Medical Science

To Cite:
Kolanek A, Kaczmarczyk K, Ślinko I, Metelkina D, Dryl-Jarmoc E, Kuliś G, Panas Z, Krawczuk K, Dziemianczuk J, Zimowski M, Kadysz P, Czajkowski M. Oral and Gut Microbiota in Children with Autism Spectrum Disorder: Symptoms and Therapeutic Approaches. *Medical Science* 2026; 30: e135ms3930
doi: https://doi.org/10.54905/disssi.v30i173.e135ms3930

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Peer-Review History
Received: 09 January 2026
Reviewed & Revised: 03/February/2026 to 30/June/2026
Accepted: 12 July 2026
Published: 27 July 2026

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

Medical Science
pISSN 2321–7359; eISSN 2321–7367

Oral and Gut Microbiota in Children with Autism Spectrum Disorder: Symptoms and Therapeutic Approaches

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ABSTRACT

Autism spectrum disorder (ASD), due to its rising prevalence, poses a global public health issue. It is a neurodevelopmental disorder marked by difficulties in social communication, language, and repetitive behaviors. These disorders may be associated with irritability, sleep problems, withdrawal, stereotypical behaviors, or sudden changes in behavior. Therefore, this review focuses on symptoms and practical therapeutic approaches related to the oral and gut microbiome. The microbiota-gut-brain axis plays an important role not only in regulating digestion but also in brain development and function. Disruptions in this axis may contribute to the development or persistence of symptoms associated with ASD. The gut microbiota is essential for maintaining homeostasis, and dysbiosis can negatively affect key physiological processes. Studies have shown differences in the composition of the gut and oral microbiomes between individuals with ASD and neurotypical control subjects. Diet can further modulate the gut microbiome and influence selected outcomes.

Keywords: autism spectrum disorder; gut microbiota; oral microbiota; gastrointestinal symptoms; food selectivity; probiotics; supportive interventions; microbiota-gut-brain axis

1. INTRODUCTION

Autism spectrum disorder (ASD) is a chronic, multifaceted neurodevelopmental disorder, first manifesting in newborns and young children defined by enduring deficits in social communication and social reciprocity, alongside the presence of restricted, repetitive patterns of behavior, interests or activities, in children, characteristic features include absent response to name, unusual sensory response, limited or no use of communicative gestures and a lack of imaginative play (Anwar et al., 2020, Billeci et al., 2023; Hirota & King, 2023; Taha et al., 2025). It is important to consider comorbidities in studies of the microbiota in children with ASD. Approximately 70% of children with ASD have at least one additional diagnosis,

and 41% exhibit two or more. This indicates the high health burden of this group and the difficulties that comorbidities pose both in everyday clinical practice and research efforts (Lefter et al., 2019).

Gastrointestinal (GI) disorders are highly prevalent in children with ASD, with reported rates ranging widely from 9% to 91% substantially higher than in neurotypical children and nearly half of children with ASD experiencing at least one chronic GI symptom, such as food allergies, malabsorption and feeding maladjustment and most commonly constipation, diarrhea and abdominal pain (Wasilewska et al., 2009; Horvath et al., 1999; Holingue et al., 2018; Adams et al., 2011). Because comorbit symptoms impair daily functioning such as nutrition, sleep, pain, oral hygiene and burden on caregivers, it should be taken seriously.

