INDEXED *Feature*

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Health Research in Latin America[1]

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This presentation summarizes the principal results of studies on the status of health research in Argentina, Brazil, Cuba, Mexico, and Venezuela that were conducted by research groups in those countries,[3] and also briefly assesses health research output in Chile based on a review of the published literature. The initiative for these studies arose out of a PAHO/WHO line of technical cooperation seeking to strengthen the processes involved in formulating national policies on health-related research and technologic development.

Rapid changes in Latin America's economic base and in world politics and economics have made the debate over scientific and technologic development in the region more relevant than ever. It seems certain, however, that this debate should not be based upon old formulas. New policies and strategies for scientific and technologic development must start from a clear diagnosis of the situation with special emphasis on analysis of the world context, technologic change, and conditions prevailing in the region.[4]

A quick look at the world situation reveals a marked trend toward formation of global megamarkets and emergence of competitive patterns based on mastery of new technologies that are themselves speeding up the pace of change. This trend, together with changing world politics and the economic crisis in the region, is rapidly eroding Latin America's existing development models; and what is now being seen is a tendency to seek out and introduce new models.

A key consideration here, part and parcel of Latin America's precarious infrastructure, is the precarious nature of its scientific and technical production. The average Latin American country's expenditure on research and development comes to barely 0.6% of its GNP, whereas

[1]These five studies were financed by the PAHO/WHO Grants Program. This feature was also published in Spanish in the *Boletín de la Oficina Sanitaria Panamericana*, Vol. 114, No. 2, 1993, pp. 142–157.

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[3]The principal researchers responsible for studies in the indicated countries were as follows: In Argentina: Dr. Marta Novick, Centro de Investigaciones y Estudios Laborales/Consejo Nacional de Investigaciones Científicas y Técnicas (CIEL-CONICET); in Brazil: Dr. Maura Pacheco and Dr. Francisco Viacava, Financiadora de Estudios de Proyectos (FINEP); in Cuba: Dr. Patricia Sierra Blazquez, Ministerio de Salud Pública; in Mexico: Dr. Gladys Faba Beaumont, Centro Nacional de Información y Documentación en Salud/Secretaria de Salubridad y Asistencia (CENIDS/SSA); and in Venezuela: Dr. Jorge Diaz Polanco, Centro de Estudios para el Desarrollo, Universidad Central de Venezuela.

[4]The conclusions that follow are largely based on the study by Ignacio Avalos (*1*).

in the developed countries this figure averages roughly 2.7%.

According to an IDB report (2), in 1973 Latin America contributed only 0.97% of the scientific articles in the database of the Institute for Scientific Information (ISI). This modest contribution was smaller than that of Belgium, Czechoslovakia, or Israel. The situation had not changed greatly as of 1984, a year when Latin America accounted for only 1.14% of the total number of articles published—despite the fact that it then had some 8% of the world's population, 6% of its GDP, 11.15% of the people enrolled in higher education, and 2.42% of the scientists and engineers. Moreover, the whole region was contributing only 0.6% of the works cited in bibliographic references, an indication of the low impact its production was having on the international scientific community.

Besides being limited in volume, Latin America's scientific production is also fairly concentrated. In 1973–1984 five countries (Argentina, Brazil, Chile, Mexico, and Venezuela) with about three-quarters of the region's geographic territory accounted for approximately 90% of its published scientific works. Moreover, if anything this concentration is becoming more marked, because in 1973 the other countries accounted for 13% of the scientific works produced, whereas the figure for 1984 was 8.7%.

It is within this context that the modest studies described below were conducted. Although essentially exploratory and descriptive, they seek to lay the foundation for more detailed future studies and help to define health science and technology policies that will evoke the potential contribution of scientific activity in this field to the integral development of Latin American societies.

In fact, this potential is considerable. Development of science and technology in the health field can play a key role in reviving economic development—partly because it can help to improve the productive potential of the countries' human resources. In addition, it offers many opportunities for building and strengthening a technologic base, permitting development, adoption, and incorporation of new technologies in such areas as pharmaceuticals, immunobiologicals, medical supplies, etc.

It should also be noted that despite all the difficulties cited, Latin American science has demonstrated marked quality and originality in certain areas. Among other things, medical research has led the way to a promising malaria vaccine and to advanced methods for using recombinant DNA to diagnose several diseases (3); and the science of epidemiology, combined with application of the social sciences to health, has made progress in elucidating relationships between various social groups' living conditions and their health status.

AIMS AND METHODS

The general aim of the study was to describe and analyze the status of health research in each of the five countries selected. In this connection, "health research" is defined as the process of producing knowledge about health conditions and the social responses for improving them. "Health conditions" embrace the biologic, psychological, and social processes that define the level of health of an individual or population; and "social responses" correspond to activities organized by society to improve it.[5]

Using these two categories (health conditions and social responses) and two levels of analysis (of the individual and the population), three types of health research may be identified. These are

[5]Based on Frenk J, et al. (4).

biomedical research, the study of health conditions at the individual level; clinical research, the study of responses at the individual level; and public health research, the study of conditions and responses at the population level.

