

A bibliometric analysis of prognostic studies in rheumatoid arthritis from 2000 to 2021

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Abstract

Objective

A bibliometric analysis of the current status and hotspots in rheumatoid arthritis (RA) research was conducted using prognostic studies from various countries, institutions, and individuals throughout the world.

Methods

Data from 2000 to 2021 were collected from the Web of Science core collection. Bibliographic co-occurrence analysis system (BICOMB) software was used for bibliometric analysis, VOS viewer software was used for visualization of the studies on the RA-prognostic channel. The published papers were analyzed in terms of numbers, document type, journal, references cited, authors, high-frequency words, and research.

Results

A total of 2759 papers were included. The field of RA prognosis appears to be in a stable stage, with material published in core European and American journals by core researchers and teams. The most cited references were the "The American Rheumatism Association 1987 revised criteria for the classification of rheumatoid arthritis" (Citations = 296), while Dr Smolen was the most productive author with 38 papers and 606 citations. Collaborations between institutions occurred more frequently within countries, while international collaborations were most frequent with United States-based institutions (total link strength = 1427). The top four research frontiers were "evaluation methodology", "Disease-Modifying Anti-Rheumatic Drugs(DMARDs)", "diagnostic criteria", and "management standard".

Conclusion

The annual scientific output on RA prognosis has grown steadily throughout the world. However, there is still a gap between China and western nations in terms of articles of high quality. It is suggested that Chinese researchers should focus on research quality, collaborations between institutions both domestically and internationally, and follow scientific and technical trends in the field.

Introduction

Rheumatoid arthritis (RA) is a systematic inflammatory disorder exemplified by chronic erosive arthritis¹. Its worldwide prevalence is between 0.5% and 1%, with differences seen in different populations², for instance, the prevalence in northern Europe and North America is estimated at 0.5%-1.1%, while that in China is 0.2–0.93%³. RA is more common in women and the elderly, with most studies reporting a female: male ratio between 2:1 to about 3:1⁴. It is possible that both genetic and environmental factors influence this distribution, either separately or jointly. Reports show that RA patients who do not receive timely or standard

treatment have significantly higher rates of disability than other RA patients, with disability rates reaching 60% within 5–10 years and up to 90% over 30 years or more⁵. RA causes not only inflammation and destruction in the joints but also damages various organ systems, including the cardiovascular and respiratory systems⁶. Patients are required to use long-term medication which frequently results in side effects such as bone marrow suppression, liver and kidney toxicity, and gastrointestinal tract complications, amongst others. An additional problem is that many individuals with RA live in rural areas where they have difficulty accessing suitable treatment, and their disability has economic impacts on both patients and their families. Thus, it is necessary to consider the issues of RA treatment and prognosis.

In gaining an understanding of a research field, it is helpful to consider the current status and trends, together with its core researchers and institutions. This is usually performed by an intensive investigation of the academic literature⁷. However, current escalations in the volume of available information render this extremely time-consuming, and researchers require efficient strategies to acquire and integrate the information. Bibliometric analysis has been proven useful and effective for the identification of trends and hotspots in various research fields⁸. Bibliometrics uses the analysis of word frequencies, co-words, citations, and clusters, as well as visual analysis. The internet provides extensive data and information in different formats. A recent development in integrating this information is visualization using knowledge maps. There are usually created using bibliometric software applications such as Cite space, Gephi, and Vosviewer, amongst others. Both bibliometrics and visualization have been effectively used in a variety of fields. However, it appears from the perusal of major databases that such analysis of the RA prognosis field is lacking, and there is no available information on the hot topics or trends in the field.

We, therefore, conducted a bibliometric investigation of the RA prognosis field using co-word analysis of the available English language literature.

Materials And Methods

Data collection

The core collection of Web of Science (<http://apps.webofknowledge.com>) was chosen as the database. The retrieval type was TI= ([rheumatoid* arthritis*] OR [RA] OR [rheumatic* arthritis*] OR [chronic* infectious* arthritis*] OR [ostarthritis*]) AND TI=([prognos*] OR [outcome*]). Searches focused on papers related to RA prognosis published between 2000 and October 19, 2021. The search yielded 2759 articles. The article citations were downloaded and stored in “txt” format.

Data extraction

The “Bibliographic Item Co-Occurrence Matrix Builder” (BICOMB) created by China Medical University was used to extract and classify the information in the dataset⁹. The 2759 retrieved articles were imported into BICOMB in plain text format. The analysis included the chronological distribution, article type, journal source distribution, highly cited references, core authors, and frequency of keywords.

Data visualization using knowledge maps

The VOS viewer software was used. This displays a knowledge map using a label view and a density view to evaluate the research trends and hotspot areas in the literature. In this study, the author, the country and region of the author, and the keywords were selected as the co-occurrence analysis and analysis units for visual analysis by setting the type of data¹⁰. Inter-node links indicated the associations between the various components.

Data analysis

Core author calculation

In terms of Price's law¹¹, if the number of papers published by a core author is M , the greatest number of papers published by the author is calculated as $MP = 0.749 \cdot \sqrt{NP_{max}}$, where NP_{max} is the number of articles published by the most prolific author. The least number of articles by a core author is calculated as $MC = 0.749 \cdot (\sqrt{NC_{max}})$, where NC_{max} is the highest number of citations received by a single article. In accordance with Ms. Zhong Wenjuan's¹² core author comprehensive indexing method, the weight of the journal and the number of citations of the author's articles are given as 0.5, and the publication, citation, and composite indices are determined as:

Publication index = publications by core author candidates/average publications by core author candidates,

Citation index = citations of core author candidates/average citations of core author candidates,

Composite index = quantity of publications $\times 0.5$ + quantity of cited $\times 0.5$.

