

## Coronavirus: an overview of Brazil's international scientific collaboration throughout history

Coronavírus: um panorama sobre a colaboração científica internacional do Brasil ao longo da história

Coronavirus: una visión general de la colaboración científica internacional de Brasil a lo largo de la historia

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### ABSTRACT

The worldwide research effort on covid-19 is reflected in the increase in scientific publications. In order to investigate and describe Brazil's international scientific collaborations on the topic, we performed a bibliometric analysis using the Scopus database as our data source, with a search strategy that included terms related to the virus and the disease. For the period ranging from 1989 to 2020, 3,255 publications were retrieved, 1,310 of which were international scientific collaborations, which were classified in terms of nationality, institutional affiliation, the journals in which they were published and their disciplines. The co-authored publications on covid-19 involved 148 countries, 104 of which are new partners. Over the period analyzed, new areas of knowledge were incorporated into the discussion on the subject.

**Keywords:** Coronavirus; Covid-19; Scientific collaboration; Brazil; Pandemic.

## RESUMO

O esforço mundial de pesquisa sobre covid-19 tem refletido no aumento de publicações científicas. A fim de investigar e descrever como vem se dando a colaboração científica internacional do Brasil no tema, foi realizada análise bibliométrica, que utilizou a base de dados Scopus como fonte de dados, com uma estratégia de busca que incluiu termos referentes ao vírus e à doença. Foram recuperadas 3.255 publicações, entre 1989 e 2020, das quais 1.310 são em colaboração científica internacional, que foram descritas em relação à nacionalidade, afiliação institucional, periódicos que publicaram os trabalhos e sua área temática. Essas publicações em coautoria sobre covid-19, envolveram 148 países, sendo que 104 deles são novos parceiros. Ao longo do período analisado, novas áreas de conhecimento foram incorporadas na discussão sobre o tema.

**Palavras-chave:** Coronavírus; Covid-19; Colaboração científica; Brasil; Pandemia.

## RESUMEN

El esfuerzo de investigación mundial sobre covid-19 se ha reflejado en el aumento de publicaciones científicas. Para investigar y describir cómo se ha venido desarrollando la colaboración científica internacional de Brasil en el tema, se realizó un análisis bibliométrico, que utilizó como fuente de datos la base de datos Scopus, con una estrategia de búsqueda que incluyó términos referentes al virus y la enfermedad. Se recuperaron 3.255 publicaciones, entre 1989 y 2020, de las cuales 1.310 se encuentran en colaboración científica internacional, las cuales fueron descritas en relación a nacionalidad, filiación institucional, revistas que publicaron los trabajos y su área temática. Estas publicaciones en coautoría sobre covid-19 involucraron a 148 países, 104 de los cuales son nuevos socios. Durante el período analizado, se incorporaron nuevas áreas de conocimiento a la discusión sobre el tema.

**Palabras clave:** Coronavirus; Covid-19; Colaboración científica; Brasil; Pandemia.

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## ARTICLE INFORMATION

This article is part of the dossier **Metric studies of scientific healthcare information, part 1.**

### Authors' contributions:

Research concept and study design: Rosane Abdala Lins, Rosangela Cordeiro de Souza Assef Neto, Cícera Henrique da Silva, Maria Cristina Soares Guimarães.

Acquisition, analysis or interpretation of data: Rosane Abdala Lins, Rosangela Cordeiro de Souza Assef Neto, Cícera Henrique da Silva, Maria Cristina Soares Guimarães.

Writing of the manuscript: Rosane Abdala Lins, Rosangela Cordeiro de Souza Assef Neto, Cícera Henrique da Silva, Maria Cristina Soares Guimarães.

Critical review of intellectual content: Rosane Abdala Lins, Rosangela Cordeiro de Souza Assef Neto, Cícera Henrique da Silva, Maria Cristina Soares Guimarães.

**Declaration of conflicts of interest:** none.

**Sources of financing:** none.

**Ethical considerations:** none.

**Acknowledgments/Additional contributions:** none.

**Article history:** submitted: May 30, 2021 | accepted: Aug. 28, 2021 | published: Nov. 10, 2021.

**Prior submission:** none.

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## INTRODUCTION

The public health crisis that still threatens the world since the emergence and spread of the SARS-CoV-2 virus, which causes severe acute respiratory syndrome 2, covid-19, has caused an exponential increase in the number of scientific publications and Brazil has taken part with a growing volume of publications since the beginning of 2020.

The time between the emergence of the first cases and the declaration of a global health emergency was very short.

