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Dyslexia screening: a bibliometric analysis in mapping research patterns and emerging trends

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ABSTRACT

Dyslexia is a neurodevelopmental disorder that hinders reading, spelling, and writing abilities, creating challenges for academic success and necessitating early screening for timely intervention. This study presents a bibliometric analysis of global research on dyslexia screening from 2000 to 2023, using VOSviewer version 1.6.19 to analyze 839 publications from the Web of Science Core Collection (WoSCC). The findings reveal a growing interest in dyslexia screening, with a steady increase in both publications and citations. Key journals, such as Dyslexia and Journal of Learning Disabilities, are identified as central contributors to the field. Keyword analysis shows a focus on diagnostic tools and associated comorbidities, while collaboration patterns highlight strong research networks in Europe, the United States, and emerging contributions from Australia, Canada, and Brazil. However, the study also underscores the need for more inclusive and cross-regional collaborations to ensure the global applicability of screening tools. The implications of this study are significant, offering a roadmap for future research and emphasizing the importance of developing culturally sensitive and widely accessible dyslexia screening methods. This comprehensive analysis sets the stage for more targeted and impactful research and interventions in the field of dyslexia screening.

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1. INTRODUCTION

Dyslexia, a neurodevelopmental disorder affecting reading, spelling, and writing abilities, despite normal intelligence and the absence of significant visual or auditory impairments [1], [2], poses a considerable challenge to academic development in children and may persist into adulthood if not identified and managed effectively [3], [4]. As scholars and practitioners strive to deepen their understanding of this complex condition, a comprehensive analysis of research patterns and trends is imperative. This bibliometric study aims to unveil the intricate tapestry of dyslexia research by systematically examining the scholarly landscape.

In recent decades, the field of dyslexia research has undergone substantial evolution, propelled by advancements in neuroimaging [5], [6], cognitive psychology [7], and educational methodologies [8]. There has been a significant trend in dyslexia towards integrating advanced technologies, including computerized [9], [10], eye-tracking devices [3], and neuroimaging techniques [11], [12], into dyslexia screening tools [13]. This technological shift aims to enhance precision and efficiency and provide deeper insights into the cognitive

processes associated with dyslexia. Interdisciplinary collaboration [5], [9], [11], [12], have emerged as a noteworthy pattern in dyslexia screening research, with researchers from psychology [14], neuroscience [15], education [16], [17], and technology enriching the understanding of dyslexia and developing comprehensive screening protocols [11], [13], [18].

This academic exploration, led by Helland [19], provides a comprehensive analysis of trends in early dyslexia screening, highlighting its critical role in promptly identifying and addressing learning challenges. Employing rigorous bibliometric methods, this study systematically examines the existing literature by emphasizing key indicators, such as citation patterns, collaborative networks, and thematic clusters. The analysis elucidates the evolving landscape of dyslexia screening, emphasizing technological integration, interdisciplinary collaboration, early intervention, data-driven approaches, and cross-cultural considerations.

A pivotal trend in current dyslexia screening research emphasizes the crucial need for early identification and intervention, specifically targeting preschool and early primary school years [3], [20], [21]. This recognition stems from a consensus in the academic community that intervention during these early stages significantly enhances outcomes for individuals with dyslexia. Concurrently, there is a growing focus on cross-cultural considerations, with researchers exploring the influence of cultural and linguistic factors on screening outcomes [17], [22], [23]. This trend aligns with a broader commitment to inclusivity and equity in dyslexia research with the aim of developing screening tools that are culturally sensitive and applicable across diverse populations.

Understanding study trends and patterns in dyslexia not only advances scientific knowledge, but also provides significant insights for stakeholders in designing more effective interventions and educational programs. Consequently, this bibliometric analysis is anticipated to contribute to deepen understanding of dyslexia by mapping key research trends, identifying influential studies, highlighting research gaps, thereby guiding future inquiries and advancing the field of dyslexia [24]. By synthesizing existing literature, the analysis will clarify critical concepts and inform evidence-based educational interventions, ultimately enhancing the effectiveness of strategies used to support individuals with dyslexia and paving the way for more targeted, impactful research and practice [25], [26]. Bibliometric analysis, an approach utilizing bibliographic data to examine and evaluate the impact of scholarly research in a specific field, holds promise for comprehensively understanding trends and patterns in dyslexia research [27]. Within the dyslexia context, bibliometric analysis allows for a nuanced exploration of research priorities, identification of key research themes, and assessment of prevalent methodologies employed [28].

