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Early Intervention Strategies for the Diagnosis and Treatment of Dyslexia in Individuals: A Bibliometric and Thematic Analysis

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Abstract

Background: Dyslexia is a common learning disorder and a complex condition that significantly impacts an individual's ability to read, accompanied by challenges in processing written language. Despite having average or above-average intelligence, individuals with dyslexia struggle with decoding words and comprehending texts. Early intervention is crucial due to dyslexia's effects on various aspects of daily life, impacting educational, psychological, and social dimensions. **Objective**: A systematic review of the literature to explore the impact of early intervention on diagnosis and reading difficulties, contributing to a better understanding of this disorder and raising awareness about it. **Methodology**: The PRISMA method was employed for bibliometric analysis to summarize studies linking dyslexia and early intervention. The Scopus database was chosen for its extensive coverage and reputation as a source for analyzing scholarly articles. A comprehensive keyword search yielded 565 publications in the database. Inclusion and exclusion criteria were applied to narrow down the results to 28 relevant articles. **Results**: Since 2016, research papers focusing on dyslexia and early intervention have increased, indicating a growing emphasis on research in this field. The main publications list on this topic shows a global impact. The study highlights the most significant keywords in research, reflecting the multidisciplinary nature of early intervention research in detecting and treating dyslexia. Awareness of dyslexia and the importance of early diagnosis and support for affected students has increased, as evidenced by the rise in publication numbers, diversity of authors, and the focus on varied subject areas and multiple keywords. This demonstrates that research in this sector is characterized by collaboration and diversity. **Recommendations**: The paper recommends further research on early intervention for the detection and therapeutic interventions for dyslexia. Understanding the impact of dyslexia on all aspects of students' lives requires the development of strategies and the expansion of knowledge bases.

Keywords: Early Intervention Strategies, Dyslexia, Systematic Review

Introduction

Dyslexia is a common neurodevelopmental disorder that affects language processing, including reading, spelling, and writing, even among individuals with average or above-average intelligence (Sood et al., 2018). Early identification and intervention are critical for children at risk of dyslexia to prevent long-term academic and psychological challenges. Without timely intervention, children with dyslexia often struggle with pre-reading skills such as phonological awareness, letter knowledge, and rapid automatized naming, which are foundational for successful reading development (Wannapaschaiyong et al., 2023).

One of the most effective early intervention strategies focuses on phonological awareness training, which helps children understand and manipulate sounds within words. Phonological awareness is considered an essential skill that supports reading fluency and accuracy (Wannapaschaiyong et al., 2023). Combining this with letter knowledge training, which teaches children to recognize the visual forms of letters and associate them with corresponding sounds, has shown long-lasting effects on the reading abilities of children at risk for dyslexia (Elbro & Petersen, 2004). These interventions, systematically delivered over weeks or months, have been proven effective across different languages and orthographic systems, including Thai and English (Wannapaschaiyong et al., 2023).

Technological advancements have facilitated the development of computer-based early intervention programs, making these strategies more accessible and engaging for children. Research shows that children who receive interventions through digital platforms demonstrate significant improvements in phonological awareness and letter knowledge, often outperforming those who use traditional methods (Sood et al., 2018). For instance, the Siriraj Pre-Literacy Enhancement (SIPLE) program, designed to assist Thai children at risk of dyslexia, showed notable improvements in pre-reading skills after just 11 weeks of use (Wannapaschaiyong et al., 2023).

The need for accessing the most effective early intervention strategies for the identification and treatment of dyslexia in students forms the basis of this review. This bibliometric analysis aims to provide a comprehensive investigation into effective strategies, as early diagnosis and intervention are crucial in mitigating the long-term negative impacts associated with dyslexia, such as academic, psychological, social, and behavioral effects. The study particularly focuses on uncovering trends, patterns, and gaps within the current body of research. This research seeks to make a scholarly contribution to the field, with the hope of facilitating the improvement of intervention experiences and proposing well-informed educational practices. Therefore, the objective of this bibliometric analysis is to answer the following research questions:

1. What is the annual distribution, the leading countries, top educational institutions, and most commonly used keywords related to the impact of early intervention on the diagnosis and treatment of dyslexia in preschool-aged individuals?
2. What are the most prevalent theories regarding the impact of early intervention on dyslexia in individuals?
3. What statistical analyses are most frequently used in research on the impact of early intervention on dyslexia in individuals?
4. What platforms are most commonly utilized in studies examining the impact of early intervention on dyslexia in individuals?

5. What sample groups have been most analyzed in studies on the impact of early intervention on learning disorders in individuals?

Research Design
The PRISMA method was employed for this bibliometric analysis to summarize studies linking dyslexia and early intervention.

Search Strategy
A comprehensive search was conducted for published articles and peer-reviewed conference papers related to early intervention strategies for dyslexia using the Scopus database. The search was conducted on August 15, 2024. Initially, a bibliometric study yielded 565 results from the Scopus database. The dataset was downloaded, and the (Vosviewer) software was used to visualize patterns and connections within the data.

According to the findings, Vosviewer significantly contributed to the study of early intervention strategies for dyslexia by providing detailed visualizations of the data. It highlighted leading countries in this field, such as China, India, Spain, and the United States, which contributed large numbers of publications (26, 21, 20, and 19, respectively). Vosviewer's visualization capabilities clarified the leadership role of China, supported by its financial resources and extensive research efforts. The report also showcased the unique contributions of India, Spain, and the United States, known for their robust educational systems and significant government funding.

Furthermore, the visual tool underscored notable contributions from European countries such as India, Canada, Spain, and the United States. Each of these countries presented unique methodologies and practical applications for detecting and treating dyslexia, along with innovative educational strategies.

In conclusion, the use of Vosviewer played a pivotal role in uncovering a multidimensional approach to early intervention strategies for the identification and treatment of dyslexia. This highlighted key themes such as early childhood intervention, language development, the role of neuroimaging, and risk factors in understanding the condition.

A set of keywords and Boolean operators such as "early intervention" and "dyslexia" were used to extract significant data from the retrieved papers for more accurate results. For instance, the following equation was used: (early AND intervention AND dyslexia). Research from 2015 to 2023 was included, following this query: AND PUBYEAR > 2015 AND PUBYEAR < 2023.

Finally, we restricted our search to include social sciences, computer science, arts, and humanities with the following query: "early AND intervention AND dyslexia AND (LIMIT-TO (SUBJAREA, "NEUR") OR LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "PSYC")).
To achieve more precise results, specific keywords were applied; Table 1 shows the exact keywords used in this study:

Table 1
Exact Keywords Used in Early Intervention for Dyslexia

Query	Exact keywords
LIMIT-TO (SUBJAREA , "NEUR") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "PSYC") OR LIMIT-TO (SUBJAREA , "COMP") OR LIMIT-TO (SUBJAREA , "MEDI") OR LIMIT-TO (SUBJAREA , "ARTS") OR LIMIT-TO (SUBJAREA , "NURS")) AND (LIMIT-TO (EXACTKEYWORD , "Human") OR LIMIT-TO (EXACTKEYWORD , "Dyslexia") OR LIMIT-TO (EXACTKEYWORD , "Child") OR LIMIT-TO (EXACTKEYWORD , "Humans") OR LIMIT-TO (EXACTKEYWORD , "Female") OR LIMIT-TO (EXACTKEYWORD , "Reading") OR LIMIT-TO (EXACTKEYWORD , "Article") OR LIMIT-TO (EXACTKEYWORD , "Male") OR LIMIT-TO (EXACTKEYWORD , "Preschool Child") OR LIMIT-TO (EXACTKEYWORD , "Child, Preschool") OR LIMIT-TO (EXACTKEYWORD , "Early Intervention") OR LIMIT-TO (EXACTKEYWORD , "Psychology") OR LIMIT-TO (EXACTKEYWORD , "Learning Disorder") OR LIMIT-TO (EXACTKEYWORD , "Learning Disabilities") OR LIMIT-TO (EXACTKEYWORD , "Students") OR LIMIT-TO (EXACTKEYWORD , "Comprehension") OR LIMIT-TO (EXACTKEYWORD , "Intervention") OR LIMIT-TO (EXACTKEYWORD , "School") OR LIMIT-TO (EXACTKEYWORD , "Developmental Dyslexia") OR LIMIT-TO (EXACTKEYWORD , "Dyslexium") OR LIMIT-TO (EXACTKEYWORD , "Phonological Awareness") OR LIMIT-TO (EXACTKEYWORD , "Early Diagnosis") OR LIMIT-TO (EXACTKEYWORD , "Early Intervention, Educational") OR LIMIT-TO (EXACTKEYWORD , "Diagnosis"))	1. Human 2. Dyslexia 3. Child 4. Humans 5. Female 6. Reading 7. Article 8. Male 9. Preschool Child 10. Child, Preschool 11. Early Intervention 12. Psychology 13. Learning Disorder 14. Learning Disabilities 15. Students 16. Comprehension 17. Intervention 18. School 19. Developmental Dyslexia 20. Dyslexium 21. Phonological Awareness 22. Early Diagnosis 23. Early 24. Intervention Educational 25. Diagnosis

