A Scientometrics Analytics on Immune system-related conditions and AI-driven computational methods: Trend and Exploration

Deepti Rani Pattanaik
Department of Statistics
Sambalpur University
E-mail: 97deeptirani@gmail.com

Prof. Monalisha Pattnaik
Department of Statistics
Sambalpur University
E-mail: monalisha_1977@yahoo.com

Abstract

In the previous decade, there has been a concerning rise in both prevalence and incidence rates of autoimmune diseases. According to recent studies, these illnesses affect about 10% of the population, with a significantly higher frequency in women than in men. A comprehensive study conducted in the UK has underscored this trend, revealing significant socioeconomic, seasonal, and geographical variations in the manifestation of these diseases. Furthermore, evidence indicates that individuals diagnosed with one autoimmune condition are at an elevated risk of developing additional autoimmune disorders, although this correlation is not uniform across all conditions. The principal purpose of this research is to highlight and carefully review the corpus of existing material that explores the use of ML technique in the framework of autoimmune diseases. This includes an assessment of the present level of understanding as well as an all embracing and impartial review of recent advancements, areas requiring improvement, concerns, and potential future research directions. Utilizing R programming and bibliometrix codes, a descriptive bibliometric analysis was conducted, resulting in a matrix that encompasses all relevant documents. Data was sourced from the WOS database, During the time frame from 2002 to 2025, specifically concentrating on the terms "Immune system-related conditions" and "AI-driven computational methods." The final dataset comprised 419 publications, revealing a connection between autoimmune diseases and machine learning. Key themes identified include "Rheumatoid Arthritis," "Pathogenesis," and "Inflammation." In the current research landscape, topics such as systems, consensus, and cell death have gained significant adhesion. This paper provides a comprehensive overview of the bibliometric measure linking autoimmune diseases and machine learning, thereby contributing to the advancement of scientific research in this domain.

Keywords:-Immune system-related conditions, AI-driven computational methods, Scientometric analysis.

1. Introduction

Autoimmune disorders can arise when the immune system unintentionally targets healthy cells. Conditions like “multiple sclerosis”, “psoriasis”, “Crohn's disease”, “Type 1 diabetes”, and “an inflammatory joint

disorder", "a chronic autoimmune condition", "Addison's disease", and certain thyroid disorders fall into this category. The immune system plays a vital part in safeguarding the body against infections and diseases by generating specific cells that target foreign invaders upon detection. Typically, the immune system can differentiate between the body's own cells and those that are foreign. However, in the case of autoimmune diseases, it may misidentify certain body components, such as joints or skin, as foreign entities. This misidentification causes autoantibodies to be produced., which are proteins that target healthy cells. While some autoimmune disorders can affect the entire body, others may be localized to a single organ. Various factors that may elevate the risk of developing autoimmune diseases include sex, family history, environmental influences, ethnicity, nutrition, and other health conditions, such as obesity and the presence of other autoimmune disorders. Autoimmune diseases collectively affect approximately 10% of the worldwide population, according to a comprehensive study that examined data from 22 million individuals. The impact is notably greater on women, who experience a prevalence rate of 13%, compared to 7% in men. More than 80 distinct autoimmune disorders have been recognized, with conditions such as "an inflammatory joint disorder", "type 1 diabetes", and "multiple sclerosis" being among the most common. Furthermore, research indicates a propensity for autoimmune diseases to co-occur, suggesting that individuals diagnosed with one autoimmune disorder are at an increased risk of developing others. The underlying causes of these associations remain under investigation, with hypotheses pointing to shared genetic or environmental factors. There is a pressing need for enhanced research and awareness to fill existing knowledge gaps and to improve both diagnosis and treatment, particularly in areas with limited access to healthcare. Global initiatives should prioritize the identification of modifiable risk factors, the enhancement of healthcare delivery systems, and the investment in innovative therapeutic strategies. Although a growing quantity of intervention researches have focused on autoimmune diseases, there remains a significant deficiency in robust evidence regarding the application of machine learning techniques in this field. Consequently, this bibliometric study was carried out to quantify the available data and examine the use of machine learning on autoimmune diseases. The main goals of this research are to present a thorough and impartial assessment of the current landscape, identify areas requiring enhancement, address existing challenges, and suggest potential research directions, considering factors such as journal sources, authors, countries, and keyword frequency. This paper aims to furnish future research with comprehensive insights into the current understanding of machine learning applications on autoimmune diseases, thereby promoting further research-driven initiatives on strategic planning and related domains.

