

Cardiovascular Research Publications from Latin America between 1999 and 2008. A Bibliometric Study

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Abstract

Background: Cardiovascular research publications seem to be increasing in Latin America overall.

Objective: To analyze trends in cardiovascular publications and their citations from countries in Latin America between 1999 and 2008, and to compare them with those from the rest of the countries.

Methods: We retrieved references of cardiovascular publications between 1999 and 2008 and their five-year post-publication citations from the Web of Knowledge database. For countries in Latin America, we calculated the total number of publications and their citation indices (total citations divided by number of publications) by year. We analyzed trends on publications and citation indices over time using Poisson regression models. The analysis was repeated for Latin America as a region, and compared with that for the rest of the countries grouped according to economic development.

Results: Brazil (n = 6,132) had the highest number of publications in 1999-2008, followed by Argentina (n = 1,686), Mexico (n = 1,368) and Chile (n = 874). Most countries showed an increase in publications over time, led by Guatemala (36.5% annually [95%CI: 16.7%-59.7%]), Colombia (22.1% [16.3%-28.2%]), Costa Rica (18.1% [8.1%-28.9%]) and Brazil (17.9% [16.9%-19.1%]). However, trends on citation indices varied widely (from -33.8% to 28.4%). From 1999 to 2008, cardiovascular publications of Latin America increased by 12.9% (12.1%-13.5%) annually. However, the citation indices of Latin America increased 1.5% (1.3%-1.7%) annually, a lower increase than those of all other country groups analyzed.

Conclusions: Although the number of cardiovascular publications of Latin America increased from 1999 to 2008, trends on citation indices suggest they may have had a relatively low impact on the research field, stressing the importance of considering quality and dissemination on local research policies. (*Arq Bras Cardiol.* 2015; 104(1):5-15)

Keywords: System for Evaluation of Publications; Publications / statistics & numerical data; Epidemiology; Bibliometrics Citation Databases.

Introduction

Cardiovascular diseases are the leading cause of death in Latin America and the second cause exclusively among people aged 15-59 years^{1,2}. Research is an important strategy for disease control and overall health improvement and was included as one of the 11 essential public health functions monitored by the Pan-American Health Organization (PAHO) among member countries³. In particular, research on health system performance and economic assessments has been identified as one of the top priorities to improve cardiovascular health in the Americas⁴.

Bibliometrics comprises a series of methods aimed to quantitatively evaluate scientific literature, which can be used to assess research productivity^{5,6}. Jahangir et al⁷ have previously conducted a bibliometric analysis of cardiovascular research articles from Latin America identified through the *PubMed* database (National Library of Medicine, National Institutes of Health, Bethesda, MD), which were published between 2001 and 2010. During this period, the total number of cardiovascular publications from Latin America indexed in *PubMed* increased about 18 fold, from 41 in 2001 to 726 in 2010. However, address information in *PubMed* is generally limited to the corresponding author, which may have led to an underestimation of the number of publications identified. Moreover, few data are currently available regarding the evolution of cardiovascular research publications from individual countries in Latin America, as well as other bibliometrics outcomes as citations.

We conducted a bibliometric analysis aimed to estimate the number, geographic distribution and citations of cardiovascular research publications from countries in Latin America. We explored associations between these outcomes and measures of country development level. In addition,

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we analyzed time trends on the number of publications and citations by country, as well as in Latin America, and contrasted these trends with those of other countries grouped according to economic development.

Methods

Study design and data source

We analyzed all cardiovascular research articles, reviews and conference proceedings published between 1999 and 2008 indexed on the Thomson Reuters *Web of Knowledge Science Citation Index Expanded* (SCI-EXPANDED), *Social Sciences Citation Index* (SSCI) and *Conference Proceedings Citation Index-Science* (CPCI-S, Thomson Reuters, NY). The study methods have been fully described elsewhere⁸. Briefly, we created and calibrated a bibliometric filter to capture cardiovascular research publications from the Thomson Reuters database using a previously published iterative approach in order to achieve precision (the proportion of retrieved publications that are relevant) and recall (the proportion of relevant publications that are retrieved) greater than 90%^{6,9}. Based on a previously used definition, we defined cardiovascular publications as: "all publications on the study of the cardiovascular system (heart and blood vessels) and its functions in health and disease, including heart disease and stroke, invasive/interventional cardiology, cardiac and vascular surgery, which is the practice of diagnostic and therapeutic procedures that involve entry into the heart and major blood vessels"⁶. Final precision and recall achieved were 0.905 and 0.903, respectively.

We applied the filter to the Thomson Reuters *Web of Knowledge* for publication years 1999 through 2008. We cleaned retrieved publication records by removing duplicates (based on the title) and any publication missing an address. We also queried search results in the *Web of Knowledge* for corresponding citation reports. We merged cleaned records with their five-year post-publication citation count (including the year of publication) and excluded publications without citation reports. We performed all searches in January 2013 to provide comparable citation estimates over time.

The Northwestern University institutional review board provided exemption from ethics review since this study did not meet criteria for Human Subject Research. Results from this study have been made publicly available at: <http://182.74.145.48:8080/ccdcgmc-webapp/generate.ccdcgm>.

Countries classification and development data

For the present analysis, we used the list of Latin American countries defined by the Population Division of the Economic Commission for Latin America and the Caribbean (ECLAC), United Nations, which includes Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela¹⁰. We classified other countries according to the 2011 World Bank Income Groups based on their gross national incomes¹¹. High-income countries were additionally classified as

members of the Organization for Economic Cooperation and Development (OECD) or non-OECD members¹². For each country, the human development index (HDI) and the gross domestic product (GDP) per capita in 2000 and 2008 were obtained from the World Bank development indicators¹³.

Bibliometric outcomes

We aggregated publication data by country for the total number of publications and total five-year post-publication citations. We used address information from authors and institutions to identify countries involved in each publication. We calculated the total number of publications by summation of integer counts, crediting every country contributing at least one co-author with a per-publication score⁵. We did not apply weights by author order or reprint addresses.

We calculated total five-year post-publication citation counts as the sum of all five-year post publication counts for any paper to which a country contributed, including the year of publication. We estimated a citation index for each country and year by dividing the total number of five-year post-publication citations by the total number of publications from the corresponding year. This citation index approximates the mean five-year post-publication citations of publications from a particular country in a particular year.