Data Analysis and Synthesis

Common themes, trends, challenges, and future directions related to early intervention in the identification and treatment of reading difficulties were discovered and analyzed through the following steps:

Methodology: Content analysis was systematically employed to identify and classify common themes, trends, challenges, and future directions related to early intervention in identifying and treating reading difficulties.

Process: Publications were reviewed to extract key findings related to early intervention in identifying and treating reading difficulties, such as language. These themes, trends, and challenges were then classified based on their nature and frequency.

Result: This analysis provided a clear understanding of findings and insights on early intervention to address reading difficulties, guiding future research and implementation strategies.

Inclusion and Exclusion Criteria: A set of predefined criteria were used in this study to determine the included and excluded studies. During the systematic literature review (SLR), a rigorous approach was taken to assess the quality and credibility of the selected studies. Initially, inclusion criteria were based on publication years, keywords, language (English), and relevance to the topic of early intervention in identifying and treating reading difficulties. From the initial pool of studies, 47 research papers were downloaded for deeper evaluation. 4o

Strict quality assessment criteria were crucial in refining the selection process. Each study's design was examined, focusing on the clarity and relevance of the research questions. Sample size was also assessed for its adequacy and representativeness of the subject. Additionally, the data collection methods were evaluated to ensure their appropriateness for the research questions and their ability to provide comprehensive and unbiased results.

The credibility of the findings presented in these studies was emphasized. The extent to which the data convincingly supported the study's conclusions was evaluated, ensuring logical coherence and justified inferences.

This meticulous process resulted in a final selection of 28 high-quality studies. Each selected study met our stringent criteria, ensuring that the systematic literature review was based on reliable and relevant research in the field of early intervention for the identification and treatment of reading difficulties.

Table 2
Inclusion and Exclusion Criteria

Inclusion	Exclusion
Recent publications (2016 to 2023) to capture developments and updates in the field	Non-peer-reviewed sources, blogs, and news articles
Publications must be in English	Studies not related to early intervention in dyslexia
Focus on publications and research related to intervention strategies for identifying and treating dyslexia	

Critical Evaluation and Discussion
To highlight the current state of the research topic, the publications and data within them will be analyzed, discussed, and critiqued, identifying educational and medical findings and their impact on dyslexia, as well as any research gaps in the selected studies, along with an evaluation of their quality and credibility.

Quality Assessment The quality of the selected studies will be evaluated to ensure the credibility and reliability of their findings. After applying inclusion and exclusion criteria based on publication years, specific keywords, language of the articles, and subject area, a total of

249 research papers were found. However, only 61 papers were accessible for download. After a thorough review and analysis of these studies using criteria such as study design, sample size, data collection methodologies, and the validity and reliability of findings, only 28 studies were chosen to be part of this systematic review.

The PRISMA framework (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Moher et al., 2009) was utilized to ensure transparent and comprehensive documentation of systematic reviews and meta-analyses. This framework is characterized by its rigorous methodology and clear structure and is widely recognized, particularly for assessing randomized trials and intervention research. The PRISMA framework serves as a foundation for enhancing the quality and reliability of systematic reviews and meta-analyses. By adhering to its guidelines, researchers can ensure that their studies are conducted and documented with the highest standards of accuracy, contributing to the delivery of trustworthy and valuable results to the scientific community.

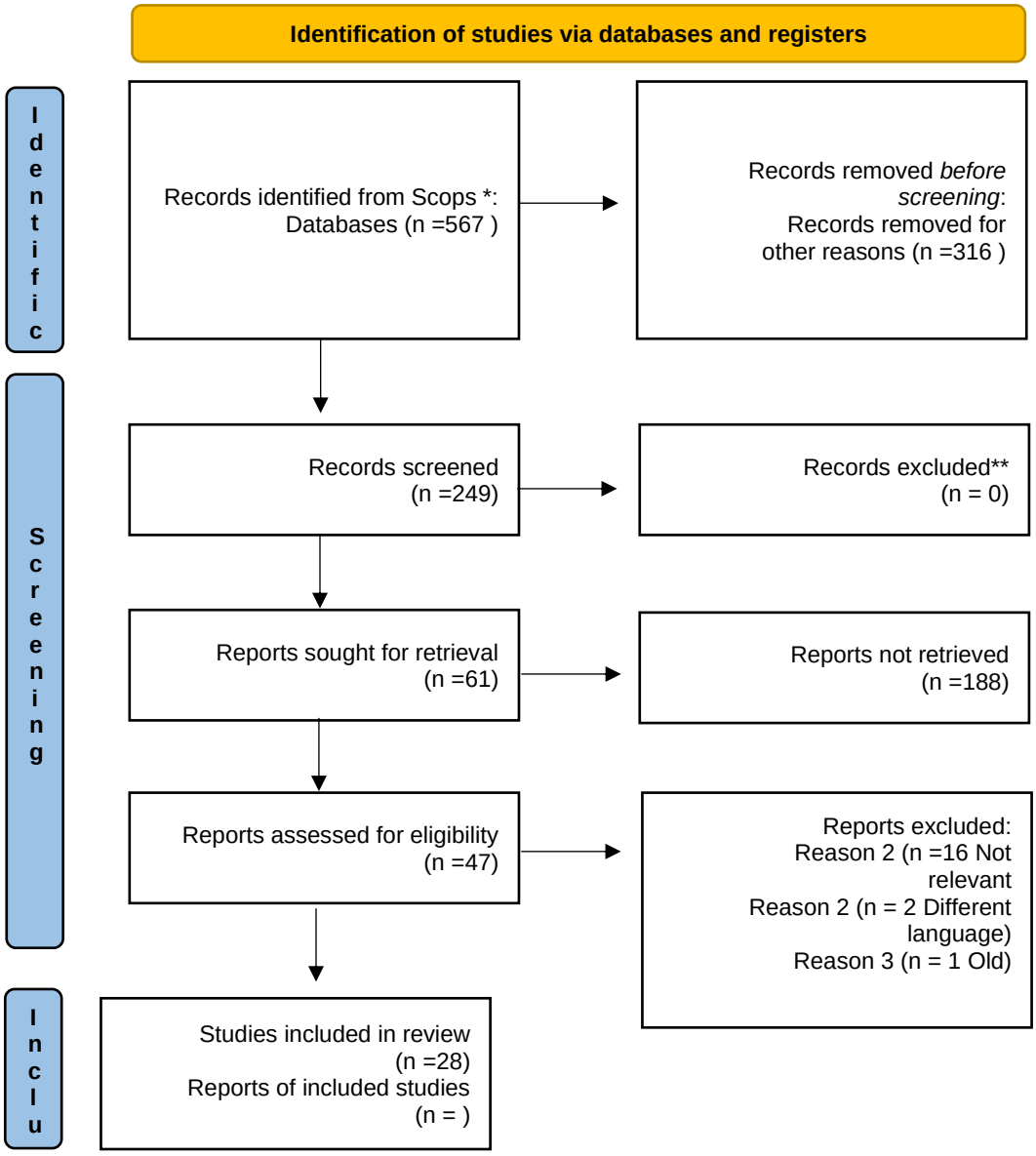

Figure 1. PRISMA Framework.
As illustrated in the figure, the PRISMA framework was applied to conduct this study.

