

# Production of scientific articles on health in six Latin American countries, 1973–1992<sup>1</sup>

Alberto Pellegrini Filho,<sup>2</sup> Moisés Goldbaum,<sup>3</sup> and John Silvi<sup>4</sup>

## ABSTRACT

The production of articles resulting from biomedical, clinical, and public health studies that originated in Argentina, Brazil, Chile, Cuba, Mexico, and Venezuela from 1973 through 1992 was analyzed to discover trends in health research in Latin America. From the database of the Institute for Scientific Information (ISI), 41 238 articles with first authors who resided in those countries were extracted. These articles were analyzed by subject area, type of study, country, number of authors and institutions that participated in the investigation, and citations received by each article. Also analyzed were 95 articles in epidemiology selected from a pool of 570 published by authors from the six countries in 11 public health journals that enjoy international prestige.

The results showed that the number of published works increased by 117% between the first and last five-year periods within the study period. Clinical research was distributed the most evenly among the countries, and public health research was the most concentrated (60.7% originated in Brazil). The numbers of biomedical and public health research articles showed relatively more growth than those reporting on clinical research throughout the period. A relative decrease was found in articles by only one author, which suggests a greater frequency of team efforts, and an increase was seen in articles with authors tied to two or more national or foreign institutions, which indicates greater cooperation between institutions and countries. The average number of citations received by each article was three, which was less than half the number received per article in the ISI database (7.78). Regarding the subset of 95 articles in epidemiology, the great majority (96%) dealt with infectious diseases or maternal and child health, while in the international literature 78% of such articles were about chronic diseases. This group of articles gave evidence of more cooperation with international institutions and had a citation index of 4.36 per article.

It is concluded that, despite the inherent limitations, this type of study reveals some general trends in the development of research in the six Latin American countries with the greatest scientific production and makes it possible to formulate hypotheses on the factors that influence these trends. Taken with the proper caution, the results of studies like this one can be of great value in defining health science and technology policies.

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<sup>2</sup> Program of Research Coordination, Division of Health and Human Development, Pan American Health Organization, Washington, D.C., U.S.A. Mailing address: PAHO; 525 Twenty-third Street, NW; Washington, DC 20037, USA.

<sup>3</sup> Department of Preventive and Social Medicine, University of São Paulo School of Medicine, São Paulo, Brazil.

<sup>4</sup> Health Situation Analysis Program, Division of Health and Human Development, Pan American Health Organization, Washington, D.C.

This article examines a number of research trends by analyzing publication of scientific works in the health field in Argentina, Brazil, Chile, Cuba, Mexico, and Venezuela during the period 1973–1992. The analyses relate to articles published in journals with an international scope by authors residing in these six countries during the period in question. Previous studies (1, 2) have analyzed health research trends by

considering ongoing projects and information obtained from a number of databases—including a preliminary analysis of published scientific works included in the database of the Institute for Scientific Information (ISI) in Philadelphia, Pennsylvania, for the period 1972–1982. The study presented here was based on a compilation of works published in internationally recognized journals indexed in the ISI database.

## THE NATURE AND LIMITATIONS OF THE STUDY

The type of study we are concerned with here falls within the ambit of scientometrics, a discipline developed in the early 1970s by sociologists and historians of science interested in conducting quantitative analyses in this field. In the mid-1970s, concern about research costs and the need to evaluate research productivity led planners of scientific and technologic activities to recognize scientometric studies' potential for supporting the planning process, which to that point was based almost exclusively on expert opinions.

This acknowledged potential notwithstanding, scientometric studies have been criticized for both their conceptual approach and their methodology (3). As regards the former, scientometrics has been criticized for conceiving of science in terms of an input-output model and for devoting itself exclusively to measuring the inputs and outputs of scientific activity, with no concern for analyzing science as a process that is influenced by both intrinsic and extrinsic factors and that in turn exercises an influence on those factors. Such critics point out that an article published in one of the major, widely recognized journals is virtually the only product of scientific research acknowledged by these studies.

With regard to methodologic issues, there is a tendency to criticize scientometrics' lack of parameters and criteria for assessing both scientific production and productivity. Scientometric studies generally limit their scope to making comparisons between countries or to analyzing historical series in a single country in order to identify trends. Comparisons between countries are criticized for not taking into account cultural differences influencing publication; and similarly, comparisons between production and productivity in different areas or different types of research (basic and applied) are criticized for not considering different publication patterns. Moreover, not all articles are equal; nor do they represent equivalent efforts that would

allow them to be compared without considering such differences.

The citation index (the relative number of times one source is cited by others) that is often used in scientometric studies appears to offer a typical example of an indicator that was established before an *a priori* definition of the thing to be indicated (quality, impact, or some other attribute) was arrived at. Moreover, there is generally no way to eliminate the distortions caused by self-citations, citations based on "cronyism" among group members, indirect citations, negative citations, etc.

The most frequently used source for scientometric studies, the ISI database, is not considered appropriate for analyzing scientific work in developing countries, as it includes only articles published by authors from those countries in the industrialized world's most prestigious journals. The ISI database also exhibits a tendency to favor English-language publications.

To overcome these limitations in the future, it will be necessary to satisfy numerous methodologic needs: the need to combine quantitative and qualitative approaches; the need to develop local parameters for studying scientific production in developing countries; and the need to establish new indicators that will respond to well-defined questions and take account of the diversity existing between areas, disciplines, types of research, etc.

Meanwhile, with regard to current criticism of scientometric studies, there appear to be two possible options. These are (1) abandon this type of study, because of its lack of utility, until appropriate methodologies become available; or (2) continue conducting studies of this sort with proper appreciation of their limitations and using the results with care to define policies. As the existence of the present study suggests, we favor the second position. However, we do recognize the study's superficial and partial nature—as well as its potential for helping to improve understanding as well as to describe in a limited manner the evolution experienced by health research in our region.