To the best of our knowledge, few studies [24], [26], [29] have employed bibliometric analysis to discover and analyze themes and clusters in this area. The reliance on specific databases like the social sciences citation index (SSCI) and science citation index expanded (SCI-E) in [26], and the focus on top-cited studies in [24], could lead to a biased representation of the research landscape. These databases may not include all relevant studies, especially those published in non-English languages, regional journals, or emerging research areas, potentially overlooking significant contributions from less dominant regions or disciplines. Besides, Ram [29] conducted a foundational bibliometric study of dyslexia research, providing a global overview spanning five decades (1967–2016) using the Scopus database. While this study offers valuable historical insights, its long-time span may limit its ability to capture rapid developments in recent years. Building upon this work, Wu *et al*. [26] extended the analysis using a similar bibliometric framework with more recent data. However, both studies adopt a predominantly retrospective approach, which may underrepresent emerging research directions. In contrast, Zhang *et al*. [24] employed a citation-based bibliometric analysis focusing on the 100 most highly cited dyslexia studies indexed in the Web of Science. Although this approach effectively identifies influential publications, its emphasis on citation counts may bias the representation toward older, well-established research while overlooking newer but potentially impactful studies.

Despite this, a very limited literature review on dyslexia screening has used bibliometric analysis to assess progress in the field. To address these issues, bibliometric measurements are used to evaluate the amount of research published on dyslexia screening and identify gaps in the literature that might strengthen the justification and novelty of the study. Hence, this article offers a bibliometric analysis of dyslexia screening by focusing on five main research questions (RQs):

- RQ1: what are the total publications and citations by year?
- RQ2: what is the top 10 journals contributing to dyslexia screening research?
- RQ3: what are the most popular keywords associated with the study and how have they evolved/changed over the past ten years?
- RQ4: what is co-occurrence, co-citation, and international collaboration between countries?

2. METHOD

The core elements of bibliometric research are scientific mapping, network analysis, and performance measurements [30]. This paper presents the results of a time-limited bibliometric analysis conducted between 2000 and 2023. Bibliometrics refers to the collection, management, and analysis of bibliographic data from

scientific literature [28], [31]. In addition to general descriptive data such as publishing journals, year of publication and main author categorization, it also contains more complicated approaches such as the analysis of co-citations of documents [26]. An iterative sequence of acceptable keywords, literature search, and analysis is necessary for a successful literature search, compilation of the bibliography, and reliable results [32]. In this study, an attempt was made to limit high-level publications, as they can contribute to the understanding of the theoretical perspective on the development of the research topic. This study relied on the Web of Science transdisciplinary database for data collection, as previously stated [33], [34]. To ensure that only first-class publications were considered, only articles published in rigorously peer-reviewed and high-quality academic journals were examined, excluding books and conference proceedings [35]. SSCI and SCIE from the Web of Science Core Collection (WoSCC) database from January 2000 to December 2023 were explored for analysis clarivate analytics' WoSCC has the most prevalent bibliographic data and citations in the social sciences and humanities, which is why the publications in the current study were retrieved using it [34], [36].

2.1. Data search strategy

A screening sequence was used to determine the search terms for the article search. Study was initiated by querying Web of Science database with TS=((dyslexi* OR "read* disorder" OR "spell* disorder" OR "specific learn* disorder") AND screen*+dyslexia screening+spelling disorder+writing disorder+reading disorder), thereby assembling 1642 articles. The search query was then revised so that the search terms "dyslexia" OR "reading disorder" would focus on students as learners. This process yielded 1241 results, which were additionally screened to include only research articles in English, and articles that were reviews were also excluded. The refinement included 839 articles used for bibliometric analysis. Until December 2023, all articles from the Web of Science database related to dyslexia screening and focusing on students were included in this study. Figure 1 shows the methodology used in this study.

