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Research Trends in Autism Spectrum Disorder: Evidence from Scopus-Indexed Bibliometric Data

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ABSTRACT

This study aims to analyze the intellectual structure and research trends in Autism Spectrum Disorder through a bibliometric approach based on Scopus-indexed publications. Data were retrieved using relevant keywords and filtered based on document type, language, and publication period to ensure quality and consistency. The analysis was conducted using VOSviewer to examine co-occurrence of keywords, co-authorship networks, and citation relationships. The results reveal a significant increase in ASD-related publications over time, indicating growing global research interest. The co-occurrence analysis identifies several dominant research clusters, including clinical and cognitive studies, early childhood diagnosis, genetic and biological mechanisms, and technology-based diagnostic approaches such as neuroimaging. The density visualization further confirms that core research themes are concentrated around clinical intervention and behavioral understanding, while emerging topics such as functional connectivity and advanced diagnostic imaging are gaining attention. Additionally, collaboration patterns show that research output is largely dominated by developed countries, suggesting the need for broader global participation. Despite the rapid development of the field, several gaps remain, particularly in underrepresented regions and longitudinal research designs. This study provides a comprehensive overview of the evolution of ASD research and offers insights into future directions, emphasizing the importance of interdisciplinary integration and technological innovation in advancing the field.

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1. INTRODUCTION

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by persistent challenges in social communication, restricted interests, and repetitive behaviors [1], [2]. As defined in contemporary clinical frameworks, Autism Spectrum Disorder encompasses a broad spectrum of symptoms and severity levels, reflecting substantial heterogeneity across individuals [3]. Over the past two decades, ASD has transitioned from a relatively

underexplored clinical diagnosis to a major global research priority, driven by increasing prevalence rates and growing societal awareness. Recent estimates suggest that ASD affects a significant proportion of children worldwide, with variations across regions due to differences in diagnostic practices, awareness, and healthcare systems. This growing recognition has not only intensified clinical and psychological research but has also expanded scholarly attention into education, public health, neuroscience, and social policy domains. Consequently, ASD research has evolved into a multidisciplinary field, necessitating systematic approaches to understand its intellectual structure and developmental trajectory [4].

The rapid expansion of ASD-related publications reflects broader transformations in scientific inquiry, particularly the integration of interdisciplinary perspectives and advanced analytical technologies. Early research predominantly focused on clinical diagnosis and behavioral characterization, emphasizing symptom identification and classification. However, contemporary studies increasingly explore underlying neurological mechanisms, genetic factors, and environmental influences, signaling a paradigm shift toward more comprehensive and integrative approaches. In parallel, advancements in digital technologies have introduced novel methods for early detection and intervention, including machine learning, neuroimaging, and assistive communication tools. These developments underscore the dynamic nature of ASD research, where traditional boundaries between disciplines are increasingly blurred. Despite this progress, the vast and fragmented body of literature poses challenges for researchers seeking to identify dominant themes, emerging trends, and potential research gaps within the field.

In this context, bibliometric analysis has emerged as a powerful methodological approach to systematically map scientific knowledge and uncover hidden patterns within large datasets. By utilizing structured bibliographic data from reputable databases such as Scopus, researchers can quantitatively evaluate publication trends, citation networks, and collaborative relationships across time and space. Furthermore, visualization tools like VOSviewer enable the identification of thematic clusters and the exploration of intellectual structures through co-occurrence and co-citation analyses. These techniques allow for a more nuanced understanding of how research topics evolve, how scholars interact, and which areas attract the most academic attention. In the context of ASD research, bibliometric analysis is particularly valuable given the field's rapid growth and interdisciplinary complexity, offering a comprehensive overview that cannot be achieved through traditional narrative reviews alone.

Although several studies have attempted to examine ASD research trends, many remain limited in scope, focusing on specific subtopics such as intervention strategies, diagnostic tools, or educational approaches. Moreover, previous reviews often rely on qualitative synthesis, which may be subject to selection bias and lack the ability to capture large-scale structural patterns. There is still a notable gap in the literature regarding comprehensive bibliometric mapping that integrates multiple analytical dimensions, including keyword co-occurrence, author collaboration networks, and citation impact. Additionally, the global distribution of ASD research remains uneven, with a concentration of publications originating from developed countries, potentially overlooking context-specific challenges in developing regions. Addressing these limitations requires a systematic and data-driven approach that can provide a holistic view of the research landscape, identify underexplored areas, and guide future scholarly efforts. Therefore, this study aims to map the research trends and intellectual structure of Autism Spectrum Disorder through a bibliometric analysis of Scopus-indexed publications.

