ORIGINAL ARTICLE

GEOGRAPHICAL DISTRIBUTION AND INTERNATIONAL COLLABORATION OF LATIN AMERICAN AND CARIBBEAN SCIENTIFIC PUBLICATIONS ON TUBERCULOSIS IN PUBMED

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ABSTRACT

Objective: The objective of the study was to describe the geographical coverage of Latin American and Caribbean scientific publications on tuberculosis and its international collaboration. **Materials and methods:** The records were retrieved from the PubMed database (2009-2018), limiting the search to Latin American and Caribbean countries. Articles were analyzed in several categories, such as the total number, countries, institutions, authors, collaborations, and citations. The software UCINET and VOSviewer were used. **Results:** 2,495 items were recovered, 4.2% of world production. More than half of the research came from Brazil (52.5%), Mexico (16.6%) and Peru (10.5%). 97.6% of the production is co-authored, with a rate of international collaboration of 24.5%. The countries with the highest production in international collaboration are Brazil (39.1%), Peru (26.8%) and Mexico (16%); they are also the countries with the best OutDegree, OutCloseness and Betweenness. The United States (11.9%), United Kingdom (5.8%), France (2.1%), Spain and Switzerland (1.7%), South Africa (1.7%) and Italy (1.6%) are the main collaborators with Latin America. **Conclusion:** Brazil, together with Peru and Mexico, is the undisputed leader in Latin American and Caribbean tuberculosis production, due to the volume of articles and its position in the collaborative network. The eradication of tuberculosis requires continuing research in international collaboration, to carry out more effective health policies on tuberculosis.

Keywords: Tuberculosis; Bibliometrics; Social Networking; Latin America; Caribbean Region (Source: MeSH NLM).

INTRODUCTION

Tuberculosis (TB) is the leading cause of death from infectious disease and is among the top ten causes of mortality worldwide [1]. Although its incidence is declining, the Sustainable Development Goals to eradicate it by 2030 are still far from being achieved [2]. The World Health Organization's (WHO) "End TB" strategy aims to reduce the incidence of the disease by 90% [3] and its mortality by 95% between 2015 and 2035 [4].

Given the prevalence of TB, the delay in its clinical detection and, consequently, in its diagnosis and treatment, the emergence of multidrug-resistant strains, as well as the involvement of particularly vulnerable populations, the WHO has emphasized the importance of intensifying studies on TB as a priority measure for its eradication [5]. This requires that studies to be carried out with international collaboration [6]. Establishing cooperation networks facilitates the management and optimization of resources and allows the sharing of infrastructures and capacities, which is especially important in developing countries. It also makes possible to ge-

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nerate and distribute knowledge at an interdisciplinary level and to increase the productivity of studies, favoring innovation in health [7]. Thus, the use of social network analysis to evaluate collaboration patterns becomes an essential tool for providing information and establishing new research policies. Social network analysis makes possible to observe and describe the relationships between different bibliographic elements, such as authors or countries, providing a visible and organized structure of information flows.

Although there are several bibliometric studies that analyze the behavior of TB publications at the international level [8] in specific geographic areas, such as Korea [9] or Brazil [10], or on the international collaboration of Latin American TB production in Brazil, Peru, Mexico, Colombia and Argentina [11], no bibliometric study has been found to focus on the international contribution of all Latin American and Caribbean countries.

PubMed is the most widely used international database in biomedicine due to the characteristics and volume of indexed papers, its age and functionality worldwide [12]. Its free access, compared to other databases, such as Scopus, makes it the most consulted database. Although LILACS (Latin American and Caribbean Literature in Health Sciences) and SciELO (Scientific Electronic Library Online) have a greater number of indexed Latin American journals, these are mostly published in Spanish and Portuguese. This fact a priori reflects a lower internationalization of research, since countries such as the United States of America (USA) or the United Kingdom, in the case of collaborating with Latin American countries, prefer Anglo-Saxon journals so that the research can be more widely disseminated.

The aim of this study was to describe the geographic coverage of Latin American and Caribbean scientific publications on TB and their international collaboration in PubMed.

KEY MESSAGES

Motivation for the study: Given the high impact of tuberculosis in Latin America and the Caribbean, a bibliometric study was conducted to identify the countries in Latin America and the Caribbean that conduct the most research on tuberculosis, and to identify the network of collaboration between these countries and the rest of the world.

