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Research Article

Bibliometric Analysis of Medicinal Plants' Original Articles from Latin America and the Caribbean Region

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ABSTRACT

The use of medicinal plants by health professionals and the general population is widespread in Latin America and the Caribbean (LAC) region due to its cultural tradition and extensive biodiversity. We aimed to describe the scientific production of medicinal plants in LAC, using bibliometric and co-words analysis for original articles from three databases published from 1970 to 2020. We analyzed 14,397 original articles from Web of Science, Scielo, and LILACS databases. Annual scientific production of medicinal plants in LAC increased from 2000 to 2010 but remained constant. More than half of the included articles had authors from Brazilian institutions, but articles with authors from Cuban institutions had the highest rate of articles per million country inhabitants. LAC countries mostly collaborated with the United States and western Europe. *Ilex paraguariensis* A.St.-Hil., *Uncaria tomentosa* (Willd. ex Schult.) DC., and *Baccharis trimera* (Less.) DC. are the most frequently mentioned medicinal plants. We observed the anti-inflammatory, antimicrobial, antitumor, and antioxidant activity of medicinal plants assessed in these studies, mostly from basic and laboratory research. Overall, the scientific production of medicinal plants in LAC increased and assessed most of its main therapeutic effects. However, more efforts are needed to increase regional collaboration and promote clinical and translational research. These results could be valuable information for decision-makers and scientists to determine future research prioritization and funding.

Keywords: Bibliometric, Phytotherapy, Ethnopharmacology, Medicinal plants, Plant Extracts, Latin America.

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INTRODUCTION

Medicinal plants are used directly or indirectly for health-related purposes, such as preventing, curing diseases, or reducing symptoms.[1] The medicinal use of plants or their derivatives is an activity done for thousands of years worldwide until today.[2] In that sense, a 2015 report described that more than a third of the United States population used medicinal plants during the survey.[3] Its use may be motivated by dissatisfaction with conventional medical treatment, positive previous medicinal plant experiences, and traditional family use.[4] Thus, medicinal plants are the most popular way of applying for complementary and alternative medicine globally.[5,6]

Despite its popularity, the use of medical plants is controversial for various reasons, such as the Non-specific indications for use without follow-up, inadequate knowledge about its pharmacokinetics and pharmacodynamics, and unawareness of adverse effects and interactions with other therapeutic substances.[7] Therefore, there is a need to direct research efforts on the subject. In this sense, scientific production on medicinal plants has been focused on systematic reviews and randomized clinical trials in recent years,[8] where middle-income countries like China, India, Brazil, and Iran have the highest scientific production.[9]

Latin America and the Caribbean (LAC) is a region with middle-income countries, with a great cultural tradition and extensive biodiversity.[10,11] Therefore, medicinal plants use is frequent in physicians[12] and the general population.[11,13] Similar to several countries in the world,[14] LAC countries began regulating and supervising the use of medicinal plants while promoting their research.[15] However, formal training of health

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professionals on the use of medicinal plants[11] and research in many LAC countries is still limited.[16]

Bibliometric studies assess scientific production and identify areas where research is carried out.[17] Likewise, they contribute to determining the impact of the scientific output through the study of collaboration networks, the dynamics of production, analyzing authors, institutions, and contributing countries.[18] In this sense, studies on medicinal plants worldwide have been mostly related to specific pathologies such as HIV/AIDS, cancer, diabetes, infections, pain,[19] and COVID-19.[20] Previously, in 2019, a bibliometric study described the world scientific production on medicinal plants where countries such as China, India, and the United States stand out, while only Brazil is mentioned as a country from LAC.[9] Likewise, in 2005 another study briefly described the scientific production in LAC on medicinal plants.[16] However, its authors used a database that did not include many LAC scientific journals and used a limited search strategy. In Peru, the scientific production of medicinal plants was also described but limited to a particular country in LAC.[21] Identifying the scientific production of medicinal plants appropriately would allow a better understanding of the scientific activity in the region, while seeing the most relevant topics of interest and identifying collaboration networks. Therefore, the objective of our study is to describe the scientific production of medicinal plants in LAC from three databases.

METHODOLOGY

Study design

Bibliometric study that assessed original scientific articles whose studied medicinal plants in LAC countries with Spanish or Portuguese as official language. We included original scientific papers published in scientific journals indexed in the Web of Science Core Collection (https://www.webofscience.com/), LILACS (https://lilacs.bvsalud.org/es/), or Scielo Citation Index via Web of Science, which studied medicinal plants from one of the following LAC countries: Argentina, Bolivia, Brazil, Colombia, Chile, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Mexico, Cuba, Dominican Republic, or Puerto Rico. Scientific articles such as conference abstracts, letters to the editor, editorial, and correction were excluded, as well as gray literature and articles published in 2021.

Procedures

The search strategy was developed using Web of Science as a reference database due to its adequate capacity for creating complex search strategies (Supplementary methods 1). This search strategy had three sections. For the first one, we used the terms related to phytotherapy, ethnomedicine, and medicinal plants/herbs/roots/leaves, which were identified in the Medical Subject Headings (MeSH) registry and bibliometric studies with similar objectives.[9,19,21-24] These terms were searched with the field tag "subject" (TS =). Second, the LAC countries whose official language is Spanish or Portuguese, and their respective names, were considered search terms. These terms were searched with the same previous field labels and the country/region field tag (CU =). Finally, because Web of Science is a database that registers scientific journals in different areas of knowledge, it was decided to use as a search field label those areas of knowledge (SU =) related to health.[25] Only the documents found with the filters of "Research Article" and "Review Articles" were selected. Then, the search strategy was adapted to the LILACS database, and we used the "Articles" filter. LILACS database specializes in health sciences, so we did not' specify the areas of health knowledge in the search strategy. To collect the articles from the Scielo database, the Scielo Citation Index search engine from the Web of Science database was used.

