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Original article

Bibliometric analysis of Peruvian scientific production in cardiology and cardiovascular medicine

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The authors declare that they have no conflicts of interest.

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ABSTRACT

Objective. To determine the characteristics and trends of the articles published on cardiology and cardiovascular medicine in the Peruvian context, and to understand how it has changed over the years. **Materials and methods**. We carried out a bibliometric study of original articles published up to 2020 by Peruvian authors in journals indexed under the category "Cardiac & Cardiovascular Systems" in Web of Science (WOS). The articles were included according to the selection criteria in the Rayyan web application and the bibliometric analysis was conducted using the Bibliometrix package, which is in R programming language, and VOSviewer. **Results**. A total of 159 published articles were included, and we observed an increase in the number of publications since 2015. The most cited article was a clinical trial by Fitchett *et al*. and published in 2016. Miranda JJ was the Peruvian author with the highest number of published articles followed by Hernández AV and Málaga G. The institutional affiliation with the highest number of original articles was Universidad Peruana Cayetano Heredia. Regarding the terms or keywords, we found that most of the published studies had terms related to epidemiology, while in the most recent articles, the terms were related to outcomes or specific interventions that are used in clinical studies. **Conclusions**. In the last five years, there has been an increase in the scientific production on cardiology and cardiovascular medicine by authors with Peruvian institutional affiliation, with a larger production from the Universidad Peruana Cayetano Heredia. The journal with the highest number of publications by authors with Peruvian institutional affiliation on cardiology and cardiovascular medicine was Circulation, where two of the most cited articles with Peruvian institutional affiliation were also found.

Keywords: Cardiology; Cardiovascular diseases; Bibliometric; Publications; Peru (source: MeSH NLM).

Introduction

Cardiovascular disease (CVD) is the leading cause of death and a major contributor to morbidity and mortality worldwide [1]. Prevalent cases of CVD are expected to have doubled between 1990 and 2019, exceeding 500 million globally [1]. Likewise, the burden and mortality from CVD has increased significantly during the same period, with years of life lost due to disability doubling from 17.7 million to 34.4 million, and the number of deaths from CVD increasing by more than 6 million between 1990 and 2019 [1]. These figures are much higher in low- and middle-income countries [2], where almost 80% of deaths occur [2]. In this sense, research in cardiology and CVD is important because of the constant increase in morbidity and mortality due to these pathologies, which have caused great concern in health systems around the world, especially in countries with limited health resources [3].

Scientific research is a mechanism to study and improve the health of populations, and to curb the increasing burden of chronic noncommunicable diseases through the principles of evidence-based medicine, public policy making, and allocation of national and international funds [4]. However, middle- and low-income countries have the greatest challenges due to the scarcity of evidence-based information, the quality of the information, restrictions in the use of health databases and the allocation of resources for research [4-6], all of which leads to low scientific production on CVD [7]. Therefore, bibliometric studies are ideal to address this problem, since they provide information on the research process, volume, evolution, visibility and structure, in order to assess the scientific activity and impact of both the research and the sources [8].

There are few records of bibliometric analyses regarding scientific production in cardiology and cardiovascular health, most of which include authors from the European Union, the United States, Asia, and Cuba [9,10]. Currently, there is no record of Peruvian scientific production in cardiology and cardiovascular health. Therefore, the aim of this study was to determine the characteristics and trends of articles published on cardiology and cardiovascular medicine in the Peruvian context, and to understand how it has changed over the years.

Materials and methods

We carried out a bibliometric analysis of original articles published by Peruvian authors in journals indexed under the category "Cardiac & Cardiovascular Systems" in Web of Science (WOS).

Search strategy

The search strategy included the terms "Peru OR Peruvian" searched in all WOS fields ("All Fields") under the category "Cardiac & Cardiovascular Systems", and only document types under the classification of "Articles" were selected. The search was conducted on September 11, 2021. We considered including only articles published up to 2020 because 2021 is still ongoing. No language restrictions were considered.