Altmetric attention scores (AAS)

The AAS denotes a weighted count of the degree of electronic media attention received by an article, for example, on Facebook, Twitter, news sites, and blogs. This represents a way of assessing the extent of the spread of scientific research into the media. We selected the Altmetric plug-in to query score.

h index

The *h* index was initially suggested by Jorge Hirsch¹³ as a gauge of both publication and citation numbers, as follows "A scientist has index *h* if *h* of his or her N_p papers have at least *h* citations each and the other $(N_p - h)$ papers have fewer than $\leq h$ citations each". In this study, *h* index was obtained from the citation report in Web of Science.

Results

The descriptive data, maps, and analyses of authors, journals, article types, institutions, and countries of articles in the RA prognosis field are discussed below. Co-citations of cited authors and references are also included.

Chronological distribution

Based on the search strategy, 2759 publications were included in the analysis. As shown in Fig. 1, the number of citations rose gradually from 2000 until 2017, after which it slowed slightly. Overall, there has been a steady increase in the number of publications on RA prognosis over the past 20 years. Of the total 2759 articles, 892 (33.3%) were published between 2000 and 2011, while 1867 (67.7%) appeared between 2012 and 2021. There was a peak of 234 papers in 2017. Currently, the rate of publication appears to be stable at around 200 papers per year.

Distribution of article types

Figure 2 presents the details of the article types. The article types included article, review, meeting abstract, letter, and others. Meeting abstracts (n = 1595) accounted for 57% of the total number of articles, followed by articles (n = 975), accounting for 35%. There are thus relatively fewer journal articles about RA, and the principal means of communication appears to be by meeting abstract.

Source journals

There were a total of 310 journals publishing in the RA prognosis field. Of the 2759 publications retrieved, 1958 (71%) were published in 10 journals. These journals are listed in Table 1. ANNALS OF THE RHEUMATIC DISEASES published the greatest number of articles (653; 23.63%), followed by ARTHRITIS & RHEUMATOLOGY (329; 11.90%), and SEMINARS IN ARTHRITIS AND RHEUMATISM (301; 10.89%). Publications in these three journals accounted for 1283 (46.42%) of the total publications included in this study. The journal with the highest IF was ANNALS OF THE RHEUMATIC DISEASES, with an IF of 16.10 in 2020; this journal also contributed the largest number of articles on RA prognosis. The majority (80%) of RA prognosis-related articles were found in journals from the United States of America and the United Kingdom.

Table 1
The top 10 journals

Journal	Occurrence frequency	Proportion of frequency (%)	IF(2020)	Country	Publication frequency	Open Access
ANNALS OF THE RHEUMATIC DISEASES	653	23.63	16.10	USA	Monthly	No
ARTHRITIS AND RHEUMATOLOGY	329	11.90	9.59	USA	Monthly	No
SEMINARS IN ARTHRITIS AND RHEUMATISM	301	10.89	4.75	USA	Bimonthly	No
RHEUMATOLOGY	220	7.96	5.61	UK	Monthly	No
JOURNAL OF RHEUMATOLOGY	185	6.69	3.35	Canada	Monthly	No
VALUE IN HEALTH	66	2.39	4.75	USA	Bimonthly	No
CLINICAL RHEUMATOLOGY	58	2.10	2.39	UK	Monthly	No
ARTHRITIS RESEARCH AND THERAPY	54	1.95	4.15	UK	Monthly	Yes
CLINICAL AND EXPERIMENTAL RHEUMATOLOGY	50	1.81	3.32	Italy	Bimonthly	No
ARTHRITIS CARE AND RESEARCH	46	1.66	4.06	USA	Bimonthly	No

Distribution of cited references

A total of the 29 052 cited references were counted; the top 10 are shown in Table 2. The most-cited paper, discussing the RA classification standards, was published by the American Rheumatism Association (ACR) in 1988, with 296 citations. The AAS of the co-cited article, the European League Against Rheumatism (EULAR)'s recommendations for RA management, published in 2013, had the top score of 492 and also ranked first in the *h* index.

Table 2
Top 10 co-cited references in RA prognosis

No.	Article Title	First Author	Year	Citation	Cluster	Link	Altmetric	<i>h</i> Index
1	The American-Rheumatism-Association 1987 Revised Criteria For The Classification Of Rheumatoid-Arthritis	ARNETT FC	1988	296	2	1298	32	79
2	Modified Disease-Activity Scores That Include 28-Joint Counts - Development And Validation In A Prospective Longitudinal-Study Of Patients With Rheumatoid-Arthritis	PREVOO MLL	1995	176	4	958		8
3	Measurement Of Patient Outcome In Arthritis	FRIES JF	1980	120	1	617	29	88
4	The American-College-Of-Rheumatology Preliminary Core Set Of Disease-Activity Measures For Rheumatoid-Arthritis Clinical-Trials	FELSON DT	1993	89	1	547	15	128
5	2010 Rheumatoid Arthritis Classification Criteria An American College Of Rheumatology/European League Against Rheumatism Collaborative Initiative	Aletaha D	2010	146	4	515	91	74
6	Treating Rheumatoid Arthritis To Target: Recommendations Of An International Task Force	Smolen JS	2010	74	3	530	24	121
7	The Premier Study - A Multicenter, Randomized, Double-Blind Clinical Trial Of Combination Therapy With Adalimumab Plus Methotrexate Versus Methotrexate Alone Or Adalimumab Alone In Patients With Early, Aggressive Rheumatoid Arthritis Who Had Not Had Previous Methotrexate Treatment	Breedveld FC	2006	68	3	546	21	107