The first cases occurred in December 2019, in Hubei province, China, and were reported by the Chinese government in January 2020, according to the World Health Organization (WHO) (WORLD HEALTH ORGANIZATION, 2020a).

In the last two decades, two instances of outbreaks caused by coronaviruses have made headlines and turned public health agendas and research into an international concern. The first was in 2003, an outbreak of Severe Acute Respiratory Syndrome (SARS) caused by a beta-variant coronavirus (SARS-CoV), which started in southern China and spread to 33 countries on five continents, resulting in 8,700 cases with 744 deaths. The second occurred in 2012, starting in Saudi Arabia, caused by the Middle East Respiratory Syndrome Coronavirus (MERS-CoV). The first cases were detected in dromedaries and later in humans. Since then, several epidemics have been reported in the Arabian Peninsula, caused by the virus (CONTINI *et al.*, 2020; KUMAR *et al.*, 2020; SINGHAL, 2020).

The SARS-CoV-2 virus was named this because it is genetically related to the virus responsible for the SARS epidemic in 2003 (GORBALENYA *et al.*, 2020). Like its epidemic predecessors, it attacks the lower respiratory system and causes viral pneumonia. It can also affect the gastrointestinal system, heart, kidneys, liver and the central nervous system, even leading to multiple organ failure (LIU *et al.*, 2020).

The disease was officially declared a pandemic by the WHO on March 11, 2020. Since then, according to data from August 2021, more than 205 million cases have been confirmed, and among these there have been more than 4 million deaths worldwide, which translates into a pandemic of staggering proportions (WORLD HEALTH ORGANIZATION, 2020b). Daily monitoring of the numbers of infections and deaths, from an international perspective, has been carried out by several institutions that have developed data panels such as [Covid-19 Case Tracker](#), by Johns Hopkins University, in the United States and [Monitora Covid](#), from the Oswaldo Cruz Foundation (Fiocruz), in Brazil.

Many viral infections are preventable or controlled by vaccines, antivirals and public health strategies. Pandemics, however, demand broader national and international actions due to the scope of the global health emergency – in the sense of planning and implementing both social protection measures and strategies for mobilizing science to obtain responses aimed at broader production of knowledge in all thematic areas. When facing the unknown and uncertainty, it is hoped that the best answer regarding how to protect life will come from science.

Currently, in this society linked through interconnection and relationship networks in times of pandemic, science enterprise, as a collective, will emerge as a driving force to assemble a large puzzle that allows us to understand the different dimensions and expressions of the virus and ways to tackle it (ENQUIST, 2009).

Bill Gates (GATES, 2020) emphasizes that, in addition to technical solutions, diplomatic efforts will be needed to expand international collaboration and the sharing of data and information. For example, the development of antivirals and vaccines involves a large number of clinical trials and licensing agreements that cut across national borders. Thus, it is critical to make the most of global forums to help build consensus on research priorities and trial protocols so that promising vaccines and antivirals can flow quickly through this complex process. The author cites the WHO platforms as an example: World Health Organization R&D

Blueprint, the International Severe Acute Respiratory and Emerging Infection Consortium Trial Network and the Global Research Collaboration for Infectious Disease Preparedness, whose work should be to obtain conclusive clinical trial results and regulatory approval within 3 months, without compromising patient safety (GATES, 2020).

An example of this effort to stimulate international collaboration was that, under the coordination of WHO, in April 2020, scientists representing several countries signed a public declaration committing to joint collaboration for the development of a vaccine against the disease (WORLD HEALTH ORGANIZATION, 2020c).

The response of the scientific community in other public health emergencies, such as SARS, MERS, H1N1, Ebola and Zika, was documented in studies that show that the number of scientific publications grew after the WHO declared an outbreak or epidemic (RODRIGUEZ *et al.*, 2020). In the case of the covid-19 pandemic, this same trend in the number of publications was seen.

As expected, with the number of cases spreading rapidly around the world, the worldwide research effort reflected this through an increase in the number of publications indexed in databases and preprint repositories. To get an idea of the extent of this trend, there were 126,674 publications on coronaviruses indexed in PubMed (the main source of information in the area of health sciences) on January 14, 2021. The total published between 1949 and 2019 was 56,429. The number published in the year 2020 was 70,245, greater than the total for the prior 70 years.

In [medRxiv](#), the main preprint repository in the health sciences domain, providing access to data from medRxiv and bioRxiv, the number of works indexed as of December 2020 was 18,989, with 12,851 in the year 2020.