## THE STUDY PERIOD AND THE ROLE OF GOVERNMENT

The period covered, 1973–1992, is relatively long for studies of this type. This length makes it easier to observe with some clarity a number of aspects of the evolution of health-related scientific activity in the six study countries. The period also appears unique in the history of Latin America, because scientific production underwent a dramatic upsurge in terms of both quality and quantity, and recognition of the importance of science and technology for socioeconomic development was further consolidated. This recognition was manifested in the early part of the study period by creation in most countries of entities for planning scientific and technologic development. Also, in those countries that already had such entities, their designations were generally changed from "research boards" to "scientific-technologic development boards," indicating a new and broader sphere of action.

During this period a number of important economic, social, political, and institutional transformations took place. The region experienced economic crises, adjustments, and renewal—as well as deterioration and, ultimately, recovery of democratic institutions. All of these macro processes have, in the final analysis, affected development of science and technology in the region and can be related, at least hypothetically, to some of the results of this study.<sup>5</sup>

<sup>5</sup> While the roles of a number of internal and external factors are perpetually debated (4), it is generally recognized that both internal and external factors play a role in the development of scientific activity (5). The former include factors of a logical-cognitive nature, because in all historical periods the ultimate progress of science has depended upon the cognitive material accumulated during the preceding period. Factors of an extrinsic nature include those related to the material life of societies, such as levels of socioeconomic development, education, and culture. To more accurately analyze the extent to which each of these factors exerts an influence, it will be necessary to conduct more in-depth studies designed specifically for that purpose. By way of contrast, the current study is intended to describe general trends and to formulate a number of hypotheses regarding factors that may be correlated with those trends.

The same period also saw a process of health research "demedicalization." That is, health research ceased to be conducted primarily by physicians working within a health service setting and broadened its scope in terms of problems researched, disciplines involved, approaches employed, types of research performed, professional background of the researchers, and institutional settings where research was conducted.

It is also relevant to note that at present the status of science and technology in the health field is beset by a number of contradictions. On the one hand, there is a strong demand for new knowledge that will contribute to greater understanding of the complex health situation and support processes of health sector reform currently underway in most countries of the region. At the same time, biomedicine's dynamic development requires that groups working actively in this field make an enormous effort to keep their command of strategically important knowledge and technologies current, not only to resolve health problems but also to advance other sectors where such technologies may be applied. On the other hand, precisely when these needs are becoming most critical, it is possible to observe a significant decline in the resources available for research in a number of countries. In large measure, this is the result of reductions in public expenditures, which constitute the primary source of funds for health research.

There is widespread recognition of the pressing need for government to refrain from limiting its role to that of funder and implementor of research and to expand its regulatory role in the field of scientific and technologic activity, spearheading the process of calling together the various actors involved in such activities in order to define goals in a coordinated manner. However, we see on the contrary that science and technology boards, the government agencies charged with taking on such responsibilities in the countries of the region, are experiencing reductions not only in their human

and financial resources but in their political strength.

This study is one in a group of PAHO activities directed at cooperating with countries of the Americas in the process of overcoming these challenges and contradictions. Specifically, it seeks to call attention to some of the characteristics of scientific production during the study period, thus contributing to improved understanding of the current situation and historic trends, and thereby helping to provide a stronger base for policies in the field of health science and technology.

## METHODOLOGY

This study employed the ISI database referred to above. This database is quite selective and includes approximately 3 500 journals, including those most important in diverse scientific fields. According to its creator, E. Garfield, its selective coverage is due not only to economic limitations but also to the fact that in any field the number of truly important journals that are frequently read and cited is relatively small, reflecting a precept known as "Bradford's law" (6). In the ISI database itself, which is already quite selective, more than 50% of the articles and 80% of the citations appear in only 500 journals. Accordingly, this database does not permit one to develop an inventory of the sum total of scientific production in the six study countries, but instead provides a basis for inventorying a portion of that production circulating in the international literature that is deemed of the highest quality by those responsible for this database.<sup>6</sup>

The ISI database used, known formally as the ISI Database Science Indicators File, includes the Science Citation Index, the Social Sciences Citation Index, and the Arts and Humanities

Citation Index. To cover all science fields, this database uses 89 category codes ("CatCodes"). Each of the codes relates to a group of journals, and it is assumed that all of the articles published in those journals pertain to that code. We selected 38 of these codes in order to delimit the area of science pertaining to human health. We then subdivided this set into category codes dealing primarily with biomedical, clinical, and public health research (7). During the period in question, the 38 codes included 1 975 journals, from which data on the articles analyzed in this study were obtained.

The six countries selected—Argentina, Brazil, Chile, Cuba, Mexico, and Venezuela—have in the past accounted for almost 90% of the literature relating to scientific production in Latin America and the Caribbean, with regard to both science in general and health science in particular (6). It should be noted that Cuban scientific production recorded in the database is quantitatively smaller than that of four other countries not included in this study (Colombia, Jamaica, Peru, and Uruguay). However, Cuba's inclusion is justified because of the particular characteristics of science and technology policies in that country.<sup>7</sup> Over the 20-year study period, 32 Latin American health journal titles (29 from the six study countries) were included in the ISI database, which annually included between 17 and 21 such titles (Annex 1).

For the entire period of 1972–1992, 72 899 published entries by primary (first-listed) authors residing in one of the six countries were obtained. A decision was then made to work exclusively with research articles, to the exclusion of editorials, notes, letters, reviews, meeting summaries, etc., which reduced the number of entries

<sup>6</sup> The countries of Latin America and the Caribbean that in the 1970s contributed approximately 1% of the articles to the database increased their participation to 1.5% during the 1980s (6).

