Exploring the Terrain of Parkinson's Disease Research: An In-Depth Bibliometric Study

Manisha Sharma, Rajeev Pourush, and Prateek Bhanti

School of Engineering and Technology,Mody University of Science & Technology,Lakshmangarh, India

Corresponding Author – Manisha Sharma

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ABSTRACT

Parkinson represents a progressive neurological condition that significantly diminishes individuals' quality of life. This research undertakes a bibliometric analysis aimed at elucidating the research landscape surrounding this disorder, thereby offering insights into prominent contributors, pivotal publications, and emerging research trends. Articles published from 1974 to 2024 were sourced from the database of Scopus, with data extracted on titles, authors, journals, and the nations involved in the research. The analysis utilized the R package and VOSviewer for bibliometric evaluation, which included visualizations of co-authorship and co-occurrence networks. The United States, the UK, and Italy were identified as the foremost contributors in terms of both publication output and citation impact. The co-authorship analysis indicated robust international collaborations, while the co-occurrence mapping revealed thematic clusters within the research. Key authors and journals were recognized, showcasing a variety of research interests. This study offers a thorough overview of the research landscape concerning Parkinson's disease, pinpointing major contributors, influential works, and evolving trends. Notably, France, the USA, Spain, the UK, and Germany ranked among the most frequently cited nations. The research also applies Lotka's laws to analyze publication distribution, thereby providing a structured perspective on the field. The results of this study lay the groundwork for future investigations aimed at improving the management, treatment, and comprehension of Parkinson.

I. INTRODUCTION

Parkinsonism refers to a variety of clinical syndromes, which include idiopathic Parkinson along with progressive supranuclear palsy as well as multiple system atrophy [1]. The hallmark of Parkinson is the availability of motor symptoms, which include bradykinesia, resting rigidity, tremor, as well as postural instability [2]. In the initial phases of the condition, individuals with vascular Parkinsonism frequently display a distinctive shuffling gait along with pronounced episodes of gait freezing [3]. Additionally, postural instability and challenges with gait are notable motor symptoms in cases of idiopathic Parkinson's disease [4].

Recent research has advanced the identification of multiple candidate genes linked to genetic variants of Parkinson's disease (PD) [5]. Nonetheless, a significant obstacle for researchers lies in the precise differentiation of various Parkinsonian disorders, especially in light of the development of disease-modifying therapies [6]. Parkinson's disease stems from the relentless deterioration of neurons in the substantia nigra, a critical brain region essential for dopamine generation [7]. The primary categories of parkinsonism encompass drug-induced parkinsonism, idiopathic Parkinson, and several other forms [8].

In the early phase of the condition, individuals may exhibit minor symptoms that never substantially interfere with their routine work. Generally, tremors as well as movement-related issues appear predominantly on one side of the body, along with alterations in posture, walking patterns, and facial expressions [9]. In contrast, the fifth and culminating phase of Parkinson's disease is marked by severe motor dysfunction, necessitating help with all daily tasks. Increased rigidity in the legs may render standing or walking unfeasible without assistance [10].

Individuals diagnosed with Parkinson's disease typically have a life expectancy of approximately 16 years following the initial diagnosis or the emergence of symptoms. Nevertheless, individuals who receive a diagnosis at a younger age, particularly around 30 years old, may experience a significantly longer duration of the disease, potentially extending up to 40 years [11].

Advanced stages of Parkinson are associated with a heightened occurrence and intensity of pain. It is imperative to ascertain the origin of this pain in order to develop and apply effective pain management techniques. Adhering to medication regimens is vital, particularly if pain intensifies as the effects of Parkinson's medications diminish [12]. Although hereditary forms of Parkinson's disease are extremely uncommon, the vast majority of cases are classified as idiopathic, with the underlying cause remaining unidentified [13]. While a conclusive cure for Parkinson's disease remains elusive, current research endeavors are aimed at enhancing the understanding of this condition. This research encompasses the examination of genetic factors and biomarkers linked to Parkinson along with the exploration of novel therapeutic strategies [14]. The main categories of pharmacological interventions typically employed in the management of Parkinson's include dopamine agonists and levodopa [15].