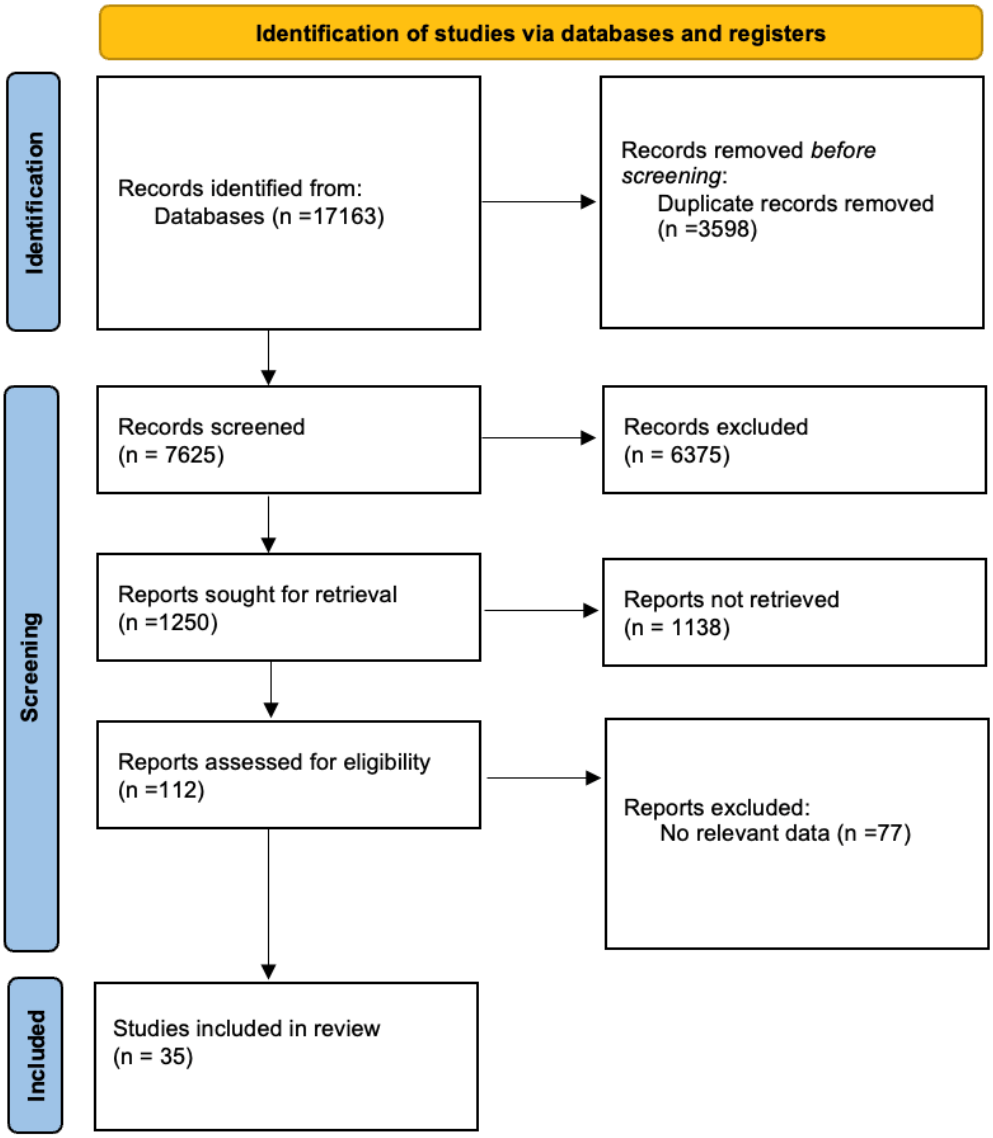

Figure 1. PRISMA flow diagram

2. REVIEW METHODS

A literature review was conducted using the PubMed database, covering English-language publications from 1999 to 2025. The review focused on studies concerning autism spectrum disorder, gastrointestinal symptoms, the oral and gut microbiome, the microbiota-gut-brain axis, diet, probiotics, prebiotics, fecal microbiota transplantation, microbiota transfer therapy, and washed microbiota transplantation. Our review included original research articles, clinical studies, systematic reviews, and meta-analyses. Exclusion criteria: lack of full text, publications in languages other than English, and studies not related to ASD or the microbiome, and studies

focused only on adult populations. During the selection, we made based on titles, abstracts, and full texts. We grouped the results by the main topic: gut microbiota, oral microbiota, microbiota-gut-brain axis, GI symptoms, dietary interventions, and microbiota-modulating therapies. The article screening process followed the PRISMA guidelines (Figure 1).

3. RESULTS AND DISCUSSION

Microbiota-Gut-Brain Axis

The microbiota-gut-brain (MGB) axis represents bidirectional communication between the central nervous system and the gastrointestinal microbiota, providing a key pathway through which changes in the gut microbiota can influence brain function and development (Cryan and O'Mahony, 2011). This communication occurs primarily through the vagus nerve and the enteric nervous system, which regulate the functions for appetite and modulation of cognitive processes, emotions, anxiety, and stress responses (Mayer et al., 2006; Collins et al., 2012). GI symptoms (especially constipation) often coexist with an increased stress response, poorer cognitive function, and speech disorders in children with ASD (Hicks et al., 2018). Furthermore, the incidence of constipation appears to be the severity of the child's social and language difficulties (Jašarević et al., 2015). Despite a growing body of evidence suggesting that MGB axis abnormalities may play a role in the development and/or maintenance of, the current evidence remains mainly associative (Johnson et al., 2020).

