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Global Research output on Cardiovascular Drugs and Heart Diseases: A Bibliometric Analysis from 2000-2023

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Abstract: **Background: Cardiovascular diseases (CVDs) remain the leading cause of mortality worldwide imposing a substantial burden on public health system and economies. The continuous rise in the prevalence of heart diseases, coupled with the increasing health care costs associated with their management, underscores the urgent need for innovative therapeutic approaches. As the severity of the problem grew, more countries conducted studies on Cardiovascular drugs, and the number of studies has expanded dramatically, particularly in the last decade. As a result, it is critical to retrace relevant CVD research produced between 2002 and 2023.**

Method: This research used bibliometrics to investigate CVD-related papers obtained PubMed from 2002 to 2023. This study performed a statistical analysis of the countries, institutions, journals, authors, research areas, author keywords to provide an overview of the CVDs field as well as research trends, research hotspots, and future research directions in the field.

Results: A total of 4601 articles from 1028 sources with time span of 2000-2023 was used for this assessment. A total of 23,847 authors contributed in the articles. The total keywords used by authors summed up to 12,493. China produced the most papers, but the United States had the most significant influence. The University of Oxford was the leading research institution. Bibliometric revealed that key words such as randomized controlled trials as topic, human, female, male, risk factors, prospective studies, primary and secondary prevention, treatment outcome were the most common keywords.

Conclusion: It is crucial to support the translation of research finding into clinical practice, thereby contributing to the advancement of effective and personalized cardiovascular care on a global scale.

Keywords: **Cardiovascular drugs, heart diseases, Global research output, Bibliometrics, Cardiovascular health trends.**

1. INTRODUCTION

Cardiovascular diseases (CVDs) stand as a formidable global health challenge, causing a substantial burden of morbidity and mortality. According to the World Health Organization (WHO), CVDs are responsible for an estimated 17.9 million deaths annually, constituting the leading cause of death globally [1]. The prevalence of cardiovascular diseases continues to rise, driven by factors such as sedentary lifestyles, dietary habits, and an aging population [2].

The impact of cardiovascular diseases extends far beyond the immediate health concerns of affected individuals. CVDs, encompassing conditions such as heart attacks, strokes, and heart failure, carry a substantial socioeconomic burden. The toll on healthcare systems is marked by escalating costs associated with medical care, rehabilitation, and lost productivity

[3]. In the United States alone, the American Heart Association estimates an annual cost exceeding $300 billion, covering direct medical expenses, productivity losses, and other associated costs [3]. This dual burden of human suffering and economic strain underscores the urgency of addressing cardiovascular health comprehensively.

Bibliometric analysis is an effective method for quantitatively assessing academic papers and can be used to investigate the evolution of certain fields, and the results can provide an overview of a certain field as well as research trends, hot topics, distribution of research power and future research directions [17, 18]. The advantage of bibliometric is that it is not limited by geography, allowing data to be collected by country in a particular area to analyze research globally [19]. In addition, specific data analysis software can process the results of bibliometric analyses and present them in a more three-dimensional form. Therefore, bibliometric analysis have been applied to many fields, such as medicine, chemistry, psychology, computer science, and robotics [17, 20].

2. METHODS

Data source

The journals and publications were collected from PubMed. This database was selected because it is a valuable database for cardiovascular drugs and heart diseases due to their comprehensive coverage of scholarly literature. The rationale lies in the ability of this database to provide access to a wide range of peer-reviewed articles, academic papers and conference proceedings from various sources. It is favored for its extensive collection that enables thorough and in-depth literature reviews, aiding in identification of current trends, key search findings and emerging perspectives within the field of cardiovascular medicine [22].

