

# A Bibliometric Analysis of Global Research Trends in Psoriasis and Metabolic Syndrome

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**Background:** Psoriasis is a frequent form of chronic inflammation in dermatology that is unmistakably linked to the metabolic syndrome (MetS) and its elements. This study was to explore the current status and new developments in the global research, and the holistic landscape of this field more intuitively through bibliometric analysis of scientific output and activity.

**Methods:** Publications regarding psoriasis and MetS were searched and chosen from the database of the Web of Science Core Collection. Excel 2019, VOSviewer, and CiteSpace software were utilized to conduct bibliometric analysis.

**Results:** There were 1096 publications included. The scientific outputs in this field had increased from 2004 to 2022, and the expansion could continue in the following years. The United States contributed the most publications (241, 21.99%) and had the most citation frequency (13,489 times). The University of California System was the most productive affiliation. Girolomoni G., Armstrong A.W., Gisondi P. and Gelfand J.M. were key and influential researchers. *Journal of the European Academy of Dermatology and Venereology* published the greatest number of articles (65 articles). By analyzing keyword frequency and clustering, we have identified the following areas of research interest and frontiers: prevalence, risk, association, gene expression, waist circumference, adipose tissue inflammation, vascular inflammation, cardiovascular disease, psoriatic arthritis, and fibrosis.

**Conclusion:** This bibliometric analysis elucidates research domain of psoriasis and MetS, portraying present hotspots and future emerging trends. This field has generated significant interest and displays potential for further growth. The United States has made distinguished contributions, and currently dominates this field.

**Keywords:** psoriasis, metabolic syndrome, gene expression, vascular, inflammation

## Introduction

Psoriasis is an immunologically mediated refractory inflammatory skin condition with multisystemic consequences.<sup>1-3</sup> Recent studies strongly indicate a positive relationship between psoriasis and metabolic syndrome (MetS).<sup>1,4</sup> MetS is a condition characterized by enhanced inflammatory cytokine activity and a pro-inflammatory state. It is an umbrella term for a group of conditions that includes insulin resistance, obesity, type 2 diabetes, hypertension, and dyslipidemia.<sup>1,4</sup> Increasing observational studies have repeatedly confirmed strong associations between psoriasis and MetS and its components. The incidence of MetS among individuals afflicted with psoriasis is between 20% and 50%, with psoriasis patients having at least twice the risk of developing metabolic syndrome compared to non-psoriatic individuals.<sup>1</sup> Emerging evidence indicates that psoriasis and MetS have a common genetic background, multiple metabolic risk factors, and pathogenic pathways. In the Chinese Han population, psoriasis vulgaris and MetS might share overlapping susceptible genes.<sup>5</sup> The correlation between psoriasis and MetS is of significant clinical importance. Certain conventional systemic treatments should be administered with caution in psoriatic individuals with MetS due to their potential adverse effects on coexisting metabolic conditions, especially with prolonged use. As a consequence, it is essential for dermatologists to provide recommendations.

Recently, the association between psoriasis and MetS has gained substantial attention, with numerous related achievements being published. However, few efforts have been made to comprehensively and systematically assess the global scientific outputs and current status in this area. Therefore, we integrated two visualization tools into a fitting visualization method to examine the worldwide state, focal areas of research, and pioneering tendencies in this domain.

Bibliometrics has the capabilities to quantitatively and objectively analyze scientific outputs on a particular topic and visualize the field's development and emerging trends over time.<sup>6-8</sup> It usually takes advantage of visualization tools such as VOSviewer, HistCite, and CiteSpace for creating knowledge network maps through mathematical and statistical methods.<sup>6,9,10</sup> Thus, researchers can evaluate scientific outputs qualitatively and quantitatively, thereby tracing research developments, and exploring emerging hotspots. Researchers from various research fields have adopted it as an auxiliary research method.<sup>8,10-13</sup> However, a bibliometric analysis of research on psoriasis and MetS has not yet been performed.

This study aims to comprehensively and systematically evaluate the research on psoriasis and MetS. Our aim was to estimate the pattern of publication for global research in this field. Moreover, we sought to evaluate the international collaboration of authors, affiliations and countries. Additionally, we analyzed the research hotspots and emerging trends in this field.

## Materials and Methods

### Data Source and Search Strategy

We conducted a literature search for the Science Citation Index-Expanded (SCIE) of Web of Science Core Collection (WoSCC) database. The search was performed by two independent authors who used the search strategy: Topic=(psoria\*) AND Topic=(Metabolic Syndrome). To prevent any deviations caused by database updates, data was retrieved on February 8, 2023, within a single day.

### Inclusion and Exclusion Criteria

Only original articles and reviews related to psoriasis and MetS written in English language were included. Since the first article about psoriasis and MetS in SCIE database was detected in 2014. Thus, the timespan was set from 2004 to 2022. We excluded studies written in non-English, and all other source types including meeting abstracts, letters, early accesses, editorial materials, proceedings papers, corrections and retracted publications.

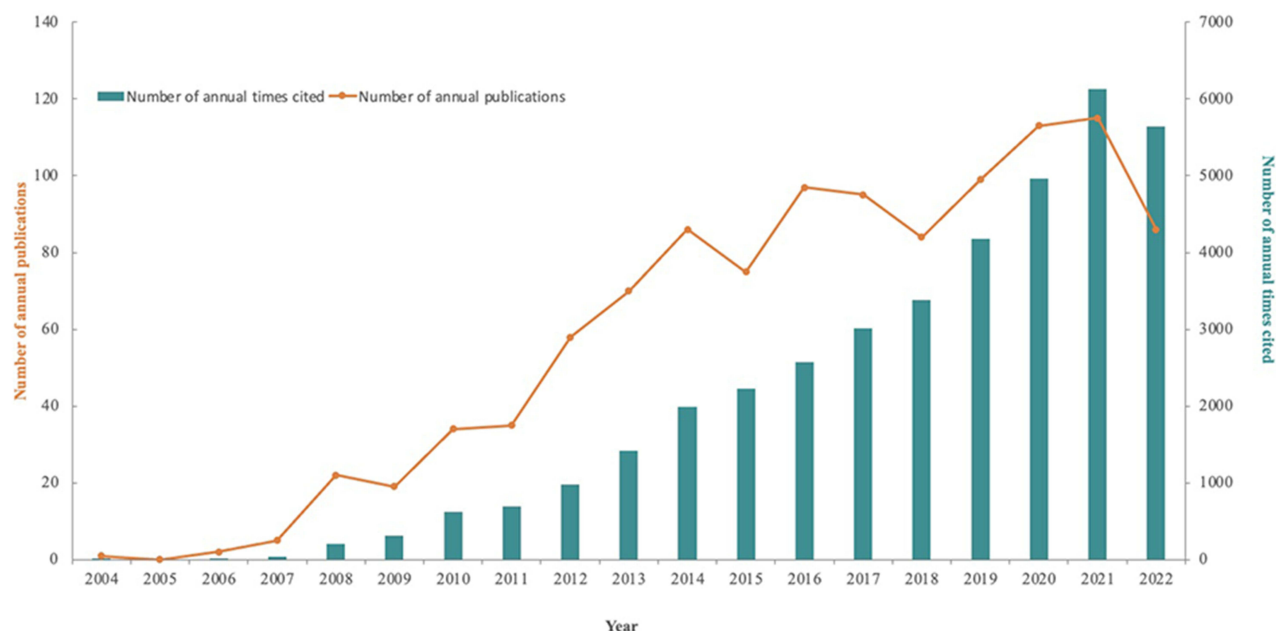
### Data Acquisition and Visualized Analysis

The full records of all results were exported in TXT format. Subsequently, various variables such as the annual output amount, average citations per item, Impact Factor (IF), and Journal Citation Reports (JCR) categories were calculated. Technical abbreviations shall be explained upon first use. Network visualization maps of co-authorship, citation and co-citation, and keyword co-occurrence were built using VOSviewer<sup>6</sup> (Version 1.6.17). CiteSpace<sup>14</sup> (Version 6.1.R6) was utilized to construct a visual co-occurrence network. This includes the detection of a citation-burst analysis of keywords and references.

