ORIGINAL ARTICLE

Arquivos Brasileiros de Oftalmologia

Analysis of ophthalmological and vision-related publications in Latin America

Análise de publicações oftalmológicas e relacionadas à visão na América Latina

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ABSTRACT | Purpose: To assess scientific production related to ophthalmology and vision in Latin America during the period from 2006 to 2015. **Methods:** The PubMed, Lilacs (Bireme), Google Scholar, SciELO, and Medigraphic databases were evaluated for this retrospective, descriptive, and comparative study. **Results:** A total of 1,510 articles was identified. Brazil was the leader in quantitative production in ophthalmology, averaging 85.4 articles per year. Mexico was in second place with 27.4, and Argentina was in third place with 11.1 articles per year. Forty-one percent of articles were published in English, 28.1% dealt with the subspecialty of the retina, and 63% were published by researchers affiliated with universities. The frequency of male first authors was 58.9%, and the journal *Arquivos Brasileiros de Oftalmologia* accounted for 36.42% of the identified articles. **Conclusions:** Brazil stands in first place in Latin America in ophthalmologic scientific production. Nearly half of the researchers in ophthalmology in Latin America included in our study were listed in databases other than PubMed.

Keywords: Bibliometrics; Scientific and technical activities; Ophthalmology

RESUMO | Objetivo: Avaliar a produção científica relacionada à oftalmologia e à visão na América Latina durante o período de 2006 a 2015. **Métodos:** As bases de dados PubMed, Lilacs (Bireme), Google Scholar, SciELO e Medigraphic foram utilizadas para realizar um estudo retrospectivo, descritivo e comparativo. **Resultados:** Foram identificados 1,510 artigos, sendo que o Brasil foi a principal fonte de produção quantitativa, com uma média de 85,4 artigos por ano; o México aparece em segundo lugar com 27,4 e a Argentina em terceiro lugar com 11,1 artigos por ano. Quarenta e um por cento dos artigos foram publicados em inglês; 28,1% trataram da subespecialidade da retina; e a principal fonte institucional de publicações foram as universidades, com 63%. A frequência de primeiros autores do sexo masculino foi de 58,9%, e a revista *Arquivos Brasileiros de Oftalmologia* representou 36,42% dos artigos identificados. **Conclusões:** O Brasil ocupa o primeiro lugar na América Latina na produção científica oftalmológica. Os bancos de dados não indexados no PubMed foram incluídos em nosso estudo, representam quase metade dos pesquisadores em oftalmologia na América Latina.

Descritores: Bibliometria; Produção científica e tecnológica; Oftalmologia

INTRODUCTION

Bibliometrics is defined as "the quantitative and scientific study of publications"[1]. Numerous bibliometric studies have been conducted in the field of medicine, spanning areas such as oncology[2], anesthesiology[3], gastroenterology[4], and ophthalmology[5]. The number and percentage of published scientific journal articles provide insight into the level of research activity in a country. In a wide range of countries, including the United States, Great Britain, Germany, Australia, and Japan, sustained growth has been observed in recent years in bibliometric publications in the field of ophthalmology[6].

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In a study by Ragghianti et al.[6] examining bibliometric publications in Latin American countries, ophthalmological publications accounted for 1.9% of publications in Argentina, Brazil, Chile, Paraguay, and Uruguay, in contrast to 3.3-3.7% in European countries. This reflects a more modest proportion of ophthalmological research in Latin America compared to some regions.

However, the scope of the above study was limited to PubMed. The role of Mexico in the publication of ophthalmological and vision-related articles within Latin America has yet to be investigated in a published study. We hope the current work will lead to greater awareness among Latin American ophthalmologists of the need for increased scientific research in vision-related fields in conjunction with other medical research. Increased awareness necessitates bibliometric analyses of the current situation, so that each country's professional community can promote the goal of increased research among ophthalmologists.

