



Commentary

Constraints on Research in Biological and Agricultural Science in Developing Countries: The Example of Latin America

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Abstract: Science is an international effort, receiving contributions from researchers across the globe. The capacity of a country or a region to generate and publish quality research varies greatly according to the location examined. Among the factors that dictate the quantity and quality of scientific research are the availability of infrastructure and human resources, the traditions related to research endeavors, and, most significantly, local governmental support for research. There are several conditions that both individually and cooperatively limit research activities in Latin America, such as insufficient governmental support, a paucity of material and technical resources, heavy teaching loads, the absence of peer networks, and multiple constraints on publication. This commentary has been developed to discuss each of the issues that permit and, more frequently, limit biological and agricultural research endeavors in Latin America.

Keywords: developing countries; research; constraints; Latin America; scientific investigation



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1. Introduction

Scientific research is a practice that should not, and does not, respect international borders with respect to benefitting the peoples of the earth. While there are many trained scientists in undeveloped regions, most of the research and publications in recent decades have originated from developed countries. This is due to the major gap between high- and low-resource settings [1]. Countries in Latin America, for the most part, fit into the latter category, which is the result of systemic barriers to conducting and publishing quality research. The most significant reason for this disparity is the lack of sufficient funding for research, which is exacerbated by the failure of governments to recognize the importance of scientific investigation. This results in multiple negative consequences in the form of heavy teaching and administrative burdens on researchers and the reduced quality and maintenance of equipment. A scarcity of resources constrains, and often prevents, productive integrated research efforts. Other factors, particularly the structure of academic publishing institutions, encumber researchers in Latin America in a number of ways. First, the cost of subscriptions to journals is often prohibitive; thus, the newest research is often unavailable. Nevertheless, researchers are required to publish in these journals for credibility [1]. The lack of peer review and effective mentoring networks in Latin American institutions have a widespread dampening effect on research and publication. The purpose of this article is to elaborate on the nature of constraints on research and publication in Latin America and propose corrective interventions.

2. Lack of Governmental and Institutional Support for Researchers

2.1. Lack of Funding

Emerging economies struggle to commit sufficient funding for research relative to their gross domestic product. For example, countries such as Japan, Great Britain, and the

United States invest almost 3% of their gross domestic product into research [2]. In stark contrast, most Latin American countries invest less than 1% of their GDP in this manner (Figure 1). This obvious shortcoming and consequent lack of funds retards the progress of scientists in this region. The result is that only the most successful individuals in the field of research and technology obtain local or external funding. The recent economic crisis in this region has further exacerbated these limitations. This is particularly true in the more developed countries in the area, where local funding was previously available through government councils. These limitations are often volatile and dependent on current government policies [3] and, more recently, hampered by political interference [4]. The situation has worsened in the less developed countries in the region that have depended heavily on international funding through special programs sponsored by foreign sources. Unfortunately, the recent COVID-19 pandemic has caused the support offered by international aid programs to underdeveloped countries to nearly cease [5,6].