We further aggregated bibliometric outcomes for the Latin America region. We calculated the total number of publications and total number of five-year post-publication citations by year by adding the individual estimations from each country. Then, we calculated an annual citation index as reported above for individual countries. For comparison, we conducted the same calculations for other groups of countries classified according to the World Bank Income Groups.

Statistical analysis

We created Poisson regression models to analyze the time trend on the total number of publications (outcome, in integer counts) by country in Latin America, using 1999 as baseline (year 0). We created similar Poisson models to analyze the time trend on the citation indices, including the total number of five-year post-publication citations as outcome and the log of total number of publications by year as offset parameter. We only included years with publications for this analysis. After exponentiation, coefficients for the time variable (per year increment) from Poisson regression models can be interpreted as the relative annual change on the outcome (taking into account differences in the offset parameter, if included). These coefficients can be transformed to annual change percentage using the following equation:

$$\text{Annual change percentage} = (e^{\text{coefficient}} - 1) \times 100$$

We created linear regression models to analyze the association between the total number of publications from each country in Latin America with their corresponding HDI and GDP per capita in 2000 and 2008 based on data availability. Because the outcome distribution and the presence of years without publications for some countries,

we log-transformed the total number of publications before the analysis using the following equation:

$$\begin{aligned} &\text{Log-transformed number of publications} \\ &= \log(\text{number of publications} + 1) \end{aligned}$$

To meet the linearity assumptions, we transformed HDI through exponentiation before the analysis. We created a similar linear model to analyze the association of the citation index from each country in Latin America with its corresponding HDI and GDP per capita in 2000 and 2008. No mathematical transformations were required for the analysis of the citation indices.

Finally, we analyzed time trends on the total number of publications and citation index from the Latin America region. We created similar Poisson regression models as reported above for individual countries. For comparison, we conducted the same analyses for other groups of countries classified according to the World Bank Income Groups. We performed a sensitivity analysis by excluding China from the upper-middle income countries group, because China has shown the fastest growing and highest number of bibliometric outcomes between 1999 and 2008 among these countries⁸.

We conducted all statistical analyses using STATA IC v11.2 (College Station, TX) and R v2.15.2 (The R Foundation for Statistical Computing; Vienna, Austria) with a 2-sided level of significance $\alpha < 0.05$. We report the statistical significance from Poisson regression models through the 95% confidence interval for the annual change percentage. Specifically, a 95% confidence interval excluding 0% indicates that the increase or decrease in the outcome over time was statistically significant at the significance level adopted.

Results

We retrieved a total of 456,120 publications from 1999 to 2008 from the Thomson Reuters *Web of Knowledge*. After we removed duplicates and matched records with citation reports, we included 430,712 publications with complete information in the present analysis (a flowchart is shown in Figure 1). Overall, the number of cardiovascular publications retrieved increased over time, from 37,849 publications in 1999 to 54,459 in 2008.

Table 1 shows the number of publications from countries in Latin America between 1999 and 2008, and Figure 2 shows the geographic distribution of publications in 2000 and 2008. Brazil ($n = 6,132$) published most frequently during the period analyzed, followed by Argentina ($n = 1,686$), Mexico ($n = 1,368$) and Chile ($n = 874$). These four countries accounted for almost 90% of all publications from Latin America in 2008. Nine countries had at least one year without publications.

Most countries demonstrated increases in the number of publications over time. The top countries with greater relative increase in the number of cardiovascular publications were Guatemala, Colombia, Costa Rica, Brazil and Bolivia. In the additive scale, Brazil was the country with the greatest increase in the number of publications (from 305 publications

in 1999 to 1,241 in 2008), followed by Mexico (from 78 in 1999 to 231 in 2008), which surpasses Argentina in the total number of cardiovascular publications in 2008.

Table 2 shows annual citation indices from publications between 1999 and 2008 for each country in Latin America. About half of the countries showed an increase in their citation indices over time, led by Honduras, Dominican Republic, Peru, Guatemala, Costa Rica and Argentina. However, several countries showed a decrease in their citation indices, including El Salvador, Ecuador, Paraguay and Colombia. Citation indices from Brazil remained stable during the time period analyzed.

Development and bibliometric outcomes

Figure 3 shows the number of cardiovascular publications versus HDI and GDP per capita in 2008. Overall, the number of cardiovascular publications was higher among the countries with higher development indicators. In contrast, we found no association between citation indices and HDI or GDP per capita in 2008 (Figure 4). We found similar results when number of cardiovascular publications and citation index were analyzed versus development indicators in 2000 (data not shown).

Bibliometric outcomes for Latin America

Figure 5 (left panel) shows the number of cardiovascular publications from the Latin America region by year between 1999 and 2008. For comparison, cardiovascular publications from other groups of countries classified according to the World Bank Income Groups are also displayed. The total number of cardiovascular publications (integer counts) from Latin America between 1999 and 2008 was lower than that from OECD high-income and other upper-middle income countries, but higher than total cardiovascular publications from other lower-middle income countries, non-OECD high-income countries and other low income countries. Between 1999 and 2008, cardiovascular publications from Latin America increased by 12.9% (95% confidence interval: 12.1% - 13.5%) annually (Table 3, top panel). This increase was lower than that observed for other upper-middle income countries (18.1% [17.6% - 18.5%]) even after excluding China (14.3% [13.8% - 14.9%]), but similar to the increase from other lower-middle income countries (13.7% [12.6% - 14.7%]). All other groups of countries showed a smaller increase in their number of publications, including OECD high income countries (3.6% [3.5% - 3.7%]), non-OECD high income countries (10.6% [9.3% - 11.9%]), and other low income countries (8.7% [4.9% - 12.6%]).

Figure 5 (right panel) shows the evolution of citation indices for the Latin America region and other groups of countries classified according to the World Bank Income Groups by year. Between 1999 and 2008, the citation index for Latin America increased 1.5% (1.3% - 1.7%) per year. This increase was lower than that observed in all other groups of countries (Table 3, bottom panel). However, by 2008, the citation index for Latin America was only surpassed by citation indices for OECD and non-OECD high-income countries.

