ORIGINAL ARTICLE

BIBLIOMETRIC ANALYSIS OF PERUVIAN SCIENTIFIC OUTPUT ON COVID-19

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ABSTRACT

Objective: To describe the Peruvian scientific output on COVID-19 up to January 31, 2021. **Materials and methods:** We carried out a bibliometric study using two databases (MEDLINE and SciELO). We included original or short original articles with at least one author with Peruvian institutional affiliation. Scientific output was described according to: institution, approval by a Research Ethics Committee, registration in the platforms established by regulations, scientific journals in which they were published, research funding, and Peruvian collaboration networks. **Results:** A total of 106 articles were analyzed, only three (2.8%) were clinical trials. Of the top 10 institutions with the highest scientific output, only two did not belong to the education sector. A total of 53 (50.0%) articles had no information regarding ethical aspects or it was not explicitly stated whether or not it was approved by a Research Ethics Committee. Only 8 (7.7%) of 104 articles were registered in PRISA; 12 (11.3%) articles were published in Peruvian journals. Regarding funding, 71 (67.0%) investigations did not specify the source or they were self-financed. We found international collaboration in 70 publications (66.0%). **Conclusions:** The most productive Peruvian institutions are found in Lima. Half of the articles did not state ethical aspects in any part of the document. Almost all of the studies were not registered on the platforms established by regulations. In more than half of the articles the source of funding is not stated or they were self-financed.

Keywords: Bibliometrics; National Scientific and Technological Production; Scientific Publication Indicators; Collaboration Indicator; Coronavirus Infections; Pandemics; Ethics Committees, Research; Periodical; MEDLINE; Peru (Source: MeSH NLM).

INTRODUCTION

In December 2019, cases of pneumonia caused by a new coronavirus, called SARS-CoV-2 [1], appeared in the city of Wuhan in China, causing the "coronavirus disease 2019" (COVID-19). This disease rapidly spread to other countries, became a global public health threat, and was considered a pandemic in March 2020 [2].

On March 6, 2020, Peru reported its first case of COVID-19 [3] and on March 17, community transmission of SARS-CoV-2 began in the Peruvian territory [4]. By February 10, 2021, Peru was the sixth country with the highest number of confirmed cases (1,212,309) and deaths (43,045) in the Americas region [5,6]. By the same date, the most populated Peruvian area, Metropolitan Lima, accounted for 42.2% (511,764) of all positive cases in the country and 39.7% (17,073) of all deaths [7].

In such a scenario, scientific research is a fundamental activity to produce evidence for decision-making. Scientific output related to COVID-19 has increased exponentially

Cite as: Vásquez-Uriarte K, Roque-Henriquez JC, Angulo-Bazán Y, Ninatanta Ortiz JA. [Bibliometric analysis of Peruvian scientific output on COVID-19]. Rev Peru Med Exp Salud Publica. 2021;38(2):224-31. doi: https://doi.org/10.17843/rpmesp.2021.382.7470.

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Received: 02/25/2021
Approved: 05/05/2021
Online: 06/22/2021

https://doi.org/10.17843/rpmesp.2021.382.7470

worldwide [8,9], which has led to the publication of studies on preprint servers, fast track editorial processes and, consequently, the increase of cases of retractions and other ethical misconduct in scientific publications [10].

In order to establish guidelines for research on COVID-19, the Peruvian State issued a supreme decree aimed at promoting clinical trials on the prevention, diagnosis and treatment of this disease, and to register all scientific research carried out in the country [11]. Clinical trials, under the Clinical Trials Regulation (Supreme Decree No. 021-2017-SA), are registered in the Peruvian Registry of Clinical Trials (REPEC, https://ensayosclinicos-repec.ins.gob.pe/), the rest of the clinical trials or other research designs are registered in the platform of Health Research Projects (PRISA, https://prisa.ins.gob.pe/), both registration procedures were developed and are managed by the Instituto Nacional de Salud.

However, to date, the dynamics of Peruvian research in the context of this pandemic is not known; therefore, this research aimed to characterize the Peruvian scientific output on COVID-19 in two databases as of January 31, 2021.

KEY MESSAGES

Motivation for the study: To learn about the characteristics of Peruvian scientific output on COVID-19.

Main findings: The most productive Peruvian institutions are located in Lima. Half of the articles did not include ethical aspects in any part of the document and almost all the studies were not registered in the Health Research Projects Platform (PRISA).

