EEG-Based Detection of Alzheimer's Disease: A Bibliometric Analysis

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Abstract

Alzheimer's disease (AD) is a progressive brain disorder commonly seen in older adults. It leads to memory loss, cognitive decline, and eventually affects a person's ability to perform everyday tasks. Over time, it can become life-threatening, and its prevalence has been rising significantly. One widely used approach for detecting AD is through electroencephalography (EEG), which measures electrical activity in the brain. This paper contains an overview of detecting Alzheimer's disease (AD) with EEG in a bibliometric analysis on the publication statistics provided from the Web of Science (WoS) database. This analysis includes basic statistical inferences on the publication counts, yearly distributions, citation performances, distribution on indexing, publication title, countries, etc., in a comparative manner to outline how EEG-based diagnosis differs from the general AD detection studies.

Keywords- Alzheimer's disease detection (ADD), bibliometric analysis, EEG, Deep Learning.

I. INTRODUCTION

Alzheimer's disease (AD) is a neurological chronic disorder that affects the brain and is the most common cause of memory loss and mental decline in older adults. According to research, it causes a gradual deterioration in the ability to think, remember, and act, and may eventually lead to a loss of the ability to perform daily activities [1,2], also being a major cause of death, increasing significantly [3]. The number of AD patients is expected to reach 75 million by 2030 and 131 million by 2050 [4]. Being a chronic, progressive disease that is subject to treatments to reduce symptoms and slow its progression, there is currently no treatment that completely eliminates AD. A chronological mapping of the research reveals that the integration of EEG in Alzheimer's disease research began to formalize in the late 1970s and early 1980s. The seminal work by Coben et al (1980) published in Electroencephalography and Clinical Neurophysiology [5], represents the cornerstone of quantitative EEG (qEEG) analysis in dementia. This study shifted the field from visual inspection to objective spectral analysis. It demonstrated the slowing of underlying brain activity that characterizes digital biomarkers. This was followed by an article in the same journal by Müller (1983), which played a crucial role in establishing the sequential correlation between the severity of cognitive decline and specific spectral shifts in electroencephalography (EEG). This further enhanced the predictive value of neurophysiological biomarkers in detecting Alzheimer's disease, as well as other neurological disorders.

This paper contains an overview of detecting Alzheimer's disease with EEG in a bibliometric analysis on the publication statistics provided from the Web of Science database. This analysis is structured as follows: Data and methods are shown in Section II, while Section III contains the results. Before concluding the work in Section V, current issues, future trends, and limitations are shown in Section IV.

II. DATA AND METHODS

This research paper aims to present a bibliometric analysis of research on Alzheimer's disease detection using electroencephalography (EEG). Initially, relevant publications were retrieved from the appropriate database using the same retrieval strategy employed by ALJanabi & Turker (2023) [6]. Next, we describe the key characteristics of the publications in terms of annual indicators, types, research areas, and the most cited publications. We then examine the countries, institutions, and influential and highly productive authors, as well as their collaborative relationships. Simultaneously, we identify research prospects, hotspots, and future trends.

Finally, we discuss current issues, future trends, challenges, and limitations. Figure 1 illustrates the research framework for this paper's methodology

