This shift reflects the transition from foundational research to exploring biochemical and immunological mechanisms underlying gut-brain communication. Increased mentions of terms like “randomized controlled trial” and “probiotic bifidobacterium” signify growing interest in microbiome-based interventions targeting neurological and psychiatric disorders.

WoS micro topic analysis reveals an exponential rise in gut-brain axis research, shifting from observational studies to mechanistic insights, with a growing focus on microbiota, neurodegenerative diseases, neuroinflammation, oxidative stress, and gut-derived metabolites as key modulators of brain function and neurological disorders. The keyword co-occurrence analysis, conducted using VOSviewer, reinforces these findings by extracting the most prominent themes. Emerging terms such as "chain fatty acids," "oxidative stress," and "inflammation" highlight the metabolic and immune pathways central to GBA research. The exponential rise in studies focused on conditions like irritable bowel syndrome, Parkinson's disease, and Alzheimer's disease reflects the field's increasing emphasis on neurodegeneration and neuroinflammation. With evolving methodologies like fecal microbiota transplantation (FMT) and clinical trials, the field is progressing toward translational applications with significant therapeutic potential.

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