The structure of this paper is as follows: The literature review is presented in Section 2, and the research parameters and methodology are explained in Section 3. Section 4 presents and discusses the results analysis,

and Section 5 concludes by making management implications, utilizing this method to identify potential gaps in the literature, and offering recommendations for conducting research on novel issues.

2. Review of the Related Literatures

Stafford, et al. (2020) has done systematic analysis of 169 papers on machine learning (ML) methods for tackling autoimmune disease clinical concerns revealed that the supervised ML methods such as Random forests and SVM were the most widely used. Most models relied on data from multiple sclerosis, an inflammatory joint disorder, and inflammatory bowel illness. A limited number of research incorporated diverse sources of data, and 8.3% of publications employed cross-validation to provide robust model evaluation. Future developments may include combining several data types to create more complicated predictive models. Liu et al. (2022) carried out a bibliometric review of the inflammatory bowel disease (IBD) literature diagnosis exposing its hotspots, development tendencies, and current state. The study found 818 keywords focusing on associated conditions brought on by IBD, including autoimmune disorders and colon cancer, as well as approaches for diagnosis and treatment. Future research hotspots include precision medicine and IBD treatment. Tao et al. (2024) conducted bibliometric analyses on 5,710 papers in the Journal of Dermatology and Autoimmunology (JDTA). They discovered that the number of articles remained steady between 2004 and 2023, with the US, Italy, France, and China leading the way. The analysis also discovered that JDTA papers primarily investigated autoimmune disorders, particularly SLE and RA, with an emphasis on “cell function”, “autoantibody expression”, “animal studies”, “disease activity”, “pathogenesis”, and “therapy”. It was the initial research to examine articles using numerous bibliometric variables, offering new perspectives on areas of interest and advancements in autoimmune research. Wu, et al. (2022) performed a bibliometric analysis of exosomes on AIDs from 2002 to 2021, covering data from USA and China. The study focuses on understanding the mechanism of endogenous exosomes in AIDS and their therapeutic applications. The study focuses on developing research hotspots in immunomodulation, biomarkers, MicroRNA(miRNA), mesenchymal stem cells, and treatments. The findings are mostly cited in Frontiers in Immunology and the Journal of Immunology. Zhang et al.'s (2023) analysis examined 2516 published publications on gut microbiota and Alzheimer's disease (ADs) and found a rising trend. The most popular topics included intestinal control, multisystem ADs, and immune-related cells. The findings can assist researchers better comprehend current Alzheimer's and gut microbiota studies. Watad et al. (2017) examined the literature on autoimmune illnesses using open-source tools. They analyzed 169,519 articles from six specialist publications. Trending subjects included microRNAs, genetics, vitamins, pregnancy management, and gender. The study emphasizes the necessity of studying autoimmune illnesses and their effects on health. Xie et al. (2023) used bibliometric approaches to review the literature on Systemic Lupus Erythematosus (SLE) from 2013 to 2022. They reviewed 18,450 publications and discovered an increase trend in articles published over the last decade. The

most productive nations included the United States, China, Japan, Italy, and the United Kingdom. The study emphasized SLE's research status, significant contributors, hotspots, and trends, as well as references for future research to enhance SLE research progress. Deng et al. (2024) examined 530 studies on glycosylation in Alzheimer's disease (AD) from 2003 to 2023. The United States, China, and Leiden University received the highest rankings in this field. The study concentrated on antibody glycosylation, specifically IgG and IgA, and its function in AD. Ouyang et al. (2024) conducted a bibliometric analysis of 3348 articles on autoimmune encephalitis (AE). The United States, China, Germany, England, and Japan had the most publications, with Oxford, Udice French Research Universities, the University of Pennsylvania, l'Institut National de la Sante de la Recherche Medicale Inserm, and the University of Barcelona ranking among the top five institutions. The most productive authors were J. Dalmau, A. Vincent, H. Pruss, C. G. Bien, and F. Graus. Recent research hotspots include NMDAR encephalitis diagnosis and treatment. Danieli et al. (2024) explore machine learning applications in diagnosing organ-specific autoimmune illnesses and major systemic disorders. They highlight the potential for early disease diagnosis and prognostic models, with further research aiming to develop algorithms using rich databases for early intervention and therapeutic guidance. Forrest et al. (2023) developed a machine learning model using electronic health data from 161,584 people to determine which patients should undergo rheumatological examinations for SARDs. The model predicted more autoantibody-tested subjects and a higher percentage of those carrying autoantibodies. The model identified autoantibody needs up to five years before testing, suggesting machine learning-detectable clinical signs could aid in autoimmune testing. Ma et al. (2022) used large-scale public RNA sequencing of a single cell data to analyze datasets from 15 SLE patients and eight donors of good health. They found that inflammatory microenvironment weakens interactions among PBMC subpopulations, resulting in anomalous appearances or changes to signaling patterns. They developed an efficient mathematical model making a distinction between SLE patients and healthy donors using random forest machine learning and accurately identify patients with “an inflammatory joint disorder” and “multiple sclerosis”. An integration pipeline was created by Kruta et al. (2024) to employ machine learning for patient classification using data in conjunction with laboratory and clinical values. Up to 96% of the forecasts made using our methodology were accurate. Ceccarelli et al. (2023) explore the potential of artificial intelligence (MLM) in diagnosing and treating “Lupus Nephritis (SLE)”, focusing on disease-related aspects like pregnancy and quality of life, with several models showing promising performance. Usategui et al. (2023) propose a machine learning system for diagnosing SLE patients using the extreme gradient boosting approach. The system identifies trends in patient data, enabling accurate classification and differentiation. The suggested approach outperforms other methods, with a 4.49% higher prediction value than k-Nearest Neighbors. The system also has a larger area under the curve and balanced accuracy, demonstrating its effectiveness in creating automatic diagnostic support systems for SLE patients. Zhao et al. (2024) attempt to find research hotspots and cooperative networks for AI application in rheumatic disease by bibliometric