Main findings: More than half of the research came from Brazil. One out of four articles was conducted with international collaboration. The United States, United Kingdom, and France are the main collaborators with Latin America.

Implications: Tuberculosis eradication must rely on international collaboration to enable more effective health policies to be designed.

MATERIALS AND METHODS

Study design

Retrospective descriptive study with a bibliometric approach.

Data collection and processing

The recollection of registries was carried out on December 22, 2019, from the open access database PubMed as it is one of the most important international databases in the biomedical field that serves as a reference for health professionals and researchers in the Latin American region. The citations received were searched in Web of Science. The search terms were tuberculosis or TB (title, abstract or MeSH) refined for Latin American and Caribbean countries, shown in the following search strategy, for the period 2009-2018: (tuberculosis[Title/Abstract] OR TB[Title/Abstract] OR tuberculosis[MeSH] OR TB[MeSH]) AND (Argentina[Affiliation] OR Belize[Affiliation] OR Brazil[Affiliation] OR Brazil[Affiliation] OR Bolivia[Affiliation] OR Chile[Affiliation] OR Colombia[Affiliation] OR Costa Rica[Affiliation] OR Cuba[Affiliation] OR El Salvador[Affiliation] OR Ecuador[Affiliation] OR Haiti[Affiliation] OR Honduras[Affiliation] OR Guatemala[Affiliation] OR Jamaica[Affiliation] OR Mexico[Affiliation] OR Panama[Affiliation] OR Paraguay[Affiliation] OR Peru[Affiliation] OR Puerto Rico[Affiliation] OR Dominican Republic[Affiliation] OR Dominican Republic[Affiliation] OR Uruguay[Affiliation] OR Venezuela[Affiliation]) Filters: from 2009 - 2018. 4205 records were retrieved.

Data filtering was based on the elimination of incomplete records, registries attributed by mistake to certain countries, as in the case of New Mexico, or those that did not address the TB topic. This resulted in 2,495 records and subsequently the country, authors and affiliating institutions fields were standardized.

Analysis of bibliometric indicators

The bibliometric indicators analyzed were: (a) Total scientific production (number and percentage of indexed articles) and percentage of Latin American production from the total number of indexed records in PubMed; (b) Growth rate

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to measure the percentage evolution of production (2009-2018); c) Relationship between the cumulative annual number of articles and temporal coverage by linear, logistic and exponential equations; d) Latin American and Caribbean institutions with ten or more papers and most prolific authors (≥10 articles) [13] and their affiliation, mainly when the author signs as the first author. If the author did not have production as first author, being the last author was taken into account; e) Collaborative level to measure the depth of collaboration (ratio between total number of authors or countries and total number of articles) and international collaboration rate to observe the extent (percentage of articles signed by two or more countries); f) Correlation between the number of articles and number of articles in collaboration by country with Pearson correlation; g) Total number of citations by country and average number of citations received with standard deviation (SD). The number of citations used was that directly provided by Web of Science for each registry; h) The structure of the international collaborative social network was analyzed through network density, degree centrality and its normalized value, closeness centrality and betweenness centrality and its normalized value [14].

The density of the network ranges from 0 (dispersed network) to one (strongly connected). The degree centrality is the number of links of a node (author, country) in the network; therefore, the greater the connection of the node, the greater its prestige within the network. Closeness centrality is the distance between nodes in the network, it establishes that the closer the node is, the better the ability to interact with other members. Betweenness centrality is the number of shortest paths passing through a given node, indicating that the greater the betweenness, the greater the flow capacity of the information transmitted between the other nodes.

Data analysis

The PubMed records were exported to Refworks and subsequently to Excel for data management. Once the cooperating countries were obtained, the table with the corresponding matrix was made in excel for export to UCINET 6.0 [14]. The networks were visualized with NetDraw, integrated in the UCINET package. Subsequently, they were exported to VOSviewer (Visualization of Similarities viewer) [15] to visualize the international collaborative social network. The graphical representation of the results was obtained from the VOSviewer clustering algorithm. The default values of VOSviewer were used for the co-authorships. The image provided by VOSviewer identifies the number of items produced by the size of the nodes and the intensity of relationship connecting the different nodes by the thickness of the linking lines. Nodes corresponding to the same cluster are recognized by color. Microsoft Excel® was used for the statistical analysis. The statistical parameters used were: absolute frequencies, percentages, mean and standard deviation (SD) and Pearson correlation.