The search was carried out on August 30th, 2021, in all databases. First, the complete bibliometric information of the selected documents was exported using the three mentioned databases. Then, duplicate records were excluded using End Note X8 software (Clarivate Analytics, Philadelphia, United States). In addition, from the total of documents analyzed, a random sample of 100 papers was selected to check compliance with the selection criteria. This was done to verify that the papers found through the search strategy meet the selection criteria.

Statistical analysis

We reported the total annual scientific production in a column graph. In addition, the absolute and relative frequency of the main scientific journals and the articles with the highest number of citations were reported according to the Web of Science database. This analysis was performed with Microsoft Excel 2020 software (Microsoft, Washington, United States). Scientific production by countries was evaluated according to the size of their population in 2019 (Available at: https://population.un.org/wpp/DataQuery/). For this analysis, the institutions from Puerto Rico were considered within the United States' institutional affiliation due to their economic, political, and institutional dependence on the United States.

Graphs were obtained with the collaboration clusters between countries (using the records only from the Web of Science Core Collection), where the size of the circles represents the number of articles, and the thickness of the lines indicates the number of articles in collaboration. Co-word analysis graphs were also obtained with the most important keywords of the scientific articles obtained from the Web of Science Core Collection and Scielo Citation Index. For this last analysis, general keywords such as Aqueous extract, ethnobotany, ethnomedicine, extract, herbal medicine, medicinal plant, natural product, phytomedicine, plant, plant extract, traditional medicine, and others were excluded. Graphics were made with the free software VOSviewer

v1.6.519 (Leiden University, Leiden, The Netherlands). Only a few databases were used in all these previous-mentioned analyses due to their ability to export specific and reliable information for analysis. Finally, a co-word analysis was carried out using the free online software of Voyant Tools (https://voyant-tools.org/) to identify the most common two-words terms and then the medicinal plants that are most frequently mentioned in the titles of the articles identified in all the databases.

Ethics

The present study is a bibliometric analysis that assessed articles published in scientific journals indexed in databases. Sensitive information was not obtained, analyzed, or manipulated from people or animals. The protocol was approved by the Research Ethics Committee from the EsSalud National Cardiovascular Institute.

RESULTS

A total of 15,792 articles were obtained (WoS = 10,070, Scielo: 2,626, LILACS: 3,096). After eliminating duplicates (n = 1,231) and those articles that were published in 2021 (n = 164), 14,397 articles were obtained that were included in the analysis. From 1970 to 1997, fewer than 100 articles were published in these databases per year. A progressive increase in the annual scientific production of articles on medicinal plants was observed until 2011, with 904 articles. After a fall from 2012 to 2014, there was a new peak in 2018 with 1,047 articles, which decreased during the years 2019 and 2020 to 908 articles per year (Figure 1).

Almost two-thirds of the articles on medicinal plants have at least one author affiliated with an institution from Brazil. Then, there are Mexico, Argentina, and Chile. On the other hand, the Dominican Republic, Nicaragua, El Salvador, and Honduras had seven, four, three, and two articles, respectively. Although 15 registries were identified with institutional affiliation from Puerto Rico, they were attached to the institutional affiliation of the United States. Cuba and Brazil have the highest rate of articles per million inhabitants in 2019 (Table 1).

Eight out of the 15 journals with the highest number of scientific articles published on medicinal plants were not LAC countries. In addition, those journals that have a score greater than 2.2 in the 2020 Journal Impact Factor are not from LAC countries either. 14 journals are indexed in Web of Science (except *Revista Brasileira de Plantas Medicinais*), and 5 in LILACS (*Revista Brasileira de Farmacognosia, Latin American and Caribbean Bulletin of Medicinal and Aromatic Plants, Cadernos de Saúde Pública, Ciência and Saúde Coletiva*, and *Revista de Saúde Pública*) (Table 2).

Among the ten original articles with the highest number of citations on medicinal plants in LAC, eight were published between 2000 and 2010. The first author' affiliation country from these articles were from Brazil (n = 6), Mexico (n = 2), Argentina (n = 1) and Chile (n = 1). However, the medicinal plants studied in these articles were mostly from Brazil and Mexico. Therefore, almost all of these studies included different species or families of medicinal plants in the same study (Table 3).

Figure 2 describes the analysis of co-authorship according to the country of institutional affiliation of the LAC countries with a minimum of 20 articles on medicinal plants. Among the Non-Latin American countries with the most co-authorship are the United States (226 with Brazil and 73 with Mexico), Italy (87 with Brazil and 23 with Chile), Spain (58 with Brazil, 41 with Argentina, 39 with Mexico, 37 with Chile and 32 with Cuba), and France (51 with Brazil, 25 with Mexico and 26 with Peru).

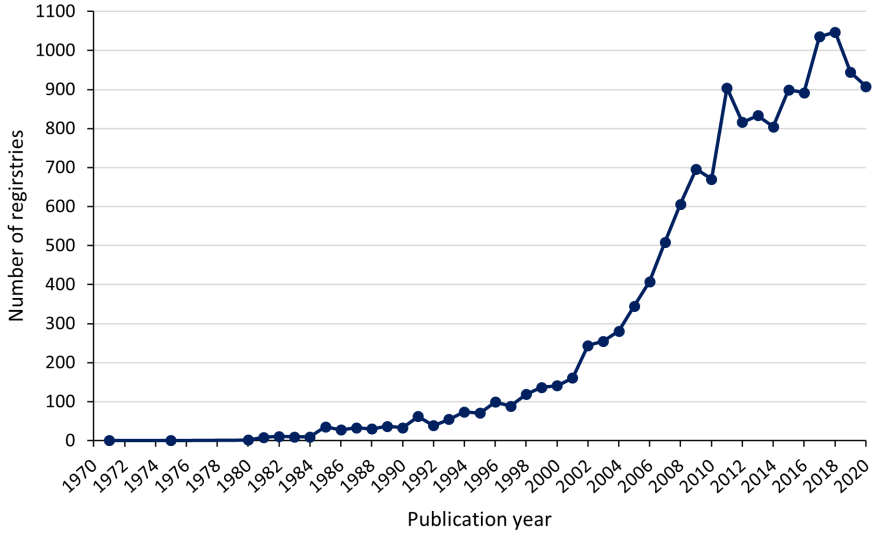

Figure 1: Annual scientific production on medicinal plants in Latin America and the Caribbean 1970-2020 (Web of Science, Scielo, and LILACS: n = 14,397).

