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REVIEW

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Global trends and research hotspots in acupuncture treatment for cardiovascular diseases over the past decade: a bibliometric study

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Abstract

Background This study aims to examine the status and emerging trends of acupuncture treatment for cardiovascular disease (CVD) over the past decade. By conducting a visual analysis of existing literature, it seeks to offer new insights for future research directions.

Methods From the Web of Science Core Collection database, we retrieved papers on acupuncture treatment for CVD published between January 1, 2014, and December 31, 2023. Bibliometric analyses were conducted using VOSviewer and CiteSpace software to elucidate research progress and identify key research hotspots.

Results We identified 346 publications related to acupuncture for CVD that were published between 2014 and 2023. We determined the most productive journals, countries, institutions, authors, author patterns, and main directions for future research in the field of acupuncture. China was the top publishing country with 267 publications; Beijing University of Chinese Medicine was the leading institution with 42 publications; and the journal *Evidence-Based Complementary and Alternative Medicine* was the most prolific, with 43 publications. High-frequency keywords included "blood pressure," "acupuncture," "electroacupuncture," "stimulation," and "mechanism." The top five keywords by centrality ranking were "electroacupuncture," "myocardial ischemia," "stimulation," "randomized controlled trial," and "acupuncture."

Conclusion While progress exists in bibliometric research on acupuncture treatment for CVD, more comprehensive analyses remain essential. This study provides a multidimensional overview, delineating current advancements and emerging trends, offering evidence-based insights for clinical practice and quantitative references for identifying collaborators, key institutions, and future directions.

Keywords Acupuncture, Cardiovascular disease, Bibliometric study, Citespace, VOSviewer, Visual analysis

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Introduction

Cardiovascular disease (CVD) is a group of diseases caused by lesions of the heart and blood vessels, including coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatic heart disease, congenital heart disease deep vein thrombosis, and pulmonary embolism [1–5]. The high disability and mortality rates associated with CVD have long posed significant challenges to global public health. Among these, ischemic heart disease is the leading cause of CVD-related deaths worldwide [6]. Although the global age-standardized CVD mortality rate has been significantly reduced by 34.9% from 1990 to 2022, attributed to behavioral changes and improvements in environmental risk factors, population growth, and aging trends have led to an upward trend in the overall number of CVD deaths [7]. The World Health Organization predicts that by 2030, the global population aged 60 and above will increase by 34%, and by 2050, the worldwide elderly population will reach 2.1 billion, which will undoubtedly further exacerbate the burden of CVD [8]. High systolic blood pressure, dietary risks, environmental particulate air pollution, high low-density lipoprotein (LDL) cholesterol, high body mass index (BMI), high fasting blood glucose, and smoking are significant contributory factors to the risk of CVD today [9–10]. Reducing mortality rates is more challenging for low- and middle-income regions compared to high-income regions [11]. Hence, the global health threat posed by CVD necessitates a more proactive and comprehensive response.

Despite extensive preclinical and clinical research, the multifactorial complexity of CVD means that current treatment outcomes remain limited [12]. Existing pharmacological therapies, surgical interventions, and risk assessment strategies have provided some improvement for early-stage CVD patients [13]. However, medication side effects, surgical risks, and high economic burdens have not effectively curbed the progression of CVD [14–15]. Therefore, identifying effective and affordable alternative therapies to prevent and improve CVD is of significant practical importance. Acupuncture, as an important therapeutic tool in Chinese medicine, has been used clinically for thousands of years. By stimulating specific points on the body, acupuncture can inhibit inflammatory responses, reduce cellular apoptosis, and regulate autophagy, demonstrating therapeutic potential in cardiovascular health improvement [16–18]. Acupuncture offers various application methods, including electroacupuncture (EA), manual acupuncture, and combination techniques such as warm needling and heat-sensitive moxibustion, offering diverse clinical options. Despite its growing recognition for minimal side effects and evident efficacy, acupuncture still lacks sufficient attention and research focus in the field of CVD. The significant potential of acupuncture in CVD treatment calls for increased attention and in-depth research to fully explore its benefits and application prospects.

Although studies have been conducted to analyze the current status of acupuncture in the treatment of CVD, the existing literature is still limited in terms of period, study dimensions, and capturing the latest trends [19]. Therefore, this study, by extending the analysis period to 2014–2023, covering post-COVID publications, and employing co-occurrence network analysis, timeline clustering, and Kleinberg's burst detection algorithm, aims to provide a more comprehensive map of the development of the field, illustrating an overview of research and exploring hot topics and emerging trends.

Methods

Data sources

All publications were sourced from the Web of Science Core Collection (WOSCC). The data search strategy included topics related to "cardiovascular disease" and "acupuncture therapy." All extracted studies were published within the past decade. The search strategy is as follows: TS = (CVD OR cardio* OR CHD OR heart OR cardiac OR coronary OR myocardial* OR angina OR infarct* OR ischemia* OR "ischaemic attack" OR "peripheral atrial" OR "peripheral vascular disease" OR "peripheral artery disease" OR "aortic disease" OR "aortic aneurysm" OR "arrhythmia" OR "ventricular dysfunction" OR "mortality" OR "blood pressure" OR "hypertension" OR "hyperlipidemia") AND TS = ("acupuncture" OR "electroacupuncture" OR "acupuncture treatment" OR "acupuncture point"). The time span was set from 2014 to 2023, with a language restriction to English.

Data processing

The documents exported from the Web of Science database were imported into CiteSpace 6.1.6 and VOSviewer 1.6.20. CiteSpace 6.1.6 was used to perform cluster analyses on cited journals, authors, cited authors, keywords, and cited references, as well as to analyze the co-citation network of journals and detect burst keywords, cited authors, and cited references. VOSviewer 1.6.20 was utilized for network visualization analyses of countries, organizations, authors, and cited authors, and for density visualizations of organizations, authors, cited authors, and cited references. GraphPad Prism 8 was employed to construct trend graphs of the total number of publications and cumulative publications, while Scimago Graphica was used to visualize the global distribution of publications. With the above software, centrality analysis was performed to measure the importance of the relevant nodes in the network. Additionally, CiteSpace was used to calculate module values (Q values) and silhouette