Gastrointestinal Symptoms, Diet, and Gut Microbiota

Gut bacteria serve many functions, among others supporting digestion, metabolism, immune function, and neuroendocrine regulation. These gut microorganisms interact closely with host cells, and any dysbiosis can adversely affect key physiological processes and may contribute to the development of numerous health disorders (Anwar et al., 2020). Recent studies have shown that individuals with ASD have a gut microbiota composition that differs from that of individuals with typical development (Johnson et al., 2020). Research has shown that individuals with ASD exhibit an increased Bacteroidetes-to-Firmicutes ratio compared to neurotypical controls, although no specific microbiome signature has been identified for autism; however, consistently reported findings include reduced microbial diversity, and lower abundance of Bifidobacterium, which may be related to the typical low dietary diversity, rather than with autism (Palmer et al., 2025; Navarro et al., 2016; Finegold et al., 2010). Research shows that children with ASD who have chronic GI symptoms have a different gut microbiota compared to the control group (Wang et al., 2023). Similarly, dietarydisorders seem to influence constipation and overall digestive health through alteration of specific gut taxa, including Turicibacter, Coprococcus 1, and Eggerthellaceae (Li et al., 2023). Ultimately, all studies confirm that gastrointestinal symptoms are much more common in children with ASD than in their neurotypical peers. The most reported symptom was constipation, followed by diarrhea; abdominal pain, altered stool pattern, flatulence, reflux, food refusal, and selective eating were also described.

Irritability, withdrawal, sleep problems, or repetitive behaviors may be a sign that patient is experiencing pain or discomfort. Food selectivity is also an important problem. A restricted diet, repetitive behaviors, and sensitivity to stimuli can cause a child to consume too little fiber and fluids, increasing the risk of constipation. Children with ASD often have difficulty eating, which may make them more vulnerable to deficiencies in important nutrients. For this reason, it is worth regularly monitoring the levels of iron, calcium, iodine, magnesium, selenium, vitamin D, vitamin E, vitamin B12 and biotin (Gray, 2025; Li et al., 2023).

Oral Microbiota and Oral Health

Oral cavity microbiota play an important role in maintaining oral health (Patel et al., 2022). Many children with ASD experience sensory hypersensitivity, picky eating, speech difficulties, and oral hygiene problems; given that the mouth is the starting point of the digestive tract, the oral microbiome plays an important role in ASD. An analysis of oral microbiome activity successfully differentiated children with ASD from their typically developing children. They were also able to distinguish children with ASD who had GI disturbance from those without, with AUC = 0.857 (Hicks et al., 2018). Another study found no significant differences in overall alpha- and beta-diversity of the microbiome (Evenepoel et al., 2024). Some bacteria, including Solobacterium, Stomatobaculum, Ruminococcaceae UCG.014, Tannerella, and Campylobacter, were more common in children with ASD with repetitive behaviors, and anxiety, and difficulties in social interaction (Evenepoel et al., 2024). Additionally, children with ASD often have poor oral hygiene, tooth decay, limited access to dental care, and therefore co-occurring oral dysbiosis (Patel et al., 2022).

Diet and Microbiota-Targeted Nutritional Approaches

Diet plays an important role in modulating the gut microbiota (Santocchi et al. 2020). Given that a large proportion of children with ASD have restrictive and avoidant eating habits, this may lead to reduced intake of prebiotics naturally present in foods, thereby reducing the availability of fermentable substrates that support microbial diversity (Navarro et al., 2016). In ASD, dietary interventions are primarily studied in the context of GI symptoms, food selectivity, inflammation, and potential modulation of the gut microbiota. After 3 months of a diet without processed foods and preservatives, children with ASD experienced improved daily functioning, a reduction in some autism symptoms, and a marked reduction in GI symptoms (El Raghy et al., 2025).

