



Research article

Visibility, collaboration and impact of the Cuban scientific output on COVID-19 in Scopus

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ABSTRACT

Introduction: COVID-19 is a disease with worldwide impact that has fully caught attention of researchers. The Cuban scientific output, after one year of confronting this pandemic, has not been studied from a bibliometric perspective.

Objective: To characterize the output of original scientific articles and review articles on COVID-19 published by Cuban authors in the journals included in the Scopus bibliographic database, the collaborations in these publications and their impact, according to the citation of the research in the world literature.

Materials and methods: A cross-sectional, descriptive and observational study was performed, using a bibliometric approach. A search strategy was used to retrieve articles on the subject and bibliometric indicators of output, visibility, leadership, collaboration and impact were studied.

Results: Cuba contributed 2.5% of the Latin American output and 0.2% of the world output. Of the national scientific output (133 articles, 111 original and 22 reviews), 84.2% were authored by a Cuban corresponding author (Cuban leadership). However, the majority (n = 20; 71.4%) of articles with international collaboration (n = 28; 21.1%) had foreign corresponding authors. Of the total, 33.8% (n = 45) corresponded to articles without collaboration. Only 13.5% of the articles (n = 18) were published in journals with high visibility (Q1). Of all the output, 68.4% (n = 91) was in Cuban journals. The output in English represented 29.3% (n = 39) and achieved greater impact than the articles in Spanish in terms of citations. As the visibility of the journals increased according to the quartiles where they are, the percentage of articles published in English and cited articles increased too, but Cuban scientific leadership decreased.

Conclusions: The greater the leadership in Cuban research, the lower its impact, and the lower the indexes of international collaboration. Cuban researchers are not yet able to systematically generate research that has a significant impact on the international scientific community.

1. Introduction

In December 2019, a series of cases of pneumonia of unknown origin were detected in the city of Wuhan, China, spreading with great ease [1]. Subsequently, a virus was identified as the causative agent and was named SARS-CoV-2; likewise, the disease was denominated COVID-19. Consequently, the World Health Organization declared this outbreak a pandemic on March 11, 2020 [2]. One year later, the global number of

infected people exceeded 120 million, with more than two million deaths [3]

The contingency generated by COVID-19 motivated researchers from all over the world to channel their scientific activity towards confronting the pandemic. Hence, in record time, an unprecedented avalanche of knowledge was generated and several publishers offered online and open access publications on the disease, which are now available to the scientific community [4].

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This increase in scientific output was the subject of various bibliometric studies worldwide [4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23], in Latin America [24, 25, 26, 27, 28], Iran [29], India [30], in nursing journals [31], in relation to pediatrics [32] and a stroke [33], as well as in comparison to other coronaviruses [34, 35].

Cuban science has contributed significantly to the confrontation with COVID-19, facilitating the prediction, the improvement of therapeutic protocols and the improvement of action models for the reduction of risks and vulnerabilities in the face of the pandemic. Based on these elements, a knowledge base has been built that has become a reference and support for government management in dealing with the pandemic [36, 37] and has also resulted in the publication of articles in scientific journals.

Evaluating scientific output on a certain topic is important from a strategic and decision-making point of view for any country. In this sense, articles on COVID-19 published in Cuban medical journals ninety days after the beginning of the pandemic [38, 39], in journals of national medical universities [40], as well as in Cuban student journals [41, 42] have been studied from a bibliometric point of view. However, it is necessary to evaluate the national scientific output after one year of confronting the pandemic. Thus, the present study aimed to characterize the output of original scientific articles and review articles on COVID-19 published by Cuban authors in journals included in Scopus, the collaborations in these publications and their impact, in terms of citations of the studies in the world literature.

2. Materials and methods

2.1. Design

An observational, descriptive and cross-sectional study was conducted through a bibliometric analysis of Cuban scientific output on COVID-19, published in journals indexed in Scopus.