Individuals diagnosed with Parkinson's disease typically maintain a life expectancy that is normal or close to normal, largely attributable to contemporary therapeutic approaches and pharmacological treatments that facilitate effective management of symptoms. Such interventions be instrumental in diminishing both the frequency and intensity of complications that might otherwise lead to mortality [16].

Consequently, it is essential to address the existing research gap pertaining to the annual spread of published papers and the prominent journals. The study examines key authors in the field, country collaboration networks, author-nation-journal interconnections, and relationships among countries and the most commonly utilized index keywords in Parkinson's research.

The scientific inquiries explored in this study are as follows. (RQs):

RQ1: What are the key publication sources and their growth trends?

RQ2: Which authors have made the groundbreaking contributions in this subject?

RQ3: What is the global distribution of research contributions?

RQ4: Which research themes are most prominent in the field?

The study seeks to elucidate the chronological trends in Parkinson's research by tackling these research questions. It aims to identify key journals and authors that have significantly impacted the field, explore the connections among countries, authors, and journal sources, and emphasize the predominant index keywords frequently utilized in this domain of inquiry.

II. MATERIALS AND METHODS

A bibliometric and thematic analysis was conducted to classify research on Parkinson's disease, addressing the research questions outlined in the introduction. The Scopus database served as the primary source for collecting pertinent articles published from 1946 to 2024. The search strategy included the following terms: 'TITLE-ABS-KEY (parkinson's AND disease OR primary AND parkinsonism OR paralysis AND agitans OR idiopathic AND parkinsonism AND ion AND epilepsy OR fit OR seizure) OR TITLE-ABS-KEY (parkinson's AND disease OR primary AND parkinsonism OR paralysis AND agitans OR idiopathic AND parkinsonism AND classification AND using AND machine AND learning) OR TITLE-ABS-KEY (Parkinson's disease OR primary parkinsonism OR paralysis agitans OR idiopathic parkinsonism AND ion AND epilepsy OR seizure OR fit classification using machine learning) OR TITLE-ABS-KEY (Parkinson's disease OR primary parkinsonism OR paralysis agitans OR idiopathic parkinsonism detection using EEG signal).' The collected data underwent a comprehensive process of data collection along with retrieval and refinement within the bibliometric mapping analysis. The biblioshiny tool, part of the bibliometrix package [13], was

employed to import data from Scopus in BibTex format. The study's inclusion criteria mandated that articles be published in English and pertinent to the research topic, leading to the exclusion of non-English articles and duplicates. An overview of the essential information derived from the gathered data is presented in Table 1.

The dataset spans from 1946 to 2024, comprising 92 documents from 79 sourceswith a yearly increase of 1.42The typical age of a document is 13.6 years, with 28.9 citations per document. It includes 1923 Keywords Plus and 315 Author's Keywords. A total of 601 authors contributed, with 7 single-authored documents, and an international co-authorship rate of 20.45%. The document types consist of 61 articles, 6 book chapters, 2 conference papers, and 23 reviews.

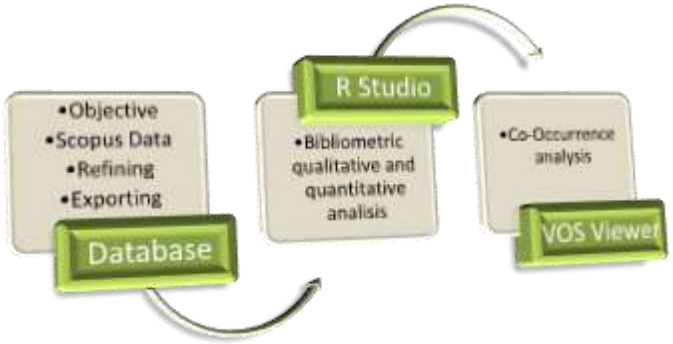

Fig. 1. Steps in the research process

The RStudio mapping program was used to carry out a descriptive bibliometric study. Several packages that are pertinent to bibliometric are available in the R environment.