It is important to note that this increase, particularly of preprints, reflects a change in the traditional flow of scientific communication and reflects the urgency of sharing initial findings more quickly. The traditional process of evaluating and disseminating research results is highly dependent on the time frames and processes of scientific editorial teams, and this work is now being carried out by the scientific community itself. Thus, other forms of communication between peers are strengthened, such as fast track and preprints, which allow faster access to the initial results of research.

It is essential to recognize the need for global collaboration, given the magnitude of the problem, which calls for a series of large-scale analyses, exchange of perspectives, synthesis of knowledge and translation into different languages, to inform evidence-based policy and practice (HOSSAIN, 2020). As a collective enterprise, scientific collaboration has always been taken and analyzed as recognition and evidence that the advance of knowledge, in normal, paradigmatic or even pandemic times, is the result of an effort to complement and synthesize dispersed knowledge and expertise.

Recognized for its importance in the scientific field as a driver of growth, scientific collaboration has been the subject of research in the field of information science in Brazil and worldwide.

Bibliometric analyses of scientific production are valuable perspectives for monitoring the advance of knowledge on the subject and, in particular, can provide a picture of the development and strengthening of scientific collaboration during a global pandemic.

Information Science authors have been investigating scientific collaboration, as noted by Maia and Caregnato, as information technology and ease of movement have led to an increase in co-authorships through shared studies and collaboration networks. These collaborations between authors have increased in all disciplines, although the degree of collaboration is not the same across them. The authors observed that the number of scholars in the natural sciences is much greater than that in the social sciences. In the latter, theoretical studies generate publications with fewer authors than those in the former, of an experimental nature (MAIA; CAREGNATO, 2008).

Co-authorship has also been the subject of analysis in bibliometric and scientometric studies as an indication of scientific collaboration between people, institutions and countries, although it cannot be assumed to be synonymous with collaboration, since not all of the authors listed in a work are responsible for the intellectual work: “not all collaborations result in an article, and co-authorship does not always indicate collaboration” (VANZ; STUMPF, 2010, p. 45). In a book published in 1963, in English, but whose Portuguese version was published in 1976, Price had already announced that if the pace of growth in the pattern of collective authorship in chemistry continued, articles with a single author would disappear.

There are a variety of reasons that lead researchers to publish jointly or individually, even when they have worked together on a research project. There is evidence of their collaboration when they publish results in a joint article. However, if they publish individually, for any reason, the collaboration is not evident (GRACIO, 2018).

In a 2010 review article, Vanz and Stumpf (p. 51) listed 17 reasons for the existence of scientific collaboration:

1. a desire to increase scientific popularity, visibility, and personal recognition;
2. increased productivity;
3. rationalization of the use of scientific labor and the time devoted to research;
4. reduction of the possibility of error;
5. facility in obtaining and/or expanding financing, resources, special equipment or materials;
6. increased specialization in science;
7. possibility of “attacking” major research problems;
8. increased professionalization of science;
9. a desire to enhance one’s experience through the experience of other scientists;
10. a desire to carry out multidisciplinary research;
11. joining forces to avoid competition;
12. training of researchers and advisees;
13. the need for outside input to confirm or assess an issue;
14. potential for greater dissemination of the research;
15. a way to maintain concentrated on the research and disciplined until the results are delivered to the rest of the team;
16. sharing enthusiasm for a research topic with someone;
17. a need to work physically close to other researchers, out of friendship and a desire to work with someone you like.

The “possibility of ‘attacking’ major research problems” and the “rationalization of the use of scientific labor and the time devoted to research” are highlighted here, as reasons related to this study.

Recent studies in the area (SOBRAL *et al*, 2016, p. 3) point to an increase in collaborative work, “encouraged by the principle of sharing resources and reducing costs, which, intentionally or not, stimulates the formation of teams.”

It is important to emphasize the social aspect of scientific collaboration, in which the commitment of individuals and institutions participating in the distribution of activities throughout the research project timeline, and in writing and submitting the resulting publication can be seen (GRACIO, 2018).

In this sense, countries are expected to be in accordance with the literature on information metric studies described here, consolidating growth in their co-authored scientific publications on covid-19.

In particular, with regard to Brazil, it is worth investigating and describing how international scientific collaboration on the subject has been taking place, starting with research on coronaviruses, and continuing on to SARS, MERS and covid-19.

Thus, the objective of this paper is to describe publications by Brazilians together with researchers from other countries on the subject over the years, specifically focusing on publication practices during epidemics related to coronaviruses.