The subject of this study, the status of health research, was broken down into three basic units of analysis, these being (1) research in progress, (2) scientific and technical potential (not covered in this article), and (3) scientific production. The five country studies first provided a separate description and analysis under each of these headings and then sought to relate them to one another and to socioeconomic macroindicators.

For purposes of the study, "research in progress" was considered to be any project under way at the time the study was conducted for which there were formal protocols that defined the project's aims, methodology, and expectations. The main variables used for classifying the projects were (a) the project's title; (b) its subject area, based on the medical subject headings (MeSH) of the U.S. National Library of Medicine; (c) its discipline, based on UNESCO categories; (d) the entity carrying out the project; (e) the type of research (basic, applied, or developmental);[6] (f) the type of research according to the categories defined above (biomedical, clinical, or public health); and (g) the type of financing employed (the institution's regular budget, grants from national or international agencies, etc.). Regarding the project investigators, an effort was made to determine their age, gender, area of training, highest academic degree, place where this degree was obtained, and type of institutional affiliation. For this purpose a project investigator was defined as a person participating in at least two phases of the project—considering as one phase either statement of the problem, objectives, and hypothesis or analysis of the results.

"Scientific and technical potential" is traditionally viewed as consisting of four elements: scientific personnel, the technical and material base, scientific information, and organization of the system of scientific activities (5). The present study did not analyze the technical and material base because it was too difficult to obtain information in this area.

For purposes of the study, "scientific production" was considered to include articles published in national or international journals by researchers in the selected countries during the period 1979–1988. Scientific works by Chilean authors, because of their importance in the Latin American context, were also included under this heading. The articles in question were classified according to subject (MeSH), type of research (biomedical, clinical, public health), and the publication's country of origin.

Information on scientific production was collected using databases that list Latin American and international publications. Under a contract with the Center for Information on Sciences and Humanities (CICH) of the Autonomous National University of Mexico (UNAM), access was gained to the articles listed in the Latin American databases CLASE, PERIODICA, and BIBLAT and to the international databases BIOSIS PREVIEWS, CAB ABSTRACTS, CA SEARCH, EMBASE (*Excerpta Médica*), INTERNATIONAL PHARMACEUTICAL ABSTRACTS, MEDLINE, MENTAL HEALTH ABSTRACTS, and SCISEARCH. An effort was made to avoid possible duplication of the same article listed in different databases by identifying and applying pro-

[6]The term "developmental research" refers to the systematic application of scientific and technical knowledge for the development of new materials, products, devices, processes, and methods, or for the improvement of those already existing.

cedures designed to detect repetitions. In addition, the Latin American Center on Health Sciences Information (BIREME) provided a list of articles from the LILACS database for the period 1981–1987; and a list of publications by Latin American authors in the ISI database for the period 1972–1982 was obtained.

For data on "research in progress" and "scientific and technical potential," the study relied on secondary sources—i.e., information already on file in national databases. In Argentina the sources were the CONICET[7] databases and the Resources Survey of the Science and Technology Secretariat (Relevamiento de Recursos y Actividades de Ciencia y Tecnología—RRACYT). In Brazil the projects examined were those supported by the Financiadora de Estudios de Proyectos (FINEP), the country's major agency for financing research in health and the biologic sciences during the years 1987–1989. In Cuba the information was obtained from the project registration system of the Office for Scientific Information of the Ministry of Public Health (Dirección de Información Científica del Ministerio de Salud Pública). In Mexico eight information systems were consulted that together covered 84.3% of the health sector institutions and 36% of the educational institutions, the most important of these systems being the National System of Health Information Resources (Sistema Nacional de Recursos de Información en Salud—SINARIS) of the Department of Health and Welfare. In Venezuela, because the information available tended to be unreliable, data were collected directly from primary sources by administering a questionnaire to investigators, a procedure that permitted organization of a database called ISVEN located at the Center for Development Studies (Centro de Estudios para el Desarrollo—CENDES).

In general, shortcomings relating to the available information, its completeness, and the ways it was organized greatly reduced the possibilities for assessing the situation and drawing comparisons between the countries studied. Except in Venezuela, however, use of secondary sources was the only method that seemed appropriate, because scientific activity was sufficiently extensive and the study's resources sufficiently limited to preclude procuring the desired information directly from the investigators and institutions involved. In addition, this procedure satisfied a major aim of the study: to gain familiarity with the characteristics—content; principal users; data collection, analysis, and distribution methods; etc.—of the existing scientific and technical information systems that necessarily play a key role in the planning of scientific activity. In this context it should be noted that the study's two major aims—to analyze the status of health research and to examine the characteristics of scientific and technical information systems—both contribute to the more fundamental objective of helping to upgrade the processes for defining health research policies in the countries of Latin America.