Search strategy

A comprehensive search strategy was used to gather publications and articles related to cardiovascular drugs and heart diseases to analyze publication patterns, trends, and treatment strategies in this field. The search string used in gathering the data for the analysis are: (“Cardiovascular drugs” OR “Cardiac medications”), (“heart diseases” OR “Cardiac disorder” OR “Cardiovascular conditions”) and (“Global research output” OR “Pharmaceutical intervention”). The search results formed the text corpus of this study. The extracted variables were: PMID number, author names, affiliations, title, abstract, journal, and database entry year. The keywords used are; “cardiovascular drugs”, “heart diseases”, “bibliometric analysis”, “publication patterns”, “treatment strategies”. Date range; the publications and articles used for this analysis used a 23 years phase that ranged from 2000 to 2023.

Validation of the search strategy

In the current study, the development of the search query was continuously fine-tuned until the top 200 cited documents in the retrieved literature were free of any false-positive results. Furthermore, the search query was tested for missing data (false-negative) by adopting a previously published method which relies on the correlation between the retrieved research output for active authors and their actual research output in this field [23].

Visualization Tools

The visualization tools and software used for this study included all the tools in BIBLIOMETRIC software. This software was used to analyze and measure various aspects of publications and research such as the impacts of authors, journal or research in cardiovascular drugs and heart disease. It helps identify trends, key contributors and influential studies, aiding in the evaluation of research progress, knowledge dissemination and development therapeutic interventions.

Bibliometric indicators

In the current study, the following bibliometric indicators were presented: (1) volume and growth of publications on cardiovascular drugs over the past two decades; (2) research output from different world regions; and (3) most active countries, institutions, and journals involved in publishing scientific articles on cardiovascular drugs.

Data Analysis

Retrieved data were exported from PubMed to Microsoft Excel for analysis and table presentation. Graphics were created using Statistical Package for Social Sciences (SPSS, version 21). Geographical distribution of publications was carried out using the World Health Organization (WHO) geographical classification. Visualization maps were created using VOS-

viewer program [24]. International research collaboration among active countries was assessed using the "link strength" indicator extracted from visualization maps. The normalized citation value was obtained from the network visualization maps created by VOS viewer. The Hirschindex (h-index) was used to measure the scientific impact of authors, institutions, countries, and a body of literature.

3. RESULTS

Growth Trend of publications

From 2000 to 2023, A total of 4601 articles on cardiovascular drugs and heart diseases was published by by authors in different countries. The growth trend of articles related to the cardiovascular drugs field from 2002 to 2023 was described (Figure 1). The maximum productivity was observed in 2021 (n = 412) while the minimum productivity was observed in 2001 (n=44). The growth analysis of the number of publications during the study period shows an exponential growth trend pattern. The annual publication increases yearly with a total growth rate of 7.9%.

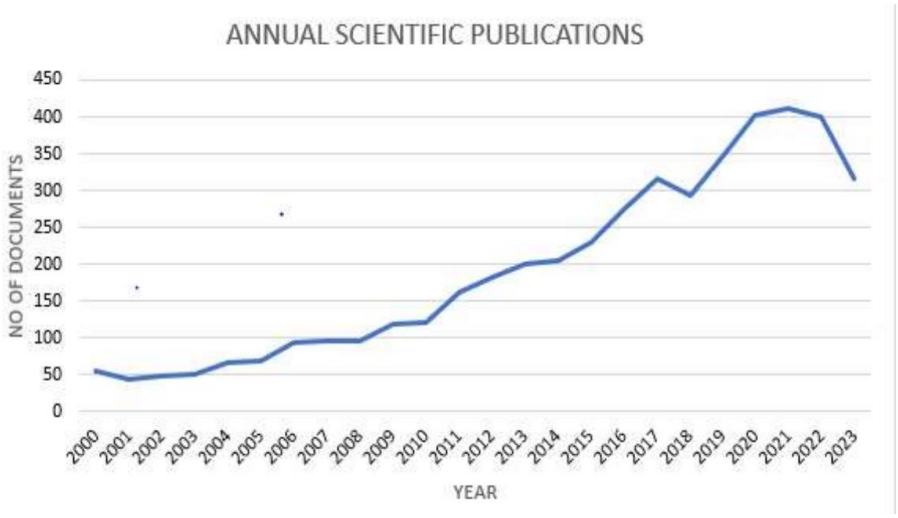

Figure 1: Annual Publication Trends

Analysis of most cited articles

The top 10 papers with the highest citation frequencies published during the period 2000–2023. Chen *et al* journal on "Effect on left ventricular function of intracoronary transplantation of autologous bone marrow mesenchymal stem cell in patients with acute myocardial infarction" in the 'American Journal of Cardiology' has the highest number of citation (703). The top 10 most frequently cited journals are listed in table 1.

