

A Bibliometric Analysis of the Cannabis and Cannabinoid Research Literature

Jeremy Y. Ng (✉ NGJY2@MCMASTER.CA)

McMaster University <https://orcid.org/0000-0003-0031-5873>

Research Article

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Abstract

Background: Cannabis refers to a flowering plant in the family Cannabaceae, which has been used medically, recreationally, and industrially. The history of cannabis has been both long and complex, however, the last few decades have seen a large increase in the volume of literature on this topic. The objective of the present bibliometric analysis is to capture the characteristics of peer-reviewed publications on the topic of cannabis and cannabinoid research.

Methods: Searches were run on April 02, 2021, and results were exported on the same day to prevent discrepancies between daily database updates. Only “article” and “review” publication types were included; no further search limits were applied. The following bibliometric data were collected: number of publications (in total and per year), authors and journals; open access status; journals publishing the highest volume of literature and their impact factors; language, countries, institutional affiliations, and funding sponsors of publications; most productive authors; and most highly-cited publications. Trends associated with this subset of publications were identified and presented. Bibliometric networks were constructed and visualized using the software tool VOSviewer.

Results: A total of 29 802 publications (10 214 open access), published by 65 109 authors were published in 5474 journals from 1829 to 2021. The greatest number of publications were published over the last 20 years. The journal that published the largest number of publications was Drug and Alcohol Dependence (n=705). The most productive countries included the United States (n= 12 420), the United Kingdom (n=2236), and Canada (n=2062); many of the most common institutional affiliations and funding sponsors also originated from these three countries.

Conclusions: The number of publications collectively published on the topic of cannabis follows an upward trend. Over the past 20 years, the volume of cannabis research has grown steeply, which can be largely attributed to the existence of a large amount of funding dedicated to research this topic. Future research should continue to investigate changes in the publication characteristics of emerging cannabis research, especially as it is expected that the body of publications on this topic is expected to rapidly grow.

Background

Cannabis refers to a flowering plant in the family Cannabaceae; while the exact number of species within the genus is disputed, the following three are generally recognized: *Cannabis sativa*, *Cannabis indica*, and *Cannabis ruderalis*. The cannabis plant contains about 540 chemical substances [1], and over 100 of them are classified as cannabinoids, of which cannabidiol (CBD) and tetrahydrocannabinol (THC) are the most prominent. THC is primarily responsible for the plant’s psychoactive effects [1, 2], while CBD is of particular interest to healthcare researchers and clinicians, as this specific compound is responsible for cannabis’ purported therapeutic value [3]. The term “marijuana” refers to the parts of or the products from the cannabis plant that contain THC, while industrial hemp refers to plants that have minimal THC [1].

Cannabis is sometimes used interchangeably with the term “hemp”, however, the latter only refers to varieties cultivated for non-drug uses. The cannabis plant is widely used for hemp fibre, hemp seeds and oils, hemp leaves for use as vegetables and juices, and as a recreational drug [4]. Medically, cannabis has long been considered of value as a general analgesic, anesthetic, antidepressant, antibiotic, and sedative; its history dates back to 2700 BCE where cannabis was first documented in a Chinese pharmacopoea by Chinese Emperor Shen Nung, who is widely regarded as the Father of Chinese Medicine [5, 6].

The effects of cannabis are dependent on strength and quantity, the environment in which it is taken, and the experience of the individual using it. Psychological effects tend to predominate, with the user commonly experiencing a mild euphoria. Individuals using cannabis often report distortions in time and space [7]. Acute intoxication may result in the following: visual hallucinations, anxiety, depression, extreme variability of mood, paranoid reactions, and psychoses lasting up to six hours. Physical effects include reddening of the eyes, mouth and throat dryness, moderate increases in heartbeat, tightness in the chest (if smoked), drowsiness, unsteadiness, and muscular incoordination [8, 9, 10]. Many questions concerning the medical and social impacts of individuals using cannabis globally have been of interest to researchers since THC was first synthesized and isolated in 1969 [11]. Cannabinoids are now known to affect cell receptors in the brain and body, changing how they behave and communicate [2], and may serve as a promising therapy in treating and/or managing epilepsy, nausea and vomiting induced by cancer chemotherapy and weight loss, loss of appetite associated with HIV AIDS, chronic pain, and muscle spasticity associated with multiple sclerosis [1].