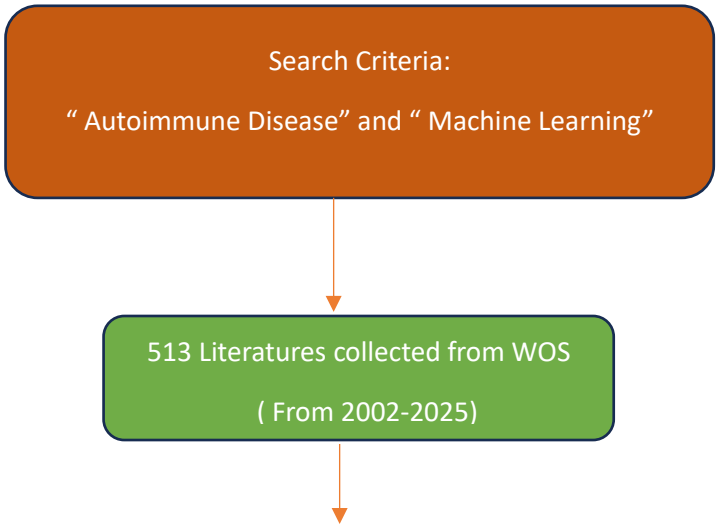
analysis. They searched Web of Science for articles and used software tools to analyze parameters, generate citation networks, and evaluate trends. Adnan, et al. (2024) analyzed SLE research trends published in Pubmed journals between 2012 and 2021. The study collected 17,230 items, resulting in 3,811 articles published in 804 journals. China was the most producing nation, followed by Italy and the United States. Pan HF was the most productive author, writing 61 pieces over the previous nine years. Studies on a chronic autoimmune condition, lupus nephritis, hydrochloroquine, therapy, autoimmune illness, autoantibodies, and autoimmunity are among the current topics in SLE research. Koo et al.'s (2021) study examined the production of spinal cord injury (SLE) research worldwide between 1971 and 2020. According to the data, the number of publications produced increased steadily, averaging 8.0% year. The United States topped the global productivity list, and the most articles were published in Lupus. The analysis found five closely related SLE research clusters, offering a thorough summary of the field's evolution over the last 50 years.

3. Research Parameters and Methodology

3.1 Bibliometric Analysis

The study employed bibliometric analysis to quantify and visualize the utilization of machine learning techniques on autoimmune diseases, a well-established method for the quantitative assessment of scholarly publications within specific domains. This approach utilizes various analytical and computational methods to investigate the characteristics of literature related to a particular subject, including evaluations of authors, institutions, countries or regions, and journals. It also identifies research hotspots and forecasts future research directions. Massimo Aria of the Federico II University of Naples created the Bblioshiny tool, which was used to perform the bibliometric analysis described in this article. This Java application integrates the functionalities of the Bibliometrix package with the user-friendly interface of a web application built on the Shiny package environment.