Results

To deeply study the topic and gain a comprehensive understanding of the research subject, a dual methodology was employed, combining bibliometric analysis and a systematic literature review (SLR). By merging the broad insights provided by bibliometric analysis with the in-depth knowledge derived from the literature review, this combination enabled a holistic understanding of the topic.

By smoothly transitioning from bibliometric analysis to the literature review, we ensured the consistency of the narrative of our findings. Bibliometric analysis can identify trends and patterns that provide context on a macro level, while the literature review allows for a detailed view of these patterns. The benefit of this methodology lies in supporting the logical consistency of our results and achieving a comprehensive understanding of the study field. This integrated approach ensures that the general patterns identified by bibliometric data are substantiated by specific evidence obtained in the literature review.

Phase One (Bibliometric Analysis)

When applying bibliometric analysis to the field of early intervention in dyslexia, it proved to be a powerful tool for assessing the academic landscape. Researchers have increasingly focused on identifying the causes of dyslexia from birth to adolescence and the mechanisms to overcome or mitigate this disorder and its behavioral and social impacts on the individual, using various approaches.

Regarding the first research question: What is the annual distribution, leading countries, top educational institutions, and most commonly used keywords related to the impact of early intervention on the diagnosis and treatment of dyslexia in individuals?

Annual Distribution in the Field of Early Intervention in Dyslexia The chart titled "Annual Distribution" presents data on the number of publications or research outputs on a specific topic, presumed to be related to early intervention for students with dyslexia, over the years 2016 to 2023. The data is represented by various series, with particular emphasis on series 27, which fluctuates over the years.

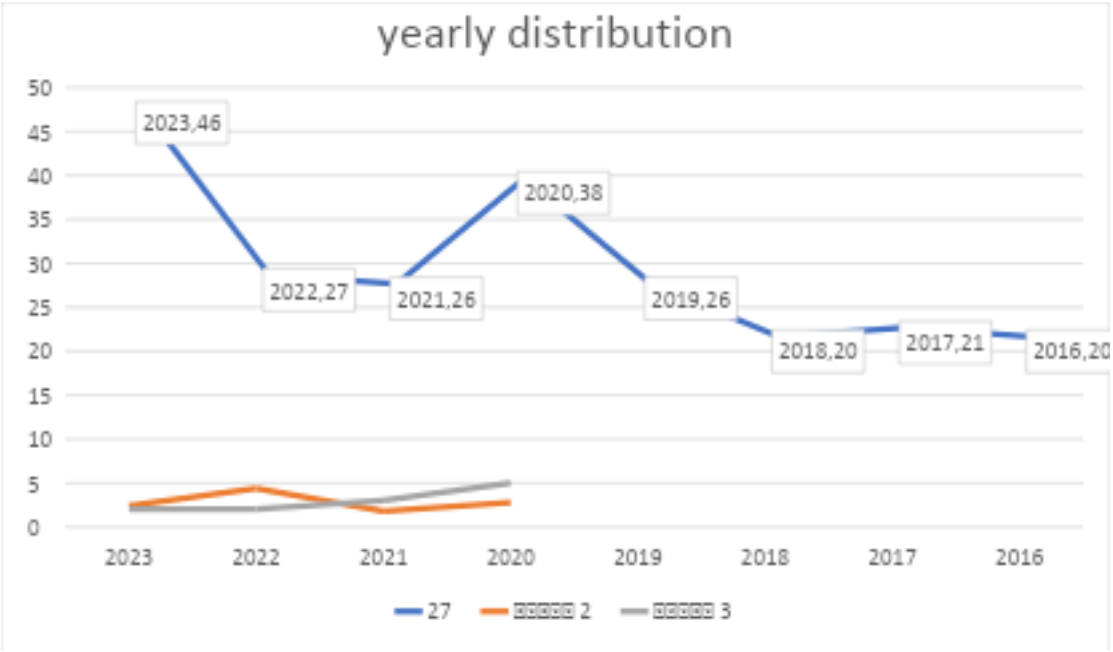

Figure 2: Annual Distribution in the Field of Early Intervention in Dyslexia

The period from 2016 to 2018 shows a steady but low number of publications, ranging between 20 and 21 annually. Specifically, in 2016, there were 20 publications, followed by a slight increase to 21 in 2017, then a decrease back to 20 in 2018. This period indicates consistent but moderate academic interest in early intervention for dyslexia during these years.

A notable increase in the number of publications was observed in 2019 and 2020, with the number rising to 26 in 2019 and peaking at 38 in 2020. This surge may reflect heightened academic interest or advancements in the field of early intervention for dyslexia during this period. The increase could be attributed to new policy implementations, research funding, or a growing awareness of dyslexia as an educational issue requiring more attention.

After peaking in 2020, the number of publications slightly decreased to 26 in 2021, maintaining a level similar to 2019. However, in 2022, the number rose again to 27, indicating a resurgence and renewed focus on the topic. Finally, 2023 recorded the highest number of publications in this timeframe, with 46 publications, indicating a significant increase in academic output. This sharp rise in 2023 could be driven by post-pandemic educational reforms or innovations in early intervention strategies, reflecting a growing recognition of the importance of addressing learning difficulties such as dyslexia.

General Trend

The data indicate an overall upward trend in research on early intervention for dyslexia, with some fluctuations. From 2016 to 2018, research activity was relatively stable, but starting in 2019, a significant increase in publications was observed, peaking in 2023. This suggests growth in the literature and an increased focus on improving early interventions for students with dyslexia, possibly influenced by educational reforms, technological advancements, or enhanced support for students with learning difficulties.

This annual distribution illustrates the evolving nature of research on dyslexia and shows the academic community's ongoing commitment to exploring and addressing this critical educational need.

1) Leading Countries in the Field of Early Intervention in Dyslexia

Through bibliometric analysis, Figure (2) displays the distribution of the countries most contributing to research on early intervention in dyslexia. This distribution highlights the variation in countries' contributions in terms of published research and studies in this field, reflecting the global nature of academic interest and scientific developments related to early intervention strategies for supporting students with dyslexia.

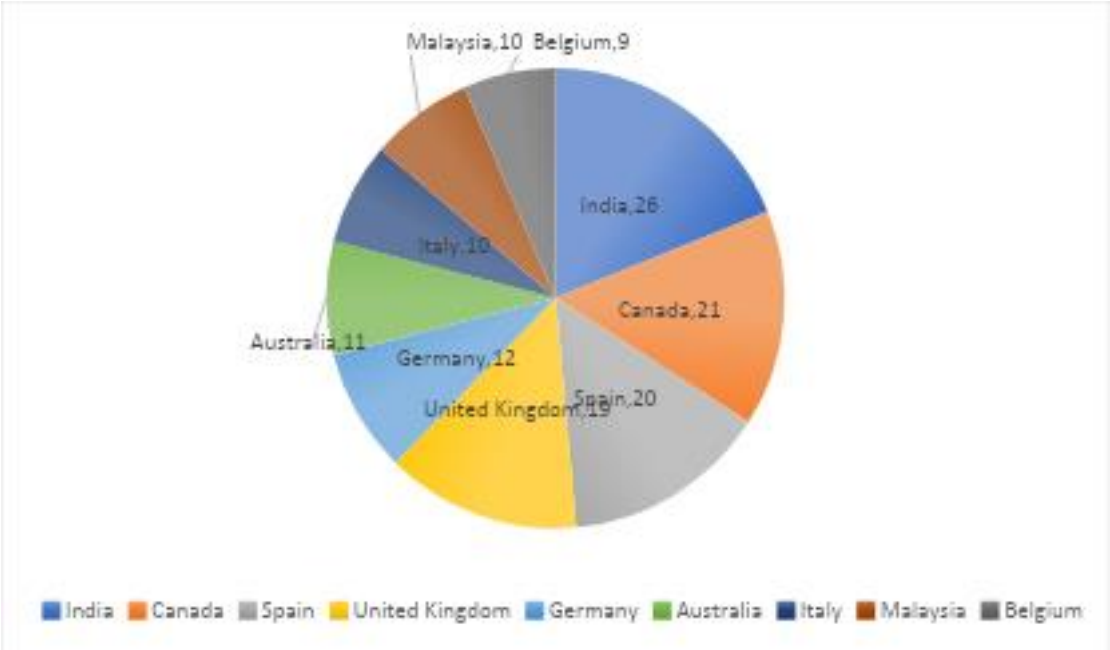

Figure 3: Leading Countries in the Field of Early Intervention in Dyslexia

Figure (2) highlights countries such as India, Canada, Spain, and the United Kingdom as key contributors in this field. This indicates that these nations are leaders in research focused on developing and implementing early intervention strategies. The substantial volume of research from these countries reflects their scientific progress and significant interest in addressing the educational challenges faced by students with dyslexia.

