Diabetes and Behaviour Studies Using Animal Models: Analysis of Global Trends

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ABSTRACT

The relationship between diabetes and behavior is examined in retrospective studies in humans, as well as in animal models. In this study, it was aimed to present data to researchers working in this field by making a bibliometric analysis of worldwide trends in diabetes and behavior studies using animal models.

This bibliometric study investigates studies of diabetes and behavior using animal models conducted between 1990 and 2023. As a result of searches made in the Web of Science (WOS) database using the keywords "Diabetes, animal, behavior", 2695 of 2710 studies were selected. The complete textual data underwent thorough analysis using VOSviewer software (version: 1.6.20) to ensure accuracy and reliability.

In this study, information was given about 2695 articles and 123666 citations to these articles taken from WOS database. The average number of citations per article is 54 and the H index is 158. Since 2002, both the number of articles and the number of citations have increased rapidly. Almost all of the articles were published in the fields of health sciences and the majority (25%) in the fields of neurosciences. USA, Germany and England are the countries that publish the most articles on this subject (74%). Most of the articles (50%) were published by Elsevier, Springer Nature and Wiley publishing houses, and a large proportion (95%) are in the SCI-Expanded category.

The findings of our study show that many researchers are active in the field of diabetes and behavior using animal models and that research in this field is increasing.

Keywords: Diabetes, animal model, behavior, physiology

Introduction

Diabetes is a significant health issue globally, showing an increasing trend and paving the way for various diseases. Type 1, which has a congenital or genetic origin, is observed more rarely. Type 2 diabetes, which is predisposed by nutritional disorders, sedentary lifestyle, and other factors, is more commonly observed, especially in the adult population. The Lancet (2023) published a study projecting that by 2050, the diabetes rates in 89 out of 204 countries worldwide will surpass 10% according to the age-standardized rate (1). The study suggests that the majority of the diabetes cases mentioned can actually be prevented or their frequency reduced through various measures, particularly in the case of type 2 diabetes, with appropriate preventive measures. The oxidant/antioxidant system imbalance caused by diabetes and the resulting damage from oxidative stress causes a variety of diseases including cardiovascular problems related to diabetes or complications associated with gestational diabetes (2-4).

Increasing sugar levels lead to Advanced Glycation End-Products (AGES) which can culminate in pathologies such as microvascular complications and conditions like Diabetic Neuropathy of the Retina (5, 6).

The treatment of diabetes is determined depending on the severity of the disease. When changes in the diet profile and exercise are not sufficient, the treatment can advance to medications regulating glucose metabolism and ultimately insulin injections or insulin pump. In 2022, the World Health Organization (WHO) has set global targets for diabetes mellitus. According to these goals, by the year 2030, specific objectives are aimed to be achieved regarding the diagnosis, treatment, blood sugar monitoring, and access to related equipment for the diabetic population (7). While efforts are being made to prevent diabetes on one hand, significant endeavors are also being exerted in the research field for the treatment of diabetes (8-10).

In this field, substantial research is conducted through experimental studies with laboratory

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animals. Following the modeling of diabetes triggered by surgical procedures or chemical injections, attempts are made to understand and treat various pathologies caused by diabetes (11 12,13). One of these experimental research areas is the cognitive and behavioral changes caused by diabetes. Research studies in this field focus on different components of behavior, such as anxiety, learning, and memory (14-16).

The relationship between diabetes and behavior is the subject of numerous studies published each year by various research groups worldwide. As knowledge accumulates over the years and relationships between these two concepts begin to emerge, new questions pave the way for further research. It is observed that topics intensely researched for a certain period may receive less attention over the next 20-30 years, but occasionally regain attention based on recently gathered data. The current paradigms of science are formed and updated in the light of accumulated data, making it valuable for researchers in the field to understand global research trends. Bibliometric analyses, increasingly popular as a method, serve as valuable references to guide researchers in this field (17). Bibliometric analyses, which numerically evaluate current literature publications, query various parameters in this field such as keywords, research years, authors, and journals. After processing these data with programs like VOSviewer software, bibliometric analyses can reveal global trends.