<sup>7</sup> During the study period, Cuba consolidated a science and technology planning model based on the problems faced at various levels (national, sectoral, local, etc.), one defined by corresponding government agencies under the coordination of the Academy of Science.

**TABLE 1. The 41 238 selected articles published in 1973–1992 whose first authors resided in one of the six study countries, by country, 5-year period (within the 20-year study period), and type of research involved**

Country	Type of research	Number of articles				
		1973–1977	1978–1982	1983–1987	1988–1992	1973–1992
Argentina	Biomedical	1 028	1 050	1 622	1 668	5 368
	Clinical	1 052	1 576	1 687	1 751	6 066
	Public health	41	19	48	41	149
Brazil	Biomedical	749	1 366	1 946	2 947	7 008
	Clinical	628	1 540	1 615	2 085	5 868
	Public health	47	80	264	281	672
Chile	Biomedical	237	516	554	692	1 999
	Clinical	794	821	946	1 228	3 789
	Public health	18	11	32	49	110
Cuba	Biomedical	37	59	97	145	338
	Clinical	43	77	75	94	289
	Public health	3	0	2	7	12
Mexico	Biomedical	289	446	669	905	2 309
	Clinical	1 012	1 264	1 392	1 372	5 040
	Public health	23	30	31	40	124
Venezuela	Biomedical	215	277	330	264	1 086
	Clinical	144	283	256	288	971
	Public health	17	2	10	11	40
All	Biomedical	2 555	3 714	5 218	6 621	18 108
	Clinical	3 673	5 561	5 971	6 818	22 023
	Public health	149	142	387	429	1 107
Total		6 377	9 417	11 576	13 868	41 238

to 42 292. The first year of the ISI database (1972) was excluded for reasons of consistency and uniformity, and this further reduced the number of articles to a total of 41 238.

The data recorded for each article included its year of publication, title, authors' names, authors' respective institutions and countries of residence, journal in which the article was published, and (for articles published after 1982) the number of citations received from other sources in each year following the article's publication.

For the most part, the analysis presented below should be regarded as an initial approximation limited to identifying major trends of a general nature for the entire health research field over a period of 20 years. However, to help explore the potential for conducting a study in greater depth, trends of scientific production in the field of epidemiology were also assessed. From the ISI database list of nearly 40 journals dealing with public health research we se-

lected 11 international journals<sup>8</sup> that we considered to be of greatest importance. A review was conducted of the data registered on the 570 articles published by those journals in 1973–1992 whose first author resided in one of the six study countries. In this way, 95 articles on epidemiology were selected for more detailed analysis.

## PRINCIPAL FINDINGS AND DISCUSSION

As noted above, in 1973–1992 primary authors residing in the six study countries published a total of 41 238

articles listed in the journals selected from the ISI database. Of these, 38.3% were published in the first 10-year period (1973–1982) and 61.7% in the second. In comparing production by 5-year periods (Table 1), the following increases were found: in 1978–1982 a total of 9 417 articles appeared (48% more than the 6 377 published in 1973–1977); in 1983–1987 the number rose to 11 576 (23% more than in 1978–1982); and in 1988–1992 it rose to 13 868 (20% more than in 1983–1987).

It is interesting to note that this evolution bears no relation to the number of health-related journals published in the six study countries that were indexed in the ISI database, a number that remained more or less stable throughout the study period and that respectively stood at 17, 21, 20, and 18 journals in each of the successive 5-year portions of that period.

As may be seen, from the first to the last 5-year period the number of published articles rose by 117% (from

<sup>8</sup> The 11 journals selected: *American Journal of Epidemiology*, *American Journal of Public Health*, *American Journal of Tropical Medicine and Hygiene*, *Bulletin of the World Health Organization*, *Epidemiology and Infection*, *International Journal of Epidemiology*, *Journal of Clinical Epidemiology*, *Medical Care*, *Preventive Medicine*, *Public Health Reports*, and *Transactions of the Royal Society of Tropical Medicine and Hygiene*.

6 377 to 13 868), with variations occurring in the rate of growth. These variations could be related to the instability of resources available for research that was observed during the period. The greatest increase in the number of articles, which occurred from the first to the second 5-year period, coincided with a rise in economic indicators and a growth of expenditures for science and technology within the region as a whole. Subsequently, during the 1980s and particularly beginning in 1983, most countries saw these expenditures reduced (8), a reduction that was followed by a period of recovery at the end of the decade.

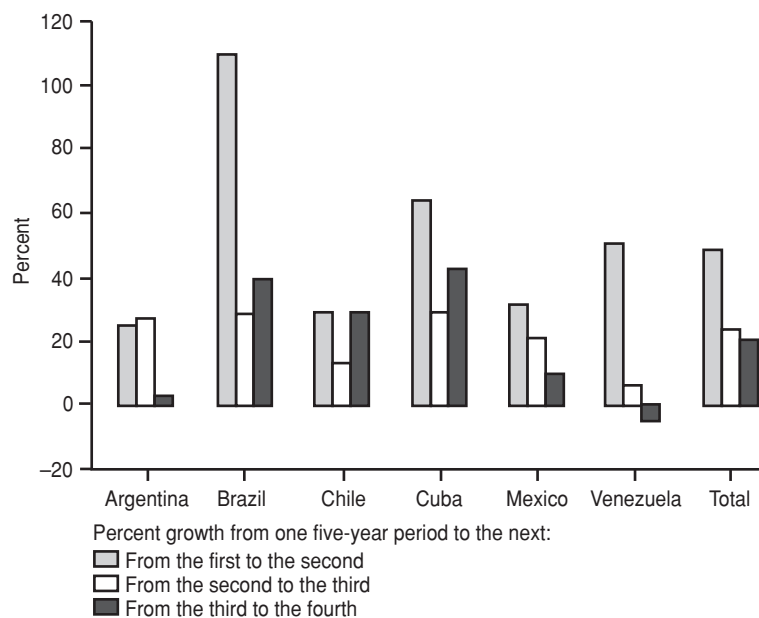
### Country data

Disaggregating the data by country, as in Figure 1, shows that the increase in the number of articles was not consistent from one country to another. In particular, there was a sharp 110% increase in the number of articles by Brazilian authors from the first to the second 5-year period, a reduction in this growth rate to 28% from the second to the third period, and a slight recovery to 39% from the third to the fourth period. Chile and Cuba followed a similar pattern, though the increase from the first to the second period was not so marked.