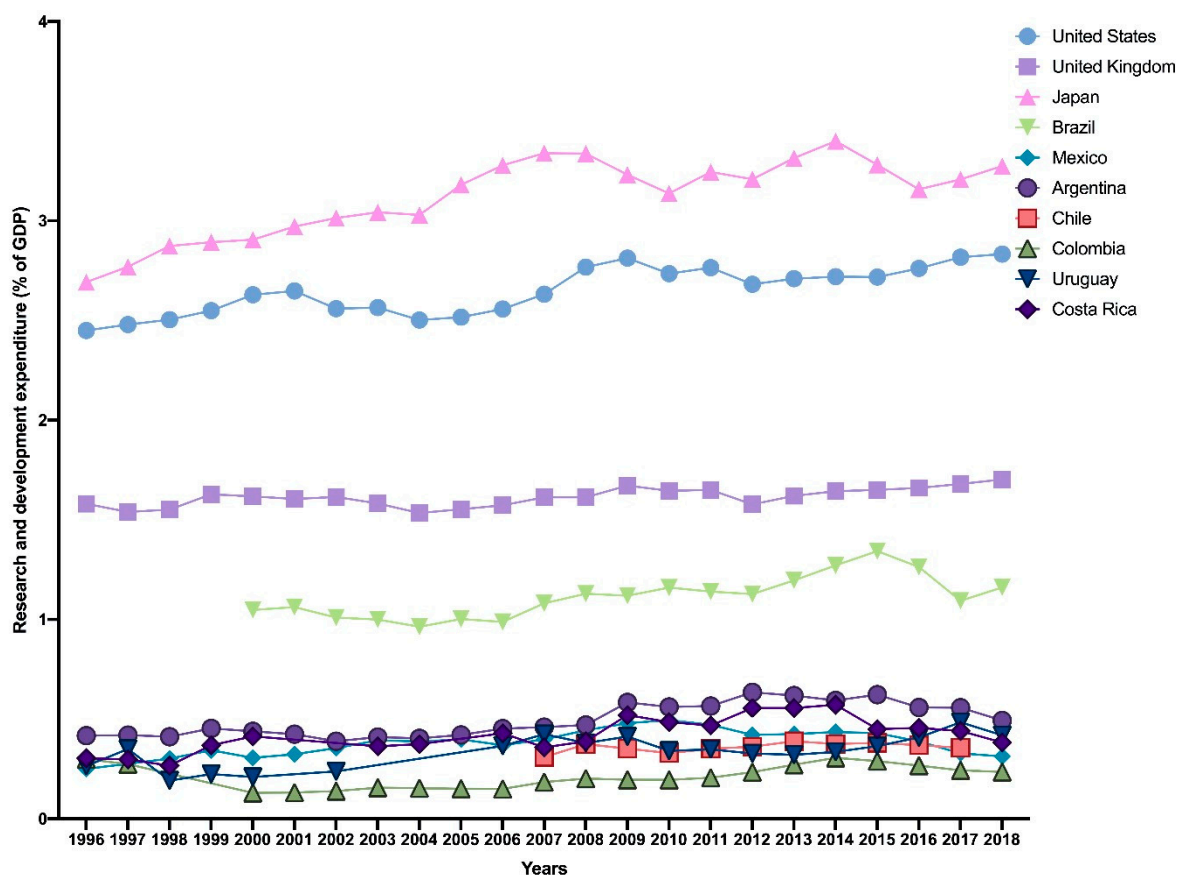


Figure 1. Research and development expenditure expressed as percentage of GDP from 1996 to 2018. Source: <https://ourworldindata.org/grapher/research-spending-gdp> (accessed on 1 March 2023).

There have been further consequences of the COVID-19 crisis. Programs that shared common research activities and resources, both social and economic, have diminished considerably during the period when travel between countries was interdicted. The feasibility of field work declined dramatically compared to previous years and decades. The optimistic view, whether justified or not, is that brighter days are coming, as most travel regulations related to health issues have been eliminated.

2.2. Insufficient Research Infrastructure, including Inadequate Laboratories, Absence of Key Equipment, and Lack of Provision for Maintenance

As can be seen in Figure 2, the lack of funding research in biological and agricultural sciences is probably the principal limitation to the successful production of up-to-date

science by researchers in developing countries. In addition, the lack of the most modern equipment and of the supplies and reagents necessary to generate credible data constitutes a major shortcoming. This restricted access to the latest equipment results in research conducted at a shallower depth, which is often incomparable to that published by laboratories in more developed countries around the world. This insufficiency reaches far beyond the latest equipment, as scientists in developing countries face persistent problems such as a lack of maintenance and repair of critical equipment in their institutions [7]. This is more evident in countries where such equipment has been donated through international projects, for which subsidized repairs and maintenance are conducted through existing programs. This funding usually ceases with a project's end, and scientists are left with problems such as a lack of replacement parts and inadequate professional service for maintenance and repair. In addition, it is often difficult to update instruments or software due to a lack of funding and expertise on the part of those who maintain the equipment.

SCI Publications (2000 - 2023)