The purpose of this bibliometric study is to highlight the trends of diabetes and behavior studies conducted using animal models on a global scale. The primary goal is to investigate the significance of publications in this area and review the relevant trends and objectives.

Materials and Methods

Our research utilized a systematic approach to data collection, a refined search strategy, and advanced network analysis software to guarantee the reliability and accuracy of our findings. Employing these methodologies enabled us to gather and analyze the most up-to-date and comprehensive data present in the literature. Furthermore, the examination of this data yielded valuable insights into the prevailing trends and patterns in scientific research pertaining to diabetes and behavior studies conducted with animal models. By scrutinizing factors like influential researchers, countries, and frequently used keywords, we identified global publication

trends in diabetes and behavior studies involving animal models.

Data Collection Method and Search Strategy: In this bibliometric study, research on global trends in diabetes and behavior studies conducted using animal models between 1990 and 2023 (last access date: January 02, 2024) was examined. The analysis was performed utilizing the "Web of Science Core Collection (WOS, Clarivate Analytics, Philadelphia, PA, USA)" database. A total of 2710 studies were found through searches using keywords "diabetes, animal, behavior, physiology" in the database. After eliminating inappropriate studies, those prior to 1990, and non-article works, 2695 remaining articles were utilized for analysis. Extracted data from the database, encompassing article titles, authors' names, publication years, journal names, and citation counts, underwent thorough analysis. Materials were accessed through Van Yuzuncu Yil University's online library and digital resources. The search language employed was English.

This study examined global trends in diabetes and behavior studies conducted with animal models by employing bibliometric methods and utilizing data from the WOS database. WOS stands as a comprehensive database covering academic articles across diverse disciplines, making it a vital resource for interdisciplinary research. Specifically, publications from the WOS database were collected using precise search terms and subjected to thorough bibliometric analyses. Data were extracted through the online interfaces of the WOS database and analyzed using diverse parameters. The analysis encompassed aspects such as publication growth, the most active countries and institutions, and keyword mapping. All articles underwent meticulous review.

Network Analysis: In this study, VOSviewer (version 1.6.20, Leiden University, Netherlands) was utilized to analyze "collaboration network, highlights, and future trends" with the aim of identifying trends in the global tendencies of diabetes and behavior studies conducted using animal models and determining significant topics in research in this field. The systematic data collection process used the Data from the Web of Science database, along with the complete text of the included publications, were gathered and assessed through the VOSviewer software. Employing text mining and data visualization techniques, including bubble maps and other graphical methods, these analyses were carried out to guarantee the accuracy and reliability of the study. (Figures: 2, 3, 4).

Results

A total of 2695 articles published in the WOS database were included in the analysis. These articles have received a total of 123,666 citations (excluding self-citations, the total number of citations is 122,613). The average citation per article is 54, and the H-index is 158. There has been a noticeable upward trend in both the volume of citations and the quantity of articles, especially since 2002. The distribution of publications and citations is illustrated in Figure 1.

Article numbers were predominantly in the fields of Neurosciences Neurology (25%), Endocrinology Metabolism (18%), Pharmacology Pharmacy (10%), and Biochemistry Molecular Biology (9%). Other areas that scientifically evaluated the topic included physiology, behavior, and cell biology. The distribution of publications based on research fields is outlined in Table 1.

The United States leads in the number of published articles (n=1550; 58%), followed by Germany (n=233; 9%), the United Kingdom (n=208; 8%), and China (n=204; 7.6%). Publications spanned globally, originating from a total of 160 countries, including the top 4 mentioned, with Turkey ranking 40th. The first 20 countries in this ranking are presented in Table 2.

Evaluation based on Bibliographic coupling by countries shows that the USA, Brazil, India, and England have a larger representation among the foremost countries in this field (Figure 2).

In the international collaboration network, clustering is noticeable between the USA, China, and Brazil, as well as between the USA and the UK, Japan, Switzerland, and Germany (Figure 3).