## Results

### Trends in the Output of Publications and Citations

A total of 1096 publications about psoriasis and MetS were retrieved from the SCIE of WoSCC database, comprising 797 articles and 299 reviews. The annual literature output was below 100, except in 2020 and 2021. Notably, from 2004 to 2007, publication output was exceptionally low, signaling a research hiatus during that period. From 2008 to 2022, there was an overall increase in the yearly publication volume, reflecting increasing research interest. While the number of publications on psoriasis and MetS fluctuated, an overall upward trend was observed. In contrast, the annual total citations of articles have been rapidly rising since 2004. The total number of citations was 38,555, with an average of 35.18 citations per item (Figure 1).



**Figure 1** Trends in the annual number of outputs and the annual total citations of articles.

## Contributions of Countries/Regions

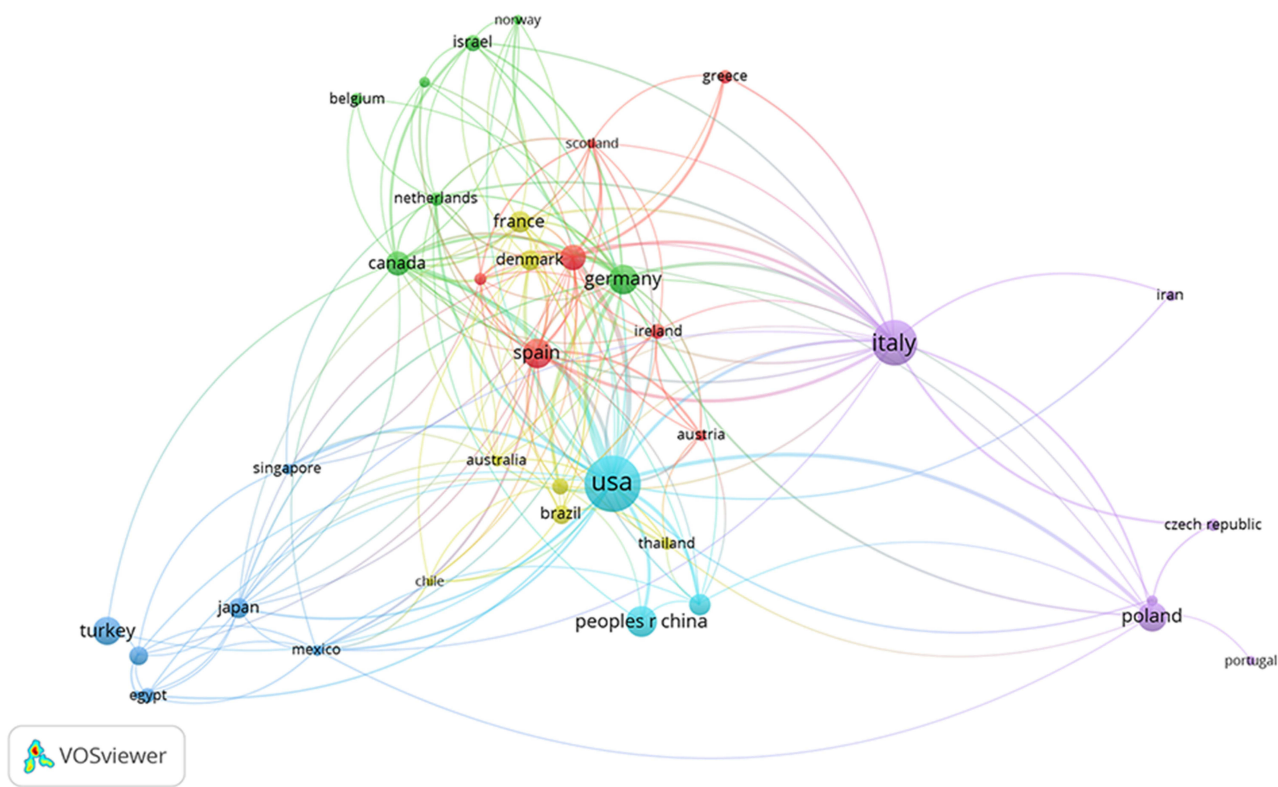
Seventy-three countries/regions have contributed to the study of psoriasis and MetS. Table 1 shows the top 10 most productive countries and regions in their outputs on the subject, with the United States leading at 21.99% (241/1096) of the overall publication numbers, followed by Italy at 14.69% (161/1096) and China at 6.66% (73/1096). The United States also had the most citations (13,489) and the highest H-index (63). Figure 2 illustrates the close collaboration between these countries/regions, highlighting the United States' extensive collaborations with countries such as Germany, England, and Canada.

## Contributions of Affiliations

From the 1096 publications, 1698 affiliations were identified. The United States represented a significant share of the research network. The University of California System led in publication volume, closely followed by the University of Naples Federico II and Harvard University. The University of Pennsylvania and the University of California System achieved the highest average citations per article and H-index, respectively. For further details, refer to Table 2.

**Table 1** The Top 10 Productive Countries/Regions for Publishing Research on Psoriasis and MetS

| Rank | Countries/<br>Regions | Article<br>Counts | Percentage<br>(n/1096) | H-Index | Total<br>Citations | Average Article<br>Citations |
|------|-----------------------|-------------------|------------------------|---------|--------------------|------------------------------|
| 1    | United States         | 241               | 21.99%                 | 63      | 13,489             | 55.97                        |
| 2    | Italy                 | 161               | 14.69%                 | 40      | 5837               | 36.25                        |
| 3    | China                 | 73                | 6.66%                  | 17      | 934                | 12.79                        |
| 4    | Spain                 | 70                | 6.39%                  | 24      | 2065               | 29.50                        |
| 5    | Germany               | 68                | 6.20%                  | 29      | 4846               | 71.26                        |
| 6    | Poland                | 67                | 6.11%                  | 18      | 1001               | 14.94                        |
| 7    | Turkey                | 63                | 5.75%                  | 18      | 835                | 13.25                        |
| 8    | England               | 51                | 4.65%                  | 28      | 3427               | 67.20                        |
| 9    | Canada                | 45                | 4.11%                  | 24      | 2450               | 54.44                        |
| 10   | Taiwan                | 38                | 3.47%                  | 18      | 1399               | 36.82                        |



**Figure 2** International collaboration map of research on psoriasis and MetS generated by VOSviewer.

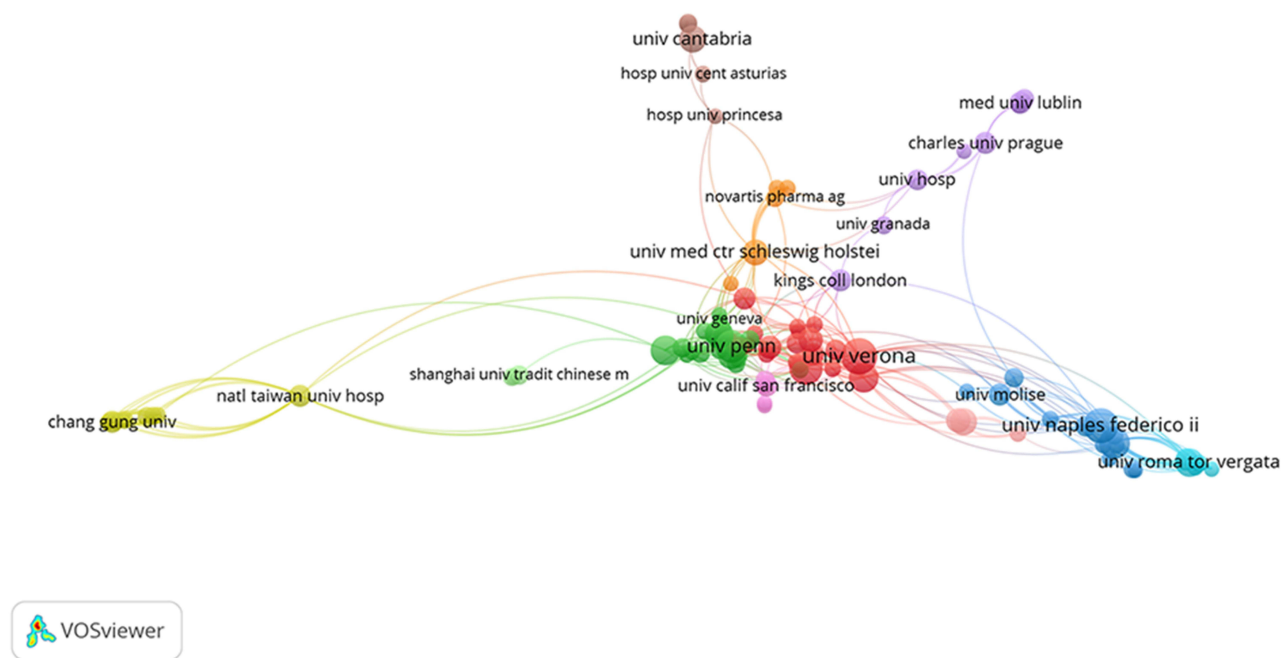
VOSviewer was used to generate a network visualization map for affiliations’ collaboration. We visualized affiliations with a minimum of 5 publications. **Figure 3** reveals the collaboration map among 109 affiliations, represented by 109 nodes. The affiliations were organized into ten clusters of various colors, and there was considerable coordination between the affiliations, particularly those inside the same cluster.