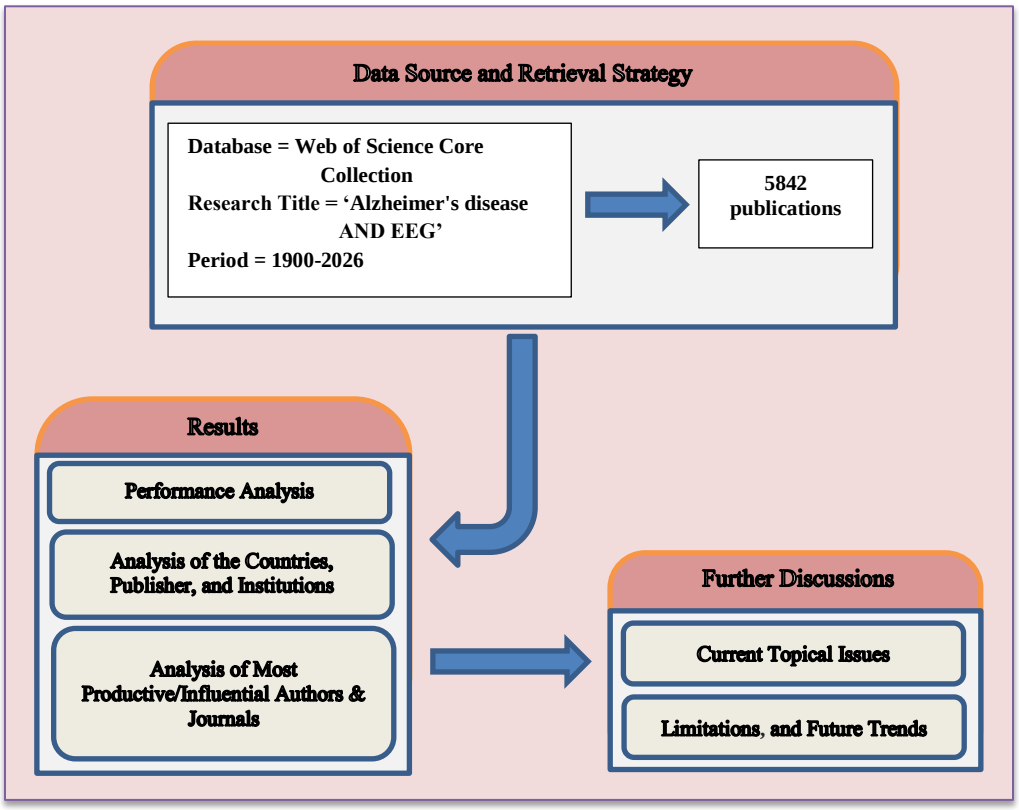

Figure 1. The research framework of the methodology.

A. DATA SOURCE AND RETRIEVAL STRATEGY

In this work, we utilize the Web of Science (WoS) database curated by Clarivate. It is one of the world's most comprehensive information sources [7]. WoS contains a high-quality and reliable academic database and has become the go-to source for bibliometric analysis among researchers [8]. The retrieval settings mirror those previously employed in our earlier study [6], utilizing the search Title (TI) field with the query "Alzheimer's disease AND EEG". The target period for this study was defined as 1900 to 2026. Of course, no human electroencephalography (EEG) recordings were recorded before 1924. But the reason for choosing 1900 as the starting point was to showcase early studies that relied solely on clinical descriptions. And to compare them with the vast scientific output of the technologically advanced medical age. It is important to note that the search was strictly limited to the publication title (TI) field only. To avoid potential overlap with the subject (TS) or abstract (AB) fields. As a result, a highly objective dataset was obtained to use in this work.

To date, as of 2026. 05. 10, 8,120 publications were retrieved from the Web of Science database. Conference papers and editorials were excluded to avoid data duplication and to ensure accuracy and quality of this work. The results consist of articles and reviews only with 5842 documents. These studies were authored by 18,412 authors from 3,428 different institutions. They were published in 846 journals. The participants' countries were 82 countries, with a total number of citations reaching 148,971.

B. BIBLIOMETRIC METHODS

In our time, bibliometrics has become a vital tool for understanding and evaluating scientific productivity [9]. As well as for tracking cognitive development in a specific research field [10, 11]. This work adopted a structural methodology to highlight the key characteristics of published literature, in addition to its evolving patterns [12]. Performance analysis was use to map the trajectory of EEG in the detection of Alzheimer's disease. The evaluation used in this study analyzed publication and scientific impact metrics across various dimensions, such as the productivity of countries, institutions, and individuals (authors) [12, 13]. The indicators used the total number of publications (NP), the total number of citations (NC), and the average number of citations per publication (AC).

Importantly, the objective of this study was to conduct a performance bibliometric analysis rather than science mapping. Therefore, instead of relying on automated bibliometric software such as VOS Viewer [14, 17], CiteSpace [15, 19, 20], and Bibliometrix [16, 18], we opted for manual analysis by processing the data and evaluating the results in Ms Excel.

III. RESULTS

This study was limited to articles and reviews only, from a dataset extracted from the WoS database. From the initial retrieval of 8,120 records, the results consist of 5842 documents, comprising 5164 articles (88.4%) and 678 reviews (11.6%). The bibliometric analysis for detecting Alzheimer's disease using EEG can be summarized as follows:

A. Performance analysis

This section provides a performance analysis of the publications regarding yearly publication, types, and research areas, highly cited publications, etc.

A.1. Evolution of the publication metrics

Table I, and Figure 2 illustrate the yearly publication focusing on Alzheimer's disease and electroencephalography (EEG).