TABLE 1:
CHARACTERIZATION OF BIBLIOMETRIC ELEMENTS

Depiction		Results
MAIN INFORMATION ABOUT DATA		
	Timespan	1946:20242
	Sources (Journals, Books, etc)	79
	Documents	92
	Annual Growth Rate %	1.42
	Document Average Age	13.6
	Average citations per doc	28.9
	References	
DOCUMENT CONTENTS		
	Keywords Plus (ID)	1923

	Author's Keywords (DE)	315
AUTHORS		
	Authors	601
	Authors of single-authored docs	7
AUTHORS COLLABORATION		
	Single-authored docs	7
	Co-Authors per Doc	6.7
	International co-authorships %	20.45
DOCUMENT TYPES		
	Article	61
	Book chapter	6
	Conference paper	2
	Review	23

The research predominantly relied on the Bibliometrix R Package, which served as an essential instrument for the analysis. A cohesive methodology for bibliometric network clustering and mapping was adopted, adhering to the protocols specified in [17]. Additionally, VOSviewer was employed for the purposes of mapping and clustering. This combination with VOSviewer facilitated the production of diverse outputs thereby offering a streamlined and holistic perspective [18]. The principal steps undertaken in this investigation are illustrated in Figure 1.

RQ1: What are the key publication sources and their growth trends?

The examination of primary publication sources reveals the most significant journals that contribute to the study of neurological disorders, with a particular focus on Parkinson and associated conditions is elaborated in Fig.1. Parkinsonism and Related Disorders stands out as the foremost source, publishing the higher number of articles (5), which underscores its critical role in the dissemination of research within this area. Movement Disorders closely follows, with three articles, further establishing its importance as a vital platform for developments in movement-related neurological issues. Additionally, several other journals, such as Acta Neurologica Belgica, Frontiers in Neurology, and Frontiers in Immunology, each contributing two articles, illustrate the interdisciplinary character of research in this domain.

The inclusion of the Encyclopedia of Sleep and the Handbook of Clinical Neurology indicates an expanding acknowledgment of sleep disorders and a more comprehensive neurological context in the study of Parkinsonism and associated conditions. Furthermore, the presence of Revue Neurologique and Pediatriya illustrates the contributions from both clinical neurology and pediatric fields, thereby underscoring the importance of varied research perspectives. The

distribution of publications among these sources reveals a well-rounded combination of specialized and interdisciplinary research, reflecting the dynamic nature of neurological investigations. These observations highlight the growing collaboration among neurology, immunology, and clinical sciences, which is instrumental in shaping the future direction of research concerning Parkinson's disease and movement disorders.