No.	Article Title	First Author	Year	Citation	Cluster	Link	Altmetric	<i>h</i> Index
8	EULAR Recommendations For The Management Of Rheumatoid Arthritis With Synthetic And Biological Disease-Modifying Antirheumatic Drugs: 2013 Update	Smolen JS	2014	68	4	284	492	121
9	Development And Validation Of The European League Against Rheumatism Response Criteria For Rheumatoid Arthritis - Comparison With The Preliminary American College Of Rheumatology And The World Health Organization International League Against Rheumatism Criteria	vanGestel AM	1996	65	5	418	12	7
10	Clinical And Radiographic Outcomes Of Four Different Treatment Strategies In Patients With Early Rheumatoid Arthritis (The Best Study) - A Randomized, Controlled Trial	Goekoop-Ruiterman YPM	2005	62	3	546	44	24
10	Infliximab And Methotrexate In The Treatment Of Rheumatoid Arthritis	Lipsky PE	2000	62	1	401	16	115

Distribution of authors and co-authorship in research groups

Altogether, 8879 authors were involved in the included RA prognosis studies. The core authors (comprehensive index ≥ 1) are shown in Table 3. Of the core authors, Emery, P (115 publications) ranked first, followed by Strand, V (70 publications), and Keystone, E (69 publications). The information on author co-citations was also analyzed. Of the co-cited authors, Smolen, JS (606 co-citations) ranked first, followed by Wolfe, F (453 co-citations), and Aletaha, D (408 co-citations). In summary, Smolen, JS ranked first (4.75) in the comprehensive index, while Emery, P ranked first in the *h* index (121).

Table 3
Core authors in RA prognosis

No.	Author	Papers	Papers of first author	Cited article number	comprehensive index	h-index
1	Smolen JS	38	9	606	4.75	121
2	Emery P	115	30	225	3.87	162
3	Wolfe F	21	15	453	3.39	115
4	Strand V	70	48	254	3.12	79
5	Aletaha D	22	6	392	3.02	74
6	Pincus T	14	5	408	2.95	100
7	van der Heijde D	54	10	190	2.37	145
8	Combe B	66	15	105	2.07	80
9	Fleischmann R	67	25	64	1.82	95
10	Keystone E	69	10	49	1.76	83
11	Dougados M	57	6	66	1.62	138
12	Sokka T	17	10	179	1.52	66
13	Genovese MC	34	12	110	1.43	67
14	Scott DL	16	2	159	1.37	12
15	Young A	37	1	91	1.37	38
16	Keystone EC	36	12	89	1.33	66
17	Tanaka Y	46	9	51	1.29	62
18	Ostergaard M	35	2	86	1.29	86
19	Weinblatt ME	29	3	105	1.29	78
20	Curtis JR	36	15	76	1.25	108
21	Burmester GR	42	3	56	1.24	114
22	Boers M	19	2	129	1.24	94
23	Westhovens R	43	6	50	1.23	62
24	Kremer JM	19	1	113	1.13	71
25	Gossec L	24	7	90	1.09	65

Collaborations between individuals, institutions, and countries, is critical for the success of most large-scale trials. Figure 3.A shows the network visualization of authors involved in research on RA prognosis. Thirteen groups included 122 authors, with the largest group consisting of 21 members centered on Michael Weinblatt. The highest co-cited author was Edward Keystone with 2844 co-citations, followed by Paul Emery (2578), and FC Breedveld (1461). Keystone and Haraoui, both Canadian scholars, appeared to work closely together, largely on medication policy and the use of drugs in a Canadian setting. Other authors, such as Breedveld, appear to focus more on their own research teams rather than collaborators. As shown in Fig. 3.B, these highly productive authors represent the backbone of recent research. Figure 4 indicates that most publications in the field were from the United States, followed by the United Kingdom, with the majority of Chinese publications dating from 2017 onwards.

Distribution of keyword hotspots

The clusters of similar keywords are shown in Fig. 5.A The 38 keywords are divided into four categories; each category is shown in a different color (red, blue, yellow, or green). Table 4 shows the keywords contained within each cluster. The clusters represent the features and trends in research into RA prognosis, as follows:

Table 4
Co-occurrence analysis of keywords

Cluster1 RED	Cluster2 GREEN	Cluster3 BLUE	Cluster4 YELLOW
Rheumatoid Arthritis (566)	Methotrexate (182)	Prognosis (135)	Remission (95)
Disease-activity (234)	Double-blind (114)	Disease (129)	Recommendations (77)
Quality-of-life (96)	Therapy (106)	Follow-up (91)	Criteria (75)
Disability (79)	Modifying antirheumatic drugs (92)	Mortality (93)	American-college (80)
Validation (86)	Combination therapy (83)	Joint damage (56)	Management (59)
Clinical-trials (58)	Etanercept (68)	Radiographic progression (56)	Classification (52)
Fatigue (47)	Infliximab (56)	Damage (45)	
Health-assessment questionnaire (47)	Adalimumab (49)	Risk (74)	
Patient-reported outcomes (42)	Efficacy (58)		
Impact (46)			
Pain (42)			
Questionnaire (41)			
Prevalence (51)			
Validity (47)			

Cluster 1 (shown in red) represents characteristics associated with RA assessment. The keywords include “disease-activity”, “quality of life”, “validation”, and “clinical trials”. In terms of “clinical trials”, for example, Japanese researchers proposed that alterations in anti-citrullinated peptide antibody (ACPA) titers are predictive of relapse in RA patients in remission¹⁴.

Cluster 2 (colored green) represents DMARDs. As also shown in Fig. 5.B, we found that although methotrexate appeared many times in the literature, most occurrences were concentrated around 2013. More recent studies have been concerned with etanercept, infliximab, adalimumab, and other TNF inhibitors.

