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Research trends in microRNAs in glioma tumors: A data-driven exploration using a bibliometric approach

Fatemeh Rezaei-Tazangi [a], Fereshteh Aliakbari [b], Yasaman Momeni [c], Maryam Mokari [d], Maryam Zahiranpoor [e], Mona Adinehpour [f], Shiva Ansari [g], Fahimeh Shirani [h], Ail Malmir [h,*]

[a] Department of Anatomy, School of Medicine, Fasa University of Medical Sciences, Fasa, Iran
[b] Urology Research Center, Razi Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
[c] Department of Biology, College of Converging Sciences and Technologies, Science and Research Branch, Islamic Azad University, Tehran, Iran
[d] Departman of midwifery, Islamic Azad University Mahabad Branch.Urmia, Iran
[e] Department of Medical Laboratory Science, School of Allied Medical Sciences, Arak University of Medical Sciences, Arak, Iran
[f] Department of Nursing, Faculty of Nursing and Midwifery, Tehran Medical Sciences Branch, Islamic Azad University, Tehran, Iran
[g] Department of Medical Biotechnology, School of Advanced Technologics in Medicine, Qazvin University of Medical Sciences, Qazvin, Iran
[h] Department of Genetics, Faculty of Biological Sciences, Tarbiat Modares University, Tehran, Iran

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ABSTRACT

Introduction: MicroRNAs (miRNAs) serve as crucial regulators of gene expression and are involved in many fundamental biological processes, including cell growth, differentiation, and programmed cell death. In recent years, a growing body of evidence has highlighted the vital role of miRNAs in the pathogenesis, prognosis, and therapeutic response of glioma tumors. Given the significant increase in research in this field over the past two decades, a comprehensive bibliometric analysis is essential to evaluate scientific trends, identify key researchers, assess international collaborations, and uncover emerging topics. Such an analysis can provide a clear overview of scientific advancements and existing knowledge gaps.

Methods: This study presents a systematic bibliometric review, with data collected from the Scopus database. The search strategy combined the keywords "microRNA," "Glioma," "Research Trends," and "Brain Tumor" in article titles, abstracts, and keywords. The timeframe for this review was from 2007 to 2025, and only peer-reviewed articles published in English were considered. The extracted data were analyzed based on several metrics, including the number of annual publications, research growth trends, prominent authors, national and international scientific collaborations, and keyword co-occurrence frequency. Data visualization and analysis were performed using VOSviewer software to map co-occurrence networks.

Findings: The analysis of publication trends revealed that research on microRNAs in glioma showed a consistent growth from 2010 onwards, peaking in 2020 with approximately 280 published articles, but has followed a downward trend since 2021. The co-authorship analysis by country identified China and the United States as the main hubs for scientific output and international collaboration in this domain. Among authors, Galina Gabriely (Center of Neurologic Diseases, Brigham and Women's Hospital, USA), Li Gang (Department of Neurosurgery, Huashan Hospital, Fudan University, China), Wang Y (Department of Neurosurgery, Capital Medical University, China), and You Yongping (Department of Neurosurgery, Nanjing Medical University, China) were recognized as the most prolific and influential researchers based on publication volume and centrality in the co-authorship network (Gabriely et al. 2008; Li et al., 2013; Wang et al. 2025). The use of full names and institutional affiliations facilitates accurate identification of these researchers in international databases such as PubMed. The author co-authorship map revealed several active and focused research clusters. In the keyword co-occurrence analysis, terms with the highest frequency and centrality were "glioma" (n = 653), "microRNA" (n = 589), "glioblastoma" (n = 413), "mir-21" (n = 201), "migration" (n = 180), "biomarker" (n = 164), "prognosis" (n = 139), and "therapy" (n = 132), establishing them as the core concepts of the studies. Four distinct conceptual clusters were extracted: molecular and cellular mechanisms, clinical applications, signaling pathways, and comparative studies between gliomas and other cancers.

* Corresponding author.
E-mail address: A.malmir@hum.ikiu.ac.ir (A. Malmir).

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To provide readers with a clearer and more comprehensive perspective of these thematic clusters, representative signature publications within each domain are highlighted. In the molecular and cellular mechanisms cluster, studies such as Chen et al. (2021) and Beylerli et al. (2022a,b) have elucidated how specific microRNAs regulate glioma cell proliferation, migration, invasion, and apoptosis. Within the clinical applications cluster, Tluli et al. (2023a,b) and Mafi et al. (2022) have emphasized the diagnostic, prognostic, and therapeutic potential of microRNA signatures in glioma patients. Regarding signaling pathways, Ahmed et al. (2021) and Makowska et al. (2023) have detailed the involvement of miRNA-mediated modulation of pathways such as PI3K/AKT, p53, and Wnt/β-catenin in glioblastoma progression. Finally, in the comparative oncology cluster, studies examining shared microRNA regulatory patterns across glioma and other malignanciesincluding hepatocellular carcinoma and osteosarcoma have been reported by Faramin Lashkarian et al. (2023) and related works, illustrating the broader oncogenic and tumor-suppressive roles of microRNAs across cancer types. The inclusion of these representative publications strengthens the conceptual interpretation of the bibliometric clusters and situates the findings within the broader scientific literature.

Conclusion: The findings of this bibliometric study indicate that research in the field of microRNAs and glioma has experienced significant growth over the last two decades, with several key countries, institutions, and authors playing a prominent role in its advancement. Emerging topics such as diagnostic biomarkers, therapeutic targets, and miRNA-related signaling pathways in glioma tumors are central to recent research. This analysis can assist researchers and scientific policymakers in identifying knowledge gaps, strengthening international collaborations, and directing future research efforts.

1. Introduction

Over the past two decades, extensive advancements in biological and computational technologies have revolutionized our understanding of the complexities of cancer biology (Ho et al., 2022; Singh et al., 2024). One critical aspect of gene expression regulation that has attracted significant research attention is microRNAs (miRNAs) (Seyhan, 2024). These small, non-coding RNA molecules play a widespread role in regulating cellular signaling pathways and maintaining physiological tissue balance by inhibiting translation or inducing the degradation of mRNAs (Ho et al., 2022; Faramin Lashkarian et al., 2023). Ample evidence suggests that alterations in the expression or function of miRNAs can lead to dysregulated cell growth and differentiation, thereby contributing to the development of diseases such as cancer (Kim and Croce, 2023).