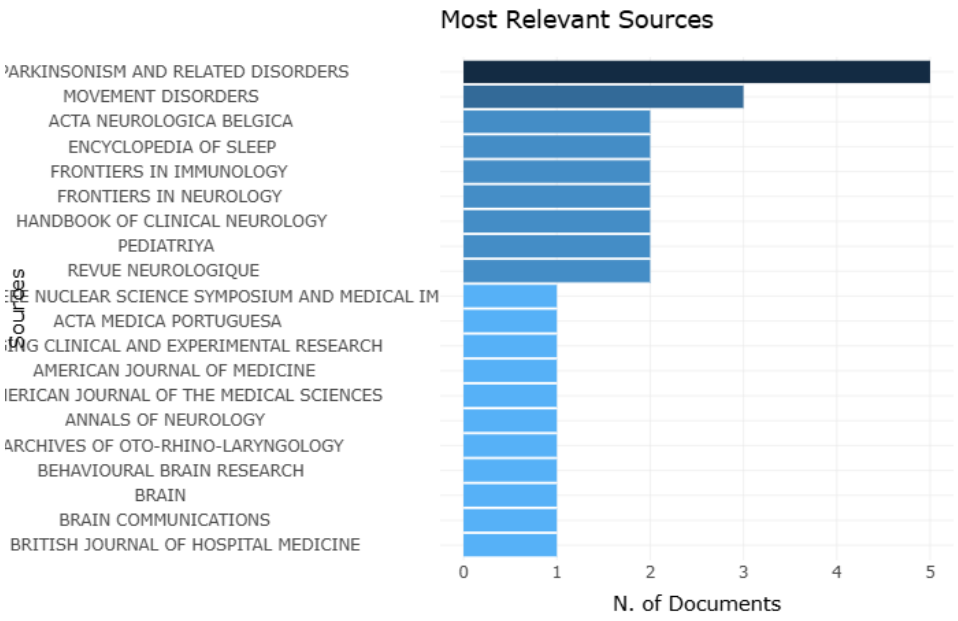

Fig.2.Most Relevant Sources

The analysis of key publication sources based on citation metrics reveals significant insights into their impact on neurological research is shown in Fig.3. *Parkinsonism and Related Disorders* demonstrates strong influence with an h-index and g-index of 5, 163 total citations, and contributions since 1995, making it a leading source in Parkinson's research. *Movement Disorders* has the highest total citations (225) despite a lower h-index (3), indicating a strong impact per article. Other sources like *Acta Neurologica Belgica*, *Frontiers in Neurology*, and *Handbook of Clinical Neurology* have moderate citation influence, suggesting consistent contributions. Notably, *Frontiers in Immunology* and *Annals of Neurology* have high m-index values, reflecting recent impactful publications. *Brain* and *Behavioural Brain Research* also show high citation numbers, underscoring their relevance. The presence of *Encyclopedia of Sleep* and *Pediatriya* indicates interdisciplinary research, while sources like *Revue Neurologique* and *British Journal of Hospital Medicine*, with long publication histories, contribute to foundational neurological studies. These findings highlight a diverse publication landscape with sources varying in longevity, citation impact, and thematic focus, shaping the field of neurology.

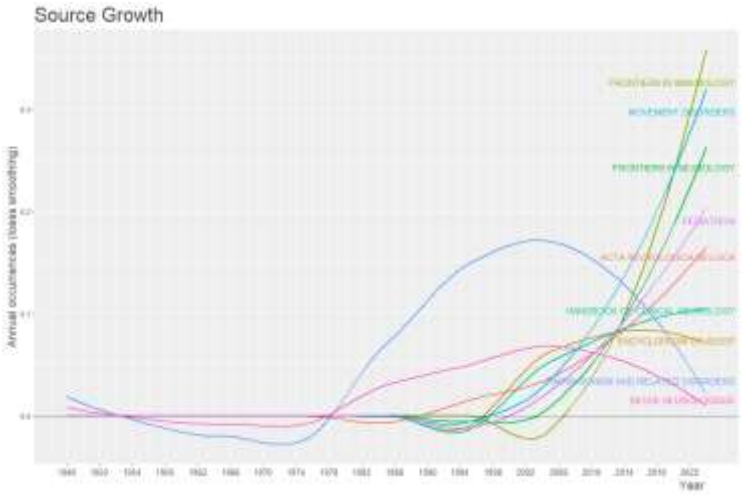

Fig.3. Bibliometric Networking Map exhibiting Source growth

RQ2: Which authors have made the groundbreaking contributions in this subject?

The statistical distribution of research output following Lotka's Law demonstrates the inverse relationship between the number of documents written and the number of authors is shown in Fig.4. The distribution begins at **x = 1**, showing that the highest percentage of authors contribute only one publication, reaching **100% on the y-axis**. As the number of publications per author increases (x = 2, x = 3), the percentage of contributing authors declines significantly. This pattern aligns with Lotka's Law, where the number of authors producing **n** publications is reverse correlation to $\mathbf{n^2}$. The decreasing trend indicates that only a small fraction of authors are highly productive, while the majority contributes a limited number of papers. The absence of data at **x = 0** suggests that every author in the dataset has published at least once. This result highlights the common scientific authorship trend, where a few prolific researchers drive a significant portion of contributions, while most authors have limited publications.