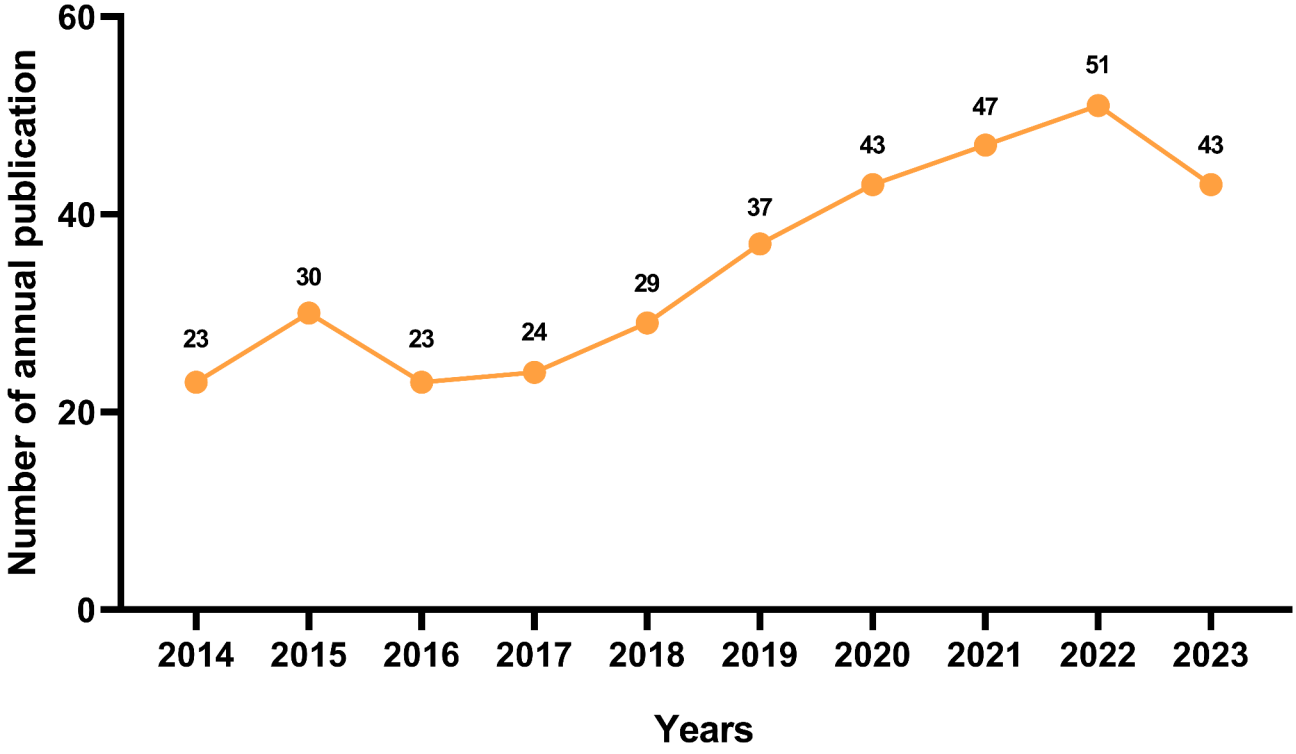


Fig. 1 Annual publications on acupuncture for CVD (2014–2023)

Table 1 Top 10 countries/regions by productivity and centrality in the field of acupuncture for CVD (2014–2023)

Countries	Documents	Citations	Organization	Documents	Citations
China	267	2460	Beijing University Chinese med	42	254
USA	46	597	Chengdu Univ Tradit Chinese med	32	516
South Korea	20	140	Nanjing Univ Chinese med	22	337
Japan	15	121	Guangzhou Univ Chinese med	22	171
Brazil	5	49	Tianjin Univ Tradit Chinese med	16	146
Germany	5	8	China Acad Chinese med	15	106
United Kingdom	5	43	Capital med univ	14	143
Canada	4	28	Anhui Univ Chinese med	14	49
Turkey	4	18	Kyung hee univ	14	86
Australia	4	18	china med univ	14	181

values (S values) to assess the quality of the identified clusters. Q values generally range between 0 and 1, with $Q > 0.3$ indicating a significant community structure. When $S > 0.7$, the clusters are considered highly reliable.

Results

Analysis of total and cumulative publications

Through our database search, we identified 346 articles that matched the criteria for this study. The annual publication counts are shown in Fig. 1. From the figure, it is evident that the overall trend is one of growth, despite some fluctuations in certain years such as 2016 and 2023, where there was a slight decrease in publication numbers compared to the previous year. From 2016 to 2022, the total number of publications showed an upward trend, with an average annual output of approximately 36 papers. The highest number of publications was in 2022, with 51 articles. These results indicate that the topic of acupuncture for CVD has been receiving increasing attention in recent years.

Analysis of National and institutional contributions

This study includes publications from 29 countries/regions and 439 organizations. The top five countries are China, the United States, South Korea, Japan, and Brazil. The most cited countries are China (2460 citations) and the United States (597 citations) (Table 1). Figure 2A shows that the strongest collaboration exists between

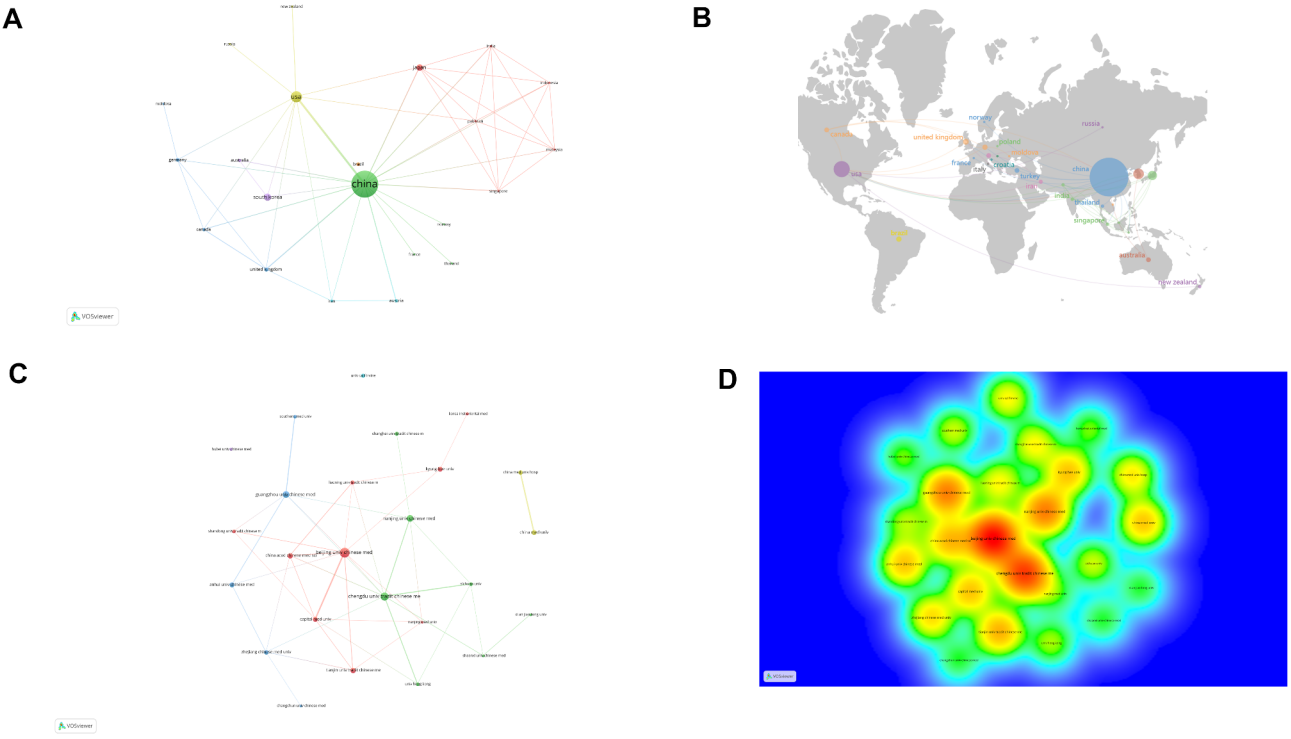


Fig. 2 (**A**) Visualization of countries. Each node represents a different country, and the size of the nodes corresponds to the number of published articles. (**B**) Geographic distribution. The color intensity indicates the number of published articles in each geographic area. (**C**) Institutions. Each node represents a different institution, and the size of the nodes corresponds to the number of published articles. (**D**) Density map for acupuncture of CVD from 2014 to 2023. The darker the shade of yellow, the higher the frequency of occurrences

