Trends in adipokine-related studies in cardiovascular disease: A bibliometric analysis from 2002 to 2024

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ABSTRACT

Introduction: Adipokines are bioactive proteins secreted by adipose tissue and are increasingly recognised for their role in obesity, inflammation, metabolic dysfunction, and cardiovascular disease (CVD). As research on adipokines and CVD has expanded over the past two decades, bibliometric analysis provides an important approach for mapping publication trends, research hotspots, citation patterns, and international collaboration. This study aimed to analyse global research trends related to adipokines and cardiovascular disease from 2002 to 2024.

Materials and Methods: A bibliometric analysis was conducted using publications retrieved from the Scopus database. Publications were identified using predefined search terms related to adipokines and cardiovascular disease. Bibliometric indicators included publication trends, author keywords, citation patterns, country contributions, and international collaboration. The retrieved data were analysed using Biblioshiny and VOSviewer version 1.6.16 to visualise bibliometric networks and research patterns.

Results: A total of 1,283 documents from 602 sources were included in the analysis. Annual publication output increased substantially from 2002 and peaked around 2013–2014. Keyword analysis identified obesity, adiponectin, leptin, inflammation, and metabolic dysfunction as dominant research themes associated with cardiovascular disease. Citation analysis demonstrated several highly influential publications related to adipokines and cardiometabolic disorders. The United States contributed the largest publication output, citation impact, and international collaboration within the field.

Conclusion: Research on adipokines and cardiovascular disease has expanded substantially over the past two decades, with major thematic emphasis on obesity, metabolic dysfunction, and inflammatory pathways. This bibliometric analysis provides a comprehensive overview of the intellectual structure and global research landscape in this field. The findings may help identify future research priorities related to adipokines as potential biomarkers, preventive targets, and therapeutic approaches in cardiovascular disease.

KEYWORDS:
Adipokines; bibliometrics; cardiovascular disease

INTRODUCTION

Obesity has become a global pandemic contributing substantially to the increasing prevalence of cardiometabolic diseases worldwide.[1-2] Obesity is strongly associated with cardiovascular disease (CVD) through multiple mechanisms, including haemodynamic alterations, insulin resistance, hypertension, dyslipidaemia, and adipose tissue dysfunction.[3]

Adipose tissue functions as an active endocrine organ that secretes cytokines, hormones, growth factors, and adipokines involved in metabolic and inflammatory regulation.[4] In obesity, adipose tissue dysfunction alters adipokine secretion and promotes chronic low-grade inflammation, oxidative stress, endothelial dysfunction, and vascular homeostasis impairment.[5] Several pro-inflammatory adipokines, including leptin, resistin, visfatin, RBP4, IL-6, and FABP-4, have been associated with cardiovascular pathogenesis.[6-7] In contrast, anti-inflammatory adipokines such as adiponectin, FGF-21, and GDF-15 may exert cardioprotective effects.[8-9] These findings indicate that adipokines play an important role in linking obesity with cardiovascular disease.[10]

Given the complexity and growing body of research on adipokines, obesity, and cardiovascular disease (CVD), bibliometric analysis provides a useful approach for mapping the development of this research field. Unlike systematic reviews, which are primarily intended to synthesise evidence related to specific clinical questions, bibliometric analyses evaluate publication trends, citation patterns, collaboration networks, keyword structures, and the intellectual evolution of a scientific field. This approach is therefore useful for identifying dominant themes, emerging

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research hotspots, knowledge gaps, and future research directions.

Bibliometric studies are increasingly used to evaluate scientific productivity and research development through quantitative and visual mapping techniques. These analyses help researchers identify influential publications, leading countries, collaborative networks, and thematic structures within a particular field.[11-12] Although bibliometric analysis does not directly assess clinical effectiveness, it provides important insights into the evolution of adipokine-related cardiovascular research and may support future studies on biomarkers, risk stratification, prevention, and therapeutic targets for cardiometabolic disease. To date, however, no comprehensive bibliometric study has systematically mapped the global research landscape linking adipokines and cardiovascular disease over the past two decades. Therefore, this study aimed to analyse global research trends, citation patterns, keyword structures, and country contributions related to adipokines and cardiovascular disease from 2002 to 2024.