Article selection

The metadata of the complete records identified during the search were downloaded as a .ciw file. They were then imported into the Rayyan web application, where two authors (FABL and GWBM) independently reviewed and selected the titles, abstracts and authors of each of the records that met the inclusion criteria: original article published up to the year 2020 with at least one author with affiliation to a Peruvian institution. Conflicts during the selection process were solved by consensus among the reviewers (FABL and GWBM). The WOS "Accession Number" of each of the records that were not included was extracted to exclude them from the initial search and obtain the final complete records for the bibliometric analysis.

Bibliometric analysis

The bibliometric indexes were obtained using the Bibliometrix package which is in R programming language [11]. The VOSviewer software version 1.6.17 (Leiden University, Leiden, The Netherlands) [12] was also used to elaborate bibliometric networks based on co-authorship, using information on the names of the authors, institutional affiliations, and keywords from the retrieved records. Prior to network analysis, data standardization regarding authors, institutional affiliation and keywords was carried out manually to eliminate redundancies and inconsistencies by creating thesauri in .txt format under the two-column format (label and replace by) as established in the VOSviewer software manual version 1.6.17 [13]. Microsoft Excel was also used to create tables and graphs.

We reported the total number of articles, total number of journals, total number of citations, number of articles published annually, ten articles with the highest number of citations, journals with the highest number of publications, co-authorship network according to authors, co-authorship network according to institutional affiliations, and keyword co-occurrence network.

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Network analyses were conducted using the fractional counting method on documents with: a maximum of 50 authors, a minimum of 1 document per author, association normalization method, node repulsion of 2, node attraction of 1, cluster resolution of 1, minimum cluster size of 1, weight according to number of articles, score for temporality according to average publication per year, and for the case of keyword co-occurrence network we used a threshold of five mentions for co-occurrence in titles and abstracts. Node values were established according to the recommendations of the VOSviewer software manual version 1.6.17 [13].

Ethical considerations

Approval from an ethics committee was not requested for the study because it was an analysis of publications from bibliographic databases.

Results

A total of 174 articles were found; of these, 15 were excluded using the Rayyan web application based on the title, abstract and authorship of each article. The final database included 159 articles, from a total of 63 journals. The average annual number of articles published was 3.61; the highest increase in articles was observed in 2014, and a higher production was found in 2019 and 2020 (26 papers); also, a fourth-order polynomial trend was observed in publications between 1976 and 2020 with an R2 of 0.88 **(Figure 1).**

Collectively, the selected articles had a total of 4854 citations, with an average of 30.53 references per paper. The most cited article was a clinical trial conducted by Fitchett *et al*. and published in the European Heart Journal in 2016 [14]. This article, entitled Heart failure outcomes with empagliflozin in patients with type 2 diabetes at high cardiovascular risk: results of the EMPA-REG OUTCOME® trial, had a total of 568 citations, followed by the article by Packer *et al*. (408 citations) published in 2015 [15] and the one by Penaloza and Arias-Stella. (341 citations) published in 2007 [16]. Most articles by Peruvian authors on cardiology and cardiovascular medicine were published in the Global Heart journal (n = 13), followed by Circulation (n = 12) and Journal of the American Heart Association (n = 10) **(Table 1).**

As for Peruvian authors, Miranda JJ, who is affiliated to the Universidad Peruana Cayetano Heredia, was the author with the highest number of articles published in the area of cardiology, and with a greater presence as of 2014; unlike authors Hernández AV (with Peruvian affiliations to the Universidad San Ignacio de Loyola and Universidad Peruana de Ciencias Aplicadas) and Málaga G (with Peruvian affiliations at Universidad Peruana Cayetano Heredia and Hospital Nacional Cayetano Heredia) who had greater production around the year 2018 according to the average of publications per year. In addition, we observed that Lemor A was the author who has published more articles recently **(Figure 2).**