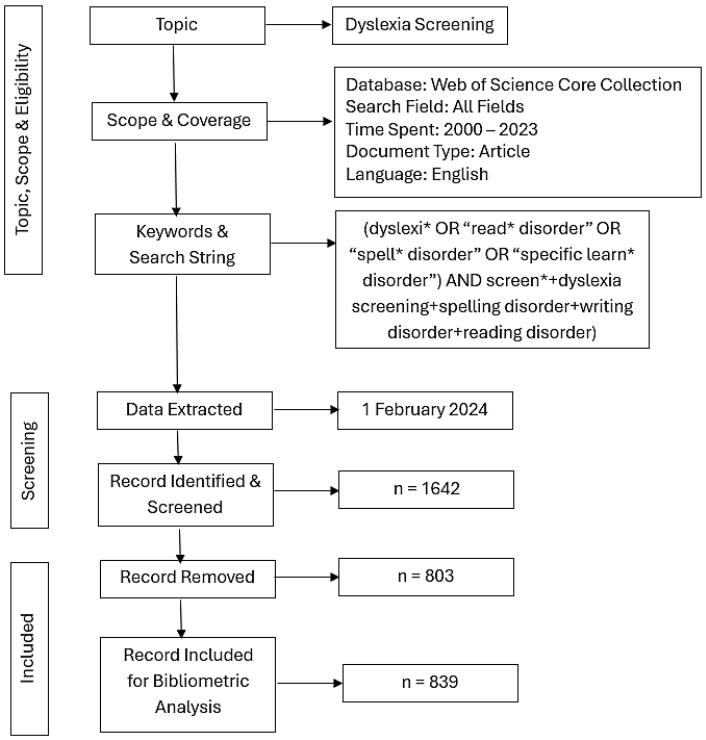

Figure 1. Adaptation of the article selection process from Hassan *et al.* [37]

2.2. Data analysis

The records were extracted from the WoSCC database between 2000 and December 2023. They were in plain text format, including year of publication of the study, the title of publication, author's name, journal, citation, and keyword, and analyzed using VOSviewer version 1.6.19. This program was used to analyze and create maps using VOS clustering and mapping techniques. VOSViewer is a replacement for the multidimensional scaling (MDS) method, which focuses on positioning objects in low-dimensional regions so that the distance between any

two elements adequately represents their similarity and relatedness [38], [39]. In addition, patterns based on mathematical relationships were discovered by applying visualization techniques to the dataset using VOSviewer, and analyses, such as keyword co-occurrence, citation analysis, and co-citation analysis, were performed. The evolution of the research topic over a period can be revealed by analyzing the co-occurrence of keywords [28] and is successful in discovering important topics in different fields [39], [40]. Citation analysis is important for identifying important research problems, trends, and methods, and analyzing the historical relevance of a discipline's main field of interest [34]. One of the most used bibliometric techniques is co-citation analysis of documents, which is based on network theory to determine an appropriate data structure [33].

3. RESULTS

Based on the data obtained, the research design focused on analyzing the bibliometric attributes of the documents such as literature distribution, and research trends according to the year of publication, the most influential countries, keywords, and journals in the field of dyslexia research. Most results are displayed as frequency, while co-occurrence of author keywords, the citation by country, co-authorship and co-citation are mapped using VOSviewer. The analysis of the data was subdivided according to the research questions (RQs).

3.1. Literature distribution

A total of 839 publications were identified in this study. Figure 2 shows a clear upward trend in both the number of publications and citations related to dyslexia screening over the past two decades, from a low of 10 in 2000 to a high of 90 in 2023. This indicates a growing interest in dyslexia screening. The number of citations per year has grown significantly, rising from 200 in 2000 to 1600 in 2023. This highlights the research on dyslexia screening is gaining traction and having an impact on the field. The steeper increase in citations compared with publications indicates that the research being published has a more significant impact on the field. This could be due to factors such as higher quality research, more relevant topics being addressed, or wider dissemination of findings.