Authors and Co-Authorship

The psoriasis and MetS papers included work from 5039 authors in total. There were 171 articles (15.60%) produced by the top 10 most active writers. Among them, five were from the United States, four were from Italy, and the remaining author was from Portugal. Girolomoni G. from University of Verona contributed the most articles (22 articles), followed

**Table 2** The Top 10 Productive Affiliations Ranked by the Numbers of Publications

| Rank | Affiliations                     | Countries     | Article Counts | H-Index | Total Citations | Average Citations per Article |
|------|----------------------------------|---------------|----------------|---------|-----------------|-------------------------------|
| 1    | University of California System  | United States | 46             | 26      | 3045            | 66.20                         |
| 2    | University of Naples Federico II | Italy         | 38             | 21      | 1178            | 31.00                         |
| 3    | Harvard University               | United States | 32             | 20      | 1920            | 60.00                         |
| 4    | University of Verona             | Italy         | 30             | 21      | 2458            | 81.93                         |
| 5    | University of Copenhagen         | Denmark       | 29             | 16      | 1044            | 36.00                         |
| 6    | University of Pennsylvania       | United States | 26             | 20      | 3428            | 131.85                        |
| 7    | Medical University of Bialystok  | Poland        | 25             | 10      | 327             | 13.08                         |
| 8    | Harvard Medical School           | United States | 22             | 15      | 1410            | 64.09                         |
| 9    | University of Toronto            | Canada        | 22             | 15      | 1326            | 60.27                         |
| 10   | University of California Davis   | United States | 20             | 17      | 1688            | 84.40                         |

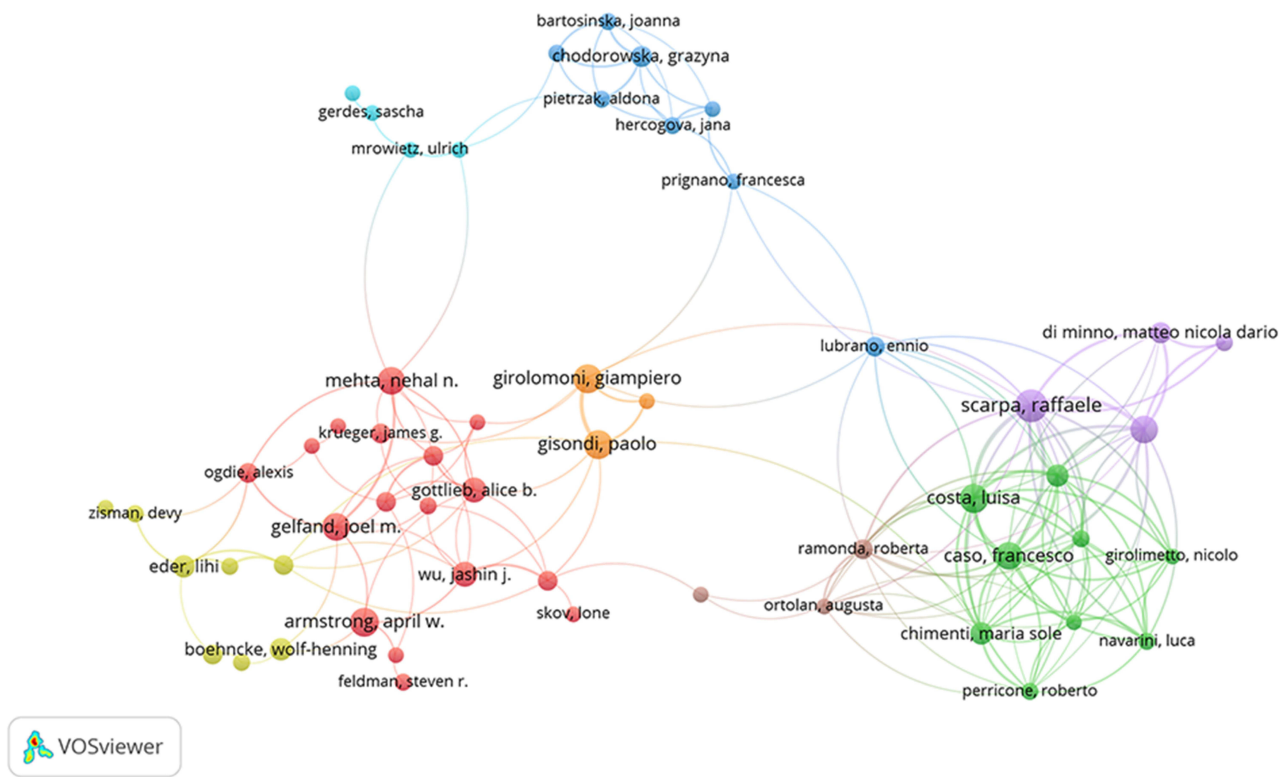


**Figure 3** The affiliations' collaboration network visualization map generated by VOSviewer.

by Armstrong A.W. from University of Southern California with 21 articles, and Gisondi P. from University of Verona with 19 articles. Regarding the total citations, Gelfand J.M. (2958 times) from University of Pennsylvania ranked first, followed by Girolomoni G. (2101 times) from University of Verona and Gisondi P. (1776 times) from University of Verona. See Table 3 for details. As displayed in Figure 4, Scarpa R., Caso F., and Gelfand J.M. were located at a central position of the cooperating clusters in the cooperative network map of authors. The prolific authors engaged in active collaboration.

**Table 3** The Top 10 Most Productive Authors in Publications on Psoriasis and MetS

| Rank | Author         | Count | H-Index | Total Citations | Countries     | Institutions   |
|------|----------------|-------|---------|-----------------|---------------|--|
| 1    | Girolomoni G.  | 22    | 17      | 2101            | Italy         | Sections of Dermatology and Venereology, Department of Medicine, University of Verona                                      |
| 2    | Armstrong A.W. | 21    | 16      | 1676            | United States | University of Southern California, Los Angeles   |
| 3    | Gisondi P.     | 19    | 18      | 1776            | Italy         | Sections of Dermatology and Venereology, Department of Medicine, University of Verona                                      |
| 4    | Gelfand J.M.   | 18    | 14      | 2958            | United States | Dermatology and the Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania                         |
| 5    | J.J. Wu        | 17    | 9       | 834             | United States | Department of Dermatology, University of Miami Miller School of Medicine, Miami, FL, USA                                   |
| 6    | Costa L.       | 16    | 11      | 377             | Portugal      | Rheumatology Unit, Department of Clinical Medicine and Surgery, University Federico II                                     |
| 7    | Caso F.        | 15    | 10      | 363             | Italy         | Rheumatology Unit, Department of Clinical Medicine and Surgery, University Federico II                                     |
| 8    | Peluso R.      | 15    | 12      | 471             | Italy         | Rheumatology Unit, Department of Clinical Medicine and Surgery, University Federico II                                     |
| 9    | Mehta N.N.     | 14    | 14      | 1581            | United States | Section of Inflammation and Cardiometabolic Diseases, National Heart, Lung and Blood Institute, Bethesda, Maryland (Mehta) |
| 10   | Gottlieb A.B.  | 14    | 11      | 1002            | United States | Department of Dermatology at New York Medical College, Valhalla  |



**Figure 4** The authors' collaboration network visualization map generated by VOSviewer.

Journals and Co-Cited Journals

Two hundred and ninety-five scholarly journals published papers concerning psoriasis and MetS. Table 4 presents the leading 10 active journals by publication quantity in ranked order. Four of these journals were from the United States and two came from England, and the others were from Poland, Sweden, Japan, and Germany. These journals published 303 articles, taking up 27.65% of all the publications. There were 9 journals with at least 20 publications, of which *Journal of the European Academy of Dermatology and Venereology* (IF 2022=9.228) published the largest number of articles (65, 6.28%), followed by *British Journal of Dermatology* (IF 2022=11.113) and *Journal of the American Academy of Dermatology* (IF 2022=15.487). The *British Journal of Dermatology* attained the highest value of H-index (33), and *Journal of the American Academy of Dermatology* had the highest IF (IF 2022=15.487) and largest number of total citations (3956 times).