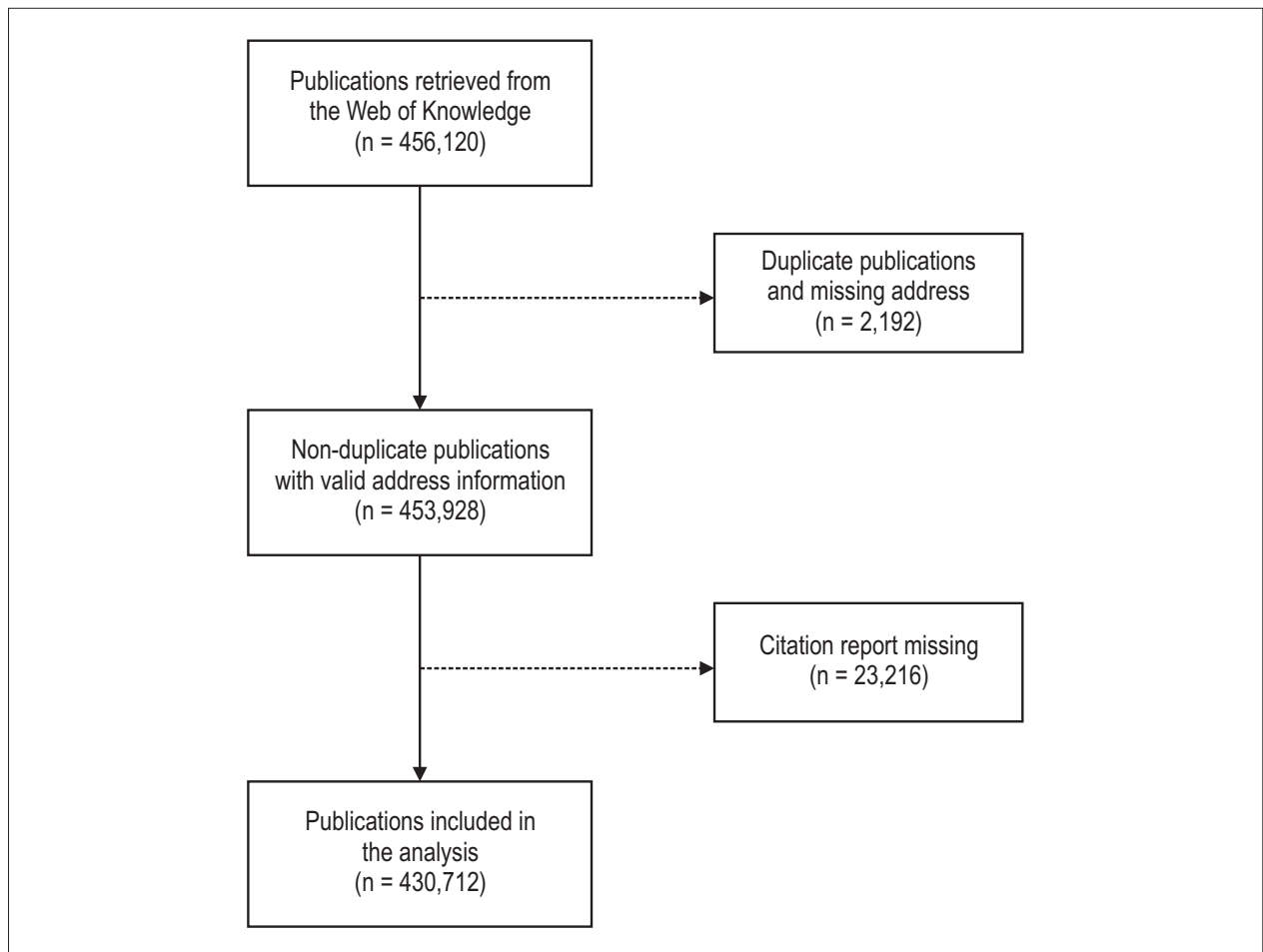


Figure 1 – Flowchart of publications considered for inclusion.

Discussion

We analyzed the number, geographic distribution and temporal trend of cardiovascular research publications from countries in Latin America between 1999 and 2008. We observed a high concentration of publications in only four countries (i.e., Brazil, Mexico, Argentina and Chile), all of them with high development indicators. In addition, we observed an increase in the number of publications in most countries analyzed. In particular, Brazil was the country with the largest absolute increment in publications, representing the main driver for the overall increase observed in the region. In contrast, we observed a less consistent evolution of citation indices over time, including several countries with a statistically significant decrease during the period analyzed. As a consequence, the citation index of cardiovascular publications from Latin America modestly increased compared with those of all other groups of countries analyzed. Although we found a statistically significant increase in the total number of cardiovascular publications from Latin America, our results suggest that these publications may have had a low impact on the cardiovascular research field.

Results regarding the geographic distribution and temporal trend of cardiovascular research publications

from Latin America were consistent with a bibliometric analysis conducted by Jahangir et al⁷ through PubMed. Authors reported that Brazil, Mexico, Argentina and Chile were the leading countries with the highest number of publications in Latin America⁷. Jahangir et al also reported that the total number of cardiovascular publications from Latin America increased from 41 in 2001 to 726 in 2010 (about 18 fold)⁷. Our estimation of that increase was more conservative (about 3 fold between 1998 and 2008) and similar to the increase observed in other low-middle income countries. This difference with prior results could be attributed to the higher number of publications we retrieved. Our results expand the current knowledge by showing that the increase in the number of cardiovascular publications from Latin America was consistent with an increase in the number of publications from the vast majority of the countries in the region. A prior bibliometric analysis on public health publications conducted through Scopus has reported a low visibility of publications from Latin America¹⁴. In this analysis, Latin America accounted for only 3.3% of world citations although producing 6.5% of all citable publications. Although we observed that the citation index for cardiovascular research publications from Latin America in 2008 was only surpassed by citation indices

Table 1 – Number of cardiovascular research publications (integer counts) and estimated annual change of Latin American countries (1999-2008)

