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NEW INSIGHTS OF CARDIOVASCULAR DISEASES IN MOROCCO BETWEEN 1953 AND 2024: A BIBLIOMETRIC ANALYSIS

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Cardiovascular diseases are critical health conditions characterized by disturbed heart and vessel function. These conditions are serious health issues that require intensive attention to avoid complications. This study was used bibliometric analysis to assess scientific research output on cardiovascular diseases in Morocco during 1953-2024. The main goal of the present study was to evaluate scientific production and research development with the aim of highlighting the available outcomes found by different researchers to manage cardiovascular diseases in Morocco. The first step involves publication collection using Scopus database. The extracted data were imported into VOSviewer software and analyzed to determine annual scientific production, author and institution productivity, and relevant sources. The results revealed that the number of articles published using different study types has increased significantly in the last decade. Publications of natural remedies remain scarce, particularly according to a map of co-occurrence keywords. Based on the search approach, a bibliometric analysis of cardiovascular diseases identified different potential subjects for future research. Consequently, research on the biological properties of natural products against different cardiovascular diseases is of paramount importance to fully unveil the mechanism of action of bioactive compounds extracted from natural products

***Keywords**: Cardiovascular diseases, heart failure, hypertension, atherosclerosis, natural products, phytochemistry*

INTRODUCTION

Cardiovascular diseases (CVDs) are complicated multifactorial critical conditions that have been highlighted as a considerable global burden for both health, healthcare systems and their complications are considered a substantial health concern. They include different ailments, including cardiac muscle disease and vascular disease of different organs (heart, brain, and vital organs)[1]. Evidence has shown that inflammation plays a pivotal role in the installation and progression of cardiovascular diseases, leading to the appearance of clinical symptoms[2]. Statistically, CDVs are the third leading cause of death annually, reaching approximately 24 million cases by 2030[3]. Evidence supporting the reduction of classic CVD risk variables, such as lipids, blood pressure, and blood glucose, coupled with quitting smoking, to prevent and minimize CVD occurrence is well-established[4]. According to Elkafssaoui et al., 1455 cases of cardiovascular diseases occur in Morocco each year. The authors reported that the main causes of cardiovascular disorders were arterial diseases, cardiomyopathies, valvulopathies, and ischemic heart disease[5]. Atherosclerotic cardiovascular disease is associated with a high incidence of cardiovascular diseases. The condition is characterized by the accumulation of lipids in the arterial wall, local

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inflammation, oxidative stress and endothelial destruction[6]. Various strategies have been adopted to manage CVDs, including cholesterol reduction, increased physical activity, decreased sodium intake, and the use of natural agents[7]. In fact, herbs and plant-derived extracts have a significant place in the traditional medical habits of different cultures in treating and preventing CVDs [8]. The pleiotropic effects of natural products make them potential candidates for new and effective drug discovery.

In the age of big data, bibliometric analysis is a comprehensive knowledge system that can objectively and quantitatively analyze available data in particular fields [9]. This statistical tool aids in summarizing research hotspots and advancement trends in the field of cardiovascular diseases using data extracted from different databases. the pathophysiology of CVDs and risk factors have been elucidated. However, despite significant progress in this area of study, glaring gaps in the body of knowledge call for careful bibliometric analysis. Using a graphical representation, bibliometric analysis shows the arrangement and dissemination of knowledge on a specific topic [10]. At present, there is no bibliometric analysis of cardiovascular diseases in Morocco. To predict future research paths, the present study uses the Scopus database and VOSviewer to create and evaluate visual diagrams from various angles that highlight the focal points of research in this field.