Ethical considerations

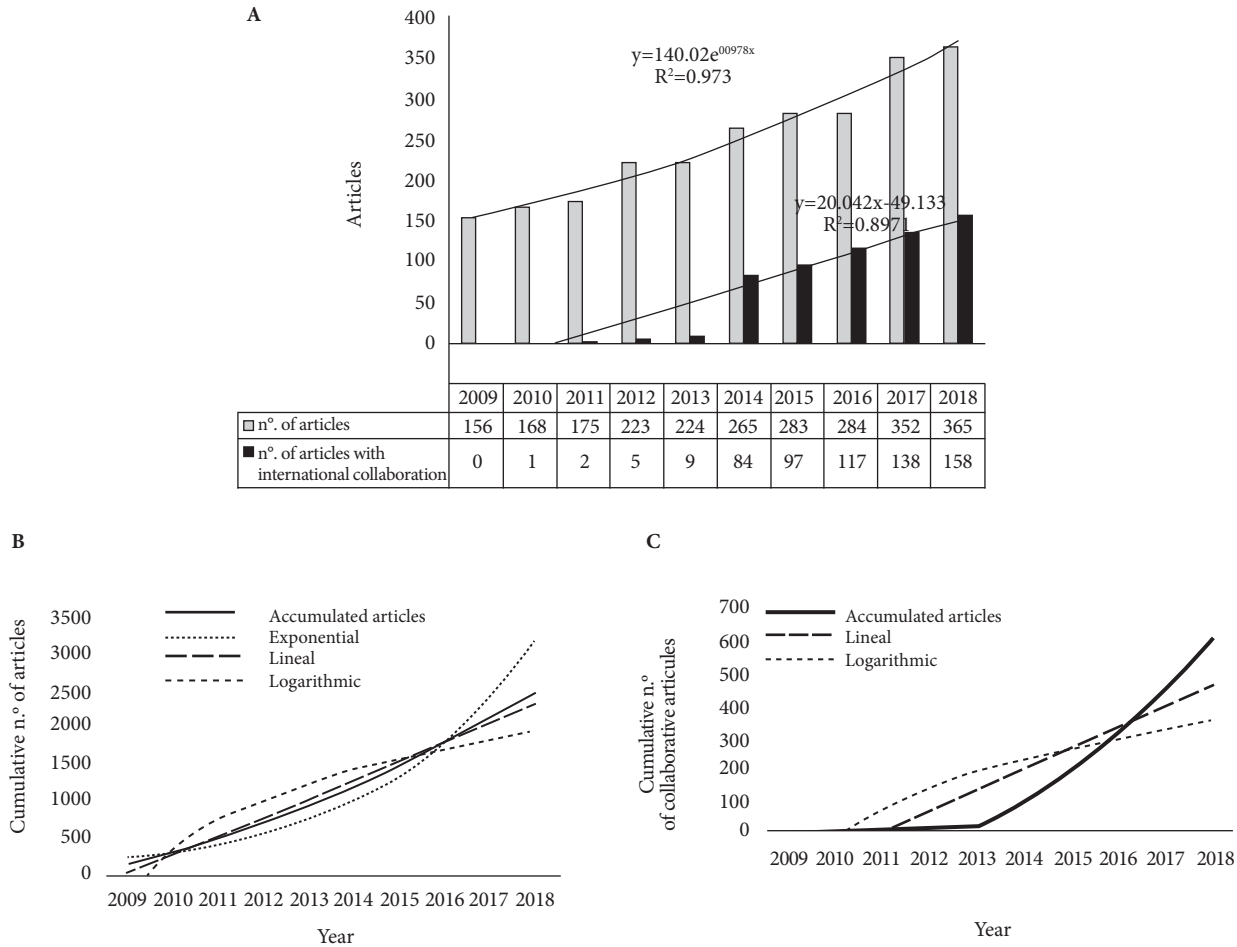
Since this was a study based on data from scientific articles, it was not considered to be submitted for approval by an ethics committee.

RESULTS

The production on TB indexed in PubMed (2009-2018) from Latin American and Caribbean countries is 2,495 articles, 4.2% of the world production. Throughout the period, we observed an exponential growth (R^2=0.9) (Figure 1), with a growth rate of 133.9%; 50% of the production is from the last four years. A total of 611 articles were published in collaboration with two or more countries. In this case the growth does not follow an exponential trend but a linear one (R^2=0.8) (Figure 1). In the relationship between the annual cumulative number of articles and temporal coverage, the linear equations obtained a high coefficient of determination (0.9), while for the exponential and logistic equations it was 0.9 and 0.8, respectively; while, for international collaborative production, only linear and logarithmic growth were adjusted, with a coefficient of determination of 0.8 and 0.5, respectively (Figure 1).

