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Research article

Development and trends in metabolomics studies in psoriasis: A bibliometric analysis of related research from 2011 to 2024

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ABSTRACT

Background: Psoriasis is a chronic, inflammatory skin disease with autoimmune characteristics. Recent research has made significant progress in the field of psoriasis metabolomics. However, there is a lack of bibliometric analysis on metabolomics of psoriasis. The objective of this study is to utilize bibliometrics to present a comprehensive understanding of the knowledge structure and research hotspots in psoriasis within the field of metabolomics.

Methods: We conducted a bibliometric analysis by searching the Web of Science Core Collection database for publications on metabolomics in psoriasis from 2011 to 2024. To perform this analysis, we utilized tools such as VOSviewers, CiteSpace, and the R package "bibliometrix".

Results: A total of 307 articles from 47 countries, with the United States and China leading the way, were included in the analysis. The publications focusing on metabolomics in psoriasis have shown a steady year-on-year growth. The Medical University of Bialystok is the main research institution. The International Journal of Molecular Sciences emerges as the prominent journal in the field, while the Journal of Investigative Dermatology stands out as the highly co-cited publication. A total of 2029 authors contributed to these publications, with Skrzydlewska Elzbieta, Baran Anna, Flisiak Iwona, Murakami Makoto being the most prolific contributors. Notably, Armstrong April W. received the highest co-citation. Investigating the mechanisms of metabolomics in the onset and progression of psoriasis, as well as exploring therapeutic strategies, represents the primary focus of this research area. Emerging research hotspots encompass inflammation, lipid metabolism, biomarker, metabolic syndrome, obesity, and arthritis.

Conclusion: The results of this study indicate that metabolism-related research is thriving in psoriasis, with a focus on the investigation of metabolic targets and interventions within the metabolic processes. Metabolism is expected to be a hot topic in future psoriasis research.

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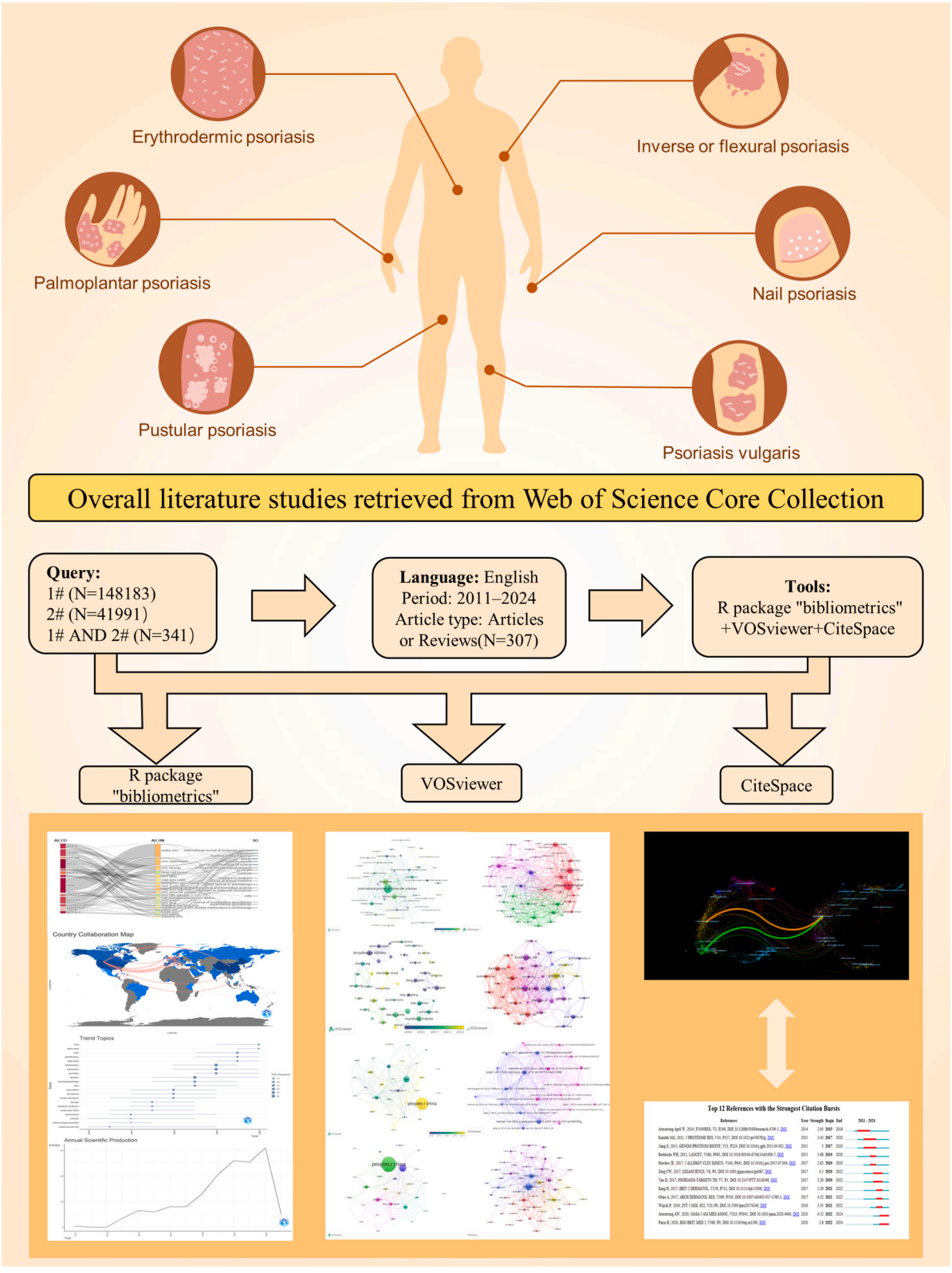


Fig. 1. Classification of psoriasis and flow diagram of the included publications, methods, and results of bibliometric analysis.

1. Introduction

Psoriasis is a chronic, inflammatory, systemic, and autoimmune skin disease characterized by various phenotypes (Fig. 1), including psoriasis vulgaris, erythrodermic psoriasis, pustular psoriasis, inverse or flexural psoriasis, palmoplantar psoriasis, and nail psoriasis [1]. These phenotypes can coexist in the same individual, with psoriasis vulgaris being the most prevalent manifestation. The disease manifests as persistent skin inflammation, presenting as circumscribed, scaling, and erythematous plaques. The etiology of psoriasis is multifactorial, involving a complex interplay of genetic, immunological, and environmental factors. Studies focusing on immunology and genetics have highlighted the significance of IL-17 and IL-23 in driving the pathogenesis of psoriasis. The introduction of biological therapies targeting these cytokines has revolutionized psoriasis care [2].

Metabolomics analysis initially relied on gas chromatography-mass spectrometry (GC-MS), a prevalent laboratory diagnostic and clinical examination method employed for metabolic profiling [3]. Subsequently, the introduction of high-performance liquid chromatography and nuclear magnetic resonance (NMR) technologies facilitated deeper investigations into drug metabolism within the body. Metabolomics explores a diverse range of small molecules (<1500 Da) present in biological systems, encompassing carbohydrates, lipids, amino acids, and nucleotides, aiming to identify changes in their composition. Several studies have employed metabolomics techniques to analyze peripheral blood, skin lesions, and urine samples from individuals with psoriasis, focusing on alterations in carbohydrates, lipids, amino acids, and nucleotides. These 4 molecular classes are not only distinct entities but also intricately interconnected [4].