**Table 4** The Top 10 Journals of Research on Psoriasis and MetS Ranked by Publication Outputs

| Rank | Journal   | Count | IF 2022 | JCR 2022 | H-Index | Total Citations |
|------|---|-------|---------|----------|---------|-----------------|
| 1    | Journal of the European Academy Dermatology and Venereology (England) | 65    | 9.228   | Q1       | 29      | 2494            |
| 2    | British Journal of Dermatology (England)                              | 48    | 11.113  | Q1       | 33      | 3461            |
| 3    | Journal of the American Academy of Dermatology (United States)        | 41    | 15.487  | Q1       | 28      | 3956            |
| 4    | Postepy Dermatologii i Alergologii (Poland)                           | 25    | 1.664   | Q4       | 9       | 239             |
| 5    | Journal of Dermatological Treatment (Sweden)                          | 23    | 3.230   | Q2       | 11      | 446             |
| 6    | Journal of Dermatology (Japan)  | 22    | 3.468   | Q2       | 15      | 618             |
| 7    | Archives of Dermatological Research (Germany)                         | 21    | 3.033   | Q2       | 14      | 951             |
| 8    | International Journal of Dermatology (United States)                  | 20    | 3.204   | Q2       | 13      | 396             |
| 9    | International Journal of Molecular Sciences (United States)           | 20    | 6.208   | Q1       | 10      | 526             |
| 10   | Dermatologic Therapy (United States)                                  | 18    | 3.858   | Q2       | 8       | 368             |

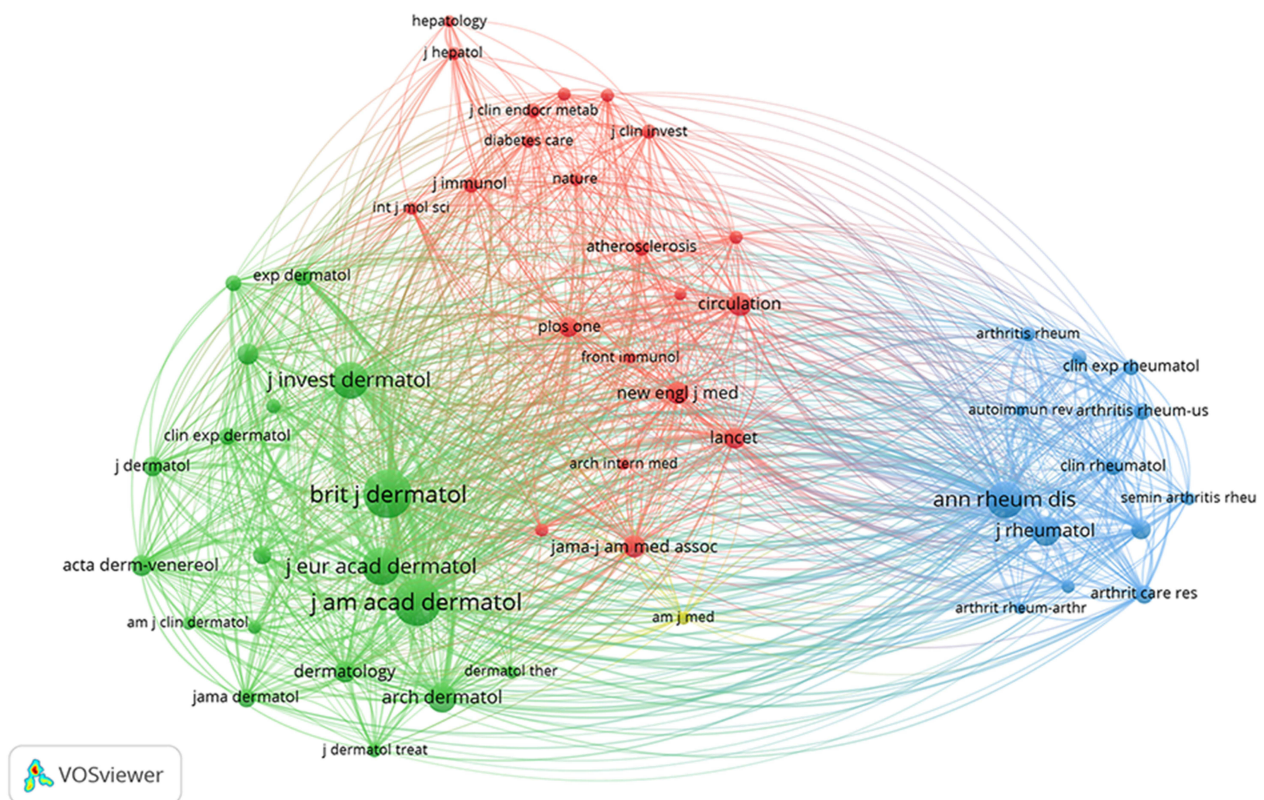


Co-citation exists when two journals are cited by one or more works simultaneously. Journal influence is measured by the number of co-occurrences, which indicates whether the journal is significantly influential in a particular field of research.<sup>8</sup> Of the 4464 co-cited scholarly journals, seven had co-citations exceeding 1000, of which four were published in England, two in the United States and one in Canada. The *British Journal of Dermatology* obtained the highest amount of co-citations (n=3591, IF 2022=11.113), followed by the *Journal of the American Academy of Dermatology* (n=3377, IF 2022=15.487) and the *Journal of the European Academy of Dermatology and Venereology* (n=2149, IF 2022=9.228). Only journals with co-citations greater or equal to 200 (54/4464, 1.21%) were included in the co-citation network (Figure 5). *British Journal of Dermatology* and *Journal of the American Academy of Dermatology* exhibited larger bubbles caused by greater co-citations. Additionally, *British Journal of Dermatology* showed active co-citation relationships with *Journal of the American Academy of Dermatology* and *Journal of the European Academy of Dermatology and Venereology*.

## Top Cited Publications and References Bursts

Table 5 presents the 10 most cited original articles on psoriasis and MetS.<sup>15–24</sup> Notably, *Journal of the American Academy of Dermatology*, *Archives of Dermatological Research* and *British Journal of Dermatology* have an important impact on researchers and academics in this field. The study authored by Neimann et al,<sup>15</sup> published in *Journal of the American Academy of Dermatology*, has the highest number of citations with 739 to date. Table 6 lists the top 10 co-cited references,<sup>15–18,22,25–29</sup> each with more than 100 citations and at least 115 co-citations.

References with high-frequency citations of related research within a specific period are known as “citations bursts”. In this study, we utilized the CiteSpace software to analyze the 25 references with the most frequent citation bursts. The time interval is represented by the blue line segment in Figure 6,<sup>1,2,15–18,22,24–41</sup> and the red line segment indicates the time frame during which the references were actively co-cited. Sixty-four percent of the top 25 references experienced citation surges from 2009 to 2019, suggesting significant interest in the study of psoriasis and MetS, which may continue to grow. Notably, the most recent citation bursts were detected in 2018 and 2019 indicating continued interest in the topic.