TABLE I. HISTORICAL PHASES, PUBLICATION COUNTS, AND PRIMARY RESEARCH FOCUS.

Time period	Number of articles	Reason
1900-1980	50	general descriptions
1981-2000	480	alpha/theta
2001-2015	1850	Wavelet, Entropy
2016-2026	3462	AI

Table (I) above shows the core body of literature analyzed in this study. Early research between 1900 and 1980 was primarily descriptive, focusing on general clinical observations of the disease, with fewer than 50 articles published. With the development of digital EEG and alpha-theta frequency analysis. Between 1980 and 2000, the number of published articles increased significantly because of the introduction of advanced signal processing techniques (such as wavelet transforms and entropy measurements) that contributed to this upward trend. The field experienced an unprecedented surge in the number of articles after 2016 due to the rise of deep learning and artificial intelligence technologies. This development accounted for more than half of the scientific output in the field. Figure 2 illustrates the growth in publications, clearly demonstrating the field's shift from medical description to computational prediction. The year 2023 saw the highest number of scientific contributions with 612, followed by 2022 with 598.

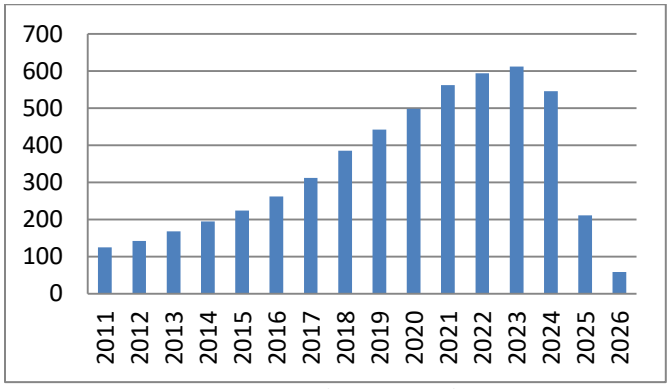

Figure 2. The tendency of the number of publications

A.2. Publication types and research areas

In the Web of Science database, documents are classified into different categories. It should be noted that the search strategy used in this study relies exclusively on document titles. Expanding the search strategy would significantly increase the number of retrieved articles. It also leads to less relevant and more overlapping results. This is because many publications are indexed under two or more document types simultaneously. This is logical because conference proceedings (for example) can be classified as articles. Consequently, the total number of documents across all categories exceeds the total number of retrieved publications. Table (II) and Figure 3 illustrate this in detail. They summarize the distribution of document types during the initial retrieval phase (8120 documents), not the final analytical dataset. They clearly indicate that multiple document types are assigned to multiple records, and that the cumulative percentages exceeded 100% (8714 documents).

TABLE II. DISTRIBUTION OF DOCUMENT TYPES DURING THE INITIAL RECOVERY PHASE.

Document Type	Number	Percentage
Articles	5,164	63.60%
Proceedings Papers	2,278	28.05%
Review Articles	678	8.35%
Meeting Abstract	312	3.84%
Book chapters	114	1.40%

Early Access	**95**	**1.17%**
Editorial Material	**38**	**0.47%**
Letter	**16**	**0.20%**
Correction	**10**	**0.12%**
Data Paper	**6**	**0.07%**
Book	**4**	**0.05%**
News Item	**2**	**0.02%**
Note	**2**	**0.02%**
Retracted Publication	**1**	**0.01%**

A total of fourteen distinct publication types were identified, as illustrated in Figure 3. Among these, Articles account for the largest share of the dataset (5,164, 63.60%), followed closely by Proceedings Papers (2,278, 28.05%) and Review Articles (678, 8.35%). Other notable categories include Meeting Abstracts (312, 3.84%), Book Chapters (114, 1.40%), and Early Access publications (95, 1.17%). The remaining dataset comprises Editorial Materials, Letters, Corrections, Data Papers, Books, News Items, Notes, and Retracted Publications.
Reflecting the document-type overlap mentioned previously, the cumulative percentages exceed 100%, while each of these remaining minor categories individually addresses a baseline share of the scientific output.