China and the United States. From the collaboration network, it is evident that Asian countries have the closest relationships. The top five institutions by output (Table 1) are Beijing University of Chinese Medicine, Chengdu University of Traditional Chinese Medicine, Nanjing University of Chinese Medicine, Guangzhou University of Chinese Medicine, and Tianjin University of Traditional Chinese Medicine. Chengdu University of Traditional Chinese Medicine has the highest citation count (516 citations). Figure 2C and D, in addition to verifying these patterns, demonstrate that institutional collaborations mainly consist of two parts: a northern collaboration network centered in Beijing and a southern collaboration network centered in Chengdu. These findings may reflect the regions where CVD is most prevalent. Most of these active organizational networks are based in China. Additionally, the Beijing collaboration network has partnerships with Kyung Hee University and the Korea Institute of Oriental Medicine in South Korea.

Analysis of author

A total of 328 authors have contributed to research on acupuncture for CVD, and we used CiteSpace software to generate a map of authors associated with the acupuncture for CVD from 2014 to 2023 (Fig. 3A). We conducted its network visualization using VOSviewer (Fig. 3B). Table 2 lists the top ten influential authors in this field. With 20 publications, Fanrong Liang is the most active author, followed by Cunzhi Liu, Jingwen Yang, Guangxia Shi, and Shengfeng Lu. Moreover, Fanrong Liang is also the most frequently cited author and the leading researcher in this domain.

Analysis of cited authors

Using CiteSpace software, we generated a cited authors map consisting of 400 nodes and 729 links (Fig. 4A). Additionally, we performed a network visualization of cited authors related to acupuncture for CVD from 2014 to 2023 using VOSviewer (Fig 4C–D). The top five most-cited authors were Li P., Tjen-A-Looi S.C., Zhou W., Li J., and Gao J.H. (Table 2). We also analyzed the strongest citation bursts among the top 25 cited authors (Fig. 4B). Utilizing the "Citation/Frequency Burst History" feature in the "Visualization" section of CiteSpace, we obtained significant citation burst detection results. The red bars indicate the duration of the citation bursts, as well as the start and end years, revealing that Yang L.F. had the strongest citation burst from 2014 to 2017, making him a leading author in this field. Running CiteSpace also provided us with cluster analysis results (Fig. 5 and Table 3), identifying 15 clusters: #0 preoperative, #1 myocardial ischemia-reperfusion injury, #2 cardiac arrhythmia,

Fig. 3 (**A**) Author collaboration network for acupuncture of CVD from 2014 to 2023 visualized using CiteSpace. (**B**) Author collaboration network visualized using VOSviewer for the same period. Links represent collaboration relationships between authors, and nodes of the same color indicate membership within the same cluster

Table 2 Top 10 most prolific and cited authors in the field of acupuncture for CVD

No.	Author	Documents	Citations	Cited Author	Citations	Total link strength
1	Fanrong Liang	20	442	Li P.	160	1741
2	Cunzhi Liu	12	117	Tjen-A-Looi S.C.	106	1281
3	Jingwen Yang	12	117	Zhou W.	98	942
4	Guangxia Shi	9	92	Li J.	57	402
5	Shengfeng Lu	9	200	Gao J.H.	52	255
6	Liqiong Wang	8	44	Flachskampf F.A.	51	354
7	Zhiling Guo	8	104	Wang J.	50	299
8	Jianfeng Tu	7	27	Zhao L.	50	217
9	Yu Wang	7	34	Liu Y.	47	262
10	Bingmei Zhu	7	155	Li M.	46	579

#3 endothelial dysfunction, #4 hypertension, #5 ECG, #6 stable angina pectoris, #7 heart failure, #8 adenosine, #9 moxibustion, #10 protocol, #11 chronic disease management, #12 spontaneously hypertensive rats, #13 hypothalamus, #14 electroacupuncture, and #15 nervous system. These clusters reveal the focus and direction of research on CVD.

Analysis of journal and cited journal

The journals related to acupuncture for CVD are listed in Table 4. *Evidence-based complementary and alternative medicine* is the most productive journal, having published 43 articles. The cited journals map was generated through CiteSpace and VOSviewer (Fig. 6). Table 5 presents the top 10 journals with the highest citation counts and centrality. The top cited journals in terms of frequency and centrality rankings were *Circulation* ($n = 213$) and *Journal of hypertension* (centrality = 0.24), respectively.

Analysis of keyword

Through a co-occurrence analysis of keywords, we identified common themes in the field of acupuncture for CVD (Fig. 7). The keyword co-occurrence map comprises 271 nodes and 469 links (Fig. 7B). The five most common keywords are "blood pressure," "acupuncture," "electroacupuncture," "stimulation," and "mechanism." The top five keywords by centrality ranking are "electroacupuncture," "myocardial ischemia," "stimulation," "randomized controlled trial," and "acupuncture." We obtained cluster analysis results totaling 12 clusters during CiteSpace (Fig. 7B). The five largest clusters are "blood pressure" (Cluster #0, size = 32, silhouette = 0.955), "essential hypertension" (Cluster #1, size = 27, silhouette = 0.875), "myocardial injury" (Cluster #2, size = 27, silhouette = 0.866), "involvement" (Cluster #3, size = 25, silhouette = 0.906), and "autonomic nervous system" (Cluster #4, size = 24, silhouette = 0.928). We created network visualizations and density maps of keywords using VOSviewer (Fig. 7C and D). "Burst words" refer to keywords that frequently appear within a specific period, indicating emerging trends or frontline topics through their increased