MATERIAL AND METHODS

Data collection and bibliometric analysis

This review aimed to conduct a deep screening for scientific data related to cardiovascular disease in Morocco using the Scopus database. Data search was launched using the following words ‘’cardiovascular’’ and ‘’diseases’’, and ‘’Morocco’’ as the main keywords selected to perform the search strategy. More than 300 articles related to cardiovascular diseases in Morocco were gathered and checked for relevance, scope, and inability to provide full text. Data extracted from the Scopus database were used to create visual representations using VOSviewer. The Scopus database is an online bibliographic multidisciplinary publication database developed by Elsevier that covers more than 27950 active peer-reviewed journals in different fields. Additionally, it supports a range of software applications for bibliometric data retrieval, including countries, institutions, authors, titles, and publication dates.

The examination of data extracted from the Scopus database consists of the following steps: the significant themes discussed and researched were identified by analyzing the data, which were exported to VOSviewer for bibliometric analysis and visualization of the findings **(Fig. 1)**.

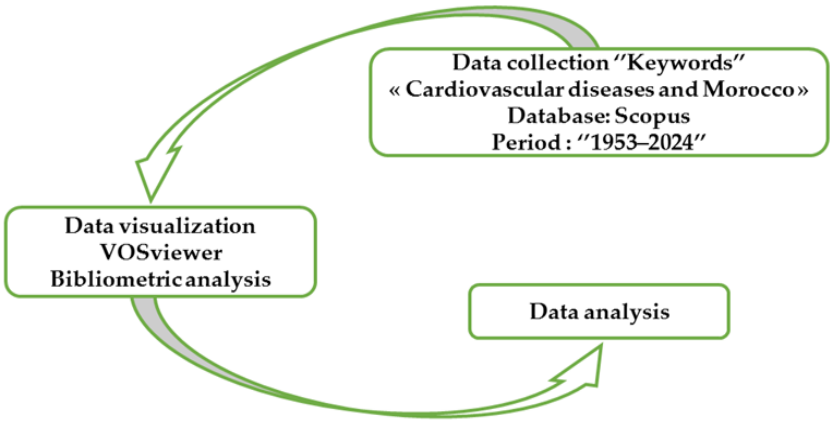

Fig. 1: Methodology procedure.

RESULTS AND DISCUSSION

Results

Publication trend and historical background

Screening of the Scopus database revealed that the initial research on cardiovascular diseases in Morocco was a 1953 paper entitled "Three therapeutics in present cardiology in Morocco" [11]. The present study used a total of 308 papers that were found in the Scopus database, the majority of them were articles (79.5%), reviews (11.7%), conference papers (3.2%), book chapters (1%), and others (4.6%). The overall research productivity in Morocco concerning cardiovascular diseases accounted for 0.03% of global publications (848429 publications). The annual productivity of Morocco increased from 98 in 2013 to 310 in 2024. The annual average productivity growth in Morocco was approximately 4.33 over 71 years. According to the Scopus database, the first paper on cardiovascular diseases was published in Morocco in 1953. Notable publication delays were registered from 1954 to 1984 and from 1987 to 1993. Subsequently, scientific production steadily increased, particularly after 2018, when the highest number of publications published annually was 30 **(Fig. 2)**. The development of scientific production in Morocco for cardiovascular diseases could be explained by advanced technologies and the search for effective agents to treat pathologies. Of the 308 articles on cardiovascular disease, 210 articles (68.18%) were published within the last decade**.**

Contributing authors

Most authors who have contributed to advancing scientific studies on cardiovascular diseases in Morocco are shown in **Fig. 3**. Based on the data extracted from the Scopus database, the most contributing authors were Abouqal R, Kunst A.E, and Nejjari C with 8 papers for each. It is noteworthy that Abouqal R, significantly contributed to the field of research, which marks its position as a promoter of cardiovascular disease in Morocco. One of the most highly cited papers was entitled '' Withholding and withdrawing life-sustaining therapy in a Moroccan Emergency Department: An observational study", with 22 citations, whilst his last publication was related to "Adverse effects of COVID-19 vaccines in the Moroccan adults and children during the pandemic"[12]. These authors have improved our understanding of cardiovascular diseases and their clinical complications.