Implications: The most productive institutions are those that have collaboration networks and have acquired competitiveness to gain funding. The main institutions that conduct health research should have a research ethics committee, in addition to promoting and requiring the registration of research on COVID-19.

MATERIALS AND METHODS

Design and study population

A bibliometric study was carried out, in which the unit of analysis was all original and short original articles on COVID-19 published in journals indexed in the MEDLINE and SciELO databases. The search was carried out until January 31, 2021.

Articles with at least one researcher with affiliation to a Peruvian institution were included, and preprint documents (indicated by the search engine itself and verified by the researchers) were excluded because they did not go through a peer review process.

Search strategy

A systematic search was carried out in MEDLINE (accessed through PubMed, https://pubmed.ncbi.nlm.nih.gov/) and SciELO (https://www.scielo.org/) with a sensitive search equation [(COVID-19 OR SARS- CoV-2 OR 2019-nCoV OR "2019 novel coronavirus" OR "new coronavirus" OR "coronavirus disease 2019") AND Peru], based on search strategies employed in previous studies on scientific production on COVID-19 (Supplementary Material) [12,13].

Individually, two researchers reviewed each article to verify the eligibility criteria and extract information on the variables of interest. In case of discrepancy, both researchers reviewed the article together. A total of 106 articles were analyzed (Figure 1).

Variables

Bibliometric indicators to measure production: databases (MEDLINE and SciELO), month and year of publication (2020, 2021), study design, number of researchers per scientific article, researchers' institutional affiliation, country of the institution, number of affiliations per scientific article, geographical location of Peruvian institutional affiliation, first author with affiliation to a Peruvian institution (yes, no), corresponding author with affiliation to a Peruvian institution (yes, no), number of countries to which the institutional affiliations belong per scientific article, approval of the study by a research ethics committee (REC) (no information, no, yes), registration in PRISA (yes, no) or in REPEC (yes, no), institution funding the research, country of the funding institution, and country of the scientific journal.

Bibliometric indicators to measure visibility and impact: quartile (first, second, third, fourth) and SCImago Journal Rank (SJR) 2019 indicator, obtained from https://www.scimagojr.com/.

Bibliometric indicators to measure collaboration: country of the institutional affiliation.

Statistical analysis

We calculated absolute frequencies and proportions for categorical variables; for numerical variables we calculated

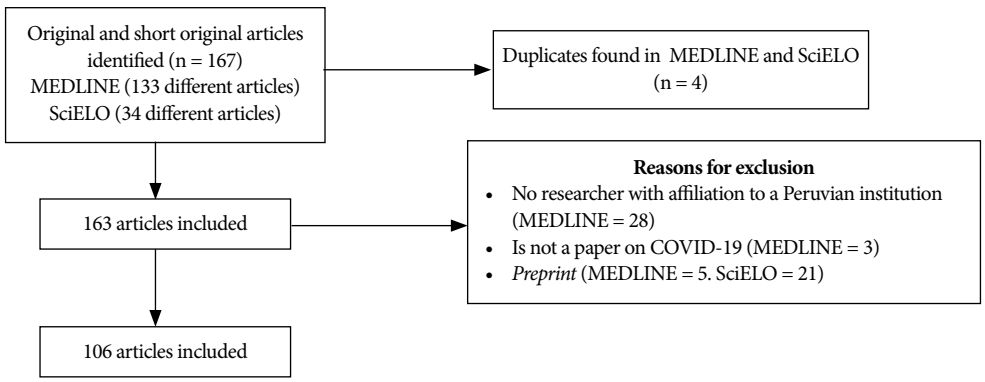

Figure 1. Flow chart of the selection process of the original articles and short original articles included in the study.

medians and interquartile ranges (IQR), because their data did not have a normal distribution. Calculations were carried out with the STATA v. 15.0 statistical package (StataCorp, College Station, Texas, USA).

In order to calculate international collaboration, we considered the proportion of articles with one or more institutions from countries other than Peru. To elaborate the collaboration networks, all the articles were included in a collection of the Zotero 5.0 program, in which the terms referring to the nationalities of the participating institutions were standardized. Subsequently, the collection was exported in .ris format and analyzed in the BibExcel® program version 2016-02-20, which was used to create files with .net and .vec extensions, necessary for graphing the collaborative networks. The graphs were produced with the Gephi 0.9.2.® program (Gephi contributors, 2008-2017).

Ethical Aspects

The unit of analysis for this study were the scientific articles of public access, there was no contact with human subjects. The study was approved by the Scientific Committee of the Research Unit of the Faculty of Health Sciences of the Graduate School of the Universidad Nacional de Cajamarca.