MATERIALS AND METHODS

Study design

This study employed a bibliometric analysis to evaluate global research trends related to adipokines and cardiovascular disease from 2002 to 2024. Bibliometric analysis is a quantitative approach used to examine publication trends, citation structures, research collaboration, and thematic development within a scientific field. The reporting structure of this study was adapted from published bibliometric methodological recommendations and reporting guidelines.[12]

Data source and search strategy

Publications were retrieved from the Scopus database (SciVerse Scopus; Elsevier), which is widely used in bibliometric studies because of its extensive journal coverage and citation indexing features.[13] The database search was conducted on August 2nd 2024. The search strategy used keywords related to adipokines and cardiovascular disease within the title, abstract, and keyword fields. (TITLE-ABS-KEY (cardiovascular disease) AND TITLE-ABS-KEY (adipokines)) AND (LIMIT-TO (SUBJAREA, "MEDI")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (EXACTKEYWORD, "Adipokines")) AND PUBYEAR > 2001 AND PUBYEAR < 2025. Only documents indexed in Scopus during the study period were included in the analysis.

Eligibility Criteria and Document Selection

Documents were included if they met the following criteria: (1) indexed in the Scopus database; (2) published between 2002 and 2024; (3) written in English; (4) classified as journal articles; (5) categorised within the Medicine subject area; and (6) retrieved using the predefined title, abstract, and keyword search strategy related to adipokines and cardiovascular disease. Documents were excluded if they were not indexed in Scopus, were published outside the study period, were not written in English, were not classified as journal articles, were outside the Medicine subject area, or did not match the predefined Scopus search filters.

The document selection process was conducted using Scopus-based bibliometric filtering rather than manual clinical eligibility screening. After applying the predefined search query and database filters, the final dataset was exported from Scopus and used for bibliometric analysis. Therefore, the screening process was based on database indexing fields, search terms, document type, subject area, language, and publication year, consistent with bibliometric methodology and reporting recommendations.

Bibliometric indicators and data analysis

The bibliometric indicators analysed in this study included: (1) document type and publication language; (2) annual publication trends; (3) author keyword occurrence and co-occurrence patterns; (4) citation analysis and highly cited documents; (5) the ten most cited countries; and (6) international collaboration patterns. Citation data were obtained directly from the Scopus database, including total citation counts for individual publications. Country-level publication output and citation metrics were also retrieved from Scopus by analysing annual publication and citation distributions across countries. Bibliometric analysis and visualisation were performed using VOSviewer version 1.6.16. and Biblioshiny interface in RStudio.[14-15] These software programs were used to generate and visualise bibliometric networks, including keyword co-occurrence, citation relationships, and collaboration patterns.

RESULTS

General bibliometric characteristics

Figure I summarises the general characteristics of the bibliometric dataset related to adipokines and cardiovascular disease. A total of 1,283 documents published between 2002 and 2024 from 602 sources were included in the analysis. The dataset involved 7,121 authors, with an average of 7.06 co-authors per document and an international co-authorship rate of 17.15%. The annual publication growth rate was 3.2%, with an average citation count of 34.78 citations per document. A total of 1,887 author keywords and 55,700 references were identified across the included publications.

Publication development trend

Figure 2 presents the annual publication trends related to adipokines and cardiovascular disease between 2002 and 2024. Publication output increased substantially from 2005 onward and reached a peak around 2013–2014, with approximately 120 publications per year. After this period, publication activity gradually declined with moderate fluctuations. The lower publication counts observed in recent years may partially reflect incomplete database indexing for 2024.

Most author keywords

Figure 3 illustrates the keyword co-occurrence network generated using VOSviewer. Five thematic clusters were identified, representing major research areas related to adipokines and cardiovascular disease. The largest clusters were associated with obesity, metabolic disorders, inflammation, disease pathogenesis, biomarkers, and cardiovascular risk factors. These findings demonstrate that adipokine-related cardiovascular research is closely interconnected with obesity-associated metabolic and inflammatory pathways.

