

Bibliometric Analysis of the Published Studies on the Kindling Model between 1980 and 2023

Ahmet Sarper Bozkurt 

Department of Physiology, University of Gaziantep, Faculty of Medicine, Gaziantep, Turkey

ABSTRACT

Objective: Kindling is an animal model of epilepsy induced by electrical stimulation of the brain. The present study aimed to present a different perspective with a bibliometric approach by using the literature data on the “Kindling model” related keywords in the Web of Science (WoS) online database between 1980 and 2023.

Methods: The bibliometric data were obtained from the online database WoS and analyzed and visualized with the VoS Viewer Program. The bibliometric datasets were analyzed and visualized regarding article productivity numbers according to years, article productivity numbers according to countries, the most used keywords according to authors, and cross-country cooperation.

Results: Considering the results of the analysis of the published datasets, 2022 was determined as the year with the highest article productivity, and an acceleration was observed in the publication increase rate on the subject in general. When the order of the countries in the top three in the number of article productivity was examined, the USA, Germany, and Japan are the main countries, respectively. The most used keywords by the authors were determined as “Epilepsy”, “Kindling”, and “Hippocampus”. In the cooperation among countries, it was found that the USA, Germany, and Japan had more cooperation with other countries, respectively.

Conclusion: This study will contribute to the literature by providing a detailed understanding of the research basis, relevant research results, current research boundaries and main research focus in the Kindling Model.

Keywords: kindling model, epilepsy, bibliometric

INTRODUCTION

Epilepsy is a chronic neurological disorder characterized by recurrent seizures [1] as a common disease associated with chronic brain dysfunction [2]. More than 2/3 of epilepsy patients are not treated. More than a third of premature deaths can be attributed either directly or indirectly to epilepsy [3]. The course of epilepsy, its etiology, and the range of risk factors vary according to age and geographical distribution. Congenital, developmental, and genetic conditions are most often associated with the development of epilepsy during childhood, adolescence, and early adulthood. In underdeveloped countries, endemic infections are associated with epilepsy. The presence of epilepsy in the family's genetic history increases risk factors and might suggest that epilepsy has a very complex etiology [4]. A lot of research has been done in the last two decades to distinguish the mechanisms that cause the epilepsy disease process and to inhibit it [5]. Many different methods were used to better understand the complex mechanism of epilepsy and to develop treatments against it. One of these research methods is experimental animal models [6].

Kindling is an animal model of chronic epilepsy that has been extensively and thoroughly investigated to better understand the course of epileptogenesis and to uncover new anti-epileptic compounds as the most studied experimental animal model of epilepsy with complex processes [7]. The cellular and molecular changes that occur in Kindling-modeled experimental animals gradually provide extensive data on epilepsy [8]. A repeated and regular stimulus is applied to the brain regions of the experimental animals in which the Kindling Model will be created. As the time progresses, motor seizures are observed with the stimulus. As time progresses, the same stimulus results in intense limbic and clonic motor seizures. In 1961, Sevillano first discovered that repeated administration of this stimulus to the hippocampal region of the brain increases the intensity of seizures. The first stimulus occurs with little change in behavior or electrical brain activity. Additional stimulations result in an electrical seizure recorded after focal discharge or by electroencephalogram (EEG) [7]. This form of stimulation provides a very good opportunity to study the changes in neuronal networks. The cellular and

How to cite: Bozkurt AS (2023) Bibliometric Analysis of the Published Studies on the Kindling Model between 1980 and 2023. Eur J Ther. 29(2):188-193. <https://doi.org/10.58600/eurjther.20232902-396.y>

Corresponding Author: Ahmet Sarper Bozkurt **E-mail:** asbozkurt@gantep.edu.tr

Received: 02.04.2023 • **Accepted:** 11.04.2023 • **Published Online:** 11.04.2023



molecular changes occurring in Kindling-modeled experimental animals gradually provide extensive data on epilepsy [8].

In the present study, the purpose was to examine the studies conducted on the Kindling Model with bibliometric analysis. The word bibliometrics is of Greek origin and entered the literature by Alan Pritchard in 1969 with his study *Statistical Bibliography or Bibliometrics* [9]. Bibliometric analysis is the quantitative analysis of publications to better understand research outputs using mathematical and statistical methods [10]. Bibliometric data analysis sets provide important data on determining the scientific effect and course of research through performance analyses and bibliometric networks [11]. Examinations made through online databases provide a great convenience for us to see the current state of academic studies, their scientific volumes, and their effects, including citations [12]. Bibliometrics is very useful for developing a broad overview of resources in study areas or trends in the country [13]. A scientific dataset analysis provides a holistic approach because it includes a broad scope of academic research providing an objective analysis [14]. The study was planned to visualize a quantitative analysis of the research areas made with the Kindling Model, countries, cross-country cooperation, and the most used keywords of the authors. This research aims to examine the literature on the kindling model, which has been widely used in modeling in recent years, by using bibliometric data analysis method.