Publication distribution by country

Fig. 4 displays the publication distribution by country. It is clearly shown that Morocco was in the top of the list of countries that participated in the development of research on cardiovascular diseases. This distribution can be explained by the collaboration between Morocco's different research structures and those of other countries. The country analysis showed that Morocco had 216 articles published in the Scopus database between 1953 and 2024, followed by the Netherlands, the United States, and France with 29, 28, and 25 documents, respectively.

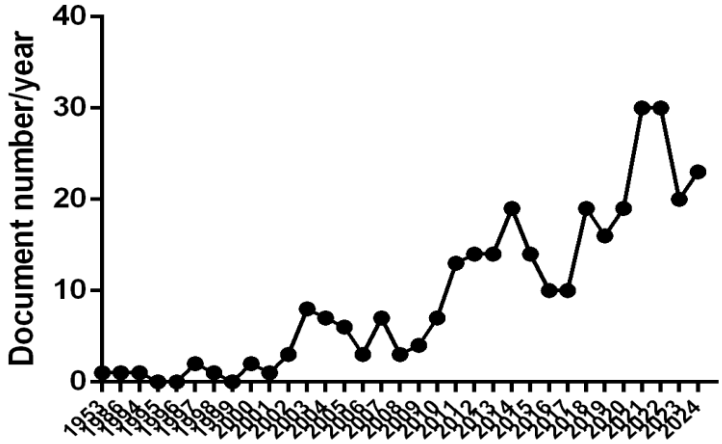

Fig. 2: Documents published in Scopus database during 1953-2024.

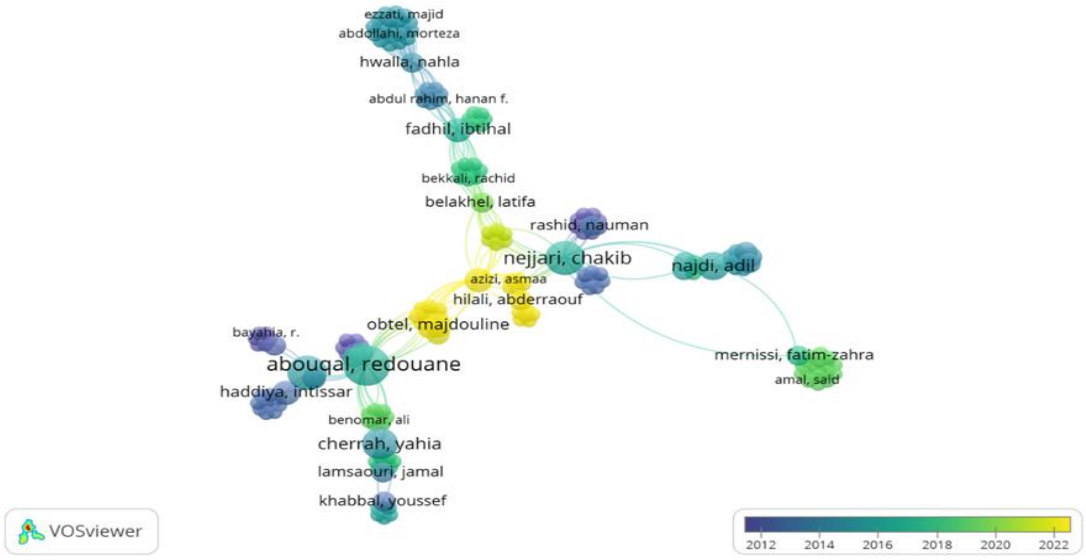

Fig. 3: Map of authors implicated in the cardiovascular disease research in Morocco.