SOME BASIC CONCEPTS

It seems proper at this point to review some of the concepts that guided design and execution of the study. One circumstance sharply restricting what could be done was that the secondary information sources, in addition to other shortcomings, were usually organized on the basis of an "input-output" model of scientific activity. This imposes severe limitations on the uses that can be made of the information gathered. Indeed, it has been

[7]Consejo Nacional de Investigaciones Científicas y Técnicas.

shown that reorganizing such information and constructing new indicators using another approach is difficult and often impossible. Hence, there is an urgent need to revise and improve the existing databases so that they will be able to meet anticipated demands of the planning process.

The "input-output" model, which is frequently used to create indicators and analyze scientific activity, has been characterized by several authors as insensitive to historical forces and out of step with the social and cognitive factors involved.[8] In fact, studies based on this model are usually limited to listing human, financial, material, and institutional resources (inputs) on the one hand, and recording the numbers of resulting scientific articles, theses, or patents (outputs) on the other. Typically, such studies do not analyze the actual process employed to produce, disseminate, and use the acquired knowledge, much less the conditioning factors, structure, and dynamics of that process. Hence, these studies seem implicitly based on the view that a specific set of inputs must result in specific outputs, regardless of the historical moment or the social setting where this process is carried out.

The alternative approach that this study has attempted to follow views science as a social phenomenon and scientific activity as a practice closely articulated with other social practices. This means that the volume and characteristics of scientific production are conditioned by and in turn significantly influence such social circumstances as the organizational methods used to produce goods and services, the productive forces' degree of development, and public levels of education and culture (*6*). Hence, beyond quantifying the inputs or outputs of scientific activity, one needs to be familiar with the dynamics of its development in a specific society, because such knowledge is needed for orienting any intervention in that activity.

Besides being influenced by the abovementioned factors linked to social practice, the scientific development dynamic is also influenced by factors intrinsic to that dynamic that are relatively autonomous. These can be considered cognitive factors in the sense that at any given point in history the most recent scientific progress will have been conditioned by the mass of knowledge accumulated during the preceding period (*7*).

These two sets of factors, material and cognitive in nature, influence one another. The history of science abounds with cases where social demands upon science could not be met because science was not adequately developed, and conversely where knowledge or inventions existed but were not incorporated into social practice because the necessary material or organizational conditions did not exist. However, when practical needs have been synchronous with the internal logic of science, then the problem to be dealt with becomes capable of drawing the attention of many investigators, giving it the status of a "cardinal problem."

Descriptive studies like the present one that delineate scientific research profiles and trends in a given field help to identify cardinal problems and so help pave the way for more sophisticated future studies. They also set the stage for gaining further insight into the determinants of the trends observed and for predicting the direction of the field's development, which is of obvious import to the planning process.

[8]See Holton C, "Can science be measured?" and Thackray A, "Measurement in the historiography of science," cited in García JC, La investigación en salud en once países de América Latina, Pan American Health Organization, Washington, DC, 1982 (PAHO/WHO document RD/21/2).

RESULTS

Research in Progress

For the reasons noted, using the methodologies employed to gather information, it has not been possible to provide a detailed analysis of the characteristics of the research process or to make comparative analyses of the countries studied. Indeed, the different groupings of projects studied in the different countries constitute samples whose selection was dictated largely by the characteristics of the host institutions of the respective information systems. (Apparent exceptions are Venezuela, where the data were collected from primary sources, and Cuba, where the health ministry's information system seems to have provided relatively universal coverage.)

The results of the study with regard to "research in progress" are as follows: Based on what is understood to be the field of health research, despite clear differences in the characteristics of the various groups of projects, it was possible to observe one feature that they all had in common—namely, the predominance of investigation oriented toward the individual (biomedical and clinical research) over that oriented toward the population as a whole (public health research) (Table 1). This pattern, which is not unique to the five countries studied, reflects a worldwide trend.

Another common feature was the paucity of developmental research, relative to basic and applied research (see Table 1). This trend implies scant progress in developing research dedicated to technologic innovation, a key bridge between utilization of knowledge and production processes (even though it is recognized that in the health sector this connection is not necessarily achieved mainly through product technology).

The multidisciplinary or interdisciplinary approach, which is essential for developing a field as complex and diversified as health, is not a characteristic feature of the scientific activity reviewed in any of the five countries studied. In all the countries except Brazil, where the social and engineering sciences have some representation, the predominance of the medical and biological sciences is all but absolute.

This situation appears to relate to the profession of the investigators. Specifically, the percentage representation of professionals in the social sciences and humanities was smaller than the percentage of research projects in those fields in Argentina and Brazil, about equal in Cuba, and only slightly larger in Mexico. Indeed, the dearth of participating professionals specializing in the social sciences and humanities in Argentina and Brazil is sufficient to suggest that a significant number of social-science–related health studies are not being carried out by social scientists but rather by other professionals, most of them presumably physicians (Tables 1 and 2).