METHODS

The current paper is a retrospective, descriptive, and comparative study. We evaluated ophthalmological publications in Latin American countries indexed in the PubMed, Lilacs (Bireme), Google Scholar, SciELO, and Medigraphic databases during the period from January 2006 to January 2015. Descriptive statistics were used, and trends in the production of articles by country were analyzed through quadratic regression. Significance was assessed using a two-tailed test, with a p-value <0.05 considered significant. Analysis of the databases was performed with Excel® 2013. The following keywords were used: contact lenses, diagnostic techniques, ophthalmological, eye, eye diseases, eye injuries, lenses, intraocular, ocular motility disorders, ocular physiology, ophthalmic surgical procedure, vision, visual science, retina, cataract, glaucoma, ophthalmology, orbit, orthoptics, vision disorder, refractive surgery, strabismus, and cornea. Along with the search criteria listed above, articles were also categorized based on the country of origin: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Uruguay, and Venezuela.

RESULTS

For our analysis, an initial search using the filters listed above yielded 15,276 articles. These were reviewed manually, and 12,173 were excluded because the main topic was not ophthalmology or vision. In addition, 897 ophthalmological and vision-related articles that fell outside the period covered by the study, and 639 articles listed in PubMed that were duplicated in other databases were eliminated. An additional 57 articles were excluded because it was impossible to determine the first author's country of origin, leaving a total sample size of 1,510 articles for the study.

Twenty countries were included in our study, and these were divided into two groups for practical purposes. The first group of four countries consisted of Brazil, Argentina, Mexico, and Cuba, whose production totaled 1340. The second group of sixteen countries, with a combined production of 170, comprised Bolivia, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Uruguay, and Venezuela.

Languages

The articles we examined were published in the following languages: English 41% (638/1510), Portuguese 34% (511/1510), and Spanish 25% (394/1510). Among the articles published in Brazil, Portuguese accounted for 59% (505/854), English for 40% (339/854), and Spanish for 1.2% (10/854). In Mexico, 57% of articles were published in Spanish (155/274) and 43% were published in English (119/274). In Argentina, 71% (79/111) were in English, and 29% were in Spanish (32/111). In Cuba, the Spanish language predominated, with 88% (89/101) of publications. The distribution of the remaining 170 articles from the other sixteen countries was as follows: Colombia 64, Chile 39, Venezuela 22, Peru 9, Paraguay 8, Panama 7, Costa Rica and Guatemala 5, Ecuador and Uruguay 3, Honduras and Bolivia 2, and El Salvador with one article. The countries with no published articles were Nicaragua, Puerto Rico, and the Dominican Republic.

Subspecialties

The ophthalmological subspecialty with the highest number of publications in our study was the retina, with 28.1% (424/1,510), followed by strabismus with 18.7% (283/1,510), the cornea with 17.7% (267/1,510), and glaucoma in fourth place with 8.61% (130/1,510).

Institutions

Sixty-three percent (949/1,510) of affiliated institutions were universities, and 37% (561/1510) were hospitals.

Three foundations were listed and were counted as hospitals due to the type of services they provided. In general, publications by hospitals were most common in Brazil, Argentina, Mexico, Cuba, Venezuela, Chile, and Colombia.

Journals of publication

The four journals most favored by Latin American authors (Table 1) were Arquivos Brasileiros de Oftalmología, which accounted for 36.42% of publications (550/1,510), Cirugía y Cirujanos with 4.8%, Archivos de la Sociedad Española de Oftalmología with 3.3% (50/1510), and Revista Brasileira de Oftalmología with 3.0% (46/1,510).

Countries

The four leading countries in quantitative production were Brazil with 56.5% of publications (854/1,510), Mexico with 18.1% (274/1,510), Argentina with 7.3% (111/1510), and Cuba with 6.6% (101/1,510). Within the study period, an annual average of 151 publications for all countries was found, with a standard deviation of 30.2 (2-854, CI 95%).

Brazil:

During the ten-year period examined, 854 articles were published in Brazil, with an annual average of 85.4 articles. The most productive year was 2008, with 126 articles (R^2=0.78, p=0.54), followed by a declining trend in subsequent years.

Mexico:

A total of 274 articles was observed, giving an annual average of 27.4. The most productive year was 2014, with 39 articles. The trend showed a nearly constant increase during the last five years (R^2=0.66, p=0.51).