Table 1: Top 10 most frequently cited articles on cardiovascular diseases

Rank	Author	Title	Journal	Year	Total Citation
1	Chen, SL et al.	Effect on left ventricular function of intracoronary transplantation of autologous bone marrow mesenchymal stem cell in patients with acute myocardial infarction.	American Journal of Cardiology	2004	703
2	Wang, GuoKun et al.	Circulating microRNA: a novel potential biomarker for early diagnosis of acute myocardial infarction in humans	European Heart Journal	2010	346
3	Liu J et al.	Predictive value for the Chinese population of the Framingham CHD risk assessment tool compared with the Chinese multiprovincial cohort study	Journal of the American Medical Association	2004	273

4	Hu, Xin yang et al.	Transplantation of hypoxia-preconditioned mesenchymal stem cells improves infarcted heart function via enhanced survival of implanted cells and angiogenesis	Journal of Thoracic and Cardiovascular Surgery	2008	207
5	Zhang, Qingjun et al.	Endothelium-specific over-expression of class III deacetylase SIRT1 decreases atherosclerosis in apolipoprotein E-deficient mice	Cardiovascular Research	2008	165
6	Wu, Yang feng et al.	Prevalence, Awareness, Treatment, and Control of Hypertension in China Data from the China National Nutrition and Health Survey 2002	Circulation	2008	158
7	Ma, J et al.	Time course of myocardial stromal cellderived factor 1 expression and beneficial effects of intravenously administered bone marrow stem cells in rats with experimental myocardial infarction	Basic Research In Cardiology	2005	156
8	Xu, FP et al.	Leptin induces hypertrophy via endothelin-1-reactive oxygen species pathway in cultured neonatal rat cardiomyocytes	Circulation	2004	154
9	Li, Xiao Hong et al	Bone marrow mesenchymal stem cells differentiate into functional cardiac phenotypes by cardiac micro environment	Journal of Molecular and Cellular Cardiology	2007	131
10	Wang, TZ et al	Cell-to-cell contact induces mesenchymal stem cell to differentiate into cardiomyocyte and smooth muscle cell	International Journal of Cardiology	2006	130

Contribution of leading countries

Analysis of different countries that contribute to the production of articles on cardiovascular diseases was conducted. The top 10 countries contributing to cardiovascular research is summarized in table 2. From the analysis, USA is the country with the most publications in this field, followed by China and Germany, whose publications account for 13.28%, 8.93%, and 3.23% of the total publications respectively. Figure 2 shows the number of publications by the 10 countries. Among the top 10 countries, 4 countries were in Europe, 2 countries were in Asia, 2 countries were in Australia and 2 countries were in the Americas, which show that cardiovascular diseases have attracted global attention.

Table 2: Leading 10 countries with a minimum productivity of 50 articles.

Rank	Countries	Articles	SCP	MCP	Frequency
1	USA	611	579	82	0.143
2	China	411	366	45	0.089
3	Germany	149	110	39	0.032
4	Netherlands	139	101	38	0.030
5	Australia	133	84	49	0.029
6	Canada	133	97	36	0.029
7	United Kingdom	125	65	50	0.027
8	Japan	97	90	7	0.021
9	Spain	91	70	21	0.020
10	Italy	82	59	23	0.018