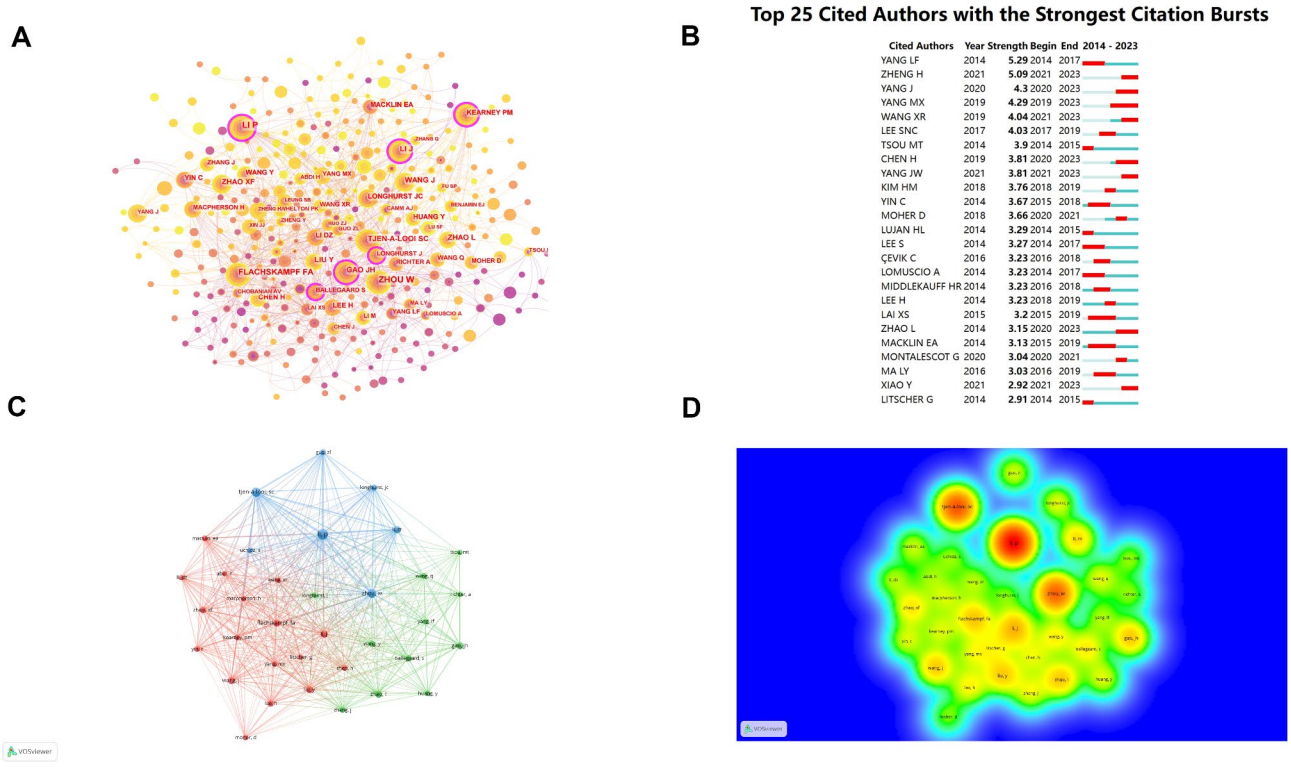


Fig. 4 (**A**) CiteSpace map of cited authors for acupuncture for CVD from 2014 to 2023. (**B**) Visualization of citation bursts for cited authors, with red bars indicating periods of frequent citations and green bars indicating periods of infrequent citations. (**C**) VOSviewer network visualization of cited authors related to acupuncture for CVD from 2014 to 2023. (**D**) VOSviewer density visualization of cited authors related to acupuncture for CVD from 2014 to 2023

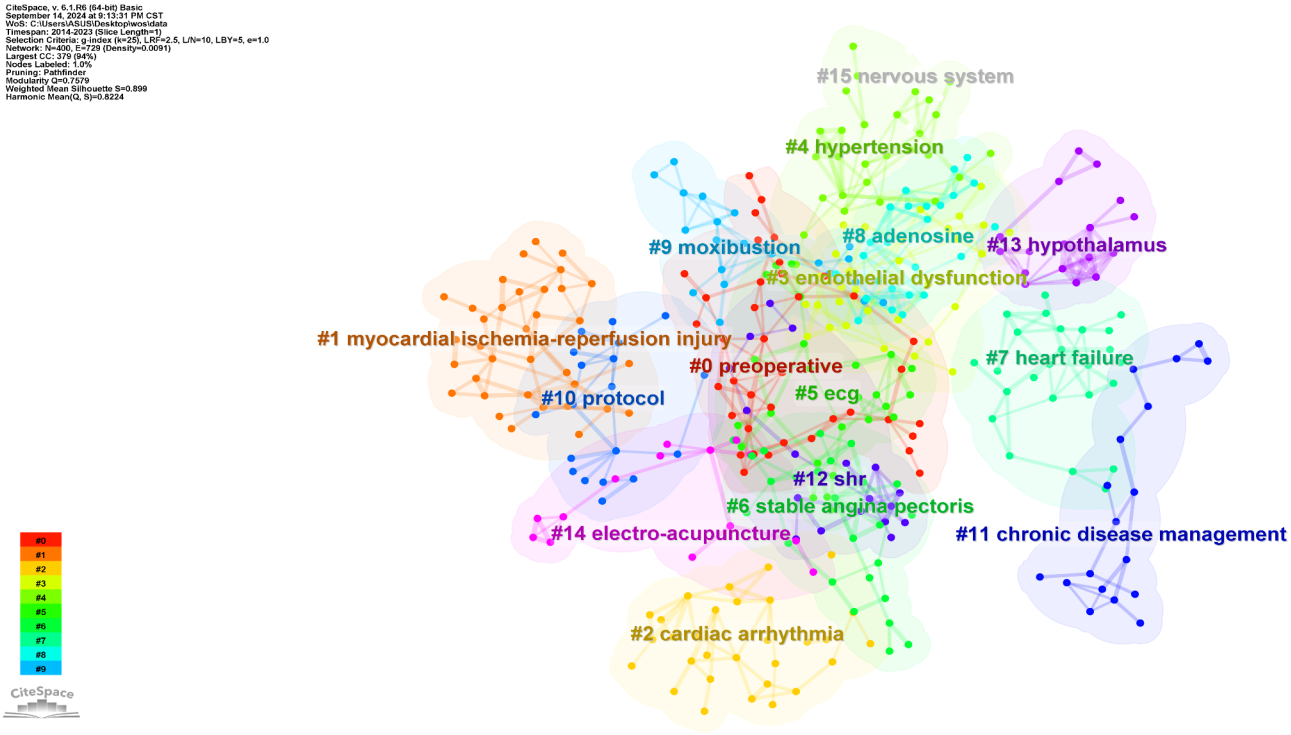


Fig. 5 Co-citation network map of clusters related to research on acupuncture for CVD. A total of 15 clusters, each representing a different research themes, are depicted in different colors on the map

Table 3 Top 15 cited authors in the field of acupuncture for CVD

Cluster-ID	Size	Silhouette	Mean (Year)	Label (LLR)	Label (MI)
0	39	0.9	2021	Preoperative	Transauricular vagus nerve stimulation
1	35	0.927	2017	Myocardial ischemia-reperfusion injury	Nlrp3 inflammasome inhibition
2	31	0.953	2016	Cardiac arrhythmia	Parasympathetic nervous system
3	31	0.846	2017	Endothelial dysfunction	Endothelial dysfunction
4	29	0.83	2017	Hypertension	Prehypertension
5	25	0.937	2015	ECG	Nerve regeneration
6	25	0.869	2016	Stable angina pectoris	Amstar 2
7	25	0.876	2018	Heart failure	Sympathetic hyperactivity
8	25	0.895	2017	Adenosine	Tianquan (PC2)
9	21	0.853	2019	Moxibustion	Mid-frequency electroacupuncture
10	19	0.842	2019	Protocol	Neiguan (PC6)
11	18	0.941	2020	Chronic disease management	Chronic disease management
12	18	0.942	2019	Spontaneously hypertensive rats	Autophagy
13	17	0.959	2016	Hypothalamus	Acupuncture
14	14	0.949	2015	Electroacupuncture	Protein kinases
15	7	0.933	2019	Nervous system	Acupuncture