## METHODOLOGY

To map Brazilian scientific publications on coronaviruses throughout history, we decided to search the Scopus database because it is considered to be an international reference for multidisciplinary research and also had more records indexed at the time of the search when accessed via the [Capes Portal](#). It was hoped that it would thus have a more interdisciplinary view of Brazilian scientific collaborations on the subject of covid-19.

The strategy used included the following search terms: “COVID-19” OR “Coronavirus” OR “Corona vírus” OR “2019-nCoV” OR “SARS-CoV” OR “MERS-CoV” OR “Severe Acute Respiratory Syndrome” OR “Middle East Respiratory Syndrome.”

The search, carried out on Jan. 14, 2021, was performed in the title, abstract and keyword fields, initially obtaining publications from all over the world. Next, the country filter provided by the database itself was used to identify the publications attributed to Brazil. The results were not filtered by date.

The records retrieved were downloaded from the database in CSV format and imported into text-mining software. The next step was elimination of duplicates and disambiguation of the affiliation variables and country of origin of the institution, with the objective of obtaining data on the institutional origin of the research and respective collaborations, through co-authorship.

Time frames were defined for the occurrences of other outbreaks that had a coronavirus (with variations) as the cause, namely SARS, starting in 2003, and MERS, starting in 2012. And the period beginning in 2020, with the covid-19 pandemic, which also had a coronavirus as the protagonist.

A limitation of this research was the use of a single data source, although the importance of the database because of its interdisciplinary coverage is recognized.

## RESULTS AND DISCUSSION

There were 3,255 Brazilian publications on coronaviruses<sup>1</sup> indexed in the Scopus database through 2020, which corresponds to 2.6% of the total worldwide (126,674). Brazil’s first publication on the subject was in 1989, in collaboration with Germany. Note that there were no Brazilian publications indexed in the database for 1998 and 2001.

Of a total of 3,255 publications, 1,310 were collaborations with other countries, or 40.2% of the total, as shown in Figure 1. In this figure, we decided to use a log scale since the magnitude of the data is very large, making a linear plot less suitable. By using this scale, we can see the percent or proportional difference between the values which, in this case, are very different in absolute terms and we can visualize the trend in the data.

Note that, so far, more than 50% of publications on the theme are collaborations only between Brazilian institutions.

The percentage of co-authored production, whether domestic or international, shows that collaborative research is a characteristic of the healthcare field, corroborated by the study by Sobral *et al* (2020, p. 2) on scientific collaboration in the field of neglected tropical diseases, which states that collaboration is “one of the

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<sup>1</sup> The term coronavirus, in the text that follows, will be used to represent all the terms used in the search, with the type or clinical expression specified only when pertinent.

clearest scientific foundations in the field of healthcare.” This is also commented on by Maia and Caregnato (2008), who mention that the number of authors in the natural sciences is much higher than that in the social sciences. Price, in his book *Little Science, Big Science*, also announced in 1976 that co-authorship would be a growing trend.

Clearly, there were few Brazilian scientific publications on coronaviruses until the early 2000s, no more than ten articles a year. Subsequently, the scenario began to change, with upward curves during the SARS and MERS epidemics, and then exponential growth related to the covid-19 theme in 2020.