2.2. Bibliometric indicators

The following bibliometric indicators were studied:

- Number of documents (Ndoc). Total number of documents in which at least one of the authors is affiliated with a Cuban institution.
- Percentage of documents (% Ndoc) with respect to the total of the studied articles.
- Citations (NCit). Total citations received by articles indexed in Scopus.
- Cited articles (Cited doc). Total number of published articles that have been cited at least once according to Scopus.
- Citations per document (Cpd). Average number of received citations.
- Types of collaboration:
 - ✓ No collaboration (NoCollab). Documents in which a national institution appears, regardless of whether more than one author, group or department participates.
 - ✓ National collaboration (NC). Documents signed by more than one Cuban institution.
 - ✓ International Collaboration (IC). Documents in which the affiliation of their authors includes the address in more than one country.
 - ✓ International and National Collaboration (IC & NC). Documents signed by more than one Cuban institution and, at least, one foreign institution.
- H-index. This index considers both the number of articles and the citations they receive. An author has an $h = x$ index if he/she has x articles that have been cited at least x times [43]. This indicator is also used to characterize groups (a group of authors, a department, or a country).
- Quartiles (Q). According to the SCImago Journal & Country Rank (SJR), the journals indexed in Scopus are placed in quartiles, where those in the first quartile have the highest impact. There are journals

that do not appear in the ranking (non-ranked) due to their recent inclusion in the database [44].

- High-quality publications (% Q1). Percentage of publications in journals included in the quartile of maximum visibility.
- Articles in Spanish (Ndoc Sp). Articles published in Spanish.
- Articles in English (Ndoc Eng). Articles published in English.
- Overlap (Ndoc Sp & Eng). Articles published in two languages, in this case, both in Spanish and English.
- Scientific leadership (% Lead). Percentage of articles from a country in which the corresponding author belongs to a Cuban institution. These are referred to as lead documents [45].
- % Q1 Lead. Percentage of articles in journals included in the first quartile in which the corresponding author is affiliated with a Cuban institution.
- % IC Lead. Percentage of articles in which the authors' affiliation includes the address of more than one country and the corresponding author is affiliated with a Cuban institution.

2.3. Data collection and processing

To retrieve the publications, Scopus (<http://www.scopus.com>) was accessed on March 12, 2021, and an advanced search was performed using a filter by country (Cuba), source (journals) and type of articles (article and review). Most of the terms used for the search were extracted from previous bibliometric articles [4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35] and the PubMed Medical Subject Headings (MeSH) related to the disease included in the MeSH catalog in its 2021 update were also used: COVID-19 vaccines, COVID-19 testing, COVID-19 serological testing and COVID-19 nucleic acid testing. The search strategy we used is shown in Table 1.

Initially, 134 articles with Cuban authorship were retrieved and after normalization, one article related to dramaturgy was eliminated, which had the term COVID-19 in the abstract and was published in the *Theatre Journal*. Similarly, 45 articles published in English were detected, and after a manual review it was found that six of these had been published in Spanish.

In regard to Latin American scientific output, the same filters were used as in the previous strategy and we could obtain information corresponding to Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Uruguay and Venezuela. The SCImago Journal & Country Rank platform (<http://www.scimagojr.com>) was accessed to know the location of the journals by the quartile they were in 2019. The analysis of scientific cooperation networks among countries was performed with VOSviewer software version 1.6.15 and the full counting method [46]. The scientific cooperation networks consist of nodes representing the countries involved in the collaboration, and links connecting the collaborating nodes. The thickness of the links represents the intensity of the collaboration in terms of number of articles.

3. Results

3.1. Output and citation of original and review articles

Scopus indexes 133 articles (111 original articles and 22 reviews) with Cuban authorship, of which 114 (85.7%) were published in 2020 and the remaining 19 (14.3%) in 2021. The articles have been cited 111 times (0.8 citations per document) and have an overall h-index of 5 (Table 2).

3.2. Languages of publication

Articles in Spanish represented 69.9% ($n = 93$) of the total; they received 60 citations (0.6 Cpd) and their h-index was 5. The documents

Table 1. Search strategy.