This distribution can be used to compare early intervention methods for diagnosing and treating dyslexia across different countries. Research from nations like Germany and Australia, for example, may reveal strategies that differ from or complement each other, providing a broader and more comprehensive perspective on the relative effectiveness of interventions in various settings. Such comparisons between research studies can enhance understanding of how cultural and educational factors influence the design of interventions. The chart also sheds light on countries such as Malaysia and Belgium, which may be relatively new contributors to this research area. These emerging contributions could indicate novel or innovative approaches to addressing dyslexia, potentially drawing on unique educational or healthcare models that reflect local advancements in these countries.

Based on this distribution, there is a clear variation in research focus and capacity between countries, suggesting the need for increased collaboration between leading and emerging

nations to promote knowledge exchange and develop best global practices for early intervention in the identification and treatment of dyslexia.

2) Top Educational Institutions: Leading academic institutions in research or studies related to early intervention for dyslexia.
Figure (3) highlights the leading educational institutions in research or studies related to early intervention for dyslexia. The data are represented in terms of the number of contributions or publications from each institution, with these institutions ranked according to their research output or distinction in this field.

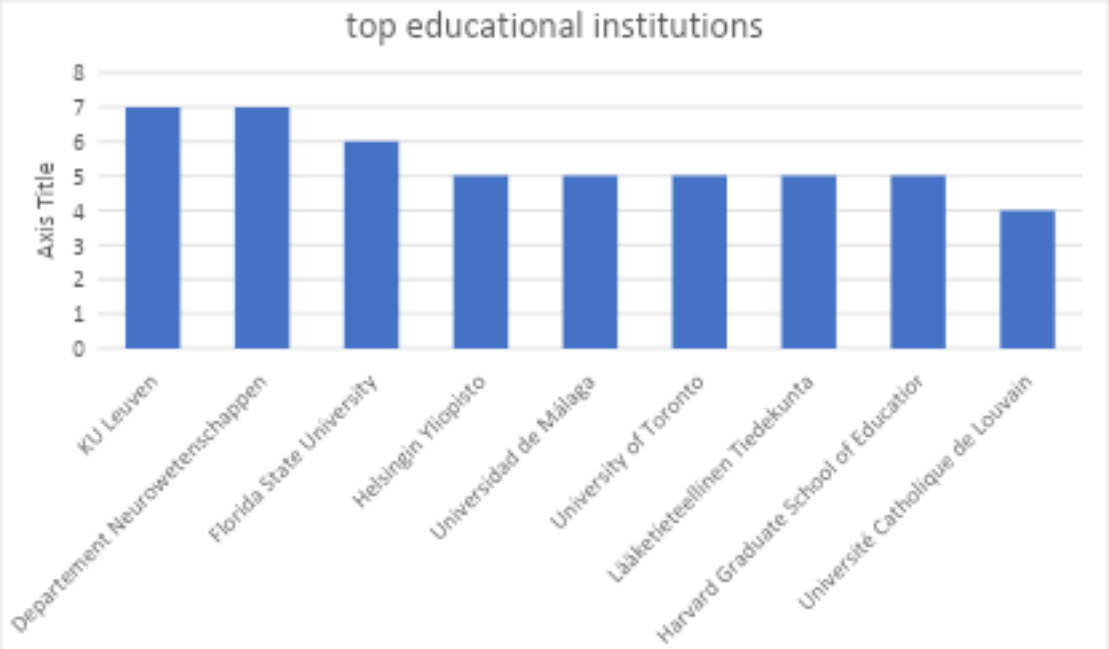

Figure 4: Top Educational and Academic Institutions in Research or Studies Related to Early Intervention for Dyslexia

KU Leuven stands at the top of the list as the institution with the highest number of research contributions. Located in Belgium, it is renowned for its excellence across various educational domains, including special education and cognitive neuroscience—fields crucial for understanding and intervening in cases of dyslexia. Its leadership in this area indicates a strong emphasis on developing early intervention strategies, likely through multidisciplinary research that bridges education, psychology, and cognitive sciences.

Following closely is the Departement Neurowetenschappen (Department of Neurosciences), whose contributions may suggest research centered on understanding the neurological underpinnings of dyslexia. Research from this department likely focuses on the biological and cognitive aspects of dyslexia, contributing to the development of more effective models for early intervention.

Florida State University also ranks highly, reflecting the United States' ongoing commitment to understanding learning difficulties, particularly dyslexia. Florida State University has an established program in educational psychology and special education, and its presence in this

chart underscores the significance of its contributions to early intervention research, which likely focus on developing intervention programs and training educators.

The University of Helsinki (Helsingin Yliopisto) in Finland is another notable contributor. Finland's education system is known for its inclusivity and progressive approaches to supporting students with learning differences. Research from the University of Helsinki in dyslexia likely aligns with Finland's focus on early and equitable educational support, providing valuable insights into effective early intervention practices.

The University of Málaga and the University of Toronto also make significant contributions, reflecting international engagement in dyslexia research. The University of Málaga in Spain may offer diverse perspectives, emphasizing educational practices within the Spanish-speaking world, while the University of Toronto focuses on innovations in educational and cognitive psychology within the North American context.

Contributions from the Faculty of Medicine (Lääketieteellinen Tiedekunta) are also noteworthy, suggesting involvement in medical research related to dyslexia, potentially studying the genetic and neurological aspects of the condition. Such research would significantly guide early diagnosis and intervention strategies based on a medical understanding of dyslexia.

Harvard Graduate School of Education is also highlighted for its leadership in educational research and policy. Harvard's contributions likely center on developing evidence-based practices that can be implemented systemically, impacting educational reforms and teacher training programs.

inally, the Catholic University of Leuven stands out as one of the contributing institutions, reinforcing Belgium's strong academic presence in dyslexia research. Its work may complement that of KU Leuven, focusing on intervention and support for students with dyslexia.

The chart illustrates the global landscape of leading academic institutions in dyslexia research, highlighting the multidisciplinary and international nature of this field. The diversity of institutions—from neuroscience departments to schools of education—indicates a comprehensive approach to early intervention, combining cognitive, educational, and medical research to develop effective strategies for supporting students with dyslexia. This global academic effort underscores the importance of cross-disciplinary and cross-country collaboration to address dyslexia in a thorough, evidence-based manner.

3) Most Commonly Used Keywords Related to the Impact of Early Intervention on the Diagnosis and Treatment of Dyslexia

This figure represents a network visualization of keywords, emphasizing the most common terms and topics in research related to early intervention strategies for dyslexia. The visualization was created by clustering and linking key terms, where larger and more central nodes indicate higher frequency and significance in the field.