University of California (7.9%), Harvard University (5.2%), and the US National Institutes of Health (4.4%) were the leading organizations in terms of the number of publications. Accordingly, most of the leading affiliations were based in the United States. In this context, 15 of the 5282 records are shown in Table 3.

The majority of articles in this field were published in Elsevier (29.5%), Springer Nature (12%), and Wiley (8.7%) journals.

The assessment of Web of Science Indexes indicates that a significant proportion of articles are published in the "Science Citation Index Expanded (SCI-Expanded)" category (94.7%), succeeded by the "Social Sciences Citation Index (SSCI)" (11.3%), and "Emerging Sources Citation Index (ESCI)" (3.9%), as detailed in Table 4.

When analyzed based on selected keywords, it is observed that among the largest and most interconnected topic areas are keywords such as diabetes, type 2 diabetes, diabetes mellitus, streptozotocin, and animal models (Figure 4).

Discussion

This research demonstrates the global increase in scientific publications on diabetes and behavior studies conducted using animal models. The study aims to identify global trends and clusters related to diabetes and behavior studies conducted using animal models, revealing the specific areas of focus in this field and the countries where these studies are most prevalent. Additionally, important journals, authors, and studies in this field have been identified, indicating potential areas for increased use of animal models in diabetes and behavior studies in the future.

The analysis of the 2695 articles obtained from the examined WOS database indicates an increase in both the number of published articles and citations since 2002. While the publication range was between 10-40 articles annually in the 1990s, reaching around 180 articles in 2022 is indicative of the growing interest in this field. The rising number of articles on the examination of diabetes and its pathology in animal behavior models can be considered as an indicator of the increasing interest on this topic. The global spread of diabetes like a pandemic disease is considered as a significant factor contributing to the increase in research on this subject (18). The global increase in diabetes, attributed to lifestyle changes, along with the rising global average age, supports the growth of research in the field of diabetes-behavior-animal models (19).

Publication categories reveal that the forefront categories include Neurosciences Neurology, Endocrinology Metabolism, Pharmacology Pharmacy, and Biochemistry Molecular Biology (Table 1). Considering the endocrine, metabolic, and neurological effects caused by diabetes and efforts to address them in the fields of pharmacology and pharmacy, it is not surprising that these publication categories are prominent. However, the diversity of the topic in addressing various contexts, including nutrition dietetics, physiology, psychology, psychiatry, genetics, among others, is an expected outcome.

Table 1: Categories of Publications

Research Areas	Record Count	% of 2.695
Neurosciences Neurology	678	25.158
Endocrinology Metabolism	487	18.071
Pharmacology Pharmacy	273	10.130
Biochemistry Molecular Biology	252	9.351
Behavioral Sciences	241	8.942
Physiology	194	7.199
Science Technology Other Topics	183	6.790
Nutrition Dietetics	158	5.863
Cell Biology	154	5.714
Psychology	142	5.269
Psychiatry	141	5.232
Research Experimental Medicine	133	4.935
Genetics Heredity	80	2.968
Life Sciences Biomedicine Other Topics	72	2.672
Veterinary Sciences	71	2.635
Showing 15 out of 84 entries		

Table 2: Countries with Highest Number of Publications

Countries/Regions	Record Count	% of 2.695
USA	1550	57.514
GERMANY	233	8.646
ENGLAND	208	7.718
CHINA	204	7.570
CANADA	153	5.677
BRAZIL	140	5.195
JAPAN	140	5.195
FRANCE	137	5.083
INDIA	125	4.638
NETHERLANDS	123	4.564
SPAIN	117	4.341
AUSTRALIA	115	4.267
ITALY	115	4.267
SWEDEN	112	4.156
SWITZERLAND	83	3.080
DENMARK	76	2.820
IRAN	66	2.449
MEXICO	58	2.152
SCOTLAND	58	2.152
FINLAND	56	2.078
Showing 20 out of 160 entries		

When considered in the context of the selected keywords, the United States takes the lead, followed by Germany, the United Kingdom, and China, respectively. Despite China surpassing the United States in the number of publications worldwide in recent years, the United States continues to be at the forefront, ranking second in the list of countries with the highest number of publications (www.scimagojr.com/countryrank.php?order=itp