Table 4 Top 10 academic journals related to acupuncture for CVD

Rank	Journal	Publications	IF(2023)
1	*Evidence-based complementary and alternative medicine*	43	NA
2	*Medicine*	26	1.6
3	*Acupuncture in medicine*	21	2.5
4	*Journal of traditional chinese medicine*	18	2.6
5	*Acupuncture & electro-therapeutics research*	10	0.3
6	*BMC complementary medicine and therapies*	9	3.9
7	*Frontiers in cardiovascular medicine*	8	3.6
8	*Scientific reports*	8	4.6
9	*Trials*	8	2.5
10	*Chinese journal of integrative medicine*	8	2.9

citation-burst or rising frequency over a certain period. The graph highlights the top 10 keywords with the highest citation burst rates, reflecting periods of intensive research activity and interest in the field (Fig. 7E). The top five burst words are "double-blind, " "cardioprotection, " "blood pressure," "heart rate," and "oxidative stress." Finally, burst words continuing into 2023 are "depression" (2022–2023) and "systematic review" (2021–2023).

Analysis of co-cited reference

We used CiteSpace to generate a co-citation map of references from the past 10 years, which includes 403 nodes and 735 links. Additionally, the top 10 most frequently cited references and those with the highest centrality are listed in Tables 6 and 7. A cluster analysis of co-cited references was conducted to identify common themes in similar articles, resulting in fourteen clusters (Fig. 8A). The cluster ID is the number assigned to each cluster, displayed as #0, #1, etc. The larger the cluster size (i.e., the number of members within the cluster), the smaller the cluster ID number. According to the log-likelihood ratio algorithm in CiteSpace, based on titles, the five largest clusters are "cardioprotection" (Cluster #0, size = 43, silhouette = 0.871), "acupuncture" (Cluster #1, size = 38, silhouette = 0.949), "electroacupuncture" (Cluster #2, size = 32, silhouette = 0.930), "spontaneously hypertensive rats" (Cluster #3, size = 32, silhouette = 0.862), and "stable angina pectoris" (Cluster #4, size = 26, silhouette = 0.965) (Fig. 8). CiteSpace used two metrics to evaluate cluster validity: modularity and silhouette. The results indicate that the cluster structure is significant and highly reliable, with a total modularity of 0.8278 and a weighted mean silhouette of 0.9312. Additionally, we analyzed the evolution of these clusters over time (Fig. 8B), revealing that clusters #8 and #13 were identified as the most recent areas of focus.

Discussion

CVD are complex illness intricately linked to environmental, dietary, and aging factors [20], and unfortunately often progresses alongside an increased risk of mental health disorders and cognitive impairments [1–21]. Thus, it is crucial to explore and implement effective strategies for preventing and treating CVD. With the growing understanding of CVD's importance, current management strategies include both pharmacological and non-pharmacological approaches. Antiplatelet drugs such as aspirin and clopidogrel help manage conditions such as coronary artery disease and stroke [22–23]. Statins stabilize plaques by lowering blood lipid levels [24], and calcium channel blockers and diuretics help control blood pressure to mitigate CVD progression [25–26].