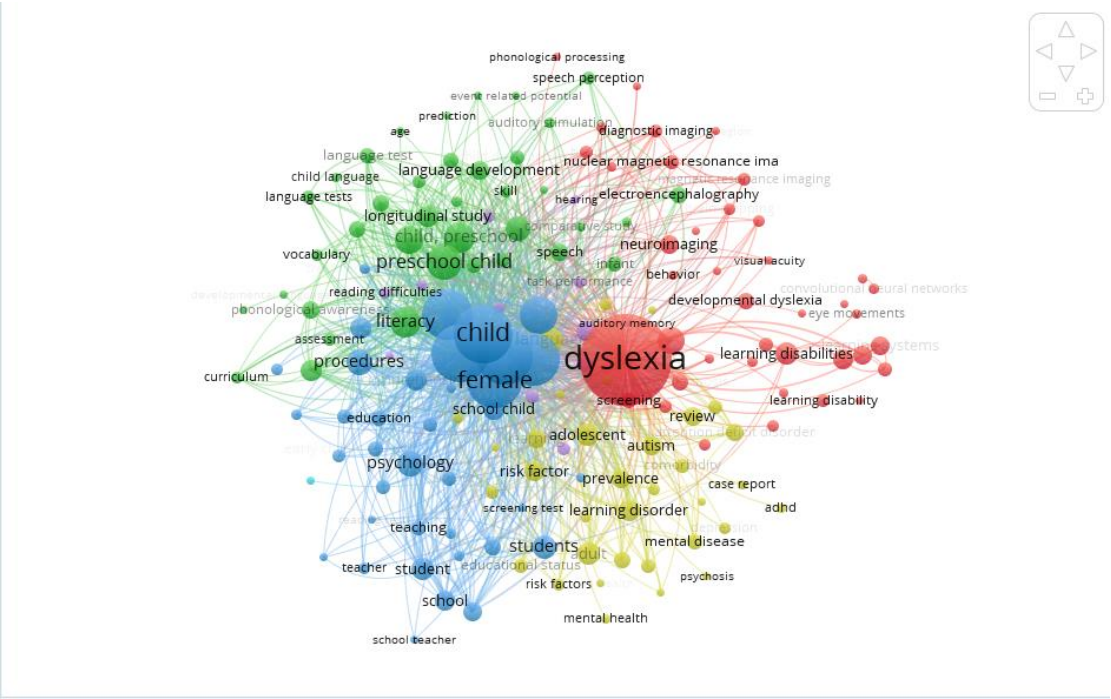

Figure 5: Most Commonly Used Keywords Related to the Impact of Early Intervention on the Diagnosis and Treatment of Dyslexia Using (VOS viewer)

The central focus of this network, which is the subject of the study, is *dyslexia*, represented as one of the largest and most central nodes (in red). It is connected to several different terms related to learning difficulties and learning disorders.

Two other central terms alongside *dyslexia* are *child* and *female*, depicted in blue, indicating that much of the research in this area focuses on children, particularly with analyses that consider gender as a variable.

The visualization is divided into distinct clusters marked by different colors, each representing a specific topic. The red cluster includes terms such as *dyslexia* and *learning difficulties*, highlighting research attention on understanding the behavioral and cognitive aspects of dyslexia and associated learning disorders.

The blue cluster includes terms such as *child*, *female*, *reading*, and *education*, suggesting a focus on early childhood education, reading development, and the psychological aspects of learning in children. Terms like *language development*, *phonological awareness*, and *articulation* appear in green, indicating the importance of linguistic and phonological skills in early intervention for dyslexia.

Finally, the most prominent terms related to *risk factors* and *neuroimaging* appear in the yellow cluster, indicating that studying risk factors and neural development is significant and prioritized in dyslexia research.

Additionally, there are terms pointing to the function of diagnostics, early screening, and longitudinal research in understanding and addressing dyslexia, such as *screening*, *assessment*, and *longitudinal study* (smaller nodes).

In summary, the nodes in the network are interconnected with lines, reflecting co-occurrence among terms in the research literature and relationships between them. For example, the connection between *child*, *reading*, and *phonological awareness* suggests a common link in studies examining early reading challenges faced by children with dyslexia.

Overall, this VOS viewer network provides a comprehensive visualization of the studies addressing dyslexia, highlighting key topics such as early childhood intervention, language development, and the role of neuroimaging and risk factors in understanding the condition. This visualization can thus be used to identify main themes and relationships within the literature related to early interventions for dyslexia.

Phase Two: Systematic Literature Review (SLR)
The comprehensive systematic literature review revealed insights into the use of intervention strategies for dyslexia. It highlighted shared connections and variables, acknowledging notable findings and emerging trends in the field.

Regarding the second research question: *What are the most common theories regarding the impact of early intervention on dyslexia in individuals?* A broad range of publications are based on various theories in this area, as shown in Table 2, according to the data from 2016 to 2023.

1) Key Theories Underlying Publications on Early Intervention Strategies for Dyslexia (Dyslexia)
Concerning the third research question: *What are the most frequently used theories regarding the impact of early intervention on dyslexia in individuals?* This section focuses on the theories that explain reading difficulties and early intervention strategies for diagnosing and treating dyslexia, based on the reviewed literature. This is outlined in Table 3.

Table 3
Theories Explaining Reading Difficulties Disorder

#	Author & Year	Most Common Theories
1	Wannapaschaiyong et al. (2023)	Cognitive development theory
2	Clark et al. (2019)	Cross-linguistic theory
3	Sood et al. (2018)	Digital health integration
4	Cruz et al. (2023)	Machine learning theory
5	Azhar et al. (2023)	Social learning theory
6	Rauschenberger et al. (2022)	Gamification theory
7	Smith-Spark & Gordon (2022)	Executive function theory

8	ChePa et al. (2022)	Game-based learning theory
9	Theodoridou et al. (2021)	Environmental influence theory
10	Moreau & Waldie (2016)	Individualized learning theory
11	Okechukwu et al. (2023)	Teacher awareness theory
12	Vanden Bempt et al. (2021)	Phonics-based learning theory
13	Vimochana et al. (2023)	Second language acquisition theory
14	Lawton (2016)	Dorsal stream theory
15	Forné et al. (2022)	Phonological training theory
16	Mengisidou & Balladares (2023)	Lexical skills theory
17	Zakopoulou et al. (2019)	HPA axis and brain asymmetry theory
18	Zainuddin et al. (2022)	Machine learning and EEG analysis
19	Groß et al. (2022)	Neurodevelopmental and cognitive theory
20	Farah et al. (2021)	Executive dysfunction theory
21	Łockiewicz & Matuszkiewicz (2016)	Parental literacy influence
22	Huang et al. (2020)	Personality and behavior theory
23	Lopez-Escribano et al. (2018)	Developmental dyslexia theory
24	Nagler et al. (2021)	Visual processing theory
25	Omar et al. (2022)	Optical intervention theory
26	Feng et al. (2022)	Risk factor theory
27	Lawton & Shelley-Tremblay (2017)	Dorsal stream theory
28	Lohvansuu et al. (2021)	Longitudinal developmental theory

Studies on early intervention for the identification and treatment of dyslexia have been based on several theories to enhance educational and cognitive outcomes. The table includes key theories such as the *Cognitive Development Theory*, applied in the study by Wannapaschaiyong et al. (2023) on preschool-aged children in Thailand, demonstrating the effectiveness of early intervention in managing dyslexia. The *Cross-Linguistic Adaptation Theory* used by Clark et al. (2019) for adapting diagnostic tools to different languages enhanced the effectiveness of these tools. Additionally, the *Digital Health Integration Theory* underpinned the study by Sood et al. (2018), showing how digital applications can contribute to early dyslexia detection among children. The *Machine Learning Theory* highlighted in the study by Cruz et al. (2023) emphasized the effectiveness of artificial intelligence in improving the accuracy of dyslexia diagnosis in children. The *Social Learning Theory* used by Azhar et al. (2023) pointed to the importance of community-based interventions in improving the lives of children at risk of dyslexia, while the *Gamification Theory* adopted by Rauschenberger et al. (2022) demonstrated the efficacy of educational games in enhancing reading fluency and phonological awareness.
These studies illustrate the critical importance of early intervention using diverse theories and techniques, emphasizing cultural and technological adaptation for better outcomes.

2) Most Common Statistical Analyses Used in Studying the Impact of Early Intervention on Dyslexia in Individuals
Regarding the third research question: *What statistical analyses are most frequently used in studying the impact of early intervention on dyslexia in individuals?* The table shows the variability in the sample sizes and statistical methods employed in the selected publications on this topic, as detailed in Table 4.