The production includes a total of 10,594 authors from 7,383 institutions belonging to 22 Latin American countries and 70 from the rest of the world. Brazil accounts for 52.5% of the articles, followed by Mexico (16.6%) and Peru (10.5%). Of these, the countries with the best fit in the exponential growth of the literature, because they approach an R^2 of 1, are Peru and Brazil. Of the production, 97.6% was co-authored, with an international collaboration rate of 24.5%. The level of collaboration between authors was 7.6 (SD 4.4), between institutions 5.01 (SD 2.3) and between countries 3 (SD 1.8). Brazil is the country with the highest production in international collaboration (39.1%) followed by Peru (26.8%) and Mexico (16%) (Table 1).

The analyzed production shows a correlation of 0.9 between countries with the highest production and countries with the highest number of papers in international collaboration. The total number of citations for the production was 23,635. The mean number of citations for the production without international collaboration is 8.5 (SD 16.6), while for the in-



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
n°. of articles	156	168	175	223	224	265	283	284	352	365
n°. of articles with international collaboration	0	1	2	5	9	84	97	117	138	158

Figura 1. A. Evolution of the number of articles and collaborative production**. B.** Relationship between the cumulative number of articles and year. **C.** Relationship between the cumulative number of collaborative articles and year of publication.

ternational production it is 10.9 (SD 25.8). In most cases the SD is higher than the average, due to the high dispersion of citations.

The ten institutions with the highest production in international collaboration are: Universidad Peruana Cayetano Heredia (47.1%), Socios en Salud (15%) and Asociacion Beneficacion PRISMA (14%) of Peru; Fundacao Oswaldo Cruz of Brazil (12.6%); Instituto de Medicina Tropical Alexander von Humboldt, of Peru (7.4%); Instituto Nacional de Ciencias Médicas y Nutrición "Salvador Zubirán" of Mexico (6.9%); University of Sao Paulo of Brazil (5.9%); Instituto Mexicano del Seguro Social (IMSS) (5.2%); Universidade Federal do Rio de Janeiro (4.7%); and, Universidade Federal do Rio Grande do Sul (4.6%) of Brazil.

The most prolific authors (≥10 articles) working in international collaboration are: R.H. Gilman (n=61) from Universidad Peruana Cayetano Heredia, Asociación Benéfica PRISMA of Peru and Johns Hopkins Bloomberg School of Public Health of USA; D. Moore (n=43) from Universidad Peruana Cayetano Heredia of Peru and London School of Hygiene and Tropical Medicine of UK; C. A. Evans (n=37) from the PRISMA Charitable Association and Universidad Peruana Cayetano Heredia of Peru and London Imperial College and Wellcome Trust Imperial College Centre for Global Health Research of the United Kingdom; C. Seas (n=26) from Instituto de Medicina Tropical Alexander von Humboldt, Universidad Peruana Cayetano Heredia and Hospital Nacional Cayetano Heredia of Peru; L. Lecca (n=30) from Socios en Salud and Ministerio de Salud of Peru, and Harvard Medical School and Brigham and Women's Hospital of USA; R. Calderón (n=15) from Socios en Salud Perú and Universidade Federal do Rio de Janeiro of Brazil; J. Galea (n=12) from Socios en Salud Perú and Harvard Medical School from USA; J. Grandjean (n=16) from Socios en Salud Perú and Institute of Child Health University College London from United Kingdom; R. Hernández-Pando (n=55) from Instituto Nacional de Ciencias Médicas y Nutrición "Salvador Zubirán" from Mexico; A. Trajman (n=42) from Universidade Federal do Rio de Janeiro

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Table 1. Geographical coverage of Latin American and Caribbean scientific production on TB indexed in PubMed (2009-2018).