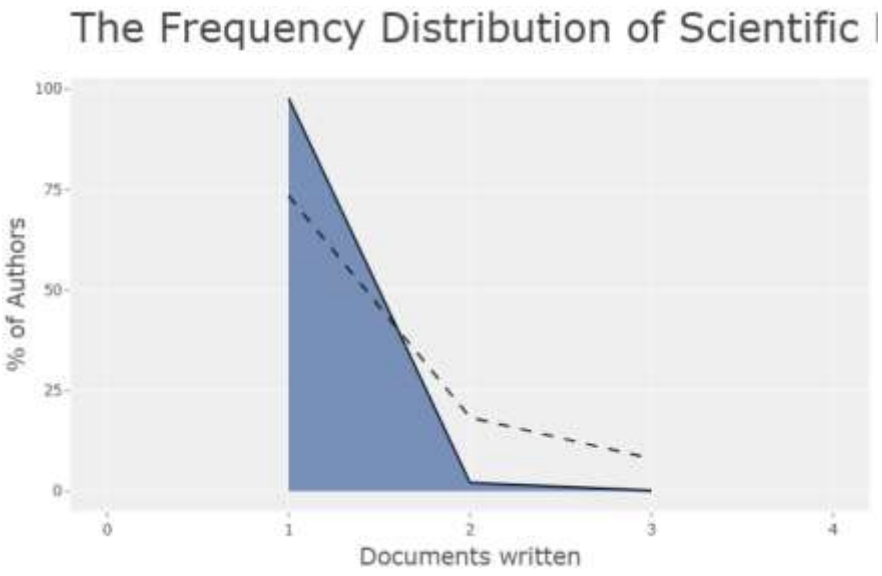

Fig. 4. Frequency distribution of scientific productivity

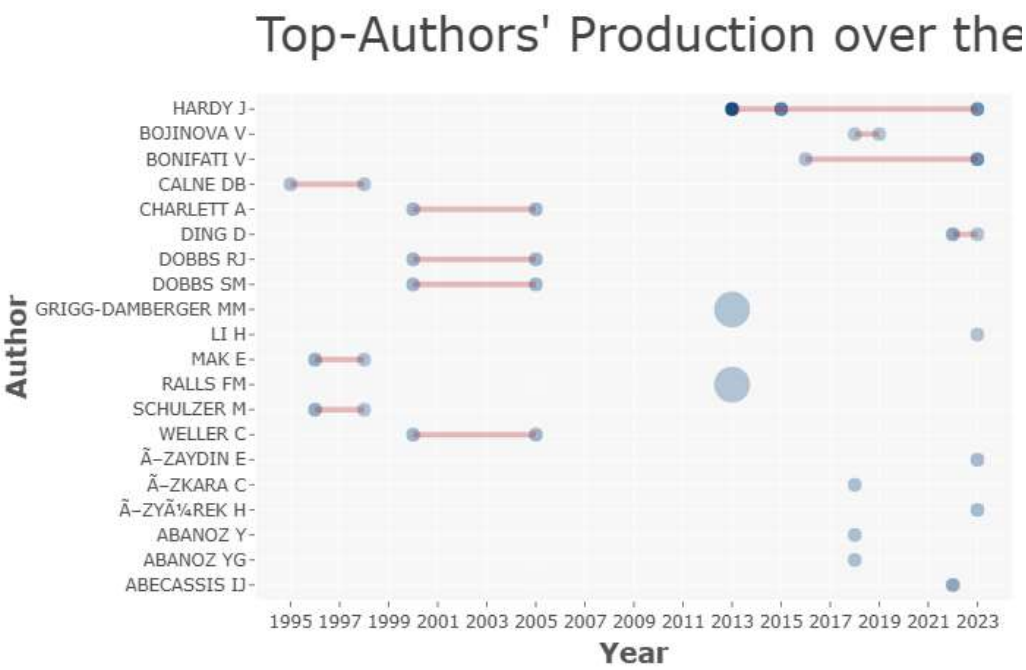

Fig. 5 Bibliometric Networking Map exhibiting Top author production over time

The analysis of top author production over time (1995–2023) reveals variations in research contributions within the field as shown in Fig.5. HARDY J leads with **three** publications, while several authors, including BOJINOVA V, BONIFATI V, CALNE DB, CHARLETT A, and others**,** have contributed **two** articles each. The fractionalized article **count**, which accounts for co-authorship contributions, varies significantly, with GRIGG-DAMBERGER MM and RALLS FM having the highest fractionalized score (**1.00**), indicating sole authorship or dominant contribution to their respective papers. Other authors, such as DING D and LI H**,** have lower fractionalized values, suggesting shared authorship across multiple contributors. The data underscores a pattern where a **small** group of researchers drive a significant portion of the contributions, aligning with the broader trend of scientific authorship distributions. Over the years, the increasing participation of multiple authors points out the mutual involvement in research in this field.

RQ3: What is the global distribution of research contributions?

The worldwide landscape of research contributions reveals a significant prevalence of publication output from the USA, Italy, and India as shown in Fig.6.