Operator	Field	Search term
	TITLE-ABS-KEY	2019 ncov, 2019 novel coronavirus, 2019 novel coronavirus (2019-ncov), 2019 novel coronavirus disease, 2019 novel coronavirus pneumonia, 2019-nCoV, 2019-novel CoV, coronavirus 2019, coronavirus disease 2019, cov-19, covid, COVID-19, COVID-19 vaccines, COVID-19 testing, COVID-19 serological testing, COVID-19 nucleic acid testing, covid-19 diagnosis, covid-19 pandemic, covid-19 pneumonia, COVID-19 virus infection, covid-2019 epidemic, ncov-2019, new coronavirus, novel coronavirus, novel coronavirus outbreak, novel coronavirus pneumonia, SARS-CoV-2, sars-cov-2 infection, severe acute respiratory syndrome coronavirus 2, Wuhan coronavirus
AND	SRCTYPE	j
AND	AFFILCOUNTRY	Cuba
AND	LIMIT-TO	DOCTYPE, "ar" OR DOCTYPE, "re"

in English (n = 39) accounted for 29.3%. They received 51 citations, their h-index was 3 and the average number of citations per document is 1.3. One article was published in both Spanish and English and has not been cited (Table 2).

3.3. Typologies

The original articles have received 93 citations with an average of 0.8 citations per document. Seventy-eight articles (70.3%) were published in Spanish, 32 (28.8%) in English and one (0.9%) in both languages. The review articles have been cited 18 times and reached an average of 0.8 citations per document. Fifteen (68.2%) were published in Spanish and the remaining seven (31.8%) in English.

3.4. Scientific collaboration, leadership and visibility

One third of the Cuban scientific output corresponds to articles without collaboration (n = 45; 33.8%), which have received 17 citations (15.3% of the total) and have an average of 0.4 citations per document. The 41.4% of the documents (n = 55) were published in collaboration with authors from several national institutions, have been cited 51 times and the average number of citations per document is 0.9. In addition, 21.1% of the articles (n = 28) were published with international collaboration and received 39 citations, with the highest average number

Table 2. General indicators of the Cuban scientific output in Scopus after one year of confronting the COVID-19 in the country.

Indicator	Value
Ndoc	133
NCit	111
Cited doc (%)	39 (29.3)
Cpd	0.8
h index	5
Ndoc Sp (%)	93 (69.9)
Ndoc Eng (%)	39 (29.3)
Ndoc Sp & Eng (%)	1 (0.8)
Lead (%)	112 (84.2)
NC (%)	55 (41.4)
IC (%)	28 (21.1)
IC Lead (%)	8 (6.0)
IC & NC (%)	5 (3.8)
NoCollab (%)	45 (33.8)

of citations per document (1.4). Five articles (3.8%) involved national and international collaboration in unison and were cited 0.8 times on average. The published articles with some type of international collaboration had an average number of citations per document (1.3) that almost doubled the citations of those published only by Cuban researchers, regardless of whether they collaborated or not (0.7). (Table 2).

Two thirds of the articles published in journals belonging to the quartile of maximum visibility (Q1) were carried out with foreign researchers (IC + IC & NC). In other words, only one third of the high-quality articles were published by Cuban researchers, regardless of whether they collaborated or not (Table 3).

In 112 documents (84.2%) the corresponding author (scientific leadership) belongs to a Cuban institution. Seven of the nine most productive institutions have a high percentage of leadership (above 70%), headed by the Luis Díaz Soto Central Military Hospital and the Institute of Hematology and Immunology, leaders in all their articles (Table 4).

3.5. Cuban contribution to international output and publications in the best journals

The world and Latin American scientific output amounts to 82,504 and 5,322 articles, respectively. Cuba contributed 2.5% of the output volume to the Latin American region and 0.2% to the world. In the regional context, Cuba ranks eighth in terms of number of published documents, after Brazil (n = 2681; 50.4%), Mexico (n = 966; 18.2%), Colombia (n = 531; 10.0%), Argentina (n = 455; 8.5%), Chile (n = 449; 8.4%), Peru (n = 312; 5.9%) and Ecuador (n = 226; 4.2%).

With respect to the h-index values, Cuba is in the twelfth place in Latin America, this place is shared with Guatemala and Paraguay (h = 5) and preceded by Brazil (h = 48), Colombia (h = 29), Mexico (h = 28), Chile (h = 22), Argentina (h = 21), Peru (h = 17), Ecuador (h = 12), Venezuela (h = 10), Bolivia (h = 8), Costa Rica, Honduras and Uruguay (h = 7), as well as the Dominican Republic and Puerto Rico (h = 6).