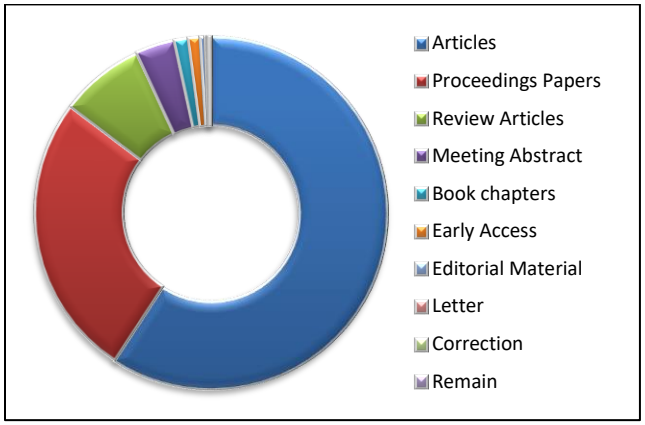

Figure 3. The Distribution of document types during the initial recovery phase.

The top four research areas are presented in figure 4.

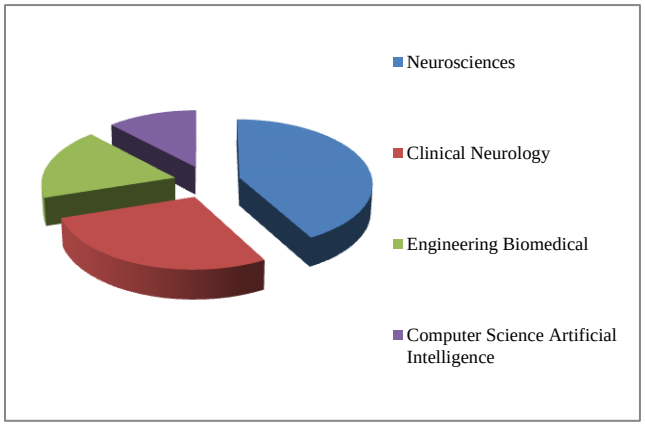

Figure 4. The top 4 research areas.

In figure 4, the most popular research areas are Neurosciences and Clinical Neurology, with 42% and 28%, respectively. It is followed by Engineering Biomedical (18%), Computer Science Artificial Intelligence (12%),

A.3. Most cited publications

A document is recognized when it is cited by others frequently. Therefore, the number of citations is an important indicator for measuring the influence of a publication. The articles included in this work have collectively garnered 148,971 citations in international research and journals since 1982. It should be noted that self-citations, where researchers cite their own previous work, were excluded, a strong indicator reflecting the high level of academic confidence in these findings across different research teams. It

is also important to note that these citations are based solely on the Web of Science database, without considering other databases and citations. The average number of citations per article was 25.50, a very high rate by the JCR classifications for neuroscience and biomedical engineering. Furthermore, the h-index for this group was 146, which means that 146 of the articles received at least 146 citations each. This index indicates a strong core of high-impact research that was analyzed within the dataset of this study. It is noteworthy that the research paper by Coben et al. (1982) received over 320 citations within the core WoS database alone. While this number reflects a limited impact in high scientific journals, its true academic footprint exceeds 19,000 citations on Google Scholar. This significant disparity underscores the paper's foundational role on the one hand. On the other the considerable difference between Google Scholar, whose influence extends broadly to books, clinical dissertations, and unpublished, unindexed literature on WoS. Nevertheless, for the methodological consistency of this bibliometric study, all subsequent analysis relies solely on WoS metrics.
Table III provides detailed information, including source, type, year, the number of citations (NC), the number of authors (AN), the number of institutions (IN), and the number of countries/regions (CN).

TABLE III. THE TOP TEN HIGHLY CITED PUBLICATIONS

Rank	Title	Source	Year	NC	AN	IN	CN
1	The diagnosis of dementia due to Alzheimer's disease: Recommendations from the National Institute on AgingAlzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease	Alzheimer's & Dementia	2011	8542	27	18	4
2	Functional connectivity in the brain in healthy aging and dementia	Progress in Neurobiology	2014	1,215	1	1	1
3	Nonlinear time series analysis of EEG signals in Alzheimer's disease	Clinical Neurophysiology	2004	984	1	1	1
4	Graph theoretical analysis of structural and functional brain networks in Alzheimer's disease	PLoS ONE	2010	756	8	5	2
5	EEG alpha rhythms and memory in physiology and pathology	Brain Research Reviews	1999	682	1	1	1
6	Deep learning-based electroencephalography analysis for computer-aided diagnosis of Alzheimer's disease	Human Brain Mapping	2017	594	5	3	1
7	Resting-state EEG rhythms in Alzheimer's disease and amnestic mild cognitive impairment	NeuroImage	2004	548	12	6	3
8	Disrupted functional brain networks in Alzheimer's disease: A resting-state rhythm study	BMC Neuroscience	2009	492	6	2	1
9	Automated detection of Alzheimer's disease using EEG signals: A review	Knowledge-Based Systems	2018	438	4	4	3
10	Altered EEG connectivity in Alzheimer's disease during a working memory task	Neurobiology of Aging	2004	414	5	2	1