The last few decades have seen a large increase in the volume of literature on the topic of cannabis and cannabinoids [12, 13], and the application of a bibliometric analysis can facilitate better understanding of the field. Most recently, extensive cannabis research efforts have taken place in countries such as Canada, where on October 17, 2018, the Cannabis Act came into force legalizing the sale and use of recreational cannabis across Canada [14], making the substance easier to study. A bibliometric analysis is a research methodology that involves the statistical assessment of scientific publications or books, to identify the characteristics and determine the impact of the literature published in a specific academic discipline [15, 16, 17]. To date, a small number of bibliometric analyses have been conducted, however, their search strategies have not been highly comprehensive, hence even the most well-conducted ones to date have reported that less than 1500 publications have been published on cannabis and cannabinoids globally [12, 13] The objective of the present bibliometric analysis is to capture the characteristics of peer-reviewed publications on the topic of cannabis and cannabinoid research.

Methods

Publication Search and Characteristics

A single search was run on Scopus on April 02, 2021 as follows: “(TITLE (cannabi* OR hashish OR marijuana OR marihuana)) AND (LIMIT-TO (DOCTYPE,"ar") OR LIMIT-TO (DOCTYPE,"re"))”. Search results were exported in batches due to the download limits imposed by Scopus; all downloads were

completed on the same day to prevent discrepancies between daily database updates. Searches were only conducted on Scopus because it is the largest abstract and citation database of peer-reviewed literature [18]; in comparison, Web of Science contains considerably fewer indexed publications, while OVID databases do not provide certain metrics such as publication citation counts [19]. Only “article” and “review” publication types were included, and no further search limits were applied. The following bibliometric data were collected: number of publications (in total and per year), open access status, publications per journals, journal names and impact factors, language of publication, document type, publication country, author affiliations, funding sponsors, most highly published authors and most highly-cited publications. Trends associated with this subset of publications were identified and presented. Bibliometric networks were constructed and visualized using the software tool VOSviewer (version 1.6.1) [20, 21].

Results

A total of 29 802 publications (10 214 open access), published by 65 109 authors were published in 5474 journals from 1829 to 2021. Since the 1960s, an upward trend with respect to the volume of publication can be observed, with 2020 marking the year with the most publications; Fig. 1 depicts the number of publications published per year. Drug and Alcohol Dependence published the largest number of publications (n = 706), followed by Addictive Behaviors (n = 419) and the British Journal of Pharmacology (n = 356). The 30 journals that have published the highest number of publications were hand-searched on InCites Journal Citation Reports; the 2019 impact factors of these journals ranged from 1.214 to 7.730. Table 1 provides complete details of the journals included in this bibliometric analysis, including full journal title, number of publications published, and impact factor.

The subject area containing the largest number of publications was medicine (n = 17 124), followed by pharmacology, toxicology and pharmaceuticals (n = 8604), then biochemistry, genetics and molecular biology (n = 5827). Publications were primarily published in English (n = 27 715), followed by German (n = 658), then French (n = 490). The breakdown by document type was article (n = 26 296) and review (n = 3506). The most common publication countries included the United States (n = 12 420), the United Kingdom (n = 2236), and Canada (n = 2062). The most common affiliations were the University of Toronto (n = 455), King's College London (n = 428), and the National Institutes of Health (n = 426); the most common funding sponsors were the National Institutes of Health (n = 5848), the US Department of Health and Human Services (n = 5778), and the National Institute on Drug Abuse (n = 4371). The general characteristics of eligible publications are summarized in Table 2. In addition, the 10 most highly-published authors are provided in Table 3, and the 10 most highly-cited publications are provided in Table 4.

Figures 2–5 represent bibliometric networks constructed and visualized using the software tool VOSviewer. Figure 2 depicts a co-authorship analysis of the 50 most productive countries. In a co-authorship analysis, the relatedness of items is determined based on the number of co-authored publications. Figure 3 depicts a co-occurrence analysis of the 500 most frequent author keywords used

across all publications. In a co-occurrence analysis, the relatedness of items determined based on the number of publications in which they occur together. Figures 4 and 5 depict a citation analysis of the 500 most cited authors, and the 100 sources publishing the largest number of cannabis publications, respectively. In a citation analysis, the relatedness of items is determined based on the number of times they cite each other.