Also worthy of mention is the small growth observed in Argentina, Mexico, and Venezuela from the third to the fourth period. This pattern was especially marked in the case of Venezuela, which recorded a major increase from the first to the second period, followed by a very slight increase from the second to the third period and negative growth from the third to the fourth period. It is possible that this pattern is related to the stringent policies of economic adjustment and a decline in public expenditures that were observed in these countries in the late 1980s.

As already indicated, authors in the six study countries selected produced close to 90% of the health-related articles from Latin America and the Caribbean that were recorded in the ISI. Within this group, a large concen-

**FIGURE 1. Percentage growth (by five-year period over the years 1973–1992) in the number of articles appearing in the selected health-related journals whose primary authors resided in one of the six study countries**



Source: Institute for Scientific Information, Philadelphia, Pennsylvania, U.S.A.

tration of articles (61%) was found to be produced by authors from one of two countries; that is, 28.1% of the primary authors resided in Argentina and 32.9% lived in Brazil. This concentration exhibited an upward trend during the study period. For example, if the two delimiting years are considered, 57% of the articles in 1973 were by authors from Argentina and Brazil, as were 68% of the articles in 1992.

It is also interesting to note a change that has occurred in the relative numbers of articles published by Argentine and Brazilian authors. Argentines accounted for over a third of all the 1973 articles (38% of the total), twice the Brazilian share (19%). By 1992, however, these positions had been reversed, with Brazilians accounting for almost half the total number of articles (45%) and Argentines for only 23%. This change began to emerge from the first to the second five-year period, when Brazilians went from contributing 22% of the total number of articles produced by the six countries to 32%, while the number of articles originating in Argentina dropped from 33% to 28%. This reversal was attributable

both to the sizable 110% increase in Brazilian article production from the first to the second period and to the Argentines' poor performance (an increase of only 25%, which was lower than the average 48% growth recorded by residents of the six study countries), a situation that could be linked to political and institutional instability and to emigration of scientists from Argentina during the mid-1970s.

### Production by type of research

As Table 2 shows, published research articles in the three areas of biomedicine, clinical medicine, and public health were not evenly distributed among the six study countries. Clinical research, the type of research most commonly practiced in Latin America and the Caribbean, was fairly evenly distributed; but biomedical and public health research were concentrated primarily in Brazil and Argentina, whose authors accounted for almost 70% of the articles published in those areas. Moreover, authors in Brazil accounted for 60.7% of the 1 107 public health

**TABLE 2. Percentage distribution by country of the study articles published in the areas of biomedical, clinical, and public health research, 1973–1992**

Country	Type of research		
	Biomedical	Clinical	Public health
Argentina	29.6	27.5	13.5
Brazil	38.7	26.6	60.7
Chile	11.0	17.2	9.9
Cuba	1.9	1.3	1.1
Mexico	12.7	22.9	11.2
Venezuela	6.0	4.4	3.6

Source: Institute for Scientific Information, Philadelphia, Pennsylvania, U.S.A.

articles, a share that exhibited an upward trend during the study period.<sup>9</sup>

The latter figure is of some concern, as public health research (i.e., research on health systems and health status) should be more broadly represented in all countries, it being an element essential for decision-making and development of health policies affecting a wide range of health problems and population groups.

As Table 3 shows, the vast majority of the research articles were in the areas of biomedicine or clinical medicine rather than public health, indicating that the individual focus continues to prevail over the population approach. Over the entire study period, only 2.7% of the articles were classified as being in the area of public health research, as compared to 53.4% in the area of clinical research and 43.9% in the area of biomedical research. However, over the 20-year period an upward trend was noted in the share of articles devoted to public health and biomedicine, matched by a corresponding decline in the share devoted to clinical research.

This tendency appears to parallel, with some delay, world trends previ-

ously observed in the international literature. In 1982 PAHO conducted a study on trends in scientific production, comparing the content of world medical literature with that of Latin American medical literature (9). For the former, the Index Medicus (IM) of the United States National Library of Medicine was used, while for the latter the Index Medicus Latinoamericano (IMLA) of the Latin American and Caribbean Center for Information on the Health Sciences (BIREME) was used.

In the world literature surveyed, the subject areas reflecting the greatest degree of expansion between 1966 and 1980 were health-related physical sciences (+193%), biological sciences (+143%), and public health (+148%), while growth of all the scientific literature examined in this period was 51%. Comparing the profile of production catalogued in the IM for 1980 and in the IMLA for 1979–1982, it was observed that, of the 14 MeSH (medical subject headings), the large majority (42%) of the articles from the IMLA were included under the heading “illnesses,” while in the IM only 15% of the articles were classified under that heading. This could indicate a greater

relative development of clinical research, i.e., research on diseases, in Latin America as opposed to study of underlying biologic phenomena. In fact, the share of production accounted for by health-related articles in the biologic and physical sciences was found to be greater in the world literature (respectively 12% and 5% of the IM entries, as compared to 9% and 1% of the entries in the IMLA).