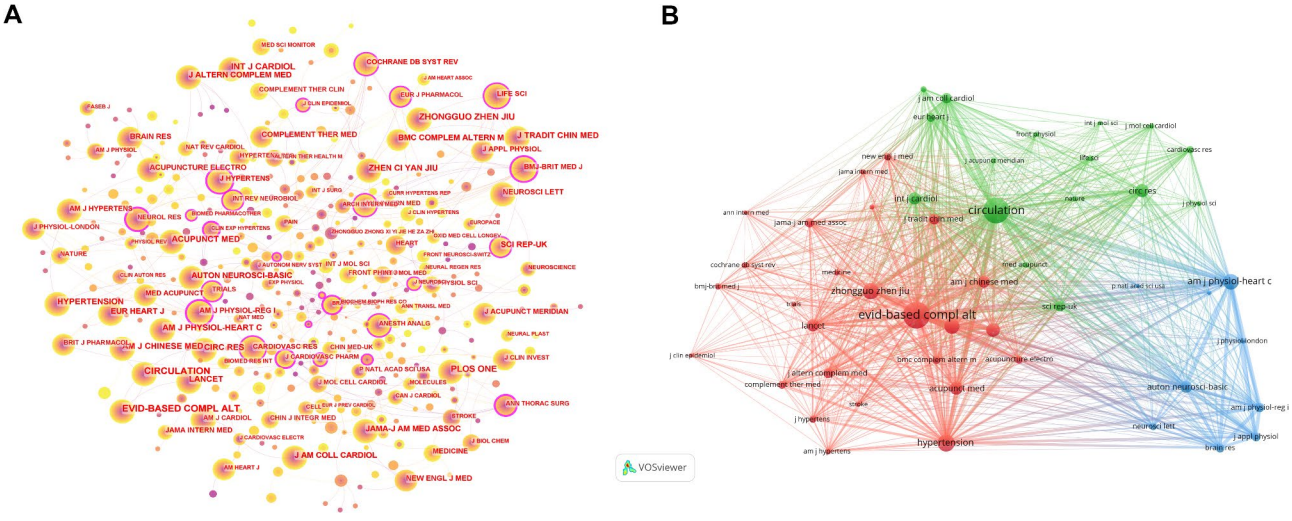


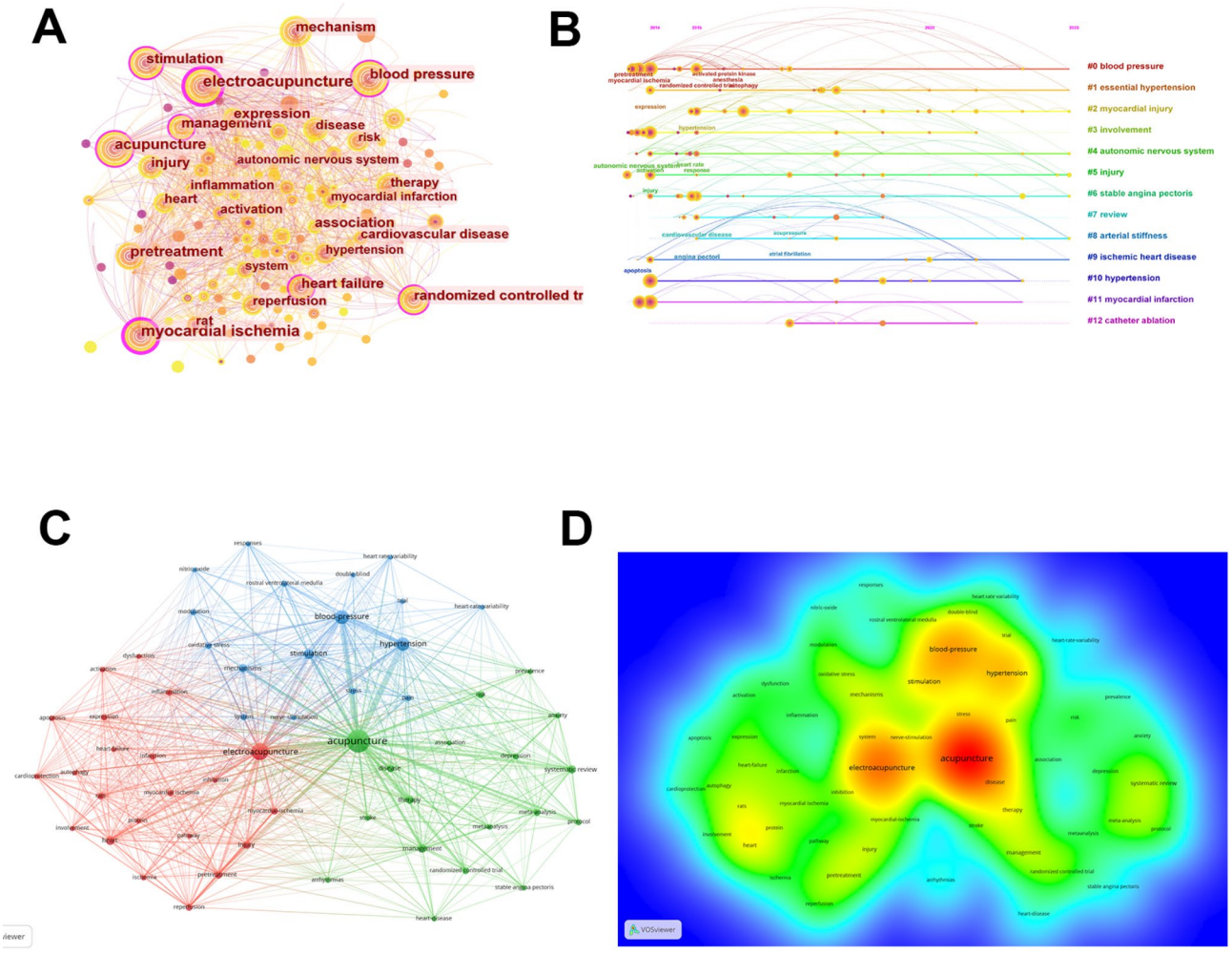
Fig. 6 (**A**) Map of cited journals for acupuncture for CVD from 2014 to 2023. Nodes with purple rings represent high centrality, indicating key points. (**B**) VOSviewer network visualization of cited journals related to acupuncture for CVD from 2014 to 2023. Links indicate co-citation relationships between cited journals, and nodes of the same color represent the same cluster

Table 5 Top 10 most cited journals, and centrality data for cited journals related to acupuncture for CVD

Rank	Frequency	Journal	Rank	Centrality	Journal
1	213	*Circulation*	1	0.24	*Journal of hypertension*
2	208	*Evidence-based complementary and alternative medicine*	2	0.24	*Annals of thoracic surgery*
3	140	*Chinese acupuncture & moxibustion*	3	0.23	*American journal of physiology-regulatory, integrative and comparative physiology*
4	135	*Plos one*	4	0.23	*BMJ british medical journal*
5	118	*International journal of cardiology*	5	0.23	*Journal of cardiovascular pharmacology*
6	112	*Acupuncture in medicine*	6	0.23	*Clinical and experimental hypertension*
7	111	*American journal of physiology-heart and circulatory physiology*	7	0.22	*Neurological research*
8	106	*Acupuncture research*	8	0.21	Brain research bulletin
9	102	*Lancet*	9	0.18	*Cardiovascular research*
10	101	*Circulation research*	10	0.18	*International review of neurobiology*

Interventional and surgical treatments are employed for more severe CVD cases [27–28]. However, the chronic and progressive nature of CVD presents numerous challenges. Long-term medication can lead to side effects like liver and kidney damage, drug intolerance, and dependence [29]. Interventional and surgical treatments may cause postoperative adverse reactions and impose significant economic burdens [30]. These limitations highlight the advantages of acupuncture as a non-invasive therapy, including its effectiveness, safety, and cost-effectiveness. To study the development of acupuncture in treating CVD, we conducted a bibliometric analysis of relevant literature from the past decade from the Web of Science Core Collection using CiteSpace and VOSviewer. This study provides an overview of the field and global research trends.

Data analysis indicates that over the past decade, the annual number of publications on acupuncture for CVD has increased steadily. This suggests that acupuncture's potential as an adjunctive therapy for CVD is gradually being recognized. Internationally, many countries and regions have prioritized this field. The top five countries are China, the United States, South Korea, Japan, and Brazil, with China ($n = 2460$) and the United States ($n = 597$) being the most cited. The strongest collaboration is between China and the United States. Collaboration networks indicate that Asian countries have the closest collaborative ties. These findings are generally consistent with previous bibliometric studies related to acupuncture [31]. Additionally, Chinese institutions have maintained a leading position in the field of acupuncture for CVD due to their high output and citation rates. This has resulted in a northern collaboration network centered on Beijing and a southern network centered on Chengdu. Internationally, Beijing's collaboration network also has partnerships with Kyung Hee University and the Korea Institute of Oriental Medicine in South Korea. These results may be attributed to acupuncture being an



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Top 10 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2014 - 2023
double blind	2018	**3.39**	2018	2019	
cardioprotection	2014	**3.23**	2020	2020	
blood pressure	2014	**3.11**	2016	2018	
heart rate	2015	**2.93**	2015	2017	
oxidative stress	2018	**2.79**	2018	2020	
depression	2022	**2.69**	2022	2023	
system	2014	**2.64**	2017	2018	
metaanalysis	2016	**2.61**	2021	2021	
systematic review	2018	**2.58**	2020	2023	
heart	2014	**2.41**	2014	2015	

Fig. 7 Keyword analysis related to acupuncture for CVD from 2014 to 2023. (**A**) Keyword map generated using citeSpace. (**B**) Visualization of the co-occurrence network and cluster analysis of keywords over time. In this visualization, each horizontal line represents a cluster, and each node on the line represents a keyword. Co-occurrence relationships between keywords are depicted as lines connecting the two nodes, and the size of each node represents co-occurrence frequency. (**C**) Network visualization of keywords using VOSviewer. (D) Density visualization of keywords using VOSviewer. (**E**) Top 22 keywords with the strongest citation bursts from CiteSpace. In this graph, the starting point of the blue line indicates the year of publication of the article. The start of the red bar represents the onset of the burst period, and the end of the red bar marks its conclusion