Data Extraction Mechanism



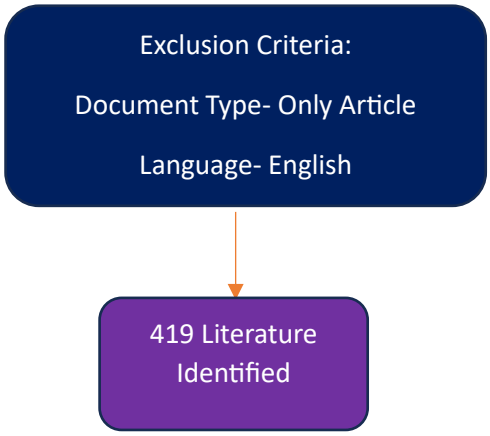


Figure 1. The Topic Search Query

4. Result & Analysis

Description	Results
Timespan	2002-2025
Sources (Journals, Books, etc)	227
Documents	419
Annual Growth Rate %	3.06
Document Average Age	2.42
Average citations per doc	12.26
References	19785
DOCUMENT CONTENTS	
Keywords Plus (ID)	1231
Author's Keywords (DE)	1259
AUTHORS	
Authors	3385
Authors of single-authored docs	7
AUTHORS COLLABORATION	
Single-authored docs	8
Co-Authors per Doc	9.85
International co-authorships %	24.58
DOCUMENT TYPES	
Article	406
article; early access	9
article; proceedings paper	4

The information was sourced from the Web of Science Database, which is an essential resource for conducting bibliometric analyses. The results discussed in this research were mainly based on a timeline from 2002 to 2025. The entire analysis was fundamentally organized around the primary terms "Autoimmune disease" and "AI-driven computational methods," which were interconnected using the "AND" operator. The selection criteria were restricted to articles published in English. As shown in Table 1, our final dataset included 419

papers written by 1231 authors, published during the designated period. Overall, there were 3385 contributors, with 7 individuals linked to single-author works.

Table 1: Main information about data

Frequency of Publications

The Figure 1 depicts scientific papers that illustrate the use of Machine learning in Autoimmune disease. In 2009, the number of publications began to rise, then become stable till 2010. After that there has been a rising & falling tendency continued until 2022. Then it gets the highest peak in 2023. And become stable till 2024. Again, it gets a downward trend after 2024.

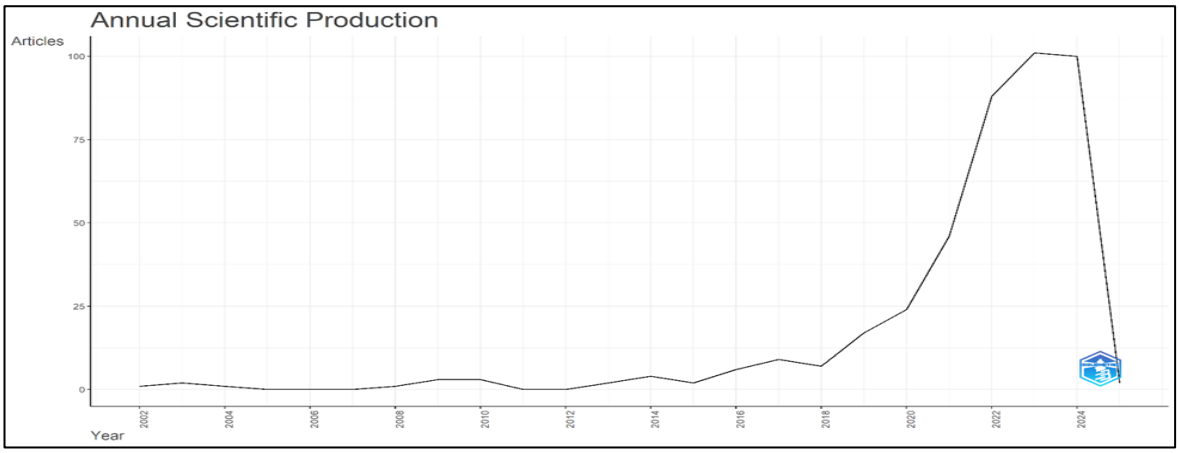


Figure 2. Frequency Of Publications

4.2 Most Productive Sources

A thorough examination has been conducted on the most significant and recognized publications that have featured articles regarding the application of AI-driven computational methods in Autoimmune diseases. Figure 3 presents the ranking of the to