Among the collaborations between LAC countries with at least one article on medicinal plants, the highlights are Brazil with Cuba (36 co-authorships), with Argentina (38 co-authorships), with Colombia (27 co-authorships), and with Mexico (26 co-authorships), and that of Argentina with Chile (22 co-authorships). The countries with the least number of scientific articles identified as Uruguay (n = 52) and Paraguay (n = 38) had an essential collaboration with Brazil with 16 and 10 co-authorships, respectively. Finally, Guatemala with 45 scientific articles evaluated had eight co-authorships with Colombia (Figure 3).

In the keyword co-occurrence analysis, four clusters were observed. 1) The first cluster, with 52 related terms such as infection, bacteria, antibacterial, antiviral, malaria, and *Trypanosoma crusi*. Plant families such as astaceae, euphorbiaceae, fabaceae, and myrtaceae were identified within this same cluster. 2) The second cluster, had 34 related terms such as inflammation, cytokines, nociception, pain, anti-inflammatory, contraceptive, NF-Kappa-b, mouse, and models. Within this cluster, the *Lamiaceae* plant family was identified. 3) The third cluster had 25 related terms: oxidative stress, free radicals, antioxidant, diabetes, obesity, high blood pressure, flavonoids, glutathione, and fruits. Finally, the fourth cluster had 15 related terms: cancer, DNA damage, genotoxicity, mutagenicity, apoptosis, growth, and *in-vivo*. Mostly of the observed key-words in all clusters are related to basic and laboratory research, such as: "*In vitro*", "Cells", "Rats", "Model", "Formalin test", and "High performance liquid chromatography (HPLC)" (Figure 4).

In the co-words analysis of the titles of all the assessed scientific articles, various species of medicinal plants were identified. Table 4 describes the species that were mentioned at least 20 times in the scientific articles' titles.

DISCUSSION

The main findings of our study showed that the annual scientific production of medicinal plants in LAC increased progressively during the first decade of the 21st century. However, it remained without essential changes during the last years. More than half of the assessed scientific production involves researchers from Brazil, thus participating in collaboration with the rest of the LAC countries. Except for Mexico, the other countries in the region do not exceed 10% of the total scientific production. The species *Ilex paraguariensis* A.St.-Hil., *Uncaria tomentosa* (Willd. ex Schult.) DC., *Baccharis trimera* (Less.) DC., *Mikania glomerata* Spreng., and *Rosmarinus officinalis* L. are the most frequently identified medicinal plants in the evaluated scientific articles. These assessed its anti-inflammatory, antimicrobial, antitumor activity, and role in treating chronic Non-communicable diseases, mostly with laboratory and basic research.

The trend of increasing annual scientific production on plants in LAC is also observed in other areas of medicine in the region, as is the case of the scientific output related to stroke,[36] bariatric surgery,[37] and epilepsy.[38] Similarly, there is an increase in studies on phytotechnologies for treatments[24] and worldwide ethnopharmacology.[22] This increase seems unrelated to the number of indexed journals at WoS or LILACS, because these databases maintained a constant number of indexed journals during the last 25 years.[39,40] However, during the last decade, the annual scientific production on medicinal plants in LAC remained constant, following the trend of what was reported in a bibliometric study of medicinal plants in worldwide, where since 2010, the annual scientific production stabilized.[9] Although the causes of this stabilization are unclear, part of the reason is likely because the financing of Brazilian public institutions has not increased in recent years, being the country with the highest number of articles on the subject.[41] And also, the rest of LAC countries also had several reductions in research and development funding during the last years.[42]

Likewise, the National Center for Complementary and Integrative Health funding from the United States did not increase between 2010 and 2017.[43] Nevertheless, this country is one of the main ones collaborating with research on medicinal plants in LAC. Similarly, part of the explanation for the differences in scientific production on medicinal plants between LAC countries may be related to the general scientific production of the countries evaluated and their support for science. Coincidentally, the countries that publish the most scientific articles on medicinal plants are the countries that lead the Latin American ranking of scientific production in the period 1996–2019, according to the SCImago Journal and Country Rank.[44] Regarding the preponderance of scientific articles in Non-Latin American journals, this may be because the authors look for journals with a more significant impact than those published in the region. Indeed, despite the improvement in the editorial processes, the number of open access journals, and the journals in Scopus or WoS, the presence of Latin American journals in these databases is still limited.[45,46]

Brazil is the country that contributes the most to research on medicinal plants in LAC. It is also among the leading countries with the most scientific production in medicinal plants or related topics, along with the United States, China, South Korea, India, and other Western European countries.[22,24,47] The great scientific production from Brazilians institutions could be partly explained by state funding to graduate programs and students at the country's universities, which produce scientific publications in chemistry, food sciences, biotechnology, and biological sciences.[41] Consequently, Brazil has more than 60 medicinal plant-based drugs registered in its national surveillance system,[48] which have them integrated into the legal practice of health professionals.[49,50] For its part, Cuba, which has the highest rate of articles on medicinal plants per million inhabitants in LAC, also has an intense implementation of medicinal plant-based drugs within

Table 1: Country of affiliation in scientific articles on medicinal plants in Latin America and the Caribbean (Web of Science and Scielo: *n* = 12,696).

Country	n	%	Articles per million inhabitants' rate (2019)
Brazil	7,295	64.4%	34.32
Mexico	1,332	11.8%	10.33
Argentina	686	6.1%	15.18
Chile	358	3.2%	18.73
Cuba	445	3.9%	39.29
Colombia	330	2.9%	6.49
Peru	248	2.2%	7.52
Venezuela	128	1.1%	4.50
Ecuador	78	0.7%	4.42
Bolivia	70	0.6%	6.00
Costa Rica	70	0.6%	13.74
Panama	61	0.5%	14.14
Uruguay	57	0.5%	16.41
Paraguay	54	0.5%	7.57
Guatemala	47	0.4%	2.62

Table 2: Scientific journals with the highest number of scientific articles on medicinal plants in Latin America and the Caribbean (Web of Science, Scielo, and LILACS: *n* = 14,397).