Another shared feature was extensive participation by women in health-related scientific work. As Table 2 shows, women constituted a majority of the project investigators in Argentina and Venezuela. Overall, the findings suggest that this female participation has been increasing and that participation by younger women (under age 40) is especially marked. Of course, this is a complex phenomenon. On the one hand, it may be a positive indication of greater female presence in a sector that has a major commitment to social development; or else, it could reflect declining interest in research on the part of young males because of the low salaries and limited opportunities for social advancement.

Despite these similarities in results from the five countries, however, there were also marked differences. For example, the

Table 1. Characteristics of health research projects under way in five countries (1987–1989).

Characteristics	Countries				
	Argentina (N = 2 633)	Brazil (N = 1 014)	Cuba (N = 2 091)	Mexico (N = 3 460)	Venezuela (N = 1 776)
Host institutions (%):					
Universities	45.7	80.1	39.8	20.3	82.0
Health services	32.1	2.6	5.5	79.7	9.5
Private companies	0.8	1.7	0.0	0.0	1.4
Research institutions	8.3	15.1	32.9	0.0	7.0
Other	13.1	0.5	21.8	0.0	0.0
Subject areas (%):					
Diseases	26.1	39.3	16.6	29.3	21.9
Diagnostic and therapeutic techniques and equipment	17.1	7.7	22.6	22.6	17.9
Biological sciences	28.0	9.1	18.1	11.7	21.3
Chemicals and drugs	7.7	16.6	12.9	12.1	10.8
Other	21.1	27.3	29.8	24.3	28.1
Discipline (%):					
Medical science and technology	64.2	19.2	75.2	88.1	49.9
Exact and natural sciences	26.2	65.8	17.5	6.6	41.5
Social sciences and humanities	3.8	6.3	5.2	4.7	3.5
Engineering science and technology	2.1	8.5	1.9	0.2	0.0
Agriculture and livestock science and technology	1.8	0.0	0.2	0.4	5.1
Other	1.6	0.0	0.0	0.0	0.0
Type of research (%):					
Basic	33.8	37.1	6.3	—	24.2
Applied	63.5	55.2	89.5	—	67.3
Technologic development	2.7	7.7	4.2	—	8.5
Subject (%):					
Biomedical	40.6	77.0	38.2	16.8	59.5
Clinical	47.0	7.9	31.4	61.7	28.5
Public health	12.4	15.1	30.4	21.5	12.0

Source: Country reports, Pan American Health Organization, Washington, D C., 1991.

data from Brazil and Mexico show two distinct research patterns. The Brazilian data suggest a process taking place primarily in academic circles, one strongly directed toward research that is basic and biomedical with a disciplinary focus that is largely biological. This work is typically carried out by groups of researchers, many of whom have doctorates and training in the natural and exact sciences. In contrast, the Mexican data point to a research process taking place primarily in health institutions that consists mainly of clinical research undertaken by physicians who generally do not have a postgraduate degree and are working in isolation.

Results from the other countries fall between these two extremes. The Venezuelan situation resembles the Brazilian in that university and biomedical research predominate and a high percent-

Table 2. Characteristics of investigators in the five study countries (1987–1989).

Characteristics	Countries				
	Argentina (N = 3 930)	Brazil (N = 5 339)	Cuba (N = 11 478)	Mexico (N = 4 297)	Venezuela (N = 2 647)
Investigators per project	*1.49*	*5.26*	*5.49*	*1.24*	*1.49*
Sex:					
Male	47.5	53.2	57.2	—	48.5
Female	52.5	46.8	42.8	—	51.5
Age:					
20–39 years	59.2	53.5	47.6	—	42.5
40–59 years	28.6	40.5	36.9	—	54.4
≥60 years	6.6	6.0	15.5	—	4.1
Unknown	5.6	—	—	—	—
Highest degree:					
Bachelor's degree	—	32.0	0.0	58.0	10.1
Master's degree	—	25.8	85.6	7.3	25.6
Doctorate	—	42.2	14.4	3.4	40.9
Other[a]	—	0.0	0.0	31.3	22.4
Profession:					
Medical science and technology	54.2	35.8	75.1	82.1	—
Agriculture and livestock science and technology	2.1	0.0	0.1	0.7	—
Engineering science and technology	2.9	8.3	1.9	0.3	—
Exact and natural sciences	32.4	52.3	17.6	9.4	—
Social sciences and humanities	1.5	3.8	5.3	7.6	—
Other	1.5	0.0	0.0	0.0	—

[a]Refers to postgraduate training not leading to an academic degree.
Source: Country reports, Pan American Health Organization, Washington, D.C., 1991.

age of researchers have doctoral degrees. On the other hand, there seems to be a more even balance between the biological and medical disciplines, as well as less collective research activity and more of a tendency toward independent investigation. Research in Argentina and Cuba appears more evenly distributed among the biomedical, clinical, and public health categories. The Cuban situation seems to resemble that of Brazil in having a predominance of collective research, and that of Mexico in having a greater predominance of physicians serving as agents of the investigative process (see Tables 1 and 2).