Table 3: Top Affiliations Ranking

Affiliations	Record Count	% of 2.695
UNIVERSITY OF CALIFORNIA SYSTEM	214	7.941
HARVARD UNIVERSITY	141	5.232
NATIONAL INSTITUTES OF HEALTH NIH USA	118	4.378
PENNSYLVANIA COMMONWEALTH SYS OF HIG EDU	104	3.859
US DEPARTMENT OF VETERANS AFFAIRS	102	3.785
VETERANS HEALTH ADMINISTRATION VHA	98	3.636
UNIVERSITY SYSTEM OF OHIO	94	3.488
HARVARD MEDICAL SCHOOL	93	3.451
HELMHOLTZ ASSOCIATION	87	3.228
UNIVERSITY OF LONDON	85	3.154
UNIVERSITY OF WASHINGTON	85	3.154
UNIVERSITY OF WASHINGTON SEATTLE	85	3.154
UNIVERSITY OF TEXAS SYSTEM	84	3.117
INST NAT DE LA SANTE RECHERCHE MED INSERM	82	3.043
UNIVERSITY OF PENNSYLVANIA	80	2.968
Showing 15 out of 5.282 entries		

Table 4: Web of Science Categories Index

Web of Science Index	Record Count	% of 2.695
Science Citation Index Expanded (SCI-Expanded)	2552	94.694
Social Sciences Citation Index (SSCI)	304	11.280
Emerging Sources Citation Index (ESCI)	105	3.896
Conference Proceedings Citation Index Sci (CPCI-S)	97	3.599

&ord=desc&year=2020). Therefore, it is not surprising to find the United States at the top in articles examined. In addition, considering diabetes as a significant health issue and a major economic burden in the United States, it can be seen as a significant trigger for the research of both diabetes and its behavioral dimensions [20].

University of California, Harvard University, and the U.S. NIH (National Institutes of Health) are leading organizations with the highest number of publications. The high number of publications from other U.S. universities may be considered as a contributing factor to the United States having the highest number of publications in this field. The dominance of Elsevier, Springer Nature, and Wiley as the journals with the most publications in this field, corresponding to the Netherlands, the United Kingdom, and the United States, respectively, aligns with the results of the country based bibliographic analysis.

In the Web of Science Indexes, a significant number of articles are situated within the "Science Citation Index Expanded (SCI-Expanded)" category, while a lesser representation is observed in the "Social Sciences Citation Index (SSCI)" and "Emerging Sources Citation Index (ESCI)" categories.

Although various categories are emerging in bibliographic data sources, the prevalence of the Web of Science category as the most referenced and detailed information source continues to affirm its status as a primary reference in the field [21].