Of the articles, 13.5% (n = 18) were published in the best journals (% output Q1). These documents received 21 citations, representing 18.9% of the total, with an average of 1.2 citations per document. All were published in English and only 7 (38.9%) were led by Cuban researchers (% Q1 Lead). As the visibility of the journals increases according to the quartiles they belong to, the percentage of articles published in English and cited articles increases, but Cuban scientific leadership decreases (Table 3).

The distribution of the journals according to quartiles is as follows: Q1 (n = 18), Q2 (n = 7), Q3 (n = 11), Q4 (n = 11) and non-ranked (n = 5). The Cuban authors published in 52 journals and seven of these published five or more articles, of which one (*Revista Cubana de Cardiología y Cirugía Cardiovascular*) is not yet in the SCImago ranking due to its recent incorporation into Scopus. An equal number (n = 3) of journals belong to the lowest visibility quartiles (Q3 and Q4). (Table 5).

Table 3. Indicators by quartiles after one year of confronting the COVID-19 in Cuba.

Indicators	Q1	Q2	Q3	Q4	Non-ranked
Ndoc (%)	18 (13.5)	8 (6.0)	37 (27.8)	60 (45.1)	10 (7.5)
NCit	21	23	20	44	3
Cpd	1.2	2.9	0.5	0.7	0.3
Cited doc (%)	9 (50.0)	3 (37.5)	9 (24.3)	16 (26.7)	2 (20.0)
Ndoc Sp (%)	-	-	29 (78.4)	57 (95.0)	7 (70.0)
Ndoc Eng (%)	18 (100)	8 (100)	7 (18.9)	3 (5.0)	3 (30.0)
Ndoc Sp & Eng (%)	-	-	1 (2.7)	-	-
Lead (%)	7 (38.9)	6 (75.0)	33 (89.2)	58 (96.7)	8 (80.0)
NC (%)	5 (27.8)	4 (50.0)	12 (32.4)	33 (55.0)	1 (10.0)
IC (%)	10 (55.6)	3 (37.5)	7 (18.9)	4 (6.7)	4 (40.0)
IC & NC (%)	2 (11.1)	-	-	2 (3.3)	1 (10.0)
NoCollab (%)	1 (5.6)	1 (12.5)	18 (48.6)	21 (35.0)	4 (40.0)

Table 4. Indicators of output, visibility, leadership, impact and collaboration in the most productive institutions (≥ 7 articles).

Indicator	Medical University of Havana	Pedro Kourí Institute of Tropical Medicine	Luis Díaz Soto Central Military Hospital	National Institute of Cardiology and Cardiovascular surgery	Center of Molecular Immunology	University of Havana	Hermanos Ameijeiras Clinical-Surgical Hospital	National Institute of Neurology and Neurosurgery	National Institute of Hematology and Immunology
Ndoc (%)	37 (27.8)	17 (12.8)	9 (6.8)	9 (6.8)	8 (6.0)	7 (5.3)	7 (5.3)	7 (5.3)	7 (5.3)
NCit	40	22	3	6	4	5	4	2	-
Cpd	1.1	1.3	0.3	0.7	0.5	0.7	0.6	0.3	-
Cited doc (%)	16 (43.2)	9 (52.9)	1 (11.1)	3 (33.3)	3 (37.5)	2 (28.6)	2 (28.6)	1 (14.3)	-
Ndoc Sp (%)	30 (81.1)	6 (35.3)	5 (55.6)	4 (44.4)	1 (12.5)	3 (42.9)	5 (71.4)	3 (42.9)	6 (100)
Ndoc Eng (%)	7 (18.9)	11 (64.7)	4 (44.4)	4 (44.4)	7 (87.5)	4 (57.1)	2 (28.6)	4 (57.1)	1 (14.3)
Ndoc Sp & Eng (%)	-	-	-	1 (11.1)	-	-	-	-	-
Lead (%)	34 (91.9)	13 (76.5)	9 (100)	4 (44.4)	7 (87.5)	4 (57.1)	6 (85.7)	5 (71.4)	6 (100)
NC (%)	24 (64.9)	8 (47.1)	4 (44.4)	2 (22.2)	6 (75.0)	3 (42.9)	3 (42.9)	3 (42.9)	3 (42.9)
IC (%)	2 (5.4)	4 (23.5)	-	5 (55.6)	1 (12.5)	3 (42.9)	1 (14.3)	4 (57.1)	-
IC Lead (%)	-	1 (5.9)	-	-	-	-	-	2 (28.6)	-
IC & NC (%)	2 (5.4)	2 (11.8)	1 (11.1)	-	1 (12.5)	1 (14.3)	1 (14.3)	-	-
NoCollab (%)	9 (24.3)	3 (17.6)	4 (44.4)	2 (22.2)	-	-	2 (28.6)	-	4 (57.1)
Q1 (%)	2 (5.4)	6 (35.3)	-	1 (11.1)	4 (50.0)	3 (42.9)	2 (28.6)	1 (14.3)	-
Q1 Lead (%)	-	3 (17.6)	-	-	3 (37.5)	-	2 (28.6)	-	-
Q2 (%)	3 (8.1)	3 (17.6)	2 (22.2)	2 (22.2)	2 (25.0)	-	-	-	-
Q3 (%)	12 (32.4)	4 (23.5)	5 (55.6)	2 (22.2)	1 (12.5)	1 (14.3)	-	3 (42.9)	-
Q4 (%)	20 (54.1)	3 (17.6)	1 (11.1)	1 (11.1)	-	2 (28.6)	3 (42.9)	2 (28.6)	7 (100)
Non-ranked (%)	-	1 (5.9)	1 (11.1)	3 (33.3)	1 (12.5)	1 (14.3)	2 (28.6)	1 (14.3)	-