Country	Number of cardiovascular research publications by year of publication										Estimated annual change % (95%CI)
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Argentina	159	140	147	177	150	161	173	176	209	194	3.5 (1.7, 5.2)
Bolivia	2	3	0	4	0	1	3	3	5	7	17.7 (2.5, 35.0)
Brazil	305	350	381	408	466	548	635	702	1,096	1,241	17.9 (16.9, 19.1)
Chile	69	59	77	79	83	84	93	96	108	126	7.1 (4.7, 9.7)
Colombia	9	14	17	16	16	18	19	28	42	63	22.1 (16.3, 28.1)
Costa Rica	0	6	2	7	10	2	10	6	16	10	18.1 (8.1, 28.9)
Cuba	28	15	26	22	36	24	17	17	20	36	0.9 (-3.4, 5.4)
Dominican Republic	0	1	2	0	0	0	0	1	1	0	-5.9 (-30.9, 28.0)
Ecuador	4	5	2	3	7	7	3	2	6	1	-3.0 (-12.9, 117.7)
El Salvador	0	1	1	0	0	0	0	1	1	0	0.0 (-28.9, 40.6)
Guatemala	0	0	1	2	1	0	7	7	7	4	36.5 (16.6, 59.7)
Haiti	0	0	0	3	1	0	3	4	0	0	11.3 (-10.0, 37.4)
Honduras	1	0	0	0	0	0	0	0	1	0	-5.9 (-42.2, 53.1)
Mexico	78	100	121	129	125	116	128	137	203	231	10.2 (8.2, 12.3)
Nicaragua	0	0	0	0	0	0	0	0	0	0	NE
Panama	1	2	3	1	3	6	1	6	2	2	6.3 (-6.9, 21.4)
Paraguay	0	1	1	0	1	1	2	1	2	1	14.8 (-8.5, 43.9)
Peru	1	7	8	6	7	6	8	9	15	13	14.6 (5.8, 24.1)
Uruguay	15	12	8	12	18	11	13	15	19	31	9.3 (3.4, 15.6)
Venezuela	31	47	26	40	49	25	42	46	54	70	7.0 (3.6, 10.7)
Latin America (total)	703	763	823	909	973	1,010	1,157	1,257	1,807	2,030	12.9 (12.1, 13.5)

95%CI: 95% confidence intervals; NE: non-estimable.

for OECD and non-OECD high-income countries, we also observed that the citation index of Latin America barely increased during the period analyzed.

The increase in the number of cardiovascular publications from Latin America should be considered in the context of local actions undertaken to promote health research. In 2001-2002, PAHO conducted a series of workshops including national and subnational health authorities as well as other key respondents in order to evaluate the performance of the 11 essential public health functions in Latin America and the Caribbean using a consensus methodology based on predefined indicators¹⁵. As result, health research was identified as having one of the poorest performances in the region¹⁶. Following these workshops, several countries developed initiatives to promote local health research. For example, the San Carlos University in Guatemala incorporated the Essential Public Health Functions strategy from PAHO as part of its Human Resources Development Strategy and its Master program in Public Health¹⁷. Costa Rica consolidated a National Health Research and Technological Development Plan, among other initiatives¹⁷. Brazilian health authorities developed and implemented a National Agenda of Priorities in Health Research, defined based on criteria as burden of diseases,

cost-effectiveness and impact on equity, among others¹⁷. In our study, Guatemala, Costa Rica and Brazil were at the top of countries with the highest relative increment in the number of cardiovascular publications. However, it is not possible to know to what extent these particular interventions contributed to the increase observed. In the case of Brazil, results should be considered in the context of a country with rapid expansion in science¹⁸, with similar improvements in other fields such as analytical chemistry and veterinary medicine^{19,20}.

Economic funding is an essential factor to support and promote research. Maceira et al²¹ examined the public financing for health research in Argentina, Bolivia, Chile, Paraguay and Uruguay between 2002 and 2006. Authors have reported important differences regarding total available funds, time trends, as well as resource allocation between those countries. Argentina was the leading country on total funds measured in constant dollars, followed by Chile, Uruguay, Bolivia and Paraguay²¹. In particular, Argentina and Chile showed some similarities in their resource allocation profile, including that none of those countries had an explicit method for research prioritization²¹. Between 2002 and 2006, Argentina and Chile allocated 41% and 42% of their public financing for research on non-communicable diseases,

