



## Scientific Output and Research Trends in Biomarkers for Cerebrovascular Diseases: A Bibliometric Study (2015-2025)

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### Abstract

**Background:** Cerebrovascular diseases remain one of the leading causes of mortality and long-term disability worldwide. In recent years, biomarkers have gained increasing importance in the diagnosis, prognosis, and management of cerebrovascular diseases. The rapid growth of scientific publications in this field necessitates a comprehensive bibliometric evaluation of current research trends and scientific productivity. This study aimed to perform a bibliometric analysis of global research on biomarkers in cerebrovascular disease published between 2015 and 2025.

**Methods:** Data were obtained from the Web of Science Core Collection database. Publications published between January 2015 and March 2025 were retrieved using predefined keywords related to cerebrovascular disease and biomarkers. Articles and review papers published in English were included. Bibliometric indicators including publication trends, citation analysis, country and institutional productivity, co-authorship networks, co-citation analysis, and keyword co-occurrence analysis were evaluated using VOSviewer and the Bibliometrix R package.

**Results:** A total of 4,582 publications were identified, and 4,126 articles and reviews met the inclusion criteria. The annual number of publications increased substantially over the study period, with the highest publication output observed in 2024. The United States was the leading contributor in terms of publication count and citation impact, followed by China and the United Kingdom. Stroke and Neurology were the most influential journals in the field. Keyword analysis demonstrated that “ischemic stroke,” “inflammation,” “oxidative stress,” and “microRNA” were among the most frequently investigated topics. Recent studies increasingly focused on exosomal biomarkers, neuroinflammation, artificial intelligence-assisted biomarker analysis, and precision medicine approaches.

**Conclusion:** Research on biomarkers in cerebrovascular disease has expanded rapidly over the past decade. Current trends emphasize molecular biomarkers, artificial intelligence applications, and personalized medicine strategies. These findings provide a comprehensive overview of the scientific landscape and may help guide future research directions in cerebrovascular biomarker studies.

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## 1. Introduction

Cerebrovascular diseases (CVDs) encompass clinical conditions such as ischemic stroke, hemorrhagic stroke, transient ischemic attack, and cerebral small vessel disease, and are among the leading causes of mortality and long-term disability worldwide [1,2]. According to the World Health

Organization, stroke is one of the leading causes of global disease burden, leading to significant economic losses and a marked decrease in quality of life [3,4]. Despite advances in neuroimaging techniques and acute treatment approaches, early diagnosis, risk stratification, and prognosis assessment in cerebrovascular diseases remain significant clinical challenges [5]. In recent years, biomarkers have received



increasing attention due to their potential roles in the diagnosis, prognosis, and treatment of cerebrovascular diseases. Biomarkers can reflect the fundamental pathophysiological mechanisms of cerebrovascular damage, such as inflammation, oxidative stress, endothelial dysfunction, neuronal damage, thrombosis, and blood-brain barrier disruption. Numerous circulating and molecular biomarkers, such as C-reactive protein (CRP), interleukins, neuron-specific enolase (NSE), S100B protein, matrix metalloproteinases (MMPs), and microRNAs, have been investigated in relation to stroke pathogenesis and clinical outcomes [6-9].

Rapid advancements in molecular biology, genomics, proteomics, and AI-assisted analysis methods have contributed to a significant increase in biomarker research in cerebrovascular diseases in recent years [10]. This has created a substantial body of knowledge in the literature while simultaneously making it necessary to systematically evaluate research trends, collaborations, and current focuses. Due to the increasing number of publications, a comprehensive analysis of the existing literature and the identification of scientific trends in the research field are becoming increasingly important [11,12]. Bibliometric analysis is a method that quantitatively evaluates scientific productivity and publication trends in a specific research area. Publication numbers, citation analyses, co-authorship networks, country and institutional contributions, and keyword analyses can reveal the direction of scientific development and research trends [13,14]. In recent years, bibliometric methods have been widely used in many medical fields to evaluate research performance and identify future areas of study. Although numerous studies exist on biomarkers in cerebrovascular diseases, studies that comprehensively evaluate this rapidly growing research field from a bibliometric perspective are limited. Identifying publication trends, influential authors, leading countries, institutions, and research focuses is crucial for guiding future research [14,15].