Table 5. Indicators of output, impact, leadership and collaboration in journals with five or more articles on COVID-19 after one year of confronting the COVID-19 in the country.

Journal (Quartile)	Ndoc	NCit	Cpd	Cited doc (%)	Lead (%)	NoCollab (%)	NC (%)	IC (%)	NC & IC (%)
Revista Habanera de Ciencias Médicas (Q4)	26	41	1.6	13 (50.0)	26 (100)	8 (30.8)	17 (65.4)	1 (3.8)	-
Revista Cubana de Pediatría (Q4)	15	1	0.1	1 (6.7)	14 (93.3)	5 (33.3)	8 (53.3)	1 (6.7)	1 (6.7)
Revista Cubana de Medicina Militar (Q3)	11	-	-	-	10 (90.9)	9 (81.8)	1 (9.1)	1 (9.1)	-
Revista Cubana de Hematología, Inmunología y Hemoterapia (Q4)	8	-	-	-	8 (100)	4 (50.0)	4 (50.0)	-	-
Revista Cubana de Investigaciones Biomédicas (Q3)	8	7	0.9	3 (37.5)	8 (100)	3 (37.5)	5 (62.5)	-	-
Revista Cubana de Cardiología y Cirugía Cardiovascular (non-ranked)	5	1	0.2	1 (20.0)	5 (100)	3 (60.0)	1 (20.0)	1 (20.0)	-
Educación Médica Superior (Q3)	5	-	-	-	5 (100)	3 (60.0)	2 (40.0)	-	-

Out of the total, 68.4% of the articles (n = 91) were published in Cuban journals and 22 have been cited at least once. These articles received 53.2% (n = 59) of all citations. The highest volume of output (n = 26) is found in *Revista Habanera de Ciencias Médicas* (19.5%), followed by *Revista Cubana de Pediatría* (11.3%). In five of the seven journals with five or more published research, all articles are led by Cuban authors (Table 5).

3.6. Most productive institutions

Medical University of Havana leads the most productive institutions and managed to participate in 27.8% (n = 37) of the total number of published articles. Pedro Kourí Institute of Tropical Medicine has the highest percentage of cited articles (52.9%). Of the articles published by researchers affiliated with the Center of Molecular Immunology, 87.5% were published in English and half of their articles were high quality, with a high percentage of leadership (3/4). All the articles affiliated with the National Institute of Hematology and Immunology (n = 7) were published in *Revista Cubana de Hematología, Inmunología y Hemoterapia*, which belongs to the fourth quartile (Table 4).

3.7. Collaboration networks

Cuban authors published with researchers from 14 other countries. The figure shows a bibliometric map of the scientific collaboration networks at this level, for which a threshold of one collaboration was established. The most prolific networks were among Cuban and U.S. researchers (Figure 1).