Scientific Production

Measuring the product of a research project in terms of the number of scientific articles published has evident limitations, since the project commonly produces a series of other results such as technologic innovations, development of human resources, development of methodologies, changes in established practices, etc., that are not directly reflected in the number of articles published. Furthermore, regional or local journals are commonly underrepresented in the international databases employed in this study. Therefore, using these databases

limits the analysis to studies accessible to the international scientific community—i.e., to Latin American studies circulating at the international level.

Through consultation of the databases cited above, the UNAM's Center for Information on Sciences and Humanities (CICH) identified 77 925 articles published between 1979 and 1988 in the five principal study countries and Chile. Of this number, 56% were published in journals of the country where the author resided (national journals) and 44% in international journals (Table 3).

Authors residing in Brazil and Mexico accounted for 59% of the published articles (33% and 26%, respectively). However, if the number of articles is divided by the number of inhabitants in each country, the rate per million inhabitants is found to be lower in Brazil (181.1) and Mexico (247.5) than in any of the other countries but Venezuela (226.1) (Figure 1). It was also found that Argentina and Venezuela were the only study countries where the number of articles published in international journals exceeded the number published in national journals (63% vs. 37% in Argentina; 53% vs. 47% in Venezuela).

The MEDLINE database is the one most frequently consulted by Latin American health professionals and is also accessible through BIREME. Considering articles retrieved only from this database (not retrieved from any of the other databases), the number of retrieved articles by authors in the six study countries was 36 937 (47.5% of the articles retrieved from all the databases). Of these articles, 36% appeared in international journals and 64% in national journals. While the apparent percentage of articles published in international journals was lower using the MEDLINE database than when all the databases were used, Argentina and Venezuela continued to register relatively high percentages of articles in international journals compared to the other countries (see Table 3).

Again using the MEDLINE database, an annual breakdown of the numbers of articles published in international journals revealed a significant drop in all the countries in 1986 and a subsequent upturn thereafter (Figure 2). Since the MEDLINE database is a stable one that includes foreign publications, it is probable that this drop was not due to any failure to publish periodicals or incorporate them into the database, but rather reflected a real drop in production. This drop could well be related to an earlier fall in research and development resources seen in virtually all the Latin American countries in 1983–1984,[9] assuming the two or three year interim was the time needed to register the impact of this resource shortfall upon article production (*8*).

With regard to subject matter, these MEDLINE listings show a predominance of clinical research articles (Figure 3). This finding could relate to the nature of that database itself, since it is associated with a medical library (the U.S. National Library of Medicine).

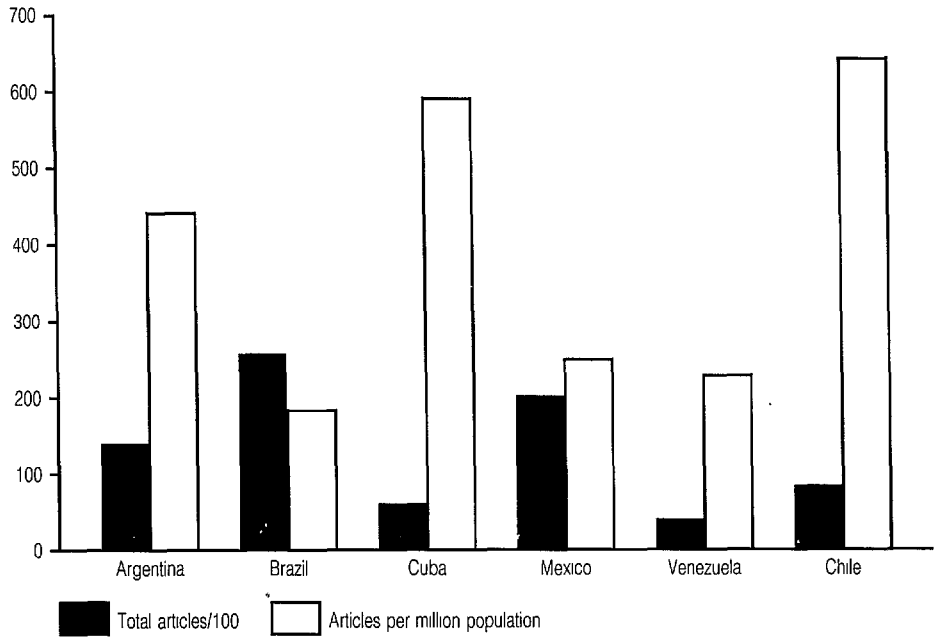
Interestingly, the Figure 3 data also show a marked net tendency of the six study countries' authors to publish biomedical research articles in international as opposed to national journals. Specifically, biomedical articles accounted for 28% of the articles published in international journals, as compared to only 18% of those published in national