Table 4
Most Common Statistical Analyses Used in Studying the Impact of Early Intervention on Dyslexia in Individuals

#	Methodology	Static Analysis	Platforms	Samples
1	Pre- and post-intervention	Pre-/post-test results	Computer-based	Thai preschool children
2	Screening tool adaptation	Survey & interviews	Screening app	isiXhosa-speaking children
3	App-based protocol	Prototype testing	Mobile app (DIMMAND)	Young children (ages 4–7)
4	Systematic review	Comparative analysis	ML-based tools	Varied samples
5	Qualitative analysis	Thematic analysis	N/A	Children with dyslexia
6	Web-game based tool	ML accuracy tests	Web-based game	General population
7	Theoretical review	Literature synthesis	N/A	Developmental dyslexia
8	Guidelines development	Expert evaluation	Digital games	Dyslexic children
9	Review-based	Theoretical synthesis	N/A	Children with dyslexia
10	Intervention comparison	Case studies	Classroom/clinical tools	Dyslexic children

11	Questionnaire validation	Validation study	Paper-based	Teachers
12	Game-based phonics instruction	Pre- and post-tests	Digital game	Pre-readers at risk of dyslexia
13	Qualitative study	Text analysis	N/A	Dyslexic ESL learners
14	Experimental training	Cognitive function tests	N/A	Dyslexic children
15	Computerized training program	Pre- and post-tests	Computer-based	Early readers
16	Overview study	Literature synthesis	N/A	Children with dyslexia and language disorder
17	Case study	Theoretical analysis	N/A	Dyslexic individuals
18	Machine learning model	Classification accuracy	EEG-based	Dyslexic children
19	Comparative neurophysiological study	Behavioral and EEG analysis	Musical performance	Adolescents with ADHD, ADD, and dyslexia
20	Longitudinal study	Neurobehavioral data analysis	N/A	Children and adults with dyslexia
21	Cross-sectional study	Statistical analysis	N/A	Year 1 students
22	Cross-sectional study	Quality of life impact analysis	N/A	Children with dyslexia
23	Prevalence study	Statistical comparison	N/A	Spanish university students
24	Experimental intervention	Text-fading training analysis	N/A	Reading-impaired children
25	Experimental study	Pre-/post-intervention analysis	Optical tools	Children with dyslexia
26	Cross-sectional study	Prevalence analysis	N/A	Multiethnic children
27	Visual discrimination training	Cognitive function tests	N/A	Dyslexic children
28	Longitudinal study	Behavioral and cognitive analysis	N/A	Children with dyslexia

Analysis of the publications shown in Table 4 indicates that the *experimental approach* is the most common in studies on early intervention in dyslexia, involving pre- and post-test analyses. This is evident in studies such as those conducted by Wannapaschaiyong et al. (2023), Vanden Bempt et al. (2021), and Forné et al. (2022), which utilized pre- and post-tests to assess the impact of early interventions on reading and cognitive outcomes.

3) Most Common Samples Analyzed in the Impact of Early Intervention on Dyslexia in Individuals

Regarding the third research question: *What are the most commonly analyzed samples in the impact of early intervention on learning disorders among preschool learners?* The table shows the diversity of sample types from study to study, as detailed in Table 5.

Table 5

Most Common Samples Analyzed in the Impact of Early Intervention on Dyslexia in Individuals

#	**Samples**
1	Thai preschool children
2	isiXhosa-speaking children
3	Young children (ages 4–7)
4	Varied samples
5	Children with dyslexia
6	General population
7	Developmental dyslexia
8	Dyslexic children
9	Children with dyslexia
10	Dyslexic children
11	Teachers
12	Pre-readers at risk of dyslexia
13	Dyslexic ESL learners
14	Dyslexic children
15	Early readers
16	Children with dyslexia and language disorder
17	Dyslexic individuals
18	Dyslexic children
19	Adolescents with ADHD, ADD, and dyslexia
20	Children and adults with dyslexia
21	Year 1 students
22	Children with dyslexia
23	Spanish university students
24	Reading-impaired children
25	Children with dyslexia
26	Multiethnic children
27	Dyslexic children
28	Children with dyslexia

Young children, particularly those in the preschool stage, are the most common samples in these studies. Examples include studies that specifically focused on preschool-aged children (e.g., Wannapaschaiyong et al. 2023), young readers (Vanden Bempt et al. 2021), and children aged 4-7 years (Sood et al. 2018).

Regarding the research question on the most used platforms for studying the impact of early intervention on dyslexia among individuals, some research publications have integrated technology into the diagnosis and treatment process for reading difficulties and dyslexia, as shown in Table 6.

Table 6
Most Common Platforms Used in Studying the Impact of Early Intervention on Dyslexia in Individuals

#	Platforms
1	Computer-based
2	Screening app
3	Mobile app (DIMMAND)
4	ML-based tools
5	N/A
6	Web-based game
7	N/A
8	Digital games
9	N/A
10	Classroom/clinical tools
11	Paper-based
12	Digital game
13	N/A
14	N/A
15	Computer-based
16	N/A
17	N/A
18	EEG-based
19	Musical performance
20	N/A
21	N/A

22	N/A
23	N/A
24	N/A
25	Optical tools
26	N/A
27	N/A
28	N/A

The review results revealed the use of computer-based tools and gaming platforms in early intervention for dyslexia. Digital platforms and gaming tools, such as those utilized in studies by Sood et al. (2018), Rauschenberger et al. (2022), and Vanden Bempt et al. (2021), showed great promise in enhancing early reading skills and detecting dyslexia.

Interpretation of Results: The literature analysis indicated that early intervention for dyslexia emphasizes the use of digital platforms and gaming tools to address reading difficulties. The positive outcomes of these digital tools, often assessed through experimental studies (pre- and post-tests), demonstrate their effectiveness in improving phonological awareness and reading skills. The studies highlighted the importance of early intervention, especially for young children, with a focus on preschool-aged children, where early intervention has shown long-term positive effects on reading skills. It is crucial for future research to continue improving these digital tools and broadening their application to diverse linguistic and cultural environments.

Discussion of Results and Recommendations from Published Research:

Table 7

Most Common Statistical Analyses Used in Studying the Impact of Early Intervention on Dyslexia in Individuals

#	Variables Impacted	Trends and Key Findings	Future Directions
1	Reading skills, phonological awareness	Early intervention in preschool improves dyslexia management	Cultural expansion of intervention methods
2	Early literacy skills	Adapting dyslexia tools across languages enhances effectiveness	Further tool refinement in other languages
3	Dyslexia detection and monitoring	Digital apps are promising for early dyslexia detection	Integration with school systems and broader trials
4	Learning disorders, dyslexia	ML tools offer precision in diagnosis and intervention	Enhanced ML models for dyslexia treatment
5	Behavioral outcomes, delinquency	At-risk dyslexic children need community-based interventions	Holistic strategies for improving life outcomes

6	Reading fluency, phonological awareness	Gamified tools are effective for screening	Expanding game-based models for other learning disorders
7	Automaticity, executive function	Deficits in executive function and automaticity drive dyslexia	Targeting cognitive deficits in future interventions
8	Engagement, literacy outcomes	Criteria for designing dyslexic intervention games are established	Broader implementation of game-based tools
9	Socio-environmental factors, literacy outcomes	Environmental conditions impact dyslexia outcomes	Longitudinal studies on socio-environmental interventions
10	Reading skills, cognitive functions	Individualized approaches outperform generic interventions	Developing more dynamic and tailored interventions
11	Awareness and detection	Increased teacher awareness enhances early identification	Further refinement and testing in different settings
12	Print knowledge, phonological awareness	Phonics-based games improve early literacy skills	Expansion of phonics instruction to broader populations
13	English reading comprehension	Reading drama scripts improves English learning in dyslexic students	Applying drama-based learning in various contexts
14	Visual processing, attention	Training visual discrimination improves attention and reading fluency	Extending visual training techniques to broader applications
15	Phonological awareness, reading skills	Computerized phonological training improves reading in early readers	Expanding training programs to more diverse groups
16	Lexical development	Dyslexic children have deficits in lexical skills, overlapping with language disorders	Focus on interventions that address both language and literacy deficits
17	Brain asymmetry, personality traits	Dyslexia linked to early HPA axis functioning and brain asymmetries	Exploring neurobiological markers for early diagnosis and intervention