Discussion

The objective of the present bibliometric analysis is to capture the characteristics of peer-reviewed publications on the topic of cannabis research. The search conducted on Scopus yielded nearly 30 000 peer-reviewed publications, representing the largest bibliometric analysis of cannabis literature to date to the author's knowledge. An increase in the volume of literature was observed beginning in the 1960s, however, the most recent 20 years (2000–2020) have represented the largest increase in volume of research published on the topic of cannabis. This can largely be attributed to the fact that more than \$1.5 billion of cannabis research was funded between 2000 and 2018 [22]. One analysis provided a breakdown of this collective funding by country, finding that more than \$1.4 billion funded researchers in the United States; the United Kingdom at \$39.9 million and Canada at \$36.1 million represented a distant second and third respectively [22]. In the present study, it was found that the United States was by far the most productive country with respect to cannabis research at 12 420 publications, followed by the United Kingdom at 2236 and Canada at 2062, matching the order and approximate proportions as found by the aforementioned analysis. It is also unsurprising that out of the top 10 institutional affiliations responsible for publishing this cannabis research, 5 originate from the United States, 1 from the United Kingdom, and 1 from Canada. Additionally, with respect to funding sponsors, 6 are based in the United States, 2 in Canada, and 1 in the United Kingdom (excluding the European Commission). It has also been found that more cannabis research has focussed on the harms associated with the substance, as opposed to its medical uses, especially in the United States [23, 24]. This is also reflected in the present study's findings, as nearly half ($n = 14$) of the 30 journals having published the highest number of cannabis publications contain harm-associated words in their titles such as "dependence", "addictive/addiction", "forensic", "drug", and "abuse". In contrast, only a single journal – the Journal of Medicinal Chemistry – exclusively publishes medical cannabis research, while the remaining journals have titles indicating that they publish a mixture of cannabis research relating both to harms and medical properties (i.e. pharmacology journals).

Comparative Literature

To date, only a small number of bibliometric analyses of cannabis and cannabinoid research have been conducted. To the author's knowledge, the present study includes the largest number of cannabis research publications ($n = 29\ 802$) in comparison to previously published bibliometric analyses of the same topic. Liu et al. (2020) conducted a bibliometric analysis of cannabis and cannabidiol research published between 1940 and 2019, capturing the characteristics of 1167 publications. They found that the historical development of this research topic could be clearly divided into studies that focussed on the

following three aspects: chemistry, pharmacology, and molecular biology. Despite the considerably smaller quantity of literature captured, the trends that they identified with regards to most productive countries, and journals publishing the highest volume of cannabis research, were similar to the present study's findings [12]. Another bibliometric analysis conducted by Matielo et al. (2018) captured the characteristics of six decades of research on the cannabis plant totalling 1284 publications. This number is likely due to the fact that they sought to capture research conducted at the intersection of cannabis and the following six topics only: biochemical, biology, forensic genetics, genetics, molecular markers, and traceability [13]. Prior to this study, the two aforementioned bibliometric analyses represent the most comprehensive ones to date with respect to cannabis and cannabinoid literature. Others have focussed on more specific subsets of publications; for example, Yeung et al. (2019) analysed the 100 most highly-cited studies published on the topic of cannabis, cannabinoids and endocannabinoids. Despite the authors conducting their bibliometric analysis on Web of Science, a large proportion of the 100 publications they identified were also identified as highly-cited publications in the present study; in fact, the order of the 6 most highly-cited publications were identical [25]. Treister-Goltzman et al. (2019) identified trends in publications specific to medical cannabis; similar to the present bibliometric analysis, the authors found a large increase in the number volume of publications on this topic over the approximate last two decades, much of which originated from the United States [26]. Lastly, three additional bibliometric analyses are worth mentioning as they all sought to characterize a subset of publications relating to substance use and addictions research, all of which included cannabis. Comparisons are not made, however, as the primary objectives as well as the totality of included publications of these studies were considerably different to that of the present study [27, 28, 29].