**Figure 5** The journal co-citation network visualization map generated by VOSviewer.

**Table 5** The Top 10 Highly Cited Articles About Psoriasis and MetS

| Title  | Journal  | IF 2022 | Year | Citations |
|--|--|---------|------|-----------|
| Prevalence of cardiovascular risk factors in patients with psoriasis <sup>15</sup>   | Journal of the American Academy of Dermatology         | 15.487  | 2006 | 739       |
| Increased prevalence of the metabolic syndrome in patients with moderate to severe psoriasis <sup>16</sup>   | Archives of Dermatological Research                    | 3.033   | 2006 | 477       |
| Prevalence of metabolic syndrome in patients with psoriasis: a hospital-based case-control study <sup>17</sup>   | British Journal of Dermatology                         | 11.113  | 2007 | 468       |
| Prevalence of Metabolic Syndrome in Patients with Psoriasis: A Population-Based Study in the United Kingdom <sup>18</sup>  | Journal of Investigative Dermatology                   | 7.590   | 2012 | 303       |
| Epidemiology and comorbidities of psoriasis patients in a national database in Taiwan <sup>19</sup>  | Journal of Dermatological Science                      | 5.408   | 2011 | 220       |
| Co-morbidity and Age-related Prevalence of Psoriasis: Analysis of Health Insurance Data in Germany <sup>20</sup>   | Acta Dermato-Venereologica                             | 3.875   | 2010 | 215       |
| Weight loss improves the response of obese patients with moderate-to-severe chronic plaque psoriasis to low-dose cyclosporine therapy: a randomized, controlled, investigator-blinded clinical trial <sup>21</sup> | American Journal of Clinical Nutrition                 | 8.472   | 2008 | 208       |
| Prevalence of the Metabolic Syndrome in Psoriasis Results From the National Health and Nutrition Examination Survey, 2003–2006 <sup>22</sup>   | Archives of Dermatology (Now renamed JAMA Dermatology) | 11.816  | 2011 | 207       |
| Obesity and the risk of psoriatic arthritis: a population-based study <sup>23</sup>  | Annals of the Rheumatic Diseases                       | 27.973  | 2012 | 189       |
| Psoriasis and the risk of diabetes and hypertension – A prospective Study of US female nurses <sup>24</sup>  | Archives of Dermatology                                | 11.816  | 2009 | 185       |

**Table 6** The Top 10 Co-Cited References on Psoriasis and MetS

| Rank | Co-Cited Reference  | Citations |
|------|---|-----------|
| 1    | Gelfand Joel M, et al (2006). Journal of the American Medical Association, V296, P1735. <sup>25</sup>     | 287       |
| 2    | Gisondi P, et al (2007). British Journal of Dermatology, V157, P68. <sup>17</sup>                         | 245       |
| 3    | Sommer Dorothea M, et al (2006). Archives of Dermatological Research, V298, P321. <sup>16</sup>           | 225       |
| 4    | Neimann Andrea L, et al (2006). Journal of the American Academy of Dermatology, V55, P829. <sup>15</sup>  | 224       |
| 5    | Langan Sinéad M, et al (2012). Journal of Investigative Dermatology, V132, P556. <sup>18</sup>            | 174       |
| 6    | Love Thorvardur Jon, et al (2011). Archives of Dermatology, V147, P419. <sup>22</sup>                     | 135       |
| 7    | Armstrong April W, et al (2013). Journal of the American Academy of Dermatology, V68, P654. <sup>26</sup> | 125       |
| 8    | Naldi Luigi, et al, (2005). Journal of Investigative Dermatology, V125, P61. <sup>27</sup>                | 118       |
| 9    | Boehacke Wolf-Henning, et al (2011). Experimental Dermatology, V20, P303. <sup>28</sup>                   | 115       |
| 10   | Davidovici Batya B, et al (2010). Journal of Investigative Dermatology, V130, P1785. <sup>29</sup>        | 115       |

# Analysis of Research Hotspots

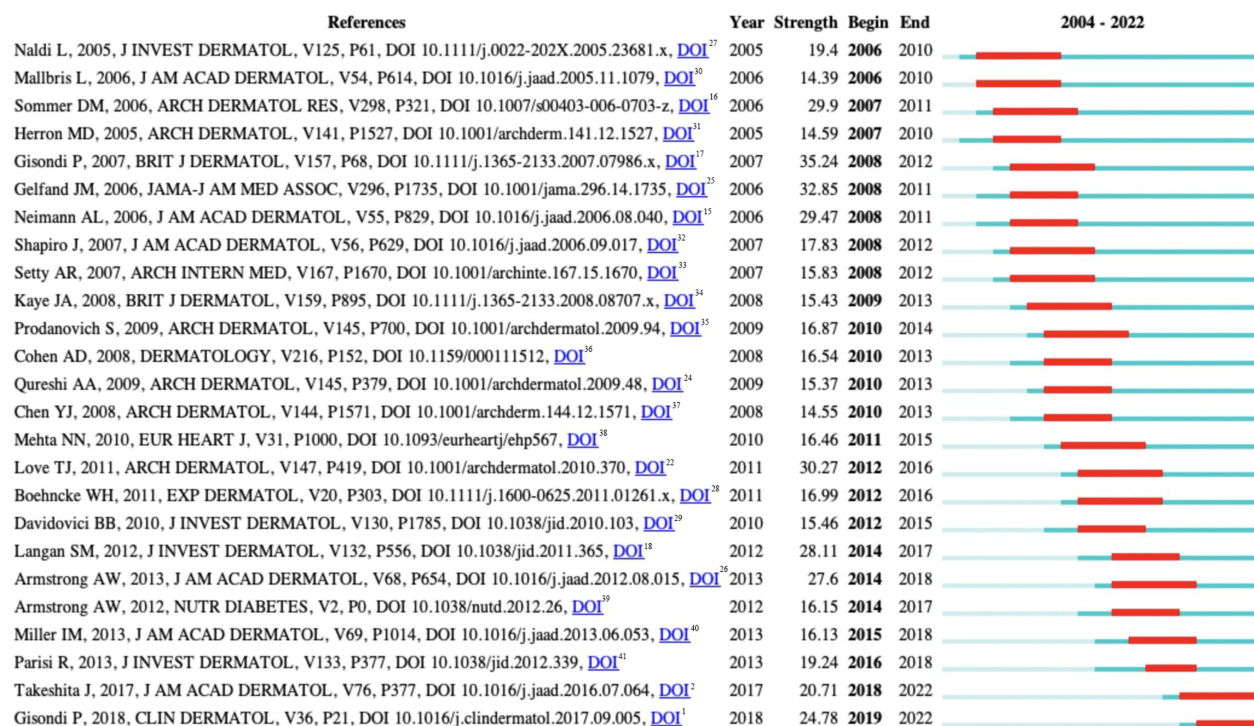
Keywords are the essence and concentration of publications, reflecting the focus of a certain research field. According to high-frequency keywords, keyword co-occurrence analysis and keyword clusters analysis, scholars could explore the current status, development, and major trends of various research hotspots in the field. Similarly, keywords with the strongest citation burst can also predict the potential frontiers in the study of psoriasis and MetS.

Table 7 displays the top 10 high-frequency keywords by CiteSpace software, including “metabolic syndrome”, “prevalence”, “disease”, “rheumatoid arthritis”, “risk”, “association”, “cardiovascular disease (CVD)”, “risk factor”, “psoriatic arthritis (PsA)”, and “myocardial infarction”. The author keyword co-occurrence analysis is illustrated in Figure 7A. Each circle, color-coded, represents the mean year in which the keyword appeared. Each circle with various size represents the frequency of the keyword occurrence. The separation between any two circles denotes the connection between them, and the thickness of the connecting line denotes the strength of the connection.