The USA demonstrates a combination of multi-country publications as well as single-country publications with a shift from 5 MCP to 10 SCP. In a similar vein, Italy begins with 1 MCP before increasing its SCP output to 7.5. India's research output consists entirely of SCP, totaling 5 documents, while Turkey, Korea, and Spain each achieve SCP figures of 2.5. Lesser contributions from Cyprus, Denmark, and Finland indicate MCP levels of up to 1.25, whereas Morocco's contributions are exclusively SCP, amounting to 1.25. This distribution indicates that while certain nations participate in international collaborative efforts (MCP), others primarily focus on independent research endeavors (SCP).

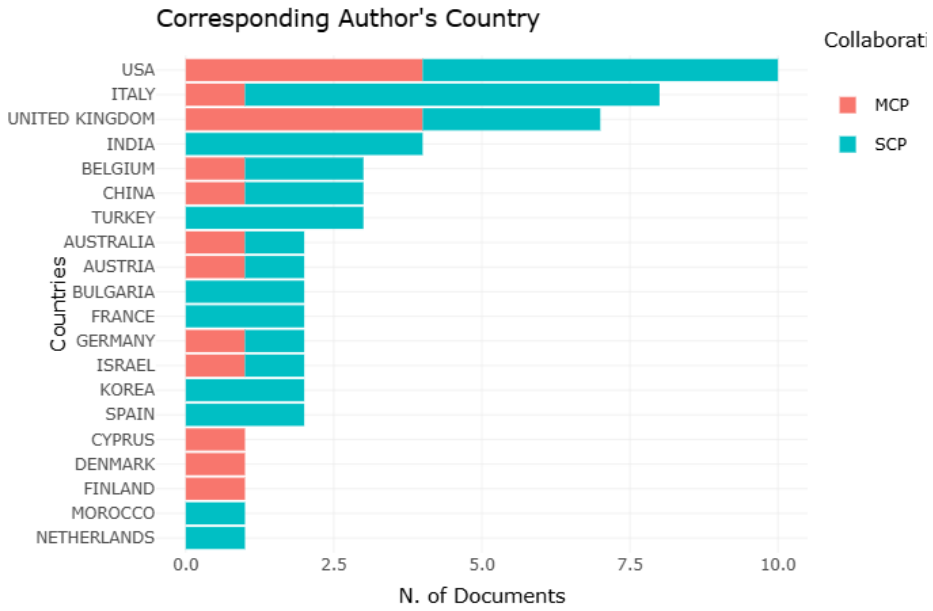

Fig. 6. Bibliometric Networking Map exhibiting Corresponding Author's Country

The country collaboration network as shown in Fig.7 highlights strong international research ties, particularly involving **France, Italy, the Netherlands, Greece, and the USA**. **France and Italy** serve as central hubs, collaborating extensively with **the USA, UK, Canada, the Netherlands, and Germany**, indicating their active role in global research partnerships. **Israel maintains a direct collaboration with the USA**, reflecting focused bilateral cooperation. Additionally, **France connects with Greece, which further links to Cyprus and then to Italy**, forming a regional research cluster. These connections emphasize the significance of cross-border collaborations in advancing scientific contributions, with leading European nations and the USA playing key roles in fostering international research networks.

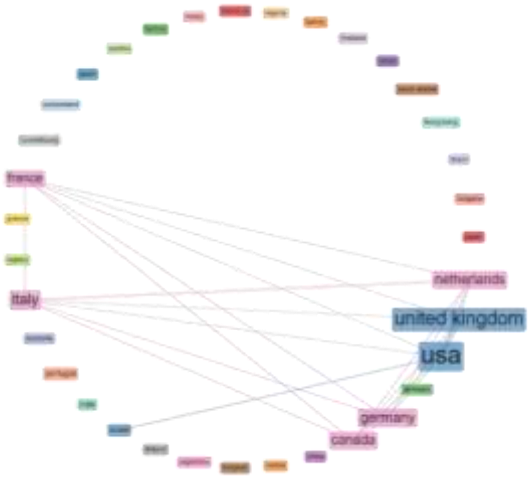

Fig. 7. Bibliometric Networking Map exhibiting Country Collabration network

RQ4: Which research themes are most prominent in the field?