Cluster 3 (colored blue) represents the identification of risk factors linked to RA prognosis. These include terms such as “joint damage” and “radiographic progression”. RA has a mortality rate about of 24%. Higher GSUS and CombUS scores have been associated with increased risk¹⁵.

Cluster 4 (colored yellow) represents RA classification and management. The keywords include “American college”, “management”, “criteria”, and “recommendations”. The EULAR recommendations have been generally accepted since 2013.

Discussion

This bibliometric analysis investigated the development and trends of research into RA prognosis between 2000 and 2021. A total of 2759 publications were identified in the Web of Science, and from these we determined the significance of articles to the field, as well as information of authors, journals, and countries in which the research was conducted, expressing this in the form of networks. To our knowledge, this is the first bibliometric analysis of the field of RA prognosis.

Global trends in RA research

The first study on RA prognosis was conducted by Colver in 1932¹⁶. Since then, there has been a steady production of articles on the subject. In the last 10 years, however, there has been a general increase in the annual numbers of publications. It is possible that this trend may be related to the 2010 classification standard of RA reformulated by the ACR and EULAR (2010 Rheumatoid Arthritis Classification Criteria An American College Of Rheumatology/European League Against Rheumatism Collaborative Initiative) and the updates issued by EULAR in 2013 on the recommended use of anti-rheumatoid arthritis drugs (EULAR Recommendations For The Management Of Rheumatoid Arthritis With Synthetic And Biological Disease-Modifying Antirheumatic Drugs: 2013 Update). In recent years, a variety of countries and organizations have published guidelines for patients with RA, including the 2018 Chinese guidelines for diagnosis (2018 Chinese guideline for the diagnosis and treatment of rheumatoid arthritis) and treatment and the 2019 EULAR update to the drug recommendations for RA management (EULAR recommendations for the management of rheumatoid arthritis with synthetic and biological disease-modifying antirheumatic drugs: 2019 update). A decrease in the number of studies on RA prognosis was visible over the past three years, and the annual number of publications is likely to be less than 200 in 2021. This suggests that research into this topic may have reached a plateau. The plateau may, however, be temporary, as researchers may continue to explore new directions and developments in RA prognosis in the future.

Citation numbers in RA research

The use of citation numbers as a measure of research quality is founded on the premise that good research is likely to be highly cited. The use of citation numbers is a key measure in bibliometric evaluation¹⁷. As shown in Table 1, the article describing RA classification criteria by FC ARNETT in 1988 was ranked first both in total link strength and number of citations and can thus be considered to occupy the core position in the citation map. However, the citation index is closely related to the publication year, implying that the earlier an article is published, the more likely it is to have a high number of citations, complicating its comparison with a high-influence article published more recently. To compensate for this, we added the AAS indicator. As shown in Table 1, the 2013 article by JS Smolen describing the EULAR recommendations for RA management was widely disseminated to the public. Although the use of the AAS resolves some drawbacks, there are still limitations, for example, the measure cannot evaluate the quality of the article but rather focuses on hot subjects or controversial topics. This suggests that the combination of several indicators would better assess citation quality. In addition, most of papers (No.1, No.4, No.5, No.6, No.8, No.9) are belong to methods or guidelines that suggest they are more likely to be cited.

Source journals in RA research

Articles published in high-impact journals tended to be cited more frequently. Our results showed that of the top 10 co-cited references, 90% were published in the top three journals. Besides the inclusion requirements of articles, this uneven distribution may also be related to the frequency of journal publication, for example, the third-ranked journal "SEMINARS IN ARTHRITIS AND RHEUMATISM" published six issues were year. In addition, journals from US and UK account for 80% of the total publications. The impact factor of a journal is often used as a measure of the journal's influence and quality, as well as of the quality of the authors' research. The highly cited article by JS Smolen on recommendations for the treatment of RA was published in the high-impact ANNALS OF THE RHEUMATIC DISEASES. Consideration of the impact and distribution of the journal, as well as its publication on specific topics, can assist individual authors in finding the most suitable journal for publishing their work.

Author analysis in RA research

Currently, the authors publishing research on RA prognosis are mostly based in Western countries. The leaders in the field appear to be the van Hoogstraten H group, the van der Heijde D team, and the Curtis JR group. van Hoogstraten H and his collaborators demonstrated that the Sarilumab + MTX combination¹⁸ is more effective than placebo + MTX in MTX-IR RA patients, while Sarilumab monotherapy was superior to adamumab monotherapy in MTX-IR RA patients¹⁹. van der Heijde D team demonstrated that CZP + MTX reduced both structural damage and RA symptoms in MTX-naive early-stage RA patients with poor prognosis. CZP efficacy was not affected by MTX dose category, suggesting that the MTX dose could be adjusted to individual patient requirements without affecting the efficacy of CZP²⁰⁻²². Curtis JR and collaborators observed a higher incidence of herpes zoster infection in patients taking tofacitinib²³, finding a higher risk of infection in patients receiving additional glucocorticoid therapy²⁴. The safety of tofacitinib in patients with severe infections, cardiovascular disease, cancer, or gastrointestinal perforation appeared to be similar to that of bDMARD²⁵⁻²⁸. The Chinese scholar Li Jiang was ranked at 22% in the number of published articles, with 9 articles. The number of citations was relatively low, possibly because the studies have only been recently published, with the first appearing in 2018. He mainly studied the associations between genetics and MTX efficacy.