Analysis of selected keywords reveal highly interconnected topic areas such as diabetes, type 2 diabetes, diabetes mellitus, streptozotocin, and animal models. When clusters are evaluated internally, the association of topics such as Diabetes, Animal Models, and Behavior with each other, as well as their association with the topics of mice and rats, is reasonable given the prevalent use of mice and rats in this field. The emergence of the insulin topic alongside streptozotocin-induced diabetes, which causes alterations in insulin levels, and the association of anxiety-depression topics with these suggest that these topics are modeled together and simultaneously examined as parameters.
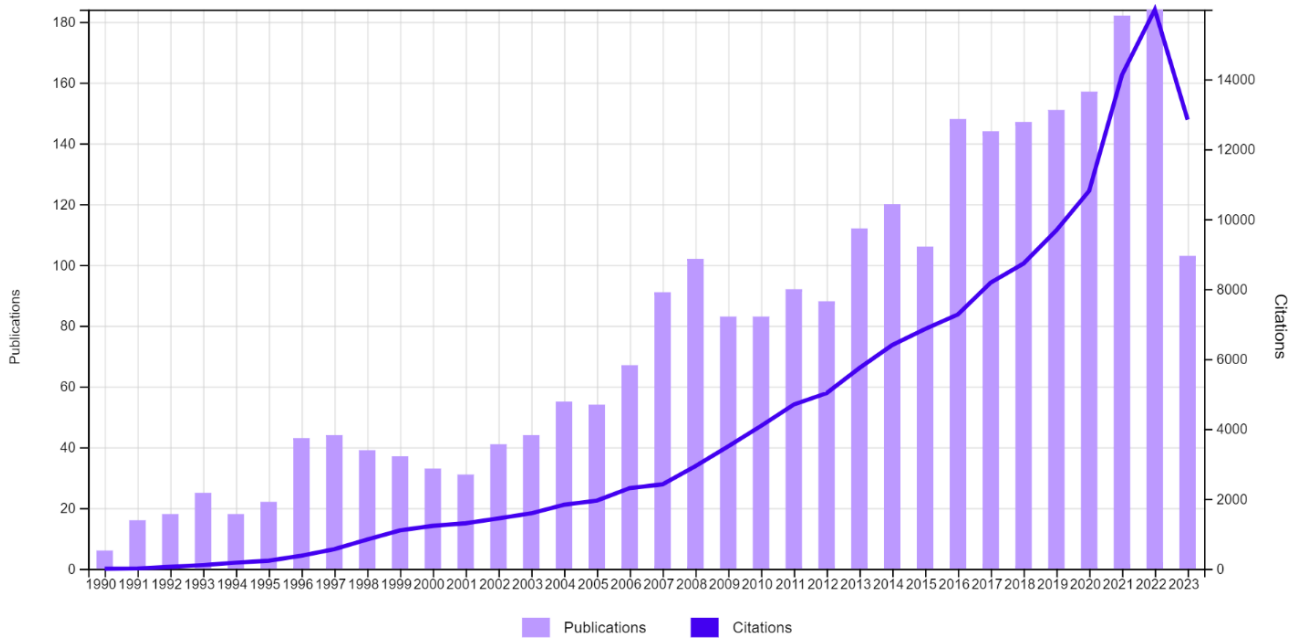
Fig. 1. Frequency of Publications and Citations By Year (Last Access 02.01.2024)
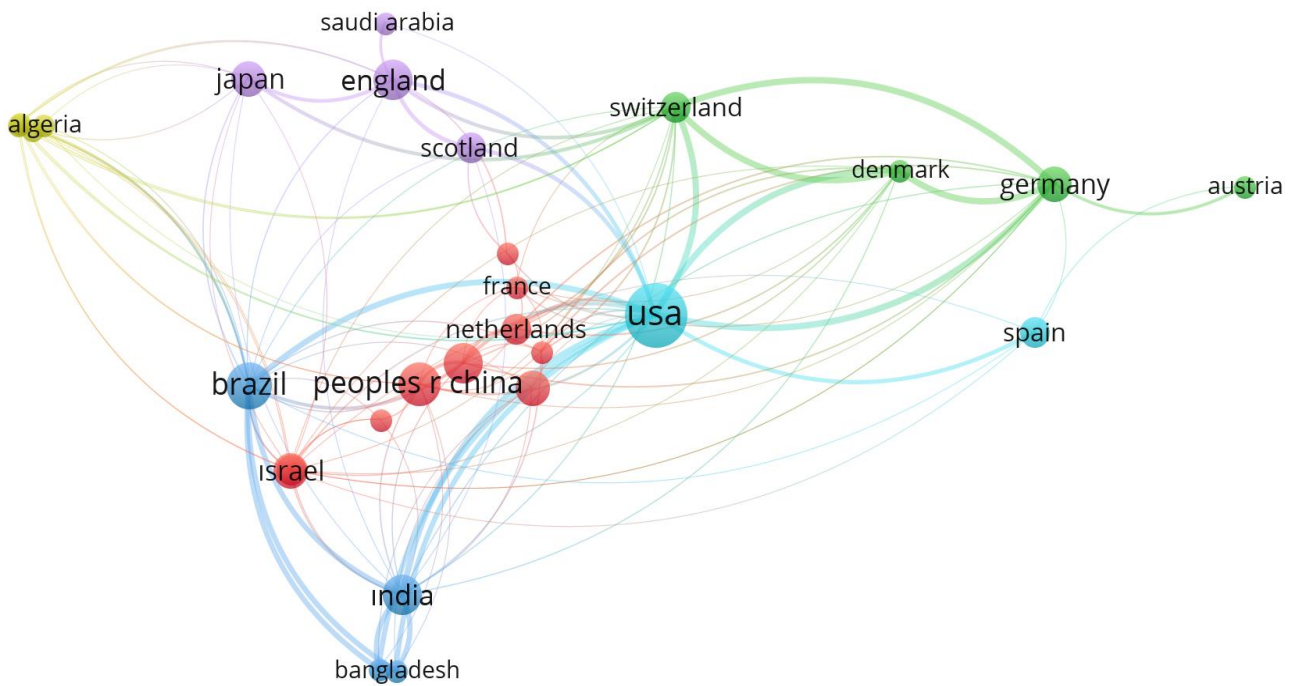