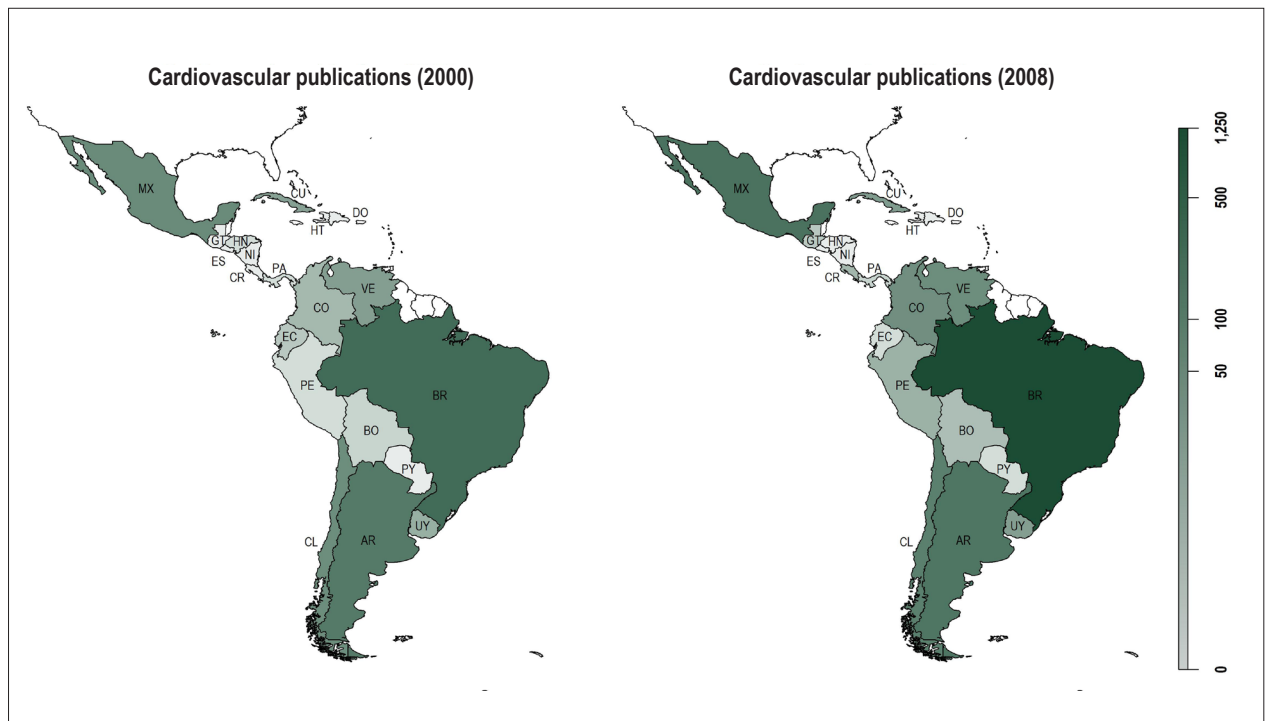


Figure 2 – Geographic distribution of cardiovascular publications (integer counts) in Latin America in 2000 and 2008. AR: Argentina; BO: Bolivia; BR: Brazil; CL: Chile; CO: Colombia; CR: Costa Rica; CU: Cuba; DO: Dominican Republic; EC: Ecuador; ES: El Salvador; GT: Guatemala; HN: Honduras; HT: Haiti; MX: Mexico; NI: Nicaragua; PA: Panama; PE: Peru; PY: Paraguay; UY: Uruguay; VE: Venezuela. Notes: Countries in white were not included as part of Latin America. The exact number of cardiovascular publications in each country is reported in Table 1.

33% and 25% for basic science, and 11% and 14% for communicable diseases, respectively²¹. Total funds increased more in Argentina (about 16% annually) than in Chile (about 6% annually) during the period analyzed²¹. Interestingly, we observed a lower increase in cardiovascular research publications from Argentina as compared with those from Chile. However, the citation index of Argentina increased more as compared with that of Chile, suggesting that the increasing resources in Argentina may have had higher impact on factors that influence result dissemination.

Despite some improvements, most of the National Research Systems for Health in Latin America were found to be inefficient after the 1st Latin American Conference on Research and Innovation for Health held in Rio de Janeiro in 2008²². In our analysis, we used citation indices as surrogates for the impact from publications. This is a result from several factors, including relevance, innovation, quality and visibility achieved from each publication and other factors, such as self-citations and ease of citations, both of which are increasing over time. Our study provides novel information suggesting that the increase in cardiovascular research publications in Latin America may have not been accompanied by a rise on these factors. Most of the countries with increases in their number of cardiovascular publications did not show a statistically significant increase in their citation indices as Brazil, or even decreased them, as is the case of Colombia. This could be explained by a reduced exposure of these

publications by having been published in languages other than English. It can also represent a local lack of interest (or even a resistance) to try to obtain high visibility of results by targeting high impact factor journals²³. In 2009, the PAHO's 49th Directing Council approved the Policy on Research for Health (CD49.R10) aimed to promote the generation of relevant quality health research in the region, local research governance, and the dissemination and use of research results²⁴. Our study results support the pertinence of that policy. Future studies should analyze time trends on citations for publications from Latin America after 2009 in order to assess their impact.

Strengths of our study include the iterative process used to build the search strategy, the rigorous testing of our filter to achieve high precision and recall, and the extensive collection of data on contact information and citations retrieved. Our study also has several limitations. First, our analysis was conducted on publications indexed in the Thomson Reuters *Web of Knowledge* and may not represent all cardiovascular publications of Latin American countries, particularly because local journals could be underrepresented. Second, we were not able to differentiate between publications of basic science research and clinical or public health research, which prevented potential shifts between those categories from being detected over time. Third, we used citation indices as a measurement of the impact of publications on the research field, which can underrepresent the actual effects that research results may have on the overall health in a particular country²⁵.

Table 2 – Citation indices of cardiovascular research publications and estimated annual change of Latin American countries by year of publication (1999-2008)*

Country	Citation index by year of publication										Estimated annual change
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% (95%CI)
Argentina	9.2	13.8	8.5	8.4	13.9	10.8	9.9	10.1	12.4	25.6	8.2 (7.7, 8.8)
Bolivia	11.5	7.3	-	2.5	-	47.0	8.0	9.0	17.6	8.7	4.6 (0.7, 8.8)
Brazil	9.0	7.8	9.4	11.3	10.1	8.7	11.1	10.3	8.5	9.1	-0.3 (-0.6, 0.2)
Chile	8.2	11.5	8.5	6.1	10.6	9.3	8.8	8.6	12.2	9.9	2.2 (1.4, 2.9)
Colombia	8.3	19.9	11.8	8.0	33.2	9.8	18.1	9.0	9.0	6.0	-9.2 (-10.2, -8.0)
Costa Rica	-	11.3	8.0	8.9	13.0	7.5	11.3	16.2	17.3	19.5	9.9 (6.9, 12.7)
Cuba	5.6	10.7	7.1	3.7	10.6	5.2	6.9	11.7	6.1	5.5	-0.7 (-2.3, 0.9)
Dominican Republic	-	8.0	0.5	-	-	-	-	10.0	18.0	-	28.4 (13.4, 45.4)
Ecuador	0.3	22.8	1.5	2.7	5.1	11.9	1.0	7.0	0.3	5.0	-13.5 (-17.5, -9.3)
El Salvador	-	2.0	13.0	-	-	-	-	0.0	0.0	-	-33.8 (-50.9, -10.5)
Guatemala	-	-	13.0	15.5	2.0	-	7.1	7.3	21.7	13.8	11.7 (4.8, 19.1)
Haiti	-	-	-	11.3	6.0	-	14.3	12.0	-	-	5.0 (-5.4, 16.6)
Honduras	3.0	-	-	-	-	-	-	-	39.0	-	37.9 (19, 59.5)
Mexico	6.2	4.9	6.0	17.4	10.0	11.3	12.1	10.7	10.4	8.2	2.0 (1.4, 2.6)
Nicaragua	-	-	-	-	-	-	-	-	-	-	NE
Panama	0.0	3.5	12.3	0.0	6.7	4.7	6.0	9.8	1.5	7.5	3.3 (-2.9, 9.6)
Paraguay	-	12.0	6.0	-	0.0	0.0	17.0	3.0	3.0	0.0	-10.5 (-18.7, -1.5)
Peru	1.0	11.3	5.8	3.0	7.0	6.8	7.8	4.3	14.7	15.0	12.2 (9.0, 15.4)
Uruguay	12.5	5.1	3.8	4.8	6.9	5.6	6.6	5.2	15.8	6.8	1.9 (0.0, 3.8)
Venezuela	4.7	3.9	9.8	9.9	11.8	8.5	15.4	6.4	7.7	7.2	2.2 (1.1, 3.4)
Latin America (total)	8.3	8.9	8.5	10.6	11.1	9.3	10.9	9.9	9.6	10.5	1.5 (1.3, 1.7)

95%CI: 95% confidence intervals; NE: non-estimable; The symbol "-" denotes no publications; (*) Only for years with publications.