Distribution of keyword hotspots in RA research

Keywords represent the essence of an article, reflecting the main content and trends of the research. High keyword frequencies over a certain period can be a reflection of a hot topic. The keyword analysis here suggested that MTX has remained the "anchor drug" for most patients. Despite its efficacy, some patients may experience side effects. The major side effects of MTX include gastrointestinal disorders²⁹, infections³⁰, nephrotoxicity³¹, hepatotoxicity³², pulmonary damage³³ and myelosuppression³⁴. The first TNF- α inhibitor, infliximab, was approved in 1998, opening the era of biological agents. TNF- α inhibitors include infliximab, etanercept, and adalimumab. Combinations of TNF- α inhibitors and MTX have proved effective in patients with active RA who do not respond to MTX alone³⁵⁻³⁷. Although an increased risk of infection was found for MTX combined with adalimumab or infliximab³⁸, the risk appears lower when etanercept was used³⁹.

Limitations

There are several limitations in this study. First, only the Web of Science database was searched. It is thus possible that other high-quality articles included in other databases may have been missed. In addition, only articles published in English were included. In addition, there may be bias in the co-occurrence analysis findings due to recent publication and, consequently, reduced citations numbers. There is also the possibility that, despite using broad search terms, certain articles on RA prognosis may have been missed.

Conclusion

Here, we conducted a bibliometric analysis of articles on RA prognosis published over the past 20 years. Although there appears to be increased collaboration between authors and countries throughout the world, this is more apparent in Western countries such as the United States and European countries. This suggests that China should strengthen its international cooperation and participate in cutting-edge research. Clinical recommendations or treatment guidelines in high-impact journals were more likely to be cited in the RA prognosis field. Although the number of papers on the prognosis of RA has increased since 2010, the number is still relatively low compared to those on the prognosis of cancer and other diseases. For example, in a bibliometric analysis of genes associated with breast cancer prognosis from 2001 to 2010, XieFei retrieved 5323 articles. This may be because of the complexity of RA and the multiplicity of its treatment methods and risk factors, indicating the importance of research into RA prognosis.

Abbreviations

rheumatoid arthritis

RA

Disease-Modifying Anti-Rheumatic Drugs

DMARDs

Declarations

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Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of supporting data

The datasets used or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

All authors declare that they have no any conflicts of interest with this paper.

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Authors' contributions

Lingyu Fu and Yuxin Yao had the idea for the study. Cui Lei and Zhijun Fan offer help with software. Ruobing Liao and Yulan Chen conducted a research and investigation process, specifically performing the evidence collection. Yuxin Yao wrote the first draft. Lingyu Fu critically revised the paper for important intellectual content. All authors approved the final draft.

References

1. Wu CT, Lo CL, Tung CH, Cheng HL. Applying Data Mining Techniques for Predicting Prognosis in Patients with Rheumatoid Arthritis. *Healthcare* 2020; 8(2).
2. Scott DL, Wolfe F, Huizinga TW. Rheumatoid arthritis. *Lancet* 2010; 376(9746): 1094–1108.
3. Yin X, Cheng F, Wang X, et al. Top 100 cited articles on rheumatoid arthritis: A bibliometric analysis. *Medicine (Baltimore)* 2019; 98(8): e14523.
4. Alamanos Y, Drosos AA. Epidemiology of adult rheumatoid arthritis. *Autoimmunity Reviews* 2005; 4(3): 130–136.
5. Colmegna I, Hitchon CA, Bardales MCB, Puri L, Bartlett SJ. High rates of obesity and greater associated disability among people with rheumatoid arthritis in Canada. *Clinical Rheumatology* 2016; 35(2): 457–460.
6. Li TH, Chang YS, Liu CW, et al. The prevalence and risk factors of sarcopenia in rheumatoid arthritis patients: A systematic review and meta-regression analysis. *Seminars in Arthritis and Rheumatism* 2021; 51(1): 236–245.
7. Wang X, Zhang Z, He X, et al Mapping publication status and exploring hotspots in a research field: Rheumatoid arthritis with depression. *J Adv Nurs* 2020; 76(11): 3003–3013.
8. Jia TY, Luo CZ, Wang SW, et al. Emerging Trends and Hot Topics in Cardiopulmonary Resuscitation Research: A Bibliometric Analysis from 2010 to 2019. *Medical Science Monitor* 2020; 26.
9. Lei C. Development of a text mining system based on the co-occurrence of bibliographic items in literature databases. *Data Analysis and Knowledge Discovery* 2008.