SCP; Single Country Publications, MCP; Multiple Countries Publications

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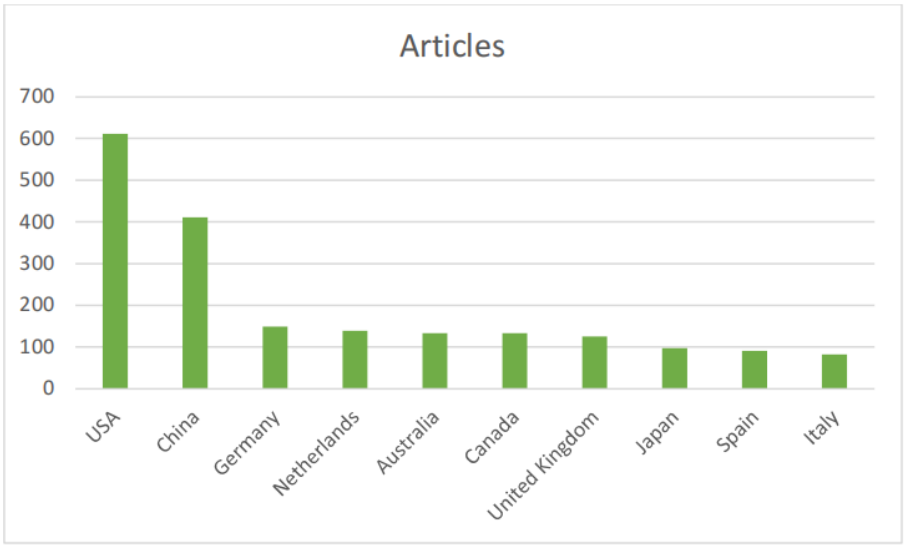

Figure 2: Leading countries in the field of cardiovascular research

Cooperation of leading countries/regions

The most impactful science comes from international collaboration, which is based on the flow and integration of knowledge. Different countries/regions may have different emphases when studying cardiovascular drugs, although resource complementarity and continuous innovation impulses can be achieved by collaboration. International collaborative publications are joint papers written by scholars from multiple countries. The number of cooperative countries (nCC) or the multiple countries publications (MCP) refers to how many countries a country has cooperated with in a certain field. It can be concluded from Table 1 that among all countries, the USA, the UK, and Australia have more cooperation with other countries. To better understand the current state of international collaboration in the cardiovascular field, a network graph between the top 10 countries/regions was created using the DDA software (Figure 3). The circle size symbolizes the countries' contributions, the lines connecting the circles indicate cooperation between countries, and the thickness of the lines indicates the number of collaborative publications. The line between the USA and China is the thickest, which indicates that the number of cooperative publications between the USA and China is the largest in this field, followed by the number of cooperative publications between the USA and Canada.

Figure 3: Network visualization map of international research collaboration among countries with minimum research output of 50 documents on cardiovascular drugs.

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Contribution of leading institutions

Statistics on the contributions of leading institutions can help us identify the most authoritative professional institutions in the field of cardiology. The analysis of the 4601 articles used in this research showed the number of institutions that have contributed in the publication of articles in the field of cardiology. Top institutions contributing to cardiovascular research is listed in table 3. The institution 'University of Oxford' has the highest number of articles contributing 8.7% of the total articles.

Table 3: Top Institutions contributing to cardiovascular research

Rank	Institution	No. of articles	Countries/Region
1	University Of Oxford	402	England
2	University Of Toronto	262	Canada
3	Harvard Medical School	228	United State
4	Sichuan University	200	China
5	University Of Michigan	192	United State
6	University Of Cambridge	178	England
7	Imperial College London	173	England
8	University Of Copenhagen	166	Denmark
9	King's College London	154	England
10	University Of Edinburgh	153	Scotland