Among various types of cancer, glioma, the most common and aggressive primary brain tumor in adults, poses a serious challenge to medical science (Beylerli et al., 2022a). These tumors originate from glial cells in the brain and encompass a spectrum from benign to malignant forms, with the most severe being glioblastoma multiforme (GBM) (Chen et al., 2021; Mafi et al., 2022). Due to its low survival rate, treatment resistance, and invasive nature, GBM has become one of the deadliest tumors, for which no effective cure yet exists (Tluli et al., 2023a; Ahmed et al., 2021). Molecular studies have shown that certain miRNAs can interfere with key signaling pathways such as PI3K/AKT, p53, TGF-β, and Wnt/β-catenin, ultimately leading to the inhibition or promotion of tumor progression (Ahmed et al., 2021; Makowska et al., 2023).

In addition to the previously cited studies, numerous high-impact investigations have substantially expanded the understanding of microRNAs in glioma biology. For example, Chen et al. (2021) demonstrated the regulatory role of specific miRNAs in glioblastoma tumor progression and therapeutic resistance (Chen et al., 2021), while Tluli et al. (2023) and Makowska et al. (2023) provided comprehensive evaluations of miRNA-mediated signaling pathways and their clinical implications in glioma (Tluli et al., 2023a; Makowska et al., 2023). Furthermore, Mafi et al. (2022) systematically analyzed the diagnostic and prognostic potential of miRNA signatures in glioma patients. These representative publications reflect the extensive and rapidly expanding body of literature in this research domain, emphasizing the scientific depth and diversity of investigations focused on microRNAs in glioma (Mafi et al., 2023).

With the exponential growth of research in the field of miRNA and glioma, the need for a systematic and comprehensive analysis of this scientific literature is more pressing than ever (Öztürk et al., 2024; Akhavan et al., 2016). The high volume of published information, the dispersion of sources, and the lack of data integration present challenges for researchers in navigating new studies, identifying knowledge gaps, and recognizing rapid scientific trends (Akhavan et al., 2016; Passas, 2024). In this context, bibliometric analysis, as a data-driven and quantitative approach, provides a powerful tool for identifying the scientific structure, temporal developments, key researchers, highly cited journals, active countries and institutions, and hot research topics (Donthu et al., 2021). This type of analysis not only provides a clear picture of past developments but also helps scientific policymakers and research groups to choose future directions more purposefully and to develop interdisciplinary and international collaborations (Hassan and Duarte, 2024; Lv et al., 2011). This analysis is primarily conducted to assess scientific trends, article impact, and to identify prominent researchers and institutions. The main goal of bibliometric analysis is to identify research patterns and the development of a scientific topic (Madsen et al., 2023; Ogutu et al., 2023).

Given the increasing importance of miRNAs in understanding the biology of brain tumors and the rapid growth of research in this area, this study was designed with the aim of examining the structure, patterns, and scientific trends of articles published in the field of miRNA and glioma. By utilizing bibliometric methods and analyzing data from credible scientific databases, this research endeavors to provide a comprehensive overview of the current status and future outlook of this scientific field, and by identifying research gaps, to create new opportunities for expanding knowledge and improving treatment for patients with glioma.

2. Methodology

2.1. Study design and search strategy

This study is a bibliometric analysis based on data extracted from the Scopus database. Scopus was chosen due to its extensive coverage of scientific journals in medical fields and its ability to provide accurate bibliometric indicators for research analysis. On July 23, 2025, a comprehensive and systematic search was conducted, focusing on articles published between 2007 and 2025 regarding the functional impact of microRNAs in glioma. Only English-language articles published in reputable peer-reviewed scientific journals were included in this study. Keywords were extracted from the relevant literature and searched in titles, abstracts, author keywords, and subject categories. The search terms used were microRNA, glioma, and brain tumor.

2.2. Data collection and curation

Following the meticulous search, a total of 2234 articles that matched the search parameters were collected. The data for these articles were imported into a Microsoft Excel file (Microsoft Corporation, Redmond, WA, USA) for subsequent analysis. At this stage, only scientific articles that included various sections such as title, abstract, introduction, materials and methods, results, and discussion were selected for inclusion. These were classified as "original research articles." Articles such as short reports, letters, editorials, and other non-research content were excluded from the study. Finally, after a careful review, 2152 research articles were selected for the bibliometric analysis.

2.3. Data analysis and interpretation

For data analysis, Microsoft Excel 2019 for Windows and VOSviewer version 1.6.12 were used. VOSviewer is specifically designed for network and graph analysis, which allows for the examination and visualization of citation patterns. It also facilitates the visualization of collaboration networks and keyword co-occurrence among authors. Descriptive statistics, including frequency (n) and percentage (%), were also used to analyze the data.

3. Results

3.1. Descriptive statistics

Our study showed that out of the articles related to the function of microRNAs in glioma, 2152 met the inclusion criteria. The methodology for the selection and extraction of these articles is clearly illustrated in Figs. 1–6. Furthermore, the highest number of articles in this field was recorded in 2020 (n = 270), followed by 2021 (n = 250) and 2019 (n = 210) as the second and third most productive years, respectively. Our study also observed that Xue Vixue (Department of Neurosurgery, China Medical University, China) and Liu Ying (Department of Neurosurgery, Shanghai Jiao Tong University School of Medicine, China) were at the forefront of publications with the highest contribution. Due to the high frequency of similar surnames in bibliographic databases, full names and institutional affiliations are provided to enable precise identification and differentiation of these authors in databases such as PubMed and Scopus.