Table 6 Top 10 most frequently co-cited references related to acupuncture for CVD

Rank	Frequency	Reference	Author and publication	Journal
1	33	Acupuncture as Adjunctive Therapy for Chronic Stable Angina: A Randomized Clinical Trial	Zhao L., 2019	*JAMA internal medicine*
2	24	Is Acupuncture Effective for Hypertension? A Systematic Review and Meta-Analysis	Zhao X.F., 2015	*Plos one*
3	21	Inhibition of NADPH Oxidase-Dependent Oxidative Stress in the Rostral Ventrolateral Medulla Mediates the Antihypertensive Effects of Acupuncture in Spontaneously Hypertensive Rats	Wang X.R., 2018	*Hypertension*
4	18	Efficacy and Safety of Acupuncture for Essential Hypertension: A Meta-Analysis	Chen H., 2018	*Medical science monitor*
5	17	Acupuncture for essential hypertension: a meta-analysis of randomized sham-controlled clinical trials	Li D.Z., 2014	*Evidence-based complementary and alternative medicine*
6	17	Long-Lasting Reduction of Blood Pressure by Electroacupuncture in Patients with Hypertension: Randomized Controlled Trial	Li P., 2015	*Medical acupuncture*
7	14	Acupuncture for essential hypertension	Wang J., 2013	*International journal of cardiology*
8	14	Efficacy of electroacupuncture pretreatment for myocardial injury in patients undergoing percutaneous coronary intervention: A randomized clinical trial with a 2-year follow-up	Wang Q., 2015	*International journal of cardiology*
9	14	Acupuncture lowers blood pressure in mild hypertension patients: a randomized, controlled, assessor-blinded pilot trial	Liu Y., 2015	*Complementary therapies in medicine*
10	12	Acupuncture for hypertension	Yang J., 2018	*Cochrane database of systematic reviews*

Table 7 Top 10 co-cited references with the highest centrality related to acupuncture for CVD

Rank	Centrality	Referencesss	Author and publication	Journal
1	0.31	Abdominal and auricular acupuncture reduces blood pressure in hypertensive patients	Abdi H., 2017	*Complementary therapies in medicine*
2	0.26	Acupuncture lowers blood pressure in mild hypertension patients: a randomized, controlled, assessor-blinded pilot trial	Liu Y., 2015	*Complementary therapies in medicine*
3	0.23	Acupuncture for essential hypertension	Wang J., 2013	*International journal of cardiology*
4	0.20	Acupuncture for essential hypertension: a meta-analysis of randomized sham-controlled clinical trials	Li D.Z., 2014	*Evidence-based complementary and alternative medicine*
5	0.20	Cardioprotection of electroacupuncture against myocardial ischemia-reperfusion injury by modulation of cardiac norepinephrine release	Zhou W., 2012	*American journal of physiology-heart and circulatory physiology*
6	0.19	Heart Disease and Stroke Statistics-2018 Update: A Report From the American Heart Association	Benjamin E.J., 2018	*Circulation*
7	0.19	Acupuncture for heart failure: A systematic review of clinical studies	Lee H., 2016	*International journal of cardiology*
8	0.17	Acupuncture at PC6 prevents cardiac hypertrophy in isoproterenol-treated mice	Zhang M., 2019	*Acupuncture in medicine*
9	0.17	Electro-acupuncture at Neiguan pretreatment alters genome-wide gene expressions and protects rat myocardium against ischemia-reperfusion	Huang Y., 2014	*Molecules*
10	0.13	2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8)	James P.A., 2014	*JAMA*

integral part of traditional chinese medicine, with a long history of practice and widespread application.

Based on the author analysis, a total of 328 authors have contributed to research on acupuncture for CVD. Among them, Fanrong Liang is considered one of the most active authors in this field, with 20 publications. His work focuses primarily on the clinical and mechanistic studies of acupuncture in treating CVD. Through clinical observations involving 404 patients, Liang investigated the efficacy of acupuncture as an adjunctive therapy for chronic stable angina. The results showed that acupuncture on sensitive points significantly reduced

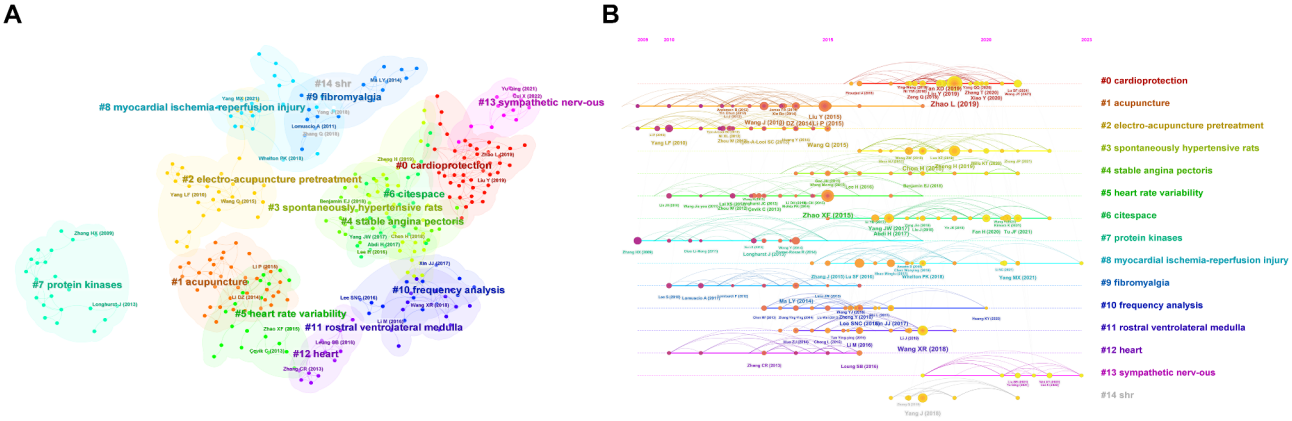

Fig. 8 Co-cited reference analysis related to research on acupuncture for CVD. (**A**) Network map of co-citation clusters. Seventeen clusters with different research themes are represented by different colors on the map. (**B**) Timeline visualization of co-cited clusters. Each horizontal line represents a cluster, and each node represents a co-cited reference. Co-citation relationships between references are shown as lines connecting two nodes, and the size of each node indicates the co-citation frequency

the frequency of angina attacks compared to non-sensitive points, sham acupuncture, and no acupuncture. The study found that acupuncture, as an adjunct to anti-anginal drugs, not only effectively improved patients' symptoms but also demonstrated good safety [32]. This finding aligns with our co-cited reference cluster analysis results. Liang's research provides high-quality clinical evidence for the application of acupuncture in treating CVD, making significant contributions to the development of this field.