4. Discussion

Scopus was selected for this study because it is one of the largest databases in terms of citations and abstracts of refereed literature and high-quality sources, besides having a wide coverage of Cuban biomedical journals. Scopus was a milestone because of its potential as a source of information for bibliometric analysis and because of the competition introduced to the Thomson Reuters monopoly with its Web of Science, in terms of functionality, services and data. With respect to Dimensions, appearing in 2018, a recent study found that, although it has a 25% greater coverage than Scopus, about half of its documents are not associated with any country or institution, which makes bibliometric studies at these levels difficult [47].

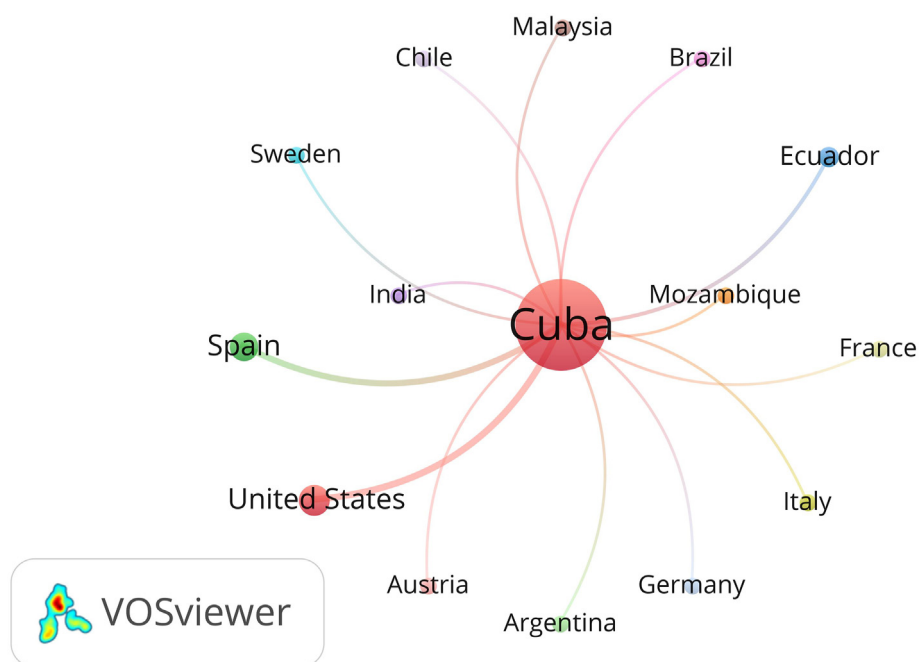


Figure 1. Scientific collaboration networks among countries with articles published with Cuban researchers.

The present research characterizes the Cuban scientific output on COVID-19 after a year of confrontation and emphasizes scientific collaborations since the approach to the disease as a pandemic requires it. This work assumes that the impact of a research is reflected in the consumption and citation it receives in the world literature once it is published.

The output of Cuban scientific articles is lower than expected due to the existing human potential and the high number of health professionals who are directly facing the pandemic, who could be a very valuable source of publishable experiences [36, 37]. This has multiple aspects of analysis, ranging from insufficient training in scientific writing and publication from undergraduate level to the existence of other priorities - justified - such as assistance, which consume much time and effort [48].

At the Latin American level, Cuba ranks eighth in terms of the number of published documents, which is relevant if the total population and the condition of an economically blockaded country are taken into account, but its twelfth position in terms of the h-index is not satisfactory and is in agreement with previous reports [48].

This research reveals the inadequacies of Cuban scientific publications in a field of medical sciences, in terms of output, visibility, leadership and impact. In order to reflect the Cuban achievements in regard to prevention, diagnosis and treatment of COVID-19 in the scientific literature, it is necessary to publish in journals of higher visibility, since only thirteen percent of the articles were high quality (Q1).

The low publication in journals in the first quartile continues to be a distinctive characteristic of Cuban science, which is not only of the health sector [49]. The fact that the greatest volume of output is concentrated in the quartiles of lower visibility has to do with the fact that almost one seventh of the articles were published in Cuban journals, which are located in those quartiles. This denotes a predilection for national journals, which is reinforced by the fact that, for example, all the articles affiliated with the National Institute of Hematology and Immunology, one of the most productive institutions, were published in *Revista Cubana de Hematología, Inmunología y Hemoterapia* (Q4).