2. METHOD

This study employs a quantitative bibliometric approach to systematically

analyze the development and intellectual structure of research on Autism Spectrum Disorder. Bibliometric analysis is selected as it enables the identification of publication trends, thematic evolution, and collaborative networks through the examination of large-scale scientific data. The data for this study were retrieved from Scopus, which is widely recognized for its comprehensive coverage of peer-reviewed literature across multiple disciplines. The search strategy was conducted using the query TITLE-ABS-KEY ("autism spectrum disorder" OR "ASD"), ensuring that the retrieved documents are directly relevant to the topic. The time span of the analysis covers publications from 2000 to 2025 to capture the longitudinal evolution of the research field. To ensure data quality and consistency, only documents categorized as articles and review papers, written in English, and published in peer-reviewed journals were included, while conference papers, book chapters, and non-English publications were excluded.

The retrieved bibliographic data were exported in CSV format and processed for analysis. The study applies several bibliometric techniques, including performance analysis and science mapping. Performance analysis focuses on descriptive indicators such as annual publication growth, most productive authors, leading journals, and countries contributing to ASD research. Meanwhile, science mapping techniques are used to explore the intellectual structure of the field through co-occurrence of keywords, co-authorship networks, and citation relationships. These analyses allow for the identification of dominant research themes, collaborative patterns, and influential publications within the dataset.

To visualize and analyze the bibliometric networks, this study utilizes VOSviewer. This software facilitates the construction of network maps based on relationships among items such as keywords, authors, and documents. The visualization outputs are interpreted using clustering techniques, where nodes represent items and links indicate relationships, with the size and proximity reflecting the strength of connections.

3. RESULT AND DISCUSSION

3.1 Result

a. Keyword Co-Occurrence Visualization

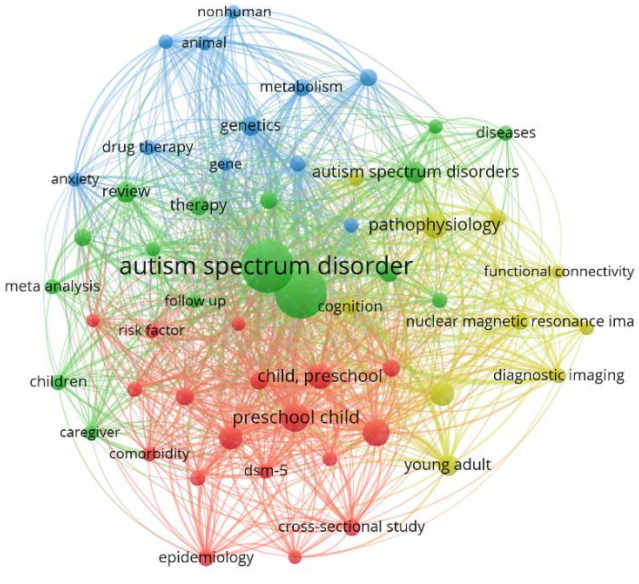

Figure 1. Network Visualization
Source: Data Analysis

Figure 1 reveals the intellectual structure of research on Autism Spectrum Disorder through the clustering of keywords into several dominant thematic groups. At the center of the network, "autism spectrum disorder" appears as the most prominent and highly connected node, indicating its role as the core focus of the research field. The dense interconnections surrounding this central term reflect the multidisciplinary nature of ASD research, where various domains such as clinical studies, neuroscience, psychology, and public health converge. The proximity of nodes suggests strong conceptual relationships, while the size of nodes indicates the frequency of keyword occurrence, highlighting the most intensively studied topics.

The green cluster represents a major thematic area focusing on clinical and psychological aspects of ASD. Keywords such as "therapy," "cognition," "pathophysiology," "review," and "follow-up" suggest that a substantial portion of the literature is dedicated to understanding behavioral characteristics, treatment approaches, and underlying mechanisms of the disorder. The presence of terms like "meta-analysis" and "risk factor" indicates a growing emphasis on evidence-based research and systematic evaluation of interventions. This cluster reflects the maturity of ASD research in terms of clinical understanding and the continuous effort to improve therapeutic outcomes and patient quality of life.

The red cluster highlights research related to early childhood and developmental diagnosis. Keywords such as "preschool child," "child, preschool," "children," "DSM-5," "epidemiology," and "cross-sectional study" suggest a strong focus on early detection, diagnostic criteria, and population-based studies. This indicates that early identification of ASD remains a critical research priority, as early intervention is widely recognized to significantly improve developmental outcomes. The inclusion of terms like "caregiver" and "comorbidity" further emphasizes the broader social and health context in which ASD is studied, including family dynamics and co-occurring conditions.