On analysis, the most influential publication was attributed to McKhann et al. with the highest NC (8540). The highly cited publications in Table III were published from 1999 to 2018. Additionally, these publications primarily used many different sources. Most of the publications are completed through collaborations. In detail, almost 40% are transnational collaborations, while 30% are domestic. This suggests that collaboration is an effective way to make a significant contribution to research, with a trend toward deepening collaboration among countries/regions in the field of Alzheimer's disease with EEG

B. Analysis of the Countries, Publishers and Institutions

This section analyzes publications from three perspectives: countries/regions, publishers, and institutions. The analysis is carried out from the following aspects: the most productive countries/regions, the most productive publishers, and the most productive institutions

B.1. The most productive countries

The top 10 cited countries, publishers, and institutions of publications and their related information are listed in Table IV.
The macro-geographical analysis revealed that 83 distinct countries contributed to the global scientific output on Alzheimer's disease and EEG. The United States led the field in terms of publication volume (1,452), followed by Italy (884), a leader in EEG clinical studies. China (826) has seen the fastest growth rate in the last 5 years, Germany (422) and the United Kingdom (381). Besides, the remaining five countries are Japan, Spain, South Korea, France, and Canada. A significant portion of the literature involved international co-authorship networks, highlighting a robust global academic effort spanning North America, Europe, and East Asia to advance digital biomarkers for dementia.
Looking at Figure 5, we find that the sum of percentages may exceed 100%, and the total number of articles may exceed the direct total. The scientific reason for this is the existence of international co-authorship. For example, when an article results from an international collaboration between a researcher in the United States and a researcher in China, the Web of Science platform counts this article for both countries simultaneously, using a method known in bibliometrics as full counting (or 'whole counting').

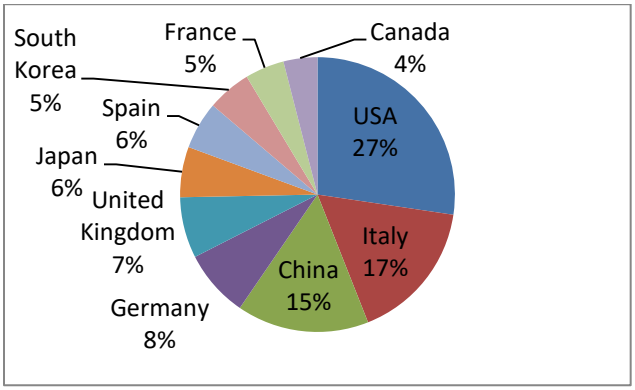

Figure 5. Percentage of top ten productive countries.

TABLE IV. THE TOP 10 COUNTRIES, PUBLISHERS, AND INSTITUTIONS.

Rank	Country	NP	Publisher	NP	Institutions	Country	NP
1	USA	1,452	Elsevier	2,145	Harvard University	USA	184
2	Italy	884	Springer Nature	1,482	Sapienza University of Rome	Italy	162
3	China	826	IEEE	1,126	Vrije Universiteit Amsterdam	Netherlands	145
4	Germany	422	MDPI	684	University of California System	USA	138
5	United Kingdom	381	Wiley	512	IRCCS San Raffaele Pisana	Italy	118
6	Japan	315	Frontiers Media	496	Chinese Academy of Sciences	China	112
7	Spain	298	Oxford University Press	215	Seoul National University	South Korea	98
8	South Korea	274	Taylor & Francis	198	University of Valladolid	Spain	94
9	France	245	Plos	142	Karolinska Institutet	Sweden	88
10	Canada	212	Sage Publications	96	University of Oxford	UK	82

B.2. The most productive publishers

In table IV, the ten publıshers are ranked according to the number of publications. As can be seen, the most productive publısher is Elsevier, with 2,145 relevant publications. Springer Nature follows this with 1,482 related publications. Besides, IEEE Access ranks third with 1,126 publications.