Conclusions

We analyzed cardiovascular research publications and their citations from Latin American countries between 1999 and 2008. During the study period, publications from Latin America increased about 12.9% (12.1% - 13.5%) annually. However, those publications were predominantly concentrated in a reduced number of countries with high development indicators. Although we also observed an improvement in citations, it was lower than that in the other countries analyzed, suggesting a relatively low impact of Latin American publications on the cardiovascular research field over the study period. Our results stress the importance of promoting cardiovascular research in less developed Latin American countries, as well as considering actions aimed to strengthen factors, such as quality, relevance and dissemination, as part of local research governance policies.

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Author contributions

Conception and design of the research: Huffman MD, Prabhakaran D; Acquisition of data: Baldrige AS, Huffman MD, Bloomfield GS; Analysis and interpretation of the data: Colantonio LD, Baldrige AS, Huffman MD; Statistical analysis: Baldrige AS, Obtaining financing: Huffman MD, Prabhakaran D; Critical revision of the manuscript for intellectual content: Baldrige AS, Huffman MD, Bloomfield GS, Prabhakaran D Supervision / as the major investigator: Prabhakaran D.

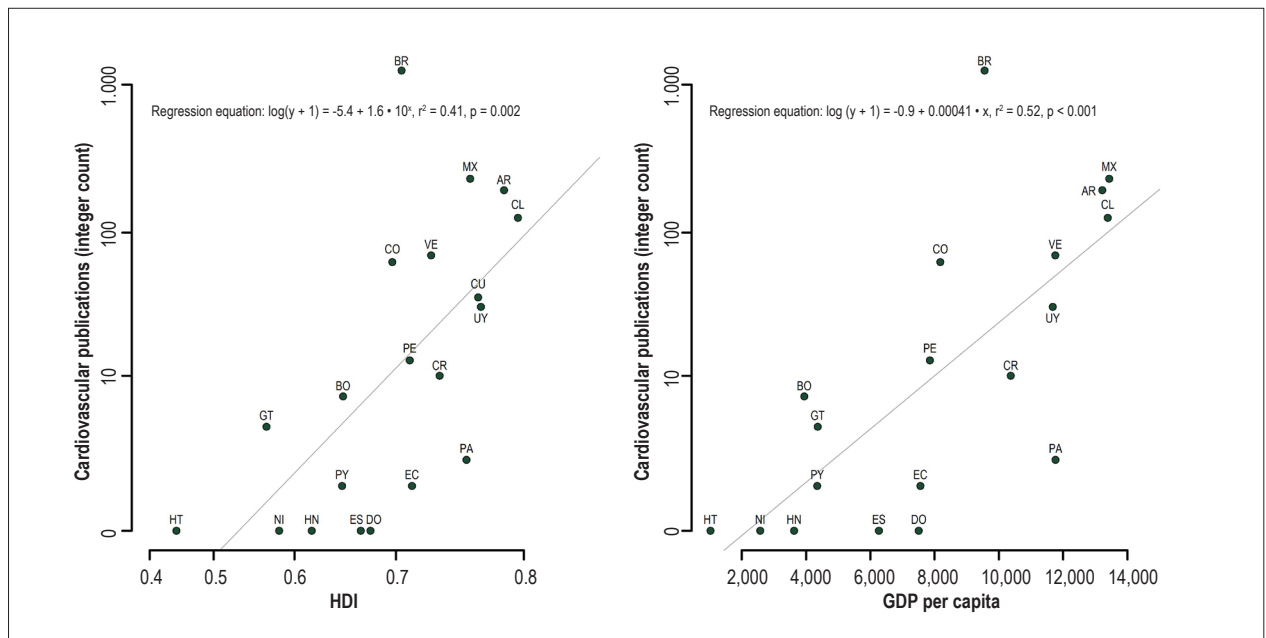


Figure 3 – Cardiovascular publications (integer counts) versus HDI and GDP per capita for each country in Latin America in 2008. List of countries: AR: Argentina; BO: Bolivia; BR: Brazil; CL: Chile; CO: Colombia; CR: Costa Rica; CU: Cuba; DO: Dominican Republic; EC: Ecuador; ES: El Salvador; GT: Guatemala; MX: Mexico; PA: Panama; PE: Peru; PY: Paraguay; UY: Uruguay; VE: Venezuela. GDP: gross domestic product; HDI: human development index. For Cuba, no GDP data were available.