10. van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* 2010; 84(2): 523–538.
11. Povedano-Montero FJ, Weinreb RN, Raga-Martinez I, Romero A, Lopez-Munoz F. Detection of Neurological and Ophthalmological Pathologies with Optical Coherence Tomography Using Retinal Thickness Measurements: A Bibliometric Study. *Applied Sciences-Basel* 2020; 10(16).
12. Zhong W. Evaluation about the Core Authors Based on Price Law and Comprehensive Index Method—Take Journal of Library Development as an Example. *Science and Technology Management Research*, 2012(4).
13. Hirsch JE. An index to quantify an individual's scientific research output. *Proc Natl Acad Sci USA* 2005; 102(46): 16569–16572.
14. Murata K, Ito H, Hashimoto M, et al. Fluctuation in anti-cyclic citrullinated protein antibody level predicts relapse from remission in rheumatoid arthritis: KURAMA cohort. *Arthritis Res Ther* 2020; 22(1): 268.
15. Moller B, Aletaha D, Andor M, et al. Sonar group for musculoskeletal ultrasound in the Swiss Clinical Quality Management Foundation. Synovitis in rheumatoid arthritis detected by grey scale ultrasound predicts the development of erosions over the next three years. *Rheumatology (Oxford)* 2020; 59(7): 1556–1565.
16. Colver T. The prognosis in rheumatoid arthritis in childhood. *Arch Dis Child* 1937; 12(70): 253–260.
17. Duthie JJ, Thompson M, Weir MM, Fletcher WB. Medical and social aspects of the treatment of rheumatoid arthritis; with special reference to factors affecting prognosis. *Ann Rheum Dis* 1955; 14(2): 133–149.
18. Zhai S. Evaluation of the Academic Impact of Data Papers Fused with Altmetrics and Citation Analysis. *Journal of the China Society for Scientific and Technical Information* 2020.
19. Burmester GR, Lin Y, Patel R, et al. Efficacy and safety of sarilumab monotherapy versus adalimumab monotherapy for the treatment of patients with active rheumatoid arthritis (MONARCH): a randomised, double-blind, parallel-group phase III trial. *Ann Rheum Dis* 2017; 76(5): 840–847.
20. Strand V, Gossec L, Proudfoot CWJ, et al. Patient-reported outcomes from a randomized phase III trial of sarilumab monotherapy versus adalimumab monotherapy in patients with rheumatoid arthritis. *Arthritis Res Ther* 2018; 20(1): 129.
21. Atsumi T, Tanaka Y, Yamamoto K, et al. Clinical benefit of 1-year certolizumab pegol (CZP) add-on therapy to methotrexate treatment in patients with early rheumatoid arthritis was observed following CZP discontinuation: 2-year results of the C-OPERA study, a phase III randomised trial. *Annals of the Rheumatic Diseases* 2017; 76(8): 1348–1356.
22. Combe B, Furst DE, Keystone EC, et al. Certolizumab Pegol Efficacy Across Methotrexate Regimens: A Pre-Specified Analysis of Two Phase III Trials. *Arthritis Care Res (Hoboken)* 2016; 68(3): 299–307.
23. Weinblatt ME, Bingham 3rd CO, Burmester GR, et al. A Phase III Study Evaluating Continuation, Tapering, and Withdrawal of Certolizumab Pegol After One Year of Therapy in Patients With Early Rheumatoid Arthritis. *Arthritis Rheumatol* 2017; 69(10): 1937–1948.
24. Curtis JR, Xie F, Yun H, Bernatsky S, Winthrop KL. Real-world comparative risks of herpes virus infections in tofacitinib and biologic-treated patients with rheumatoid arthritis. *Ann Rheum Dis* 2016; 75(10): 1843–

1847.

25. Winthrop KL, Curtis JR, Lindsey S, et al. Herpes Zoster and Tofacitinib: Clinical Outcomes and the Risk of Concomitant Therapy. *Arthritis Rheumatol* 2017; 69(10): 1960–1968.
26. Cohen SB, Tanaka Y, Mariette X, et al. Long-term safety of tofacitinib up to 9.5 years: a comprehensive integrated analysis of the rheumatoid arthritis clinical development programme. *RMD Open* 2020; 6(3).
27. Curtis JR, Lee EB, Kaplan IV, et al. Tofacitinib, an oral Janus kinase inhibitor: analysis of malignancies across the rheumatoid arthritis clinical development programme. *Ann Rheum Dis* 2016; 75(5): 831–841.
28. Cohen SB, Tanaka Y, Mariette X, et al. Wollenhaupt. Long-term safety of tofacitinib for the treatment of rheumatoid arthritis up to 8.5 years: integrated analysis of data from the global clinical trials. *Ann Rheum Dis* 2017; 76(7): 1253–1262.
29. Curtis JR, Zhang R, Krishnaswami S, et al. Use of a risk characterisation approach to contextualise the safety profile of new rheumatoid arthritis treatments: a case study using tofacitinib. *Clinical Rheumatology* 2017; 36(3): 683–688.
30. McKendry RJ, Cyr M. Toxicity of methotrexate compared with azathioprine in the treatment of rheumatoid arthritis. A case-control study of 131 patients. *Arch Intern Med* 1989; 149(3): 685–689.
31. Furst DE, Erikson N, Clute L, Koehnke R, Burmeister LF, Kohler JA. Adverse experience with methotrexate during 176 weeks of a longterm prospective trial in patients with rheumatoid arthritis. *J Rheumatol* 1990; 17(12): 1628–1635.
32. Karie S, Gandjbakhch F, Janus N, et al. Kidney disease in RA patients: prevalence and implication on RA-related drugs management: the MATRIX study. *Rheumatology (Oxford)* 2008; 47(3): 350–354.
33. Zhang A, Sun H, Wang P, Han Y, Wang X. Recent and potential developments of biofluid analyses in metabolomics. *J Proteomics* 2012; 75(4): 1079–1088.
34. Conway R, Low C, Coughlan RJ, O'Donnell MJ, Carey JJ. Methotrexate and lung disease in rheumatoid arthritis: a meta-analysis of randomized controlled trials. *Arthritis Rheumatol* 2014; 66(4): 803–812.
35. Preet Singh Y, Aggarwal A, Misra R, Agarwal V. Low-dose methotrexate-induced pancytopenia. *Clin Rheumatol* 2007; 26(1): 84–87.
36. Klareskog L, van der Heijde D, de Jager JP, et al. Therapeutic effect of the combination of etanercept and methotrexate compared with each treatment alone in patients with rheumatoid arthritis: double-blind randomised controlled trial. *Lancet* 2004; 363(9410): 675–681.
37. Breedveld FC, Weisman MH, Kavanaugh AF, et al. The PREMIER study - A multicenter, randomized, double-blind clinical trial of combination therapy with adalimumab plus methotrexate versus methotrexate alone or adalimumab alone in patients with early, aggressive rheumatoid arthritis who had not had previous methotrexate treatment. *Arthritis and Rheumatism* 2006; 54(1): 26–37.
38. Lipsky PE, van der Heijde DM, St Clair EW, et al. Infliximab and methotrexate in the treatment of rheumatoid arthritis. Anti-Tumor Necrosis Factor Trial in Rheumatoid Arthritis with Concomitant Therapy Study Group. *N Engl J Med* 2000; 343(22): 1594–1602.
39. Chen YF, Jobanputra P, Barton P, et al. A systematic review of the effectiveness of adalimumab, etanercept and infliximab for the treatment of rheumatoid arthritis in adults and an economic evaluation

of their cost-effectiveness. Health technology assessment (Winchester, England) 2006; 10(42): iii-iv, xi-xiii, 1–229.