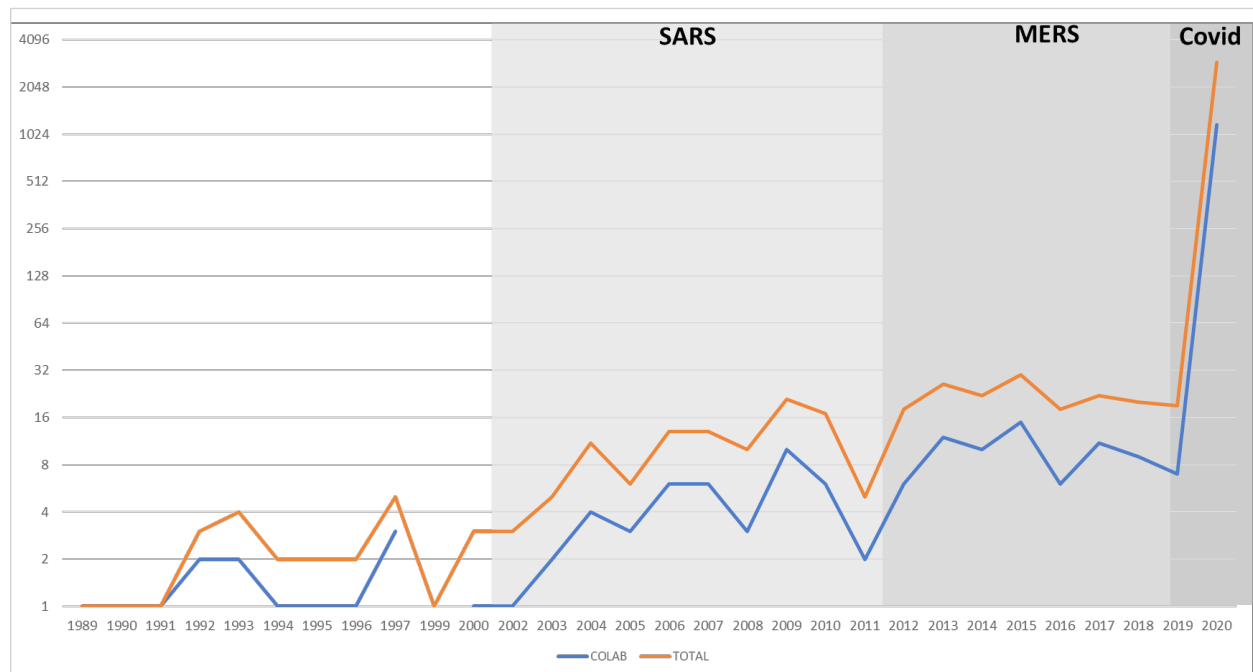


Figure 1 - Annual trend in total number of publications and in Brazilian scientific collaborations on coronaviruses  
Source: prepared by the authors based on Scopus data.

In the period from 1989 to 2002, before the first milestone, which was the SARS-CoV outbreak, a total of 28 publications were indexed. Between 2003 and 2011, the first outbreak, the number of publications jumped to 102. From 1989 to 2011, 57 publications were in collaboration with other countries, representing 43.8% of the total.

The second period highlighted begins in 2012, when the MERS-CoV epidemic occurred in Saudi Arabia. There were 174 Brazilian scientific publications in this period, from 2012 to 2019 – an increase of 72 records compared to the SARS period. During that period, 76 publications were in collaboration with other countries, or 43.6%.

In 2020, the period that represents the covid-19 pandemic, the number of indexed publications jumped to 2,951, with 1,177 involving collaboration, or 40.6% of the total. It is noteworthy that the increase in scientific publications, as well as in collaboration, was so significant in just one year (2020), suggesting a shared approach among authors and institutions regarding the possibility of “attacking” major research problems, as mentioned above by Vanz and Stumpf (2010).

Scientific collaboration between Brazil and other countries has been increasing over the years. The first partner country was Germany when, in 1989, there was a partnership between the Butantan Institute and the Max Planck Institute, which resulted in the article “A Major Role of Macrophage Activation by Interferon-Gamma during Mouse Hepatitis Virus Type 3 Infection. I. Genetically Dependent Resistance” published in the journal *Immunobiology*.

The number of collaborating countries varied over time, and during the period from 1989 to 2019, it varied from 1 to 18.

In 2020, however, there was collaboration with 148 different countries. This increase in the quantity of joint publications is evidence of the importance of scientific collaboration to fight the pandemic. Furthermore, the data attest to the importance of the participation of Brazilian researchers as partners in international collaborations, making clear their potential to contribute to solving the challenge posed.

Figure 2 shows the geographic distribution of Brazilian scientific collaborations on coronaviruses, according to co-authorship of scientific publications from 1989 to 2020.