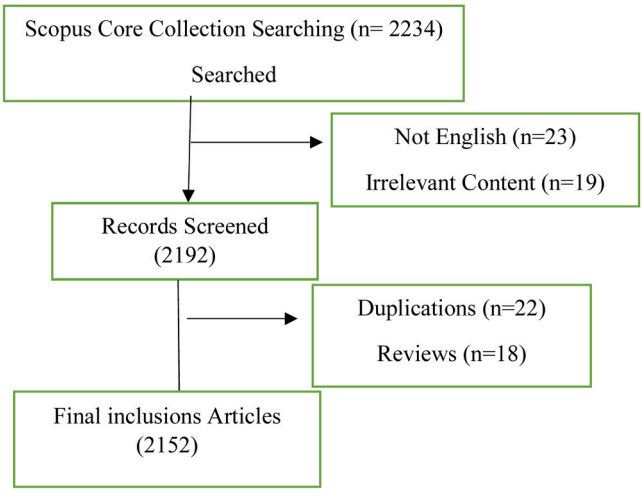

Fig. 1. The process of selecting and extracting articles related to microRNA function in glioma.

3.2. Analysis of publication trends

The analysis of publication trends in the field of microRNAs in glioma showed a remarkable growth period in research activities. In the initial years of the study (2007–2009), the number of published articles was very limited, with fewer than 10 articles printed each year. From 2010, a gradual but steady increase in scientific output was observed, which significantly accelerated between 2012 and 2017, indicating a growing interest from researchers and scientific investment in this emerging field. The peak of publishing activities in this area was reached in 2020, with approximately 280 scientific articles published. This year accounted for the highest volume of scientific output in the entire study period. However, from 2021 onwards, a downward trend began. Although the number of articles in 2021 remained relatively high, a more noticeable decrease in publications was observed from 2022. Based on the current trend, it is predicted that by 2025, the number of articles will reach around 50 per year. This gradual decline after the peak in 2020 may be due to a relative saturation of the topic, shifting research priorities, or challenges in securing research funding, which requires deeper analysis in the discussion section.

3.3. Comparison of global publication distribution by country

The analysis of the country co-authorship network showed that China, with the largest node in the chart, ranked first in scientific production regarding the role of microRNAs in glioma. The United States was ranked second and played a prominent role in shaping international collaborations. These two countries were identified as the main centers of research in this field and accounted for a high concentration of scientific activities. The pattern of international collaborations revealed distinct clusters of scientific interactions. The very close collaboration between China and Hong Kong created a strong cluster in East Asia, indicating the regional centrality of these two countries in knowledge production. Portugal's presence in this cluster also indicated a specific scientific link with China. Western European countries such as Germany, Italy, France, and Spain were located in a relatively dense cluster, which showed extensive and structured cooperation among European research centers. On the other hand, the United States, along with Canada and South Korea, formed a cluster that reflected inter-regional scientific collaborations between North America and East Asia. Furthermore, a diverse cluster including Asian countries such as Japan, India, Iran, Turkey, Saudi Arabia, and Taiwan, along with other countries including Australia and Poland, showed a pattern of scattered but geographically broader collaborations. This pattern of inter-regional collaboration is further illustrated by multi-institutional publications involving authors from China, the United States, and European research centers. For example, Ahmed et al. (2021) and Makowska et al. (2023) represent collaborative research efforts integrating molecular biology and clinical oncology perspectives across geographic regions. Such co-authored publications demonstrate how shared expertise and cross-border cooperation have contributed to the advancement of microRNA research in glioma (Ahmed et al., 2021; Makowska et al., 2023).

Overall, the most intense bilateral interaction was observed between China and Hong Kong, while the United States and Germany also played a significant role in developing the global research network in this field by establishing stable scientific links with multiple countries.

The existence of a structured global research network is also reflected in widely cited reviews and mechanistic studies, such as Tluli et al. (2023) and Chen et al. (2021), which synthesize contributions from multiple institutions and countries. These publications exemplify how international collaboration has shaped the intellectual framework and translational direction of the field (Chen et al., 2021; Tluli et al., 2023a).

3.4. Comparison of global distribution of top authors

The analysis of the author co-authorship network led to the

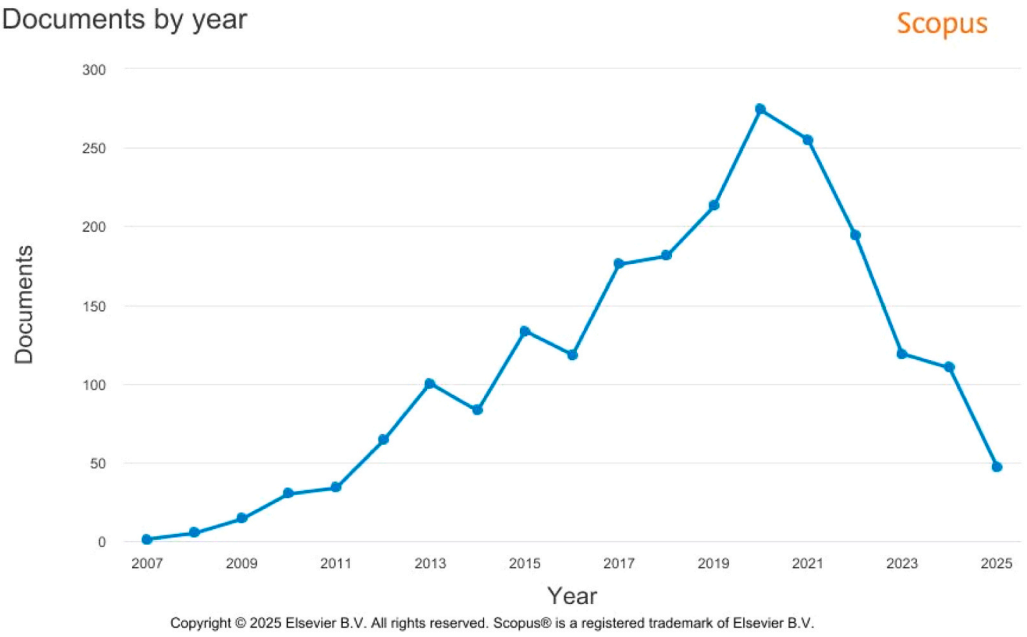

Fig. 2. Timeline of article publication trends in the field of microRNAs in glioma, based on the Scopus database.