Country	Articles n (%)	Citations n	Articles without international collaboration n (%)	Mean number of citations without international collaboration (SD)	International collaboration articles n (%)	Average citations with international collaboration (SD)
Brazil	1,310 (52.5)	11,192	1,071 (42.9)	8.0 (16.1)	239 (39.1)	11.6 (25.2)
Mexico	414 (16.6)	4,342	316 (12.7)	10.1 (17.7)	98 (16.0)	12.1 (23.7)
Peru	261 (10.5)	2,442	97 (3.9)	8.0 (11.1)	164 (26.8)	10.2 (16.3)
Colombia	189 (7.6)	1,163	143 (5.7)	6.3 (11.1)	46 (7.5)	5.7 (10.3)
Argentina	184 (7.4)	2,584	128 (5.9)	14.1 (26.6)	56 (9.2)	13.9 (34.7)
Cuba	44 (1.8)	539	33 (1.3)	5.0 (7.8)	11 (1.8)	34.3 (134.0)
Venezuela	34 (1.34)	307	22 (0.9)	10.4 (13.1)	12 (2.0)	6.8 (6.2)
Chile	51 (2.0)	234	36 (1.4)	3.1 (3.9)	15 (2.4)	8.7 (9.8)
Uruguay	20 (0.8)	218	10 (0.4)	15 (21.8)	10 (1.6)	6.8 (6.6)
Haiti	27 (1.1)	217	5 (0.2)	3.6 (4.3)	22 (3.6)	12.0 (14.9)
Ecuador	16 (0.6)	92	7 (0.3)	3.9 (4.9)	9 (1.5)	7.22 (10.1)
Jamaica	16 (0.6)	88	2 (0.1)	0	14 (2.3)	6.3 (5.2)
Panama	12 (0.5)	57	4 (0.2)	9.5 (11.4)	8 (1.3)	2.4 (3.7)
Honduras	7 (0.3)	40	3 (0.1)	9.8 (5.5)	4 (0.6)	0.3 (0.6)
Puerto Rico	2 (0.1)	40	2 (0.1)	20 (28.3)	0	0
Paraguay	5 (0.2)	28	0	0	5 (0.8)	5.6 (6.8)
Bolivia	5 (0.2)	22	0	0	5(0.8)	4.4 (7.6)
Guatemala	5 (0.2)	21	1 (0.0)	0	4 (0.6)	4.2 (5.8)
Nicaragua	1 (0.0)	9	0	0	0	0
Costa Rica	1 (0.0)	0	0	0	1 (0.2)	0
El Salvador	5 (0.2)	0	1 (0.0)	0	4 (0.6)	0
Dominican Republic	1 (0.0)	0	1 (0.0)	0	0	0

from Brazil and McGill University Health Centre from Canada; A. Kritski (n=67) from Rede Brasileira de Pesquisas em Tuberculose (REDE-TB) and Universidade Federal do Rio de Janeiro of Brazil; B.B. Andrade (n=15) from Fundação Oswaldo Cruz, Universidade Salvador, Escola Bahiana de Medicina e Saúde Pública de Basil and National Institutes of Health of USA; and; R. Dietze (n=26) from Universidade Federal do Espírito Santo of Brazil (Figure 2). In all of them, part of their production is signed as first or last author.

Latin American and Caribbean countries cooperate with 70 countries in TB research. Of these, the USA (11.9%); the United Kingdom (5.8%); France (2.1%) and Spain and Switzerland (1.7% each) stand out (Table 2). Of the international collaborations, 25.1% were established only between the Latin American countries themselves, with a level of collaboration of 2.2 (SD 0.5). Figure 3 shows the relationship between countries that carry out joint research.

The analyzed network has a density of 0.6. The USA is the country with the highest percentage of links with Latin American countries (6.3%), followed by Brazil (5.4%), the United Kingdom (3.7%) and Peru (3.7%). The countries with the highest percentage of betweenness are Brazil (15.4%), the USA (11.9%), the United Kingdom (8.8%) and France (5.7%). The countries with the greatest proximity are Brazil (79.8), the USA (78.4) and the United Kingdom (74.6) (Table 3).