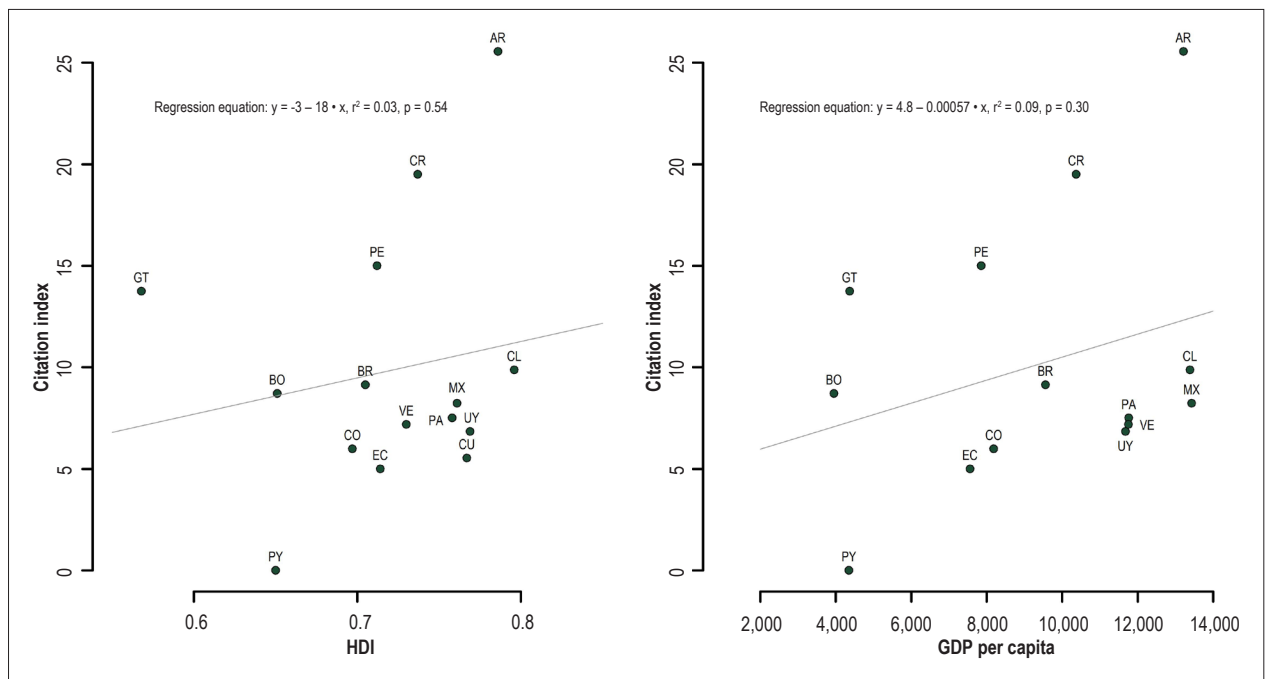


Figure 4 – Citation index versus HDI and GDP per capita for each country in Latin America in 2008. List of countries: AR: Argentina; BO: Bolivia; BR: Brazil; CL: Chile; CO: Colombia; CR: Costa Rica; CU: Cuba; DO: Dominican Republic; EC: Ecuador; ES: El Salvador; GT: Guatemala; MX: Mexico; PA: Panama; PE: Peru; PY: Paraguay; UY: Uruguay; VE: Venezuela. GDP: gross domestic product; HDI: human development index. For Cuba, no GDP data were available.

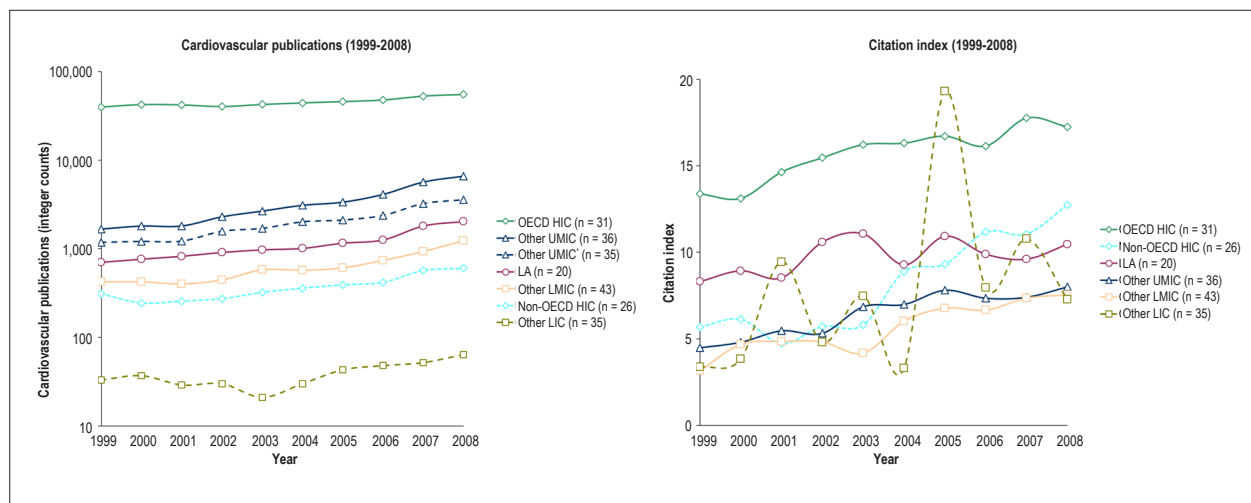


Figure 5 – Time trends of cardiovascular publications (integer counts) and citation indices from Latin America and the rest of the world according to the World Bank income groups (1999-2008). HIC: high income countries; LA: Latin America; LIC: low income countries; LMIC: low-middle income countries; OECD: Organization for Economic Co-operation and Development; UMIC: upper-middle income countries. (*) Excluding China.

Table 3 – Cardiovascular research publications (integer counts) and citation indices of Latin America and the rest of the world according to the World Bank income groups between 1999 and 2008