RESULTS

A total of 106 articles were analyzed, with a median number of researchers of 6.5 (IQR: 4.0-12.0), a median number of institutional affiliations of 5.0 (IQR: 3.0-7.0) and a median number of countries of 2.0 (IQR: 1.0-5.0). Ninety-seven (95.5%) articles were from 2020. Six were systematic reviews (5.7%) and only three (2.8%) were clinical trials, but in none of these experimental studies was the first author or corresponding author affiliated with a Peruvian institution. A growth in scientific output was observed until July 2020, then it dropped in August and November, and finally we observed a sustained decrease in publications since November 2020 (Figure 2).

Participation of Peruvian institutions

There were 78 Peruvian institutions mentioned as the affiliation of researchers, of these institutions, 55 (70.5%) were from Lima; 4 (5.1%) from La Libertad; 4 (5.1%) from Lambayeque, 3 (3.8%) from the constitutional province of Callao and 3 (3.8%) from Cusco. Of the top 10 institutions with the highest scientific production, only two did not belong to the education sector. The institution with the highest number of articles outside Lima was the Universidad Católica Los Ángeles de Chimbote in Áncash, with 6 articles (5.7%) (Table 1).

The Universidad Peruana Cayetano Heredia is the institution with the highest number of affiliations of the first author or corresponding author, with 11 (10.4%) articles of the 24 in which it appears as an affiliation. The leading institution outside Lima is the Universidad Privada del Norte de La Libertad with 5 (4.7%) articles (Supplementary Material).

Approval of studies by a REC and registration in the PRISA and REPEC platforms.

In 41 (38.7%) articles the authors stated that their study was approved by a REC, in 12 (11.3%) they stated that the study was not approved and in 53 (50.0%) there was no information on ethical aspects or they did not explicitly state whether or not it was approved by an REC. In 9 of the 12 articles not approved, the authors provide several explanations,

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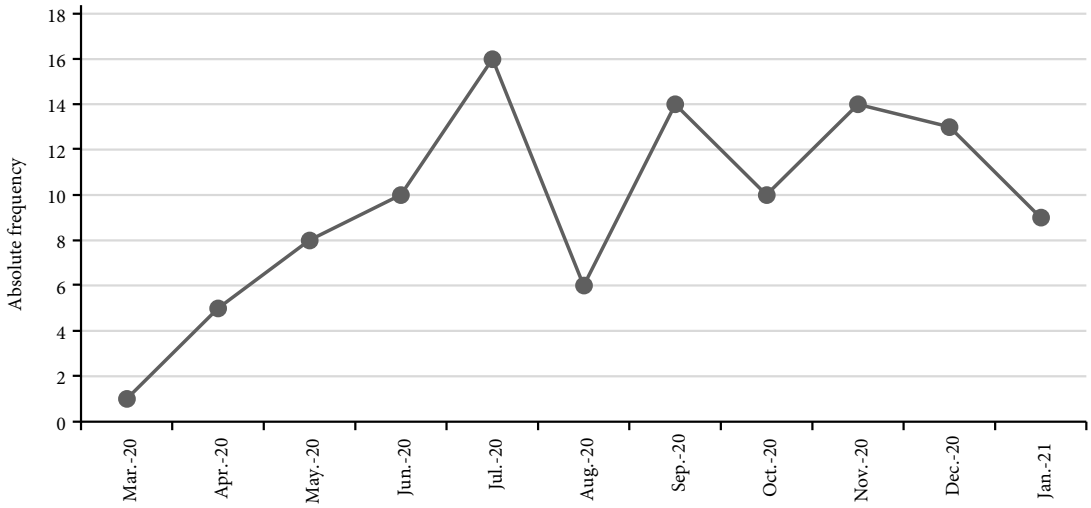

Figure 2. Distribution (by months) of Peruvian scientific output on COVID-19.

which can be summarized as: a) no human subjects were involved (n=2); b) the confidentiality of the participants was guaranteed (n=10); and c) publicly available information was used (n=8) (Supplementary Material).

Of the 3 clinical trials, 2 were registered in REPEC (codes: PER-010-20, PER-027-20) and 1 in the PRISA platform (code: EI00000001349). Of the remaining 103 articles, only 7 (6.8%) were registered in the PRISA platform (codes: EI0000000822,

Table 1. Peruvian institutions with scientific output on COVID-19 with frequency greater than or equal to three (total number of documents = 106).