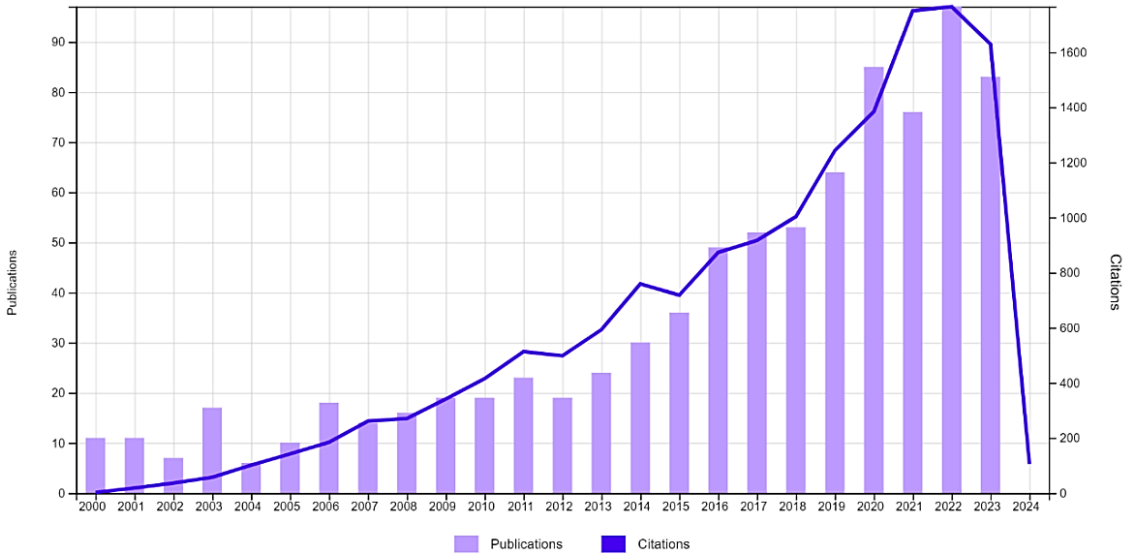

Figure 2. Total publications and citations by year

3.2. Top 10 journals

Figure 3 shows the top 10 journals that have significantly contributed to dyslexia screening research from 2000 to 2023. Dyslexia journal emerges as a leader in dyslexia screening, with 26 articles on dyslexia, underscoring its commitment in developmental disabilities research. A substantial number of published articles reflect the journal's dedicated focus on dyslexia within a specified timeframe. The Journal of Learning Disabilities ranked second, with 24 articles, followed by research in developmental disabilities, with 22 articles.

The curated list of top journals reflects the multidisciplinary nature of dyslexia screening research, encompassing developmental psychology [41], [42], psychiatry [43], [44], neuroscience [45], education [4], [46] and cognitive science. The presence of both niche and broad journals signifies the extensive reach and comprehensiveness of research on dyslexia. Notably, open-access journals such as Frontiers in Psychology

enhance accessibility and promote collaboration and knowledge exchange within dyslexia research communities. The identified journals collectively form a dynamic landscape that advances our understanding of screening for dyslexia.

Figure 3. Top 10 journals in dyslexia screening research

3.3. Author keywords

The keyword co-occurrence analysis taken from titles, abstracts, and author keywords were assigned to a specific cluster for each publication [38]. Figure 4 shows two central clusters of keywords. In this study, the keywords featured in articles published between 2000 and 2023 were ranked according to their frequency of use.

Cluster 1 (colored by orange and yellow) focuses on diagnosis and assessment, with keywords like "dyslexia", "developmental dyslexia", "screening", "tests", and "identification" being prominent. Cluster 2 (colored by blue and purple) tends to be more related to comorbidities and associated conditions that often accompany dyslexia. These include "specific learning disorder," "reading disorder," "ADHD," "autism spectrum disorder," and "working memory."