Bibliometrics is a quantitative and qualitative method for analyzing the output and status of publications within a specific research area [5]. It provides comprehensive insights into authors, keywords, journals, countries, institutions, and references. Firstly, bibliometrics helps researchers understand research trends and hot topics in a particular field [6]. By analyzing the number of publications and citation frequencies, researchers can identify current research hotspots and important areas of study [7]. This helps researchers choose appropriate research topics and ensure their work aligns with current academic trends. Secondly, bibliometrics can assess the impact and importance of a research study. By analyzing the citation count and frequencies of a paper, researchers can understand its influence in the academic community and the extent to which it has been cited by other researchers. This helps researchers evaluate the impact of their own research and determine their academic standing and value. Additionally, bibliometrics can help researchers discover potential collaborators and research networks [8]. By analyzing the authors in the literature and their collaboration relationships, researchers can identify experts and leaders in the field, as well as their collaborative networks. This helps researchers establish collaborations, expand their research networks, and gain more academic support and resources. Overall, bibliometrics has significant advantages in academic writing. It helps researchers understand research hotspots, assess research impact, and discover collaborators and research networks [9]. By employing bibliometric methods and tools, researchers can conduct more comprehensive and accurate academic research, enhancing the quality and impact of their work [10].To visualize the outcomes of literature analysis, researchers often employ various bibliometric tools such as CiteSpace, VOSviewer, and the R package "bibliometrix" [11]. These tools are widely utilized across medical domains. Despite this, no previous visualization study on metabolomics in psoriasis has been reported. Consequently, this study applies a bibliometric approach, utilizing the authoritative Web of Science Core Collection (WoSCC) database to collect relevant research on metabolomics in psoriasis from the past 10 years. By employing bibliometrics, this paper examines the global research trends and summarizes the growth of published articles, authors, institutions, countries, and research hotspots in the field of metabolomics in psoriasis. These findings provide valuable references for topic selection, collaborations, and future development trends within this field.

2. Materials and methods

2.1. Data sources and search methods

On March 6, 2024, a literature search was performed on the WoSCC. Table S1 presents the potential search keywords utilized for the search process. The search formula was set as TS=(metabolome OR "metabolomic profiling" OR metabolomics OR metabolomic OR metabonomics OR metabonomic OR "metabolism analysis" OR "metabolic change" OR "metabolic analysis" OR lipidomics OR "metabolite levels" OR lipidomic OR "lipid metabolism" OR "metabolic biomarkers" OR "glucose metabolism" OR "lipid metabolism" OR "amino acid metabolism" OR "nucleotide metabolism") AND TS=(psoriasis OR psoriatic) AND DOP= (2011-01-01/2024-03-06) AND DT= (Article OR Review) AND LA= (English). In this context, we selected a dataset derived from WoSCC as our target dataset for analytic purposes. Since the topic search of WoSCC can be interpreted as a model for keywords search based on words in the title, abstract, author keywords, and keywords plus, we chose the search topic to obtain a more precise topic [11].

3. Results

3.1. Statistical analysis of publications

Fig. 1 shows the whole analysis process. The search was conducted in the WoSCC database on March 6, 2024. Based on our search method, a total of 307 studies on metabolomics in psoriasis were identified, comprising 229 articles and 78 reviews. The time frame of the analysis can be categorized into three phases: Phase I (2011–2013), Phase II (2014–2018), and Phase III (2019–2023). As depicted in Fig. 2, In Phase I, there was only 1 paper publication, indicating a lack of research on metabolomics in psoriasis during that period. In Phase II, the number of publications showed steady growth, with an average of approximately 12.8 publications per year, signifying

the early stage of metabolomics research in psoriasis. Phase III witnessed a significant increase in the number of publications, averaging around 46.6 publications per year. Notably, in 2019, there were 27 publications related to the subject, marking a 1.68-fold increase compared to 2018. In 2023, the number of metabolomics publications in psoriasis up to 59. Over the past 5 years (Phase III), there has been a consistent upward trend in the number of publications, with a significant increase compared to the other two phases. In the past 2 months of 2024, 9 articles have been published, indicating an upward trend in this field.

3.2. Country and institutional analysis

Publications on metabolomics in psoriasis originated from 47 countries and 648 institutions. Among these countries, the number of publications was highest in China (n = 106), with the United States ranking second (n = 51), Germany (n = 29), and Italy (n = 28) (Table 1). In terms of citations, the United States and China have achieved a significant lead. Subsequently, we filtered and visualized a subset of 29 countries with 3 or more publications, creating a cooperation network according to the number and relationships of publications in each country (Fig. 3*A-C*). Remarkably, there was substantial active collaboration between different countries. China has close cooperation with countries such as the United States and Italy.

From the number of publications, the top 10 institutions in the field of metabolomics in psoriasis are spread across 6 countries, with half of them located in China (Table 2). Among these institutions, the 3 with the highest number of relevant publications are the Medical University of Bialystok (n = 17), Shanghai University of Traditional Chinese Medicine (n = 9), and Shanghai Jiao Tong University (n = 8). From the number of citations, the United States has 3 institutions ranked in the top 10, while Poland and China each have 2 institutions ranked in the top 10 (Table 2). Among these institutions, the 3 with the highest number of relevant citations are the Medical University of Bialystok (n = 298), the University of Rome Tor Vergata (n = 254), and BGI Shenzhen (n = 238).

Next, we selected 38 institutions with a minimum of 3 publications for visualization purposes and built a cooperation network relying on the number and relationships of publications from each institution (Fig. 4A and B). Fig. 4 highlights the close cooperation between the Medical University of Bialystok, Dermatol Specialized Ctr DERMAL NZOZ Bialystok, and Universidade de Aveiro. Additionally, there was active collaboration observed between the Shanghai University of Traditional Chinese Medicine and Tongji University.

3.3. Journals and co-cited publications

Publications focusing on metabolomics in psoriasis were distributed across 173 journals. The journal with the highest number of papers published in this field was the International Journal of Molecular Sciences (n = 21), followed by Metabolites (n = 13), Frontiers in Immunology (n = 11), and Frontiers in Pharmacology (n = 8). Among the top 12 journals, the journal with the highest impact factor was the Journal of the European Academy of Dermatology and Venereology (IF = 9.2), followed by the Frontiers in Immunology (IF = 7.3). Subsequently, we selected 48 journals with a minimum of 2 relevant publications for visualization, creating a journal network (Fig. 5A). Fig. 5A demonstrates that the International Journal of Molecular Sciences has active citation relationships with journals such as the Journal of Pharmaceutical and Biomedical Analysis, Scientific Reports, and Cells, among others.

As presented in Table 3, within the top 12 co-cited journals, 6 journals received more than 300 citations. Journal of Investigative Dermatology (co-citations = 741) emerged as the most cited journal, followed by British Journal of Dermatology (co-citations = 482), Journal of the American Academy of Dermatology (co-citations = 348), and Plos One (co-citations = 335). Additionally, Nature boasted the highest impact factor (IF = 64.8), followed by Annals of the Rheumatic Diseases (IF = 27.4). To visualize the co-citation

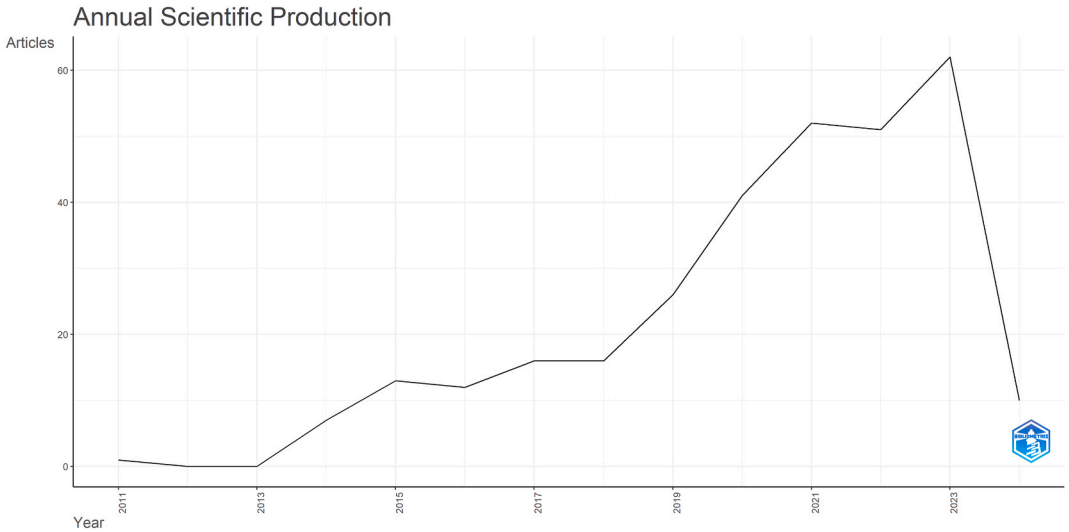


Fig. 2. Explanation of the annual research results related to psoriasis metabolomics.

Table 1
List of the top 15 countries and regions with the highest research productivity.