Nº	Institution	Location [a]	Number of documents (%)
1	Universidad Peruana Cayetano Heredia	Lima	24 (22.6)
2	Universidad Nacional Mayor de San Marcos	Lima	13 (12.3)
3	Universidad Científica del Sur	Lima	13 (12.3)
4	Hospital Nacional Edgardo Rebagliati Martins	Lima	11 (10.4)
5	Universidad San Ignacio de Loyola	Lima	10 (9.4)
6	Pontificia Universidad Católica del Perú	Lima	8 (7.5)
7	Universidad de Lima	Lima	7 (6.6)
8	Universidad Peruana de Ciencias Aplicadas	Lima	6 (5.7)
9	Hospital Nacional Guillermo Almenara Irigoyen	Lima	6 (5.7)
10	Universidad Católica Los Ángeles de Chimbote	Ancash	6 (5.7)
11	Universidad Nacional de San Agustín de Arequipa	Arequipa	5 (4.7)
12	Universidad Privada del Norte	La Libertad	5 (4.7)
13	Instituto Nacional de Salud	Lima	4 (3.8)
14	Instituto Nacional Materno Perinatal	Lima	4 (3.8)
15	Universidad de San Martín de Porres	Lima	4 (3.8)
16	Hospital Cayetano Heredia	Lima	3 (2.8)
17	Universidad Peruana Unión	Lima	3 (2.8)
18	Universidad Ricardo Palma	Lima	3 (2.8)
19	Hospital Nacional Almanzor Aguinaga Asenjo	Lambayeque	3 (2.8)

[a] If an institution has headquarters in more than one location, we considered the place where it was founded.

EI0000000834, EI00000001004, EI00000001250, EI00000001257, EI00000001519 and EI00000001626).

Scientific journals in which the articles were published.

We found 79 scientific journals, 12 of those published 33.0% of the total output; the other 33.0% was published in 31 journals; we did not find a distribution according to Bradford's Law. Thirty-four (32.1%) articles were published in journals from the United States of America; 20 (18.9%) in journals from the United Kingdom; 19 (17.9%) in journals from the Netherlands; and 12 (11.3%) in Peruvian journals. Table 2 shows the list of journals with the highest number of articles, of which PLOS ONE stands out, located in quartile 1 and classified in the multidisciplinary category in SJR 2019, with 5 (4.7%) articles. The highest ranked Peruvian journal

Table 2. Journals that published two or more research papers (total number of papers = 106).

N°	Journal	Country	Number of documents (%)	2019 Quartile: categories	SJR 2019
1	*PLOS ONE*	United States of America	5 (4.7)	Q1: Multidisciplinary Q3: Medicine (miscellaneous)	1.023
2	*Revista Peruana de Medicina Experimental y Salud Pública*	Peru	4 (3.8)	Q3: Public health, environmental and occupational health	0.268
3	*International Journal of Mental Health and Addiction*	United States of America	3 (2.8)	Q2: Psychiatry and Mental Health	0.548
4	*Science of the Total Environment*	Netherlands	3 (2.8)	Q1: Environmental Chemistry Q1: Environmental Engineering Q1: Pollution Q1: Waste management and disposal	1.661
5	*Medwave*	Chile	3 (2.8)	Q4: Medicine (miscellaneous)	0.156
6	*Revista Panamericana de Salud Pública*	United States of America	3 (2.8)	Q3: Public health, environmental and occupational health	0.41
7	*New England Journal of Medicine*	United States of America	3 (2.8)	Q1: Medicine (miscellaneous)	18.291
8	*Revista de la Facultad de Medicina Humana*	Peru	3 (2.8)	SciELO	Doesn't apply
9	*Travel Medicine and Infectious Disease*	Netherlands	2 (1.9)	Q1: Public health, environmental and occupational health Q2: Infectious diseases	1.075
10	*Microbiology Resource Announcements*	United States of America	2 (1.9)	Q4: Genetics Q4: Molecular Biology Q4: Immunology and microbiology (miscellaneous)	0.410
11	*Wellcome Open Research*	United Kingdom	2 (1.9)	Q1: Biochemistry, genetics and molecular biology (miscellaneous) Q1: Medicine (miscellaneous)	1.404
12	*Journal of Medical Virology*	United States of America	2 (1.9)	Q2: Infectious Diseases Q3: Virology	0.855
13	*Medicina Clínica*	Spain	2 (1.9)	Q3: Medicine (miscellaneous)	0.245
14	*Child Abuse & Neglect*	Netherlands	2 (1.9)	Q1: Pediatrics, Perinatology and Child Health Q1: Psychiatry and mental health Q1: Developmental and educational psychology Q1: Social work	1.424
15	*American Journal of Tropical Medicine and Hygiene*	United States of America	2 (1.9)	Q1: Medicine (miscellaneous) Q1: Parasitology Q2: Infectious Diseases Q2: Virology	1.182
16	*Death Studies*	United States of America	2 (1.9)	Q2: Arts and humanities (miscellaneous) Q2: Clinical Psychology Q3: Developmental and educational psychology	0.492