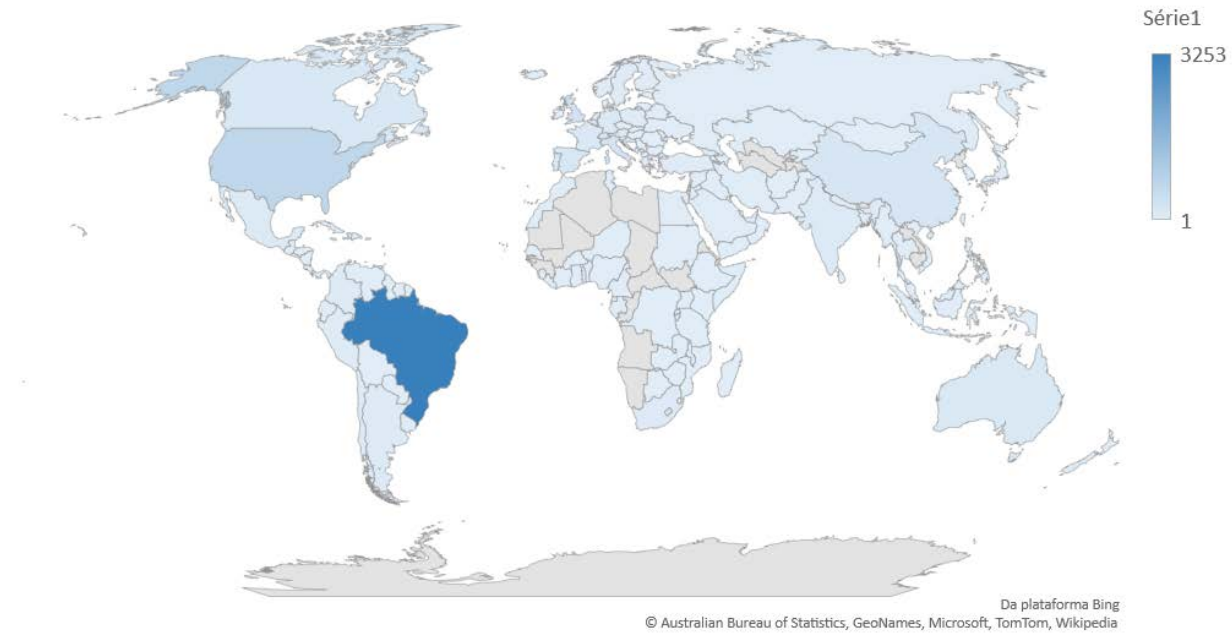


Figure 2 – Geographical distribution of collaboration between Brazil and other countries

Source: prepared by the authors based on Scopus data.

Table 1, below, shows the ten countries that published the most scientific collaborations with Brazil and trends over the period analyzed.



**Table 1 – Trends over time of scientific collaborations with the ten countries that most frequently collaborated with Brazil**

												SARS										MERS					COVID-19	Total				
		1989	1990	1991	1992	1993	1994	1995	1996	1997	1999	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016		2017	2018	2019	2020
1	United States	-	-	-	-	-	-	-	1	2	-	-	1	2	1	1	2	2	1	5	1	1	2	5	6	9	2	4	5	1	635	686
2	United Kingdom	-	-	1	-	-	-	-	-	-	-	-	1	1	-	1	2	2	-	2	-	-	-	2	2	1	2	1	-	5	257	279
3	Italy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	-	1	244	248
4	China	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	3	1	-	-	-	2	3	2	-	3	1	-	194	213
5	Spain	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	189	192
6	Canada	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	1	-	-	-	-	-	1	1	-	-	-	161	166
7	Australia	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	2	-	2	-	-	136	142	
8	Germany	1	1	-	2	2	-	-	-	1	-	1	-	-	2	-	-	-	-	-	-	-	1	1	-	1	1	-	-	1	123	130
9	France	-	-	-	-	-	1	1	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	2	1	-	-	-	-	126	131
10	Portugal	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	1	1	-	-	-	-	101	105

Source: prepared by the authors based on Scopus data.

The figures show how international collaboration has increased over the years and involves an increasingly larger number of authors from different countries. On the theme of SARS-COV, there was growth throughout the outbreaks, which corroborates the hypothesis of Gracio (2018) on the social aspect of scientific collaboration. In this case, all the countries that are among the ten that published the most already had a collaborative relationship with Brazil, which indicates that research partnerships on the subject have been formed over the years.

Brazil participated in scientific collaborations (a total of 4,752) with countries from all continents and, in particular, with all European countries. On this continent, the United Kingdom is the most frequent, as shown in Table 1, maintaining a regularity of publication in previous epidemics and intensification in this pandemic.

Germany is the country that began joint publication with Brazil the earliest, since 1989, despite not maintaining regular publication over the years and resuming the partnership in 2020. Note also that the European continent also has the largest number of publications in collaboration with Brazil (1,980).

North America ranks second among the continents that published the most in collaboration with Brazil, with the United States being the most productive and oldest partner country, with a total of 686 publications since 1996. Furthermore, it collaborated consistently in all highlighted periods (SARS, MERS and covid-19) (Table 1).

In South America, Brazil published together with all countries, with Colombia being the most representative, with 87 publications. Among these, Peru is the oldest partner, publishing with Brazil since 2009, despite not publishing regularly. The partnership intensified in 2020.

The third most important continent in terms of number of publications is Asia, and collaboration took place with 35 countries. China was the country that published most frequently with Brazil since the first SARS outbreak (2007). Taiwan is the Asian country that was the first to publish with Brazil, with a publication in 2003, but then again only in 2020.