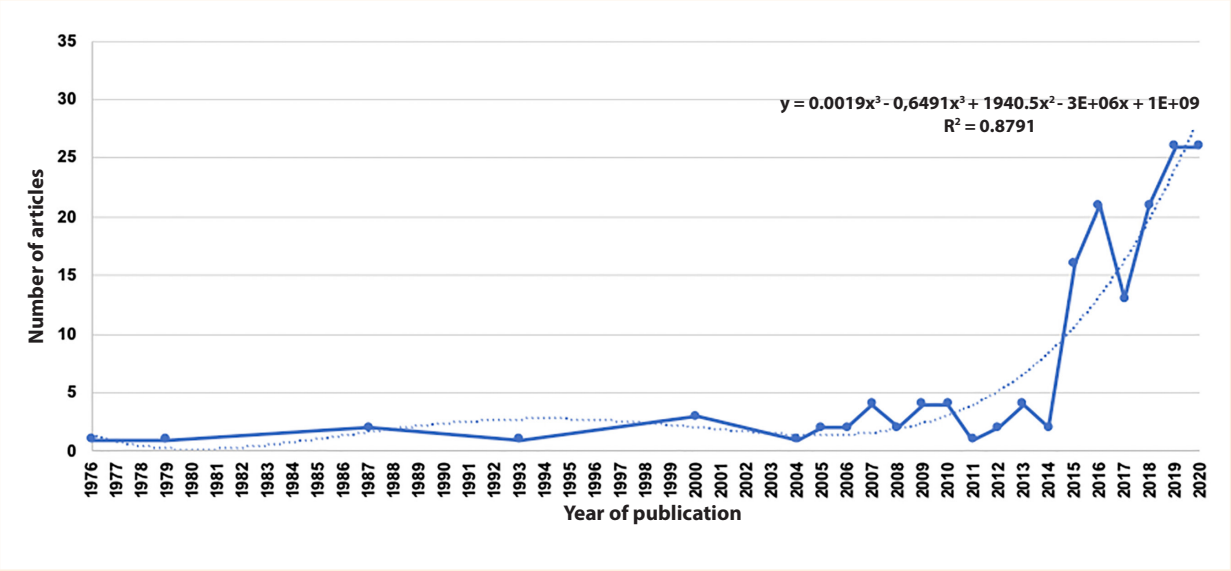

Figure 1. Trend in the publication of articles in cardiology and cardiovascular medicine by Peruvian authors in Web of Science, from 1976 to 2020.

Table 1. Articles with the highest number of citations and journals with the highest number of articles in cardiology and cardiovascular medicine with Peruvian authors.

Characteristic	Total
Article	Number of citations
Heart failure outcomes with empagliflozin in patients with type 2 diabetes at high cardiovascular risk: results of the EMPA-REG OUTCOME® trial[a]	568
Angiotensin receptor neprilysin inhibition compared with enalapril on the risk of clinical progression in surviving patients with heart failure[b]	408
The heart and pulmonary circulation at high altitudes: healthy highlanders and chronic mountain sickness[c]	341
Empagliflozin and Clinical Outcomes in Patients With Type 2 Diabetes Mellitus, Established Cardiovascular Disease, and Chronic Kidney Disease[d]	216
Effects of empagliflozin on risk for cardiovascular death and heart failure hospitalization across the spectrum of heart failure risk in the EMPA-REG OUTCOME® trial[e]	145
International collaborative project to compare and monitor the nutritional composition of processed foods[f]	109
Effect of Alirocumab on Lipoprotein(a) and Cardiovascular Risk After Acute Coronary Syndrome[g]	94
Alirocumab Reduces Total Nonfatal Cardiovascular and Fatal Events: The ODYSSEY OUTCOMES Trial[h]	88
Femoral and Carotid Subclinical Atherosclerosis Association With Risk Factors and Coronary Calcium: The AWHS Study[i]	87
Placebo-controlled study of lisinopril in congestive heart failure: a multicentre study[j]	81
Journal (quartile)	Number of articles
Global Heart (Q1)	13
Circulation (Q1)	12
Journal of The American Heart Association (Q1)	10
American Journal of Cardiology (Q1)	9
American Journal of Physiology Heart and Circulatory Physiology (Q1)	8
European Heart Journal (Q1)	8
Archivos de Cardiología de México (Q4)	7
Journal of The American College of Cardiology (Q1)	7
Heart (Q1)	6
International Journal of Cardiology (Q1)	6