Strengths and Limitations

This bibliometric study contained a number of notable strengths including the fact that the characteristics of 29 802 publications published in 5474 journals were captured, representing the largest of all bibliometric analyses on this topic to date. Searches were conducted on Scopus as this academic database has a larger coverage in comparison to other databases such as Web of Science; this decision was also justified by the fact that one study conducted cannabis-specific searches on Scopus in addition to other databases, finding that no search results were lost when compared to searching only the former [13]. Despite this, it is always possible that some literature may not have been captured by not searching other databases, however, this would have introduced considerable complexities with respect to the ability to analyse search results efficiently (i.e. deduplication of such a large volume of publications). One additional limitation includes the fact that search results were not screened manually, even though this is not typically done for bibliometric analyses that include more than a couple thousand publications as such a step is neither practical nor efficient. This was mitigated by the search strategy selected; fortunately, publications on the topic of cannabis and cannabinoid almost always include one of the following search strings inclusive of cannabi*, hashish, marijuana, or marihuana in their title, in combination with the fact that these same search strings very infrequently refer to a non-cannabis/cannabinoid topic. Despite the existence of many slang terms used to refer to cannabis, it is extremely uncommon for authors to use such a term in the title of their article.

Conclusions

The present study captured the characteristics of peer-reviewed publications on the topic of cannabis research, yielding nearly 30 000 peer-reviewed publications, representing the largest bibliometric analysis conducted on this topic to date. The most productive countries included the United States, the United Kingdom, and Canada; unsurprisingly, a large proportion of institutional affiliations and funding sponsors associated with this subset of publications also originated from these three countries. Over the past 20 years, the volume of cannabis research has grown steeply, which can be largely attributed to the existence of a large amount of funding dedicated to research this topic. Future research should continue to investigate changes in the publication characteristics of emerging cannabis research, especially as it is expected that the body of publications on this topic is expected to rapidly grow.

Declarations

Ethics Approval and Consent to Participate

This study involved a bibliometric analysis of the literature only; it did not require ethics approval or consent to participate.

Consent for Publication

The author consents to this manuscript's publication.

Availability of Data and Materials

All data generated or analysed during this study are included in this published article.

Competing Interests

The author declares that they have no competing interests.

Funding

This study was not funded.

Authors' Contributions

JYN: conceptualized and designed the study, collected the data, interpreted and analysed the data, drafted the manuscript, and gave final approval of the version to be submitted.

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Abbreviations

CBD

cannabidiol

THC

tetrahydrocannabinol

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Tables

Table 1

Characteristics of the 30 Journals Having Published the Highest Number of Cannabis and Cannabinoid Publications

Journal Name	Number of Publications	2019 Impact Factor
Drug and Alcohol Dependence	706	3.951
Addictive Behaviors	419	3.645
British Journal of Pharmacology	356	7.730
Psychopharmacology	343	3.130
Addiction	313	6.343
Substance Use and Misuse	308	1.497
European Journal of Pharmacology	306	3.263
Pharmacology Biochemistry and Behavior	246	2.519
Journal of Pharmacology and Experimental Therapeutics	243	3.561
Neuropharmacology	222	4.431
Plos One	217	2.740
International Journal of Drug Policy	202	4.444
Forensic Science International	183	2.108
Journal of Medicinal Chemistry	181	6.205
Journal of Psychoactive Drugs	181	1.859
Life Sciences	170	3.647
Journal of Analytical Toxicology	166	3.513
Brain Research	153	2.733
Neuroscience	148	3.056
Journal of Neuroscience	142	5.674
Neuropsychopharmacology	139	6.751
Biochemical Pharmacology	137	4.960
Drug Testing and Analysis	133	2.903
American Journal of Drug and Alcohol Abuse	129	2.925

Journal Name	Number of Publications	2019 Impact Factor
Journal Of Studies on Alcohol and Drugs	123	2.448
Psychology of Addictive Behaviors	121	2.780
Journal of Drug Issues	120	1.214
Journal of Psychopharmacology	118	3.121
American Journal on Addictions	113	2.371
Drug and Alcohol Review	112	2.472