The participation of the African continent stands out because of the large number of countries that started publishing with Brazil (33). South Africa was the first to publish with Brazil, with a single publication in 2014 and another in 2018, then again in 2020.

Collaboration of Brazilian researchers with researchers in Oceania is highlighted by the fact that Australia is among the ten countries that published the most with Brazil, with a few publications during the MERS and SARS outbreaks, then a large increase in 2020. This country also occupies the position of the oldest collaborator in this region, beginning in 2003.

Below, Table 2 shows the trends in international collaborations leading to publications of the ten most productive Brazilian institutions.

**Table 2 – Trends over time of the scientific collaborations of the most productive Brazilian institutions.**

		SARS										MERS										COVID-19	Total									
		1989	1990	1991	1992	1993	1994	1995	1996	1997	1999	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011		2012	2013	2014	2015	2016	2017	2018	2019	2020
1	USP					1				2	1		1		2	2	5	5	2	7	8	4	5	12	8	10	8	8	3	6	494	<b>618</b>
2	FIOCRUZ															2			1		1		1		1			2		194	<b>211</b>	
3	UFRJ														1			1		1		1			1	1	1	3		161	<b>183</b>	
4	UNIFESP			1														1		2	1	4	2					1	143	<b>167</b>		
5	UFMG														1		1	2		1	1		1	1	2			1	115	<b>133</b>		
6	UNICAMP						1				1									1	1	1	2	1	4		1		89	<b>112</b>		
7	UFRGS																	2	1					4	3	2	2	1	2	2	90	<b>111</b>
8	UERJ																													102	<b>104</b>	
9	UFPE																		1				1						2	91	<b>98</b>	
10	UFBA												2			2								1			1		1	80	<b>91</b>	

Caption: USP – University of São Paulo; UFRJ – Federal University of Rio de Janeiro; UNIFESP – Federal University of São Paulo; UFMG – Federal University of Minas Gerais; UNICAMP – State University of Campinas; UFRGS - Federal University of Rio Grande do Sul; UERJ - State University of Rio de Janeiro; UFPE - Federal University of Pernambuco; UFBA - Federal University of Bahia.

Source: prepared by the authors based on Scopus data.

The table above lists nine public universities and only one teaching and research institution. Another important detail is that publications appear throughout the period studied, before SARS and during the specific time periods considered in this study — SARS, MERS and covid-19.

Among the main Brazilian institutions, the University of São Paulo (USP) stands out with the largest number of publications (618 records) and has also been the most consistent over the years, having published on the subject since 1993.

Fiocruz, a teaching and research institution, ranks second, with 211 publications, having begun collaborations in 2006 and strengthened them in 2020 due to the pandemic.

It is important to highlight that, despite the research being concentrated along the South-Southeast axis in Brazil, some universities in the Northeast are among the top ten, such as the Federal University of Pernambuco (UFPE) and the Federal University of Bahia (UFBA), the latter having publications as far back as 2003.

The Butantan Institute, the first Brazilian institution to publish on this topic as part of an international collaboration, does not appear in Table 2 as it did not rank among the top ten institutions in terms of the number of publications. But it is important to note that this collaboration was with the Max Plank Institute in 1989, and that it had 34 publications in the period studied.

With regard to international institutions, Table 3 lists the top ten that published together with Brazilian institutions.

**Table 3 – Trends over time of the ten international institutions that published the most together with Brazilian institutions.**

												SARS										MERS					COVID-19	Total																																
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1999	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017		2018	2019	2020																													
1	University of California – US																																1						35	36																				
2	University of Toronto – Canada																																											28	28															
3	IRCCS for Oncology – Italy																																											27	27															
4	University of Barcelona – Spain																																													23	23													
5	Brown University – US																																													22	22													
6	University of Oporto – Portugal																																													1					19	20								
7	University of Washington – US																																																21	21										
8	Harvard University – US																																																1					20	21					
9	University College London – United Kingdom																																																		18	18								
10	University of Florida – US																																																		1								17	19

Source: prepared by the authors based on Scopus data.

Contrary to the contents of Table 2, which lists Brazilian institutions, in Table 3 the ten most productive partnerships with international institutions are concentrated in 2020, which suggests that these collaborations were due to the pandemic. However, other data show that partnerships exist with other institutions throughout the period studied, with fewer publications, which is why they are not included among the institutions listed in the table above.

With respect to the distribution of these publications, the 1,310 articles representing international collaborations with Brazil were published in 734 scientific journals. Box 1 lists the ten journals that contained the largest number of these publications, from 1989 through 2020.