METHODS

Bibliometrics is a field of study that applies mathematical and statistical techniques to examine publication patterns in the distribution of information and a set of tools that researchers might employ to analyze published data [15]. Bibliometric analysis includes a set of statistical methods applied to detect the changes in the framework of the subject in scientific studies, trends and originality of publications [16,17].

1. Database

An online WoS database was used to analyze bibliometric data in the present study. The WoS database was searched with the keyword "Kindling Model" between 1980 and 2023. Database coverage is an important component of a bibliometric study [18]. The WoS database was preferred in the study because it covers more research compared to other online databases.

2. Data Analysis

The datasets of the bibliometric analysis program "Bibliometric R-package" were analyzed. The ".bib" files were converted into

"bibtex" files by using the Bibliometric R-package (or R Studio) Software. The data and descriptive analyzes were classified, collected one by one, and loaded into the Bibliometric R-package Program to create science maps and statistical graphs.

3. VOSviewer

The study presents a further graphical analysis of bibliographic data by using the VOSviewer Software. VOSviewer can analyze and visualize bibliometric network data such as citation relationships between publications, journals and countries, and collaborative relationships between researchers [19]. The VOSviewer (version 1.6.14) Software was preferred to visualize network maps of bibliometric datasets. Also, the most productive cooperation between countries on the subject and the relationships between the most frequently used keywords by the authors were analyzed and visualized by using this software.

4. Limitations

In the present study, the data analysis was made by using the Web of Science (WoS) Database, which is accepted as the most widely used and most comprehensive scientific database in the world, and a constraint was formed accordingly. Also, the editing dates of the datasets in the study covered the years between 1980 and 2023 (the date of accessing the WoS database: 03.02.2023).

RESULTS

In the present study, which was conducted with the bibliometric data analysis system, analyses were made under the headings such as the number of publications, cooperation between countries, and the most frequently used keywords by the authors, and the data obtained were visualized with graphics and tables. According to the Web of Science (WoS), online database results of the publications on the keywords "Kindling Model" between 1980 and 2023, 307 sources (Journals, Books, etc.), and 1053 documents were determined by bibliometric data analysis method. The distributions of these data sets are; 825 articles, 2 articles; book chapters, 45 Articles; proceedings paper, and 84 reviews. The results of 2855 Keywords Plus (ID) and 2142 Author's Keywords (DE) analyses appeared. The number of authors conducting studies on this subject was 3263, the number of studies with a single author was 54, and the number of studies with more than one author was 3209 (Table 1).

Table 1. Main statistical information of kindling model articles in WOS.

Description	WOS
Timespan	1980:2023
Sources (Journals, Books, etc)	307
Documents	1053
Average years from publication	15.7
Average citations per documents	30.85
Average citations per year per doc	1.931
Document Types	
Article	825
Article; book chapter	2
Article; proceedings paper	45

Main Points

- Epilepsy is a chronic neurological disorder characterized by recurrent seizures.
- Kindling is an animal model of epilepsy induced by electrical stimulation of the brain.
- The bibliometric datasets were examined and the current data of the publications, the trends of research activities, and the changes in the literature in recent years were analyzed in the present study.

Review	84
Document Contents	
Keywords Plus (ID)	2855
Author's Keywords (DE)	2142
Authors	
Authors	3263
Author Appearances	4858
Authors of single-authored documents	54
Authors of multi-authored documents	3209
Authors Collaboration	
Documents per Author	0.323
Authors per Document	3.1
Co-Authors per Documents	4.61
Collaboration Index	3.27

The beginning year of the datasets of this study was 1980, and the number of publications related to the "Kindling Model" was determined as only 2. It was found that the highest number of articles was reached with 51 articles in 2022. The analysis of the dataset of the study was evaluated until 2023 (03.02.2023). When the datasets were analyzed, the acceleration in the increase in the number of articles published by years is given in Figure 1 (Fig. 1). According to WoS, the process that started with 2 studies in 1980, when the first study was conducted, appeared in double-digit numbers in 1991 (12 articles), but continued to increase in the following years, displaying a fluctuating graphic course. It reached the highest number of article publications in 2022 (51 articles). A slight decrease was observed in the number of articles (20 articles) in 2012. The number of articles published in the period until January 2023 (until 03.02.2023) was found to be 825 (Figure1).