DISCUSSION

TB, as shown by the increase in research in recent years, both worldwide and in Latin American and Caribbean countries [16], is of interest to researchers and decision-makers. Although the results of the study show an increase in scientific activity over time, there are large variations between countries. In general, the most productive Latin American countries in health research are Brazil, Mexico and Argentina, and those with the greatest impact and collaboration are Peru, Puerto Rico and Argentina. In the field of TB, this behavior is slightly different [17], where Brazil is positioned as

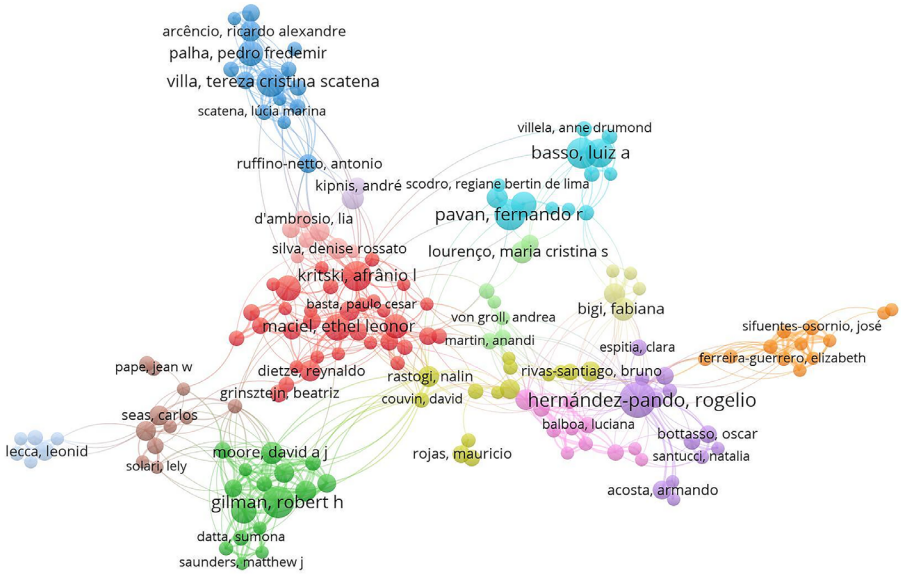

Figure 2. International collaborative network of authors with ten or more articles

the country with the most cooperative links, and Peru has the most prolific institutions and authors. Brazil, Peru and Mexico, Latin American countries with more than 50% of the estimated cases of TB in Latin America [18], are the most prolific in field studies, Brazil and Mexico occupy the sixth and eighteenth position, respectively, in the world production on health [19].

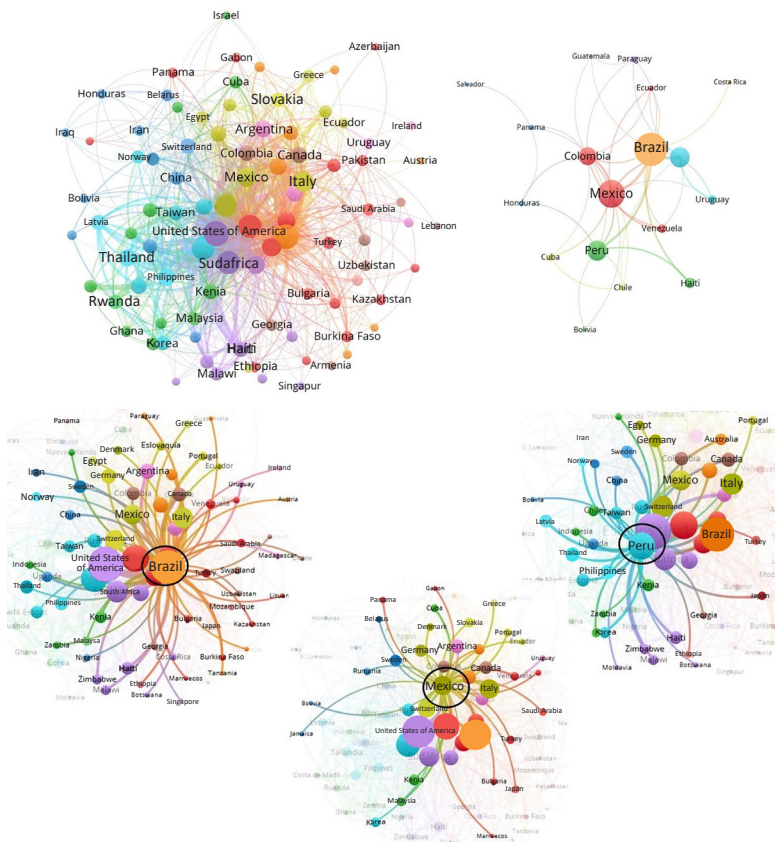

Figure 3. **A.** Representation of the international collaboration network of Latin American and Caribbean countries. **B.** Collaboration among Latin American and Caribbean countries. **C.** Isolated collaboration of Brazil, Mexico and Peru.