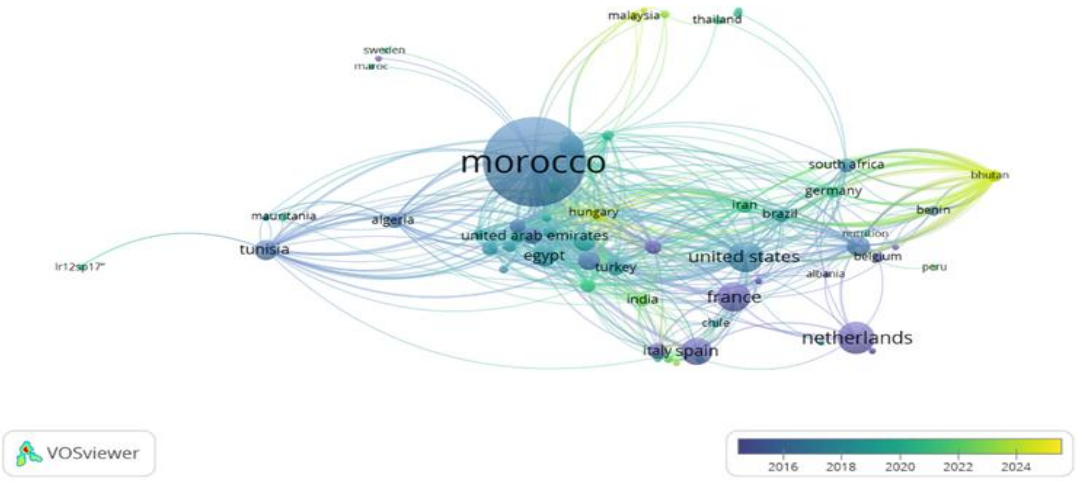

Fig. 4: Bibliometric analysis of countries in collaboration with Morocco.

Interdisciplinary areas

Research on cardiovascular diseases comes from various specialties, including ‘’medicine’’ that dominates the field with 228 documents (50.8%). The importance of this specialty reflects the paramount importance of clinical medicine in understanding critical conditions. Furthermore, the results reveal the significant impact of medical professionals in determining the direction of cardiovascular disease research. Pharmacology, toxicology, and pharmaceutics were the 48 papers. In addition, biochemistry, nursing, immunology, microbiology, chemistry and have contributed to this development of research in the field, whereas publications are still limited.

Keywords analysis

A bibliometric analysis of author keyword co-occurrence is depicted in **Fig. 5**. Results revealed 860 keywords that occurred at least 3 times in the author keywords. These keywords were associated with 7 clusters. The keywords ‘’Human’’, ‘’controlled study’’, ‘’obesity’’, ‘’risk factor’’ and ‘’body mass’’ were the recurrent keywords in the scheme for obvious causes, as we limited our study to cardiovascular diseases in Morocco. **Fig. 6** shows several nodes with different sizes representing the frequency of each keyword, and the occurrence of a keyword is schematized by the relation between nodes. Phytochemicals, polyphenols, flavonoids,

antioxidants, COVID-19, and plant leaves were the most recent 2020 clusters **(Fig. 6)**. Therefore, the least frequent keyword (represented by a diffuse hue) indicates that the research issue remains unexplored and requires further investigation in future studies (possible topic). Examples of such studies include polyphenols, flavonoids, and plant extracts. These uncharted territories offer researchers the chance to fill important knowledge and treatment gaps regarding cardiovascular diseases using natural resources that are safer, more efficacious, and not expensive.

The occurrence map analysis showed different cross-linked clusters, including participants (Human, child, infant, rat, and mouse), study type (controlled study, retrospective study, observational study, prospective study, and case report), disease complications (obesity, fever, tachycardia, neurologic disease, hypertriglyceridemia, metabolic syndrome), source (medicinal plant, olive tree, Ajuga, and plant seeds), and biological activities (antioxidant, antihypertensive, antidiabetic, anti-inflammatory, and antineoplastic).