The study cited (9) concludes that the pattern of health-related publication in Latin America over the 1979–1982 period came closer to resembling the pattern observed in the world literature in the mid-1970s than that found in 1980. What was observed in this study cannot be compared to the findings of the current study, however, as the former analyzed what was being published in the world and Latin American literature, with each article’s country of origin being regarded as the country where the journal was published rather than the primary author’s place of residence, while the current study analyzes the publication patterns of authors residing in the six study countries. However, the upward trend observed in articles on biomedical research and the decrease in those dealing with clinical research, as seen in the current study, indicates a movement of health-related scientific production by authors in the six study countries toward the pattern found in the world literature of 1980.

Although this trend was observed in all six study countries, the analyses of production curves by country, type of research, and five-year periods reveal interesting country-by-country variations (see Table 1). Thus, in Argentina the share of research articles classified

<sup>9</sup> This concentration bears no relation to the Brazilian origins of the only two public health journals produced in the six countries and indexed by the ISI between 1972 and 1992—these being the *Revista del Instituto de Medicina Tropical* and the *Revista de Salud Pública* [Journal of the Institute of Tropical Medicine and Journal of Public Health]. During the period studied, these two journals published 951 articles by authors from the six countries, 429 (45%) of them by Brazilian authors. As will be seen, of the total number of articles on epidemiology published in the 11 selected international journals, 66% (63/95) were by Brazilian authors.

**TABLE 3. Percentage distribution by type of research (biomedical, clinical, or public health) of study articles published in 1973–1982, 1983–1992, and 1973–1992**

Type of research	Years		
	1973–1982	1983–1992	1973–1992
Biomedical	39.7	46.5	43.9
Clinical	58.5	50.3	53.4
Public health	1.8	3.2	2.7

Source: Institute for Scientific Information, Philadelphia, Pennsylvania, U.S.A.

as biomedical (48%) was nearly the same as the share classified as clinical (50%) during the first 5-year period. However, the next 5-year period showed a major rise in the number of clinical research articles while the number of biomedical research articles remained constant, although the latter recovered its previous share in subsequent periods. This profile suggests that developments in the mid-1970s may have led to an expansion of clinical research that was not matched by biomedical research until the 1980s.

In the cases of Brazil and Cuba, the rate of growth in biomedical research literature was greater than that recorded for clinical research literature, and the period ended with clear domination by the former. In Cuba, the study data indicate a major growth of biomedical research over the last decade, most likely owing to efforts made by that country to promote development of biotechnology.

In contrast, Chile and Mexico (especially the latter) exhibited more enduring traditions of clinical research. However, even though our data indicate clinical research remained predominant in both countries, the numbers of biomedical research articles grew slightly faster over the 20-year study period than did the numbers of clinical research articles.

Venezuela was the only country where biomedical research appeared to predominate in the first five-year period, but where the number of clinical research articles by local authors exceeded the number of biomedical research articles by such authors in 1988–1992. In any case, the sharp decline of biomedical research articles from 1983–1987 to 1988–1992 is perhaps indicative of this discipline's vulnerability to the economic crisis and to adjustment policies implemented during the period involved.

### Collaborative scientific work

One development reflecting a certain "modernization" of scientific activity in the study countries was an increase in collaborative work. Specifically, a

relative decrease was found in the number of articles published by researchers working independently. That is, in the first decade of the study period articles by a single author accounted for 17% of the total, but that share dropped to 10% in the second decade, while articles by six or more authors increased from 8% to 15% (Table 4).

This increased tendency toward collaborative scientific activity was also indicated by a tendency toward increased collaboration between people at different institutions, both domestically and abroad. That is, there was an increase in the number of articles whose first author was from an institution in one of the countries selected and whose remaining authors were from other national or international institutions. Overall, during the entire 1973–1992 period, 73.4% of the articles were produced by authors from a single institution, while 18.8% involved authors from national institutions other than that of the first author (internal interinstitutional collaboration)

and 7.7% included authors from institutions in other countries (external interinstitutional collaboration). However, from the first to the second 10-year period, the percentage of articles by authors from a single institution declined from 77.6% to 70.9%, while the percentage of articles involving internal interinstitutional collaboration increased from 16.2% to 20.4% and the percentage involving external interinstitutional collaboration increased from 6.3% to 8.6%.

In comparing data for the entire period by research area and type of collaboration (Table 5), a relatively high percentage of biomedical research articles (10.1%) appear to have involved external interinstitutional collaboration, as compared to 5.8% of the clinical research articles and 8.4% of the public health research articles. On the other hand, a higher percentage of public health research articles appeared to involve internal interinstitutional collaboration (25.7%) than did either the biomedical research articles (18.5%) or the clinical research

**TABLE 4. Percentage distribution of the study articles published in 1973–1982 and 1983–1992 that had one, two, three to five, or six or more authors**

Number of authors per article	Period	
	1973–1982	1983–1992
1	17	10
2	25	21
3–5	50	54
≥6	8	15

Source: Institute for Scientific Information, Philadelphia, Pennsylvania, U.S.A.

**TABLE 5. Percentage distribution of the study articles in biomedical, clinical, and public health research according to the institutional affiliations of their authors (one institution, more than one institution in the same country, or more than one institution in different countries), 1973–1992**

Type of research	Institutions		
	One local	Several local	Foreign
Biomedical	71.4	18.5	10.1
Clinical	75.5	18.6	5.8
Public health	65.9	25.7	8.4

Source: Institute for Scientific Information, Philadelphia, Pennsylvania, U.S.A.

articles (18.6%). Meanwhile, a slightly higher percentage of clinical research articles were produced by authors from a single institution (75.5% versus 71.4% for biomedical research articles and 65.9% for public health research articles).

### Origins of authors and journals

The health-related scientific articles of the six selected countries do not appear to have been produced by a relatively small number of authors. On the contrary, the 41 238 articles had 20 095 primary authors, with most (63%) of the latter contributing only one article and 17% contributing only two. Only 6% of the primary authors contributed six articles or more.