Fig. 2. Bibliographic Coupling Analysis Was Performed for Countries (The Correlation Between Items Was Established By Evaluating The Number of References They Share)

As diabetes induced by streptozotocin affects the balance of antioxidants/oxidants in the body, and oxidative stress is known to play a role in pathophysiological processes, the correlation indicates an impact on oxidative stress, which is a factor contributing to many diseases (22).

Pregnancy, diabetes, and depression emerge as interrelated concepts. Women experiencing gestational diabetes are shown to be under higher psychological stress compared to normal pregnancies, and anxiety and depression are identified as significant factors in gestational diabetes itself. Therefore, the interconnected appearance of these three concepts in keyword analyses is a natural outcome. Some studies utilizing animal models investigate these topics (23, 24).
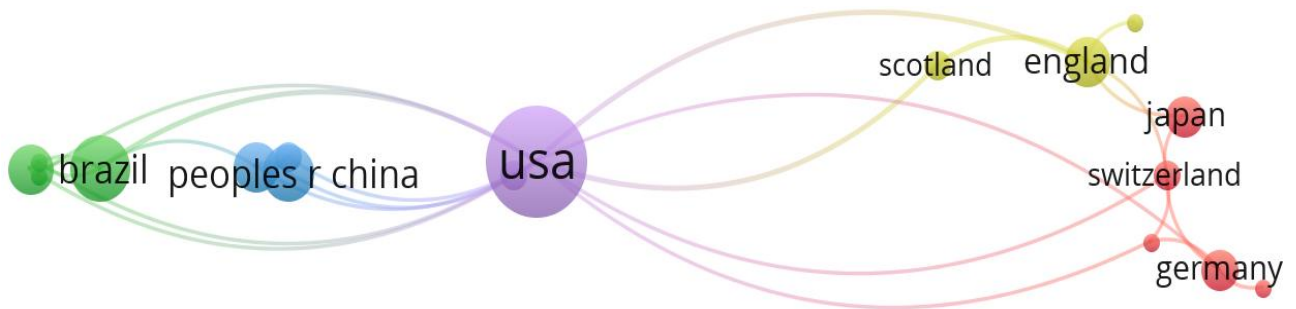
Fig. 3. International collaboration network map illustrates collaboration between countries through lines, where the thickness denotes the strength of collaboration, and the size of circles/text reflects the level of international collaboration
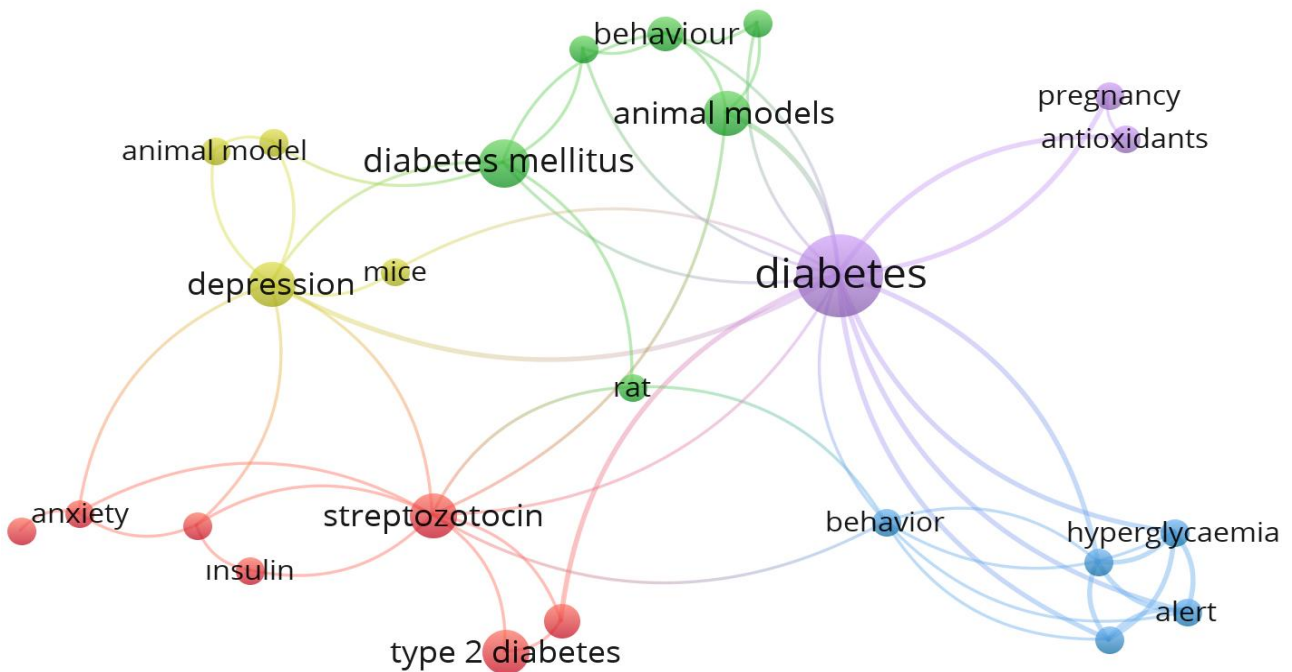