[a] 10.1093/eurheartj/ehv728; [b] 10.1161/CIRCULATIONAHA.114.013748; [c] 10.1161/CIRCULATIONAHA.106.624544; [d] 10.1161/CIRCULATIONAHA.117.028268; [e] 10.1093/eurheartj/ehx511; [f] 10.1177/1741826711425777; [g] 10.1016/j.jacc.2019.10.057; [h] 10.1016/j.jacc.2018.10.039; [i] 10.1016/j.jacc.2015.12.056; [j] 10.1097/00005344-198700003-00021

We found a total of 749 affiliations. Affiliation to the Universidad Peruana Cayetano Heredia was the most frequently reported, followed by Johns Hopkins University; however, affiliation to the Hospital Nacional Dos de Mayo was observed in the greatest number of articles around 2005 **(Figure 3).**

A total of 953 keywords were identified. As can be seen in **Figure 4,** the predominant keywords in 2014 were hypoxia, exercise, coronary-heart-disease, and cholesterol; however, the keywords that are in a greater number of articles are mortality and myocardial infarction. We also observed that the most recent articles use new keywords, such as acute coronary syndrome, alirocumab, and cardiopulmonary resuscitation.

Discussion

This study sought to assess the Peruvian scientific production on cardiology and cardiovascular medicine up to 2020 in WOS. As a

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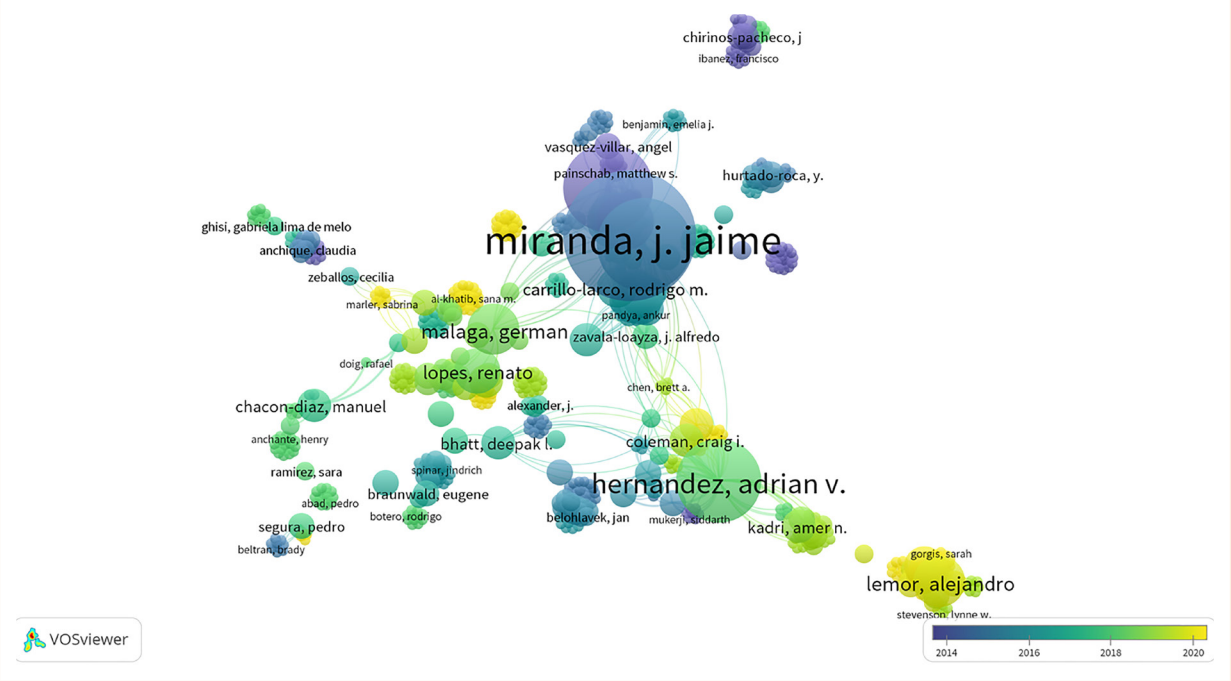

Figure 2. Visualization map of the authors' network.