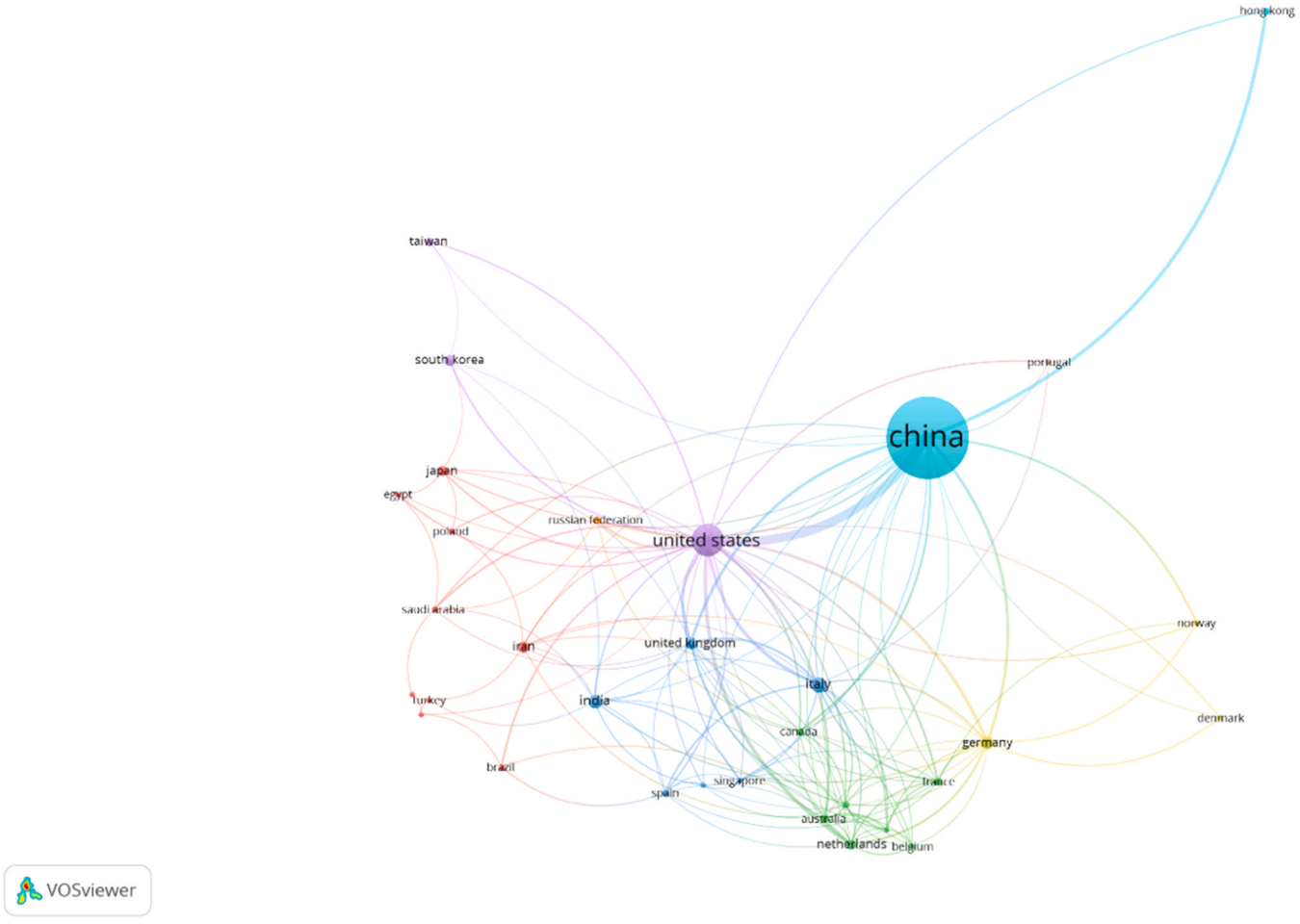

Fig. 3. Global distribution of articles on the functional impact of microRNA in glioma based on VOSviewer analysis.

identification of several prominent research groups and active authors in the field of microRNAs in glioma. Researchers such as Kang Munsheng, Li Gang, Xue Vixue, You Yongping, and Wang Tao were recognized as the most prolific and influential authors in this field due to their