Table 2
General Characteristics of Cannabis and Cannabinoid Publications

Publication Volume	
Number of Total Publications (n = 29 802)	
Number of Open Access Publications (n = 10 214)	
Document Type (# of publications)	Article (n = 26 296)
	Review (n = 3506)
Source Titles (Journals) Across All Publications (n = 5474)	
Unique Authors Across All Publications (n = 65 109)	
Subject Area of Publication (10 Highest)	
(# of publications)	Medicine (n = 17124)
	Pharmacology, Toxicology and Pharmaceutics (n = 8604)
	Biochemistry, Genetics and Molecular Biology (n = 5827)
	Neuroscience (n = 4266)
	Psychology (n = 2542)
	Social Sciences (n = 2188)
	Chemistry (n = 2167)
	Agricultural and Biological Sciences (n = 1578)
	Environmental Science (n = 864)
	Nursing (n = 676)
Language of Publication (10 Highest)	
(# of publications)	English (n = 27 715)
	German (n = 658)
	French (n = 490)
	Spanish (n = 362)
	Chinese (n = 133)
	Dutch (n = 91)
	Italian (n = 78)
	Portuguese (n = 76)

Publication Volume	
	Japanese (n = 63)
	Norwegian (n = 52)
Country of Publication (10 Highest)	
(# of publications)	United States (n = 12 420)
	United Kingdom (n = 2236)
	Canada (n = 2062)
	Germany (n = 1694)
	Italy (n = 1663)
	Spain (n = 1384)
	Australia (n = 1325)
	France (n = 1030)
	Netherlands (n = 795)
	China (n = 755)
Institutional Affiliation (10 Highest)	
(# of publications)	University of Toronto (n = 455)
	King's College London (n = 428)
	National Institutes of Health (n = 426)
	Virginia Commonwealth University (n = 386)
	Universidad Complutense de Madrid (n = 372)
	University of Washington, Seattle (n = 354)
	National Institute on Drug Abuse (n = 348)
	Harvard Medical School (n = 341)
	Inserm (n = 335)
	Universidade de Sao Paulo (n = 328)
Funding Sponsor (10 Highest)	
(# of publications)	National Institutes of Health (n = 5848)
	US Department of Health and Human Services (n = 5778)
	National Institute on Drug Abuse (n = 4371)

Publication Volume
National Institute on Alcohol Abuse and Alcoholism (n = 1007)
National Institute of Mental Health (n = 647)
European Commission (n = 434)
Government of Canada (n = 394)
National Cancer Institute (n = 317)
Canadian Institutes of Health Research (n = 314)
UK Research and Innovation (n = 299)

Table 3
10 Most Productive Authors Across Cannabis
and Cannabinoid Publications

Author Name	Number of Publications
Mechoulam, R.	228
Makriyannis, A.	225
Huestis, M.A.	180
Di Marzo, V.	172
Martin, B.R.	162
Mackie, K.	142
Pertwee, R.G.	140
Lutz, B.	96
Zuardi, A.W.	92
Guimarães, F.S.	87

Table 4
10 Highest Cited Cannabis and Cannabinoid Publications

Title	Authors	Year	Source Title	Cited By
Isolation and structure of a brain constituent that binds to the cannabinoid receptor	Devane W.A., Hanuš L., Breuer A., Pertwee R.G., Stevenson L.A., Griffin G., Gibson D., Mandelbaum A., Etinger A., Mechoulam R.	1992	Science	4340
Structure of a cannabinoid receptor and functional expression of the cloned cDNA	Matsuda L.A., Lolait S.J., Brownstein M.J., Young A.C., Bonner T.I.	1990	Nature	3923
Molecular characterization of a peripheral receptor for cannabinoids	Munro S., Thomas K.L., Abu-Shaar M.	1993	Nature	3788
Identification of an endogenous 2-monoglyceride, present in canine gut, that binds to cannabinoid receptors	Mechoulam R., Ben-Shabat S., Hanus L., Ligumsky M., Kaminski N.E., Schatz A.R., Gopher A., Almog S., Martin B.R., Compton D.R., Pertwee R.G., Griffin G., Bayewitch M., Barg J., Vogel Z.	1995	Biochemical Pharmacology	2166
International Union of Pharmacology. XXVII. Classification of cannabinoid receptors	Howlett A.C., Barth F., Bonner T.I., Cabral G., Casellas P., Devane W.A., Felder C.C., Herkenham M., Mackie K., Martin B.R., Mechoulam R., Pertwee R.G.	2002	Pharmacological Reviews	2092
Determination and characterization of a cannabinoid receptor in rat brain	Devane W.A., Dysarz III F.A., Johnson M.R., Melvin L.S., Howlett A.C.	1988	Molecular Pharmacology	1875
Cannabinoid receptor localization in brain	Herkenham M., Lynn A.B., Little M.D., Johnson M.R., Melvin L.S., De Costa B.R., Rice K.C.	1990	Proceedings of the National Academy of Sciences of the United States of America	1771
Characterization and localization of cannabinoid receptors in rat brain: A quantitative in vitro autoradiographic study	Herkenham M., Lynn A.B., Johnson M.R., Melvin L.S., De Costa B.R., Rice K.C.	1991	Journal of Neuroscience	1674