Table I: Top 10 Most Cited Publications Related to Adipokines and Cardiovascular Disease

Authors	Years	Journal	PubMed Identifier	Total Citations	Total Citations per Year
Waschki et al	2011	Chest	21273294	746	53.29
Adams et al	2017	Gut	28314735	740	92.50
Goralski et al	2007	J Biol Chem	17635925	694	38.56
Brien et al	2011	Bmj	21343206	576	41.14
Neeland et al	2012	J Am Med Assoc	22990274	481	37.00
Venteclef et al	2015	Eur Heart J	23525094	410	41.00
Bruun et al	2006	Am J Physiol Endocrinol Metab	16352667	352	18.53
Trayhurn et al	2008	Br J Nutr	18397542	351	20.65
Fantuzzi et al	2008	J Allergy Clin Immunol	18061654	343	20.18
Christiansen et al	2005	Int J Obes	15520826	340	17.00

Fig. 1: General bibliometric characteristics of publications related to adipokines and cardiovascular disease from 2002 to 2024. The figure summarises the main dataset indicators, including publication output, sources, authorship, collaboration patterns, references, and citation metrics

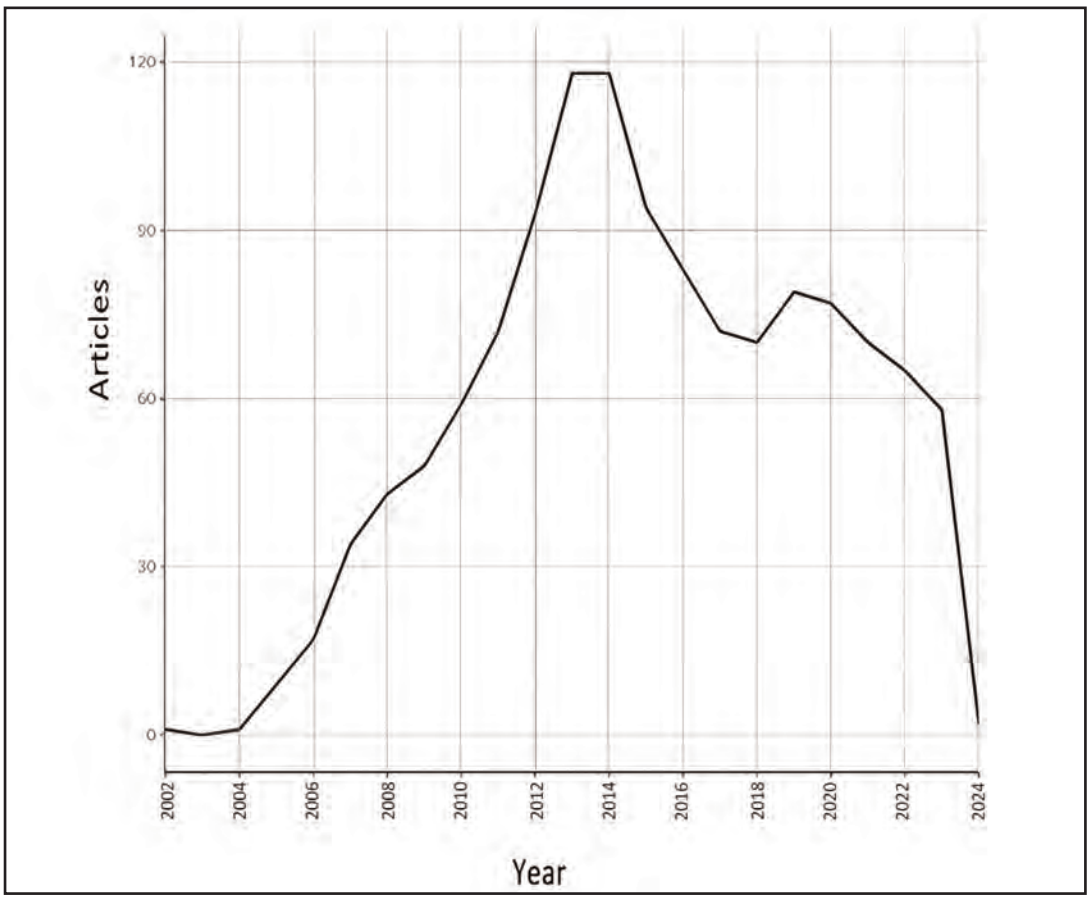

Fig. 2: Annual publication trends of studies related to adipokines and cardiovascular disease from 2002 to 2024. Publication output increased markedly after 2005 and reached its peak around 2013–2014