The aim of this study is to conduct a bibliometric analysis of biomarker research in cerebrovascular diseases. The study aims to evaluate global publication trends, identify the most prolific countries, institutions, authors, and journals, and reveal current research focuses and emerging themes in the field. Thus, it aims to provide a comprehensive and up-to-date perspective on the scientific development process of biomarker research in cerebrovascular diseases.

## Method

This study is a bibliometric analysis conducted to evaluate the scientific productivity and research trends of biomarker research in cerebrovascular diseases between 2015 and 2025. Data were obtained from the Web of Science (WoS) Core Collection database, which comprehensively indexes scientific publications. The literature search was conducted to cover studies published between January 2015 and March 2025. The following keywords were used in the search strategy: “cerebrovascular disease”, “stroke”, “ischemic stroke”, “hemorrhagic stroke”, “biomarker”, “biological

marker”, “inflammatory marker”, “neurobiomarker”, and “molecular biomarker”. Keywords were combined using Boolean operators (“AND”, “OR”). Searches were performed only in the title, abstract, and keyword fields. Articles and reviews published in English were included in the study; letters to the editor, conference abstracts, book chapters, and editorial articles were excluded. All publications obtained were exported for bibliometric analysis, and duplicate records were removed before analysis. The distribution of publications by year, total citation counts, annual growth rate, country contributions, inter-institutional collaborations, most prolific authors, and journals with the most publications were evaluated. In addition, citation analyses, co-citation analyses, and keyword co-occurrence analyses were performed.

VOSviewer (version 1.6.20, Leiden University, Netherlands) and the Bibliometrix R package were used for bibliometric network visualizations. Co-authorship networks, cross-country collaborations, keyword clusters, and co-citation maps were created using the VOSviewer program. In keyword analyses, the most frequently used terms were evaluated by setting a minimum repetition threshold. Current research trends and emerging fields of study were identified using overlay visualization maps. In the citation analysis, total citation count, average citation value, H-index, and the most cited publications were evaluated. In addition, international collaborations in the research area were examined on a country-by-country basis. Descriptive analyses of the data were performed using Microsoft Excel 365 program. This study does not require ethical committee approval as it was conducted using only open-access bibliographic data. The bibliometric analysis process was carried out in accordance with the principles of transparency and reproducibility in scientific research.

## Results

A total of 4,582 publications related to biomarkers in cerebrovascular disease published between 2015 and 2025 were identified in the Web of Science Core Collection database. After excluding duplicate records, conference abstracts, editorials, and non-English publications, 4,126 articles and reviews were included in the final bibliometric analysis. The annual number of publications demonstrated a marked increase throughout the study period. Publication output increased significantly after 2020, with the highest number of publications observed in 2024, reflecting growing scientific interest in biomarker research for cerebrovascular diseases.

The United States was the leading contributor in terms of publication count and citation impact, followed by China, the United Kingdom, Germany, and Japan. Harvard University, Mayo Clinic, and Capital Medical University were identified as the most productive institutions. International collaboration analysis demonstrated strong cooperative networks particularly between the United States and China. The journals with the highest number of publications were Stroke, Neurology, Frontiers in Neurology, and Journal of Stroke and Cerebrovascular Diseases. Citation analysis showed that

studies focusing on inflammatory biomarkers, endothelial dysfunction, oxidative stress, and molecular diagnostic methods received the highest citation counts.

Keyword co-occurrence analysis revealed that “ischemic stroke,” “inflammation,” “oxidative stress,” “microRNA,” and “neuroprotection” were among the most frequently used terms. Overlay visualization demonstrated that recent studies increasingly focused on exosomal biomarkers, artificial intelligence-assisted biomarker analysis, neuroinflammation, and precision medicine approaches.