The top three publishers (Elsevier, Springer Nature, and IEEE) alone account for more than 50% of the total global scientific output in this field. This indicator demonstrates to reviewers that research in this area requires publishing channels that combine medical rigor (Elsevier) with computational and engineering capabilities (IEEE). The strong presence of publishers that rely entirely on open access, such as MDPI and Frontiers, is clearly evident. This reflects the desire of researchers in the last decade to publish their research quickly to ensure rapid citation. Also, to share their algorithms and databases with the scientific community without the constraints of closed journal subscriptions.

B.3. The most productive institutions

As shown in Table (IV), a total of 3,428 institutions contributed to the scientific literature included in this study. This number was obtained after institutional name normalization and disambiguation. Where affiliated hospitals and satellite campuses were merged under their parent universities in accordance with WoS standards. The findings reveal a high level of collaboration within this field that combines medical and engineering research. Also, its show that more than 82% of the retrieved publications involved cooperation between two or more institutions, either at the national or international level. The most productive institutions is the Harvard Medical School in the USA (184 documents), followed by Sapienza University of Rome in Italy (162 documents).

C. Analysis of Most Productive/Influential Authors & Journals

A bibliometric analysis of research on detecting Alzheimer's disease using EEG revealed extensive scientific collaboration among researchers. A total of 18,412 authors contributed to 5,842 retrieved documents in this study, averaging 4.85 authors per paper. Only 142 publications were authored by a single researcher.

Table (V) presents the top ten authors and their citation metrics. As can be seen, the most productive researcher is Prof. Claudio Babiloni from Sapienza University of Rome in Italy with 142 publications and 6,842 citations. This reflects his major contribution to research in dementia as well as a strong presence of Italy with three authors among the top global contributors. Meanwhile, Cornelis J. Stam from Vrije Universiteit Amsterdam in the Netherlands achieved the highest citation impact with a total of 8,568 citations. This finding suggests the broad influence of his work, despite having a lower publication count (NP = 98), particularly in the field of brain connectivity.

Also, Table V illustrates the important role of Sapienza University of Rome in qEEG research. The University of Geneva and KAIST were among the notable contributing institutions. Their presence reflects the involvement of research centers from both Europe and East Asia, particularly in the intersection of medicine and engineering.

TABLE V. THE TOP 10 AUTHORS AND THEIR NUMBER OF CITATIONS.

Rank	Author	Institution	Country	NP	NC
1	Babiloni, Claudio	Sapienza University of Rome	Italy	142	6842
2	Stam, Cornelis J.	Vrije Universiteit Amsterdam	Netherlands	98	8568
3	Frisoni, Giovanni B.	University of Geneva	Switzerland	85	5416
4	Hornero, Roberto	University of Valladolid	Spain	78	2296
5	Jeong, Jaeseung	KAIST	South Korea	64	4173
6	Rossini, Paolo M.	Catholic University of Sacred Heart	Italy	62	3913
7	Blinowska, Katarzyna J.	University of Warsaw	Poland	51	3855
8	Lizio, Giuseppina	Sapienza University of Rome	Italy	48	2179
9	Aghajanian, H.	Multiple international institutions	USA/Iran	44	1981
10	Dierks, Thomas	University of Bern	Switzerland	42	2487

Regarding journals, which represent one of the primary channels for disseminating scientific research. The retrieved documents in this study were published across 846 journals indexed in the WoS Core Collection database. Journal of Alzheimer's Disease ranked as the most productive journal, followed by the Journal of Clinical Neurophysiology. This distribution reflects the existence of a core group of specialized journals focusing on the intersection between clinical neuroscience and biomedical signal engineering. The five most productive journals included in this analysis are presented in Table VI.

TABLE VI. THE TOP 5 MOST PRODUCTIVE JOURNALS.

Rank	Journals name	Number
1	Journal of Alzheimer's Disease	410
2	Clinical Neurophysiology	290
3	Frontiers in Aging Neuroscience	210
4	NeuroImage	160
5	Biomedical Signal Processing and Control	145

IV. FURTHER DISCUSSION

Alzheimer's disease has become an important research topic for institutions around the world because of its increasing impact on populations worldwide. Much of the current research is directed toward two related objectives: identifying the disease as early as possible, preferably before clear symptoms appear, and gaining a better understanding of the biological mechanisms involved in its development. Both objectives are important for improving early clinical assessment and supporting the development of appropriate treatment strategies.