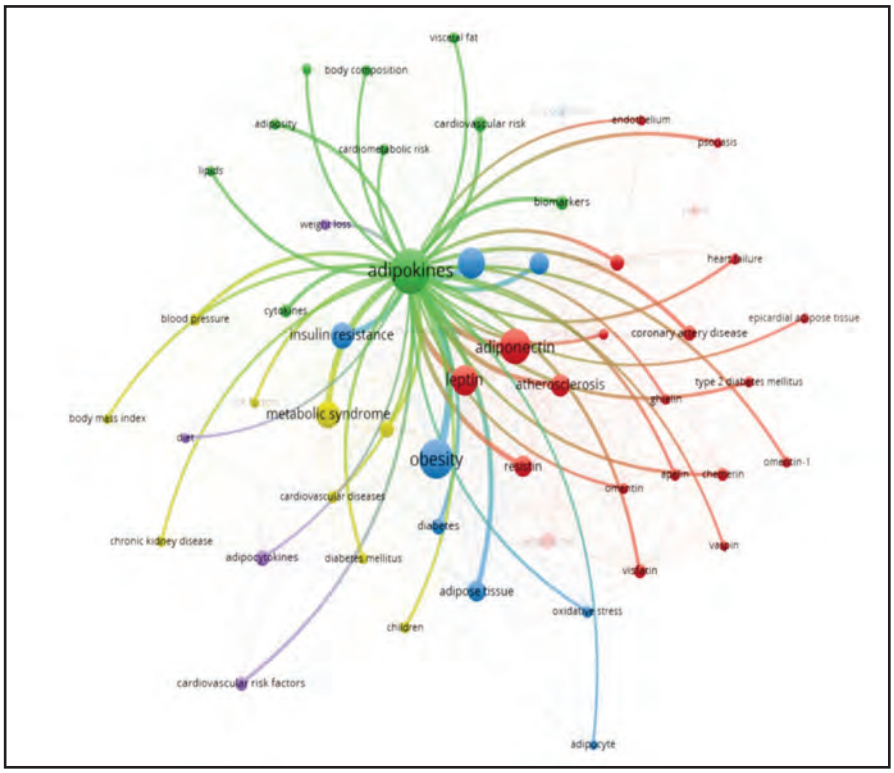

Fig. 3: Keyword co-occurrence network related to adipokines and cardiovascular disease generated using VOSviewer version 1.6.16. Node size represents keyword frequency, while line thickness indicates the strength of co-occurrence between keywords. Different colours indicate thematic keyword clusters. Major research themes identified in the network included obesity, metabolic disorders, inflammation, insulin resistance, adiponectin, leptin, atherosclerosis, and cardiovascular risk factors