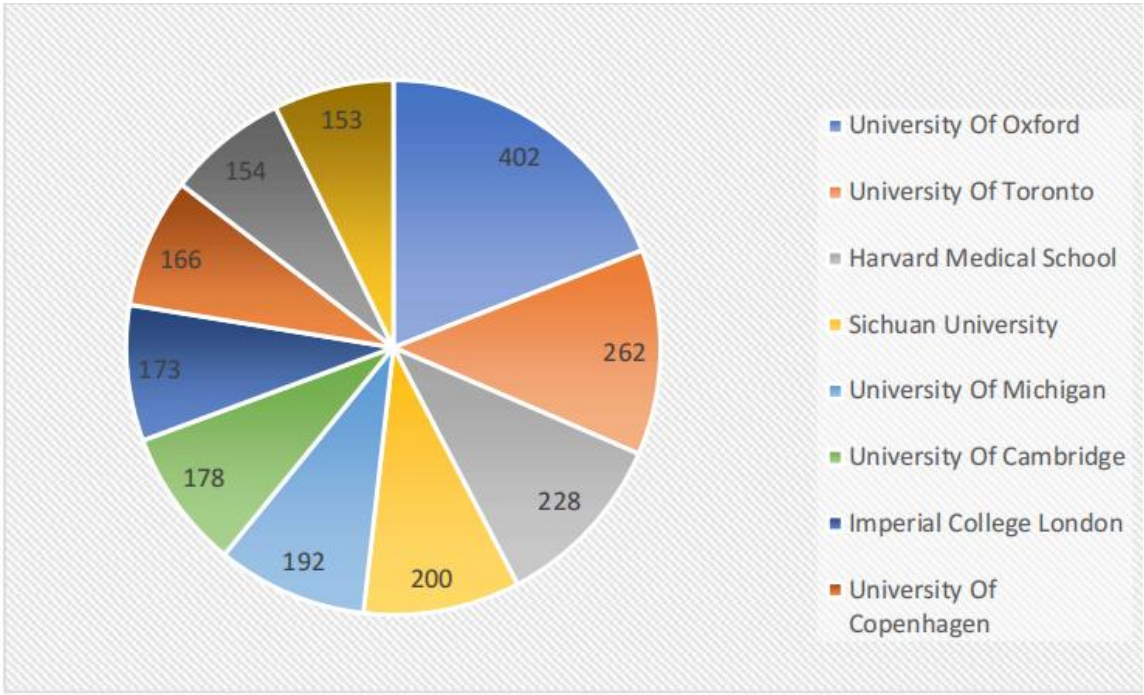

Figure 4: Top 10 Institutions contributing in cardiovascular research

Contribution of leading journals

The collation of published journals revealed that a total of 200 journals published cardiovascular diseases related research from 2020 to 2023. The top 10 journals by the number of articles are displayed (Table 4).

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Table 4: Top 10 journals publishing papers in Cardiovascular research

Rank	Journals	No of papers	Average citation	Impact factor (IF)
1	Journal of the American college of cardiology	49	3.30	2.8
2	Journal of Cardiovascular surgery	15	2.21	1.4
3	European heart journal	11	3.89	39.3
4	The American journal of cardiology	18	3.42	24
5	Circulation	17	5.73	37.8
6	Cardiovascular Research	21	10.69	10.8
7	European Heart Journal. Cardiovascular Imaging	20		6.2
8	European Heart Journal. Cardiovascular Pharmacotherapy	11	7.36	7.1
9	Journal of the American Heart Association	14	8.85	5.4
10	Atherosclerosis	15	2.11	5.3

Contribution of leading authors

Statistics on leading authors can help us understand the top experts in the cardiovascular field. A total of 23,847 authors were counted among 4,601 articles with each publication having an average of 7.1 authors. The leading ten authors in the field published at least 25 papers (table 5). Among the retrieved data, 520(11.30%) were single-authored publications and the remaining articles were multi-authored publications (n=4081, 88.69%). The degree of collaboration among the authors in the field of lifestyle-based preventive cardiology was therefore 81.7%. The degree of international co-authorship was 16.08%.