[9]For example, R&D expenditures in Brazil fell from US$ 1 862 400 000 in 1982 to US$ 1 475 300 000 in 1983 and US$ 1 231 200 000 in 1984. In Mexico the drop was from US$ 795 100 000 in 1982 to US$ 591 800 000 in 1983. And in Venezuela it was from US$ 22 800 000 in 1982 to US$ 19 800 000 in 1983. In Argentina, where the fall in scientific production was not as marked, there was a recovery between 1982 and 1983, with R&D expenditure rising from US$ 361 100 000 to US$ 483 900 000 (*8*).

Table 3. Scientific production, 1979–1988 and 1972–1982.

Characteristics	Countries					
	Argentina	Brazil	Cuba	Mexico	Venezuela	Chile
I. Scientific production, 1979–1988:						
Total no. of articles identified by CICH:	*13 891*	*25 560*	*5 945*	*20 275*	*4 138*	*8 116*
Articles, national journals	5 133	14 564	4 303	13 395	1 927	4 486
Articles, international journals	8 758	10 996	1 642	6 880	2 211	3 630
Total no. of articles per million inhabitants	*446.6*	*181.1*	*594.5*	*247.5*	*226.1*	*649.3*
Articles, national journals, per million inhabitants	165.0	103.2	430.3	163.5	105.3	358.9
Articles, international journals, per million inhabitants	281.6	77.9	164.2	84.0	120.8	291.2
Articles (MEDLINE)	*8 929*	*21 063*	*1 501*	*16 156*	*2 388*	*8 463*
Subjects (MEDLINE):						
Biomedical	2 262	4 525	420	3 076	562	1 579
Clinical	5 319	12 937	744	10 484	1 283	5 351
Public health	1 348	3 601	337	2 596	543	1 533
National journal subjects (MEDLINE):						
Biomedical	890	2 919	292	2 108	150	1 180
Clinical	2 689	9 353	418	8 221	655	4 450
Public health	795	2 685	258	2 129	360	1 264
International journal subjects (MEDLINE):						
Biomedical	1 372	1 606	128	968	412	399
Clinical	2 630	3 584	326	2 263	628	901
Public health	553	916	79	467	183	269
II. Scientific production, 1972–1982 (ISI)						
No. of articles:						
Total for period	9 197	7 172	290	5 015	1 401	5 354
1973	1 181	414	21	368	107	471
1981	1 228	1 373	53	732	202	1 088
Total per million inhabitants	295.7	50.8	28.7	61.2	76.5	428.3
Articles by subject (%):						
Biomedical	36.3	50.9	36.2	37.0	55.6	49.5
Clinical	62.1	38.4	56.2	60.5	38.9	48.2
Public health	1.6	10.8	7.6	2.6	5.5	2.4
All fields:	*13 577*	*15 962*	*661*	*9 126*	*5 295*	*7 092*
Health	9 197	7 172	290	5 015	1 401	5 354
% health	67.7	44.9	43.9	55.0	26.5	75.5
Scientific production in all fields, 1972–1982 (ISI)	Latin America and the Caribbean (1) 57 610			Six countries (2) 51 713		% (2/1) 89.7
Scientific production in health, 1972–1982 (ISI)	Latin America and the Caribbean (3) 31 374			Six countries (4) 28 429		% (4/3) 90.6
	% (3/1) 54.5			% (4/2) 55		

Figure 1. Relative scientific output in the health field by Argentina, Brazil, Chile, Cuba, Mexico, and Venezuela in 1979–1988, based on the published articles retrieved from available databases by the Center for Information on Sciences and Humanities of the Autonomous National University of Mexico and expressed as total articles divided by 100 and as articles per 1 000 000 population.

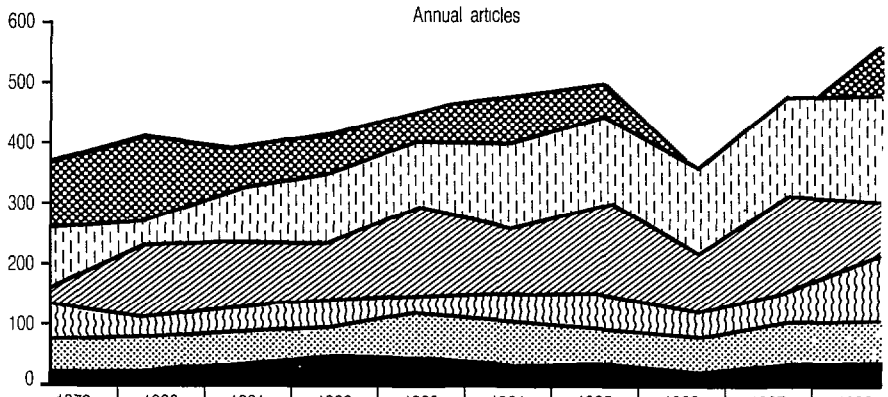


journals. This contrasts with the publication pattern of clinical research articles (which accounted for 63% of the articles published in national journals as compared to 58% of those published in international journals), and also public health articles (which accounted for 18% of the articles published in national journals as compared to 14% of those published in international journals).