With regard to the countries of origin of the selected journals, a number of interesting points were noted. For one thing, almost 30% of the study articles produced by authors residing in Argentina, Brazil, and Mexico and recorded in the ISI database appeared in journals published in the primary author's country of residence. In the case of Chile, this figure reached a level of 50%, while for Cuba and Venezuela it dropped to 10%.

Of all the articles published abroad by authors residing in Argentina, Brazil, and Chile, almost 35% appeared in journals published in the United States, while 60% appeared in European journals (20% in British journals). The U.S. journals were considerably more important for Mexican and Venezuelan authors, who respectively published 50% and 45% of their articles in them, as compared to roughly 45% in European journals (20% in British journals). Cuban authors followed a different pattern, with almost 80% of their articles in the ISI database appearing in European journals (14% in British journals and 65% in other European journals), while a scant 14% appeared in U.S. journals. Annex 2 lists the journals publishing the greatest numbers of articles whose primary authors resided in each of the six study countries.

As the foregoing data suggest, relatively few of the articles appeared in Latin American or Caribbean journals that were published in countries where the primary author did not reside. This fact can be attributed to the low degree of exchange existing among these countries, at least with regard to ISI-indexed journals. In terms of residence, the authors with the least propensity to publish in Latin American journals outside their country were those in Mexico (1.6%), Argentina (1.7%), and Brazil (2.7%). Somewhat higher percentages of authors residing in Chile (5.4%), Venezuela (6.1%), and Cuba (7.8%) published their articles in journals produced in other Latin American countries.

### Citations per article

The citations received by a particular article are traditionally used as a measure of that article's impact. Naturally, just as the scientific article is not the sole product of scientific activity, the citations received by such an article are likewise not the only measure of its impact, much less of its quality. Bearing in mind the limitations of this indicator, but recognizing its broad acceptance as an approximate measure of the reception accorded to a study by the scientific community, an analysis was made of the citations received by articles published in 1982–1992 whose first authors resided in one of the six study countries.

The ratio of the number of citations received to the number of scientific articles published in a given period is used as an indicator of the articles' impact in that period. Garfield (6) found that in 1981–1993 the average number of citations per scientific article worldwide for all of the sciences was 7.78, while for scientific articles published in Latin America and the Caribbean it was 3.52—suggesting a relative impact (citations per article from Latin America and the Caribbean relative to citations per article worldwide) of 0.45.

In the health sciences, the average number of citations per article au-

thored by residents of the six study countries was 3.10, a figure approximating that for scientific articles (all sciences) appearing in the region's journals. When an effort was made to measure the relative impact of the study articles by country (the ratio of the average number of citations received by articles from one country to the average number of citations received by articles from the six countries), the following results were obtained: Argentina, 1.00; Brazil, 0.91; Chile, 0.84; Cuba, 0.50; Mexico, 1.20; and Venezuela, 1.47.

There were also significant differences between the apparent impacts of articles in the research areas of biomedicine, clinical medicine, and public health. Overall, the apparent impact of the biomedical research articles was considerably higher, the average number of citations received being 4.03, as compared to averages of 2.29 and 1.61 for the clinical and public health research articles, respectively. In terms of relative impact, biomedical research scored 1.30, while clinical research scored 0.74 and public health research scored 0.52. Of the 90 995 citations received during the period, 60.5% cited biomedical articles, 38% cited clinical articles, and 1.5% cited public health articles, while the respective percentages of published articles in these fields were 46.3%, 50.6%, and 3.1%. All this indicates, at least in terms of citations, that articles in the field of biomedicine had the greatest impact. It should be noted that public health research, with a percentage of published articles far lower than the other two areas, registered an even lower relative participation with regard to citations received.

### Production in epidemiology

As noted in the section on methodology, in order to analyze epidemiologic research production, 11 public health journals considered of great importance were selected. The ensuing study of articles by residents of the six countries that appeared in these jour-



nals is intended to serve only as a preliminary and partial analysis of production in the field of epidemiology, as it is limited to articles published in public health journals, to the exclusion of articles on epidemiology published occasionally by journals such as *Lancet*, *the Journal of the American Medical Association*, etc. In the journals selected there were 570 articles whose first authors resided in one of the six countries; of these, 95 were in the field of epidemiology.

Brazilian authors produced the great majority (66%) of these 95 articles, a situation similar to that found for articles on public health in the broader study (see Production by Type of Research, above).

With regard to number of authors, the percentage of articles with a single author (31%) was considerably greater than that observed in the broader study, where only 12.8% of the health-related articles had a single author.

Despite this, the findings of the epidemiologic study highlighted the importance of interinstitutional collaboration, especially international collaboration, in this field. In all, only 32% of the articles (nearly all by single authors) were produced by one or more authors affiliated with a single institu-

tion; 26% listed authors affiliated with two or more institutions within a particular country (internal interinstitutional collaboration); and 42% listed authors affiliated with institutions in different countries (external interinstitutional collaboration). In contrast, the broader study found the respective percentages to be 73.4%, 18.8%, and 7.7%, indicating that the epidemiologists who published in the 11 selected journals had more contact with the international scientific community than did the general group of authors producing health-related scientific articles assessed in the broader study.