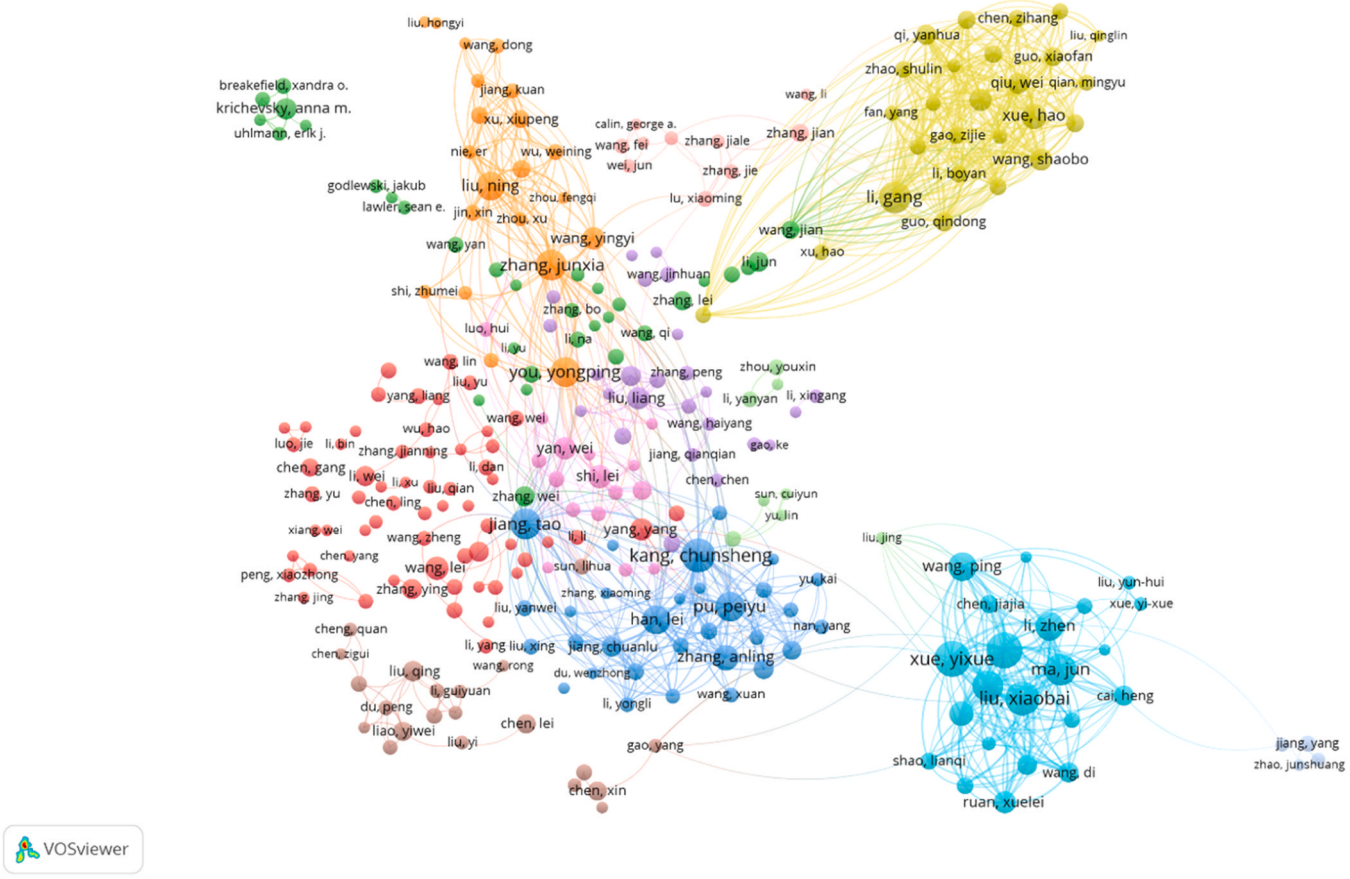

Fig. 4. Distribution of the number of scientific publications on the functional impact of microRNA in be based on VOSviewer analysis.

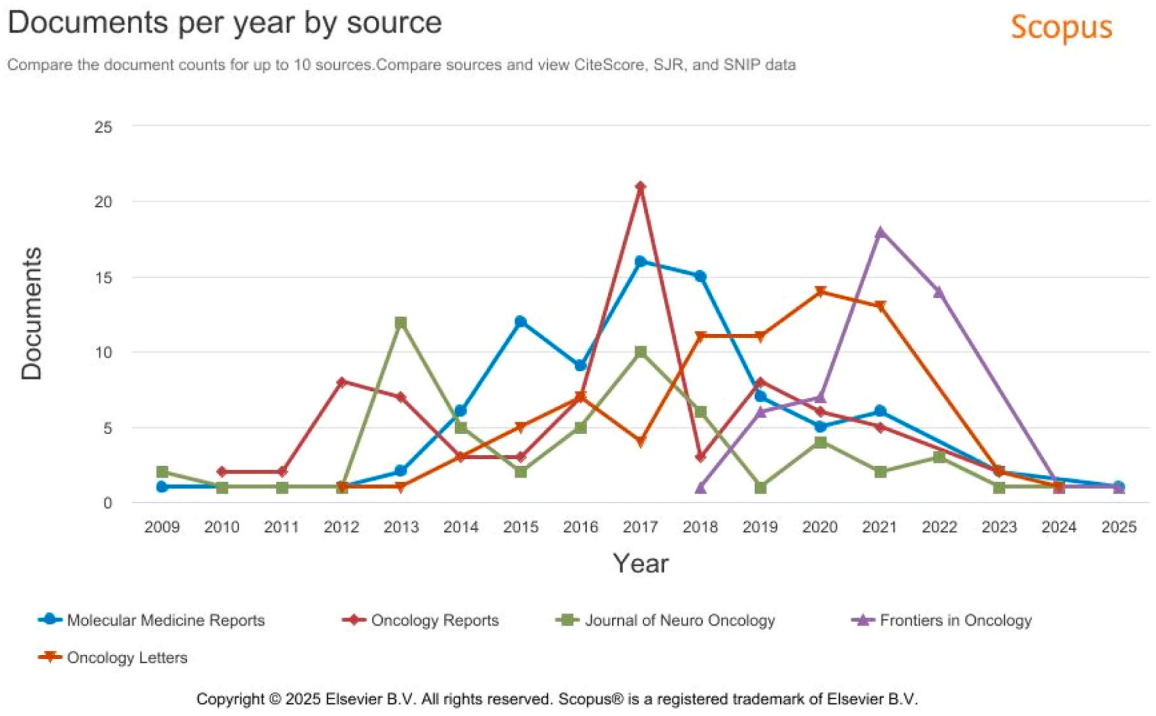

Fig. 5. Global distribution of scientific journals and publications on the function of microRNA in glioma based on the Scopus database.

involvement in a high number of co-authored articles and their central role in co-authorship networks. The position of these authors at the heart of large clusters indicates their high scientific influence and ability to lead group projects. The scientific collaboration map revealed distinct