The different colors represent the average number of publications per year. The large circles indicate the authors with the highest number of publications.

result, an increase in the number of original articles on cardiology and cardiovascular medicine by authors with Peruvian institutional affiliation is evident since 2015, with the highest production of articles being in 2019 and 2020. We identified authors and institutions, with their respective collaboration networks, who lead research on cardiology and cardiovascular medicine, as well as the main scientific journals where original articles were published and the most studied keywords in recent years.

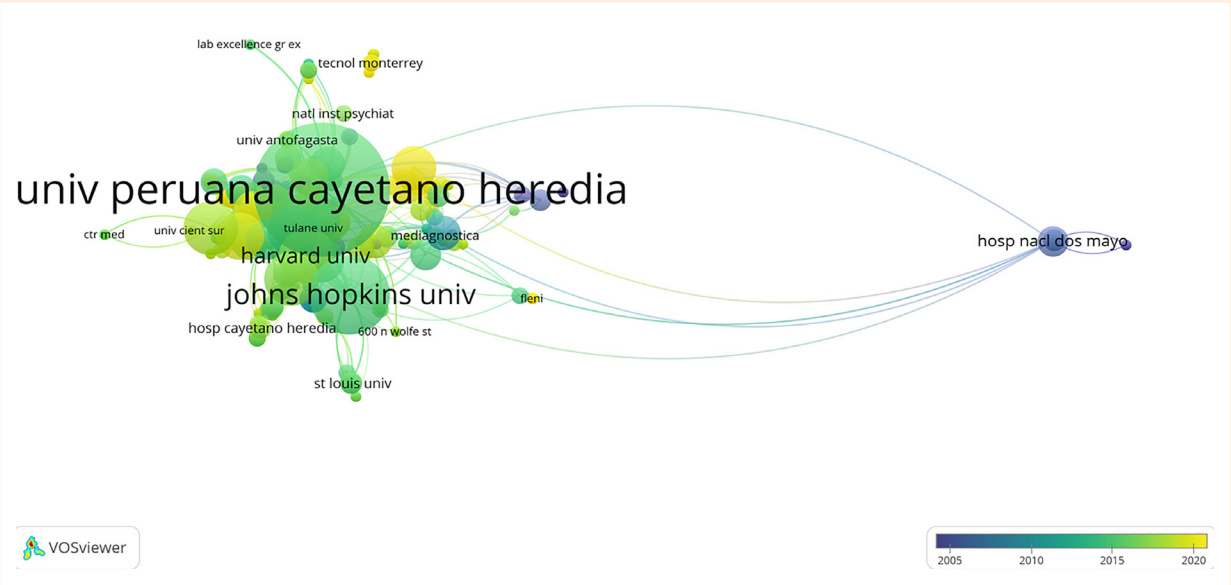

Figure 3. Visualization map of the affiliation network.

The different colors represent the average number of publications per year. The large circles indicate high-frequency affiliations.