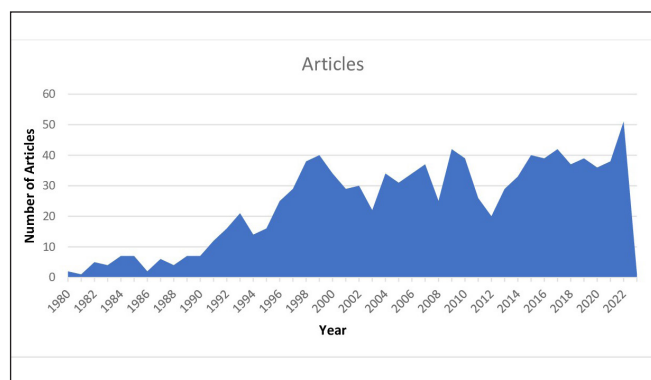


Figure 1. Illustration of the distribution of articles by year in WoS between 1980 and 2023 by years.

In this study, the analyzes of the most used keywords by the authors were made to follow the current data in the literature and the dynamics according to the years of the studies for which the Kindling Model was created. In the search results made with the term "Kindling Model" in the Web of Science (WoS) online database, where the bibliometric data set information was obtained, it was found that a total of 2142 different keywords

were used by the authors. When Figure 2 is examined, it is seen that the word it represented was used more frequently as the size of the knots increased. The line thicknesses between the nodes show the interaction between the keywords. In this context, the interaction can be expressed more as the line thicknesses between the nodes increase. As a result of the analysis of this, the most used keywords were found to be; "epilepsy" (327), "Kindling" (268), and "hippocampus" (97). In Figure 2, each node represents a keyword, and the "epilepsy" node, which is visualized in green as the largest, appears in the center of the graph (Figure 2).

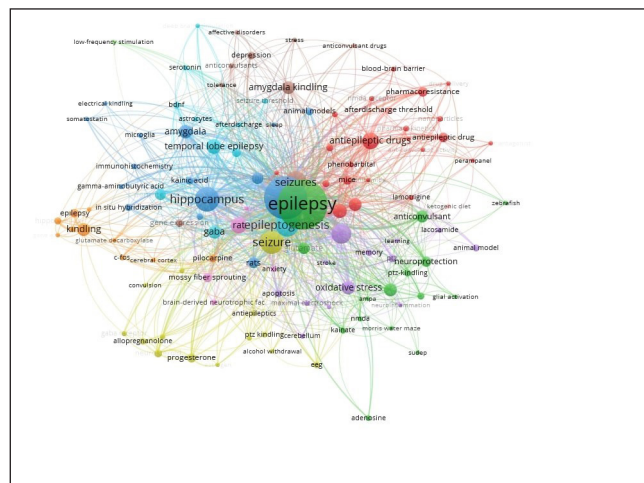


Figure 2. The Most Frequently Used Author's Keywords Between 1980 and 2023.

Keywords are important structures that constitute the contents and basis of publications. Keywords play important roles in the number of citations of articles, evaluating their effects, and increasing their availability. The most frequently used keywords by the authors were analyzed in the WoS Online Database in the present study. In this context, the most frequently used keywords by the authors were determined as "Epilepsy", "Kindling" and "Hippocampus", followed by the words "seizure" and "epileptogenesis", respectively. The first 10 words most frequently used by the authors are given in Figure 3 in order of frequency of use (Figure 3). The word cloud is one of the most used methods for the visualization of datasets. The purpose of the word cloud is to make the most used words in publications more visible. As a result of the analysis made with the term "Kindling Model" in the WoS database, the cloud of the most used words by the authors is given in Figure 4. The frequency of use of words increased as the size of the word grew according to its proximity to the central settlement. The word "Epilepsy", written in the largest font and located in the center, appeared in Figure 4. The word in second place in size is seen as "Kindling". The third word most commonly used by the authors was found to be "hippocampus" (Figure 4). Table 2 shows the order of the top 10 countries within the scope of the findings obtained according to the number of article publications and countries, the number of single article productivity, and the number of multiple articles. As well as the number of article productivity, the number of individual article productivity, and the number of multiple article productivity of the countries are also important compared to the countries. The

the most frequently used keywords by the authors, and the data obtained were visualized with graphics and tables. The place and changes of the 43-year (1980; 2023) Kindling Model concept in the literature were presented to the scientific platform with a comprehensive bibliometric data analysis. The "Kindling Model" keywords, which started publication life with two documents in 1980, increased significantly in the number of publications after 1996. It was found that the highest number of publications was reached in 2022 (50). According to the results of these datasets, it was observed that the number of publications on the subject accelerated in recent years and continues to increase. In the context of this result, it is seen that the studies conducted on the "Kindling Model" are a current issue in the scientific field literature and the tendency of the researchers to this subject is increasing.