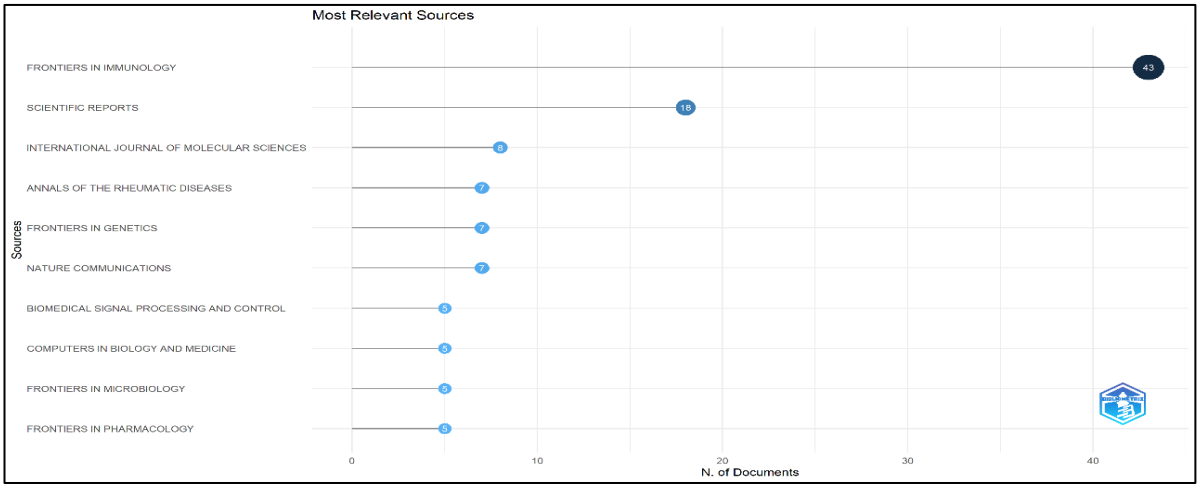


Figure 3. Most Productive Sources

p 20 most prolific sources in this area. The journals "Frontiers in Immunology," "Scientific Reports," and the "International Journal of Molecular Sciences" are identified as the three most productive outlets that have concentrated on the publication of research discussing the utilization of AI-driven computational methods techniques within the realm of Autoimmune diseases.

4.3 Mapping the Scientific Collaboration

Figure 4(a) illustrates the collaboration network, indicating that independent articles from China constitute the largest share of all publications, followed by the United States, Germany, and Italy. In contrast, countries such as Mexico, Poland, Finland, Ireland, and Saudi Arabia primarily focus on independent research, as shown in Table 2. Figure 4(b) presents the international coalitions, where the blue shading on the map signifies international research collaboration. The pink lines connecting various states denote the extent of collaboration among researchers. Notable international partnerships include those between China and the United States, the United States and Australia, the United States and Canada, Germany and Switzerland, Canada and Iran, the United States and Hungary, as well as Germany and the Czech Republic, highlighting significant collaborations across geographical boundaries. Such engagements may foster policy discussions and market partnerships.