Journal	N	%	Country	JIF 2020
Journal of Ethnopharmacology	1471	10.22	Ireland	4.360
Revista Brasileira de Farmacognosia	921	6.4	Brazil	2.010
Revista Brasileira de Plantas Medicinais	464	3.22	Brazil	NA
Latin American and Caribbean Bulletin of Medicinal and Aromatic Plants	311	2.16	Chile	0.905
Cadernos de Saúde Pública	278	1.93	Brazil	1.632
Phytotherapy Research	257	1.79	The United Kingdom	5.882
Ciência and Saúde Coletiva	233	1.62	Brazil	1.336
Evidence-Based Complementary and Alternative Medicine	209	1.45	The United States	2.630
Phytomedicine	201	1.4	Germany	5.340
Pharmaceutical Biology	197	1.37	Netherlands	3.503
Planta Medica	177	1.23	Germany	3.356
Revista de Saúde Pública	177	1.23	Brazil	2.106
Latin American Journal of Pharmacy	161	1.12	Argentina	0.249
Journal of Endodontics	140	0.97	The United States	4.171
Natural Product Communications	122	0.85	The United States	0.986

JIF: Journal Impact Factor from Web of Science Core Collection; NA: Not applicable, because the journal was indexed on Scielo and LILACS till 2016.

its health system.[51,52] In this way, the scientific production of medicinal plants in a country may help improve the evidence of its effects to integrate them safely and reliably into medical practice. However, little is known about the security and efficacy, assessed by randomized clinical trials, of these medicinal plant-based drugs approved in Brazil and Cuba, as most of its research are in laboratory or animal models.

On the other hand, there are several explanations for the low research production in others LAC countries but Brasil. Overall, researchers from LAC countries had limited access to

Table 3: Ten most cited original articles about medicinal plants in Latinamerica and Caribbean (Web of Science and Scielo: *n*=12,696).

First author	First author country	Research subject	Year	Cites	Main studied medicinal plants
Mensor Luciana L.[26]	Brazil	Antioxidant activity in medicinal plants from Brazil.	2001	1061	*Lantana trifolia* L., *Vitex polygama* Cham., *Bouchea fluminensis* (A.St.-Hil.) Cham., *Vitex cymose* Bertero ex Spreng., *Brillantaisia lamium* (Nees) Benth., *Hyptis elegans* Briq. ex Micheli, *Rhaphiodon echinus* (Nees and Mart.) Schauer, *Ginkgo biloba* L.
Nascimento Gislene GF.[27]	Brazil	Antimicrobial activity in medicinal plants from Brazil.	2000	607	*Thymus vulgaris* L., *Rosmarinus officinalis* L., *Melissa officinalis* L., *Salvia officinalis* L., *Ocimum basilicum* L., *Achillea millefolium* L., *Syzygium aromaticum* (L.) Merr. and L.M.Perry, *Punica granatum* L., *Syzygium cumini* (L.) Skeels, *Psidium guajava* L.
Ordoñez AAL.[28]	Argentina	Antioxidant activity of *Sechium edule* (Jacq.) Sw.	2006	522	*Sechium edule* (Jacq.) Sw. (Chayota).
Heinrich M.[29]	Mexico	Traditional medicine with medicinal plants in Mexico.	1998	508	Identification of the use of medicinal plants in four native cultures, for dermatological, respiratory, and gastrointestinal problems.
Holetz FB.[30]	Brazil	Antimicrobial activity in medicinal plants from Brazil.	2002	446	*Arctium lappa* L., *Tanacetum vulgare* L., *Erythrina speciosa* Andrews, *Psidium guajava* L., *Mikania glomerata* Spreng., *Spilanthes acmella* Mart., *Lippia alba* (Mill.) N.E.Br., *Achillea millefolium* L., *Piper regnellii* Miq., *Eugenia uniflora* L., *Punica granatum* L., *Sambucus canadensis* L., *Platago major* L.
Scherer Rodrigo[31]	Brazil	Antioxidant activity of *Xanthium strumarium.*	2009	378	*Xanthium strumarium* L. (Burdock or common cadillo).

First author	First author country	Research subject	Year	Cites	Main studied medicinal plants
Teixeira Duarte MC.[32]	Brazil	Antimicrobial activity in medicinal plants from Brazil.	2005	361	*Aloysia triphylla* (L'Her.) Britton, *Anthemis nobilis* L., *Cymbopogon martini* (Roxb.) W. Watson, *Cymbopogon winterianus Jowitt, Cyperus articulates* L., *Cyperus rotundus* L., *Lippia alba* (Mill.) N.E. Br. ex Britton and P. Wilson, *Mentha arvensis* var. piperita L., *Mikania glomerata* Spreng., *Mentha piperita* L., *Stachys byzantine* K. Koch, *Solidago chilensis* Meyen, and other 32 plants more.
Agra Maria de Fatima[33]	Brazil	Bibliographic review on medicinal plants used in northern Brazil.	2008	349	Identification of 650 species of medicinal plants, 407 genera and 111 families.
Galvez Ranilla Lena[34]	Chile	Antihyperglycemic and antihypertensive activity of medicinal plants in Latin America.	2010	337	Hypoglycemic activity: *Phyllanthus niruri* L., *Smilax officinalis* Kunth, *Ilex paraguariensis* A.St.-Hil., *Tagetes minuta* L. Antihypertensive activity: *Schinus mole* L., *Lepidium meyenii* Walp., *Cyclanthera pedate* (L.) Schrad., *Zingiber officinale* Roscoe.
Alarcon-Aguilara FJ.[35]	Mexico	Antihyperglycemic activity in medicinal plants from Mexico.	1998	332	*Guazuma ulmifolia* Lam., *Tournefortia hirsutissima* L., *Lepechinia caulescens* (Ortega) Epling, *Rhizophora mangle* L., *Musa* × *paradisiaca* L., *Trigonella foenum-graecum* L., *Turnera diffusa* Willd. ex Schult., *Euphorbia prostrata* Aiton.