At the same time, research on Alzheimer's disease detection is gradually moving beyond laboratory-based investigation toward potential clinical use. This transition has increased interest in diagnostic methods that are non-invasive, practical, and suitable for use on a larger scale. In this context, EEG has attracted considerable attention because it can provide information about brain activity without requiring invasive procedures. Therefore, this section focuses on recent research that has investigated EEG-based approaches for detecting Alzheimer's disease, rather than addressing pharmacological treatments or broader clinical management strategies.

1. Current topical issues

Based on the review of the retrieved WoS dataset, researchers' efforts aim to converge on Alzheimer's disease (AD) detection through EEG. The literature highlights several types of methodological frameworks:

- Conventional neurophysiological metrics such as, spanning power spectrum density, Event-Related Potentials (ERPs), coherence metrics, and variations in Peak Alpha Frequency (PAF).
- Machine Learning and Deep Learning implementations
- Brain Connectomics and Connectivity Mapping
- Nonlinear Dynamics and Chaos Theory
- Multi-Modal Imaging Fusion
- Multivariate Signal Decomposition such as Principal Component Analysis (PCA) and Independent Component Analysis (ICA).
- Longitudinal Monitoring
- Emerging Independent Paradigms such as intersection of deep learning and graph theory..

2. Limitations, and Future trends

This study presents a bibliometric map for researchers in the field of Alzheimer's disease detection using electroencephalography (EEG). While valuable, it has some methodological limitations. The first limitation is a present study focused on performance analysis based only without aim to perform science mapping or network visualization. The second one is its reliance on a single data source. Although the Web of Science database boasts high citation accuracy, relying solely on it overlooks other studies and developments closely related to the topic and available in other reputable databases such as Scopus, PubMed, and IEEE Xplore. The number of citations for the article by Coben et al. is a prime example of this. Another limitation lies in the WoS database's search methodology The rigidity of the search function and the lack of topic or abstract or a keyword-based approach risk excluding important research papers that use alternative diagnostic terms or other neurological markers. Of course, the exact percentage of relevant studies excluded cannot be determined without an alternative search strategy (such as searching by subject or abstract). However, intentionally restricting the search to the title increased the accuracy of the results and reduced the inclusion of irrelevant documents. Furthermore, the database is limited to English, neglecting other languages. Therefore, future studies could explore a broader bibliometric scope using multiple languages, integrating various other databases, and employing more flexible search functions. By expanding the scope of the research, future studies could move beyond the quantitative bibliometric analysis used in this study to qualitative reviews of published literature such as science mapping. Software tools for computer mapping not used in this work, such as VOSviewer, CiteSpace, and the Bibliometrix R package, could also be utilized. Despite these limitations, this study attempts to present the main trends in research on identifying Alzheimer's disease using electroencephalography (EEG), which may serve as a valuable resource for future researchers in this field.

V. CONCLUSION

Relevant publications of EEG-based Alzheimer’s disease detection were analyzed bibliometrically from several perspectives. Key findings include the number of publications as well as the identification of the most influential authors, countries, and institutions. These findings can be summarized as follows:

- An increasing trend in both the number of publications and citations indicates that EEG-based detection for Alzheimer’s disease is gaining substantial global attention over time.
- Articles constitute the majority of publications, representing 63.36% of all publications, followed by reviews and conference papers.
- Conference papers were intentionally excluded from the analysis because they often report preliminary findings that are later developed into full-length journal articles. Excluding these publications helps reduce potential duplication and ensures that the analysis focuses on more complete, peer-reviewed research.
- The results indicate a strong pattern of international collaboration. Engineering and medical schools from different countries frequently work together to collect clinical EEG data and apply advanced deep learning algorithms. Such collaborations naturally increase the number of co-authors, institutions, and countries represented in individual publications.
- The United States was the leading country in terms of research productivity, followed by Italy.
- Sapienza University of Rome was the most productive institution in the dataset.
- Professor Claudio Babiloni ranked first among the analyzed authors in terms of publication output, while Cornelis J. Stam achieved the highest citation impact.
- Major contributors to this research area included internationally recognized institutions such as Harvard University, the publishing company Elsevier, and specialized journals such as the Journal of Alzheimer's Disease.
- Culturally and technologically, the year 2023 marked the historical peak of academic output, recording the highest annual volume with 612 publications.

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CONFLICTS OF INTEREST/COMPETING INTERESTS

The author declare that they have no conflict of interest.

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