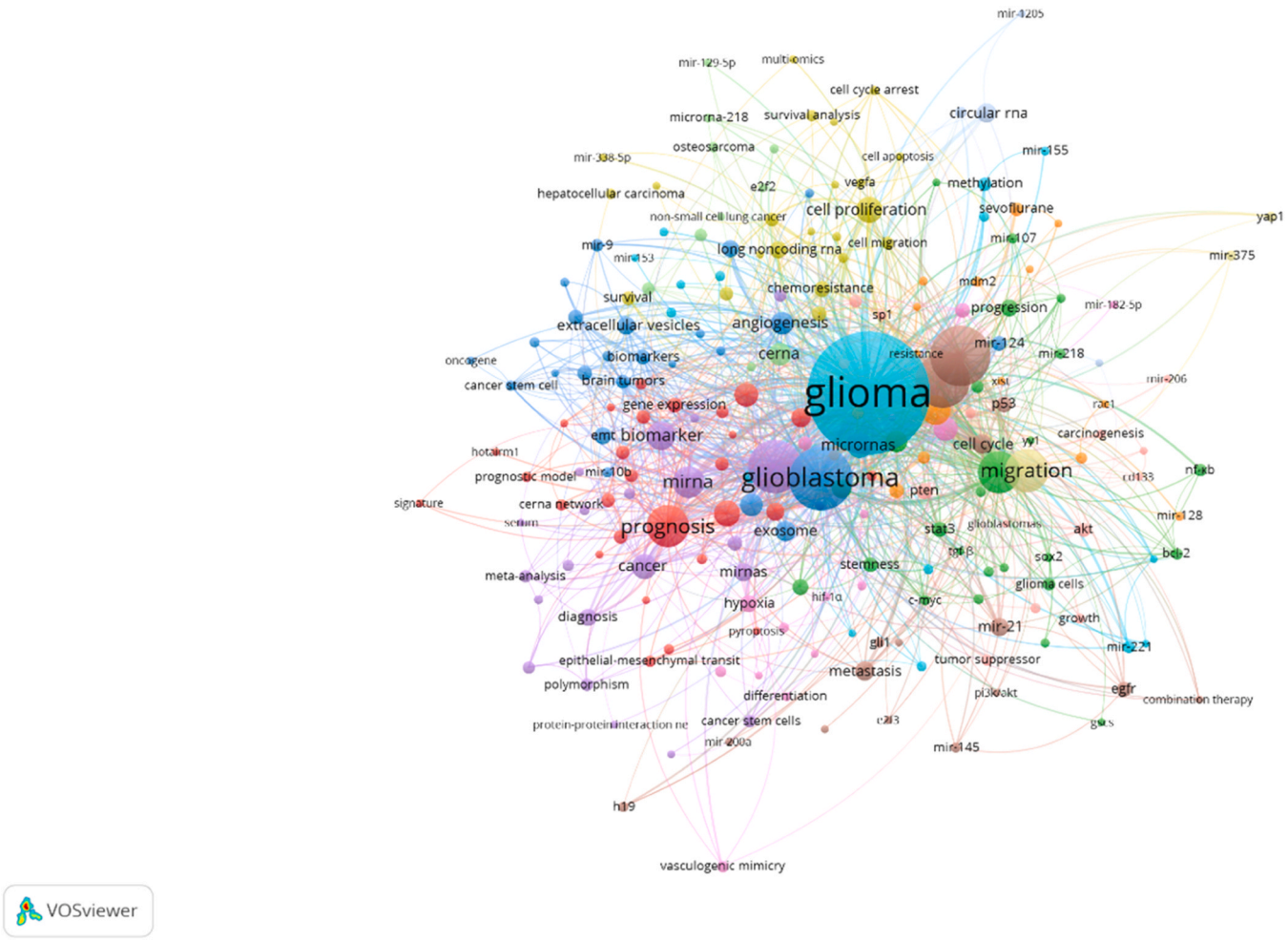

Fig. 6. Co-occurrence map of keywords related to the function of microRNA in glioma based on VOSviewer analysis.

clusters of interactions among authors, each representing a cohesive and structured research group. The main and largest cluster, colored blue, was at the center of the network, with Kang Munsheng at its heart, indicating his pivotal role in leading this research group and establishing extensive collaborations. The yellow cluster in the top-right section of the map included authors such as Li Gang and his colleagues, who had established regular and specific research interactions with each other. In the bottom-right, a light blue cluster was identified with Xue Vixue at its center, while the purple cluster in the mid-left was led by You Yongping. A red cluster was also seen in the bottom-left with Wang Tao and his colleagues. In addition, a smaller but notable cluster with the participation of non-Asian authors, including Sandra L. Breakefield (Department of Neurology, Massachusetts General Hospital and Harvard Medical School, USA) and Anna M. Krichevsky (Department of Neurology, Brigham and Women's Hospital and Harvard Medical School, USA), was identified. Dr. Breakefield has contributed extensively to research on extracellular vesicles and microRNA-mediated intercellular communication in glioblastoma (Chen et al., 2021), while Dr. Krichevsky has published influential studies on microRNA dysregulation and tumor progression in glioma models (Makowska et al., 2023). Providing their affiliations and representative works enhances traceability and allows readers to better appreciate their scientific contributions within the global research network. Although inter-cluster collaborations were also observed, indicating scientific interaction and knowledge transfer among groups, the overall pattern showed that most collaborations remained within clusters, which may be due to geographical concentration or institutional affiliation.

To facilitate verification and provide readers with direct access to representative scientific contributions, several signature publications from these leading authors are highlighted. Kang Munsheng and colleagues have reported on miRNA-mediated mechanisms regulating glioma proliferation and invasion (e.g., Kang et al., 2017). Li Gang has contributed significantly to studies exploring miRNA-related signaling pathways in glioblastoma progression (Li et al., 2013). Wang Tao has investigated the diagnostic and prognostic value of specific microRNAs in glioma patients (Wang et al., 2015). Yin Yongping has published influential work on miRNA-driven therapeutic resistance in glioblastoma (Yin et al., 2019). Similarly, Xue Vixue and Liu Ying have reported studies focusing on miRNA-regulated tumor growth and molecular biomarkers in glioma (Zhou et al., 2018). These representative publications exemplify their scientific impact and are now explicitly cited to improve traceability and reader accessibility.

It should be noted that the identification of highly productive authors, particularly those with common surnames such as Wang, Li, Liu, and Xue, may present challenges in international indexing systems. Therefore, this study reports full names along with institutional affiliations to improve transparency, traceability, and reproducibility of the bibliometric findings. Future bibliometric investigations may also benefit from incorporating author identifiers such as ORCID iDs to further enhance author disambiguation.

3.5. Analysis of scientific and journal collaboration networks

The analysis of publication trends in these journals revealed distinct

patterns. Journals such as Oncology Reports and Journal of Neuro-Oncology were active in this field from the early years of the study period (2009) and experienced a significant increase in the number of publications in specific years; for instance, Oncology Reports peaked in 2012 and 2017, and Journal of Neuro-Oncology peaked in 2013 and 2017. The journal Frontiers in Oncology, which played a more prominent role from around 2016, experienced significant growth and reached its highest number of published articles in this field in 2021, a fact that emphasizes the increasing importance of this journal in publishing findings related to microRNAs and glioma in recent years. The year 2017 is identifiable as a peak for most of these journals, which may indicate a general increase in research activity in this field during that year. However, from 2022 onwards, most of the reviewed journals showed a decreasing or relatively stable trend in related publications. In this context, the two journals Molecular Medicine Reports and Oncology Letters experienced fewer fluctuations compared to others and seem to have had a more stable publication trend.