grant opportunities or research budgets, inadequate laboratory infrastructure, equipment, salaries, and work security,[53] specially in biotechnology and ethnopharmaceutical areas. In addition, despite Brazil and other LAC countries considering traditional medicine as part of their research priorities and impulsively creating academic units in these areas,[11] these efforts may be not sufficiente to fill the gap of human and economic resources between countries. Moreover, while Brazil had more than 25 biotechnology companies for the 2010, the remaining countries of LAC, excepting Mexico, had less than 10 biotechnology companies, each.[54] Furthermore, most of these companies are dedicated to imitating the products invented elsewhere, not producing original products.[55]

The most important co-authors outside of LAC are from the United States, Italy, Spain, and France. However, although these countries contribute to research on medicinal plants worldwide, except for the United States, they are mostly surpassed by China, India, and South Korea.[9,22,47] At the global level, African and Asian countries participated in 34% and 31% of the scientific articles on ethnobotany between 2001 and 2013,[56] but they have little collaboration with LAC countries. This could be partly due to these countries' historical relationship with Western Europe, where an exchange of botanical and animal species was exchanged for centuries.[57] But, also because collaborative research relationships between LAC countries are deeper with Western Europe and the United States than other regions.[58] Similarly, it is observed that intraregional collaboration is mainly

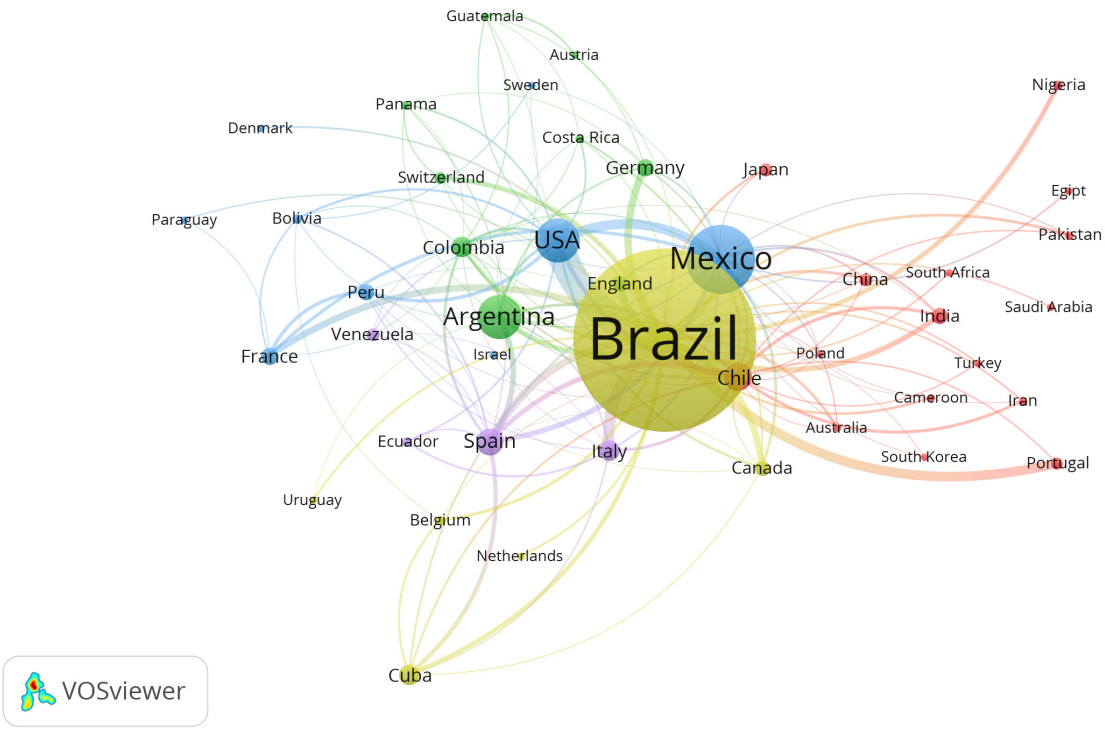

Figure 2: Analysis of co-authorship between countries on scientific publications on medicinal plants in Latin America and the Caribbean (Web of Science, *n* = 10,070). Countries with a minimum of 20 articles. Scale: 1.45, Weight with documents. Variation size: 0.66. Minimum connection force: 5. Connections between Non-LAC countries are not shown.