The blue cluster represents a more biologically oriented research stream, focusing on genetics and experimental models. Keywords such as "genetics," "gene," "metabolism," "animal," "nonhuman," and "drug therapy" indicate an emphasis on understanding the biological and molecular foundations of ASD. This cluster reflects the increasing integration of biomedical research approaches, including the use of animal models and genetic analysis, to uncover the etiology of the disorder. The presence of "anxiety" and "therapy" within this cluster also suggests an overlap between biological mechanisms and behavioral outcomes, reinforcing the interdisciplinary nature of ASD research.

The yellow cluster captures research related to neuroimaging and diagnostic technologies. Keywords such as "functional connectivity," "diagnostic imaging," and "nuclear magnetic resonance imaging" highlight the role of advanced imaging techniques in studying brain structure and function in individuals with ASD. This cluster indicates a growing trend toward the use of technology-driven approaches to improve diagnostic accuracy and deepen the understanding of neural mechanisms underlying ASD. The integration of neuroimaging with clinical and cognitive research

suggests a shift toward more precise and data-driven methodologies, pointing to future directions where artificial intelligence and digital health tools may further transform ASD research and practice.

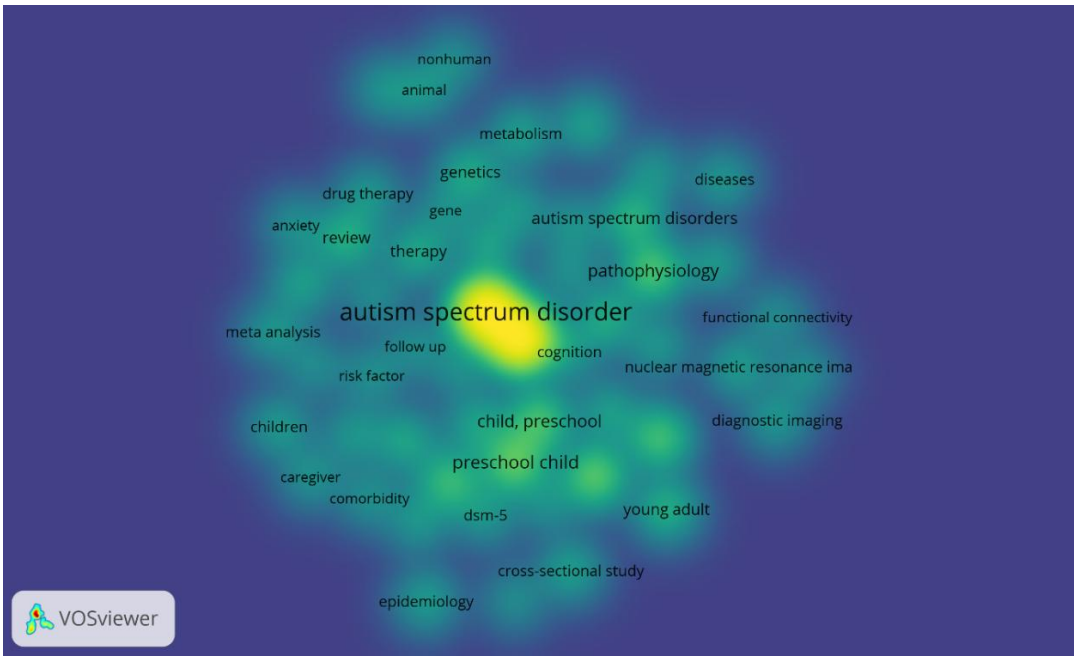

Figure 2. Density Visualization
Source: Data Analysis

Figure 2 highlights the concentration and intensity of research topics within the field of Autism Spectrum Disorder. The brightest (yellow) area is centered on the keyword "autism spectrum disorder," indicating that it is the most frequently occurring and highly connected term in the dataset. Surrounding this core, moderately dense regions (green tones) include keywords such as "cognition," "pathophysiology," "therapy," and "genetics," suggesting that these themes represent the main pillars of ASD research. The visualization reflects a well-established knowledge base where clinical, cognitive, and biological dimensions are tightly integrated, demonstrating the maturity and depth of research in these areas. In contrast, the less dense (blue to green) peripheral areas represent emerging or less intensively studied topics. Keywords such as "diagnostic imaging," "functional connectivity," "nuclear magnetic resonance imaging," and "young adult" appear with lower density, indicating growing but still developing research attention. Similarly, terms related to early childhood, such as "preschool child" and "child, preschool," show moderate density, emphasizing their importance while suggesting opportunities for further exploration.