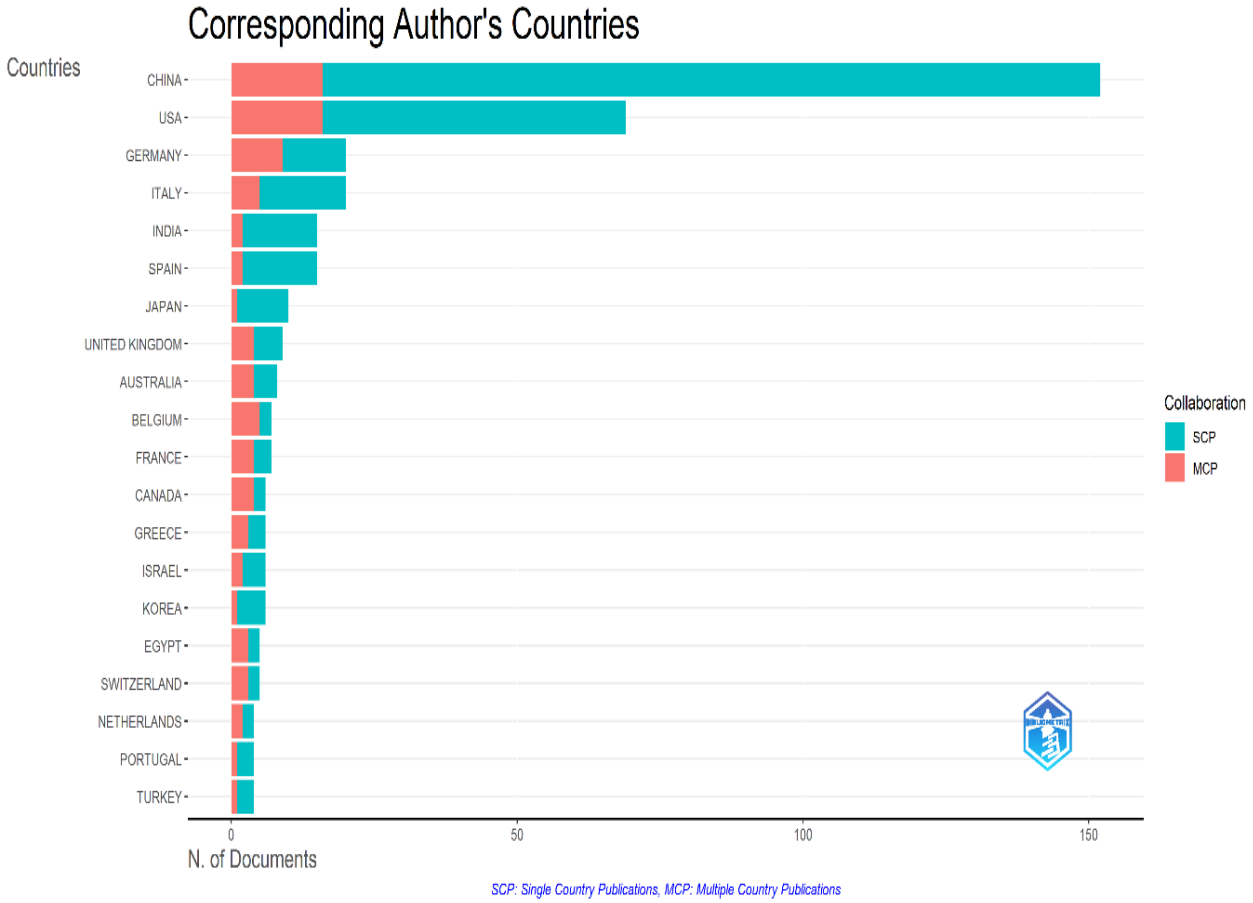


Figure 4(a) Corresponding Author Countries

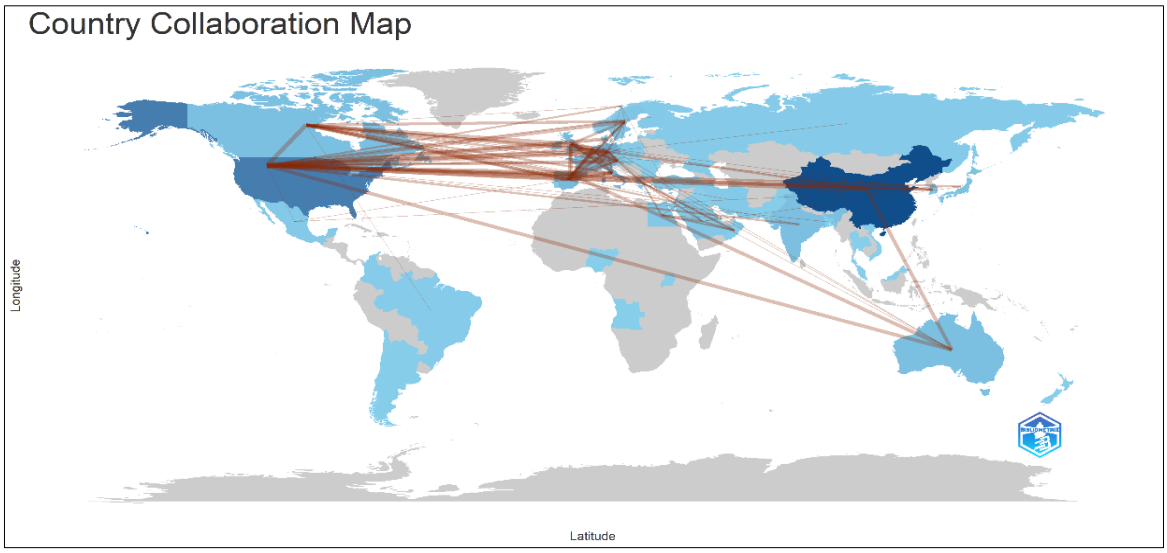


Figure 4 (b) Country Collaboration Map

Table.2: Corresponding author's Country wise distribution

Country	Articles	Articles %	SCP	MCP	MCP %
CHINA	152	36.3	136	16	10.5
USA	69	16.5	53	16	23.2
GERMANY	20	4.8	11	9	45
ITALY	20	4.8	15	5	25
INDIA	15	3.6	13	2	13.3
SPAIN	15	3.6	13	2	13.3
JAPAN	10	2.4	9	1	10
UNITED KINGDOM	9	2.1	5	4	44.4
AUSTRALIA	8	1.9	4	4	50
BELGIUM	7	1.7	2	5	71.4
FRANCE	7	1.7	3	4	57.1
CANADA	6	1.4	2	4	66.7
GREECE	6	1.4	3	3	50
ISRAEL	6	1.4	4	2	33.3
KOREA	6	1.4	5	1	16.7
EGYPT	5	1.2	2	3	60
SWITZERLAND	5	1.2	2	3	60
NETHERLANDS	4	1	2	2	50
PORTUGAL	4	1	3	1	25
TURKEY	4	1	3	1	25
DENMARK	3	0.7	1	2	66.7
MEXICO	3	0.7	3	0	0

POLAND	3	0.7	3	0	0
AUSTRIA	2	0.5	1	1	50
BRAZIL	2	0.5	0	2	100
FINLAND	2	0.5	2	0	0
IRAN	2	0.5	1	1	50
IRELAND	2	0.5	2	0	0
ROMANIA	2	0.5	1	1	50
SAUDI ARABIA	2	0.5	0	2	100

The authors keywords were chosen to provide insight into the main challenges and research trends around Auto immune disease and AI-driven computational methods. Figure 5 highlights the focus of the literature on "express" and "disease" with the importance of "rheumatoid-arthritis", "Pathogenesis", "Inflammation" ,"antibodies" as well as "autoimmune".

Figure 5. Visualization of most frequent Keywords