Rank	Country	Counts	Citations	Total link strength
1	China	106	1205	15
2	The United States	51	1287	51
3	Germany	29	722	48
4	Italy	28	771	31
5	Poland	25	417	14
6	The United Kingdom	22	701	46
7	Japan	20	197	11
8	Canada	15	174	12
9	Greece	12	212	23
10	Spain	9	224	6
11	Portugal	9	221	7
12	Sweden	9	193	23
13	Denmark	9	176	15
14	Switzerland	9	112	16
15	South Korea	9	110	1

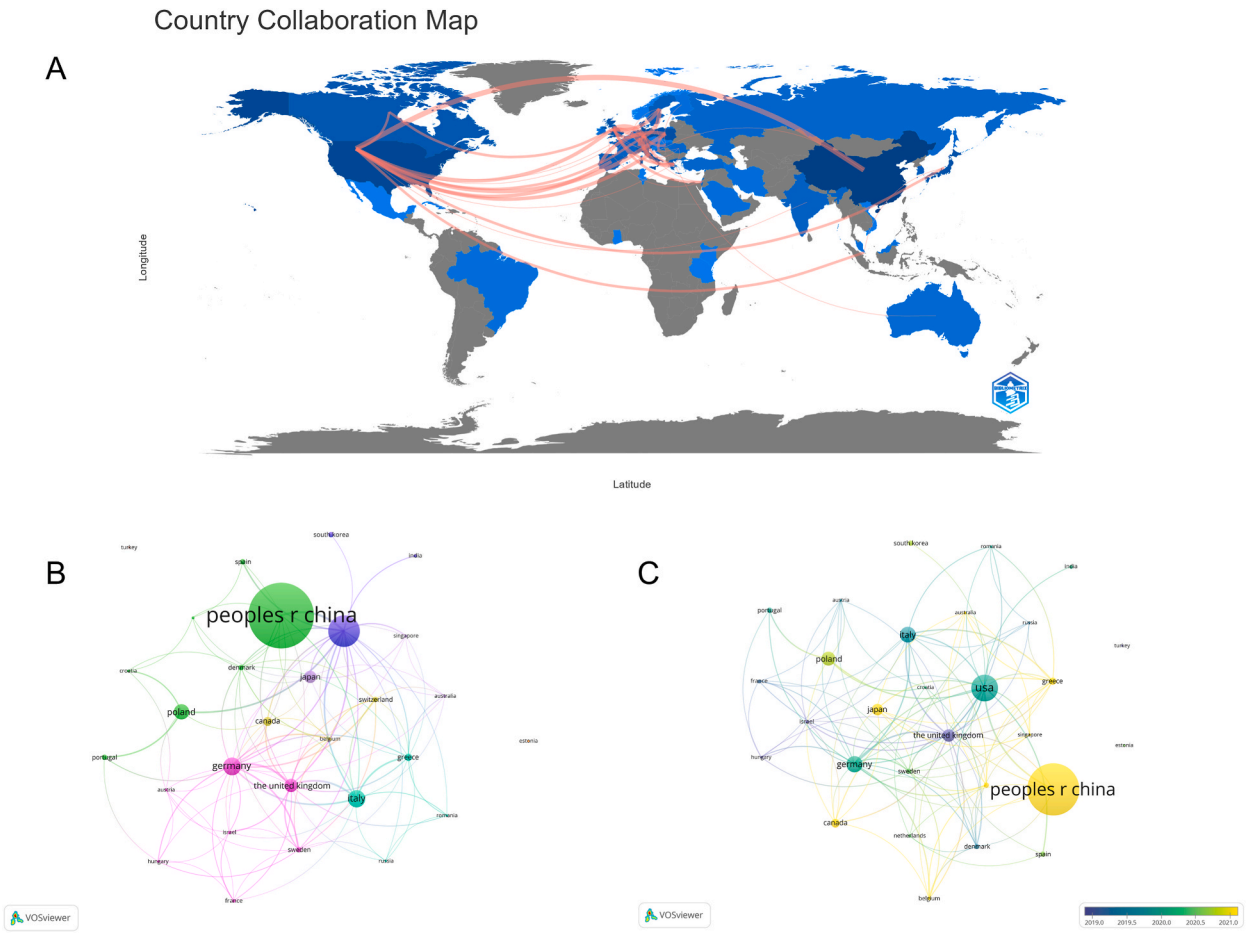


Fig. 3. The geographical distribution and visualization of countries on the research of metabolomics in psoriasis.

network, journals with a minimum co-citation count of 60 were selected, resulting in Fig. 5B. The figure demonstrates the positive co-citation relationships of the Journal of Investigative Dermatology with the British Journal of Dermatology, the Journal of the European Academy of Dermatology, and Plos One, among others.

The dual-map visualization presents the citation correlations between journals and co-cited journals, depicting clusters of citing and cited journals. In Fig. 5C, the orange pathway denotes research published in Molecular/Biology/Immunology journals, which predominantly receive citations from Molecular/Biology/Genetics literature. On the other hand, the green pathway represents

Table 2
Top 10 most productive Institutions.

Rank	Institution	Counts	Institution	Citations
1	Medical University of Bialystok (Poland)	17	Medical University of Bialystok (Poland)	298
2	Shanghai University of Traditional Chinese Medicine (China)	9	University of Rome Tor Vergata (Italy)	254
3	Shanghai Jiao Tong University (China)	8	BGI Shenzhen (China)	238
4	University of Copenhagen (Denmark)	8	National Heart, Lung, and Blood Institute (The United States)	196
5	University of Rome Tor Vergata (Italy)	7	King's College London(The United Kingdom)	195
6	The National and Capodistrian University of Athens (Greece)	7	Dermatol Specialized Ctr DERMAL NZOZ Bialystok (Poland)	188
7	Fudan University (China)	7	University of Pennsylvania(The United States)	164
8	Tongji University (China)	7	Shanghai Jiao Tong University (China)	152
9	Central South University (China)	7	Ru Ruđer Bošković Institute (Croatia)	143
10	University of Toronto (Canada)	7	Vanderbilt University (The United States)	141

research published in Molecular/Biology/Genetics journals, primarily cited by Medicine/Medical/Clinical literature.

3.4. The relationship of the countries, institutions, and journals

The relationship between countries, institutions, and journals based on the three-field plot for metabolomics in psoriasis is shown in Fig. 5D. China contained or connected with 8 targeted institutions (Shanghai University of Traditional Chinese Medicine, Guangzhou University of Chinese Medicine, Tongji University, Central South University, Shanghai Jiao Tong University, Zhejiang University, University of Copenhagen and University of Rome Tor Vergata). The United States contained or connected with 10 targeted institutions (University of Copenhagen, Medical University of Lublin, University of Toronto, Medical University of Bialystok, University of Rome Tor Vergata, National and Kapodistrian University of Athens, Shanghai University of Traditional Chinese Medicine, Tongji University, Chiba University and Shanghai Jiao Tong University). Odense University Hospital connected with 3 targeted journals (Journal of Dermatological Science, Journal of Investigative Dermatology and JCI Insight). It is worth noting that the United States has cooperated with many Chinese institutions.

3.5. Analysis of authorship and co-cited authors, and co-cited references

List diverse group of 2029 authors contributed to the research on metabolomics in psoriasis, Skrzydlewska Elzbieta, Murakami Makoto, Baran Anna, and Flisiak Iwona, have published 8 papers. (Table 4). By analyzing authors with 4 or more published papers, we constructed a collaborative network (Fig. 6*A*) that reveals extensive collaborations among researchers. Skrzydlewska Elzbieta, for instance, closely collaborates with Wronski Adam, Luczaj Wojciech, and Wojcik Piotr, among others. In recent years, Nowowieiska Julia, Looby Nikita, and Kulasingam Vathany have published numerous articles in this field.

Out of the 12702 co-cited authors, 6 authors received over 40 co-citations (Table 4). Armstrong April W garnered the highest number of citation among authors, totaling 51, followed by Boehncke Wolf-Henning (n = 50). To visualize these co-citation relationships, we filtered authors with a minimum of 20 co-citations and mapped the co-citation network (Fig. 6B). It is worth noting that there are dynamic collaborations among various authors frequently cited in the literature such as Murakami Makoto and Yamamoto Kenichi, as well as Gisondi Paolo and Takahashi Hiroshi.