Indeed, the Table 3 data show this trend in all six study countries except Cuba. (In the case of Venezuela, the international:national ratio of biomedical articles was 2.7, while the international:national ratio of public health articles was 0.5.) This general trend appears to reflect relatively greater international interest in biomedical research findings and a desire on the part of Latin American investigators working in this area to publish a significant portion of their work in journals of developed countries—a situation that has led Sandoval and Nuñez to point out that Latin American journals do not reflect, either quantitatively or qualitatively, the level of scientific research attained in their region (*9*).

To analyze 1972–1982 publication patterns, information from the Institute of Scientific Information (ISI) in Philadelphia was used. This institute, which edits *Current Contents*, compiles and publishes bibliographic information and maintains a database that includes the scientific journals that are better known internationally. As of 1980, only 17 of the 3 067 journals included in the institute's database were Latin American. However, during the 1972–1982 period a total of

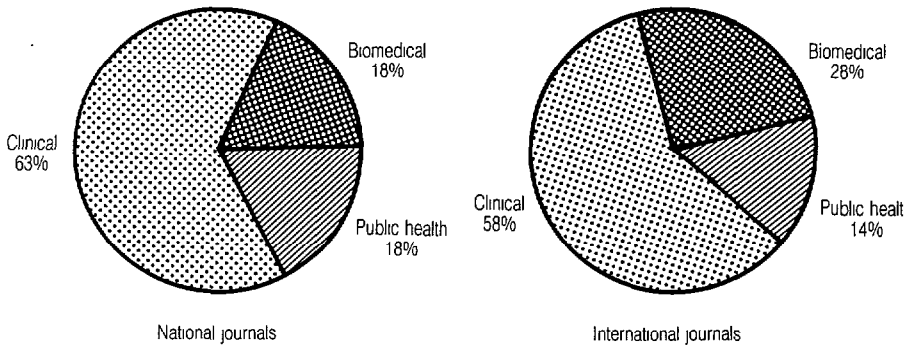
Figure 2. An annual breakdown of health-related scientific articles published by authors in Argentina, Brazil, Chile, Cuba, Mexico, and Venezuela in international journals during 1979–1988, as reflected in the numbers of articles retrieved from the MEDLINE database.



	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Brazil	373	412	393	415	455	478	500	352	444	565
Argentina	261	272	322	347	402	400	445	359	480	483
Mexico	161	230	235	232	293	258	298	215	315	308
Chile	133	111	127	137	143	151	148	118	154	216
Venezuela	74	76	86	94	116	103	90	75	104	106
Cuba	20	19	29	46	42	29	33	19	36	37

57 610 Latin American and Caribbean articles from all areas of science were recorded in this database, and 51 713 (89.8%) of these had primary authors residing in one of the six study countries (see Table 3). Over half of these Latin American and Caribbean articles (31 374) were health-related, and a comparable share of these (28 429 or 90.6%) had primary authors residing in one of the six study countries.

Figure 3. 1979–1988 articles by authors in the six study countries that were retrieved from the MEDLINE database, showing the articles published in national and international journals broken down by the type of health research (biomedical, clinical, or public health) being reported.



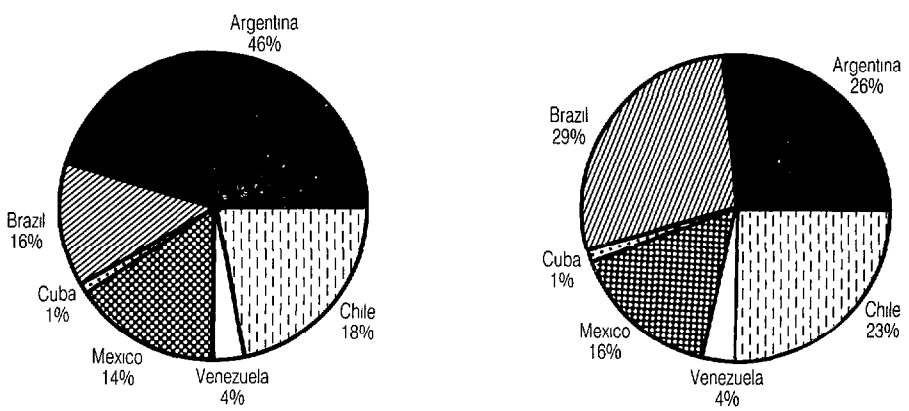
These health-related articles, both from all of Latin America and the Caribbean and from the six study countries, accounted for 54–55% of the scientific production in all fields over the 1972–1982 period. However, it is important to note that the period saw a significant shift in the relative distribution of published articles in various scientific fields. Specifically, the available data suggest that the production of scientific articles in Latin America tended to assume a distribution more similar to that of the world at large, with the percentage accounted for by health research falling from 60% in 1973 to 42% at the end of the period, while the share accounted for by physics research increased from 9.2% to 19.5% and that accounted for by research in engineering and technology rose from 2.7% to 4.5% (2).