Figures

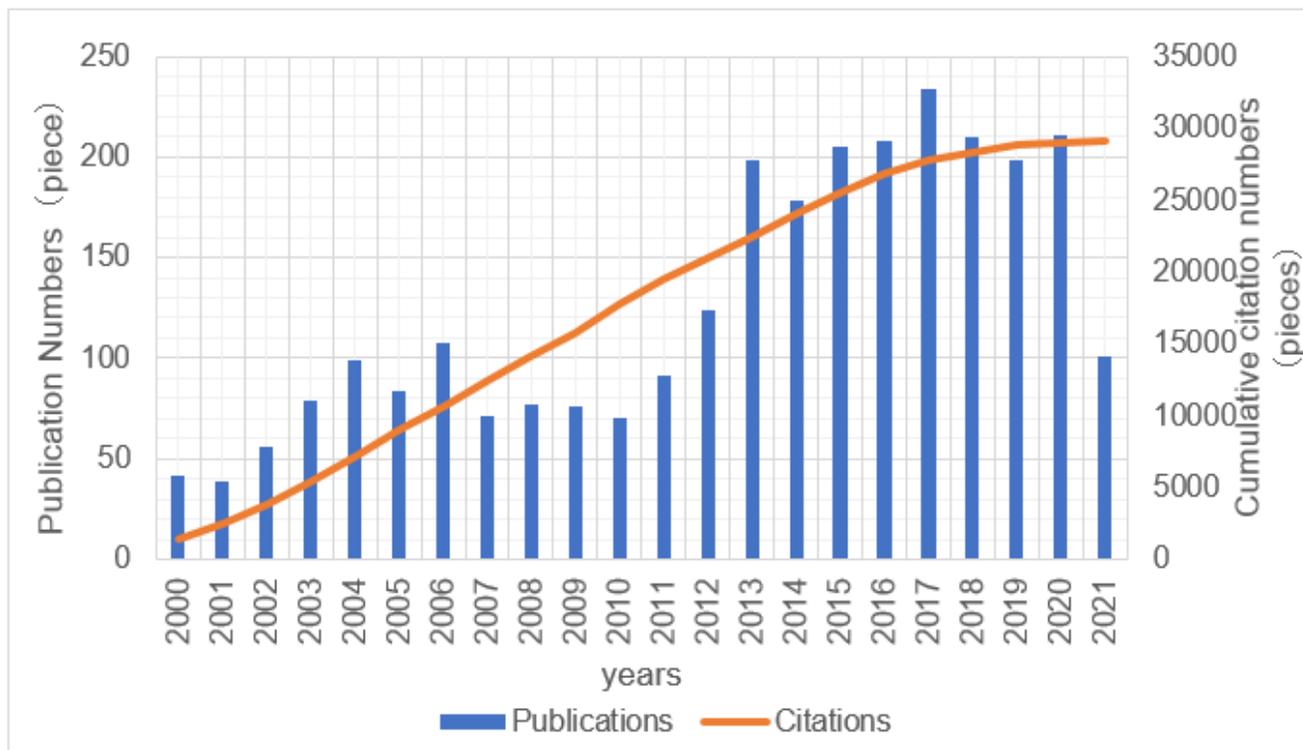


Figure 1

Chronological distribution of the publications and citations

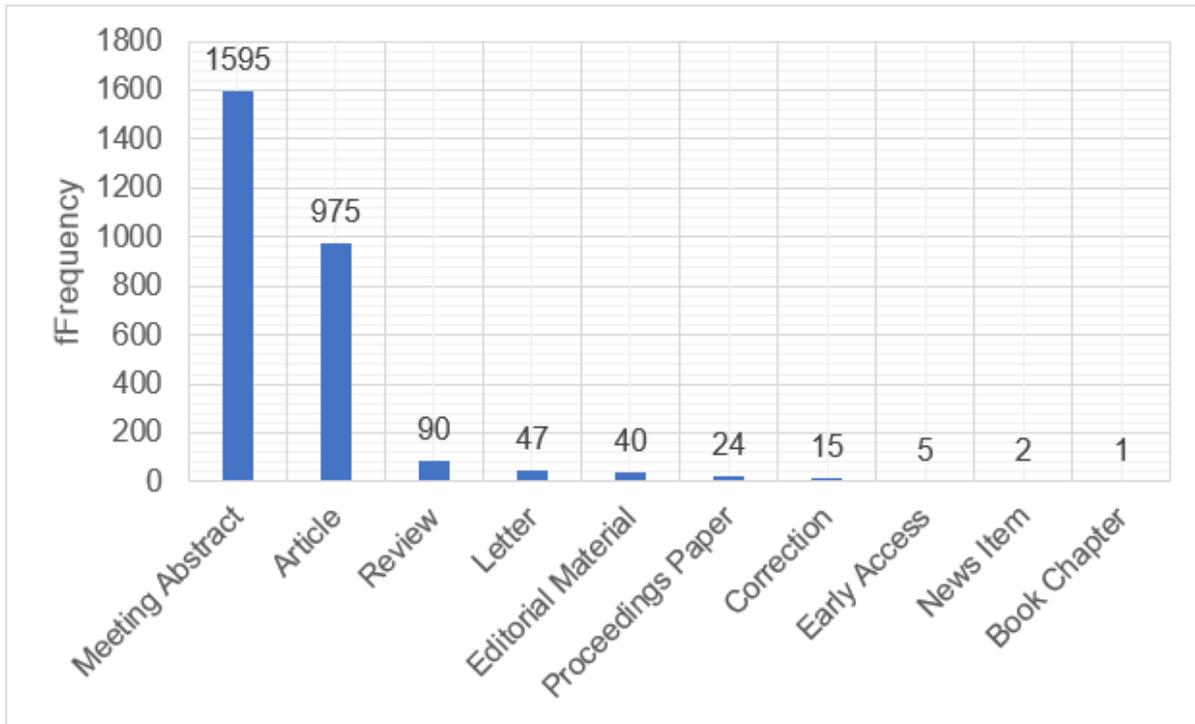


Figure 2

Distribution of article types

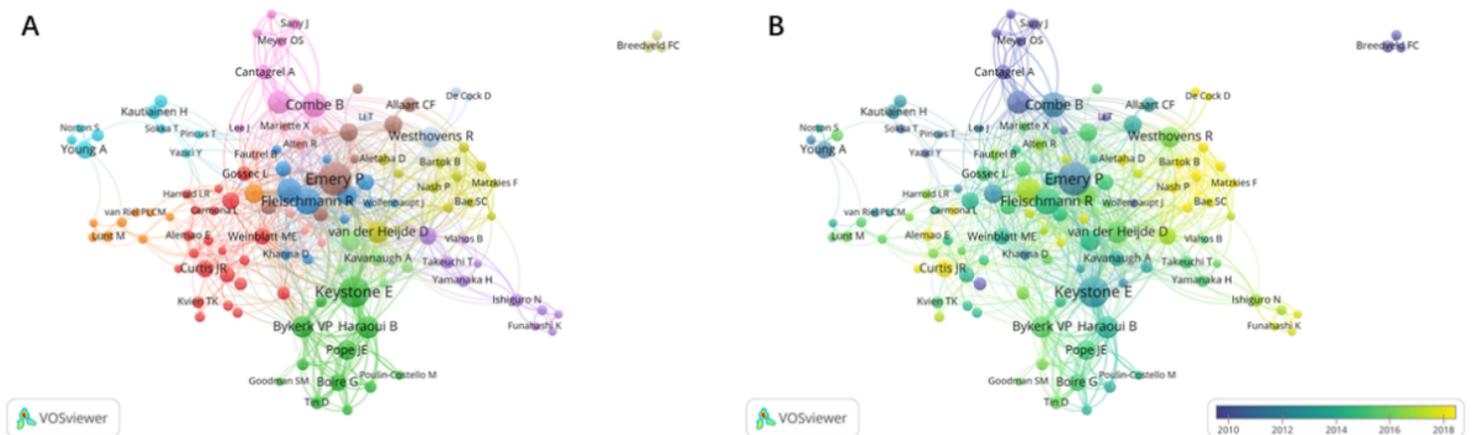


Figure 3

A: Core authors in studies on RA prognosis. Circle sizes represent the number of publications by the author, line thickness represents the degree of collaboration between the authors. The number of cited articles was over 18, the number