Table 1. Most Cited Article

Citations	Author and Year	Title
1374	[5]	Global, regional, and national burden of disorders affecting the nervous system, 1990â€“2021: a systematic analysis for the Global Burden of Disease Study 2021
432	[6]	hdWGCNA identifies co-expression networks in high-dimensional transcriptomics data

Citations	Author and Year	Title
333	[7]	Prevalence and Early Identification of Autism Spectrum Disorder Among Children Aged 4 and 8 Years â€" Autism and Developmental Disabilities Monitoring Network, 16 Sites, United States, 2022
248	[8]	The microbiotaâ€"gutâ€"brain axis and neurodevelopmental disorders
243	[9]	Candidate biomarkers in psychiatric disorders: state of the field
208	[10]	Exploring the Frontiers of Neuroimaging: A Review of Recent Advances in Understanding Brain Functioning and Disorders
197	[11]	Comorbidities in autism spectrum disorder and their etiologies
170	[12]	An in vivo neuroimmune organoid model to study human microglia phenotypes
159	[13]	Single-cell brain organoid screening identifies developmental defects in autism
155	[14]	Detection of autism spectrum disorder (ASD) in children and adults using machine learning

Source: Scopus, 2026

3.2 Discussion

The findings of this bibliometric analysis demonstrate that research on Autism Spectrum Disorder has experienced substantial growth over the past two decades, reflecting increasing global awareness and scientific interest. The dominance of the central keyword "autism spectrum disorder" and its strong connections with multiple thematic areas indicate that the field has developed into a highly integrated and multidisciplinary domain. This growth is not only quantitative but also qualitative, as evidenced by the diversification of research topics spanning clinical, psychological, biological, and technological perspectives. Such expansion aligns with broader trends in health and social sciences, where complex conditions like ASD are increasingly approached through holistic and interdisciplinary frameworks.

One of the most prominent insights from the co-occurrence and density analyses is the strong emphasis on clinical and cognitive dimensions, particularly in areas such as therapy, cognition, and pathophysiology. This suggests that a significant portion of ASD research continues to focus on understanding behavioral characteristics and improving intervention strategies. The presence of keywords such as "meta-analysis" and "review" further indicates a maturing field, where researchers are synthesizing existing knowledge to refine evidence-based practices. Compared to earlier studies that were largely descriptive, contemporary ASD research demonstrates a shift toward more rigorous and systematic approaches, reinforcing the scientific foundation of clinical interventions and support mechanisms.

At the same time, the findings reveal a substantial and growing body of research dedicated to early childhood and developmental diagnosis. The prominence of terms such as "preschool child," "DSM-5," and "epidemiology" highlights the critical importance of early identification and assessment in ASD. This focus is consistent with the widely accepted view that early intervention can significantly improve developmental outcomes and long-term functioning. Moreover, the inclusion of keywords related to caregivers and comorbidities suggests that research is increasingly considering the broader social and familial context of ASD, moving beyond individual-level analysis toward a more ecosystem-based understanding of the condition.

Another important trend identified in this study is the increasing integration of biological and technological approaches. The presence of clusters related to genetics, metabolism, and animal models indicates ongoing efforts to uncover the underlying mechanisms of ASD, while the emergence of keywords such as "functional connectivity" and "diagnostic imaging" reflects the growing role of advanced technologies in research and diagnosis. These developments suggest a paradigm shift toward precision medicine and data-driven approaches, where interdisciplinary collaboration between neuroscience, computer science, and clinical practice becomes essential. This trend also opens new opportunities for innovation, particularly in the use of artificial intelligence and digital tools for early detection and personalized intervention.

Despite these advancements, the study also highlights several gaps and challenges within the ASD research landscape. The uneven distribution of research topics and the relatively lower density of certain emerging areas suggest that some domains remain underexplored. Additionally, the global distribution of research output tends to be concentrated in developed countries, potentially limiting the generalizability of findings to diverse cultural and socio-economic contexts. Future research should therefore prioritize inclusive and cross-regional studies, as well as longitudinal designs that can capture the complexity of ASD across the lifespan. By addressing these gaps, the field can move toward a more comprehensive and equitable understanding of ASD, ultimately contributing to more effective policies, interventions, and support systems worldwide.

4. CONCLUSION

This study provides a comprehensive bibliometric mapping of research trends in Autism Spectrum Disorder, revealing a rapidly expanding and increasingly interdisciplinary field. The findings highlight that ASD research has evolved from a primary focus on clinical diagnosis toward more integrative approaches encompassing cognitive, biological, and technological dimensions. Core themes such as therapy, early childhood diagnosis, and pathophysiology remain dominant, while emerging areas including neuroimaging and advanced diagnostic technologies signal future research directions. Despite this progress, gaps persist in terms of global research representation and the exploration of underdeveloped topics. This study contributes to the understanding of the intellectual structure and evolution of ASD research, offering valuable insights for scholars and policymakers in shaping future research agendas and fostering more inclusive and innovative approaches in the field.

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