With regard to the distribution of health-related articles among the six countries, the trend observed with the CICH data was repeated. Brazil and Mexico accounted for 43% of the total number of articles (25% and 18%, respectively), but the numbers of health-related articles published in these countries per million inhabitants were relatively small (see Table 3). Chile and Argentina had the best performance in terms of scientific production per unit of population, with 428.3 and 295.7 articles per million inhabitants, respectively.

The distribution of articles among the six countries underwent a significant change between 1973 and 1981, there being a marked relative drop in Argentina and marked increases in Brazil and Chile. Argentina, which produced 46% of the health-related articles included in the database in 1973, produced only 26% in 1981. During this same period Brazil's share rose from 16% to 29%, Chile's share rose from 18% to 23%, and the shares of the others remained relatively steady (Figure 4). In absolute terms, the numbers of health-related articles from Argentina remained fairly steady in this period, rising from 1 181 in 1973 to 1 228 in 1981; but total health-related contributions from the six countries rose 82.5%, increasing from 2 562 in 1973 to 4 676 in 1981.

Regarding classification of health-related articles by discipline, the overall ratio of medical articles to natural (biological) sci-

Figure 4. Relative scientific output in the health field by authors in the six study countries in 1973 and 1981, expressed as percentages of the published articles retrieved from the ISI database in those years.



ence articles was 2:1—this ratio ranging from 4.5:1 in Mexico and 2.8:1 in Cuba to a low of about 1:1 in Chile.

With regard to subjects, defined according to the classification of periodicals in the ISI database, public health research accounted for only 4.5% of the articles recorded in 1972–1982, while clinical research accounted for 52% and biomedical research accounted for 43.5%.[10] Here again there were variations between the countries, with biomedical articles predominating in Brazil and Venezuela. A low level of collective research in this period may be suggested by the fact that 31.3% of the articles had only one author and about half had no more than two authors.

About three-quarters of the national journal articles in the ISI database were medical science (as opposed to biological science) articles, while those articles published internationally by authors in the six countries were about evenly distributed between the medical and biological sciences. Of the articles by authors in the six study countries that were listed in the ISI database, 23.8% were published in U.S. journals, 18.4% in Argentine journals, and 14.2% in Chilean journals. All of the 10 Latin American journals where ISI database articles by the authors in the six countries appeared most frequently were journals published in those six countries. Overall, these journals accounted for 43% of the articles listed. In general, there was a strong correlation between an author's country of residence and the national origin of the journal in which his article appeared.

[10]It is interesting to note that the degree of public health participation in terms of published articles is lower than the degree of public health participation in terms of research projects under way, a finding which appears to indicate that the proportion of public health research projects tending to produce articles is relatively low.

Socioeconomic Considerations

The relatively small number of countries studied makes it difficult to establish a clear correlation between scientific production and socioeconomic indicators as of the mid-1980s. However, if we analyze these countries merely in terms of associations between variables, a number of interesting observations can be made.

To begin with, we can find strong correlations between the numbers of articles coming from each of the six countries in 1979–1988 and those countries' respective population sizes, gross domestic products, and levels of energy consumption. However, if we control for population size by substituting the number of articles per million inhabitants for the number of articles, these correlations disappear. In their place we find correlations with certain indicators of social development such as literacy and life expectancy. These findings would seem to indicate, at least for the group of countries under study, that there is an association between levels of scientific activity and levels of social development.

CONCLUDING REMARKS

If there is one clear conclusion that can be drawn from this study, it is that Latin America's information systems and statistics on health science and technology are very weak. This known weakness, one consistent with the region's general pattern of scientific development, can be attributed to a gap between science and society, particularly the social sector producing goods and services. As a result of this gap, there is commonly a failure to impose any requirement that the relevance, quality, and impact of scientific production be evaluated with a view to orienting it toward meeting specific social needs.

It should also be noted that the prin-

cipal aim of this study is not one directed at publication of results. The study's principal aim is to encourage the formation of research groups—groups dedicated to examining the structure and development of health-related scientific activity, guiding the improvement of scientific and technical health information systems, and helping to mobilize resources and encourage the main actors in the field so that health research can meet the expectations of the peoples of the region.

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