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Table 2. Geographic coverage of collaborating countries of Latin American and Caribbean TB production indexed in PubMed (2009-2018).

Country	Articles n (%)	Country	Articles n (%)	Country	Articles n (%)
United States of America	298 (11.9)	Latvia	7 (0.3)	Madagascar	3 (0.1)
United Kingdom	145 (5.8)	Mozambique	7 (0.3)	Rwanda	3 (0.1)
France	52 (2.1)	Malawi	6 (0.2)	Zimbabwe	3 (0.1)
Spain	43 (1.7)	Saudi Arabia	5 (0.2)	Belarus	2 (0.1)
Switzerland	43 (1.7)	Denmark	5 (0.2)	Botswana	2 (0.1)
South Africa	42(1.7)	Indonesia	5 (0.2)	Ivory Coast	2 (0.1)
Italy	39 (1.6)	Japan	5 (0.2)	Gabon	2 (0.1)
Canada	35 (1.4)	Nigeria	5 (0.2)	Ireland	2 (0.1)
India	31 (1.2)	Norway	5 (0.2)	Kazakhstan	2 (0.1)
Belgium	27 (1.1)	Pakistan	5 (0.2)	Singapore	2 (0.1)
Sweden	24 (1.0)	Slovakia	5 (0.2)	Uzbekistan	2 (0.1)
Australia	21 (0.8)	Burkina Faso	4 (0.2)	Zambia	2 (0.1)
Germany	19 (0.8)	Georgia	4 (0.2)	Armenia	1 (0.0)
Netherlands	19 (0.8)	New Zealand	4 (0.2)	Azerbaijan	1 (0.0)
China	16 (0.6)	Romania	4 (0.2)	Cambodia	1 (0.0)
Portugal	16 (0.6)	Tanzania	4 (0.2)	Ghana	1 (0.0)
Russia	12 (0.5)	Turkey	4 (0.2)	Iraq	1 (0.0)
Uganda	11 (0.4)	Vietnam	4 (0.2)	Israel	1 (0.0)
Thailand	10 (0.4)	Bulgaria	3 (0.1)	Kenia	1 (0.0)
Malaysia	9 (0.4)	Egypt	3 (0.1)	Lebanon	1 (0.0)
Estonia	8 (0.3)	Ethiopia	3 (0.1)	Marruecos	1 (0.0)
Philippines	8 (0.3)	Greece	3 (0.1)	Moldavia	1 (0.0)
Korea	7 (0.3)	Iran	3 (0.1)	Ukraine	1 (0.0)

Brazil stands out for being the country with the highest production on TB [7], and for increasing the number of collaborative scientific works [10]. Although Haiti has a high number of estimated TB cases, its analyzed production is very low. However, its tendency to work in collaboration with the USA favors such production [19]. The growing interest of Brazil, Peru and, to a lesser extent, Mexico, together with the high-income countries that collaborate with them, reflects their scientific commitment to the field under study [8]. The USA, being part of the American region of the WHO, has established links with Latin America and the Caribbean, which, although it made it possible to achieve certain Millennium Development Goals in 2015, in the case of TB the established goals were not met [20].

Brazil, the center of the Latin American research network, has increased the number of research collaborations with Argentina, Chile and Mexico [21]. This situation extends to TB research with the exception of Peru, the third country with the highest number of collaborations with Brazil. Brazil's participation in different structured global networks on TB, such as the Brazilian Rede TB or the Global TB Network GTN [22], favors its potential for joint work [23].

In 2015, national TB research plans were established in several high and medium TB burden countries, such as Brazil, Russia, India, China and South Africa, countries of the so-called BRICS. These countries concentrate almost 50% of the global TB burden [24], and have become academic leaders of the BRICS National TB Program, participating in the BRICS TB Research Network. The results obtained show a strong collaboration between South Africa and India, a prolific country in this field of study, but the same is not true for the rest of the BRICS countries. The tendency of these countries is to collaborate with high-income countries and not with each other [16]. The geographic distribution of cooperation between Latin American and Caribbean countries is mostly between countries that are geographically close to each other [25], and it can be said that their research output is, in general, low. This could be due to the low proportion of gross domestic product that these countries devote to research.

Table 3. Centrality parameters in the international collaborative network of Latin American and Caribbean TB production indexed in PubMed (2009-2018).