There have been 15973 co-cited references in the research of metabolomics in psoriasis. Among the references listed in the top 10 co-cited publications (Table 5), each reference received a minimum of 20 co-citations, with three references receiving more than 30 co-citations. To construct a network map with the co-citation (Fig. 6C), we focused on references with a co-citation count of 10 or higher. Fig. 6C highlights the active co-cited relationships between "kamleh ma, 2015, j proteome res, v14, p557, doi 10.1021/pr500782g" and other references such as "kang h, 2017, brit j dermatol, v176, p713, doi 10.1111/bjd.15008″, " zeng cw, 2017, gigascience, v6, doi 10.1093/gigascience/gix087″ and " sorokin av, 2018, j invest dermatol, v138, p1518, doi 10.1016/j.jid.2018.02.003″ among others.

Citation bursts manifest when references receive a notable influx of citations from researchers within a specific field over a defined period. Our study employed CiteSpace to identify 12 references exhibiting substantial citation bursts (Fig. 6*D*). Each year is represented by a bar in Fig. 6*D*. The reference titled "Exploration of candidate biomarkers for human psoriasis based on gas chromatography-mass spectrometry serum metabolomics" authored by Kang Hua and Li Xia, exhibited the strongest citation burst (strength = 5.29) from 2021 to 2022. The second strongest citation burst (strength = 4.52) was associated with the reference titled "Pathophysiology, clinical presentation, and treatment of psoriasis" published in JAMA-Journal of the American Medical Association by Armstrong April W. et al., with citation bursts from 2022 to 2024. The burst strength of these 12 references varied from 2.62 to 5.29, with durations lasting between 1 and 3 years. Table 6 provides a summary of the main research contents of these 12 references, following the order of appearance in Fig. 6D.

3.6. Hotspots and frontiers

Through keywords co-occurrence analysis, we can effectively identify research hotspots in a specific field. Table 7 presents the top 20 high-frequency keywords in metabolomics research on psoriasis. Among these keywords, excluding search terms, "inflammation" appeared more than 80 times, indicating its significance as a primary research focus in psoriasis metabolomics. We filtered out those

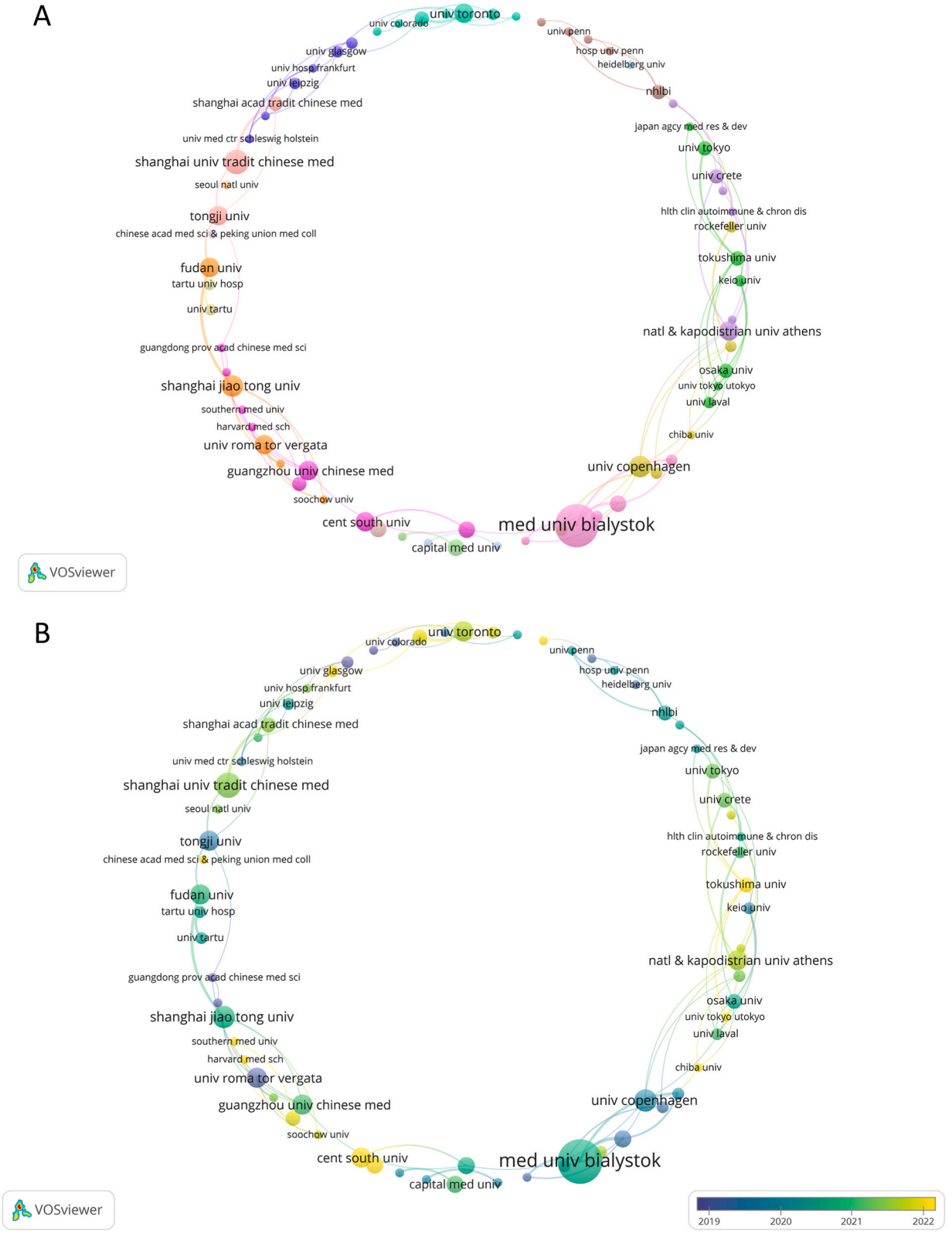
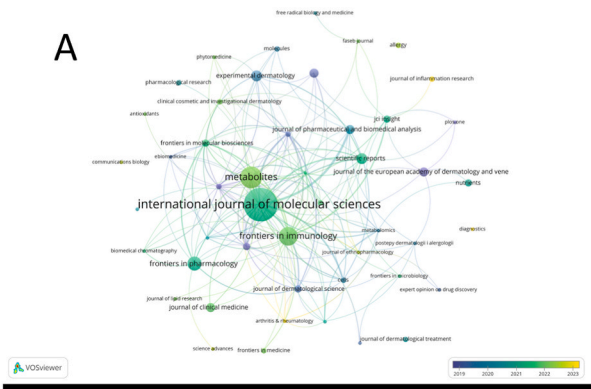
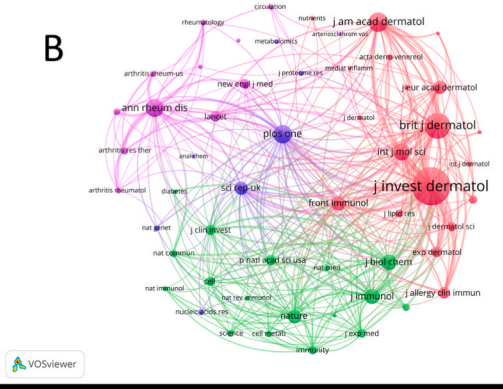
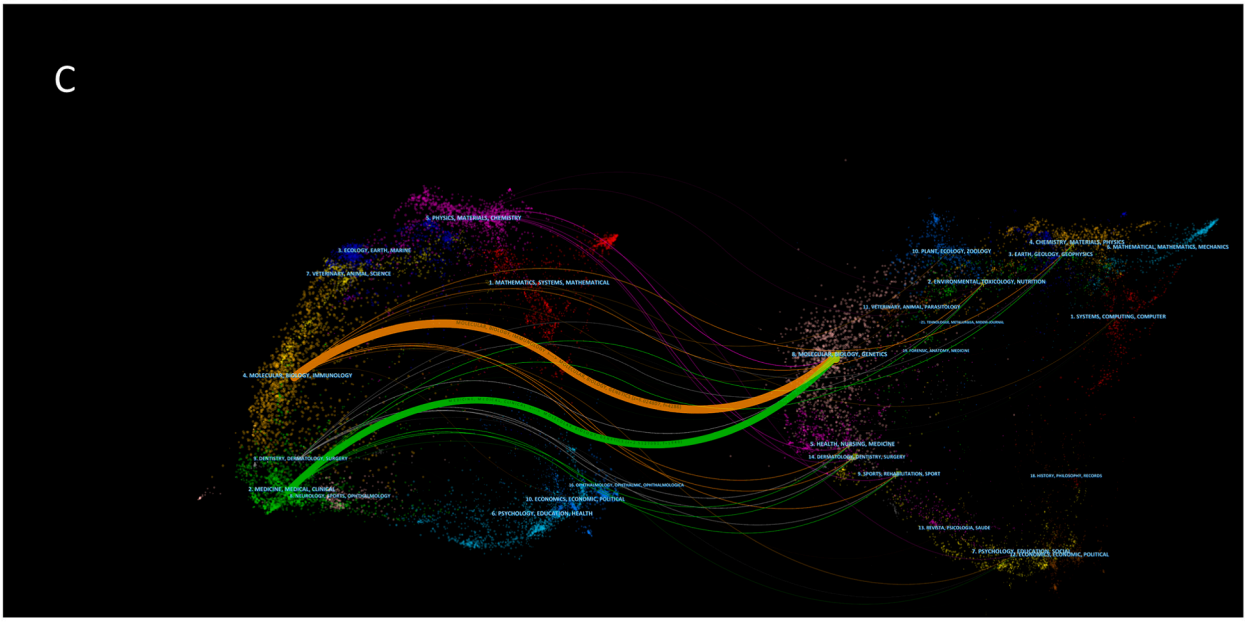