Title	Authors	Year	Source Title	Cited By
2-arachidonoylglycerol: A possible endogenous cannabinoid receptor ligand in brain	Sugiura T., Kondo S., Sukagawa A., Nakane S., Shinoda A., Itoh K., Yamashita A., Waku K.	1995	Biochemical and Biophysical Research Communications	1670
Isolation, structure, and partial synthesis of an active constituent of hashish	Gaoni Y., Mechoulam R.	1964	Journal of the American Chemical Society	1583

Figures

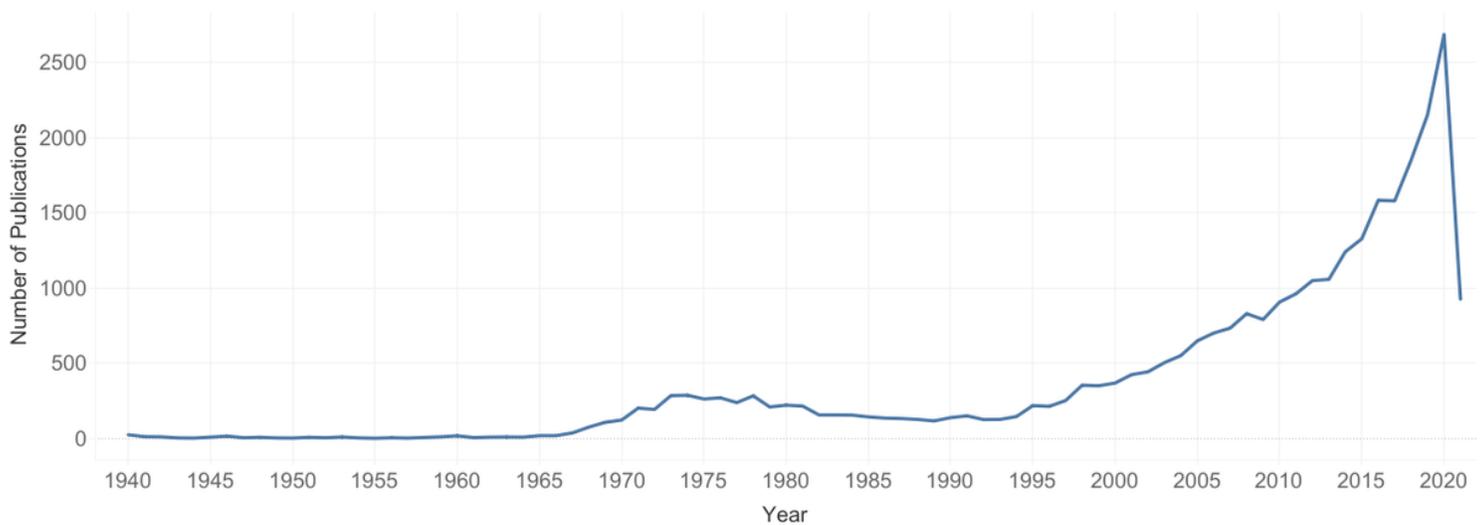


Figure 1

Number of Cannabis and Cannabinoid Publications per Year from 1940-2021

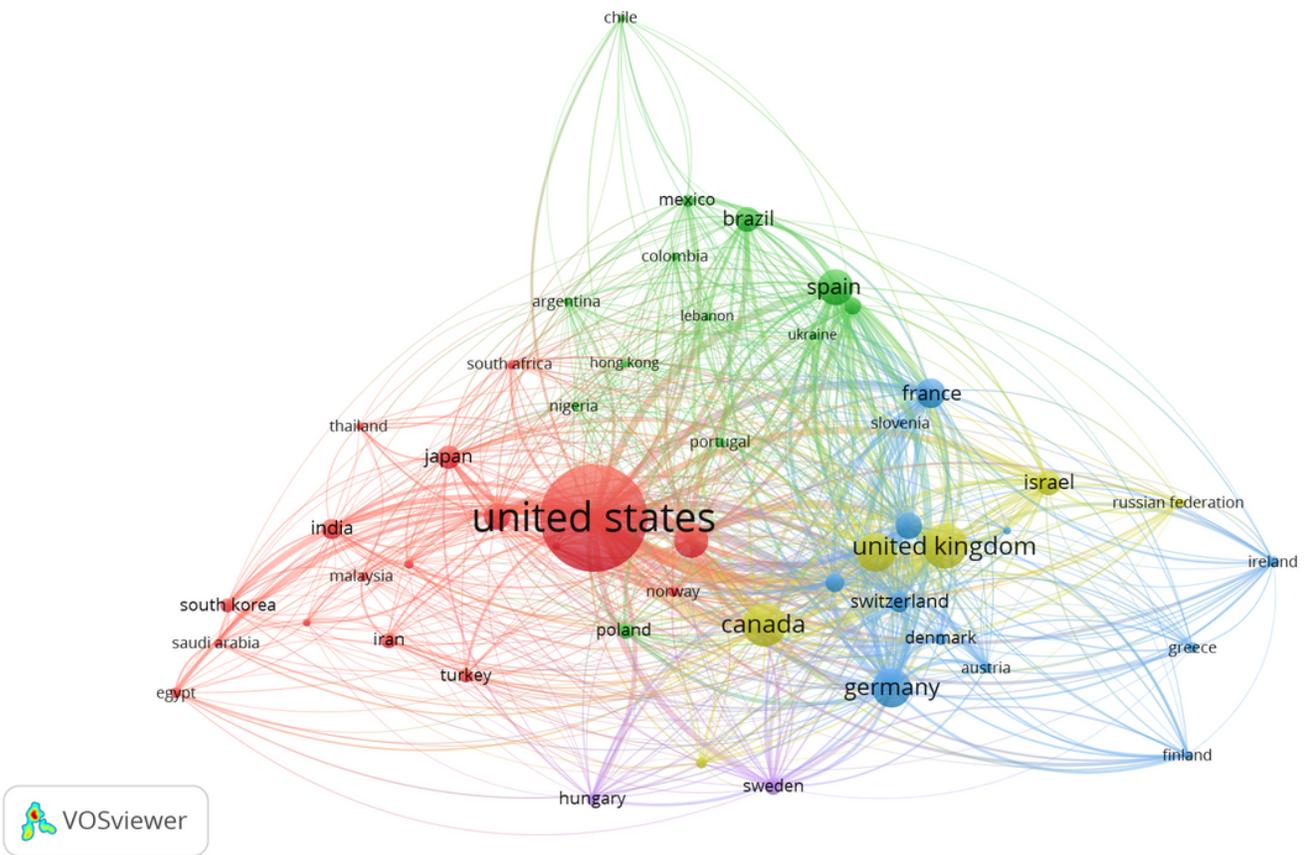


Figure 2