Argentina:

A total of 111 articles was published, representing an annual average of 11.1. The year with the lowest production was 2011, followed by an upward trend (R^2=0.004, p=0.45).

Cuba:

There were 101 publications with an annual average of 10.1 and a peak in production in 2012. A decrease in production was observed from 2013 to 2015.

Production over time

Excluding Brazil and Mexico, which deviated from the mean, the average production for the 18 remaining countries was 22 articles per year. The mean production in Latin America from 2006 to 2015 was six articles per year (SD 194.5, CI 91.06). The year with the greatest number of publications in Latin American countries was 2009, followed by a significant decrease in production (132 to 82, R^2=0.612, p=0.00000035).

Databases

Distribution by origin was as follows: 46% from PubMed (702/1,510), and 54% (808/1,510) from the remaining five databases: Google Scholar, Lilacs Bireme, SciELO, and Medigraphic.

Animal studies

Thirty-one study results were obtained in animals, comprising 2% of the articles in the study, while 98% (1479/1510) represented research with human subjects.

DISCUSSION

We were able to draw two important conclusions from our study. The first is that journals not indexed in PubMed contain practically half of the articles on ophthalmology in Latin America. Thus, we believe a representative study of a geographic region such as our own must include regional databases such as SciELO, Lilacs Bireme, etc. The study by Ragghianti et al.[6] had

Table 1. Bibliometric indices by journal

Journal	Abbreviation	IF	IPP	SNIP	SJR
Arquivos Brasileiros de Oftalmología	Arq. Bras. Oftalmol.	0.494	0.152	0.435	0.308
Cirugía y Cirujanos	Cir. Cir.	0.210	--	0.283	0.150
Archivos de la Sociedad Española de Oftalmología	Arch. Soc. Esp. Oft.	0.210	0.330	0.190	0.219
Revista Brasileira de Oftalmología	Rev. Bras. Oftalmol.	0.163	--	0.194	0.135

IF= Impact Factor; IPP= Impact per Publication; SNIP= Source Normalized Impact per Paper; SJR= Scientific Journal Rankings.
Source: webofknowledge.com, journalmetrics.scopus.com

the merit of examining ophthalmological production in the leading Latin American countries for the first time. However, the exclusion of Mexico — Latin America's second largest economy as well as a member of the G20, along with Brazil and Argentina — neglects an important source of contributions to regional scientific production.

Another bibliometric study of female authorship in ophthalmology examined three journals with a high impact factor (IF): "Journal of the American Academy of Ophthalmology" (IF 5.56), "American Journal of Ophthalmology" (IF 4.29), and "JAMA Ophthalmology" (IF 3.83). However, none of the authors in the study were Latin American[7]. In contrast, our researchers published their work in journals with IF ranging from 0.49 to 0.61; 32% of women authors published in the journal Arquivos Brasileiros de Oftalmologia, which has an IF of 0.49. It is of course easier to publish in one's country and language.

The subspecialty of glaucoma occupies the fourth place in our study as a percentage of the articles examined, with 8.61% (130/1,510). This percentage may be increased by broadening the search criteria, as seen in a bibliometric investigation by Shahrokh Ramin focused solely on this branch of ophthalmology. During the past decade, 9,483 articles on glaucoma can be found on the global level, using search criteria that include all words related to both the procedures and types of treatment for glaucoma. We recognize that one of the significant weaknesses of our article is that we collected our sample based on the keywords used as links in each article. Using generalized terms such as the names of subspecialties necessarily limits the search, producing a distortion with regard to specific terms within a specialty. Broadening these criteria has only been examined in a single study[8].