Fig. 4. The visualization of institutions on the research of metabolomics in psoriasis.







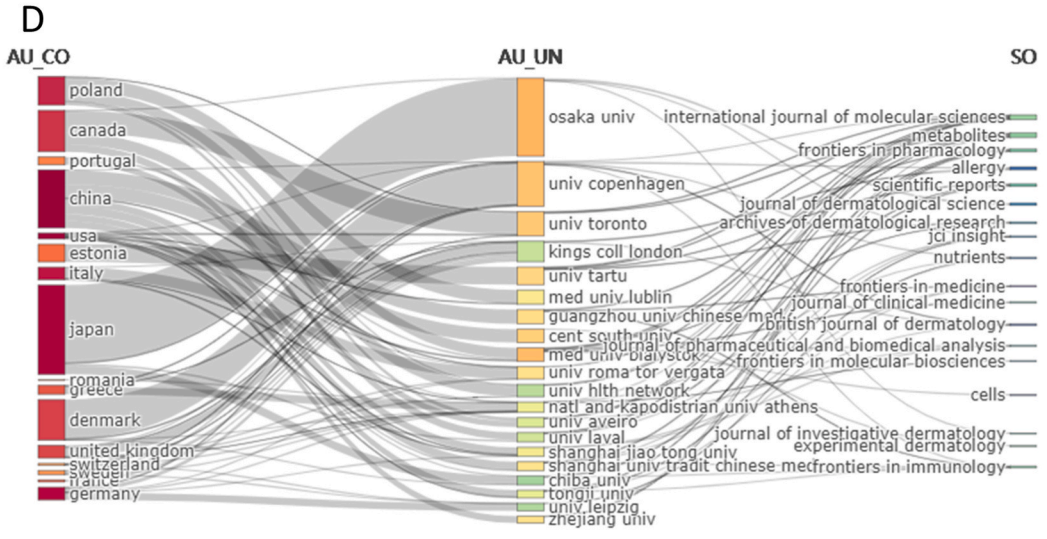


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Fig. 5. Journals related to metabolomics in psoriasis are published worldwide. (A) The visualization presents an overview of journals involved in metabolomics research in the field of psoriasis. (B) Visual analysis of journals co-cited in the field of metabolomics in psoriasis. (C) The journal dual-map overlay showcases the interconnections among various journals in the field of metabolomics research in psoriasis. (D) The relationship of the countries, institutions, and journals produced articles based on the three-field plot for metabolomics in psoriasis.

Table 3
Top 12 journals and co-cited journals for metabolomics study in psoriasis.

Rank	Journal	Counts	IF	Q	Co-cited Journal	Co-citations	IF	Q
1	International Journal of Molecular Sciences	21	6.2	Q2	Journal of Investigative Dermatology	741	6.5	Q1
2	Metabolites	13	4.1	Q3	British Journal of Dermatology	482	11.1	Q1
3	Frontiers in Immunology	11	7.3	Q2	Journal of the American Academy of Dermatology	348	13.8	Q1
4	Frontiers in Pharmacology	8	5.6	Q2	Plos One	335	3.7	Q1
5	Experimental Dermatology	6	3.6	Q3	Annals of the Rheumatic Diseases	321	27.4	Q1
6	Scientific Reports	6	4.6	Q2	International Journal of Molecular Sciences	304	6.2	Q2
7	Journal of Clinical Medicine	5	3.9	Q3	Journal of Biological Chemistry	282	4.8	Q2
8	Journal of Investigative Dermatology	5	6.5	Q1	The Journal of Immunology	271	1.3	Q4
9	Journal of Pharmaceutical and Biomedical Analysis	5	3.4	Q3	Frontiers in Immunology	246	7.3	Q2
10	Journal of the European Academy of Dermatology and Venereology	5	9.2	Q2	Nature	242	64.8	Q1
11	Archives of Dermatological Research	4	3.0	Q3	Scientific Reports	236	4.6	Q2
12	Frontiers in Molecular Biosciences	4	5.0	Q3	Journal of the European Academy of Dermatology and Venereology	231	9.2	Q2

Table 4
Top 10 authors and co-cited authors list in the field of metabolomics in psoriasis.

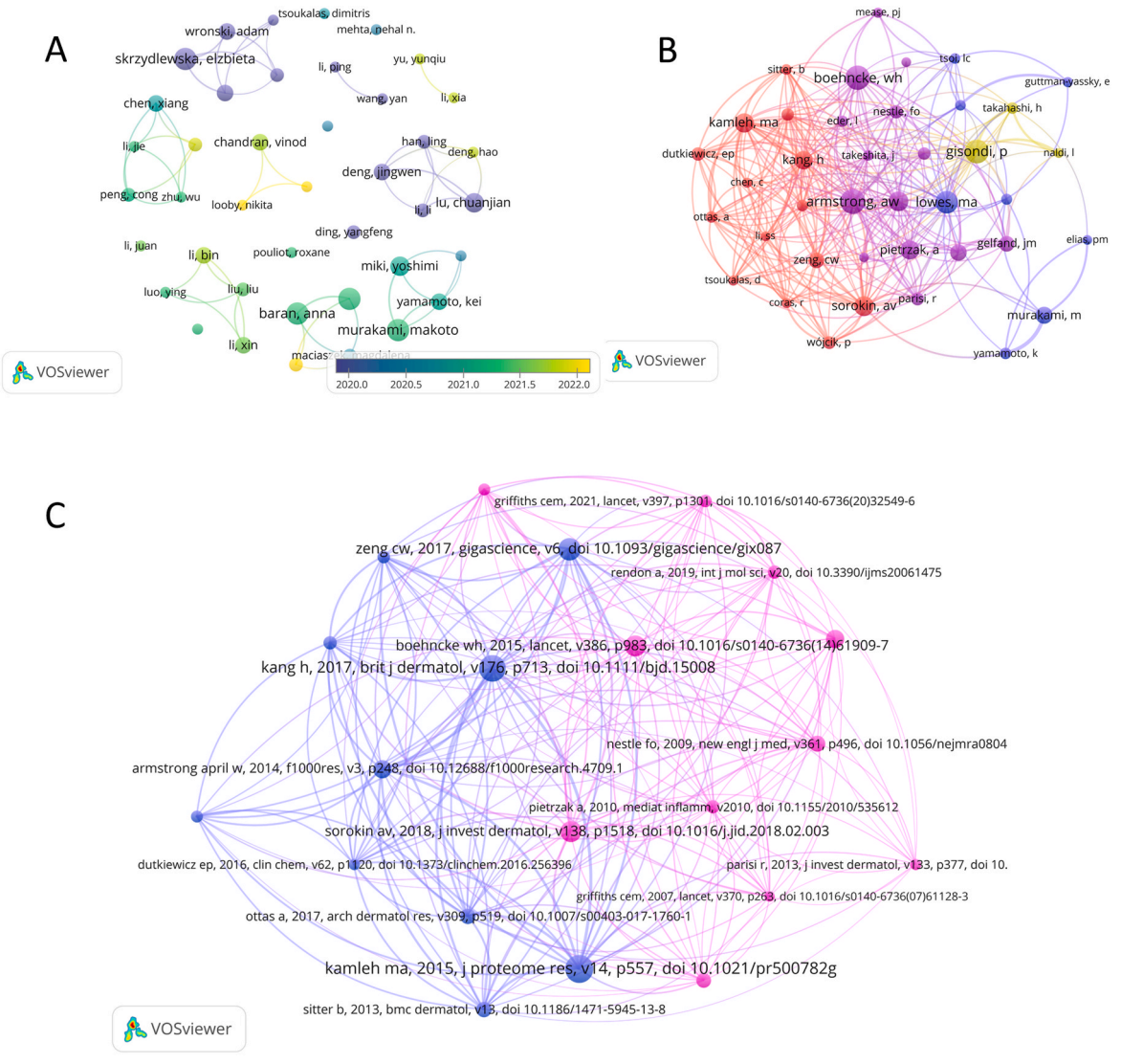
Rank	Author	Country	Counts	Citations	Co-Cited Author	Country	Citations
1	Skrzydlewska Elzbieta	Poland	8	251	Armstrong April W.	The United States	51
2	Murakami Makoto	Japan	8	68	Boehncke Wolf-Henning	Switzerland	50
3	Baran Anna	Poland	8	42	Gisondi Paolo	Italy	49
4	Flisiak Iwona	Poland	8	42	Lowes Michelle A	The United States	46
5	Lu Chuanjian	China	7	73	Griffiths, Christopher E. M.	The United Kingdom	41
6	Miki Yoshimi	Japan	7	67	Sorokin Aleksey V.	The United States	41
7	Chen Xiang	China	6	208	Kamleh Muhammad Anas	Sweden	40
8	Wronski Adam	Poland	6	188	Pietrzak Agata	Poland	39
9	Luczaj Wojciech	Poland	6	164	Kang Hua	China	38
10	Deng Jingwen	China	6	63	Murakami Makoto	Japan	35