Keywords are generally defined as important research themes for the analysis of datasets in bibliometric studies [24]. The number of keywords used by the authors in this study was presented as 2142 (Table 1). The most frequently used keywords by the most cited authors were found to be "epilepsy", "kindling" and "hippocampus" in the present study (Figure 3). The analysis of the keywords, trends, and themes identified within the scope of this study will serve as a guideline for future scientific research. The number of articles on productivity rises to high numbers with cross-country cooperation and close collaboration between authors in the Kindling Model area. The top three countries in article productivity were found to be the USA (196), Germany (111), and Japan (89), respectively. It was concluded that the cooperation network between countries is also very developed in the same countries. It is seen in these datasets that the countries with high cooperation also have a high number of article productivity. When the obtained datasets are reviewed, it can be argued that the number of articles can gain momentum in case of increased cooperation between countries in the field of "Kindling Model" keywords. A total of 1053 sources (documents) and analyses of 3263 authors' studies were included in the present study according to the Web of Science (Wos) online database datasets with the keywords "Kindling Model" between 1980 and 2023 (Table 1). Although there are few studies on the subject of epilepsy conducted with the literature review method on scientific platforms, no bibliometric research, which is a detailed analysis method that deals with the Kindling Model, was found.

CONCLUSION

The findings of the present study provide an overview of the current literature data and the trend of studies with Kindling Model keywords in the coming years. The purpose of the study was to provide a comprehensive perspective on the studies that were conducted in the past and will be conducted in the future with the analysis of the Kindling Model keywords with the datasets. These guidelines can be used in future studies (theses, projects, articles, etc.). In light of this, researchers can plan the course of their studies, their relationships to sub-branches, and critical situations such as not repeating some aspects in this field. This bibliometric study on the Kindling model may offer different perspectives to other studies in the same field. Considering the results of the study, it can be argued that the field of the Kindling Model is a current study area and academic interest is increasing

in this field with each passing day. In this context, it is expected that this study will make important contributions in emphasizing the need for the interaction between countries and authors, keyword analysis, and evaluating different approaches to the subject in studies to be conducted in the field of the Kindling Model.

Peer-review: Externally peer-reviewed.

Funding: The author declared that this study has received no financial support.

Competing interest for all authors: No financial or non financial benefits have been received or will be received from any party related directly or indirectly to the subject of this article.

REFERENCES

1. Samokhina E and Samokhin A (2018) Neuropathological profile of the pentylentetrazol (PTZ) kindling model. *International Journal of Neuroscience*. 128(11):1086-1096. <https://doi.org/10.1080/00207454.2018.1481064>
2. Vinogradova LV and Van Rijn CM (2008) Anticonvulsive and antiepileptogenic effects of levetiracetam in the audiogenic kindling model. *Epilepsia*. 49(7):1160-1168. <https://doi.org/10.1111/j.1528-1167.2008.01594.x>
3. Thijs RD, Surges R, O'Brien TJ and Sander JW (2019) Epilepsy in adults. *The lancet*. 393(10172):689-701. [https://doi.org/10.1016/S0140-6736\(18\)32596-0](https://doi.org/10.1016/S0140-6736(18)32596-0)
4. Sander JW (2003) The epidemiology of epilepsy revisited. *Current opinion in neurology*. 16(2):165-170. <https://doi.org/10.1097/00019052-200304000-00008>
5. Singh N, Saha L, Kumari P, Singh J, Bhatia A, Banerjee D and Chakrabarti A (2009) Effect of dimethyl fumarate on neuroinflammation and apoptosis in pentylentetrazol kindling model in rats, *Brain Research Bulletin*. 144:233-245. <https://doi.org/10.1016/j.brainresbull.2018.11.013>
6. Anissian D, Ghasemi-Kasman M, Khalili-Fomeshi M, Akbari A, Hashemian M, Kazemi S and Moghadamnia AA (2018) Piperine-loaded chitosan-STPP nanoparticles reduce neuronal loss and astrocytes activation in chemical kindling model of epilepsy. *International journal of biological macromolecules*. 107:973-983. <https://doi.org/10.1016/j.ijbiomac.2017.09.073>
7. Kraus JE (2000) Sensitization phenomena in psychiatric illness: lessons from the kindling model. *The Journal of neuropsychiatry and clinical neurosciences*. 12(3):328-343. <https://doi.org/10.1176/jnp.12.3.328>
8. Gorter JA, van Vliet EA, da Silva FHL (2016) Which insights have we gained from the kindling and post-status epilepticus models?. *Journal of neuroscience methods*. 260:96-108. <https://doi.org/10.1016/j.jneumeth.2015.03.025>