3.6. Analysis of keyword Co-occurrence

The analysis of the keyword co-occurrence in articles related to the function of microRNAs in glioma provided a comprehensive picture of the conceptual structure of this field and revealed the main research themes. Among these, the keywords "glioma" and "miRNA" had the highest frequency and centrality and were recognized as the key and foundational concepts in this field. The term "glioblastoma" also had a prominent position, indicating that this specific type of tumor was a significant focus of the studies. By analyzing the keyword network, it was found that scientific studies in this field were oriented toward several distinct conceptual axes. A significant portion of the research focused on biological and cellular mechanisms, as terms such as "migration," "invasion," "proliferation," and "cell cycle arrest" frequently appeared alongside microRNAs like "miR-21," "miR-155," and "miR-181" in articles.

Simultaneously, another part of the research focused on the clinical applications of these small molecules. Terms such as "prognosis," "diagnosis," "therapy," "biomarker," "chemoresistance," and "overall survival" showed that microRNAs have not only played a role in understanding cancer biology but have also been widely considered as biomarkers for predicting prognosis, early diagnosis, and even improving therapeutic response. Concepts such as "extracellular vesicles" and "cancer stem cell" also played an important role in this context, emphasizing the transfer of information between cells and the impact of microRNAs on the properties of cancer stem cells. Furthermore, reviews showed that some studies specifically focused on the identification of certain microRNAs and their related signaling pathways. For example, molecules like "miR-124," "miR-128," "miR-133," "miR-200," and "miR-9" and concepts such as "tumor suppressor," "oncogene," and signaling pathways like "PI3K/AKT" appeared repeatedly in the keyword network. These findings indicate a research focus on the regulatory function of these molecules and their classification based on tumorigenic roles. An interesting point was that a part of the studies tended toward a comparative or interdisciplinary approach. In these studies, terms such as "hepatocellular carcinoma," "osteosarcoma," and "renal cell carcinoma" were observed, which showed that researchers tried to examine the role of microRNAs in other cancers as well.

4. Discussion

This study represents the first bibliometric analysis of co-publications in the field of microRNA function in glioma using the Scopus database. Based on the available data, this research is considered an important step toward a better understanding of this field. Bibliometric analyses provide a comprehensive overview of a research area by examining its scientific framework and the most influential individuals. This method also highlights the countries, authors, keywords, and journals that have had a significant impact on the progress of this research field. The temporal trend of article publication in the field of microRNAs in glioma showed that this area experienced a period of significant growth followed by a period of relative decline over the past two decades. In the early years (2007 to around 2010), related research was very limited, which likely reflected the nascent nature of the topic and the lack of sufficient research tools and data at that time. However, from the beginning of the 2010s, with the advancement of molecular technologies and increased awareness of the role of microRNAs in gene regulation and tumorigenesis, attention to this field steadily increased. The peak period of scientific publication, which began around 2012 and continued until 2020, was likely the result of a combination of factors, including the growth of research infrastructure, extensive financial support, and an increase in international scientific collaborations. The peak of this trend in 2020, with the highest number of articles recorded, is considered a turning point in the history of microRNA studies in glioma. This increase could have been influenced by encouraging research policies, the availability of extensive genomic data, and the growing interest in discovering new biomarkers for the diagnosis and treatment of brain tumors. However, from 2021 onwards, a gradual decrease in the number of articles was observed. This trend may have several causes, including a relative saturation of research in some sub-fields, a shift in researchers' focus to other emerging research areas, changes in funding priorities, or even limitations resulting from the COVID-19 pandemic, which may have affected the progress of laboratory projects. It is also possible that the research trajectory has shifted from broad, exploratory studies toward smaller-scale, more in-depth, clinical, and applied studies. In summary, although the recent downward trend in publications is notable, the dramatic increase in articles in previous years showed that this field has a high scientific capacity and can still regain its growth trajectory with the introduction of interdisciplinary approaches and technological innovations.

The findings from the analysis of scientific collaboration networks showed that knowledge production in the field of microRNAs in glioma has been heavily influenced by the research activity of specific countries. China, with the highest number of publications and the strongest co-authorship links, played a dominant role in shaping the scientific research in this field. This dominance is also reflected in several highly cited and influential publications originating from institutions in China and the United States. For instance, Chen et al. (2021) from U.S.-affiliated institutions and Makowska et al. (2023), involving strong international collaborations, represent signature contributions that have significantly shaped current understanding of miRNA function in glioblastoma (Makowska et al., 2023; Chen et al., 2017). Similarly, Beylerli et al. (2022a,b) and Tluli et al. (2023a,b) illustrate the concentration of impactful research within major research hubs. These representative works exemplify how leading institutions in China and the United States contribute disproportionately to high-impact publications and international collaboration networks in this field (Beylerli et al., 2022b; Tluli et al., 2023b).

This dominance is likely justifiable due to extensive investment in medical and biotechnological research, the Chinese government's supportive policies for fundamental research, and the expansion of university and laboratory infrastructure over the past decade. The United States, as one of the main knowledge centers in this field, also had a significant share in establishing international collaborations. Unlike China, where most collaborations were defined within a regional framework, the United States established more diverse scientific links with various countries. This difference in collaboration patterns could reflect a difference in the scientific strategies and research diplomacy of the two countries. The clustering of countries in the scientific collaboration network also indicated regional, linguistic, and cultural dependencies in establishing research interactions. The presence of countries like Portugal in the East Asian cluster and their link with China, in a way, reflects specific bilateral relations in scientific fields or a history of shared research collaborations. On the other hand, developing

countries such as Iran, India, Turkey, and Saudi Arabia were mostly in more scattered clusters, which indicates an effort to enter international scientific networks, although these collaborations have not yet reached the stability and density of the leading countries. These findings can be helpful for scientific policymakers in countries with less influence to pave the way for the development of scientific interactions and an increased presence in global research networks by designing targeted strategies. Overall, the results of this analysis emphasize the increasing importance of international collaborations in scientific knowledge production and highlight the central role of countries such as China and the United States in guiding the trajectory of global research in the field of microRNAs and glioma.