Q: Quartile; SJR: SCImago Journal Rank

https://doi.org/10.17843/rpmesp.2021.382.7470

in SJR is Revista Peruana de Medicina Experimental y Salud Pública.

Research funding

Forty-five studies (42.5%) were self-funded and 26 (24.5%) did not indicate the source of funding The institution that funded the largest number of studies was the Universidad Espíritu Santo of Ecuador with 4 (3.8%). Only four Peruvian institutions were listed as funding entities, with the Instituto Nacional de Salud funding the most studies, 2 (1.9%) (Supplementary Material).

Collaboration networks between countries

We found international collaboration in 70 publications (66.0%), and the presence of 85 countries other than Peru. Thirty-nine articles were published with institutions in the United States, 16 with Colombian institutions and 14 with Argentinean institutions. Institutions from the United Kingdom, Ecuador and Mexico participated in 13 publications each. There were three clearly defined international collaboration networks: the first (in green), with strong interaction between the United States and Peru, and collaboration from other countries such as China, Bolivia and Australia; the second network consisted mostly of Latin American countries (in orange) and a third network (in purple), had diverse European and Asian countries. There is strong interaction between the three networks mentioned above (Figure 3).

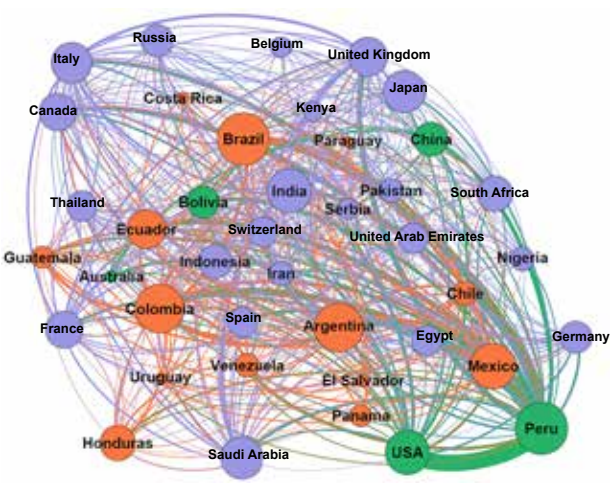

Figure 3. Collaboration networks between countries regarding Peruvian scientific output on COVID-19. The colors reflect the grouping in networks obtained by modularity.

DISCUSSION

This research found 106 published articles with at least one author with Peruvian institutional affiliation, and an increasing scientific output up to July 2020, followed by a decline from November 2020.

Regarding the Peruvian institutions with scientific output on COVID-19, we found that the most important ones were located in Lima, a finding consistent with that reported in a previous bibliometric analysis of Peruvian output on COVID-19 [14] and in accordance with what was reported in other studies on Peruvian scientific output [15-17]. The most productive institution on COVID-19 was the Universidad Peruana Cayetano Heredia, which is explained by its national and international collaboration network, and the high competitiveness they have acquired to win national and international research funds [15,18].

One of the most important designs for the production of evidence are clinical trials, which are important experimental studies that aim to evaluate the efficacy and safety of a product, such as vaccines against COVID-19 or possible treatments. At the cut-off point of this search, only 3 (2.8%) published clinical trials were found, and in none of them the first author or corresponding author was affiliated with a Peruvian institution. Conducting clinical trials requires qualified human resources to design and lead this type of studies, technology, infrastructure and compliance with a series of requirements stipulated in the Peruvian Clinical Trial Regulations [19]. Few institutions in our country comply with these requirements, which explains the low number of this type of studies, a problem noted in a previous publication [20].