**Box 1 – Principal journals that published Brazilian scientific research performed in collaboration with foreign institutions**

	Journals	Articles
1	PLoS ONE	20
1	Revista da Associação Médica Brasileira	20
2	Dermatologic Therapy	18
2	International Journal of Environmental Research and Public Health	18
3	Cadernos de Saúde Pública	17
4	Journal of Medical Virology	15
5	Arquivos Brasileiros de Cardiologia	14
5	Ciência e Saúde Coletiva	14
6	Revista de Administração Pública	13
7	Jornal Brasileiro de Nefrologia	11
7	Revista da Sociedade Brasileira de Medicina Tropical	11
8	Frontiers in Medicine	10
8	The Lancet	10
9	Intensive Care Medicine	9
9	International Braz J Urol	9
9	Revista do Colégio Brasileiro de Cirurgiões	9
10	Science of the Total Environment	8

Source: prepared by the authors based on Scopus data.

The publications in these seventeen journals are mostly concentrated in 2020, with the exception of PLoS ONE, where one article was published in each of the following years: 2015, 2017 and 2018.

Of the main journals shown in the table above, 53% of articles were published in national journals and 47% in international journals. It is important to highlight articles published in Brazil co-authored with foreign authors, representing strengthening of international collaborations in Brazilian publishing.

Among the national journals, note the business journal published by the Getulio Vargas Foundation, which indicates that some researchers in the social sciences are interested in the subject and that other disciplines are contributing to the debate.

Clearly, the titles of the journals listed above already testify to the variety of disciplines operating in these publications: clinical medicine, dermatology, health policy, virology, cardiology, nephrology and administration and public policy.

In fact, a more careful look at the subject areas of all of the journal titles analyzed clearly shows, throughout the period analyzed (1989-2020), that new disciplines are being mobilized to produce knowledge on coronaviruses and to fight epidemics/pandemics.

**Box 2 – Trends over time of subject areas of scientific publications in collaboration with Brazil**

Disciplines												SARS										MERS					Covid-19								
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020			
Medicine																																			
Immunology and Microbiology																																			
Biochemistry, Genetics and Molecular Biology																																			
Agricultural and Biological Sciences																																			
Veterinary Medicine																																			
Neuroscience																																			
Environmental Sciences																																			
Multidisciplinary																																			
Social Sciences																																			
Odontology																																			
Pharmacology, Toxicology and Pharmacy																																			
Nursing																																			
Psychology																																			
Occupational Health																																			
Chemistry																																			
Mathematics																																			
Economics, Administration and Accounting																																			
Computer Science																																			
Chemical Engineering																																			
Materials Science																																			

Source: prepared by the authors based on Scopus data.

Although 92% of scientific production is distributed in the areas of medicine (70%), immunology and microbiology (11%), and biochemistry, genetics and molecular biology (11%), some changes were observed over time, such as publications in environmental sciences which, in this study, began to appear during the SARS epidemic.

The social sciences, which until 2019 did not appear in research on this topic, stand out as a prominent area, ranking fourth among research areas, representing 10% of all publications. Other fields, such as psychology, dentistry, professional health, economics and public administration are subject areas that were incorporated into covid-19 discussions in 2020.

## FINAL CONSIDERATIONS

The purpose of this work was to describe the panorama of Brazilian scientific publications involving international collaboration. The scientific collaborations described here are reliable testimony to the increasing degree of globalization of science.

This was clear in the study undertaken here: over the last 30 years, until 2019, Brazil's international collaborations on coronaviruses resulted in 304 publications, involving 43 countries and 249 different institutions. In 2020, 1,310 co-authored publications on covid-19 were identified, involving 148 countries, 104 (70%) of which are new partners.

We can thus affirm that Brazil follows the trend observed in the literature on information metric studies, consolidating growth in its co-authored scientific publications on covid-19, although we cannot state that all are the result of collaboration.

In the dataset analyzed, the United States is the most consistent partner, and Germany the oldest. The year 2020 brought partner countries that had previously been sporadic, such as Canada, China, Spain, France, India and Italy, admittedly all initially involved in the pandemic scenario in Europe and Asia.

A brief look at the subject areas studied in these collaborations makes it clear that, for the most part, they are classified in the areas of Medicine, Immunology and Microbiology. As time passed during the period analyzed, 1989-2020, new areas joined the discussion.

This work opens up the possibility of new analyses and new investigations based on other and complementary data sources. Future studies can also be carried out, such as the investigation of open access publications and the level of interdisciplinarity of the studies, issues that were not the focus of this research.

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