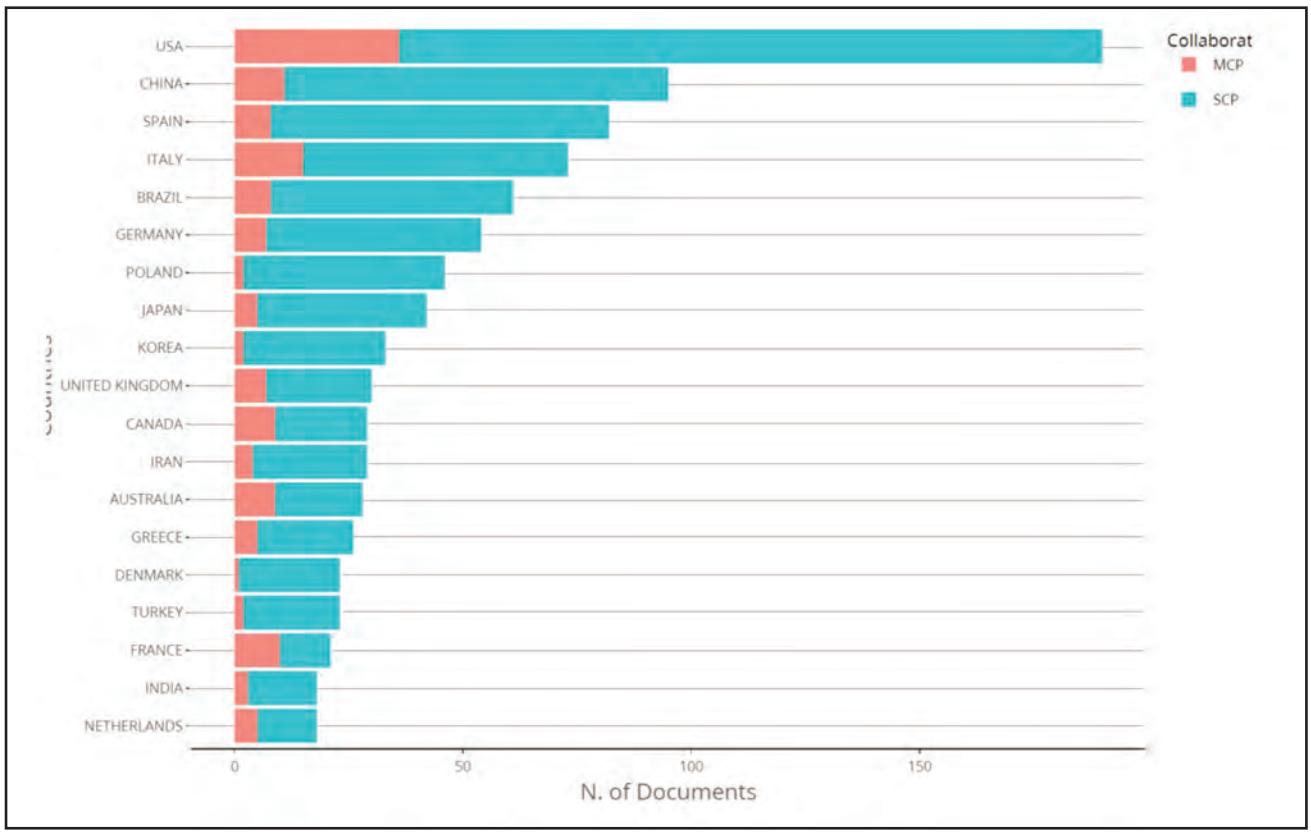

Fig. 4: Distribution of single-country publications (SCP) and multiple-country publications (MCP) related to adipokines and cardiovascular disease across contributing countries. SCP represents publications produced within a single country, whereas MCP indicates publications involving international collaboration. The United States demonstrated the highest publication output and international collaborative activity among all countries analysed

Top 10 most cited documents

Table I presents the ten most cited publications related to adipokines and disease. Adams et al.[25] published in Gut demonstrated the highest average citations per year (92.50 citations/year), whereas Waschki et al.[24] published in Chest had the highest total citation count (746 citations). Several highly cited publications were related to obesity, metabolic dysfunction, inflammation, and cardiometabolic disorders.

Table I Summarises the ten most cited publications related to adipokines and cardiovascular disease identified from the Scopus database. Total citations represent cumulative citation counts, whereas citations per year indicate annual citation impact.

Inter-country collaboration regarding the relationship of adipokines to cardiovascular disease

Figure 4 demonstrates the distribution of single-country publications (SCP) and multiple-country publications (MCP) related to adipokines and cardiovascular disease. The United States showed the highest publication output and international collaboration, followed by China, Spain, and Italy. Most countries demonstrated a predominance of domestic publications, although several countries exhibited notable international collaborative activity. Citation analysis by country indicated that the United States had the highest citation impact, followed by Italy, Germany, Canada, and Spain.