Figure 6 illustrates the thematic trends derived from the analyzed phrases. In 2018, the focus was solely on research issues pertaining to databases. By 2020, the emphasis shifted to susceptibility, biomarkers, and dysfunction. In 2021, the findings included publications related to identification, autoimmune conditions, and cancer. The year 2022 saw a significant increase in publications centered on expression, classification, and disease. In 2023, research on cells, diagnosis, and pathogenesis emerged prominently. Notably, the topics of system, consensus, and cell death garnered considerable attention in both 2023 and 2024.

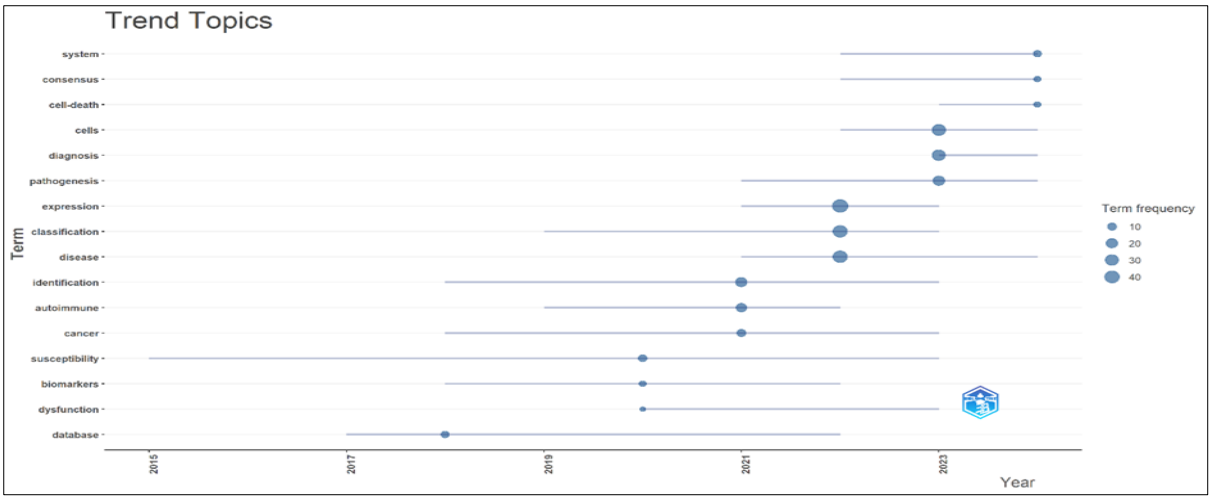


Figure.6 Trend Topics

Three Plots Field: -

Figure 7 presents a Sankey diagram in which the width of the arrows corresponds to the flow rate, illustrating the key components across three domains (such as authors, keywords, and affiliations) and their interrelations. A schematic representation featuring rectangles of varying colors was employed to depict the primary elements. The overall relationship between the elements represented by the rectangles and the other components in the diagram is indicated by the height of each rectangle. The magnitude of each element is reflected in the size of the rectangle. The work of highly cited researchers was found to be associated with machine learning, a chronic autoimmune condition, and machinery. Furthermore, the research was conducted under the guidance of Central South University, Shanxi Medical University, and Jinan University.