The use of CiteSpace software to identify strong keyword bursts has significant implications for exploring emerging trends and hotspots over time. Notably, keywords with strong citation bursts during specific periods were identified, including “waist



### Top 25 References with the Strongest Citation Bursts

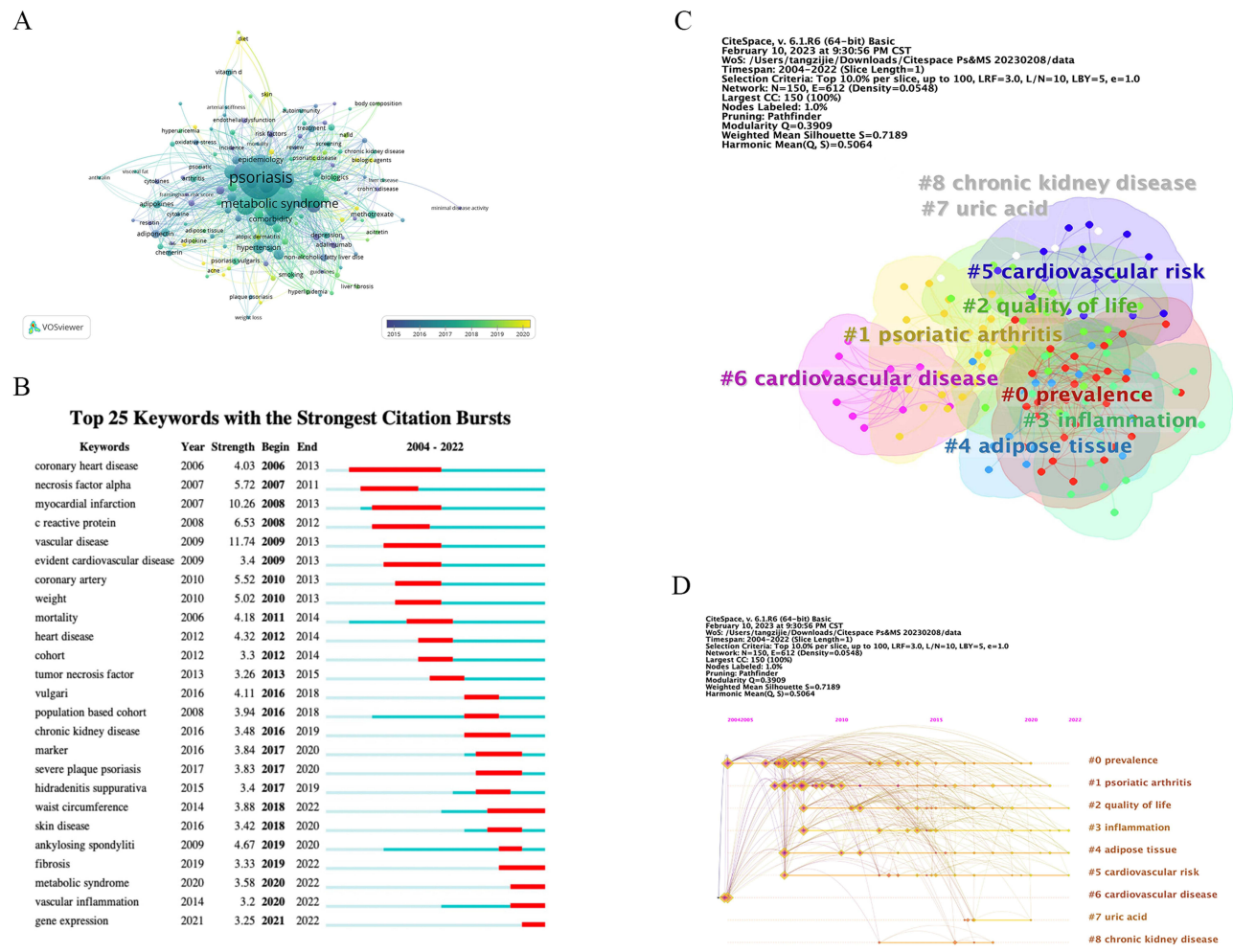


**Figure 6** The top 25 references with the strongest citation bursts generated by CiteSpace software.<sup>1,2,15-18,22,24-40</sup>

circumference" (2018–2022), "fibrosis" (2019–2022), "vascular inflammation" (2020–2022), "metabolic syndrome" (2020–2022), and "gene expression" (2020–2022). The citation bursts continue to the present time (see Figure 7B). This indicates that these research topics have been attracting enormous attention recently and have the possibility to become new research focuses in the coming years. Figure 7C presents keyword clusters analysis of research on psoriasis and MetS from 2004 to 2022. We obtained 8 clusters, mainly including cluster #0 prevalence, #1 psoriatic arthritis, #2 quality of life, #3 inflammation, #4 adipose tissue, #5 cardiovascular risk, and #6 cardiovascular disease. Moreover, we performed the timeline view of keyword clusters. As shown in Figure 7D, 4 clustering groups are the most concerned research hotspots, including cluster #2 quality of life, #3 inflammation, #4 adipose tissue, #5 cardiovascular risk.

**Table 7** The Top 10 High-Frequency Keywords on Research of Psoriasis and MetS from 2004 to 2022

| Rank | Keyword                | Frequency | Centrality |
|------|------------------------|-----------|------------|
| 1    | Metabolic syndrome     | 697       | 0.17       |
| 2    | Prevalence             | 309       | 0.04       |
| 3    | Disease                | 218       | 0.08       |
| 4    | Rheumatoid arthritis   | 211       | 0.17       |
| 5    | Risk                   | 203       | 0.06       |
| 6    | Association            | 192       | 0.06       |
| 7    | Cardiovascular disease | 191       | 0.18       |
| 8    | Risk factor            | 165       | 0.06       |
| 9    | Psoriatic arthritis    | 148       | 0.11       |
| 10   | Myocardial infarction  | 146       | 0.08       |



**Figure 7** Analysis of keywords. (A) The overlay visualization map of keywords related to psoriasis and MetS generated by VOSviewer software; (B) The top 25 keywords with the strongest citation bursts of publications generated by CiteSpace software; (C) Keyword clusters analysis generated by CiteSpace software; (D) The timeline view of keyword clusters generated by CiteSpace software.

By combining the keyword frequency and keyword clustering analyses, we were able to identify the following research frontiers and hotspots (see Table 7 and Figure 7): prevalence, risk, association, gene expression, waist circumference, adipose tissue, inflammation, vascular inflammation, cardiovascular disease, psoriatic arthritis, and fibrosis.

## Discussion

### General Information

In this era of information explosion, managing knowledge efficiently is a constant challenge for scientific researchers. This study aims to provide an innovative approach to the management of knowledge and the visualization of knowledge structures. Our article presents the latest bibliometric visualization of worldwide research on psoriasis and MetS. This is the first-ever study to take advantage of bibliometric indicators and visualization tools to analyze the current status, development, and major trends in research on psoriasis and MetS in an intuitive and informative way.

The annual number of publications in a research field can be a significant indicator to reveal the productivity and evolution of the topic over the years and can also indicate the research focus of this field. As shown in Figure 1, the development of research on psoriasis and MetS from 2004 to 2022 showed an overall rapid increase trend with small fluctuations. Specifically, the extremely small amount of publications from 2004 to 2008 demonstrates that this research remained in its infancy, whereas the annual number of publications exhibited a rapid growth in 2008 and related progress was dramatic. Since that time, the yearly number of scientific outputs has sustained a significant level. The sum of

citations a paper garners showcases its extent of influence and dissemination, hence possibly indicating its standard. Based on the citation analysis (Figure 1), the annual total citations of articles have been rapidly increasing since 2004. On the basis of current trends, we believe that this field will flourish in the future.

Among countries/regions, the United States and Italy were the most prolific countries, with an overwhelmingly greater amount of papers than any other country/region. Moreover, the United States had the highest number of citations and achieved the highest H-index, indicating its absolute advantage in this field. Remarkably, the United States and countries such as Germany, England and Canada engaged in relatively active scientific collaborations. Besides, half of the top 10 productive affiliations belonged to the USA. This result suggests that establishing top-tier scientific research affiliations is a crucial cornerstone for enhancing the standing of the country's academic institutions.

The top 10 most productive authors predominantly hailed from the United States and Italy. Girolomoni G. from the University of Verona produced the most scientific outputs, with Armstrong A.W. from the University of Southern California and Gisondi P. from the University of Verona following closely behind. Regarding the total citations, Gelfand J.M. from the University of Pennsylvania ranked first, followed by Girolomoni G. and Gisondi P. Thus, we can conclude that Girolomoni G., Armstrong A.W., Gisondi P., and Gelfand J.M. are key researchers and have exerted considerable leadership influence on this area. As a result, these authors and their teams are more likely to make remarkable achievements and contribute further crucial publications related to psoriasis and MetS. Therefore, leading researchers from renowned institutions may be suitable candidates for scientific collaboration due to the possible funding priority.

Additionally, of the top 10 journals presented in Table 4, *Journal of the European Academy of Dermatology and Venereology*, *British Journal of Dermatology*, and *Journal of the American Academy of Dermatology* may be the core journals of research on psoriasis and MetS. Among the top 10 journals, only two journals (*Journal of the American Academy of Dermatology*, IF 2022=15.487; *British Journal of Dermatology*, IF 2022=11.113) had an IF higher than 10.0. Two of the journals, including *Journal of the European Academy of Dermatology and Venereology* (IF 2022=9.228), and *International Journal of Molecular Sciences* (IF 2022=6.208) had an IF between 5.0 and 10.0. These results indicate that it is a challenge to publish articles about psoriasis and MetS in high-IF journals.