with 4 or more occurrences to further analyze these keywords and conducted cluster analysis using VOSviewer (Fig. 7*A*). The strength of the connections between keywords is represented by the thickness of the lines in the network. Fig. 7*A* reveals a total of 4 distinct clusters representing different research directions. The keywords in the blue cluster include psoriasis, inflammation, lipid metabolism, cytokine, dendritic cell, in vitro, methotrexate, mice, oxidative stress, and T-cell. The red cluster consists of keywords like activation, atopic dermatitis, cells, ceramide, differentiation, expression, fatty acids, gene, glucose metabolism, glycolysis, identification, keratinocyte, lipidomics, lipids, mass spectrometry, mechanisms, metabolism, pathogenesis, psoriasis vulgaris, and skin. The purple cluster encompasses keywords such as adipose-tissue, arthritis, association, atherosclerosis, diabetes, disease, insulin resistance, metabolic syndrome, obesity, prevalence, psoriatic arthritis, rheumatoid arthritis, risk, severity, therapy, and tnf-alpha. Lastly, the yellow cluster encompasses keywords like amino acid, biomarker, metabolite, metabolomics, plasma, and serum. These clusters provide insights into the various research directions within the field of metabolomics in psoriasis and offer valuable information about the interconnections between different keywords and concepts.

The trend topic analysis of the keywords (Fig. 7B) showed that from 2015 to 2020, the research in this period mainly focused on psoriasis comorbidities, and that the main keywords were metabolic syndrome, body-mass and cardiovascular risk. Since 2016, scholars have begun to actively explore the pathogenesis and therapeutic potential of metabolomics research in psoriasis, and the main keywords are inflammation, insulin resistance, amino-acid, fatty acids.

4. Discussion

In 2011–2013, there were only 1 paper on metabolomics in psoriasis, suggesting a lack of research foundation and limited exploration of the relationship between metabolomics and psoriasis during that time. During the period from 2014 to 2018, the field of research was in its initial phases, with an average annual publication rate of 12.8 papers. In 2014, some literature began to study the differences in metabolites between psoriasis and healthy populations [12,23], while others began to study lipid metabolism



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Top 12 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End	2011 - 2024
Armstrong April W, 2014, F1000RES, V3, P248, DOI 10.12688/f1000research.4709.1, DOI	2014	2.63	2015	2018	
Kamleh MA, 2015, J PROTEOME RES, V14, P557, DOI 10.1021/pr500782g, DOI	2015	3.43	2017	2020	
Jiang S, 2015, GENOM PROTEOM BIOINF, V13, P224, DOI 10.1016/j.gpb.2015.04.002, DOI	2015	3	2017	2020	
Boehncke WH, 2015, LANCET, V386, P983, DOI 10.1016/S0140-6736(14)61909-7, DOI	2015	3.68	2019	2020	
Hawkes JE, 2017, J ALLERGY CLIN IMMUN, V140, P645, DOI 10.1016/j.jaci.2017.07.004, DOI	2017	2.62	2019	2020	
Zeng CW, 2017, GIGASCIENCE, V6, P0, DOI 10.1093/gigascience/gix087, DOI	2017	4.5	2020	2022	
Yan D, 2017, PSORIASIS-TARGETS TH, V7, P1, DOI 10.2147/PTT.S118348, DOI	2017	3.29	2020	2022	
Kang H, 2017, BRIT J DERMATOL, V176, P713, DOI 10.1111/bjd.15008, DOI	2017	5.29	2021	2022	
Ottas A, 2017, ARCH DERMATOL RES, V309, P519, DOI 10.1007/s00403-017-1760-1, DOI	2017	4.32	2021	2022	
Wójcik P, 2019, INT J MOL SCI, V20, P0, DOI 10.3390/ijms20174249, DOI	2019	3.35	2021	2022	
Armstrong AW, 2020, JAMA-J AM MED ASSOC, V323, P1945, DOI 10.1001/jama.2020.4006, DOI	2020	4.52	2022	2024	
Parisi R, 2020, BMJ-BRIT MED J, V369, P0, DOI 10.1136/bmj.m1590, DOI	2020	2.8	2022	2024	

Fig. 6. Analysis of authors and references involved in metabolomics in psoriasis. (A) Collaboration network of authors based on VOSviewer. (B) Collaboration network of co-authors based on VOSviewer. (C) The co-cited literature on metabolomic studies of psoriasis based on VOSviewer. (D) Top 12 references with the strongest citation bursts based on CiteSpace involved in metabolomics in psoriasis.

Table 5
Top 10 co-cited references list on the field of metabolomics in psoriasis.

Rank	Co-cited Reference	Citations
1	kamleh ma, 2015, j proteome res, v14, p557, doi 10.1021/pr500782g	40
2	kang h, 2017, brit j dermatol, v176, p713, doi 10.1111/bjd.15008	38
3	zeng cw, 2017, gigascience, v6, doi 10.1093/gigascience/gix087	32
4	boehncke wh, 2015, lancet, v386, p983, doi 10.1016/s0140-6736(1461909-7)	30
5	sorokin av, 2018, j invest dermatol, v138, p1518, doi 10.1016/j.jid.2018.02.003	30
6	armstrong april w, 2014, f1000res, v3, p248, doi 10.12688/f1000research.4709.1	26
7	van der fits l, 2009, j immunol, v182, p5836, doi 10.4049/jimmunol.0802999	26
8	nestle fo, 2009, new engl j med, v361, p496, doi 10.1056/nejmra0804595	23
9	ottas a, 2017, arch dermatol res, v309, p519, doi 10.1007/s00403-017-1760-1	22
10	sitter b, 2013, bmc dermatol, v13, doi 10.1186/1471-5945-13-8	22

Table 6
12 references to primary research with strong citation bursts.