DISCUSSION

Search scope and dataset characteristics

This bibliometric analysis provides an overview of Scopus-indexed publications related to adipokines and cardiovascular disease from 2002 to 2024. The retrieved dataset consisted of 1,283 publications from 602 sources, with an average citation count of 34.78 citations per document. These findings indicate that adipokine-related cardiovascular research has developed into a sizeable and multidisciplinary scientific field over the past two decades.

The bibliometric dataset was analysed using VOSviewer and Biblioshiny to evaluate publication trends, keyword structures, citation patterns, and international collaboration networks. The findings should be interpreted within the methodological scope of Scopus-indexed bibliometric analysis because publications indexed in other databases may not have been captured.[12,16-17]

Publication development trend

The annual publication trend indicates a substantial increase in adipokine-related cardiovascular research, with the highest publication output observed around 2013–2014. There was a decline from 2015 to 2018, and there was an increase again in 2019 before there was another decline until 2023. The peak of the increasing publication trend from 2013 to 2014 may reflect growing scientific attention to the role of adipokines in cardiometabolic and cardiovascular research during that period.[18]

However, the decline observed after the peak years should be interpreted cautiously. A lower number of publications does not necessarily indicate a definitive reduction in research interest. It may also reflect changes in terminology, diversification of research topics, database indexing patterns, or incomplete indexing for more recent publication years.[17] Therefore, while the trend suggests a shift in publication output over time, further interpretation should consider methodological and database-related limitations. The observed pattern still indicates that adipokine-related cardiovascular disease research remains relevant, particularly for identifying future directions in biomarker research, risk stratification, and cardiometabolic prevention.[12,16-17]

Most Author Keywords

Keyword co-occurrence analysis indicated that adipokine-related cardiovascular research is strongly concentrated around obesity, metabolic dysfunction, inflammation, insulin resistance, adiponectin, leptin, and cardiovascular risk.[12,19] These thematic patterns suggest that adipokines are most frequently studied within the broader context of cardiometabolic dysregulation rather than as isolated biomarkers.

The prominence of obesity, metabolic syndrome, insulin resistance, adiponectin, and leptin indicates that current research has mainly focused on the mechanistic link between adipose tissue dysfunction and cardiovascular disease.[1,16] This finding is biologically plausible because altered adipokine secretion may contribute to endothelial dysfunction, chronic low-grade inflammation, oxidative stress, atherosclerosis, and impaired vascular homeostasis5. Therefore, the keyword structure supports the role of adipokines as important mediators between obesity-related metabolic abnormalities and cardiovascular outcomes.[20-21]

The relatively smaller occurrence of some cardiovascular-specific terms should not be interpreted as indicating low clinical relevance. Rather, it may suggest that the specific cardiovascular implications of adipokines remain an evolving research area.[12,22] Future studies may further investigate adipokines as predictive biomarkers, risk-stratification tools, therapeutic targets, and preventive indicators in cardiovascular disease.[22-23] Less visible nodes, such as adipocytokine and physical activity, should therefore be interpreted as terms with lower frequency within the retrieved dataset rather than terms lacking scientific importance.[12]

Top 10 Most Cited Documents

The citation analysis identified influential publications within the retrieved Scopus-indexed dataset. Highly cited documents were mainly related to obesity, metabolic dysfunction, inflammation, fatty liver disease, physical activity, and cardiometabolic outcomes.[24-25] This pattern indicates that adipokine-related cardiovascular research is closely linked to broader cardiometabolic and inflammatory research domains.

However, citation counts should be interpreted cautiously.[12,17] A high citation number does not necessarily indicate direct topic specificity or superior clinical relevance because citation impact may be influenced by publication year, journal

visibility, article type, topic breadth, and citation behaviour within each research field.[12,17] Therefore, highly cited articles in this bibliometric dataset should be interpreted as influential publications within the broader adipokine–cardiometabolic research landscape rather than as direct evidence of clinical effectiveness.