From the perspective of references, "references with citation bursts" was a helpful method to follow emerging trends of corresponding research. The term denotes the frequent citations of relevant research during a specific timeframe. This indicates significant interest in scientific publications, revealing the dynamic changes and current trends within the field. Sixty-four percent of the references had citation bursts from 2009 to 2019. The latest sources displaying citation surges were identified in 2018 and 2019, and these surges persist. This is due to two publications in *Journal of the American Academy of Dermatology* by Takeshita et al<sup>2</sup> and in *Clinics in Dermatology* by Gisondi et al,<sup>1</sup> which deserve further attention.

## The Hotspots and Frontiers

### Close Association of Psoriasis and MetS

Psoriasis is closely related to the clinical characteristics of MetS, such as insulin resistance, obesity, type 2 diabetes, hypertension, atherosclerotic dyslipidemia, and non-alcoholic fatty liver disease. Increasing observational studies have repeatedly confirmed the strong associations of psoriasis with MetS and its components. Between 20% and 50% of psoriatic patients have MetS, and those who have psoriasis are at least twice as likely to develop MetS as non-psoriatic controls.<sup>1</sup> MetS has the potential to significantly impede the quality of life for psoriatic patients.

There are various hypotheses proposing reasons for the higher risk of psoriasis in MetS patients, including genetic predisposition, multiple metabolic risk factors, and pathogenic mechanisms.<sup>1</sup> One widely accepted hypothesis suggests that increased inflammation marker levels in MetS lead to an increased risk of psoriasis. Both psoriasis and MetS share the same inflammatory pathways, including T helper (Th)-17-mediated or Th-1-mediated inflammatory pathways.<sup>29</sup> The pathological mechanisms of both psoriasis and impaired lipid regulation involve many other similar cytokines.<sup>42,43</sup> Moreover, patients with central obesity possess an excess of adipose tissue that secretes adipokines, initiating the chronic inflammation processes of psoriasis.<sup>44</sup> An additional hypothesis proposes that psoriasis and MetS share genetic loci. There could be shared susceptibility genes for psoriasis vulgaris and MetS among the Chinese Han population.<sup>5</sup> Nevertheless, several studies have shown no genetic links between the two diseases.<sup>45–48</sup>

It is yet to be established which components of MetS are potential risk factors for psoriasis. Previous studies have reported positive associations of all MetS components with psoriasis risk.<sup>49–51</sup> However, several robust recent studies pointed to abdominal obesity and dyslipidemia as the primary MetS components that strongly correlate with psoriasis risk. In contrast, there was no significant association between blood pressure and fasting glucose levels with the risk of psoriasis.<sup>1,22,52–56</sup> Most recently, Lee et al<sup>57</sup> discovered that waist circumference had the strongest association with psoriasis, followed by high-density lipoprotein (HDL) and triglyceride levels. They found no significant association between fasting glucose and psoriasis risk. Notably, blood pressure was linked to lower risk in the MetS group.<sup>57</sup>

The relationship between MetS and the severity of psoriasis has been disputed. Numerous clinical studies reveal that patients with psoriasis and MetS are more severe compared to those without MetS. A team of Japanese researchers found markedly elevated psoriasis area severity index (PASI) in the psoriatic group with MetS in comparison to those in the non-MetS group, implying a close association between MetS and the severity of psoriasis.<sup>58</sup> Furthermore, the study suggests that MetS may exacerbate or worsen the pathological process of psoriasis.<sup>58</sup> A systematic review of 3791 psoriasis patients demonstrated an increased incidence of MetS with the worsening of psoriasis.<sup>59</sup> Patients experiencing severe plaque psoriasis were more prone to MetS than those with mild psoriasis. Huang et al<sup>60</sup> investigated 399 individuals with chronic plaque psoriasis from Taiwan and found that the increase in body mass index (BMI) was linearly correlated with the severity of psoriasis, and obesity had a more pronounced effect on the severity of psoriasis in male patients. In addition, C-reactive protein (CRP) can be adopted as a marker to evaluate the severity of psoriasis, and its level of patients with MetS is higher than that of those without MetS, providing further evidence for the link between MetS and the severity of psoriasis.<sup>29</sup>

Nevertheless, some studies have shown no correlation between MetS and the severity of psoriasis. The prevalence of MetS and the severity of psoriasis did not correlate, according to a cross-sectional research of 244 psoriasis patients.<sup>49</sup> A retrospective study conducted on 86 Chinese patients with erythrodermic psoriasis revealed a greater incidence of metabolic syndrome components, such as abdominal obesity, hypertension, and dyslipidemia, among those suffering from the condition.<sup>61</sup> However, there was no difference in the incidence of hyperglycemia.<sup>61</sup> Interestingly, the study found no correlation between the severity of erythrodermic psoriasis and the prevalence of MetS.<sup>61</sup> A case-control study conducted in Thailand reported that there was no significant variation in the severity of psoriasis between the MetS group and the non-MetS group in Southeast Asia.<sup>62</sup>

An increasing number of studies have substantiated that psoriasis is not merely an inflammation of the skin, but also affects the whole-body system.<sup>63</sup> CRP is a classic biomarker for identifying systemic inflammation.<sup>64–66</sup> Studies have found that CRP levels in individuals with psoriasis are higher than in the healthy population, and its levels are directly proportionate to the severity of skin lesions.<sup>67</sup> Furthermore, patients with arthropathic psoriasis exhibited higher levels of CRP than those with skin psoriasis alone.<sup>68</sup> This indicates an increased systemic inflammation level when psoriasis affects other tissues or organs.

### Cardiovascular Disease and Psoriasis

Recently, the association of psoriasis with CVD has aroused considerable attention. The association between psoriasis and CVD has been verified through numerous clinical trials.<sup>69</sup> Furthermore, the elevated risk of CVD positively correlates with the severity of psoriasis. The mechanism may be due to the systemic inflammatory response that occurs in psoriasis which induces insulin resistance, damages endothelial cells, and ultimately leads to CVD, a process that Boehncke refers to as the “psoriatic march”.<sup>28</sup> Psoriasis and CVD share similar pathogeneses, involving common genetic factors, insulin resistance, oxidative stress, lipid metabolism, vascular endothelial cell dysfunction, and inflammatory pathways such as tumour necrosis factor (TNF) - $\alpha$  and interleukin (IL)-23/Th-17 pathways.<sup>69,70</sup> Concerning the genetic background, polymorphisms of the IL-23 gene are associated with the development or progression of CVD, whereas the polymorphisms of IL-12 and IL-17 gene are not.<sup>71</sup>

The visceral adipose tissue can release several adipokines (resistin, leptin, and visfatin), cytokines (TNF- $\alpha$ , IL-6, and IL-8), and chemokines (monocyte chemoattractant protein 1, MCP-1), which encourage atherosclerosis.<sup>72</sup> Enhanced resistin and leptin levels activate inflammatory cytokines, thereby initiating and organizing vascular inflammation.<sup>73</sup> Further research has shown that IL-17 has been linked to collagen deposition, fibrosis, and atherosclerosis.<sup>74</sup> As a result,



it is hypothesized that by targeting inflammatory pathways or cytokines, biologics could potentially benefit psoriatic patients with CVD. These findings are supported by studies which report that Secukinumab, a biological treatment, has the potential to improve flow-mediated dilation and endothelial function, ultimately resulting in a protective effect for psoriatic individuals with CVD.<sup>75</sup>

Recent research indicates that erythrodermic psoriasis is frequently associated with cardiovascular disease.<sup>61</sup> Metabolic syndrome, abdominal adiposity, and hypertension independently predict erythrodermic psoriasis, and their presence can lead to the development of cardiovascular disease.<sup>61</sup> Therefore, active intervention to manage these cardiovascular risk factors is recommended for the management of erythrodermic psoriasis.<sup>61</sup> There is limited research on whether psoriatic individuals with MetS have a higher risk of CVD compared to those without MetS. A study conducted in Spain found that psoriatic patients with MetS had an elevated risk of CVD.<sup>76</sup> Therefore, clinicians should monitor the CVD risk in psoriatic patients with MetS while treating psoriasis. Additionally, systemic inflammation of both psoriasis and MetS should be inhibited to prevent the development of CVD.