Based on the analysis of cited authors, the top five most-cited authors are Li P., Tjen-A-Looi S.C., Zhou W., Li J., and Gao J.H. Yang L.F. had the strongest citation burst from 2014 to 2017, making him a prominent author in this field. Li P.'s team discovered that EA can regulate the sympathetic nervous system and the renin-angiotensin-aldosterone system, thereby lowering blood pressure. Specific acupuncture point stimulation through the paraventricular nucleus (PVN) and other spinal cord regions significantly reduces cardiovascular reflex responses [33–34], demonstrating EA's role in modulating sympathetic and peripheral nervous system activities. This research not only provided a theoretical basis for EA to improve CVD but also laid an important preliminary foundation for subsequent research. Yang L.F.'s articles further confirmed these findings [35]. In the co-cited literature cluster analysis based on title terms, the five largest research groups were "preoperative," "myocardial ischemia-reperfusion injury (MIRI)," "cardiac arrhythmia," "endothelial dysfunction," and "hypertension." The term "preoperative" reflects the advantages of acupuncture in preventive medicine. In recent years, acupuncture preconditioning has gained increasing attention for its ability to activate endogenous protective mechanisms and reduce CVD injury [36]. Additionally, with the development of chest pain emergency protocols and rapid response pathways, MIRI has become a highly prevalent type of CVD in clinical practice. Acupuncture preconditioning has significant clinical relevance in improving MIRI and has received widespread attention. Preclinical studies have shown that acupuncture preconditioning can improve MIRI by reducing cell apoptosis, oxidative stress, and protecting microvessels [37–39]. Overall, these findings have also been replicated in other types of CVD [40]. These results suggest that acupuncture for CVD has multi-target and multi-pathway characteristics.

Analysis of international journals indicates that the top five journals have collectively published 118 relevant papers. Among them, *Evidence-based complementary and alternative medicine* is the most prolific, with 43 articles. Within the SCIE-indexed journals, *Medicine* has the highest number of publications. The impact factors of the top five SCIE journals range from 0.2 to 3.3, with an average of 1.84. In terms of cited publications, the journal with the highest citation frequency is *Circulation* ($n = 213$), while the journal with the highest centrality ranking is the *Journal of Hypertension* (centrality = 0.24). Among the top five most-cited journals, 70% are affiliated with U.S. institutions, followed by those in the U.K. and China. Overall, this analysis highlights the significant contributions of these journals to the field of acupuncture for CVD.

From the 271 extracted keywords, co-occurrence, clustering, and dynamic frontier evolution analyses show that current research mainly focuses on clinical and preclinical studies investigating the therapeutic effects and potential mechanisms of acupuncture in treating CVD. High-frequency keyword analysis indicates that myocardial ischemia is the most extensively studied type of CVD, while blood pressure is the most closely monitored risk factor. Furthermore, by analyzing the top five keywords with the highest citation burst rates, we found

that the research direction for acupuncture of CVD primarily focuses on core elements such as randomized double-blind trials, cardioprotection, blood pressure, heart rate, and oxidative stress. These keywords highlight the current research hotspots and frontiers, as well as possible mechanisms of action and key points in efficacy evaluation. It is noteworthy that research on co-morbid mood disorders in CVD has shown a significant increase in recent years, with "depression" emerging as a key research hotspot in the field in 2022–2023. This phenomenon is highly consistent with the findings of a recent meta-analysis by Lu et al., who demonstrated that acupuncture interventions can simultaneously improve angina symptoms and depression scores in CVD patients, suggesting that acupuncture has the potential to regulate both the mind and body in a bidirectional manner. From the analysis of the intervention program, most of the clinically selected acupuncture points focused on two meridians, namely, the Pericardium Meridian of Hand-Jueyin (PC) and the Heart Meridian of Hand-Shaoyin (HT), and the high-frequency acupoints included Neiguan (PC6), Tongli (HT5), and Baihui (GV20), among others [41]. Further mechanistic studies indicate that acupuncture may improve CVD combined with anxiety and depression by lowering plasma CST and NT-proBNP, inhibiting platelet activation, and modulating neurotransmitters [42–43]. The above findings reveal that research on the mechanism of acupuncture intervention for CVD co-morbid mood disorders remains to be fully elucidated. Collectively, these findings underscore that research on acupuncture to improve co-morbid mood disorders in CVD is emerging as a hot topic, a trend that has not yet been reported in previous bibliometric studies.

In the co-cited reference analysis, the most frequently cited paper is a clinical trial by Zhao et al. published in 2019, which primarily investigated the effects of acupuncture as an adjunctive therapy for improving chronic stable angina [32]. The second most-cited study, published in 2018 by Wang et al., is a preclinical experiment showing that acupuncture exerts antihypertensive effects by alleviating oxidative stress and modulating redox-sensitive pathways in the rostral ventrolateral medulla of spontaneously hypertensive rats, providing new targets for acupuncture in improving CVD [44]. Among the references with the highest centrality, the paper with the greatest occurrence is a 2017 clinical study by Abdi et al. They conducted a randomized controlled trial to explore and compare the effects of abdominal and auricular acupuncture on blood pressure in 440 obese and non-obese subjects, proving that different acupuncture methods can modulate blood pressure to varying degrees [45]. The second influential literature is that of Liu et al. who confirmed the ameliorative effect of acupuncture through an evaluator-blinded study assessing acupuncture's improvement of blood pressure in patients with prehypertension and stage I hypertension [46]. In third place, Wang et al. systematically evaluated the current clinical evidence for acupuncture in the treatment of hypertension and concluded that the current efficacy of acupuncture in the treatment of hypertension is likely to be the same as that of common medications [47]. Based on this evidence, blood pressure as an important risk factor for CVD has received special attention in experimental design.

Conclusion

Although some progress has been made in the bibliometric study of acupuncture for CVD, further systematic analyses are still needed to expand data coverage and achieve multidimensional analysis. Therefore, this study explored the overview of research of the field from multiple perspectives to demonstrate its current development and research trends. It can not only provide an evidence-based basis for clinical practice, but also provide a quantitative reference for researchers to identify potential collaborators, key research institutions, and possible future frontier directions. However, there are still some deficiencies in this study; the literature sources can be supplemented with the contents of PubMed, MEDLINE, and other databases to obtain more complete data, as well as supplementing the Chinese-language databases (e.g., CNKI, Wanfang) in the future to improve the language bias caused by the inclusion of only the English literature, and the lack of statistical analysis on the selection of acupoints in acupuncture for CVD. In the future, statistical methods can be applied to compare the combinations of selected points and identify commonly used acupoints to guide clinical practice.

Abbreviations

CVD	Cardiovascular disease
LDL	Low-density lipoprotein
BMI	Body mass index
EA	Electroacupuncture
WOSCC	Web of Science Core Collection
Q values	Calculate module values
S values	Silhouette values
PVN	Paraventricular nucleus
MIRI	Myocardial ischemia-reperfusion injury

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Author contributions

WW: Conceptualization, Software, Writing – original draft, Methodology. KW: Data curation, Formal analysis, Writing – review and editing. QZ: Validation. JZ: Investigation. HZ: Supervision. SC: Visualization. SW: Project administration. MZ: Funding acquisition, Resources.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable' for that section.

Consent for publication
Not applicable' for that section.

Competing interests
The authors declare no competing interests.

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