It is also noteworthy that the large majority of epidemiology articles (83%) by authors from the six study countries dealt with the epidemiology of infectious diseases, while only 4% dealt with chronic diseases and 13% dealt with other subjects (especially topics related to maternal and child health). In order to compare this subject profile to the corresponding profile worldwide, two epidemiology journals generally considered to be leaders in the field were consulted, these being the *International Journal of Epidemiology* and the *American Journal of Epidemiology*. The former journal published a total of 381 articles in 1987, 1989, and

1991, of which only 98 (25.7%) dealt with infectious diseases or problems relating to maternal and child health. The latter journal published a total of 344 articles during the second semesters of these years, of which only 66 (19.2%) dealt with infectious diseases or maternal and child health problems. These data indicate that while the study of chronic diseases predominates in the world's epidemiologic literature, epidemiologists within Latin America who successfully publish in journals enjoying wide circulation at the international level continue to deal almost exclusively with infectious diseases. Of the 381 articles published by the *International Journal of Epidemiology*, only three (0.78%) had primary authors residing in one of the six study countries.

With regard to citations received by articles from the study countries on epidemiology, the 77 study articles published between 1981 and 1992 received 336 citations, giving them an average impact index of 4.36 citations per article, considerably greater than that found by the broader study for articles in the area of public health (1.61), and also greater than that found by the broader study for all health-related scientific articles (3.1).

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**ANNEX 1. The 32 Latin American health journals included in the ISI database during the 1972–1992 period.**

Country	Journal title	Articles published (No.)
Argentina	<i>Acta Physiologica et Pharmacologica Latinoamericana</i>	238
	<i>Acta Physiologica Latinoamericana</i>	459
	<i>Acta Psiquiátrica y Psicológica de América Latina</i>	94
	<i>Medicina</i> (Buenos Aires)	1 312
	<i>Microscopía Electrónica y Biología Celular</i>	70
	<i>Prensa Médica Argentina</i>	1 657
Brazil	<i>Arquivos Brasileiros de Psicologia</i>	325
	<i>Arquivos Brasileiros de Psicologia Aplicada</i>	42
	<i>Arquivos de Neuro-Psiquiatria</i>	33
	<i>Brazilian Journal of Medical and Biological Research</i>	686
	<i>Memórias do Instituto Oswaldo Cruz</i>	345
	<i>Revista Brasileira de Genética</i>	726
	<i>Revista Brasileira de Medicina</i>	1 057
	<i>Revista Brasileira de Pesquisas Médicas e Biológicas</i>	170
	<i>Revista do Instituto de Medicina Tropical de São Paulo</i>	584
	<i>Revista de Saúde Pública</i>	449
Chile	<i>Archivos de Biología y Medicina Experimentales</i>	208
	<i>Revista Médica de Chile</i>	2 759
Colombia	<i>Archivos de la Sociedad Americana de Oftalmología y Optometría</i>	1
	<i>Revista Latinoamericana de Psicología</i>	97
Cuba	<i>Interferón y Biotecnología</i>	73
Mexico	<i>Archivos del Instituto de Cardiología de México</i>	156
	<i>Archivos de Investigación Médica</i>	701
	<i>Investigación Médica Internacional</i>	477
	<i>Medicina</i> (Mexico)	89
	<i>Patología</i> (Mexico)	150
	<i>Revista de Investigación Clínica</i>	938
	<i>Revista Mexicana de Radiología</i>	215
	<i>Salud Mental</i>	175
Peru	<i>Acta Médica Peruana</i>	2
Venezuela	<i>Acta Gastroenterológica Latinoamericana</i>	10
	<i>Investigación Clínica</i>	208

**ANNEX 2. Journals publishing the largest numbers of study articles in 1973–1992 whose primary authors resided in the indicated countries.**

Journal	Argentina	No.	%
<i>Prensa Médica Argentina</i>		1 645	14.2
<i>Medicina</i>		1 297	11.2
<i>Acta Physiologica Latinoamericana</i>		348	3.0
<i>Biochimica et Biophysica Acta</i> (Amsterdam)		233	2.0
<i>Acta Physiologica et Pharmacologica Latinoamericana</i>		195	1.7
<i>Biochemical and Biophysical Research Communications</i>		101	0.9
<i>FEBS Letters</i> (Amsterdam)		98	0.8
<i>Comparative Biochemistry and Physiology [B]</i> (Oxford)		94	0.8
<i>Biochemistry Journal</i> (London)		87	0.7
<i>Molecular and Cellular Biochemistry</i> (The Hague)		85	0.7
<i>Neuroendocrinology</i> (Basel)		85	0.7
Others (1 110)		7 303	63.1
Total		11 571	100.0

**ANNEX 2. (Continued)**

Brazil			
Journal	No.	%	
<i>Revista Brasileira de Medicina</i>	1 049	7.7	
<i>Revista Brasileira de Genética</i>	688	5.1	
<i>Brazilian Journal of Medical and Biological Research</i>	679	5.0	
<i>Revista do Instituto de Medicina Tropical de São Paulo</i>	522	3.9	
<i>Revista de Saúde Pública</i>	429	3.2	
<i>Arquivos Brasileiros de Psicologia</i>	316	2.3	
<i>Memórias do Instituto Oswaldo Cruz</i>	307	2.3	
<i>Comparative Biochemistry and Physiology [B] (Oxford)</i>	173	1.3	
<i>Revista Brasileira de Pesquisas Médicas e Biológicas</i>	167	1.2	
<i>Biochimica et Biophysica Acta (Amsterdam)</i>	134	1.0	
Others (1 329)	9 084	67.1	
Total	13 548	100.0	

Chile			
Journal	No.	%	
<i>Revista Médica de Chile</i>	2 742	46.5	
<i>Archivos de Biología y Medicina Experimentales</i>	197	3.3	
<i>IRCS Medical Science Biochemistry</i>	162	2.7	
<i>FEBS Letters (Amsterdam)</i>	65	1.1	
<i>Comparative Biochemistry and Physiology [B] (Oxford)</i>	57	1.0	
<i>Contraception (Stoneham, Massachusetts)</i>	52	0.9	
<i>General Pharmacology (Oxford)</i>	48	0.8	
<i>Biochemistry International (Sidney)</i>	40	0.7	
<i>Biochimica et Biophysica Acta (Amsterdam)</i>	39	0.7	
<i>Cellular and Molecular Biology (Elmsford, New York)</i>	37	0.6	
<i>Neuroscience Letters (Limerick)</i>	37	0.6	
Others (691)	2 420	41.0	
Total	5 896	100.0	