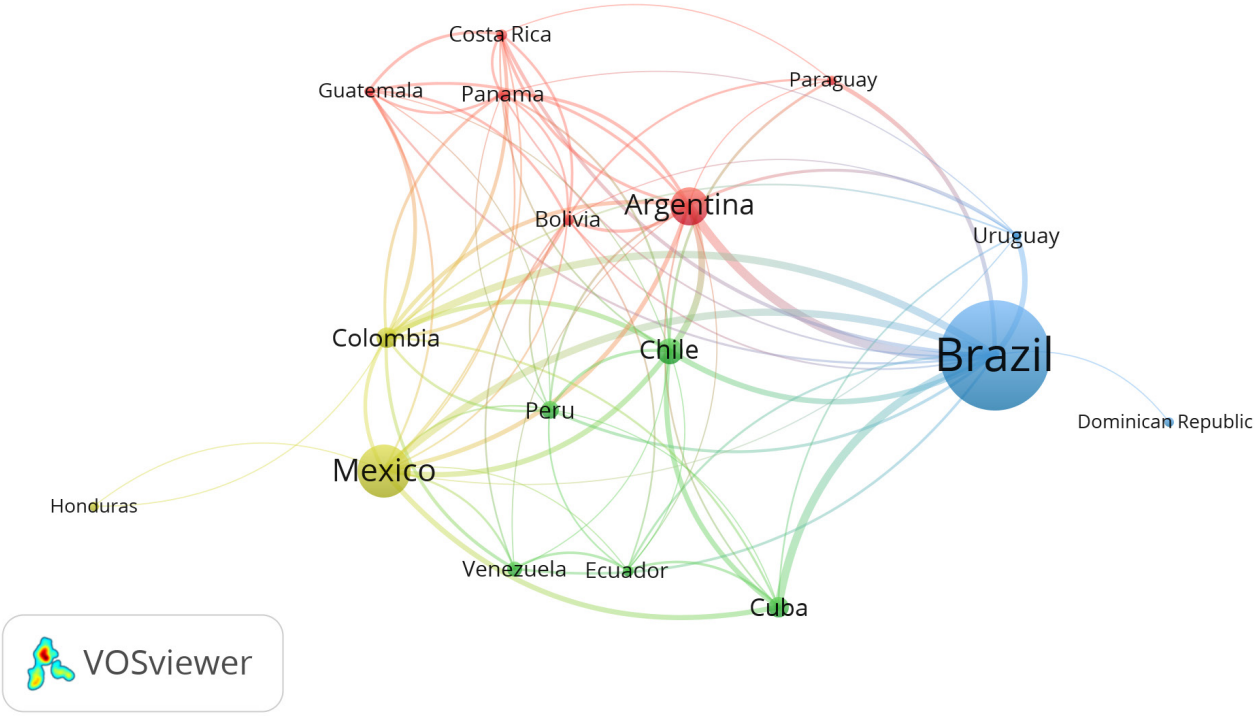

Figure 3: Analysis of co-authorship between Latin American countries on scientific publications on medicinal plants in Latin America and the Caribbean (Web of Science, *n* = 10,070). Countries with at least one article. Scale: 1.55, Weight with documents. Variation size: 0.5. Minimum connection force: 1.

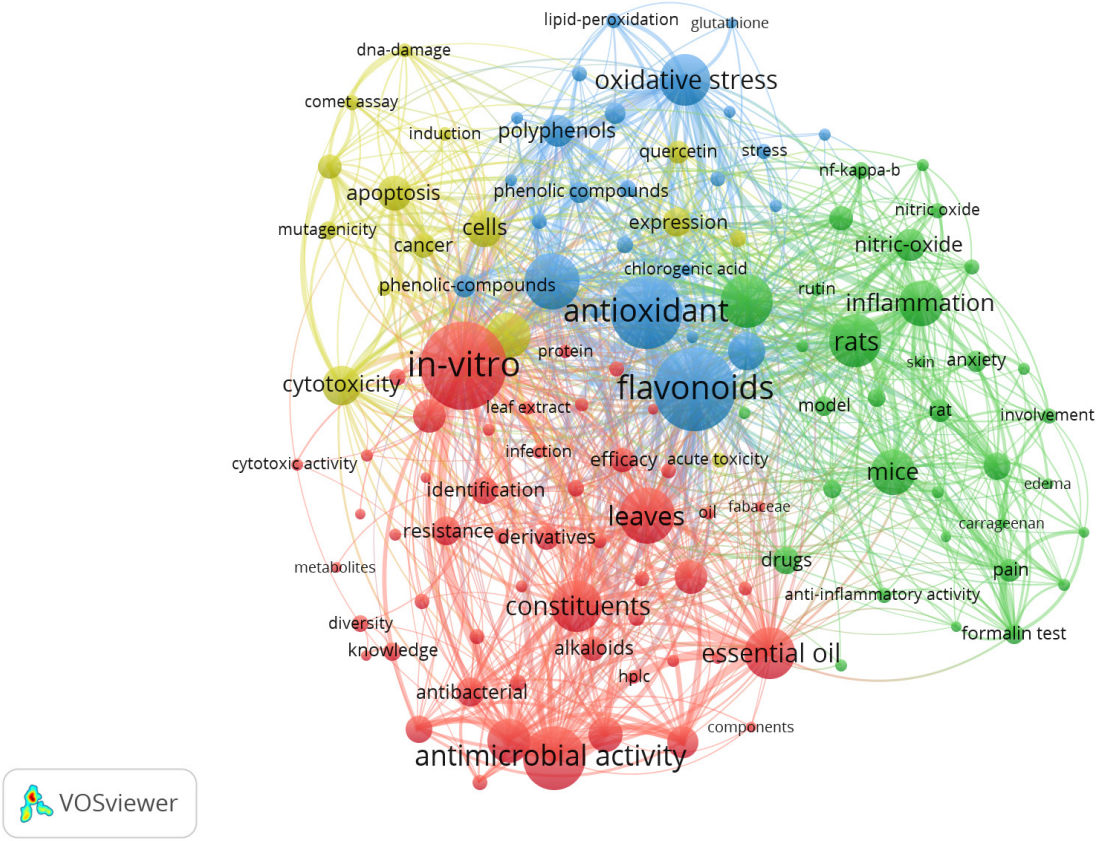

Figure 4: Analysis of co-occurrence between keywords of scientific publications on medicinal plants in Latin America and the Caribbean (Web of Science and Scielo: *n* = 12,696). Key terms with a minimum of 60 documents. Scale: 0.99, Weight with documents. Variation size: 0.80. Minimum connection force: 1.

between geographically close countries, probably because they share botanical species and their respective medicinal uses,[9] which could partially explain our results.