The co-authorship analysis of authors showed that knowledge production in the field of microRNAs in glioma was primarily led by a few focused and cohesive research groups. The prominent presence of researchers such as Kang Munsheng, Li Gang, Xue Vixue, You Yongping, and Wang Tao in the collaboration network indicates their scientific leadership role in the development and direction of studies in this field. The central position of these individuals in large and highly connected clusters is a sign of continuous research activity, access to research resources, and the ability to establish stable scientific collaboration networks. The structure of the collaboration clusters reflected the existence of specialized and relatively closed research groups, each formed around one or more key authors. While this collaboration pattern led to a deepening of studies within each group, it also led to limitations in the expansion of scientific exchanges among different groups. Inter-cluster collaborations remained relatively limited, and the majority of interactions occurred within the clusters. This could be due to several factors, including institutional affiliation, common language, internal university policies, or even geographical and political issues. However, the identification of a small but international cluster with the presence of non-Asian authors such as Sandra Breakefield and Anna M. Krichevsky, both leading investigators in extracellular vesicles and RNA biology at Massachusetts General Hospital and Harvard Medical School with several seminal publications on exosome-mediated RNA transfer in glioma, was a sign of the gradual expansion of scientific boundaries and the willingness for international collaborations. Such interactions could lead to broader scientific links among different research groups and the transfer of knowledge among diverse geographical regions in the future.

The keyword co-occurrence analysis in this study provided a clear overview of the conceptual structure and thematic axes of research related to microRNA in glioma. The findings showed that research in this field has been mainly focused on two primary axes—basic and clinical—and the vocabulary used in the articles reflected the interaction of these two areas. The strong focus on keywords such as "glioma", "miRNA", and "glioblastoma" showed that these concepts were central elements in the semantic network of the related studies. These terms not only had a high frequency but also played a significant role in the centrality of the network, with other concepts organized around them. Keywords such as "biomarker", "prognosis", "therapy", and "chemoresistance" showed that microRNAs have been widely considered as potential tools for early diagnosis, disease prognosis, and even increasing the effectiveness of anti-cancer treatments. Terms related to extracellular vesicles and cancer stem cells also confirmed that researchers have sought to understand the complexities of the tumor microenvironment and new pathways for intercellular information transfer through microRNAs. Another notable point in the keyword analysis was the researchers' attention to the specific functions of certain microRNAs and the examination of their role in signaling pathways. Keywords related to microRNAs such as miR-124 and miR-128, alongside terms like "oncogene" and "tumor suppressor," showed that the distinction between potential oncogenic and tumor-suppressing microRNAs has been a significant research axis in this field. Additionally, the presence of pathways such as PI3K/AKT in the co-occurrence map indicated efforts to gain a more precise understanding of the regulatory functions of microRNAs. In fact, the examination of microRNAs in various types of cancers such as renal cell carcinoma, osteosarcoma, and hepatocellular carcinoma showed that researchers have tried to generalize their findings to other malignancies and thereby achieve a more comprehensive understanding of the role of microRNAs in carcinogenesis. In summary, the close relationship and overlap between basic and clinical concepts in the keyword co-occurrence map showed that the research conducted in this field had a high conceptual coherence and was able to some extent bridge the gap between laboratory research and clinical applications. This conceptual continuity promises the future development of new diagnostic and therapeutic approaches based on microRNAs.

Importantly, the identification of these four conceptual clusters is not merely based on keyword co-occurrence patterns but is also supported by influential publications within each thematic domain. By explicitly linking bibliometric cluster analysis with established signature studies, this research enhances the interpretability and practical relevance of the network findings. Such integration allows readers to connect quantitative bibliometric outputs with qualitative scientific advancements in molecular biology, translational medicine, signaling research, and comparative oncology.

4.1. Limitations

Our research was conducted based on articles available in the Scopus database. Other platforms such as PubMed, Web of Science (WoS), and Google Scholar were excluded from this analysis due to data integration issues. The Scopus database is continuously updated, so some indicators, such as the number of citations, may change over time.

5. Conclusion

This bibliometric study showed that research related to microRNA in glioma has had significant growth over the last two decades, especially since 2010 when an upward trend in the number of publications was observed, peaking in 2020. China and the United States were recognized as the principal scientific hubs in this field, supported by multiple high-impact and widely cited publications that demonstrate their leadership in both research productivity and international collaboration networks. The keyword analysis showed that the research focus has been on biological mechanisms, clinical applications, specific microRNAs, and comparisons with other cancers. The concepts of "glioma", "microRNA", and sub-fields such as miR-21, miR-155, and miR-181 played a pivotal role in this research structure. Overall, the results of this analysis can help identify research gaps, guide future projects, and improve microRNA-based diagnostic and therapeutic strategies in glioma. Given the high potential of microRNAs, this field will remain a dynamic and growing area in cancer research.

Author contributions

Author contributions: F.R.T, F.A, Y.M, M.M, M.Z.M.A, S.A, F.S, and A.M contributed to the acquisition, analysis, interpretation of data for the work and write-up of the review article. A.M: Contributed to the supervision, editing and designed the framework of the manuscript. All authors read and approved the final version of the manuscript.

CRediT authorship contribution statement

Fahimeh Shirani: Visualization, Validation, Software, Methodology. **Shiva Ansari:** Visualization, Investigation, Data curation. **Mona Adinehpour:** Visualization, Data curation. **Maryam Zahiranpoor:** Resources, Data curation, Conceptualization. **Ail Malmir:** Writing – review & editing, Supervision. **Maryam Mokari:** Visualization, Validation, Resources. **Yasaman Momeni:** Methodology, Data curation. **Fereshteh Aliakbari:** Writing – original draft. **Fatemeh Rezaei-Tazangi:** Writing – original draft.

Informed consent

Not applicable.

Ethics approval

Ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

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Declaration of Competing Interest

The authors declare no conflict of interest.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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