The **co-occurrence network analysis** reveals distinct clusters of research focus areas as shown in Fig.8, demonstrating how key terms are interconnected in neurological and sleep-related disorders. Parkinson as well as multiple system atrophy is intricately associated, suggesting a convergence of their pathological mechanisms and research domains. In a similar vein, anti-NMDAR encephalitis, autoimmune encephalitis, and limbic encephalitis demonstrate a strong correlation, indicative of their shared autoimmune foundations. Furthermore, sleep-related disorders reveal significant interrelations, with sleepwalking being associated with sleep terror, REM sleep without atonia, as well as sleep behavior disorder, underscoring their importance in the study of parasomnias. Moreover, there is a notable connection between Parkinson's disease and narcolepsy, indicating a potential overlap between neurodegenerative and sleep disorders. These associations underscore the interdisciplinary character of research in movement disorders, autoimmune encephalitis, and sleep disorders, contributing for a more thorough comprehension of their basic functions and therapeutic strategies.

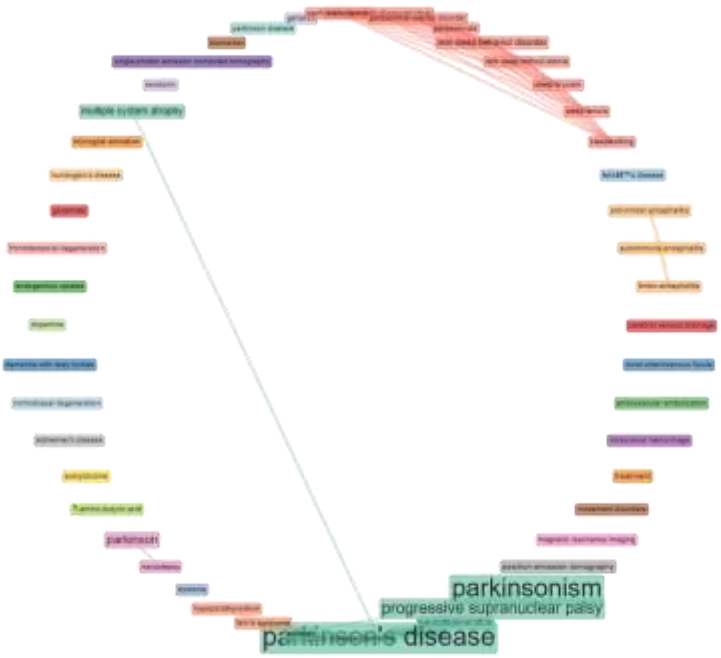

Fig. 8 Bibliometric Network Map of keywords

The tree map analysis elucidates the most prevalent keywords within the research domain, thereby underscoring significant areas of focus in the field as shown in Fig.9. The values presented reflect the frequency with which specific keywords appear in the examined research dataset. These figures indicate the keyword repetition count across a range of documents. The percentages of 6%, 5%, and 4% illustrate the relative representation of these keywords within the overall dataset. For instance, "human" (82, 6%) signifies that the term "human" is mentioned 82 times, constituting 6% of the total keywords, followed closely by "male" (77, 6%) and "parkinsonism" (74, 6%), which highlights a pronounced emphasis on human studies, particularly concerning neurological

disorders. Other notable terms include "adult" (62), "female" (60, 5%), "humans" (54), and "articles" (53, 4%), which reflect the demographic attributes of the populations under investigation. Additionally, "Parkinson's disease" (49, 4%), "seizure" (36, 3%), and "tremor" are also significantly represented, indicating a robust research focus on movement disorders and neurological conditions. The inclusion of various other keywords suggests a broad research landscape that encompasses multiple facets of neurology, aging, and disease progression, thereby reinforcing the extensive nature of investigations within this field.