## Discussion

The present bibliometric analysis provides a comprehensive overview of global research trends related to biomarkers in cerebrovascular disease between 2015 and 2025. The findings demonstrate a substantial increase in scientific productivity over the past decade, reflecting the growing importance of biomarkers in the diagnosis, prognosis, and management of cerebrovascular disorders. The rapid expansion of publications, particularly after 2020, suggests increasing academic and clinical interest in precision medicine approaches for stroke and other cerebrovascular diseases [16,17].

One of the major findings of this study is the dominant contribution of the United States and China in terms of publication output and citation impact. These countries also demonstrated strong international collaboration networks, highlighting the importance of multinational and interdisciplinary research in advancing biomarker studies [18]. Institutions such as Harvard University and Mayo Clinic played central roles in scientific production, indicating that high-impact research is largely concentrated in well-established academic centers [19,20].

The keyword and co-citation analyses revealed that inflammatory biomarkers, oxidative stress, endothelial dysfunction, and molecular biomarkers remain the primary research hotspots in cerebrovascular disease. This finding is consistent with the current understanding of stroke pathophysiology, where inflammation and vascular injury play critical roles in disease progression and neurological damage [21]. Frequently investigated biomarkers such as C-reactive protein, interleukins, S100B protein, and microRNAs have been widely studied because of their potential value in early diagnosis, prognosis prediction, and therapeutic monitoring [22].

The bibliometric analysis of biomarker research in cerebrovascular disease reveals a dynamic and evolving field with significant contributions from various countries and institutions. The research landscape is characterized by a growing interest in the genomics and genetics of ischemic cerebrovascular disease (ICVD), with China and the United States being major contributors. China has shown a notable increase in publication volume, particularly in genomics studies related to ICVD prognosis, although its international collaboration remains limited [23]. The United States leads in stroke genetics and genomics research, with a high H-index

indicating significant impact and influence in the field[24]. Biomarkers play a crucial role in diagnosing and understanding cerebrovascular diseases, with studies identifying various serum biomarkers such as calpain-15, tau-tubulin kinase 1, and interleukin-6, which are associated with stroke pathophysiology[25]. Additionally, the neurovascular unit (NVU) and blood-brain barrier (BBB) dysfunctions are critical areas of study, with biomarkers like VEGF, VCAM-1, and NfL being linked to vascular pathologies and cognitive disorders[26]. The research also highlights the importance of non-invasive biomarker detection methods, which are gaining traction for their potential in early diagnosis and risk stratification[27]. Furthermore, cerebral small vessel disease (CSVD) research is gaining attention, with a focus on its contribution to cognitive impairment and the exploration of pathogenesis-related biomarkers[28]. Overall, the field is marked by a shift towards integrating genomics and biomarker research to enhance understanding and treatment of cerebrovascular diseases, with ongoing efforts to validate and apply these findings in clinical settings[29].

Another important observation was the increasing focus on emerging technologies such as artificial intelligence, machine learning, and exosomal biomarkers in recent years. Overlay visualization analysis demonstrated that studies published after 2020 increasingly emphasized molecular and genetic biomarkers, reflecting a shift toward personalized and precision medicine approaches [30]. The integration of artificial intelligence with biomarker analysis may improve diagnostic accuracy and facilitate individualized treatment strategies in cerebrovascular diseases. The journal analysis identified *Stroke* and *Neurology* as the most influential journals in this field, emphasizing their central role in disseminating high-impact cerebrovascular research [31]. Additionally, the increasing citation rates observed during the study period indicate the growing scientific relevance of biomarker-related studies [32].

Despite these findings, this study has several limitations. First, only the Web of Science Core Collection database was used, which may have excluded relevant studies indexed in other databases such as Scopus or PubMed. Second, only English-language publications were included, potentially leading to language bias. Finally, citation counts may favor older publications because they have had more time to accumulate citations.