Regarding ethical considerations, we highlight two findings: only 41 (38.7%) studies explicitly stated that they had been reviewed and approved by a REC, although this figure is higher than the 18.3% found in original research published in journals indexed in SciELO Peru during the period 2007 to 2012 [21] and even higher than the 14.8% reported in experimental research published in Peruvian journals indexed in SciELO during the period 2006 to 2015 [22]; 50% of the publications did not include ethical aspects in the document. The most frequent reason for not requesting review by a REC was that the research was mainly a secondary analysis of data in which the confidentiality of the participants was guaranteed; however, these investigations may have other ethical, methodological, legal and administrative considerations that should be reviewed by a REC [23]. It is

preferable that researchers consult a REC about the possibility of exemption from review, especially if they have limited knowledge in this field [24]. The main institutions that carry out health research, such as universities, should have a REC; there should be an accreditation process for RECs; a network of national RECs should be promoted and strengthened; and researchers should be required to have skills in research ethics and responsible conduct in research [25].

Clinical trials registered in REPEC are those in which the research product is a pharmaceutical product or medical device (including drugs with sanitary registration that are used in a different way than authorized) [19]. Clinical trials that carry out research on products without sanitary registration are not registered in REPEC and should be registered on the PRISA platform in compliance with Supreme Decree No. 0142020SA, issued in April 2020.Unfortunately, for the other study designs, most researchers do not comply with registering their work in the PRISA platform. In order to improve this situation, it is key to strengthen the units that manage research in the institutions, since they can advise their researchers and include the registration of COVID-19 research as a requirement in their processes; as well as encourage greater promotion and demand for the registration of COVID-19 research by bodies such as the CEI, the Instituto Nacional de Salud and the Consejo Nacionalde Ciencia, Tecnología e Innovación Tecnológica.

The distribution of journals we found is quite uniform, with 3 to 5 publications in the most productive journals. Among these, it is important to note that most journals are in quartile 1 and quartile 2, and there are only 2 Peruvian journals with 2 or more publications, one of them indexed in MEDLINE and Scopus, and the other only in SciELO. In this regard, it should be noted that, during the pandemic, scientific journals became the essential way of disseminating the knowledge needed to address this public health problem, which meant that they had rapid editorial processes and were freely accessible [26,27]. In addition, Zdravkovic *et al.* argued that, in this context, the publications of high-impact journals have been of lower quality compared to what they would publish under normal conditions, probably for the reasons described above [28]. Thus, in these cases, the relationship between study quality and journal quality indicators is distorted. Future studies should reflect not only on the scientific output itself, but also on the quality of the journals published.

In 67% of the studies, the source of funding was not mentioned or they were self-funded, which shows the scarce budget allocated to research in the country [29], even more so regarding a matter of national and global public health importance such as COVID-19. Most of Peru's scientific production is based on analyses of secondary sources, with few experimental studies. Faced with this reality, the country's institutions should implement the following strategies: a) ensure that their researchers acquire the expertise to obtain the scarce national funds and, mainly, international funds, b) promote and strengthen collaboration networks with both national and international institutions. The best example is the Universidad Peruana Cayetano Heredia [15,18].

This study had some limitations; we should mention that, although a search of Peruvian scientific output was carried out in two important databases, the results did not include all the research on COVID-19, nor was a search carried out on gray literature databases, which could have provided a greater number of records. In addition, an evaluation by language was not carried out because, in recent years, many journals (especially in Latin America) have adopted simultaneous publication in two or more languages, which could distort the analysis.

It is concluded that the most productive Peruvian institutions are located in Lima, with fairly extensive collaboration networks. Half of the articles did not include ethical aspects in any part of the document. Most of the studies that are not clinical trials were not registered in the PRISA platform. About a tenth of the publications were in Peruvian journals. More than half of the articles did not indicate the source of funding or were self-financed.

We recommend that research should be carried out to assess the quality and impact of Peruvian scientific output on COVID-19, and that the search should be extended to other databases. Likewise, research should be carried out to assess compliance with ethical standards and regulations in Peruvian research.

Authors' contributions: All authors participated in the conception and design of the study. KVU, JCRH and YAB elaborated the search strategy and executed the statistical analysis plan. KVU drafted the first version of the manuscript and all authors approved the final version to be published. All authors are responsible for the content of the article.

Funding: This study was self-funded by KVU. The participation of JANO has been funded by the Universidad Nacional de Cajamarca. The participation of JCRH and YAB has been partially funded by the Instituto Nacional de Salud. Part of JCRH's time invested in this project was also funded by the Universidad de San Martín de Porres.

Conflicts of interest: The authors declare that they have no conflicts of interest.

Supplementary material: Available in the electronic version of the RPMESP.

https://doi.org/10.17843/rpmesp.2021.382.7470

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