### Psoriatic Arthritis and Metabolic Syndrome

Compared to the general population and other autoimmune diseases, patients with PsA have a higher risk and prevalence of MetS and its related components.<sup>77–80</sup> PsA patients are prone to metabolic syndrome and insulin resistance.<sup>81</sup> Approximately 40.6%–44% of patients with PsA have MetS.<sup>81–83</sup> Furthermore, patients with PsA have a high prevalence of obesity, hypertension, diabetes, hyperlipidemia, and CVD, which was about 30%–37%, 33.6%–38.7%, 11.5%–13.6%, 17.5%–20.7%, and 3.2%–7.5%, respectively.<sup>83</sup> A recent study has shown that high prevalence of MetS in PsA correlates with the severity of PsA.<sup>84</sup>

The common pathogenesis of PsA and MetS has not been fully elucidated. A chronic pro-inflammatory state and white adipose tissue (WAT) are supposed to explain the potential interconnections between them. WAT releases a large amount of adipokines that have synergistic effect on PsA inflammation and metabolic state.<sup>85,86</sup> Pro-inflammatory cytokines including TNF- $\alpha$ , IL-6 and IL-17 are elevated in skin, peripheral blood, fluid and synovial membrane of PsA patients.<sup>87</sup> These mediators induce insulin resistance.

Leptin is a representative adipokine involved in MetS as well in PsA pathogenesis.<sup>86</sup> The plasma concentrations of leptin show positive correlations with body fat mass.<sup>86</sup> Previous studies have found that leptin levels are higher in PsA patients than in non-PsA individuals.<sup>88–91</sup> Resistin can induce insulin resistance.<sup>92</sup> Elevated levels of resistin and visfatin have been found in PsA patients.<sup>93,94</sup> Although serum levels of resistin, adiponectin, and visfatin are found higher in PsA patients, its pathophysiological implications have to be explored with more extensive studies. Therefore, it is necessary for dermatologists to screen, comprehensively evaluate, and closely monitor MetS and its components of psoriatic patients. Researchers could delve deeper into the link of psoriatic arthritis with pathogenetic aspects of MetS.

### Liver Fibrosis in Psoriasis and MetS

A recent study has shown that nearly 10% of patients with psoriasis are highly susceptible to advanced liver fibrosis, whereas 78% fall under the low-risk category.<sup>95</sup> Moreover, metabolic syndrome (MetS) and its components, such as hypertension, dyslipidemia, and diabetes mellitus, are significant risk factors for liver fibrosis. It is worth noting that disease-related factors such as severe psoriasis and PsA did not exhibit a statistically significant correlation with liver fibrosis, which was surprising. Previous research has indicated an association between non-alcoholic fatty liver disease (NAFLD) and the development of liver fibrosis in individuals with psoriasis.<sup>95,96</sup> Ortolan et al<sup>97</sup> discovered that insulin resistance was the principal determinant of liver fibrosis, with PsA not proving to be a significant predictor. Methotrexate (MTX)-induced liver fibrosis is reported to be rare. Thus, MetS and its risk factors, including insulin resistance, could be a greater risk factor for liver fibrosis than the use of MTX.<sup>98</sup>

The close relationship between MetS or its components and NAFLD among psoriasis patients suggests that local and systemic pro-inflammatory/anti-inflammatory cytokine imbalance are pathogenic mechanisms shared by them.<sup>99</sup> These cytokines include IL-1, IL-6, IL-17 and TNF- $\alpha$  and they can act locally on the epidermis and dermis by disrupting the proliferation and differentiation of keratinocytes, thus forming psoriatic plaques.<sup>100,101</sup> However, they may also play a systemic role and cause insulin resistance and other inflammatory mediators involved in NAFLD with metabolic



dysfunction. To be specific, IL-17 can promote the activation of hepatic stellate cells to produce collagen, which is central to the development of liver fibrosis.<sup>102</sup> IL-17 blockade has been shown in mouse models to restore insulin sensitivity and prevents NAFLD inflammation.<sup>103</sup> Besides, genetic ablation of the IL-17A receptor also alleviates NAFLD.<sup>103</sup> Due to the impact of NAFLD on psoriasis, recommendations for managing psoriasis comorbidities, including MetS and NAFLD, were published recently.<sup>104,105</sup>

### The Holistic Approach to Psoriasis Patients with MetS

This study explores the potential for advancements in the research of psoriasis and MetS, highlighting the complex connection between the two conditions. Therefore, it is crucial to take a holistic approach when treating patients who have both psoriasis and MetS. This approach prioritizes the patient's needs and treats them as a whole person rather than a collection of separate conditions.<sup>106</sup> Additionally, Camela et al<sup>107</sup> found that co-morbidities associated with psoriasis can restrict the selection of suitable treatments, but effective drugs targeting disorders with co-morbid pathological pathways can overcome this challenge. Patients with psoriasis and metabolic syndrome can be treated with co-medications for both conditions, reducing the need for multiple medications and potential drug interactions.

## Strengths and Limitations

This study offers a systematic and comprehensive analysis of worldwide research on psoriasis and MetS through bibliometric methods. The analysis explores the current status, progress, hotspots, and frontiers in the field. Using visualized mapping, this study presents the holistic landscape of this field intuitively, facilitating managing knowledge structure effectively, especially for new academic researchers. To ensure comprehensive assessment, we adopt two visualization tools for analysis from various aspects. All the data came from SCIE of WoSCC database, one of the most comprehensive databases of scientific outputs, ensuring the consistency of the analytical data and the quality of the analysis. And almost all the articles of high quality were included. Moreover, our analysis revealed the scientific research capability of various authors, affiliations and countries, and even collaborative partnerships among them, thereby serving as a guidance for further study and potential collaboration.

However, our study inevitably has several limitations. Firstly, the data retrieval on psoriasis and MetS publications was completed within a single day, and the data were restricted to the period 2004 to 2022. Because we take into account that the database updates continuously and some literatures may be retracted afterwards. Besides, CiteSpace software has a limited analysis of time span. Thus, most recent findings were not included in this research. Secondly, our data was only obtained from SCIE of WoSCC database, considering the limited capabilities of the analysis software. As a result, publications in other databases may have been omitted. This may lead to potentially incomplete analytical data. Thirdly, publications only written in English were included in this study. Hence, it is possible that significant accomplishments published in other languages have not been considered. All mentioned above could incur deviations of bibliometric analysis from actual publications to varying degrees. Nevertheless, we believe that the vast majority of scientific outputs relating to psoriasis and MetS have been incorporated in this research, and the deviations are slight and considered acceptable, making the conclusions not be changed.

## Conclusions

This bibliometric study reveals the knowledge domain of research on psoriasis and MetS, showcasing current hotspots and emerging trends. Research on psoriasis and MetS has received extensive interest. Based on the current global trends, scientific outputs in this field will be on the rise and may flourish in the future. The United States has made tremendous progress, and actually, dominated in this research area. Further attention will be paid to vascular inflammation, cardiovascular disease, psoriatic arthritis and liver fibrosis. Especially, the pathogenic mechanism shared by psoriasis and MetS, including gene expression and adipose tissue, may be the emerging popular topics in the research of psoriasis and MetS.

## Abbreviations

MetS, metabolic syndrome; SCIE, science citation index expanded; WoSCC, web of science core collection; IF, impact factor; JCR, journal citation reports; CVD, cardiovascular disease; PsA, psoriatic arthritis; Th, T helper; HDL, high-

density lipoprotein; PASI, psoriasis area severity index; BMI, body mass index; CRP, C-reaction protein; TNF, tumour necrosis factor; IL, interleukin; MCP-1, monocyte chemoattractant protein 1; WAT, white adipose tissue; NAFLD, non-alcoholic fatty liver disease; MTX, methotrexate.

## Data Sharing Statement

The data used to support the findings in this study can be made available by the corresponding authors Rui Wang and Cheng-xin Li, without undue reservation.

## Ethics Approval and Consent to Participate

This article does not contain any studies with human participants or animals performed by any of the authors.

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## Disclosure

The authors report no conflicts of interest in this work.

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