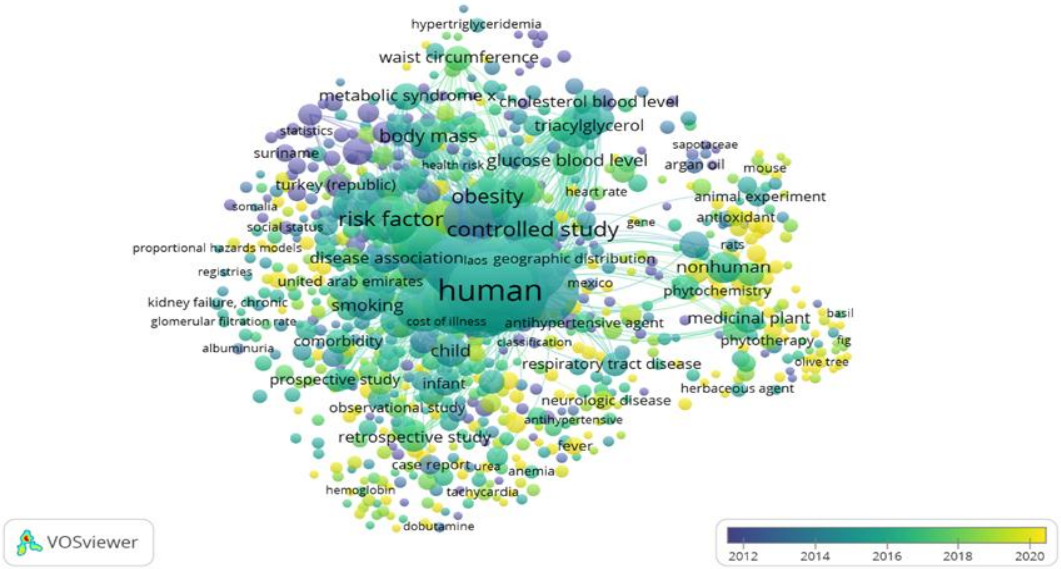

Fig. 5: Network visualization of keywords

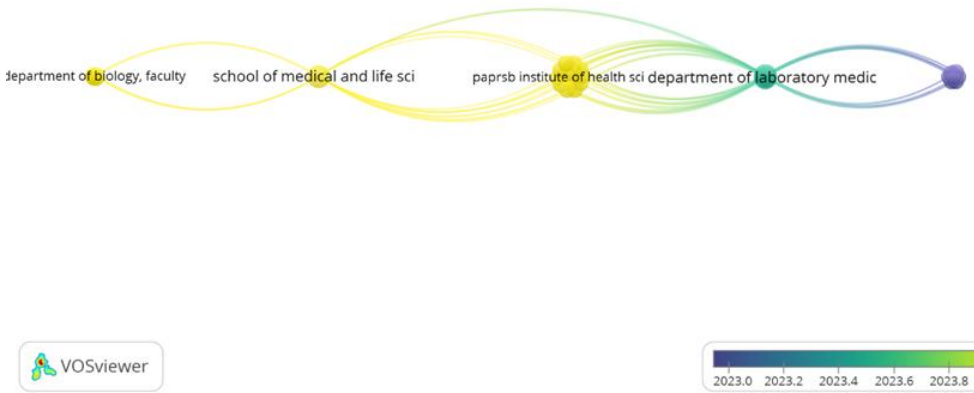

Fig. 6: Leading institutions publications on cardiovascular diseases.

Organization contributing

Bibliometric analysis revealed the institutions implicated in the scientific research development on cardiovascular diseases in Morocco. A total of 27 institutions were classified into three clusters (Cluster 1, Cluster 2, and Cluster 3). The first comprises 12 items, including the Euromed Research Center, the Euromed Faculty of Pharmacy, and School Engineering and Biotechnology and Laboratory of Human Pathologies Biology, Faculty of Sciences Mohammed V. While, the second Cluster contains 9 items, particularly the High Institute of Nursing Professions and Health Techniques Casablanca, and Biology and Health, Faculty of Sciences Abdelmalek Essaadi. The third Cluster comprises 6 items, such as the Department of Biology, Faculty of Sciences Mohammed V, Department of Chemistry, Faculty of Sciences Mohammed V **(Fig. 6)**.