In an analysis of scientific production by X.Y. Liu, the United States had an annual average of 2,253 articles per year, while China averaged 287 articles per year. Other countries such as Germany and Japan[2] had similar figures. In contrast, the mean annual production in our series was 85.4 for Brazil, 27.4 for Mexico, 11.1 for Argentina, 10.1 for Cuba, 6.4 for Colombia, 3.9 for Chile, 2.2 for Venezuela, 0.9 for Peru, 0.8 for Paraguay, 0.7 for Panama, 0.5 for Costa Rica, 0.5 for Guatemala, 0.3 for Ecuador, 0.3 for Uruguay, 0.2 for Bolivia, and 0.2 for Honduras. El Salvador, Nicaragua, Puerto Rico, and the Dominican Republic produced no publications during the period of our study. In both the United States and China, there are approximately 1000 patients per ophthalmologist; thus, there is no inequality with regard to the workload, and in theory, there should be equal opportunities for research. The number of inhabitants each ophthalmologist must serve in Latin American countries is 1727, 1089, 1069, and 1004 in Nicaragua, Honduras, El Salvador, and Venezuela, respectively. Production is higher in other countries in similar circumstances with regard to the proportion of ophthalmologists. Puerto Rico has the lowest theoretical number of inhabitants per ophthalmologist, with 924; however, it showed no authorship among the articles examined.

The above observations permit us to say that the number of ophthalmologists per inhabitant does not exhibit a firm relationship with a country's scientific production, and perhaps other factors influence the production of articles in Latin American countries[9]. We suppose that these observations are not simply due to scientific laziness, but are influenced by factors such as a lack of economic resources among researchers, or political and financial crises in Latin American countries. For example, a currency devaluation crisis may diminish support for research and cause doctors to prioritize their private practices over scientific investigation. A country's financial circumstances also influence the production of scientific literature, because ophthalmologists migrate to countries with greater opportunities, and that is where they publish their work. Researchers also prefer to move to places where greater support is offered for research. On the other hand, the existence of large low-income populations can provide an excellent opportunity to conduct basic research, for instance in countries such as Brazil where research is financed through the pharmaceutical industry, making it more profitable to launch new treatments in other countries with a higher level of development after testing[10].

Our analysis covered articles retrieved from a search of databases that include non-indexed articles in their results such as Google Scholar and Medigraphic. This enabled us to broaden our search to journals that reflect an effort on the part of researchers to publish their work, but that are unaccounted for in bibliometric studies examining only PubMed.

The mean number of articles in the countries studied was six per year (SD 194.5, CI 91.06). Mexican production of scientific literature in our field was found to be an average of 27.4 articles per year, with a statistically significant increase in the percentage of publications over time ($R^{2=}0.66$, $p=0.51$). With a more significant

relationship indicated as p approaches 1, we observed a very high correlation between the year and the number of publications. In other words, more articles are published in Mexico over time.

The results reflect the average quantitative production, since the IF of journals and the number of citations for articles were not considered. Production in Brazil from late 1995 to 2005 averaged 82.4 articles per year. Over the next ten years, Brazil showed a similar level of production, with an annual average of 85.4. However, a high correlation was observed between the year and the number of publications, with a statistically significant declining trend (R^2=0.78, p=0.54).

Argentina has one ophthalmologist for every 1009 inhabitants[9] and a study covering the years from 1995 to 2004 revealed an average annual production of 31.0. In our series, Argentina had an annual average of 11.1 articles from 2006 to 2015, with a pattern of decline in the percentage of publications which was not statistically significant (R^2=0.004, p=0.45).

We also observed that the sixteen countries of Bolivia, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Uruguay, and Venezuela produced 11.25% (170/1510) of all publications in our sample.

There are 213 ophthalmological societies in the world, divided among 193 countries, according to a 2010 report. Among their members, fully half of the ophthalmologists, including residents in training, are located in just six countries: China, the United States, Russia, Japan, India, and Brazil. In contrast, 131 countries combined account for less than 5% of these specialists[11].

The most favored journals for publication by Latin American authors, along with their IF, are: "Arquivos Brasileiros de Oftalmología" (IF 0.494), "Cirugía y Cirujanos" (IF 0.21), and "Revista Brasileira de Oftalmología" (IF 0.163)[12]. For us, the IF mainly reflects an index of popularity, since it is derived from the number of citations for an article. However, it is currently the most commonly used indicator of importance, and we can employ it to make comparisons with journals chosen by authors in other countries, such as "Progress in Retinal and Eye Research" with an IF of 9.394, followed by "Ophthalmology" with an IF of 6.75. Journals with Latin American editors and in the contributors' native language are preferred by Latin American authors. We suppose that language itself is not a barrier for publication in other high-impact journals, but that logistical difficulties complicate attempts to publish in a non-Latin American journal. Analysis of the IF and prestige of a scientific journal is influenced by the number of citations for an article; a larger number of authors from diverse countries can increase the impact of an article and thus its citation level and the ranking of the journal. This may explain the fact that by excluding non-Latin American authors, we found no articles in journals with greater IF[13]. Among countries with high levels of citations for their publications, Brazil stands in 24th place and is the only Latin American country on the list[14].