The inclusion of some highly cited articles that are not exclusively focused on adipokines and cardiovascular disease reflects the keyword-based nature of bibliometric retrieval.[12] These articles may have been captured because of their broader relevance to metabolic, inflammatory, or cardiometabolic pathways. This finding highlights the importance of interpreting citation analysis within the methodological scope and limitations of bibliometric mapping.[17]

Inter-country collaboration regarding the relationship of adipokines to cardiovascular disease

The country-level analysis demonstrated that adipokine-related cardiovascular research is largely dominated by countries with strong biomedical research infrastructure, particularly the United States, China, Spain, Italy, and Germany.[12,26] This pattern may reflect differences in research funding, institutional capacity, database visibility, international networks, and scientific productivity.[29]

International collaboration, represented by multiple-country publications, may increase research visibility and citation impact by connecting investigators across different scientific environments.[26-27] However, the predominance of single-country publications in several countries suggests that collaboration patterns remain uneven across regions. This finding indicates an opportunity to strengthen cross-national research networks, especially in regions experiencing an increasing burden of obesity and cardiometabolic disease.[28-29]

The absence of Indonesia among the leading contributors should be interpreted cautiously because the analysis was limited to Scopus-indexed publications and was not normalised by population size, number of researchers, national research funding, or institutional publication capacity.[12,30] Nevertheless, this finding may indicate an opportunity for researchers in Southeast Asia, including Indonesia, to contribute more actively to adipokine-related cardiovascular research, particularly because obesity, lifestyle factors, cardiometabolic risk, and cardiovascular disease profiles may vary across populations.[28,29]

LIMITATIONS

This study has several strengths. First, it provides a broad bibliometric overview of adipokine-related cardiovascular disease research over more than two decades, covering publications from 2002 to 2024. Second, the use of established bibliometric tools, namely VOSviewer and Biblioshiny, allowed the visualisation of publication trends, keyword structures, citation patterns, and international collaboration.[12,19] Third, the analysis included several bibliometric indicators, such as publication output, author keywords, citation counts, country contribution, SCP, and MCP, which provide a comprehensive description of the development of this research field.

However, this study also has several limitations. First, the analysis relied only on the Scopus database; therefore, relevant publications indexed in other databases, such as Web of Science, PubMed, or Google Scholar, may not have been included. Second, the findings depend on the search terms used, meaning that some relevant studies may have been missed if they used different terminology, while some broader articles may have been retrieved if they contained the selected keywords. Third, citation counts are influenced by article age, journal visibility, research field, and publication type; therefore, citation impact should not be interpreted as a direct indicator of study quality or clinical importance. Fourth, bibliometric analysis does not assess methodological quality, risk of bias, or clinical effectiveness of individual studies.[17] Finally, publication trends in recent years should be interpreted cautiously because indexing for the most recent publications may be incomplete. In addition, bibliometric visualisation outputs generated by VOSviewer and Biblioshiny should be interpreted as exploratory mapping tools rather than direct measures of causal or clinical relationships.[12,17]

Despite these limitations, the study provides a useful map of the intellectual development, dominant themes, and global contribution patterns in adipokine-related cardiovascular disease research. The findings may help researchers identify future research priorities, especially in relation to adipokines as potential biomarkers, risk-stratification tools, and therapeutic targets in cardiovascular disease.

CONCLUSION

This bibliometric study provides an overview of global research trends related to adipokines and cardiovascular disease from 2002 to 2024. The findings indicate that adipokine-related cardiovascular research has expanded substantially over the past two decades, with major themes involving obesity, metabolic dysfunction, inflammation, adiponectin, leptin, and cardiovascular risk. Publication and citation patterns show that developed countries, particularly the United States and China, have contributed substantially to this field of study. However, these findings should be interpreted within the limitations of a Scopus-indexed bibliometric analysis.

In conclusion, this study highlights that the relationship between adipokines and cardiovascular disease remains a relevant area for future scientific investigation. Further studies are needed to strengthen evidence on the role of adipokines as potential biomarkers, risk-stratification tools, and therapeutic targets in cardiovascular disease. Greater international collaboration, including contributions from underrepresented regions such as Southeast Asia and Indonesia, may help broaden scientific understanding of adipokine-related cardiovascular risk across diverse populations.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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ETHICAL APPROVAL

Not required for this study type as it is based exclusively on data from published literature.

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