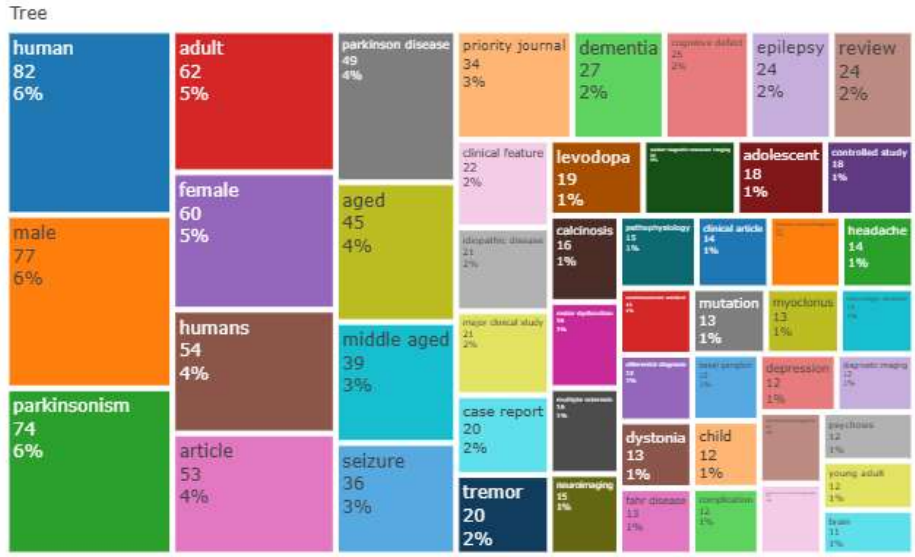

Fig. 9 Bibliometric Network of Tree Map of keywords

III. DISCUSSION

The analysis of primary publication sources identifies the most prestigious journals in the domain of neurological research, particularly concerning Parkinson's disease and related disorders (Table 1, Fig. 1). The analysis of key publication sources highlights the leading journals contributing to neurological research, particularly on Parkinson's disease. *Parkinsonism and Related Disorders* emerges as the top source with the most extensive publication record, followed by *Movement Disorders*, reinforcing their significance in the field. The presence of interdisciplinary journals like *Frontiers in Neurology* and *Handbook of Clinical Neurology* underscores the diverse research approaches. Citation metrics further reveal the impact of these sources, with high citation counts and h-index values indicating their influence in shaping advancements in neurology.

The examination of author productivity adheres to Lotka's Law, which indicates that the majority of authors produce only a single publication, whereas minorities are exceptionally productive. HARDY J stands out as the leading author in terms of publication count, trailed by several authors who each have two publications. The analysis of fractionalized authorship scores reveals disparities in individual contributions, with certain authors playing pivotal roles in their respective works. This trend underscores the collaborative essence of neurological research, wherein a limited number of researchers propel substantial progress.

The worldwide landscape of research contributions reveals differing degrees of international collaboration. The United States, Italy, and India exhibit unique trends in both multi-country and single-country publications, with the United States at the forefront in both categories. European countries such as France and Italy engage in significant collaborative efforts with the United States, the United Kingdom, and Germany, thereby establishing robust research networks.

Meanwhile, the relatively modest contributions from nations like Cyprus, Denmark, and Morocco underscore the importance of regional research initiatives.

The analysis of co-occurrence networks reveals significant research themes, notably Parkinson's disease, autoimmune encephalitis, and sleep disorders. There are notable correlations between Parkinson as well as multiple system atrophy, in addition to associations between sleepwalking and REM sleep behavior disorder. Clusters related to autoimmune encephalitis underscore common pathological mechanisms. These interrelations highlight the interdisciplinary character of research in neurology and sleep disorders.

IV. Conclusion

The examination of trends in neurological research reveals significant publication outlets, prominent authors, global contributions, and developing themes. Parkinsonism and Related Disorders stands out as a preeminent journal, with highly productive authors making substantial contributions to the discipline. Collaborative efforts on an international scale, particularly among researchers from the USA, France, and Italy, are pivotal in propelling scientific progress. Co-occurrence networks indicate strong links between Parkinson's disease, autoimmune encephalitis, and sleep disorders, highlighting the importance of interdisciplinary approaches. Additionally, the tree map analysis illustrates the central role of human studies within neurological research. The research questions collectively provide a comprehensive analysis of the field by identifying key publication sources and their growth trends, which reveal leading journals and shifts in publishing patterns. They highlight groundbreaking contributors by pinpointing influential authors driving innovation in the subject. Additionally, examining the global distribution of research contributions sheds light on regional disparities and collaboration patterns, while identifying prominent research themes helps map current trends and areas of focus, guiding future investigations. Together, these questions offer a holistic view of the field, uncovering key trends, global perspectives, and focal research areas.

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