Rank	Strength	Main research content
1	2.63	The metabolite differences help elucidate the conclusions and relevance: pathogenesis of psoriasis and psoriatic arthritis and they may provide insights for therapeutic development [12].
2	3.43	The levels of circulating amino acids are useful for monitoring both the severity of disease as well as therapeutic response to anti-TNF alpha treatment [13].
3	3	Some promising markers for psoriasis have been identified at the genome, transcriptome, proteome, and metabolome level [14].
4	3.68	To summarize recent developments in psoriasis epidemiology, pathogenesis, and genetics to better understand present trends in psoriasis management [1].
5	2.62	Psoriasis pathogenesis and the development of novel targeted immune therapies [15].
6	4.5	The elements of glycerophospholipid metabolism such as LPA, LysoPC, PA, PI, and PC were significantly altered in the plasma of psoriatic patients; this study characterizes the circulating lipids in psoriatic patients and provides [16].
7	3.29	The common strategies in metabolomics analysis, current findings in the metabolomics of psoriasis, and emerging trends in psoriatic metabolomics [17].
8	5.29	It appears that the glycolysis pathway and amino acid metabolic activity are increased in patients with psoriasis. These metabolic perturbations may stem from increased demand for protein biosynthesis and keratinocyte hyperproliferation [18].
9	4.32	We compared the targeted and non-targeted analysis results between the serum of patients with plaque psoriasis and the control group. The main differences lie in the concentrations of acylcarnitine, phosphatidylcholine, amino acids, urea, plant alcohols, and 1,11-undecanodi-carboxylic acid. The data from targeted analysis was used to establish a classification model for psoriasis. The results of this study provide an overview of the metabolomics serum profile of psoriasis and promising statistical models for monitoring the disease [19].
10	3.35	The results of our study revealed changes in lipid metabolism with enhancement of immune system-modulating mediators in psoriatic mononuclear cells. Evaluating further differential stress responses in Ps and PsA affecting lipid metabolism and immunity might be useful to improve the prevention and therapeutic treatments of psoriasis [20].
11	4.52	Psoriasis is an inflammatory skin disease, which is related to a variety of complications and seriously reduces the quality of life of patients. Local treatment is still the cornerstone of the treatment of mild psoriasis. Treatment progress of moderate and severe plaque psoriasis including inhibition of TNF- α, the biological agents of p40il-12/23, IL-17 and p19il-23, as well as oral phosphodiesterase 4 inhibitors [21].
12	2.8	Eighty one percent of the countries of the world lack information on the epidemiology of psoriasis. The disease occurs more frequently in adults than in children. Psoriasis is unequally distributed across geographical regions; it is more frequent in high income countries and in regions with older populations [22].

abnormalities and metabolic syndrome in psoriasis patients, officially opening up the research on psoriasis metabolomics [24,25]. Conversely, starting from 2019 and extending through 2023, there was a notable surge in the volume of publications, with an average annual publication of 46.6 papers. This rapid growth over the past 5 years indicates an explosive period of research in metabolomics in psoriasis, garnering increasing attention from scholars. In the latest published article, a series of studies have been conducted on the therapeutic effects of biological agents on psoriasis by affecting lipid metabolism, while mentioning the microbial community, which may become the next research hotspot [26–29].

China and the United States emerged as the top 2 countries in terms of publishing literature and establishing collaborations with other countries. China has a total link strength of 15, while the United States has 51. Among the top 10 research institutions, around 50 % are located in China. In addition, Denmark, Poland, Italy, Greece, and Canada all have 1 institution on the list. From the number of citations, the United States has 3 institutions ranked in the top 10, while Poland and China each have 2 institutions ranked in the top 10.

China, in particular, the number of publications and citations has been very active and has seen significant growth in recent years. Although China's BGI Shenzhen does not rank in the top 10 in terms of publication volume, its citation count ranks third, indicating that its published papers are of high quality and worthy of attention. It is worth noting that although the United States has the highest number of publications and citations, none of its institutions are in the top 10 in publications, suggesting a fragmented research landscape and a lack of deep involvement by any specific institution in this field. It is worth noting that the United States has cooperated with many Chinese institutions, such as Tongji University and Shanghai Jiao Tong University. Poland is ranked fifth in terms of the number of published literatures, but 2 institutions are ranked in the top 10 in citations, and these 2 institutions cooperate closely, indicating that these 2 institutions are leaders in this field of research in Poland. At the same time, among the top 10 authors in

Table 7
Top 20 keywords about psoriasis metabolomics research.

Rank	Keywords	Counts
1	psoriasis	168
2	inflammation	86
3	metabolomics	57
4	disease	52
5	expression	49
6	biomarker	45
7	rheumatoid arthritis	33
8	psoriatic arthritis	30
9	risk	28
10	skin	28
11	lipid metabolism	26
12	arthritis	24
13	association	23
14	atopic dermatitis	23
15	cells	23
16	obesity	22
17	metabolic syndrome	21
18	metabolism	21
19	pathogenesis	20
20	atherosclerosis	19

terms of publication volume, Poland has 5 authors on the list, indicating that research in this field is concentrated and in-depth, which is worth paying attention to. Meanwhile, the University of Rome Tor Vergata in Italy ranks 5th in terms of publication volume and 2nd in terms of citation volume, making it worth noting.

The International Journal of Molecular Sciences (IF = 6.2, Q2) emerged as the primary outlet for publishing research on metabolomics in psoriasis, indicating its current popularity in this field. Notably, Journal of the European Academy of Dermatology and Venereology (IF = 9.2, Q2) had the highest impact factor among the journals analyzed. It is evident that the co-cited journals mainly consisted of high-impact Q1 journals, emphasizing their quality and their contribution to the study of metabolomics in psoriasis.

In our author analysis, Skrzydlewska Elzbieta from the Institute of Medical University of Bialystok emerged as the most prolific author, focusing primarily on the relationship between lipid metabolism and psoriasis [30–33]. Baran Anna and Flisiak Iwona co-authored 8 papers, including one that explores the potential use of increased CETP concentration as a marker for liver side effects of acitretin treatment in psoriasis. They also highlighted the potential of SORT as an indicator of metabolically induced inflammation in psoriasis [34]. Additionally, 1 article and 2 reviews discussed the nature and role of all FABPs in psoriasis [35–37], while another article identified PCSK9 as a potential marker of psoriasis and a potential explanation for lipid disturbances [38]. One review discusses lipidomics in selected inflammatory skin diseases [39]. One article appears that elevated levels of ANGPTL8 may reduce the likelihood of atherogenic dyslipidemia in individuals with psoriasis, and treatment for psoriasis may impact the protective effects of ANGPTL8 [40,41].Overall, the research on metabolomics in psoriasis demonstrated strong collaboration among authors, often within distinct research teams. To make significant progress and enhance the clinical translation of research, it is important for researchers from different countries to strengthen their collaboration and engage in mutually beneficial partnerships that foster the exchange of technological innovation and expertise in various aspects of metabolomics and psoriasis.

Armstrong April W. (citations = 51) emerges as the most frequently cited author in the field of metabolomics in psoriasis, followed by Boehncke Wolf-Henning (citations = 50) and Gisondi Paolo (citations = 49). Armstrong April W. published a metabolomics study titled " Metabolomics in psoriatic disease: pilot study reveals metabolite differences in psoriasis and psoriatic arthritis" in 2014, which for the first time revealed differences in metabolites that could help elucidate the pathogenesis of psoriasis and psoriatic arthritis [12]. Armstrong April W. has published numerous high-quality reviews, providing a systematic review of the correlation between psoriasis and metabolic syndrome, obesity, smoking, cardiovascular disease [42–44], and summarizing the pathogenesis of oxidative stress [45], lipid metabolism [46], inflammation [47,48], and the research department. In 2014, Gisondi Paolo commenced research on various biological agents for psoriasis treatment [49–54]. In 2016, the focus shifted to investigating the effectiveness and safety of acitretin in children with plaque psoriasis [55]. The year 2018 saw Gisondi Paolo delve into exploring the relationship between psoriasis and metabolic syndrome [56]. During the same period, research on the use of biological agents in children was conducted [57,58]. Additionally, a review by Gisondi Paolo in 2018 emphasized the intricate interplay between immune cells and skin-resident keratinocytes in driving inflammatory and immune responses in psoriasis [59]. In 2020, Gisondi Paolo investigated the association between COVID-19 and psoriasis [60–65].