Cuba			
Journal	No.	%	
<i>Interferón y Biotecnología</i>	68	10.6	
<i>Neoplasma (Bratislava)</i>	36	5.6	
<i>Allergologia et Immunopathologia (Madrid)</i>	35	5.5	
<i>Revista Clínica Española (Madrid)</i>	24	3.8	
<i>Biotechnology Letters</i>	17	2.7	
<i>Folia Microbiologica (Prague)</i>	14	2.2	
<i>Acta Biotechnologica</i>	11	1.7	
<i>Acta Paediatrica Hungarica (Budapest)</i>	10	1.6	
<i>Haematologia (Budapest)</i>	10	1.6	
<i>Revista do Instituto de Medicina Tropical de São Paulo</i>	9	1.4	
<i>Sangre (Barcelona)</i>	9	1.4	
<i>Acta Diabetologica Latina (Milan)</i>	8	1.3	
<i>Activitas Nervosa Superior</i>	8	1.3	
<i>American Journal of Tropical Medicine and Hygiene</i>	8	1.3	
<i>Revista de Investigación Clínica (Mexico)</i>	8	1.3	
Others (191)	364	57.0	
Total	639	100.0	

Mexico			
Journal	No.	%	
<i>Revista de Investigación Clínica</i>	920	12.3	
<i>Archivos de Investigación Médica (Mexico)</i>	701	9.4	
<i>Investigación Médica Internacional</i>	394	5.3	
<i>Revista Mexicana de Radiología</i>	212	2.8	
<i>Salud Mental (Mexico)</i>	166	2.2	
<i>Archivos del Instituto de Cardiología de México</i>	145	1.9	
<i>Patología (Mexico)</i>	107	1.4	
<i>Journal of Rheumatology (Toronto)</i>	85	1.1	
<i>Biochimica et Biophysica Acta (Amsterdam)</i>	81	1.1	
<i>Medicina — Revista Mexicana</i>	79	1.1	
Others (934)	4 583	61.3	
Total	7 473	100.0	

**ANNEX 2. (Continued)**

Journal	Venezuela	No.	%
<i>Investigación Clínica</i>		205	9.8
<i>Biochimica et Biophysica Acta</i> (Amsterdam)		67	3.2
<i>Current Therapeutic Research, Clinical and Experimental</i> (New York)		47	2.2
<i>American Journal of Tropical Medicine and Hygiene</i> (Lawrence, Kansas)		28	1.3
<i>Investigación Médica Internacional</i>		27	1.3
<i>American Journal of Physiology</i> (Bethesda, Maryland)		25	1.2
<i>Comparative Biochemistry and Physiology [A]</i> (Oxford)		24	1.1
<i>Molecular and Biochemical Parasitology</i> (Amsterdam)		23	1.1
<i>Biochemical and Biophysical Research Communications</i> (New York)		22	1.0
<i>Mycopathologia</i> (Dordrecht)		22	1.0
<i>Biotropica</i>		20	1.0
<i>Journal of General Physiology</i> (New York)		20	1.0
Others (525)		1 566	74.7
Total		2 096	100.0

**RESUMEN**

**Producción de artículos científicos sobre salud en seis países de América Latina, 1973 a 1992**

Con objeto de observar las tendencias de la investigación sobre salud en América Latina, se analizó la producción de artículos resultantes de investigaciones biomédicas, clínicas y de salud pública originadas en Argentina, Brasil, Chile, Cuba, México y Venezuela de 1973 a 1992, inclusive. De la base de datos del Institute for Scientific Information (ISI) se recuperaron 41 238 artículos con primeros autores residentes en esos países. Esta producción se analizó por área de estudio, tipo de investigación, país, número de autores e instituciones que participaron en la investigación, y citas recibidas por cada artículo. Se hizo también un análisis de 95 artículos en epidemiología seleccionados de 570 publicados por autores de los seis países en 11 revistas de salud pública de gran prestigio internacional.

Los resultados muestran que el número de trabajos publicados aumentó 117% entre el primero y último quinquenio. La investigación clínica tuvo la distribución más homogénea entre los países y la de salud pública, la más concentrada (60,7% se originó en el Brasil). Los artículos de investigación biomédica y de salud pública tuvieron un incremento relativamente mayor que los de investigación clínica a lo largo del período. Se observó una disminución relativa de artículos de un solo autor —lo que sugiere trabajo en equipo más frecuente— y un aumento de artículos con autores vinculados a dos o más instituciones nacionales o extranjeras, lo cual indica mayor cooperación entre instituciones y países. En promedio, las citas recibidas por artículo fueron tres, lo que corresponde a menos de la mitad de las que reciben los artículos de la base del ISI (7,78). En cuanto al subconjunto de los 95 artículos de epidemiología, la gran mayoría (96%) trataban de enfermedades infecciosas o del área materno-infantil, mientras que en la literatura internacional 78% de los artículos estaban dedicados a las enfermedades crónicas. En este conjunto se observó más cooperación con instituciones extranjeras y un índice de 4,36 citas por artículo.

Se concluye que, pese a las limitaciones inherentes a este tipo de estudio, se pudieron notar algunas tendencias generales del desarrollo de la investigación en los seis países con mayor producción científica de América Latina y formular hipótesis sobre los factores que determinan esas tendencias. Tomados con cautela, los resultados de estudios de este tipo pueden ser de gran valor al definir políticas de ciencia y tecnología de salud.