Table 5: Most productive Authors in the field of cardiovascular diseases

Authors	Articles (n=4601)	Articles Fractionalized
Wang Y	46(1.0%)	6.49
Zhang Y	41(0.9%)	5.39
Liu Y	39(0.8%)	4.03
Li J	37(0.8%)	4.62
Wang J	34(0.7%)	4.38
Liu J	26(0.6%)	3.18
Chen J	25(0.5%)	3.30

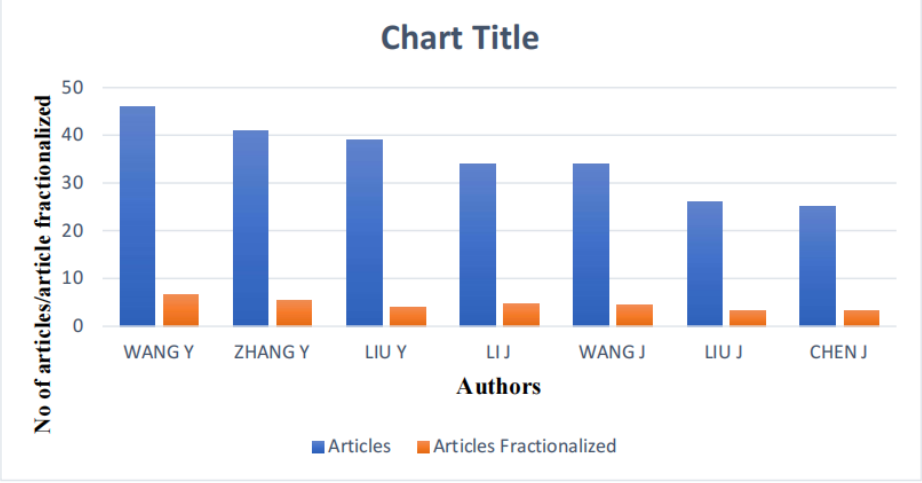

Figure 5: Number of articles produced by authors.

Analysis of author keywords

A keyword collection based on abundant academic findings in a research field over a long period of time can reveal the overall characteristics, developmental trends, and internal connections of such research. The top 10 author keywords from 4,601 publications were sorted and displayed in a chart in this study (Figure 6). The number on the chart represents the times that the author keywords appeared. A total of 12,493 author keywords were obtained. The most occurring keywords were; Humans", "Risk factors", "Treatment outcome", "Risk assessment", "Male", "Female", "Cohort studies", "Evidence-based medicine", "Randomized controlled trials as a topic".