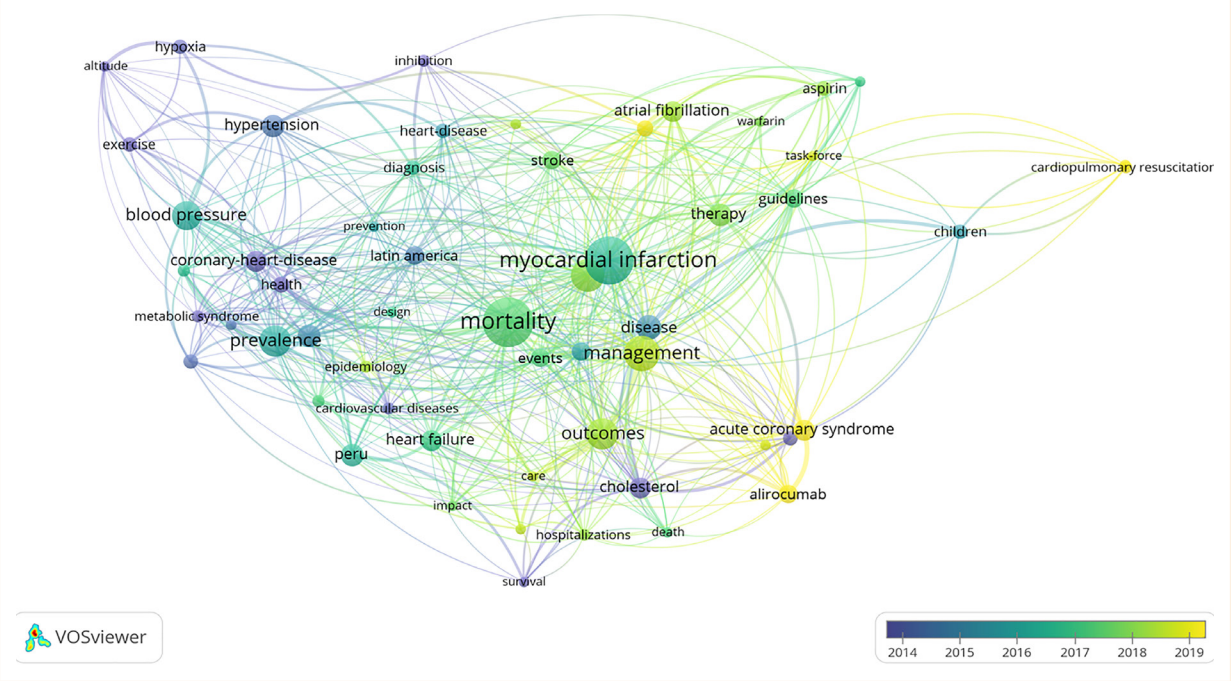

Figure 4. Keyword network visualization map.

The different colors represent the average number of publications per year. The large circles indicate high frequency keywords.

There was an increase of Peruvian scientific production (original articles) on cardiology and cardiovascular medicine since 2015, the production tripled compared to what was observed in previous years. Likewise, it is important to mention that the highest production of original articles was observed in 2019 and 2020, reaching a total of 159 articles published between 1976 and 2020. In contrast to these findings, it should be noted that global cardiovascular research output increased steadily in the last decade, with an increase of more than 40% in the number of publications in 2017 compared to 2008, and a significant increase from 2013 onwards. However, higher-income countries had the largest contribution to global cardiovascular research (with more than 80% of the scientific output) compared with middle- and high-income (16.1%), middle- and low-income (2.6%), and low-income (0.2%) countries [4]. The Latin American and Caribbean region published 4% of articles compared to high-income countries such as the United States and Canada, where Brazil, Argentina, Mexico and Chile have the highest number of publications on cardiovascular medicine, while Peru was among those with lower number of publications above Central American countries and Bolivia in 2008 [17,18]. This increase in Peruvian scientific production is important for decision making and the development of strategies for the control of cardiovascular diseases; moreover, this increase needs to be constant over time to achieve greater advances in research on cardiovascular medicine, especially due to the changes in the epidemiological profile that have led to an increase in the prevalence of chronic non-communicable diseases [19].

Regarding the articles with the highest number of citations that have an author with Peruvian institutional affiliation, we observed that the most cited article was a phase III clinical trial (RCT) conducted by Fitchett *et al.* and published in 2016, with a total of 568 citations [14], followed by a phase III RCT conducted by Packer *et al.* in 2014 (with 408 citations) [15], and the review article conducted by Penaloza *et al.* published in 2007 (with 341 citations) [16]. In addition, regarding the main scientific journals where original articles on cardiology and cardiovascular medicine were published, we found that the Global Heart journal was where most articles by Peruvian authors on cardiology and cardiovascular medicine were published, followed by Circulation and the Journal of the American Heart Association. These findings are similar to those reported by Opthof, where he observed that the four most important and most cited journals on cardiology and cardiovascular medicine were the European Heart Journal, Circulation, Journal of the American College of Cardiology and

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Circulation Research [20]. Thus, the RCTs with the highest number of citations are multicenter and conducted in different countries, which are frequently reported in high-impact journals such as those previously mentioned.

It should be noted that of the three articles with the highest number of citations, the article by Penaloza and Arias-Stella, entitled The Heart and Pulmonary Circulation at High Altitudes, was the only study conducted only by authors with Peruvian institutional affiliation [16]. This article was a literature review on the physiology, pathology, pathogenesis, and clinical characteristics of the heart and pulmonary circulation in healthy mountain people and in patients with chronic mountain sickness; the authors concluded that pioneering studies by Peruvian researchers contributed to elucidate the pathogenesis of high-altitude pulmonary hypertension and right ventricular hypertrophy in healthy people born and living at high altitude. This finding reflects the interest of altitude in Peruvian research, because Peru is an Andean country with high altitude regions, in which, it is estimated, more than five million people live [21].