Department of Biology, Faculty of Sciences Mohammed V University was classified on the top of the list of institutions working on cardiovascular diseases in collaboration with different international organizations, including School of Medical and Life Sciences, Sunway University Malaysia, and Department of Laboratory Medicine, Faculty of Applied Medical Sciences, Umm-AlQura University.

Influential papers

The screening of all articles found in the Scopus database showed that the most influential articles were ‘’ Prevalence of type 2 diabetes mellitus, other cardiovascular risk factors, and cardiovascular disease in Turkish and Moroccan immigrants in North West Europe: A systematic review’’ by Uitewaal et al., ‘’The impact of dietary habits and metabolic risk factors on cardiovascular and diabetes mortality in countries of the Middle East and North Africa in 2010: A comparative risk assessment analysis’’by Ashkan et al. and ‘’ Cardiovascular disease in the Eastern Mediterranean region: Epidemiology and risk factor burden’’ by Turk-Adawi et al., which have been cited 113, 99, and 99 times, respectively. Furthermore, Berrougui et al. and Mekhfi et al. published two articles under the following titles ‘’ Hypolipidemic and hypocholesterolemic effect of argan oil (*Argania spinosa* L.) in Meriones shawi rats’’ and ‘’ Platelet anti-aggregant property of some Moroccan medicinal plants’’, respectively. Both articles treated the importance of natural resources for treating cardiovascular diseases.

Discussion

To the best of our knowledge, this is the first bibliometric analysis designed to examine cardiovascular disease publications in Morocco over the past seventy years. The analysis of data extracted from the Scopus database revealed a significant increase in publications during the last decade. This study presents the cooperative behaviors of different authors and countries as well as their contributions to the advancement of research in the field. In fact, the treatment of the obtained results revealed that the Moroccan authors treated different subjects to improve our understanding of cardiovascular diseases, risk factors, complications, and different strategies used to manage critical conditions.

Cardiovascular diseases are common disorders and affect people of different ages. Several etiologies exist for these critical conditions, accounting for 17.9 million lives annually [13]. Several CVD etiologies have been enlightened, including obesity, diabetes, cancer, and alcohol [14]. Numerous CVDs can be caused by oxidative stress. cardiac muscles are highly dependent on oxidative phosphorylation for appropriate function and have one of the greatest densities of organelles, particularly mitochondria [15]. They produce considerable amounts of reactive oxygen species (ROS) during oxidative phosphorylation, leading to damage to cardiac components, such as lipids, proteins, and DNA [16]. These compounds lead to endothelial dysfunction, inflammation, and disturb vasomotor function [17]. To manage CVDs appropriately, different experimental models were adopted to evaluate different treatment approaches, including chemical agents and natural combinations [18].

Conventional treatments include chemical agents such as statins [19]. These chemical medications exert their effects by inhibiting 3-hydroxy-3-methylglutaryl-coenzyme A-reductase, which is implicated in cholesterol synthesis and subsequently forms atherogenic low-density lipoproteins (LDL). LDLs play a pivotal role in CVD pathogenesis, including

myocardial infarction, ischemic stroke, peripheral arterial occlusive disorders, and death from CVDs [20]. Statins affect complexes I and II as well as mitochondrial complexes III and IV. They inhibit the formation of coenzyme Q10, activate PPARα, inhibit kinases and calcium ATPases and mitochondrial complexes, inducing musculoskeletal adverse effects and other side effects [21].