Country	Degree (normalized degree)	Closeness	Betweenness (normalized betweenness)
Brazil	488 (5.4)	79.8	1259.2 (15.0)
Peru	377 (3.7)	66.4	227.2 (2.8)
Mexico	175 (1.9)	64.1	202,7 (2.5)
Argentina	105 (1.2)	61.1	258.8 (3.2)
Colombia	74 (0.8)	60.7	149.3 (1.8)
Haiti	67 (0.8)	53.8	8.4 (0.1)
Chile	47 (0.8)	56.2	29.9 (0.4)
Cuba	28 (0.3)	53.5	4.4 (0.0)
Venezuela	33 (0.4)	55.1	15.8 (0.2)
Jamaica	16 (0.2)	47.9	0.6 (0.0)
Ecuador	14 (0.1)	52.9	4.6 (0.0)
Uruguay	13 (0.1)	51.1	0
Panama	10 (0.1)	50	14.5 (0.2)
Honduras	10 (0.1)	45.3	9.1 (0.1)
Paraguay	8 (0.1)	50.8	2.6 (0.0)
Guatemala	7 (0.1)	49.7	0.2 (0.0)
Bolivia	6 (0.1)	49.2	0
Costa Rica	6 (0.1)	47.4	1.1 (0.0)
El Salvador	4 (0.0)	48.4	0.5

Globally, countries with a lower incidence of TB, such as Australia, the USA, Italy, Norway, the Netherlands and the United Kingdom, carry out cross-border contribution policies [26]. Migratory flows lead countries such as Spain [27] or the United Kingdom [26] to carry out studies on TB [27], preferably in collaboration with those countries with a long history of TB control. The migratory characteristics of Mexico's border with the USA favor the transmission of infectious diseases such as TB and contribute to the collaboration of both nations for its control.

Most countries can obtain and share information quickly, given that there are no major differences in the values of closeness centrality [7]. The privileged location in the collaboration network of Brazil, Peru and Mexico means that they have easier and faster access to resources and other members of the network, which contributes to establishing new collaborations. As they are closer and have fewer intermediaries than the other Latin American countries, they are in a position to obtain information more quickly than the rest. Likewise, Brazil, Peru and Mexico occupy positions of connection between groups that allow them to work with interfaces between subgroups of strongly united participants and to control the flow of information between them. Peru, despite having a lower volume of work than Mexico, has a higher network performance, most likely due to a high incidence of multidrug-resistant TB [28].

The USA, the country that invests the most in TB research [16], and the United Kingdom are the undisputed leaders in collaborative production with emerging countries, mainly Brazil, Mexico, Peru and Argentina. The degree centrality of these four countries reflects their commitment to TB research, as well as their interest in working together with developing countries [7]. This favors that the articles in collaboration with these countries have greater visibility and receive a greater number of citations [21].

Despite the fact that collaborative research does not reach 25%, the favorable value of network density, at over 50% [29], and the centralization associated with the large number of countries participating, suggests a good pattern of cohesion in collaboration for TB studies. These results highlight the need to continue in this direction, paying greater attention to supporting those countries that need greater opportunities to strengthen new collaborations. The internationalization of knowledge favors the possibilities of promoting joint work among researchers [29] and, thus, research can contribute to the development of more effective methods of prevention, diagnosis and treatment [30].

The use of PubMed showed the low presence of authors and institutions from Latin America and the Caribbean in the literature on TB in one of the most consulted open access bibliographic databases. Unlike databases such as LILACS or SciELO, PubMed indexes practically all the journals in English, which favors greater worldwide visibility for research carried out by Latin American authors. However, researchers from smaller countries are less likely to publish in Anglo-Saxon journals, so they publish in journals indexed in regional databases. In this sense, the use of a single database is a limitation for our study and it would be desirable to extend the use of Scopus, LlLACS or SciELO in future studies. Another limitation is the lack of representation of all Latin American countries in Web of Science, which implies a bias in the citation analysis system. In addition, in order to determine any publication bias, it would be advisable to analyze the sources of funding, external and national, public and private. Finally, the study would not reflect the totality of institutions, since PubMed between 2009 and 2013 did not indicate all the affiliations of authors and collaborators.

In conclusion, over the last decade there has been an increase in publications on TB. Brazil, together with Peru and Mexico, is the undisputed leader in TB research production in Latin America and the Caribbean, being the country with

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the highest number of articles and its position in the collaboration network. The eradication of TB requires a further increase in the number of research studies, preferably with international collaboration, in order to establish more effective health policies and optimize resources.

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