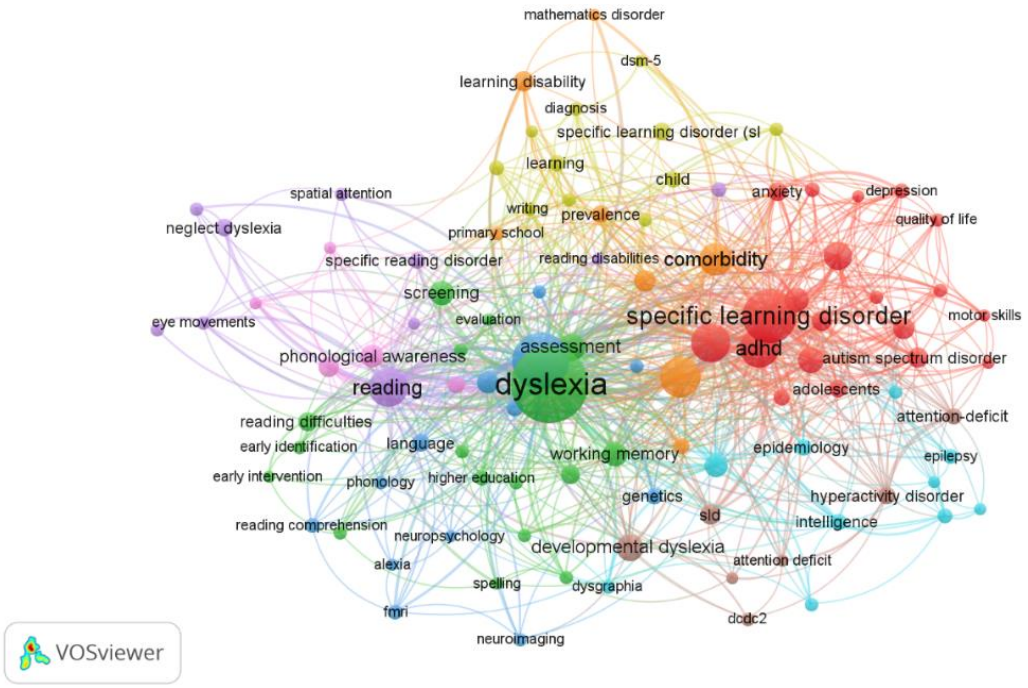

Figure 4. Author keywords' network visualization map of author keywords' co-occurrence

3.4. Authorship countries collaboration

Figure 5 illustrates several clusters of countries with strong co-authorship ties, highlighting active research collaboration in dyslexia screening. Two main clusters of collaborating countries are evident. Cluster 1 (orange and yellow) primarily involves European countries and the United States, indicating a robust network of collaboration of dyslexia screening among these nations. Cluster 2 (blue and purple) includes countries such as Australia, Canada, and Brazil, reflecting a secondary network of collaboration, possibly influenced by geographical and historical ties.

The United States emerges as a central node in both clusters, collaborating extensively with other countries. This underscores the prominent role of the US in dyslexia screening research and its significant contribution to fostering international collaboration. The thickness of the lines connecting countries represents the strength of their collaborative efforts. For example, the thick lines between the US, United Kingdom, and Germany signify strong partnerships, suggesting a well-established research network among these nations.

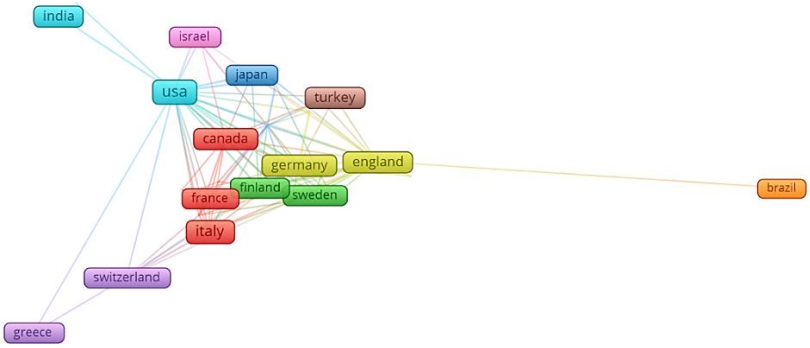

Figure 5. Co-authorship countries collaboration

3.5. Citation by countries

Figure 6 shows several clusters of countries with high citation density, indicating their influence in dyslexia screening research. The United States is a clear leader in terms of citations, with a significant lead over all other countries. Canada, the United Kingdom, and Australia follow the US, forming a group of high-citation countries. This indicates that these countries have strong research communities in dyslexia screening and make significant contributions to the field.

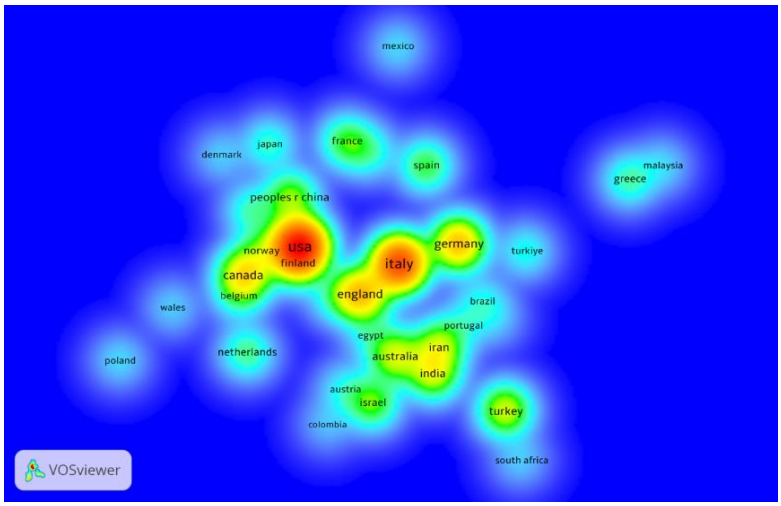

Figure 6. Citation by countries

Western European countries are well represented, with several appearing in the top 15 countries, including Germany, Norway, Spain, the Netherlands, and Switzerland. This suggests that Western Europe is a major center for dyslexia screening research. Eastern Europe and Asian countries are less well-represented,

with only China and Japan appearing in the top 15. This suggests that there is room for improvement in dyslexia screening research in these regions. The appearance of countries such as Brazil, Turkey, and Iran suggest that dyslexia screening research is becoming increasingly global. This is a positive development, as it will lead to a more diverse and comprehensive understanding of dyslexia.