The fact that *Revista Habanera de Ciencias Médicas* has the largest number of articles on COVID-19 is, to some extent, expected and has two sides to it. First, it may be related to the recent indexing the journal has achieved. That makes the journal increasingly attractive to researchers who, in their eagerness to have the highest visibility for their articles, send their proposals for publication to the journal. Second, in the initial phase of COVID-19 in Cuba, the journal launched a call to receive and prioritize articles related to the pandemic and its impact on the populations' health. Thus, it published a special issue entirely on the disease, which together with the articles on this subject that have also continued to be published in the regular issues, makes this the journal the one with the highest scientific output.

Revista Cubana de Pediatría is in second place in terms of the number of documents published, which is interesting since it is a specialized journal. This can be due to the fact that this journal also launched a call for papers on COVID-19 and published a special issue. In addition, the health of pediatric patients has always been a priority in Cuba, especially in times of pandemic. Hence, the necessary resources are allocated to provide medical care and generate research in this population group, which finally conclude with the respective publications.

As the visibility of the journals increases according to the quartiles where they are placed, the percentage of both articles published in English and cited articles increases, but Cuban scientific leadership decreases. This may be due to the fact that there is a predilection for publication in national journals, which are located in lower quartiles of visibility in Scopus [48, 50]. It is important to prioritize publication in multilingual journals. Thus, more actions are needed to urgently transform this situation. The current problem is not only to publish more, but also to know how and where to do it. It is not a matter of publishing for the sake of publishing, but of publishing at least as the best in the world. We cannot do local science and feel satisfied. We have to do competitive

science at the world level and that inexorably implies publishing our research results in the best international journals.

This can also be related to publication requirements in journals located in the high visibility quartiles, whose working language is English. In addition, positioning them in these quartiles guarantees comprehensive visibility since they constitute leading journals on different research fronts. Researchers consult their contents which ensures a more significant opportunity to receive citations.

Cuban scientific leadership decreases when analyzing the presence of papers in the most visible journals. Many factors condition this result, such as the insufficient culture of publication, the lack of research projects with funding to guarantee the translation and publication of articles in high-impact journals, the low command of English, the limitations of Internet connectivity, the ignorance that the author for correspondence is the leader of the article, among others. If this were known, this leadership would, in many occasions, pass to the Cuban author, who provides the experience, the sample and sometimes the national technology. This work could serve to clarify the leadership aspect of research [50].

International collaboration reaches its maximum expression in the first quartile, where a little more than half of the articles were published with foreign researchers. It might be possible that most Cuban researchers and managers depend on international collaboration to publish in journals of maximum visibility and in English, which has been reported previously [48, 50, 51, 52]. It is necessary to promote international scientific collaboration in order to favor visibility and impact of the research developed. The strategies to follow can be generated at an institutional and personal level. Health institutions can identify their leading authors, create collaboration agreements with foreign universities and promote scientific exchange and knowledge transfer through the coordination of scholarships or research stays. The visibility of projects, research, authors and institutions on social networks (Facebook, Twitter) and academic networks (ResearchGate, Publons, [Academia.edu](https://www.academia.edu)) is another element to incorporate in a potential strategy. Thus, it can attract the attention of researchers from all over the world with similar lines of research. In addition, Cuba has a large number of health personnel that are part of the Henry Reeve International Medical Brigade, specialized in the management of disasters and serious epidemics. In the current context of COVID-19, thousands of Cuban professionals provide medical care in different countries, with lots of experience that can be visible through the publication of scientific articles co-authored by researchers from countries receiving Cuban aid. All of the above is based on the balanced promotion of international collaboration and Cuban scientific leadership.

Although it is recognized that it is soon to evaluate the impact of articles through the received citations, it is already possible to observe that those published in journals belonging to the quartiles of higher visibility (Q1 and Q2) have had an impact on the scientific community and the implications of their results are considered by other authors, since their average number of citations is much higher than that observed in those published in less visible journals (Q3, Q4 and non-ranked).