Co-Authorship Analysis of the 50 Most Productive Countries

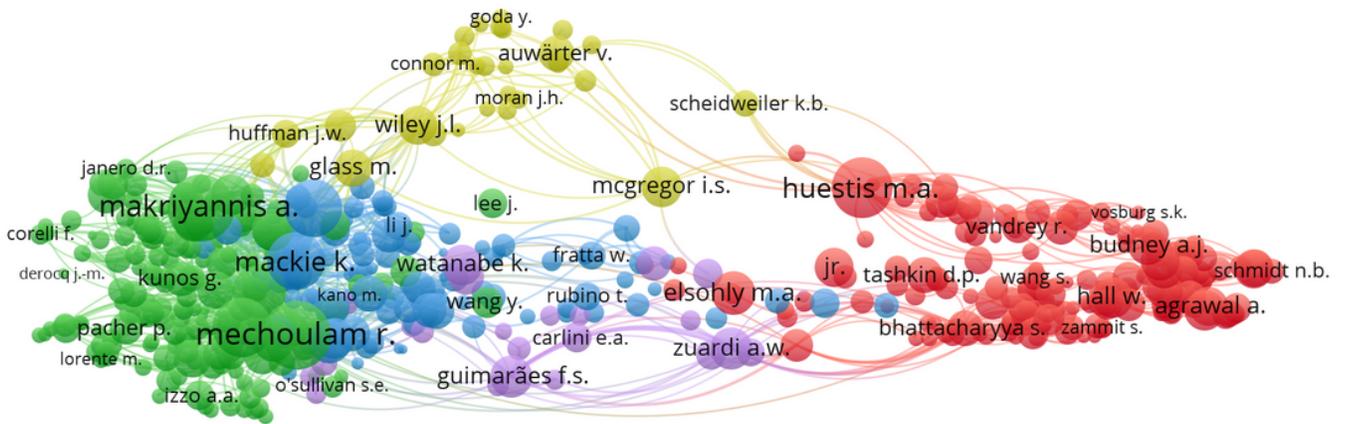


Figure 4

Citation Analysis of the 500 Most Cited Authors

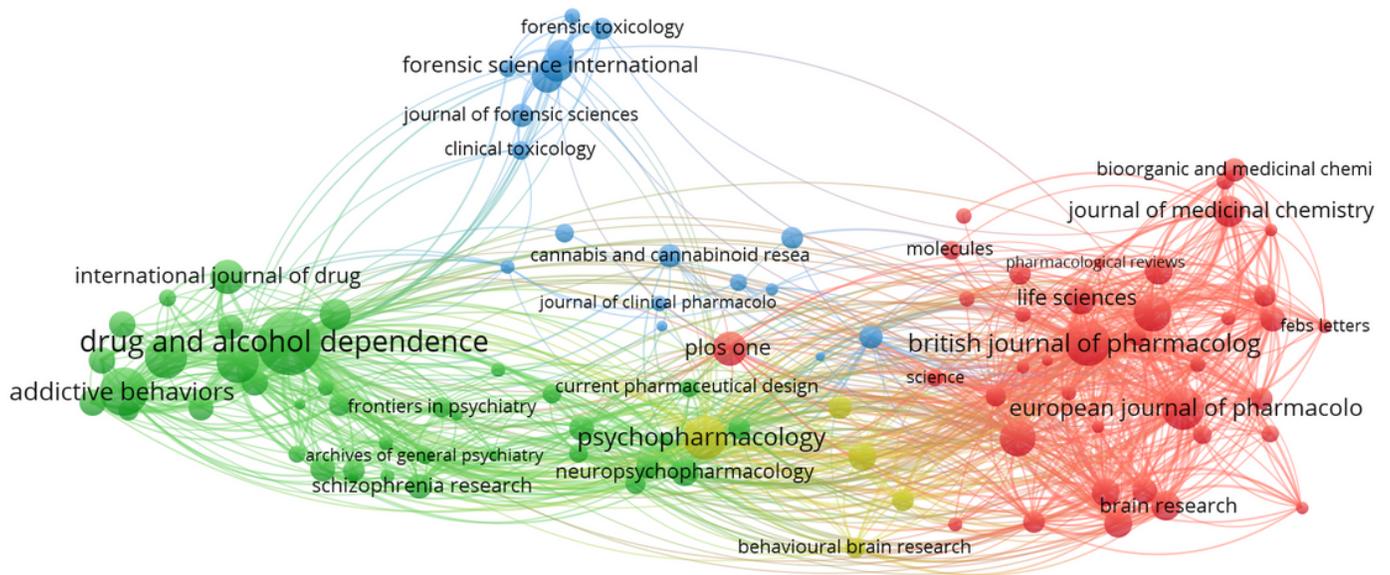


Figure 5

Citation Analysis of the 100 Journals Publishing the Largest Number of Cannabis and Cannabinoid Publications