Regarding authors with Peruvian institutional affiliation, we found that Miranda JJ was the author with the highest number of articles published in the area of cardiology, and who had greater presence from the year 2014 onwards, unlike the authors Hernández AV and Málaga G, who had a greater presence around the year 2018, according to the average publication per year. In addition, we observed that Lemor A had a greater production of articles in the last year. In Peru, there is only one institute specialized in cardiovascular pathologies and it belongs to the Seguro Social de Salud (EsSalud), which is expected to have an important scientific production [22]. Chacón-Diaz M is the author with the largest number of publications in this institution.

Regarding institutional affiliations, we found that the institution with the highest number of original articles published on cardiology and cardiovascular medicine was the Universidad Peruana Cayetano Heredia. This is consistent with what was reported about Miranda JJ, who is the author of epidemiological studies such as CRONICAS and PERU MIGRANT, which are cohort studies on chronic non-communicable diseases that belong to that university and which endorse the production on cardiology and cardiovascular diseases of this institution [23]. The Universidad Peruana Cayetano Heredia is the institution with the highest scientific production in the Peruvian territory, since one third of the scientific publications between 1997 and 2016, are linked to this institution [24]. Likewise, other international educational institutions such as Johns Hopkins University and Harvard University occupied leading positions in Peruvian scientific production on cardiology and cardiovascular medicine as part of collaborative networks. This finding could be related to the Universidad Peruana Cayetano Heredia, because researchers from this institution have maintained international alliances and funding, which is reflected in the co-authorship of publications, where more than half are articles that were written and published with professionals from institutions in the United States [24]. In addition, other institutions stood out, such as the Hospital Nacional Dos de Mayo, which is an emblematic hospital and one of the oldest in Peru, and the Hospital Cayetano Heredia, which is institutionally dependent to the Universidad Peruana Cayetano Heredia.

Finally, with regard to the co-occurrence of terms, we observed that the terms used most recently were related to altitude, exercise, hypoxia, cholesterol, and cardiovascular disease, which are terms related to risk or exposure factors that are associated with heart and cardiovascular disease [25-27]. In recent years, the terms found in a greater number of articles are mortality, myocardial infarction, outcomes, and management; terms that are linked to epidemiology [28], which reflects the interest of authors on epidemiology [29]. Finally, the terms used in 2019 were acute coronary syndrome, alirocumab, and cardiopulmonary resuscitation, highlighting the importance of specific outcomes or interventions in clinical-level studies on cardiac and cardiovascular pathologies, which have grown in size, scope, and complexity due to the emergence of new drugs or interventions [30].

Regarding the limitations of the study, we should mention that a bibliometric analysis depends on the availability of the data from the articles retrieved with the search strategy. Likewise, it should be considered that the search was conducted in a single database (WOS), so that Peruvian production on cardiology and cardiovascular medicine in other bibliographic databases such as Scopus, Medline, and SciELO was not included. Despite these limitations, we consider that the analysis of Peruvian scientific production on cardiology and cardiovascular medicine in one of the most important bibliographic databases, such as WOS, provides evidence of the advances in knowledge on these areas of research in the country and how scientific production has progressed among Peruvian researchers.

In conclusion, we found an increase in the scientific production on cardiology and cardiovascular medicine by authors with Peruvian institutional affiliation, with a larger production from the Universidad Peruana Cayetano Heredia. The journal with the highest number of publications by authors with Peruvian institutional affiliation on cardiology and cardiovascular medicine

was Circulation, where two of the most cited articles with Peruvian affiliation were also found. The terms used in the most recent articles are related to specific outcomes or interventions associated with cardiac and cardiovascular pathologies.

Authors' contribution

FABL and GWBM verified that the records obtained from the search met the inclusion criteria. All authors participated in the interpretation of the data, drafting of the manuscript, approved the final version and are responsible for the contents.

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