Medicinal plants have long been revered not only for their delectable taste but also for their nutritional value and phytochemical composition. According to the network visualization of keywords, different natural remedies were examined to treat CVDs, including argan oil, olive tree, basil, fig and other medicinal plants (**Fig.** 6). Notably, there is a scarcity of keywords related to the biological properties of natural remedies against CVDs, which presents a fertile field for developing new experimental protocols to evaluate the cardioprotective effects of natural remedies. In fact, since the dawn of human civilization, herbs have played a fundamental role in civilization due to their culinary and therapeutic properties [18].

Sari et al. conducted an experimental study to examine the cardioprotective effects of the ethanolic extract of *Ociumum basilicum* in rats. The authors found that the extract exerted significant cardioprotective effects against the deleterious effects of cisplatin [22]. In the same context, Islam et al. found that the aqueous extract of *O. basilicum* counteracted the cardiotoxicity and heart failure induced by doxorubicin in an animal model [23]. Several phytochemicals are effective in regulating lipid metabolism imbalance, pro-inflammatory factor synthesis, vascular smooth muscle cell proliferation, cardiomyocyte apoptosis, endothelial cell dysfunction, and calcium intake and release with minimal side effects [24]. The pleiotropic effects of phytoactive compounds make them potential candidates for the prevention and treatment of cardiovascular diseases. further experiments on plant-based extracts and formulations are required to develop safer and more effective CVD medications.

Conclusion

The current study was conducted using quantitative and qualitative information obtained from the Scopus database to enlighten and shift scientific interest in cardiovascular diseases in Morocco. To achieve this, a bibliometric analysis was carried out using data available in the Scopus database and VOSviewer software to evaluate the current state of the study in this field. Results revealed that significant interest was granted to CVDs, which resulted in the number of articles published in the last decade. The co-occurrence of keywords showed a limited abundance of those related to medicinal plants and their biological properties against CVDs.

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رؤى جديدة حول أمراض القلب والأوعية الدموية في المغرب بين عامي ١٩٥٣ و ٢٠٢٤: تحليل ببليومتري

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من المعروف أن أمراض القلب والأوعية الدموية هي حالات صحية حرجة تتميز باضطراب وظائف القلب والأوعية الدموية. وأن هذه الحالات الصحية خطيرة وتتطلب عناية فائقة لتجنب المضاعفات التى تحدث أثناء العلاج . وقد استخدمت هذه الدراسة التحليل الببليومتري لتقييم مخرجات البحث العلمي حول أمراض القلب والأوعية الدموية في المغرب خلال الفترة ١٩٥٣-٢٠٢٤. وكان الهدف الرئيسي من هذه الدراسة تقييم الإنتاج العلمي وتطور البحث العلمى ، بهدف تسليط الضوء على النتائج المتاحة التي توصل إليها مختلف الباحثين لحالات أمراض القلب والأوعية الدموية في المغرب.

تتضمن الخطوة الأولى للمقالة جمع الأبحاث المنشورة باستخدام قاعدة بيانات سكوبس. ثم تم استيراد البيانات المستخرجة إلى برنامج VOS viewer ، وحُللت لتحديد الإنتاج العلمي السنوي، وإنتاجية المؤلفين والمؤسسات، والمصادر ذات الصلة.وأظهرت النتائج أن عدد المقالات المنشورة باستخدام أنواع مختلفة من الدراسات قد ازداد بشكل ملحوظ خلال العقد الماضي. ولا تزال الأبحاث التى تتضمن العلاجات الطبيعية نادرة، خاصة وفقًا لخريطة الكلمات المفتاحية المتزامنة.

و بناءً على منهج البحث، حدد تحليل ببليومتري لأمراض القلب والأوعية الدموية مواضيع بحثية محتملة مختلفة. وبالتالي، يُعدّ البحث في الخصائص البيولوجية للمنتجات الطبيعية ضد أمراض القلب والأوعية الدموية المختلفة ذا أهمية بالغة للكشف الكامل عن آلية عمل المركبات النشطة بيولوجيًا والمستخلصة من المنتجات الطبيعية.