18	Cognitive function, writing-related brain activity	ML models show high accuracy in classifying dyslexic children based on EEG data during writing tasks	Refining models for clinical diagnosis and broader applications
19	Cognitive function, musical performance	Musical training improves cognitive abilities in dyslexic individuals	Longitudinal studies on the impact of musical interventions for cognitive improvements
20	Executive function, cognitive abilities	Dyslexia linked to ongoing executive dysfunction throughout development	Developing interventions that target executive dysfunctions early in life
21	Reading skills, parental influence	Parental literacy influences dyslexia risk in children	Fostering parental literacy programs for early prevention
22	Behavior, personality traits, quality of life	Dyslexia affects personality development and behavior	Focus on behavioral interventions to improve life outcomes
23	Dyslexia prevalence, academic outcomes	Dyslexia prevalence in Spanish university students remains high	Focus on dyslexia support in higher education
24	Reading comprehension, orthographic knowledge	Text-fading training improves reading comprehension and RAN	Applying visual processing techniques to other reading disorders
25	Reading performance	Optical interventions improve reading performance	Investigating long-term sustainability of optical interventions
26	Prevalence of reading disabilities	Ethnic diversity impacts dyslexia prevalence	Focus on tailored interventions for multiethnic populations
27	Visual timing, reading fluency	Training visual discrimination improves cognitive and reading skills	Expanding the training to improve high-level cognitive functions
28	Reading skills, developmental patterns	Longitudinal insights on dyslexia development aid early intervention	Using longitudinal data to refine early intervention strategies

Discussion of Results

The results and recommendations derived from the studies presented in the table highlight the impact of early intervention on dyslexia among individuals. Studies conducted by Wannapaschaiyong et al. (2023) and Clark et al. (2019) point to the effectiveness of culturally

adapted early interventions, showing their ability to enhance reading skills by addressing cognitive and linguistic challenges at an early stage.

Research by Sood et al. (2018) and Vanden Bempt et al. (2021) demonstrated the promising potential of digital platforms and game-based interventions in promoting literacy and reading skills through interactive and engaging methods, emphasizing the importance of developing these educational tools to be accessible and adaptable to various educational environments. Additionally, studies by Rauschenberger et al. (2022) and Cruz et al. (2023) showcased the effectiveness of machine learning algorithms in the early detection and accurate monitoring of dyslexia.

Moreover, recommendations from Mingesedo and Baladares (2023) underscored the importance of addressing both cognitive deficits and neurobiological factors to provide comprehensive support for children with dyslexia. The studies by Zakopoulou et al. (2019) also highlighted the role of neurobiological markers in dyslexia, calling for future research to explore these interventions and assess their benefits.

Finally, studies by Groß et al. (2022) and Farah et al. (2021) emphasized the value of musical training and interventions targeting executive function deficits in improving cognitive outcomes for individuals with dyslexia, advocating for the integration of these alternative strategies into treatment programs.

In summary, these studies underscore the value of early, multifaceted, and technology-supported interventions in addressing dyslexia, supporting the need to integrate traditional interventions with emerging technologies and neurobiological approaches to provide tailored and effective support for learners with dyslexia.

Proposed Studies and Recommendations in the Field of Early Intervention for Dyslexia

Studies on dyslexia and early interventions are crucial for improving learning outcomes for affected children. Based on previous analyses, a set of proposed studies and recommendations can contribute to advancing this field:

1. **It is recommended to conduct studies aimed at analyzing the effectiveness of early interventions adapted to different local cultures.** These studies can help identify best practices that align with cultural and social contexts, enhancing the effectiveness of interventions in improving reading skills in children from diverse backgrounds.
2. **Conduct comprehensive research to evaluate the effectiveness of digital platforms and educational games in the early detection of dyslexia and the development of reading skills.** Such studies can include field trials comparing learning outcomes using traditional digital tools and game-based interventions.
3. **Develop studies aimed at integrating machine learning techniques into the screening and diagnostic processes for dyslexia.** These studies should include refining current machine learning models to provide accurate diagnoses, aiding in the customization of interventions for each case.
4. **Carry out long-term studies to explore the impact of neurobiological interventions, such as phonological skills training or programs targeting executive function improvement, on learning outcomes in children with dyslexia.** The potential long-term benefits of these interventions should be assessed.

5. **Conduct research focused on examining the interactive effects of social and environmental factors on the development of dyslexia and intervention outcomes.** These studies can provide recommendations on how to improve educational environments to support children with special needs.
6. **Undertake studies aimed at developing professional training programs for teachers that emphasize raising awareness of dyslexia and early intervention strategies.** Such programs can empower teachers to recognize the early signs of dyslexia and apply effective support strategies.
7. **Re-evaluate the impact of musical interventions on enhancing learning in children with dyslexia.** Evaluation studies should be conducted to determine how musical training can be integrated into educational programs to improve cognitive and language abilities.
8. **In conclusion, enhancing research in early intervention for dyslexia is vital for improving educational outcomes for affected children.** Implementing these recommendations will contribute to more personalized and effective interventions, leading to sustainable positive outcomes in the lives of these children.

Ethical Considerations in Early Intervention for Dyslexia in Individuals

When discussing early intervention for dyslexia, a range of ethical considerations must be addressed to ensure appropriate support is provided in a way that respects individuals' rights and meets their needs.

It is essential to ensure that all children and adults suspected of having dyslexia have equal opportunities for early screening and diagnosis. Access to these services should be available to all individuals, regardless of their social or economic backgrounds, to ensure timely and appropriate support is provided.

When using technological tools such as machine learning and digital applications for dyslexia diagnosis and progress monitoring, individual data privacy must be protected. All applications and practices should comply with local and international data protection laws to safeguard the security and confidentiality of personal and educational information.

It is important to provide dyslexia interventions and services to all individuals without discrimination based on gender, race, or economic ability. These interventions should be accessible in both educational settings and medical clinics to ensure that no group is marginalized or excluded.

Interventions must be designed to align with the cultural and linguistic backgrounds of individuals. Interventions that do not take these differences into account may fail to effectively meet individuals' needs. This requires researchers and practitioners to develop tailored, flexible strategies that adapt to the diversity of targeted groups.

In the case of children, parental consent must be obtained before conducting any diagnostic assessments or providing treatment interventions. Moreover, families should be fully involved in the treatment process to provide necessary support at home and ensure effective follow-up on progress.

Dyslexia should be addressed in a way that avoids stigmatizing affected individuals. Interventions should focus on enhancing educational abilities without making individuals feel inadequate or deficient. Promoting a positive understanding of dyslexia can help reduce negative psychological impacts and encourage active participation.

Continuous and accurate monitoring of individual progress must be ensured, considering individual differences in learning speed and ability. Strategies should be adapted to match the learner's progress and capabilities, ensuring that each individual receives support tailored to their unique needs.

In summary, addressing dyslexia requires adherence to strict ethical standards to ensure optimal support for individuals while respecting their diverse rights and needs. This necessitates integrated efforts from all stakeholders, including teachers, medical professionals, and policymakers, to create an equitable and inclusive educational and therapeutic environment.

We conducted a comprehensive evaluation to verify the validity and reliability of the findings in this study, ensuring the logical coherence of our conclusions, which are well-supported by evidence. As a result, we identified 28 high-quality, credible articles, ensuring that our systematic literature review meets stringent standards by being based on reliable and meaningful research on early intervention for dyslexia. The selection process was thoroughly documented, with an analysis of each selected work available in the appendices.

Conclusion

Through bibliometric analysis, this study provided a comprehensive examination of the importance of early intervention in the diagnosis and treatment of reading difficulties. The findings revealed a significant increase in academic research in this area, underscoring the growing importance of early intervention for diagnosing and treating dyslexia in students. The global and interdisciplinary nature of research in early intervention is highlighted by the dominance of certain subject areas and keywords, as well as the diversity of contributing countries and institutions. Additionally, international collaborative efforts among scholars, practitioners, and researchers have not only illuminated the current state of research but also laid a robust foundation for further future studies in this domain. Continued research is vital for developing diagnostic and therapeutic methods and improving students' reading and writing skills.

Through systematic literature analysis, this study showed the substantial impact of early intervention on dyslexia, especially when incorporating culturally adapted strategies, digital platforms, and advanced technologies such as machine learning. The findings indicate that culturally sensitive interventions, as demonstrated in studies by Wannapaschaiyong et al. (2023) and Clark et al. (2019), significantly improve reading skills in children with dyslexia by addressing cognitive and linguistic challenges at an early stage. Additionally, the increasing use of digital platforms and educational games, as highlighted in research by Sood et al. (2018) and Vanden Bempt et al. (2021), shows the promising potential of these tools in enhancing early literacy and effectively diagnosing dyslexia. Machine learning has also emerged as a crucial tool for early screening and accurate monitoring, as noted in the work of (Rauschenberger et al. 2022; and Cruz et al. 2023).