Co-cited references serve as the research foundation in a particular field, representing references cited together by multiple publications [66]. In this paper, we identified the top 10 co-cited references to establish the research basis of metabolomics in psoriasis. Notably, Kamleh, MA et al.'s paper (2015) from the Journal of Proteome Research (IF = 5.37), titled "LC-MS metabolomics of psoriasis patients reveals disease severity-dependent increases in circulating amino acids that are ameliorated by anti-TNF alpha treatment" garnered the highest number of citation in metabolomics research on psoriasis [13]. These references primarily focus on the role of glucose metabolism, lipid metabolism, amino acid metabolism, and nucleotide metabolism in psoriasis [12,67–69]. Additionally, 2 reviews provide comprehensive insights into psoriasis epidemiology, pathogenesis, genetics, and current trends in management [1,

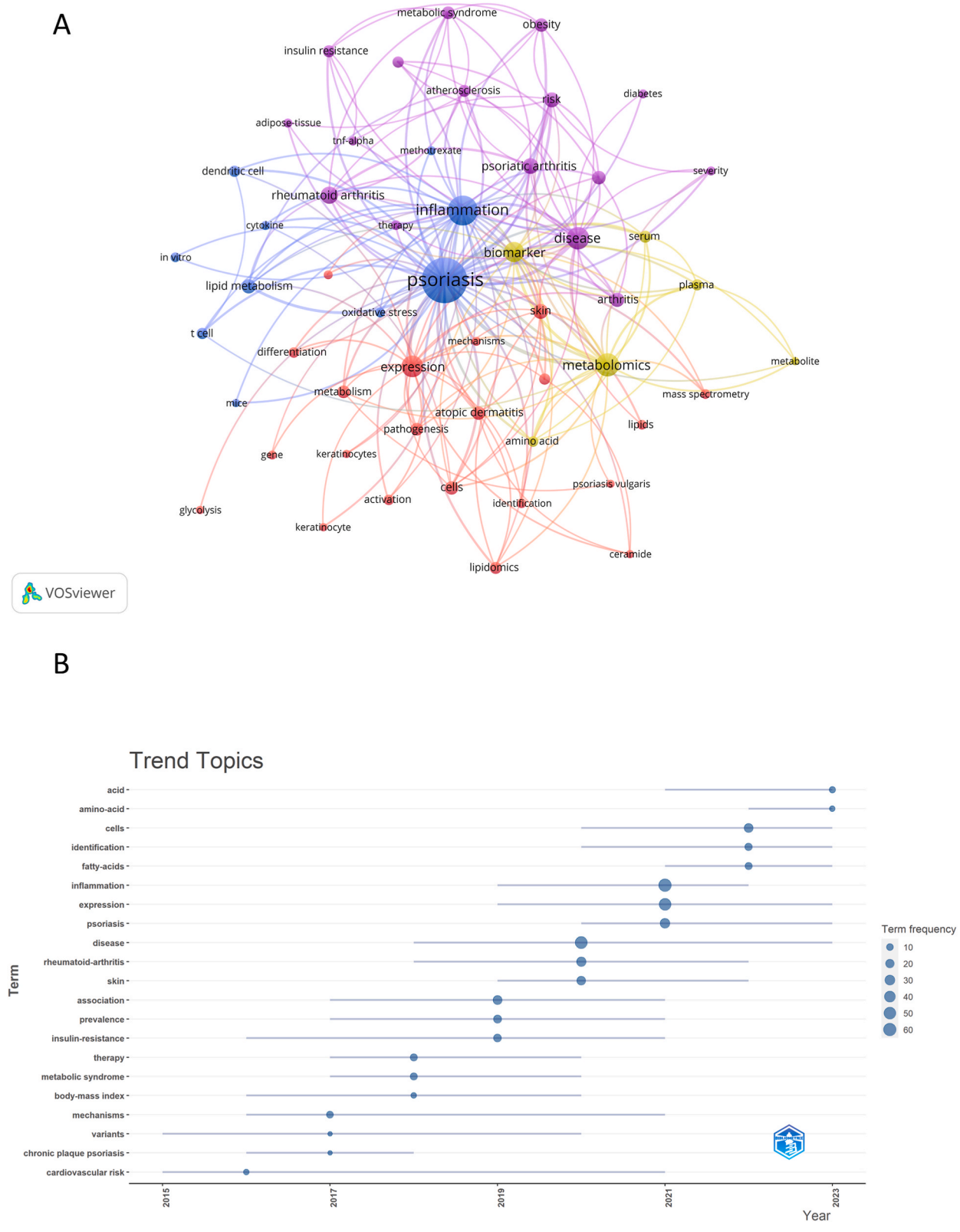

Fig. 7. The keywords analysis. (A)The cluster of keywords in the studies of metabolomics studies in psoriasis. (B)Annual trend chart of keywords changes.

70], while 1 paper underscores the pivotal role of the IL-23/IL-17 axis in psoriasis [71]. The influential papers in this field were published in both basic and clinical journals, indicating a favorable connection between fundamental and applied research in the study of metabolomics in psoriasis, facilitating rapid translation and suggesting a promising development pattern.

References that undergo citation bursts are indicative of emerging themes in a particular research area, as they have garnered considerable attention from researchers in recent years [72]. Analyzing the research content of these references with strong citation bursts (Table 6), we discovered that metabolomic analysis plays a crucial role in evaluating the similarities, differences, and efficacy of psoriasis and psoriatic arthritis through various samples such as blood, urine, and skin tissues. Besides the references exhibiting citation bursts, keywords also enable us to swiftly identify the distribution and evolution of research topics in the field of metabolomics in psoriasis. Apart from common keywords like psoriasis, psoriatic arthritis, metabolomics, and metabolism, Table 7 encompasses several notable keywords, including inflammation, biomarker, metabolic syndrome, obesity, atherosclerosis, rheumatoid arthritis, and arthritis. Through keywords analysis (Fig. 7), we can conclude that research on metabolomics in psoriasis primarily revolves around the following aspects: inflammation, lipid metabolism, biomarker, and metabolic syndrome.

This study possesses several distinct strengths. Firstly, it represents the first systematic analysis of metabolomics research in psoriasis using bibliometric techniques, offering comprehensive guidance to scholars interested in this field. Secondly, our survey utilized three bibliometric tools concurrently, including widely utilized tools like VOSviewer, CiteSpace and R package "bibliometrix", which enhances the objectivity of our data analysis process. Lastly, bibliometric analysis provides a more comprehensive understanding of hotspots and frontiers compared to traditional literature reviews.

Nevertheless, this study also exhibits certain limitations. Firstly, the data solely originates from the WoSCC database, potentially overlooking relevant studies present in other databases. Secondly, our focus on English-language publications may result in an underestimation of non-English papers. Furthermore, some recently published high-quality literature may be cited infrequently due to the short time of publication, which may lead to certain discrepancies between the research results and the real situation. As a result, more bibliometric data updates would be required to further clarify the scientific trends and hotspots in metabolomics in psoriasis research.

5. Conclusions

Metabolomics possesses significant research value and promising applications in the field of psoriasis. The increasing number of publications highlights the growing recognition of metabolomics research in psoriasis among scholars worldwide. China and the United States are leading in this area; however, there is a need to enhance cooperation and communication among countries and institutions. Examining the mechanism of metabolomics in the onset and progression of psoriasis provides valuable insights into the immune imbalance underlying the disease, aiding in the diagnosis process. Additionally, metabolomics offers distinct advantages over traditional drugs and cell therapy, making it a promising avenue for the precise treatment of psoriasis. It is crucial to emphasize not only basic research but also the translation of research findings into clinical applications, particularly the use of metabolomics in treating psoriasis patients. In conclusion, this study disseminates a comprehensive analysis of metabolomics in research on psoriasis, providing important information for investigators to formulate new diagnostic, therapeutic, and prognostic ideas or methods in psoriasis.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

If human and animal data used/analyzed in this study?

Not applicable.

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Data availability statement

All data generated during this research are included in this published article. The analysis during the study can be obtained from the corresponding author Feng Jiang on reasonable request.

CRediT authorship contribution statement

Lanfang Zhang: Formal analysis, Conceptualization. **Yuan Li:** Investigation. **Yan Zhang:** Resources. **Yuan Cai:** Validation. **Lin Li:** Visualization. **Lisheng Ying:** Conceptualization. **Qian Wang:** Methodology, Investigation. **Jie Hu:** Software. **Changsha Jia:** Project administration, Methodology. **Chuyan Wu:** Writing – review & editing. **Yunlei Bao:** Formal analysis. **Feng Jiang:** Writing – review & editing, Project administration. **Wen Yan:** Visualization, Project administration. **Ni Zeng:** Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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Appendix A. Supplementary data

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