The clusters by keywords of the studies on medicinal plants in LAC show the main therapeutic functions to which they are attributable. For example, a 2011 review identified 175 species of South American medical plants with anti-inflammatory activity, which can inhibit the synthesis of prostaglandins, arachidonic acid, and prostanoids.[59] The main species with this capacity most mentioned in the articles found were *Uncaria tomentosa* (Willd. ex Schult.) DC., *Mikania glomerata* Spreng., *Bauhinia forficata* Link, *Maytenus ilicifolia* Mart. ex Reissek, and *Eugenia uniflora* L. On the other hand, the antibacterial, antiviral, antiparasitic, and antifungal activity of various medicinal plants in the region is also described, such as *Baccharis trimera* (Less.) DC., *Mikania glomerata* Spreng., *Schinus terebinthifolia* Raddi, and *Azadirachta indica* A. Juss.[60,61] In addition, it is also recognized that some LAC medicinal plants have antioxidant activity, inhibition of α-glucosidase and angiotensin-converting enzyme 1, and may be helpful for the management of hyperglycemia and hypertension.[34] Among the best-identified plants are *Ilex paraguariensis* A.St.-Hil., *Schinus terebinthifolia* Raddi, and *Uncaria tomentosa* (Willd. ex Schult.) DC. Finally, the anticancer activity of some medicinal plants is recognized as having antitumor capacity, cytotoxic for cancer cells, and potentiating for immune cells.[62,63] Among them are *Bauhinia forficata* Link, *Maytenus ilicifolia* Mart. ex Reissek, *Calendula officinalis* L., *Annona muricata* L., and *Psidium guajava* L.

It should be noted that a large amount of the research carried out with medicinal plants is *in-vitro* or in animal models. So it is necessary the design of clinical trials in humans that assess the efficacy and adverse effects of medicinal plants.[64] This knowledge will allow a correct use of medicinal plants in clinical practice,[65] to make health decisions based on the best available scientific evidence.[66] First, however, it is necessary to consider the participation of native cultures in the process of knowledge transmission without incurring unnecessary overexploitation of the species or their culture.[67]

Some limitations of the present study include the possibility that a considerable number of scientific articles on other medicinal plants were not included in the search strategy. However, a search strategy as sensitive as possible was chosen, using combinations of terms to broaden the uptake of related scientific articles on the subject.[23] Likewise, international and regional databases were used with sufficient representation of the thematic scientific production and the region. In addition, only an 8% error rate was

Table 4: Medicinal plants most mentioned in the titles of scientific articles on medicinal plants in Latin America and the Caribbean (Web of Science, Scielo and LILACS: *n* = 14,397).

Families	Scientific name	Common name	Mentions
Aquifoliaceae	*Ilex paraguariensis* A.St.-Hil.	Yerba mate	57
Rubiaceae	*Uncaria tomentosa* (Willd. ex Schult.) DC.	Cat's claw	50
Asteraceae	*Baccharis trimera* (Less.) DC.	Carqueja	40
Asteraceae	*Mikania glomerata* Spreng.	Guaco	38
Lamiaceae	*Rosmarinus officinalis* L.	Rosemary	38
Anacardiaceae	*Schinus terebinthifolia* Raddi	Pink or Brazilian pepper	36
Fabaceae	*Bauhinia forficata* Link	Ox leg	36
Anacardiaceae	*Mangifera indica* L.	Mango	36
Passifloraceae	*Passiflora edulis* Sims	Passionflower	35
Celastraceae	*Maytenus ilicifolia* Mart. ex Reissek	Chuchuwasi	34
Meliaceae	*Azadirachta indica* A.Juss.	Nim / Neem	34
Myrtaceae	*Eugenia uniflora* L.	Capulí	32
Myrtaceae	*Psidium guajava* L.	Guava	28
Verbenaceae	*Lippia alba* (Mill.) N.E.Br. ex Britton and P.Wilson	Sage sija	28
Amaranthaceae	*Pfaffia glomerata* (Spreng.) Pedersen	Paratodo	25
Verbenaceae	*Lippia sidoides* Cham.	Pepper-rosmarin	25
Asteraceae	*Mikania laevigata* Sch.Bip. ex Baker	Guaco	24
Passifloraceae	*Passiflora alata* Curtis	Red star or Ouvaca	24
Asteraceae	*Baccharis dracunculifolia* DC.	Chirca or Chilca	23
Euphorbiaceae	*Croton cajucara* Benth.	Take out	22
Lamiaceae	*Ocimum gratissimum* L.	Clove basil	22
Asteraceae	*Calendula officinalis* L.	Gold button	22
Annonaceae	*Annona muricata* L.	Soursop	21

obtained in the manual review of the analyzed documents. Our results are generalized at the regional level and do not try to be specific to any medicinal plant species or country. Additionally, it was impossible to analyze institutions and authors due to the absence of information in a database and the incorrect data standardization. However, a detailed analysis of the co-authorship between LAC countries and other regions of the world is presented.

CONCLUSION

Research on medicinal plants in LAC has increased since 2000; but has remained quantitatively unchanged in recent years. Nevertheless, significant collaboration was observed between LAC countries with institutions in the United States and Western Europe, with Brazil being the country that participated in more than half of the articles evaluated. The main therapeutic activities in medicinal plants were anti-inflammatory, antimicrobial in infections, antitumoral in cancer, and antioxidant in chronic non-communicable diseases, mostly with basic and laboratory research. Therefore, it is necessary to intensify the clinical and translational research of medicinal plants in collaboration between LAC countries since these could have therapeutic potential in the main diseases of the region.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

LAC: Latin America and the Caribean; **LILACS:** Literatura Latinoamericana y del Caribe en Ciencias de la Salud; **HIV/AIDS:** Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome; **MESH:** Medical Subject Headings; **WoS:** Web of Science; **JIF:** Journal Impact Factor; **NA:** Not applicable.