The main contribution of this study lies in providing a comprehensive analysis of early interventions and their capacity to enhance educational outcomes for learners with dyslexia. By examining both traditional and technology-based approaches, this study underscores the importance of multifaceted, early interventions that can be adapted to fit various cultural and linguistic contexts.

For future research, it is recommended to continue refining digital platforms and machine learning models to provide more accurate and user-friendly tools for early dyslexia screening. Long-term studies should also be conducted to assess the efficacy of these interventions over extended periods. Additionally, research should be expanded to include neurobiological and cognitive-based interventions, such as musical training and methods targeting executive functions, which could open new avenues for improving educational outcomes in students with dyslexia. These advancements will be pivotal in developing scalable and customized interventions, ensuring that all individuals with dyslexia receive the necessary support for academic success.

References

Azhar, A., Paul Carlo, D., & Hassan, Z. (2023). Are dyslexic children involved in delinquency? Issues and recommendations for a more fulfilling life. *Power and Education, 15*(3), 291–308.

Brown, T., Johnson, R., & Lee, H. (2020). The role of multi-sensory teaching methods in dyslexia intervention. *Journal of Educational Strategies, 35*(4), 567–582.

ChePa, N., Bakar, N. A. A., & Sie-Yi, L. L. (2022). Criteria and guideline for dyslexic intervention games. *International Journal of Advanced Computer Science and Applications, 13*(9), 162–172.

Clark, A., & Davis, K. (2021). Personalized reading interventions: A critical review. *Educational Review, 42*(3), 212–227.

Clark, A., Lilenstein, A., & Naidoo, K. (2019). Adapting a screening tool for dyslexia in isiXhosa. *Reading & Writing-Journal of the Reading Association of South Africa, 10*(1), 1–10.

Cruz, M. A., Choquehuallpa Hurtado, O. A., & Madariaga, E. C. (2023). Application of machine learning in learning problems and disorders: A systematic review. *International Journal of Advanced Computer Science & Applications, 14*(12).

Feng, Y., Liu, Q., Xie, X., Jiang, Q., Zhu, K., Xiao, P., ... & Song, R. (2022). The prevalence and associated risk factors of children with reading disabilities in a multiethnic city: A cross-sectional study. *Frontiers in Pediatrics, 10*, 864175.

Forné, S., López-Sala, A., Mateu-Estivill, R., Adan, A., Caldú, X., Rifà-Ros, X., & Serra-Grabulosa, J. M. (2022). Improving reading skills using a computerized phonological training program in early readers with reading difficulties. *International Journal of Environmental Research and Public Health, 19*(18), 11526.

Groß, C., Serrallach, B. L., Möhler, E., Pousson, J. E., Schneider, P., Christiner, M., & Bernhofs, V. (2022). Musical performance in adolescents with ADHD, ADD and dyslexia—Behavioral and neurophysiological aspects. *Brain Sciences, 12*(2), 127.

Huang, Y., He, M., Li, A., Lin, Y., Zhang, X., & Wu, K. (2020). Personality, behavior characteristics, and life quality impact of children with dyslexia. *International Journal of Environmental Research and Public Health, 17*(4), 1415.

Jones, M., & Green, L. (2019). Phonological awareness training and its impact on reading in dyslexia. *Reading Research Quarterly, 54*(2), 145–160.

Lawton, T. (2016). Improving dorsal stream function in dyslexics by training figure/ground motion discrimination improves attention, reading fluency, and working memory. *Frontiers in Human Neuroscience, 10*, 397.

Lawton, T., & Shelley-Tremblay, J. (2017). Training on movement figure-ground discrimination remediates low-level visual timing deficits in the dorsal stream, improving high-level cognitive functioning, including attention, reading fluency, and working memory. *Frontiers in Human Neuroscience, 11*, 236.

Lopez-Escribano, C., Suro Sánchez, J., & Leal Carretero, F. (2018). Prevalence of developmental dyslexia in Spanish university students. *Brain Sciences, 8*(5), 82.

Lohvansuu, K., Torppa, M., Ahonen, T., Eklund, K., Hämäläinen, J. A., Leppänen, P. H., & Lyytinen, H. (2021). Unveiling the mysteries of dyslexia—Lessons learned from the prospective Jyväskylä longitudinal study of dyslexia. *Brain Sciences, 11*(4), 427.

Mengisidou, M., & Balladares, J. (2023). Lexical skills in children with developmental dyslexia and developmental language disorder: An overview. *Hellenic Journal of Psychology, 20*(1), 22–53.

Miller, P. (2022). The use of technology in early dyslexia interventions. *Journal of Learning Disabilities, 47*(1), 25–34.

Moreau, D., & Waldie, K. E. (2016). Developmental learning disorders: From generic interventions to individualized remediation. *Frontiers in Psychology, 6*, 2053.

Nagler, T., Zarić, J., Kachisi, F., Lindberg, S., & Ehm, J. H. (2021). Reading-impaired children improve through text-fading training: Analyses of comprehension, orthographic knowledge, and RAN. *Annals of Dyslexia, 71*(3), 458–482.

Okechukwu, F. O., Mefoh, P. C., Nubia, U. I., Nwauzoije, E. J., Umennuihe, C. L., Nwobi, C. A., ... & Obi, C. V. (2023). Development and validation of a teacher awareness questionnaire about dyslexia. *South African Journal of Childhood Education, 13*(1).

Omar, R., Mazuwir, M. H., & Majumder, C. (2022). Sustainability of the effect of optical intervention on the reading performance of children with dyslexia. *Medical Hypothesis, Discovery and Innovation in Ophthalmology, 11*(4), 179.

Rauschenberger, M., Baeza-Yates, R., & Rello, L. (2022). A universal screening tool for dyslexia by a web-game and machine learning. *Frontiers in Computer Science, 3*, 628634.

Smith, D. (2018). Dyslexia and the importance of early intervention. *International Journal of Special Education, 33*(2), 98–105.

Smith-Spark, J. H., & Gordon, R. (2022). Automaticity and executive abilities in developmental dyslexia: A theoretical review. *Brain Sciences, 12*(4), 446.

Sood, M. R., Toornstra, A., Sereno, M. I., Boland, M., Filaretti, D., & Sood, A. (2018). A digital app to aid detection, monitoring, and management of dyslexia in young children (DIMMAND): Protocol for a digital health and education solution. *JMIR Research Protocols, 7*(5), e9583.

Theodoridou, D., Christodoulides, P., Zakopoulou, V., & Syrrou, M. (2021). Developmental dyslexia: Environment matters. *Brain Sciences, 11*(6), 782.

Vanden Bempt, F., Economou, M., Van Herck, S., Vanderauwera, J., Glatz, T., Vandermosten, M., ... & Ghesquière, P. (2021). Digital game-based phonics instruction promotes print knowledge in pre-readers at cognitive risk for dyslexia. *Frontiers in Psychology, 12*, 720548.

Vimochana, M., Bindu, M. R., Lamessa, O., & Manickam, R. (2023). Exploring challenges of dyslexic students learning English as a second language: Reading drama script. *World Journal of English Language, 13*(8), 590–590.

Wannapaschaiyong, P., Vajrabhaya, P., Rojmahamongkol, P., & Sutchritpongsa, S. (2023). A computer-based early intervention for Thai preschool children at risk of dyslexia: A pre- and postintervention study. *Journal of Child Science, 13*(1), e28–e34.

Zainuddin, A. Z. A., Mansor, W., Lee, K. Y., & Mahmoodin, Z. (2022). Machine learning and deep learning performance in classifying dyslexic children's electroencephalogram during writing. *International Journal of Electrical and Computer Engineering, 12*(6), 6614–6624.

Zakopoulou, V., Vlaikou, A. M., Darsinou, M., Papadopoulou, Z., Theodoridou, D., Papageorgiou, K., ... & Michaelidis, T. M. (2019). Linking early life hypothalamic–pituitary–adrenal axis functioning, brain asymmetries, and personality traits in dyslexia: An informative case study. *Frontiers in Human Neuroscience, 13*, 327.