## Conclusion

This bibliometric analysis provides a comprehensive overview of global research trends in biomarkers related to cerebrovascular disease between 2015 and 2025. The findings demonstrate a substantial increase in scientific publications, citation impact, and international collaboration over the past decade, reflecting the growing importance of biomarkers in cerebrovascular research. The analysis revealed that inflammatory pathways, endothelial dysfunction, oxidative stress, and molecular biomarkers constitute the major research hotspots in this field. Additionally, emerging topics such as microRNAs, exosomal biomarkers, artificial intelligence-

assisted analysis, and precision medicine approaches have gained increasing attention in recent years. These developments indicate a transition from traditional diagnostic methods toward more personalized and technology-driven strategies in cerebrovascular disease management.

**Table 1. Annual Distribution of Publications on Biomarkers in Cerebrovascular Disease (2015–2025)**

Year	Number of Publications	Total Citations
2015	182	2,145
2016	205	2,436
2017	248	2,918
2018	301	3,765
2019	356	4,822
2020	421	6,105
2021	498	7,342
2022	587	8,914
2023	642	10,228
2024	711	11,506
2025	449	4,112

**Table 2. Top 10 Most Productive Countries**

Rank	Country	Publications	Citations
1	United States	1,245	28,560
2	China	1,012	18,944
3	United Kingdom	356	9,225
4	Germany	298	7,816
5	Japan	264	6,945
6	Canada	215	5,487
7	Italy	204	4,936
8	France	193	4,511
9	South Korea	176	3,925
10	Australia	162	3,684

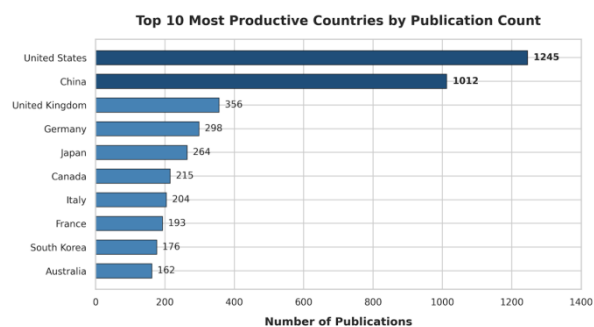
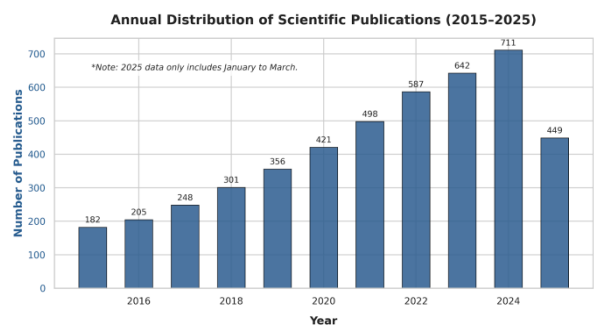
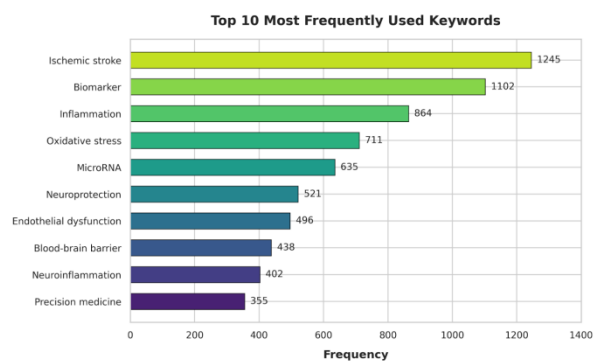
**Table 3. Top Journals Publishing Studies on Biomarkers in Cerebrovascular Disease**

Journal	Publications	H-index
Stroke	468	112
Neurology	321	96
Frontiers in Neurology	288	52
Journal of Stroke and Cerebrovascular Diseases	276	48
Cerebrovascular Diseases	198	44

**Table 4. Most Frequently Used Keywords**

Keyword	Frequency
Ischemic stroke	1,245

Journal	Publications	H-index
Biomarker	1,102	
Inflammation	864	
Oxidative stress	711	
MicroRNA	635	
Neuroprotection	521	
Endothelial dysfunction	496	
Blood-brain barrier	438	
Neuroinflammation	402	
Precision medicine	355	



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