Probiotics, Prebiotics, and Symbiotic

The International Society for Probiotics and Prebiotics defines prebiotics as substrates that are selectively utilized by host microorganisms to confer a health benefit (Navarro et al., 2016). Prebiotics support the growth of gut bacteria, primarily Lactobacilli and Bifidobacteria (Patel et al., 2022; Navarro et al., 2016). Probiotics are live microorganisms that provide a health benefit to the host by modulating gut microbial composition and function (Johnson et al., 2020). The topic of probiotic use in individuals with ASD results from the frequent coexistence of disturbances the gut microbiota along with GI and behavioral symptoms. Still, the results of the studies are not consistent; however, most of the research is based on Lactobacillus and Bifidobacterium. The study showed that probiotics significantly reduce GI symptoms (Borbélyová et al., 2025). In a 3-month study, children taking probiotics had reduced autism symptoms and fewer problems with constipation and diarrhea (Narula Khanna et al., 2025). In Santocchi et al., (2020) study, probiotic administration did not improve autism-related symptoms. Nevertheless, exploratory analyses suggested greater improvement in social affect on the ADOS-CSS and total ADOS-CSS scores in children without GI symptoms, as well as selected GI and sensory benefits in children with GI symptoms. Some probiotics, such as Lactobacillus plantarum PS128, have a positive effect on certain behaviors, but there is not yet sufficient evidence to recommend routine use of probiotics in the treatment of ASD (Liu et al., 2019; Mazzone et al., 2024). Currently, prebiotics, probiotics, and synbiotics should be considered as additional support that may help reduce GI and behavioral symptoms in children with ASD (Patel et al., 2022; Patusco & Ziegler, 2018; Taha et al., 2025).

Fecal Microbiota Transfer and Washed Microbiota Transplantation

Fecal microbiome transplantation (FMT) and washed microbiota transplantation (WMT) are experimental approaches aimed at modifying the gut microbiome ecosystem to a greater extent than probiotics or prebiotics. Research suggests that they can improve both GI symptoms and behavioral symptoms. Studies of FMT in children with ASD have shown improved social skills (Wan et al., 2024). Similarly, WMT therapy may reduce autism symptoms after several treatment cycles (Zheng et al., 2025). Additionally, it was noted that children without constipation improved more quickly, while children with constipation needed more cycles of therapy to achieve similar effects (Pan et al., 2025). Despite promising results, FMT and WMT are still experimental methods and require further research (Taha et al., 2025; Mallick et al., 2025).

Prevention and Health Education

The goal of microbiome research in ASD is to create practical strategies for patient care. Any microbiome interventions should only serve as supportive care because, for now, the most important thing is to monitor gastrointestinal problems, which are often hidden signs of pain or discomfort. Additionally, in children with ASD who have difficulty communicating, GI symptoms may include irritability and sleep disorders, withdrawal, stereotypical behavior, or sudden behavior change (Gray, 2025; Patusco and Ziegler, 2018; Olsen and Hicks, 2020). Doctors need to educate caregivers that children with limited food variety and low fiber intake are at high risk of nutritional deficiencies. Dental care aimed at early detection of dental caries is equally important.

The summarized studies presented in Table 1 suggest that findings regarding the microbiota in ASD are clinically significant but inconsistent. Most of the available scientific evidence points to the need for close monitoring and treatment of gastrointestinal symptoms, nutrition, and oral health. At the same time, microbiota-targeted therapies should be used only as adjunctive treatments for autism. Although the relationship between the gut microbiome and ASD is extensive, the potential role of microbial factors in ASD, whether from an etiological perspective or in relation to the various comorbidities affecting this population, is undeniable. Due to the complex nature of ASD, current research to elucidate the precise mechanisms associated with this disorder remains largely insufficient, and current findings are primarily associative rather than causal. Increasing attention is being paid to the influence of geographic location and diet on ASD and its associated microbiota.

Current clinical studies focusing on the microbiome are limited by insufficient sample sizes and the lack of large population-based studies, which reflects the inherent complexity and heterogeneity of ASD. Therefore, to validate the data, a greater number of studies on larger cohorts from different regions, using standardized criteria (e.g., age, sex, comorbidities), are necessary. Future studies should more carefully control for age, sex, diet, antibiotics, gastrointestinal symptoms, oral hygiene, comorbidities, and baseline microbial composition.

Table 1. Summary of studies included in the review.