It is important to know the structure and dynamics of scientific collaboration networks at the country level that the co-authorship of scientific articles underlie. In addition, that allows us to know whether these cooperation networks have evolved over time. Similar to what was previously reported [48], the main scientific collaborations were established with U.S. researchers. Despite the unjust economic, financial and commercial blockade imposed by the U.S. government on the Cuban people for more than sixty years, researchers from both nations have historically collaborated in science. In the middle of the COVID-19 pandemic, a scientific synergy can be glimpsed for the benefit of health [53]. The potential and power of science in the United States and what it could contribute to the development in Cuba is well known. Similarly, Cuban science has results to show to the world and the northern neighbor and to achieve in the near future, with the will of its protagonists, greater efforts, especially because the Cuban biotechnology industry has several

vaccine candidates in clinical trials that have shown favorable results [54, 55].

This study also reveals patterns associated with the language of publication. Articles in English received, on average, twice as many citations as articles in Spanish. In addition, all the articles published in the journals of the first two quartiles were published in English. Because English is considered the lingua franca of contemporary science, the articles published in that language have the most significant impact on the world scientific community. In addition, slightly more than ninety percent of the articles published in Spanish appeared in Cuban journals. Although these journals are open access and have the visibility offered by their indexation in Scopus and other recognized international prestige databases, their published contents do not reach the expected scientific impact.

The fact that the Medical University of Havana and the University of Havana are among the most productive institutions has been reported previously [50, 56] and could be related to the large number of faculties they have, as well as the number of teachers and undergraduate and graduate students linked to the fight against the pandemic. It is important to highlight that most of the attending physicians are also professors at different universities, this is why they declare them to be one of their affiliations. When compared to the existing literature, in most of the topics, universities stand out as the main centers of knowledge generators, and it is precisely because of this fact.

It was not a surprise that the Pedro Kourí Institute of Tropical Medicine and the Luis Díaz Soto Central Military Hospital are among the institutions with the highest number of articles, since they were among the first to be involved in the diagnosis and treatment of patients infected with COVID-19 [37]. In addition, they are institutions with a long research history where the culmination of the research cycle with its respective publication of their results in internationally visible journals is a common practice.

It is necessary to remark that the most important research centers, as well as the most renowned medical specialty institutes and hospitals, are located in the country's capital. Moreover, we can mention that they have the best resources at their disposal to carry out research, generate results and publish in internationally visible journals. On a national scale, these institutions are, in turn, the ones with the largest number of scientific collaboration agreements with foreign institutions, including some from the first world. They provide technologies that the rest of the country's institutions do not have and allow their researchers to publish in top-ranked journals, where the technological aspect applied to research is fundamental.

It would be expected that among the most productive institutions there would be other hospitals in the country, mainly those located in the main cities of other provinces as they are where the battle against COVID-19 is also fought. Thus, the research resulting from the treatment of patients and the respective publications in scientific journals would have a greater weight in the total volume analyzed at the institutional level. However, this did not happen and may be conditioned by the low culture of publication, health care burden and other factors that affect Cuban scientific output in regard to health sciences that were previously discussed.

As in all research, there exist some limitations: the main one has already been discussed (the fact that many might think that it is too early to evaluate the impact of the publications). However, we emphasize the fact that this is a study that will provide important advances in terms of the science that is being generated around such an important topic of global public health. We recognize the importance of preprints in the immediacy of the communication of scientific research results. However, in this research, only citable articles (original and reviews) were included in order to study the scientific production whose quality has been supported by a peer review process. In any case, for future studies we recommend including documents, whether citable or not, indexed in repositories, preprint servers, as well as articles published in journals not indexed in Scopus but in equally important databases, such as Web of Science, Dimensions, ScELO, Latindex, etc.

5. Conclusions

The Cuban scientific output on COVID-19 published in journals belonging to the first quartile is characterized by being written exclusively in English, and involving a greater number of international institutions in the research, which guaranteed the influence that exerts on the international scientific community. Cuban scientific leadership is inversely proportional both to the impact of COVID-19 research according to the citations it receives in the world literature, and to scientific collaborations. Cuban researchers are not yet able to systematically generate research that has a significant impact on the international scientific community. The scientific work carried out by Cuban professionals during a whole year confronting COVID-19 is not sufficiently reflected in the scientific literature.

Declarations

Author contribution statement

Ibraín Enrique Corrales-Reyes: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Frank Hernández-García, Adrián Alejandro Vitón-Castillo, Christian R. Mejía: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

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