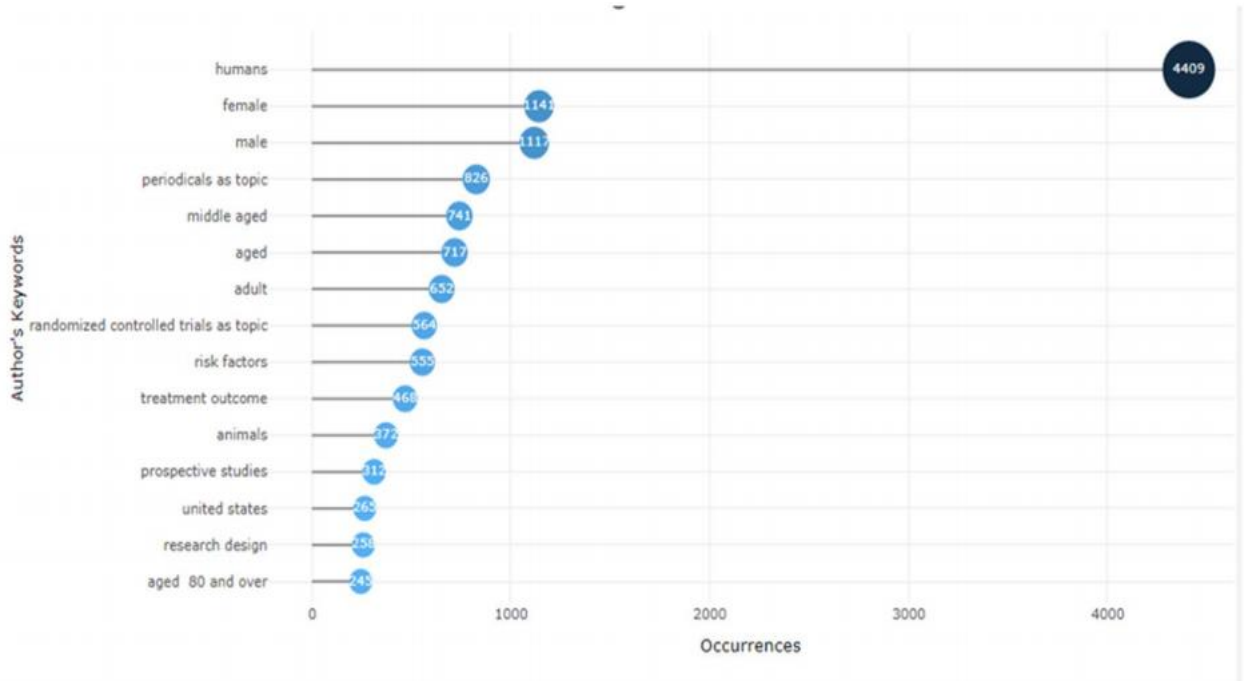

Figure 6: Most frequent author's keywords.

4. DISCUSSION

The comprehensive analysis of global research output in cardiovascular drugs and heart diseases offers valuable insights into the current state of the field [1]. From 2000 to 2023, the number of publications related to cardiovascular diseases and drug development has steadily increased, with over a hundred papers published in the past twenty years alone, indicating a significant amount of research attention directed towards cardiovascular diseases. Most of these articles adopt experimental designs such as double-blind randomized controlled trials, have sufficient sample sizes for obtaining stable results, and undergo peer review processes to ensure scientific rigor and accuracy[5]. The bibliometric analysis conducted in this study provides valuable insights into the landscape of research on cardiovascular drugs and heart diseases. Our findings indicate a steady increase in publications in this field, reflecting the growing interest and importance of addressing cardiovascular health globally [12].

The growth in research output can be attributed to several factors. Firstly, the increasing prevalence of cardiovascular diseases worldwide has driven researchers to explore new therapeutic approaches and drug targets [1]. Additionally, advancements in technology and research methodologies have enabled more in-depth studies in this field, leading to a richer body of literature [13]. Collaboration among researchers and institutions has also played a crucial role in advancing research on cardiovascular drugs and heart diseases [7]. Our analysis reveals a network of collaboration that spans across continents, highlighting the global effort to tackle cardiovascular health challenges. Collaborative research allows for the exchange of ideas, resources, and expertise, leading to more impactful research outcomes [14]. According to the author keywords chart (Figure 6), and highly cited papers, it can be found that the research on cardiovascular drugs has been the first place and plays a leading role in this field for the last decade [6]. The key analysis in our study identifies several key themes in cardiovascular drugs and heart diseases research. Terms such as "hypertension management," and "precision medicine" emerge as prominent areas of focus. These themes reflect the diverse aspects of cardiovascular health being studied,

from basic science to clinical practice [15]. Through software-based co-occurrence analysis of the publishing countries, it is evident that the United States holds a central position in this field, closely collaborating with countries such as Canada and the United Kingdom [3]. The United States contributed 27% of the global cardiovascular research output, the highest for a single country.

5. CONCLUSION

Conclusion

In conclusion, the assessment of the global research output on cardiovascular drugs and heart diseases underscores the dynamic nature of the field and the continuous pursuits of innovative solutions to tackle the ever-evolving challenges associated with cardiovascular health. The findings emphasize the importance of fostering interdisciplinary collaborations and promoting the equitable distribution of research efforts to address the diverse needs of populations worldwide. Furthermore, the collaborative nature of research in this domain was evident through the network analysis, revealing the interconnectedness of researchers, institutions, and countries. Continued investment in research in this field is crucial for improving patient outcomes and reducing the global burden of cardiovascular diseases.

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Availability of data and materials

All data presented in this manuscript are available on PubMed database using the search query listed in the methodology section.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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