Study	Design / focus	Main findings	Interpretation for this review
Adams et al., 2011; Holingue et al., 2018; Wasilewska et al., 2009; Horvath et al., 1999	Clinical and review evidence on GI symptoms in ASD.	GI complaints, especially constipation, diarrhea, abdominal pain, food selectivity, malabsorption, and feeding difficulties, were reported more frequently in children with ASD than in neurotypical children.	GI symptoms should be actively screened because discomfort may appear as irritability, sleep problems, withdrawal, or behavioral change.
Wang et al., 2023	Children with ASD and chronic GI symptoms; gut microbiota profiling.	Children with ASD and chronic GI symptoms differed from healthy controls in microbial richness and community structure, including observed species, Chao1 and ACE indices, and beta-diversity.	Supports an association between chronic GI symptoms and gut microbial alterations, but causality remains uncertain.
Hicks et al., 2018	Oral microbiome activity in children with ASD.	Taxonomic indicators distinguished children with ASD from typically developing children and also differentiated ASD children with and without GI disturbance.	Suggests that oral microbiota may have diagnostic and clinical relevance, especially in relation to GI symptoms.
Evenepoel et al., 2024	Oral microbiota and clinical characteristics in autistic children.	No significant overall alpha- or beta-diversity differences were found, but selected genera were more prevalent and associated with social difficulties, repetitive behavior, or anxiety.	Oral microbiome findings are promising but inconsistent and should be interpreted cautiously.
El Raghy et al., 2025	Dietary intervention excluding processed foods, additives, and preservatives.	After three months, children showed improvement in ATEC and GI symptom scores, despite no significant overall change in gut microbiome profile.	Diet may improve selected clinical parameters, but should not be presented as a causal treatment for ASD.
Palmer et al., 2025	Double-masked randomized controlled trial of prebiotic supplementation.	The effects of prebiotics on children's behavior, gastrointestinal problems, parents' quality of life, and microbiome composition were studied.	Prebiotics can help as additional support, but their effects depend on the child's diet, symptoms, and the type of bacteria present in the intestines.

Study	Design / focus	Main findings	Interpretation for this review
Liu et al., 2019	Randomized, double-masked, placebo-controlled trial of Lactobacillus plantarum PS128.	Targeted probiotic supplementation showed beneficial effects on selected aspects of behavioral functioning.	Supports further study of strain-specific probiotic approaches.
Santocchi et al., 2020	Randomized controlled trial of probiotic supplementation.	ADOS-CSS score did not decrease, but some children may have experienced improvements in social contacts, GI symptoms, and sensory responses.	Probiotics should be considered as additional support, not standard ASD therapy.
Wan et al., 2024	Randomized, double-masked, placebo-controlled oral FMT trial.	After FMT, improvement was observed in some areas of social functioning according to the Vineland-3 scale, without serious side effects.	FMT is still a method under investigation and requires further research.
Zheng et al., 2025	Retrospective review of washed microbiota transplantation.	Single- and multidonor WMT were associated with reduced symptom severity on ABS, CARS, and SDSC after treatment cycles, without severe adverse reactions.	WMT is promising but should be treated as an emerging, non-routine intervention.
Pan et al., 2025	Study of constipation and WMT effectiveness.	Constipation influenced early response to WMT, with different ABC score changes after the first and second treatment courses.	Baseline GI status may influence response to microbiota-transfer interventions.

4. CONCLUSION

ASD poses a significant health and economic burden for both individuals with ASD and their caregivers. It is an increasingly serious global problem that requires heightened attention and coordinated action. Managing ASD in clinical practice is often complicated by a range of severe co-occurring health conditions. Research efforts in this area must be broadened to evaluate the clinical efficacy of these microbiome-based interventions thoroughly. The most important interventions targeting the microbiota include regular monitoring of GI symptoms, assessment of diet and the risk of nutritional deficiencies, prevention of such deficiencies, and providing support for proper oral hygiene and interdisciplinary care tailored to the child's individual needs.

Acknowledgments

There are no acknowledgments to disclose.

Authors' Contributions

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Methodology: Agata Kolanek and Izabela Ślinko;
Software: Not applicable;
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Visualization: Not applicable;
Supervision: Agata Kolanek and Karolina Kaczmarczyk;
Project administration: Agata Kolanek.
All authors have read and agreed to the final published version of the manuscript.

Informed consent
Not applicable.

Ethical approval
Not applicable. This article does not contain any studies with human participants or animals performed by any of the authors.

Funding
This research did not receive any external funding like specific grant from funding agencies in the public, commercial, or nonprofit sectors.

Conflict of interest
The authors declare that they have no conflicts of interest, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Data and materials availability
All data associated with this study will be available based on the reasonable request to corresponding author.

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