of published articles was more than 8, and, the removal of correlation strength was less than 10. B: Overlay visualization map of authors. Blue lines and circles represent earlier publications, while yellow lines and circles represent more recent publications.

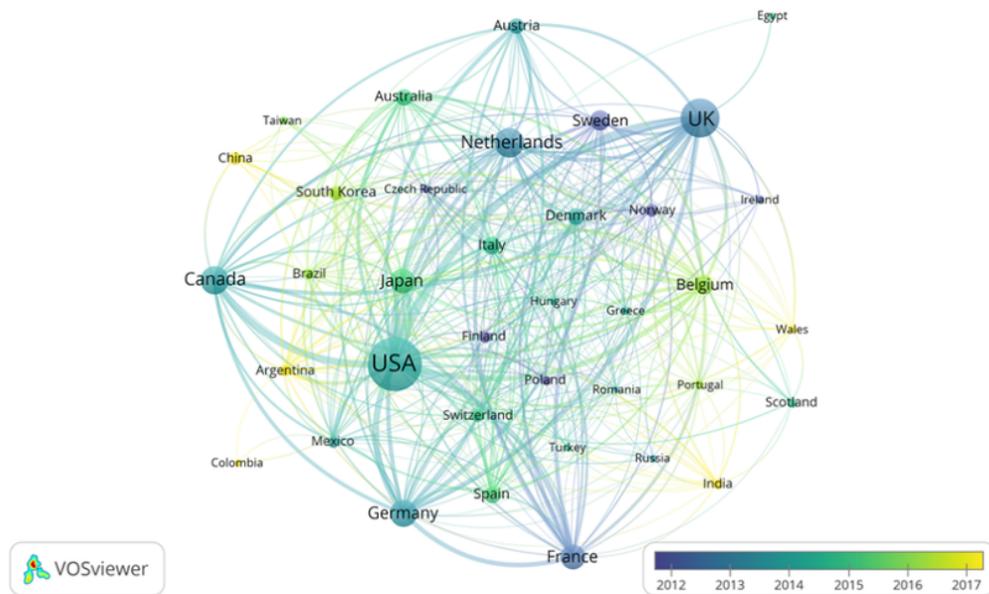


Figure 4

Core authors by country. The minimum number of publications per country was 15. Of the total number of 86 countries producing research on RA prognosis, 37 countries met this criterion.