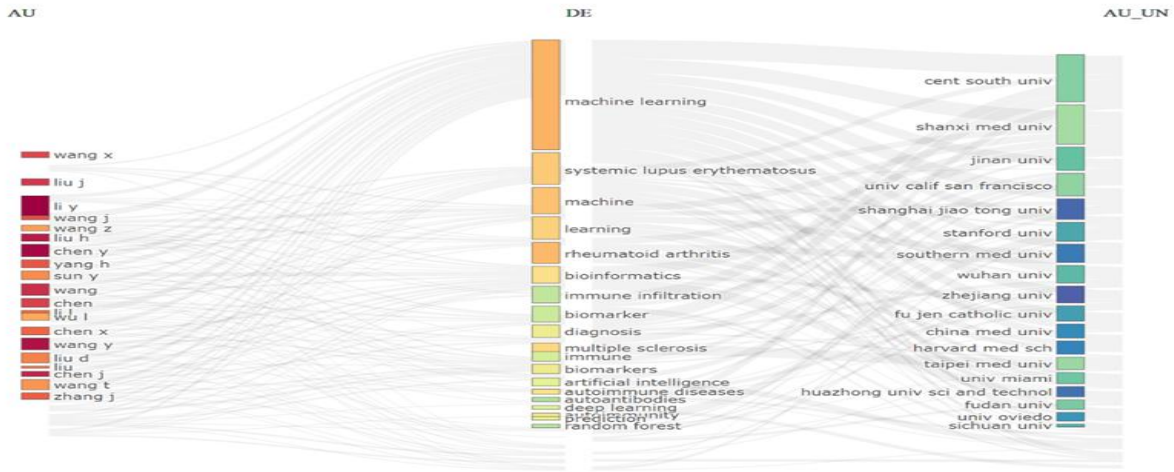


Figure 7. Three Fields Plots

5. Conclusion

This bibliometric analysis provides an overview of the research trends concerning the application of machine learning techniques in autoimmune diseases, examining various aspects such as interdisciplinary approaches, source journals, corresponding authors, keyword analysis, trending topics, and scientific collaboration. It offers a thorough and impartial assessment of the current advancements in the field, highlighting areas that require enhancement, existing challenges, and potential avenues for future research. The findings indicate a consistent increase and subsequent decline in publications from 2002 to 2024, with 2024 identified as the peak year for publications. The three most prolific journals publishing articles on the application of machine learning in autoimmune diseases are Frontiers in Immunology, Scientific Reports, and the International Journal of Molecular Sciences. The keyword analysis reveals that terms such as classification, expression, disease, diagnosis, prediction, and pathogenesis are frequently utilized in this research domain. Independent articles from China represent the largest proportion of publications, followed by contributions from the USA, Germany, Italy, and India, according to collaborative statistics. Based on the annual scientific output, it is anticipated that the trend in research related to machine learning applications in autoimmune diseases will continue to decline after 2024. China emerges as the most active nation in international author collaborations. The three most prominent trending topics post-2023 are system, consensus, and cell death. A three-field plot illustrates that the most cited research is associated with machine learning, a chronic autoimmune condition, and machine applications. Furthermore, the research has been conducted under the auspices of Central South University, Shanxi Medical University, and Jinan University.

The purpose of this study is to conduct a bibliometric analysis of publications related to the application of Machine learning in Autoimmune diseases. This work provides a comprehensive grasp of the bibliometric parameters that link the use of ML in autoimmune diseases, and it can aid scientific research in this area. Furthermore, scholars may benefit from the analysis and integration of multidisciplinary topics. Moreover, the research the research uncovered unexplored issues that researchers might analyze further and address from a managerial approach. In respect of potential research, we believe that this study will aid in the development of an effective approach of machine learning to be used in the area of autoimmune diseases. Additionally, the analysis highlights the significance of double-blind trials as an under-represented problem that is critical for making important judgements in Immune system-related conditions care.

The study undoubtedly had a number of shortcomings. First off, there may have been selection bias because we only examined records from the Web of Science core collection and only included English articles and reviews. Nonetheless, there were enough retrieved papers to accurately represent the actual state of the research. Second, it was challenging to precisely retrieve every record because of the variety of keywords and writers sharing the same name.

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