9. Adanır SS, Bahşi İ, Orhan M, Cihan ÖF (2020) Bibliometric analysis of articles published in Anatomy, the official publication of the Turkish Society of Anatomy and Clinical Anatomy between 2007-2018. *Anatomy*. 14(1):39-43. <https://doi.org/10.2399/ana.20.019>
10. Rubio C, Luna R, Ibarra-Velasco M, Lee Á (2021) Epilepsy: A bibliometric analysis (1968-2020) of the Instituto Nacional de Neurología y Neurocirugía "Manuel Velasco Suarez" in Mexico. *Epilepsy&Behavior*. 115:107676. <https://doi.org/10.1016/j.yebeh.2020.107676>
11. Ni X-J, Zhong H, Liu Y-X, Lin H-W, Gu Z-C (2022) Current trends and hotspots in drug-resistant epilepsy research: Insights from a bibliometric analysis. *Frontiers in Neurology*. 13. <https://doi.org/10.3389/fneur.2022.1023832>
12. Morandi G, Guido D, Tagliabue A (2015) A bibliometric study of scientific literature on the dietary therapies for epilepsy in Scopus. *Nutritional Neuroscience*. 18(5):201-209. <https://doi.org/10.1179/1476830514Y.0000000118>
13. Hood WW, Wilson CS (2001) The literature of bibliometrics, scientometrics, and informetrics. *Scientometrics*. 52(2):291-314. <https://doi.org/10.1023/A:1017919924342>
14. Cardona JCD, Lobo RR, Mora VR (2002) La investigación regional en España: un análisis bibliométrico. *Investigaciones Regionales Journal of Regional Research*. 1:107-138.
15. Danvila-del-Valle I, Estévez-Mendoza, C, Lara FJ (2019) Human resources training: A bibliometric analysis. *Journal of Business Research*. 101; 627-636. <https://doi.org/10.1016/j.jbusres.2019.02.026>
16. Rey-Martí A, Ribeiro-Soriano D, Palacios-Marqués D (2016) A bibliometric analysis of social entrepreneurship. *Journal of Business Research*. 69(5):1651-1655. <https://doi.org/10.1016/j.jbusres.2015.10.033>
17. Bahşi İ, Adanır SS, Kervancıoğlu P, Orhan M, Govsa F (2021) Bibliometric Analysis of Turkey's Research Activity in the Anatomy and Morphology Category from the Web of Science Database. *Eur J Ther*. 27(4):268-280. <https://doi.org/10.5152/eurjther.2021.20108>
18. Thompson DF (2018) Bibliometric Analysis of Pharmacology Publications in the United States: A State-Level Evaluation. *J. Sci. Res*. 7(3):167-172. <https://doi.org/10.5530/jscires.7.3.27>
19. Van Eck NJ, Waltman L (2014) Visualizing bibliometric networks' in *Measuring scholarly impact*. Springer. 285-320. https://doi.org/10.1007/978-3-319-10377-8_13
20. Cheng H, Wang Y, Chen J, Chen Z (2020) The piriform cortex in epilepsy: what we learn from the kindling model. *Experimental neurology*. 324;113137. <https://doi.org/10.1016/j.expneurol.2019.113137>
21. Guna V, Saha L, Bhatia A, Banerjee D, Chakrabarti A (2018) Anti-oxidant and anti-apoptotic effects of berberine in pentylenetetrazole-induced kindling model in rat. *Journal of Epilepsy Research*. 8(2):66. <https://doi.org/10.14581/jer.18011>
22. Meng X, Wang F, Li C (2014) Resveratrol is neuroprotective and improves cognition in pentylenetetrazole-kindling model of epilepsy in rats. *Indian journal of pharmaceutical sciences*. 76(2):125.
23. Donthu N, Kumar S, Mukherjee D, Pandey N, Lim WM (2021) How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*. 133:285-296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
24. Chen G, Xiao L (2016) Selecting publication keywords for domain analysis in bibliometrics: A comparison of three methods. *Journal of Informetrics*. 10(1):212-223. <https://doi.org/10.1016/j.joi.2016.01.006>