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SUPPLEMENTARY METHODS

LILACS search strategy("planta medicinal" OR "plantas medicinales" OR "hierba medicinal" OR "hierbas medicinales" OR "raíz medicinal" OR "raíces medicinales" OR "semilla medicinal" OR "semillas medicinales" OR "planta sanadora" OR "plantas sanadoras" OR "planta curadora" OR "plantas curadoras" OR "planta tradicional" OR "plantas tradicionales" OR "extracto de planta" OR "extractos de plantas" OR "preparación de planta" OR "preparaciones de plantas" OR "planta terapéutica" OR "plantas terapéuticas" OR "hierba sanadora" OR "hierbas sanadoras" OR "hierba curadora" OR "hierbas curadoras" OR "hierba tradicional" OR "hierbas tradicionales" OR "extracto de hierba" OR "extractos de hierbas" OR "preparación de hierba" OR "preparaciones de hierbas" OR "hierba terapéutica" OR "hierbas terapéuticas" OR "producto herbario" OR "productos herbales" OR "terapia herbaria" OR "remedio herbal" OR "remedios herbales" OR "remedios de hierbas" OR "remedio de hierba" OR "raiz sanadora" OR "raices sanadoras" OR "raiz curadora" OR "raices curadoras" OR "raiz tradicional" OR "raices tradicionales" OR "extracto de raiz" OR "extractos de raices" OR "preparación de raiz" OR "preparaciones de raices" OR "raiz terapéutica" OR "raices terapéuticas" OR "semilla sanadora" OR "semillas sanadoras" OR "semilla curadora" OR "semillas curadoras" OR "semilla tradicional" OR "semillas tradicionales" OR "extracto de semilla" OR "extractos de semillas" OR "preparación de semilla" OR "preparaciones de semillas" OR "semilla terapéutica" OR "semillas terapéuticas" OR "hoja sanadora" OR "hojas sanadoras" OR "hoja curadora" OR "hojas curadoras" OR "hoja tradicional" OR "hojas tradicionales" OR "extracto de hoja" OR "extractos de hojas" OR "preparación de hoja" OR "preparaciones de hojas" OR "hoja terapéutica" OR "hojas terapéuticas") OR ("Plantas medicinais" OR "plantas medicinais" OR "erva medicinal" OR "ervas medicinais" OR "raiz medicinal" OR "raízes medicinais" OR "sementes medicinais" OR "sementes medicinais" OR "plantas medicinais" OR "plantas medicinais" OR "Planta medicinal" OR "plantas medicinais" OR "planta tradicional" OR "plantas tradicionais" OR "extrato de planta" OR "extratos de plantas" OR "preparação de plantas" OR "preparações de plantas" OR "planta terapêutica" OR "plantas terapêuticas" OR "erva curativa" OR "ervas curativas" OR "erva curativa" OR "ervas curativas" OR "erva tradicional" OR "ervas tradicionais" OR "extrato de erva" OR "extratos de ervas" OR "preparação de ervas" OR "preparações de ervas" OR "erva terapêutica" OR "ervas terapêuticas" OR "produto à base de ervas" OR "produtos à base de ervas" OR "fitoterapia" OR "raiz de cura" OR "raízes de cura" OR "raiz de cura" OR "raízes curadoras" OR "raiz tradicional" OR "Raízes tradicionais" OR "extrato de raiz" OR "Extratos de raiz" OR "preparação de raiz" OR "preparações de raiz" OR "raiz terapêutica" OR "raízes terapêuticas" OR "semente de cura" OR "sementes de cura" OR "semente de cura" OR "sementes de cura" OR "semente tradicional" OR "sementes tradicionais" OR "extrato de semente" OR "extratos de sementes" OR "preparação de sementes" OR "preparações de sementes" OR "semente terapêutica" OR "sementes terapêuticas" OR "folha curativa" OR "folhas curativas" OR "folha curativa" OR "folhas curativas" OR "folha tradicional" OR "folhas tradicionais" OR "extrato de folha" OR "extrato de folha" OR "preparação de folhas" OR "preparações de folhas" OR "folha terapêutica" OR "folhas terapêuticas") OR ("Medicinal plant" OR "medicinal plants" OR "medicinal herb" OR "medicinal herbs" OR "medicinal root" OR "medicinal roots" OR "medicinal seed" OR "medicinal seeds" OR "medical plant" OR "medical plants" OR "traditional plant" OR "traditional plants" OR "plant extract" OR "plant extracts" OR "plant preparation" OR "plant preparations" OR "therapeutic plant" OR " therapeutic plants" OR "healing herb" OR "healing herbs" OR "healing herb" OR "healing herbs" OR "traditional herb" OR "traditional herbs" OR "herb extract" OR "herb extracts" OR "herbal preparation" OR "herbal preparations" OR "therapeutic herb" OR "therapeutic herbs" OR "herbal product" OR "herbal products" OR "phytotherapy" OR "healing root" OR "healing roots" OR "traditional root" OR "traditional roots" OR "root extract" OR "root extracts" OR "preparation ion root" OR "root preparations" OR "therapeutic root" OR "therapeutic roots" OR "healing seed" OR "healing seed" OR "healing seeds" OR "traditional seed" OR "traditional seeds" OR "seed extract" OR "seed extracts" OR "seed preparation" OR "seed preparations" OR "therapeutic seed" OR "therapeutic seeds" OR "healing leaf" OR "healing leaves" OR " curative leaf" OR "curative leaves" OR "traditional leaf" OR "traditional leaves" OR "leaf extract" OR "leaves extract" OR "leaf preparation" OR "leave preparations" OR "therapeutic leaf" OR "leaf therapeutics") OR (fitoterap* OR fitomedic* OR phytomedic* OR ethnomedic* OR etnomedic* OR ethnofarmacolog* OR ethnobot* OR phytotherap* OR phytoremed* OR fitoremedi*) AND (Argentin* OR Bolivia* OR Brazil* OR Brasil* OR Colombia* OR Chile* OR Ecuador* OR Ecuatorian* OR Guyana* OR Paraguay* OR Peru OR Peruan* OR Peruvian* OR Uruguay* OR Venezuela* OR Belize* OR Belice* OR "Costa rica*" OR "El Salvador" OR Salvador* OR Guatemal* OR Hondura* OR Nicaragua* OR Panama* OR Mexic* OR Cuba OR Cuban* OR Dominican* OR "Puerto Ric*") AND (db:("LILACS")).

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OR seeds) NEAR/1 (pharmaceutic* OR extract* OR preparation* OR therap* OR medic* OR healing* OR drug* OR remed*)) OR "aqueous extract")

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