The results of the present bibliometric analysis should be considered with caution, taking into account the inherent limitations caused by frequent database updates. One limiting factor for our bibliometric analysis is the fact that we only included published articles; however, there are other methods of scientific dissemination such as conferences and posters. Other studies[15] examine these outlets, which are not normally included in bibliometric analysis but merit consideration in future research.

Analyzing scientific productivity by country offers us a tool for setting goals for production in the field of ophthalmology. Scientific publications indexed in databases outside of PubMed represented 54% of Latin American publications in our study. This is a body of literature that must be taken into account to obtain an accurate picture of the situation. However, bibliometric indices for web publications that would allow us to measure the impact of these publications are non-existent beyond the citations listed by Elsevier and Thomson Reuters.

In our study, women had a higher level of representation than that seen in international publications[16], with 39% of last authors and 41% of first authors being women. While the predominant language in international publications is English, in our sample, English represented 41% of the total. Increasing mastery of English among Latin Americans would facilitate publication in the language. Among subspecialties, the retina and vitreous region remains the field with the most publications during the past two decades, both in our study, with 28.1%, and in the previous decade as shown by Ragghianti et al.[6], with 26.9%[19]. Our current results also show other findings similar to those of Ragghianti et al.[6], for instance that research at universities is predominant and clinical studies with human subjects are the most common topic of scientific publications.

The ophthalmology journal with the greatest impact in the region according to the three leading bibliometric indices is Arquivos Brasileiros de Oftalmología, as also found by Ragghianti et al.[6].

Brazil showed a decreasing trend in the number of articles published per year; this phenomenon may be a reflection of the country's economic and political situation during the period of the study. In Brazil, there are 698 scientists with doctoral degrees dedicated to research per million inhabitants; in the United States, there are 3867, in China 903, in Mexico 312, and in Argentina 1121. On a comparative basis, the presence of professionals dedicated to research is one of the indicators of economic growth in the field of scientific research[17].

The study by Ragghianti et al.[6] covered the period from 1995 to 2004, while ours examined the years from 2006 to 2015. It would be advantageous to conduct similar studies in the future to identify correlations in the factors that influence an increase or decrease in the publication of articles in our region. Mexico currently occupies second place with regard to ophthalmological production in Latin America, and its production trend has been increasing during the past ten years. However, there is still a need for increased resources to stimulate further scientific research.

Latin America is a geographically, culturally, and economically powerful region on the global level. Scientific research is a reflection of interest on the part of medical professionals in advancing their knowledge and improving their field. Thus, the level of medical research in Latin America should show a certain parallel with the region's increasing importance in the world, especially since three of the four Latin American countries with the highest scientific production belong to the G20. Brazil was the leader in quantitative production, since the IF of journals and the number of article citations were not taken into consideration.

Our study has the merit of including databases outside of PubMed, and thus not neglecting nearly half of the ophthalmological researchers in Latin America, as was the case in previous studies. "*Sans la liberté de blâmer il n'ya pas d'éloge flatteur*" ["Without the freedom to criticize, genuine praise is not possible"], writes a French author in *The Marriage of Figaro*. By this, we mean to say that our work is intended as constructive criticism of the current low levels of scientific production in Latin America, with the aim of inspiring residents, professors, and academic institutions in our countries to take a "great leap forward" in the field of ophthalmological research in Latin America. A great leap forward was proposed by Chairman Mao for the Chinese economy in the 1960s, and we can see, fifty years later, that this Asian country has positioned itself as an economic vanguard, and its scientific research is in the process of following the same path.

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