Fig. 4. Keyword analysis reveals the association of the topic with specific keywords and the frequency of their usage

Bibliometric analyses on diabetes, attempting to outline global trends in diabetes research, have become more visible in the scientific literature since the early 2000s. Geaney et al (2014) evaluated trends in this field from 1951 to 2012 (25).

However, there are gaps in data regarding global research trends in diabetes, animal models, and behavior topics. The present study aimed to contribute to the literature in this field and provide bibliometric data on these subjects.

This study conducts a bibliometric analysis to explore global trends and publication patterns in diabetes and behavior studies utilizing animal models. The study identifies the most influential countries, institutions, authors, journals, and keywords in the realm of artificial intelligence-supported medicine.

The bibliometric analysis reveals not only an increase in the number of scientific publications in diabetes and behavior studies conducted using animal models but also reflects a globally diversified and deepening research area. The trends identified in this study indicate a multidisciplinary approach, focusing not only on the physiological effects of diabetes but also on its neurological and behavioral dimensions. The analyses demonstrate that research using animal models encompasses a broad range of topics, including cognitive functions, psychological effects such as anxiety and depression, and neurological connections.

Furthermore, the identification of prominent journals, leading researchers, and significant studies in this field serves as a valuable resource for shaping future research directions and enhancing collaboration potential. In summary, the goal of this bibliometric analysis is to unveil global trends and studies within the field of diabetes and behavior conducted using animal models. The findings aim to offer insights into the future directions of research in this area.

Limitations: Bibliometric analysis is a methodology utilized solely for identifying trends and patterns in the literature; it does not evaluate the accuracy or quality of the underlying data. Additionally, the applicability of bibliometric analysis is not intended for evaluation purposes because this method is focused on analyzing existing literature data and providing a general overview of specific topics.

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