Country groups ^a	Year of publication										Estimated annual change % (95%CI)
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Number of cardiovascular research publications											
Latin American countries (n = 20)	703	763	823	909	973	1,010	1,157	1,257	1,807	2,030	12.9 (12.1, 13.5)
OECD high income countries (n = 31)	39,824	42,411	42,014	40,343	42,562	44,289	45,891	47,754	52,880	55,198	3.6 (3.5, 3.7)
Non-OECD high income countries (n = 26)	309	244	256	273	322	359	391	418	569	602	10.6 (9.3, 11.9)
Other UMIC including China (n = 36)	1,669	1,805	1,809	2,295	2,664	3,097	3,358	4,107	5,662	6,600	18.1 (17.6, 18.5)
Other UMIC excluding China (n = 35)	1,181	1,211	1,219	1,575	1,699	2,014	2,109	2,378	3,232	3,573	14.3 (13.8, 14.9)
Other LMIC (n = 43)	422	424	401	445	579	572	609	740	933	1,237	13.7 (12.6, 14.7)
Other LIC (n = 35)	33	37	29	30	21	30	43	48	52	64	8.7 (4.9, 12.6)
Citation index											
Latin American countries (n = 20)	8.31	8.93	8.52	10.60	11.07	9.27	10.94	9.89	9.61	10.47	1.5 (1.3, 1.7)
OECD high income countries (n = 31)	13.38	13.12	14.64	15.47	16.23	16.31	16.72	16.15	17.77	17.25	3.0 (3.0, 3.1)
Non-OECD high income countries (n = 26)	5.68	6.13	4.73	5.71	5.80	8.89	9.31	11.18	11.06	12.73	11.5 (11.1, 12.0)
Other UMIC including China (n = 36)	4.48	4.80	5.46	5.32	6.85	6.99	7.81	7.35	7.40	8.00	5.8 (5.7, 6.0)
Other UMIC excluding China (n = 35)	3.78	3.88	4.61	4.16	5.90	5.34	5.79	5.92	5.62	6.28	5.0 (4.8, 5.3)
Other LMIC (n = 43)	3.15	4.68	4.85	4.82	4.17	6.02	6.77	6.66	7.35	7.55	8.4 (8.00, 8.8)
Other LIC (n = 35)	3.36	3.84	9.45	4.80	7.48	3.30	19.30	7.96	10.79	7.28	3.9 (2.6, 5.2)

95%CI: 95% confidence intervals; LIC: low-income countries; LMIC: low-middle income countries; OECD: Organization for Economic Co-operation and Development. UMIC: upper-middle income countries.

^a n represents the number of countries within each group.

^b Baseline year: 1999.

^c Per year increment.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any thesis or dissertation work.

References

1. Barcelo A. Cardiovascular diseases in Latin America and the Caribbean. *Lancet*. 2006;368(9536):625-6.
2. World Health Organization (WHO). The global burden of disease: 2004 update. Geneva; 2008.
3. Muñoz F, López-Acuña D, Halverson P, Guerra de Macedo C, Hanna W, Larriéu M, et al. Las funciones esenciales de la salud pública: un tema emergente en las reformas del sector de la salud. *Rev Panam Salud Pública*. 2000;8(1-2):126-34.
4. Ordúñez-García P, Campillo-Artero C. (eds.). Regional consultation: priorities for cardiovascular health in the Americas: key messages for policymakers. Washington, DC: Pan American Health Organization; 2011.
5. Clarke A, Gatineau M, Grimaud O, Royer-Devaux S, Wyn-Roberts N, Le Bis I, et al. A bibliometric overview of public health research in Europe. *Eur J Public Health*. 2007;17 Suppl 1:43-9.
6. Lewison G. The definition of biomedical research subfields with title keywords and application to the analysis of research outputs. *Res Evaluation*. 1996;6(1):25-36.
7. Jahangir E, Comande D, Rubinstein A. Cardiovascular disease research in Latin America: a comparative bibliometric analysis. *World J Cardiol*. 2011;3(12):383-7.
8. Huffman MD, Baldrige A, Bloomfield GS, Colantonio LD, Prabhakaran P, Ajay VS, et al. Global cardiovascular research output, citations, and collaborations: a time-trend, bibliometric analysis (1999-2008). *PLoS One*. 2013;8(12):e83440.
9. Lewison G. Definition of cancer research: journals, titles, abstracts or keywords? *DJLIT*. 2011;31(5):333-9.
10. CELADE - Population Division. Economic Commission for Latin America and the Caribbean - ECLAC. [Cited in 2014 Jun 10]. Available from: <http://www.cepal.org/celade/default.asp?idioma=IN>
11. A Short History. The World Bank Group, 2013. [Cited in 2013 Mayo 7]. Available from: <http://data.worldbank.org/about/country-classifications/a-short-history>.
12. OECD. Better Policies for Better Lives. Ratification of the Convention on the OECD. [Cited in 2013 July 10]. Available from: <http://www.oecd.org>
13. World Development Indicators. The World Bank Group, 2013. [Cited in 2013 May 7]. Available from: <http://data.worldbank.org/data-catalog/world-development-indicators>
14. Zacca-Gonzalez G, Chinchilla-Rodriguez Z, Vargas-Quesada B, de Moya-Anegón F. Bibliometric analysis of regional Latin America's scientific output in Public Health through SCImago Journal & Country Rank. *BMC Public Health*. 2014;14:632.
15. Pan American Health Organization. (PAHO). Public health in the Americas: conceptual renewal, performance assessment, and bases for action. Washington, DC; 2002.
16. Pan American Health Organization. (PAHO). Public health capacity in Latin America and the Caribbean: assessment and strengthening. Washington, DC; 2007.
17. Pan American Health Organization. (PAHO). World Health Organization (PAHO/WHO). The essential public health functions as a strategy for improving overall health systems performance: trends and challenges since the public health in the Americas Initiative, 2000-2007. Washington, DC: Health Systems and Services Area (HSS), Project Health Systems Based on PHC for Social Protection, Office of the Assistant Director; 2008.
18. Bacal F. Impact of the Brazilian scientific publications on the recent scientific developments in cardiology. *Arq Bras Cardiol*. 2009;93(6):538-40.
19. Christopher MM, Marusic A. Geographic trends in research output and citations in veterinary medicine: insight into global research capacity, species specialization, and interdisciplinary relationships. *BMC Vet Res*. 2013;9:115.
20. Zezzi Arruda MA, Kubota LT. (Bio)analytical research in Latin America. *Anal Bioanal Chem*. 2013;405(24):7561-2.
21. Maceira D, Paraje G, Aramayo F, Masi SD, Sanchez D. Financiamiento público de la investigación en salud en cinco países de América Latina. *Rev Panam Salud Pública*. 2010;27(6):442-51.
22. Becerra-Posada F, Minayo M, Quental C, de Haan S. National research for health systems in Latin America and the Caribbean: moving towards the right direction? *Health Res Policy Syst*. 2014;12:13.
23. Monjeau A, Rau JR, Anderson CB. Regional science: Latin America should ditch impact factors. *Nature*. 2013;499(7456):29.
24. Pan American Health Organization. (PAHO). PAHO's policy on research for health. Washington, DC; 2010.
25. Lewison G. Beyond SCI citations – New ways to evaluate research. *Curr Sci*. 2005;89(9):1524-30.