4. DISCUSSION

This research shows the trend of literature distribution in the past two decades in dyslexia screening. The results of the bibliometric study in Figure 2 show the overall trend was clearly upward for both publications and citations. This suggests that screening for dyslexia is a growing and active field. This finding shows that there has been an increase in the awareness of dyslexia in recent years. This is partly due to the efforts of advocacy groups and celebrities who have spoken about their own experiences with dyslexia [47], [48]. Furthermore, significant advances have been made in the development of new and more effective dyslexia screening tools [49]–[51]. These tools have made it easier to identify children who are at risk for dyslexia, which has led to an increase in the number of children being screened for the condition.

Figure 3 illustrates the top ten journals which contributed major contributions to dyslexia screening research from 2000 to 2023 such as niche journals like Dyslexia and Journal of Learning Disabilities, and open-access journal such as Frontiers in Psychology. This highlight that the journal has become a go-to platform for scholars aiming to publish high-impact research in this niche area, reinforcing its reputation as a critical contributor to the understanding of dyslexia. Besides, the finding also shows that the most frequently used keywords in diagnosis and assessment is 'Dyslexia' while 'Specific Learning Disorder' for comorbidities as shown in Figure 4. This indicates that research is increasingly recognizing the complex interplay between dyslexia and other conditions [52]–[54], and the need for holistic approaches to assessment and intervention [41], [46].

Figure 5 reveals interesting triangular collaboration, highlighting two main networks which are dominated by European countries and the US, and another including Australia, Canada, and Brazil. However, these patterns of collaboration on dyslexia screening could have significant consequences. The existing clusters may drive innovations [55], [56] and the best practices within their networks, but the relative separation between clusters might mean that breakthroughs in one region are not quickly adopted or adapted on another. There needs to be a concerted effort to foster more inclusive and cross-regional collaboration to enhance the effectiveness of dyslexia screening worldwide. This could involve initiatives such as international conferences, collaborative funding opportunities, and joint research projects that bring together experts from across these clusters.

The analysis of citations by countries shows that Figure 6 provides a valuable snapshot of the global landscape of dyslexia screening research. It shows that the US is the dominant force in the field, but the western countries are also making significant contributions in dyslexia screening research. The Figure 6 also highlights the growing importance of international collaboration of dyslexia screening research.

5. CONCLUSION

Overall, this research showed that bibliometric analysis of global research trends in dyslexia screening from 2000 to 2023, emphasizing the importance of early detection and intervention. As the field of dyslexia research evolves, driven by advancements in technology and interdisciplinary collaboration, this study provides crucial insights into the most influential publications, emerging themes, and key international partnerships. However, there are few suggestions for future recommendations: i) analysis is based solely on publications indexed in the WoSCC, which is limited. It will be more useful to include other databases; ii) the analysis only limited to those published in English and will be more relevant if in the future, researchers can include non-English languages; and iii) the study's time frame focuses publications between 2000 and 2023, which is better if covers until current year for the latest developments in dyslexia screening research. Future research may explore the impact on emerging technologies and cross-cultural factors on the effectiveness of dyslexia screening tools.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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Mohd Syazwan Zainal	✓	✓	✓	✓		✓	✓			✓	✓	✓	✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

INFORMED CONSENT

The informed consent was obtained in written form from all participants and/or their legal guardians prior to data collection.

ETHICAL APPROVAL

The researchers confirm that all research was performed in accordance with relevant guidelines/regulations applicable when human participants are involved (e.g., Declaration of Helsinki or similar). The study received approval from the Educational Policy Planning and Research Division, Ministry of Education, Malaysia [KPM.600-3/2/3-eras (19883)] on 8th April 2024. Written consent was acquired from the parents' respondents.

DATA AVAILABILITY

The data utilized in this study are available upon request from the corresponding author [MEEMM]. All data have been anonymized and can be made accessible for academic research purposes, subject to reasonable requests. Data sharing will comply with relevant confidentiality agreements and ethical guidelines to safeguard the privacy rights of minor participants.

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