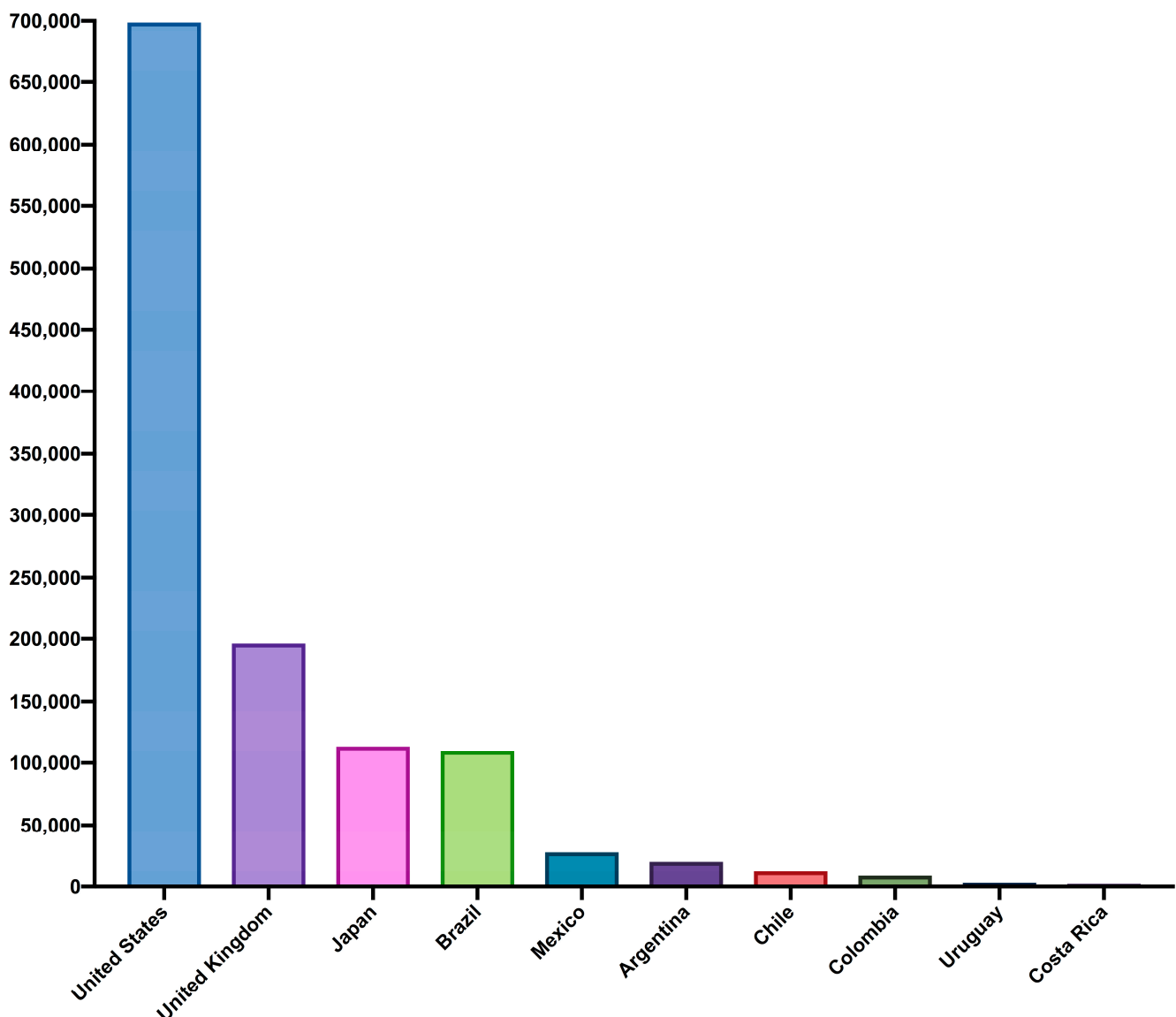


Figure 2. Total publications in biological and agricultural sciences per country from 2000–2023. Source: <https://www.webofscience.com/wos/woscc/summary/aa61e6ed-7360-43a0-a395-38f0e77dfb1d-76f77d91/relevance/1> (accessed on 1 March 2023).

These shortcomings have created a catch-22 situation for many scientists, particularly those trained in industrialized countries, as they cannot continue with the topics and focuses of research for which they were trained. Notwithstanding, there are some success stories of scientists returning from the more developed world to laboratories in the region who have found niches permitting the continuation of their productive research [8].

2.3. Lack of Support for Interactive Teams and Projects and Consequent Competition for Scarce Resources, Thereby Engendering Poor Collegial Interactions

International funding organizations often prefer to support integrated research teams. Nonetheless, the successful exploitation of interactive teams is often challenging because individual interests conflict with team integration. Some researchers are individualistic by nature and resist cooperation in research teams, thus retarding the progress that could be achieved via an integrated approach. Competition often ensues at the expense of both progress and collegiality, a problem often exacerbated in developing countries. Indeed, a chronic penury of resources is probably the most significant cause of the failure of integrated programs and often impairs normal cooperation among scientists. Nonetheless, there is a tendency toward a reversal of this trend. Gaillard et al. [8] reported that in Latin America in 1988, only ten percent of the articles from the region had two or more authors from two or more countries. In a recent survey, Adams and Pendlebury [9] demonstrated that Latin American scientists are increasingly seeking international cooperation, and, presently, almost 35% of communications in the database *Journal Citation Reports* were published via international collaboration (Figure 3). Unfortunately, less than 10% of research cooperation occurs between scientists in this region; rather, the most common interactions are with scientists in the industrialized world [10].

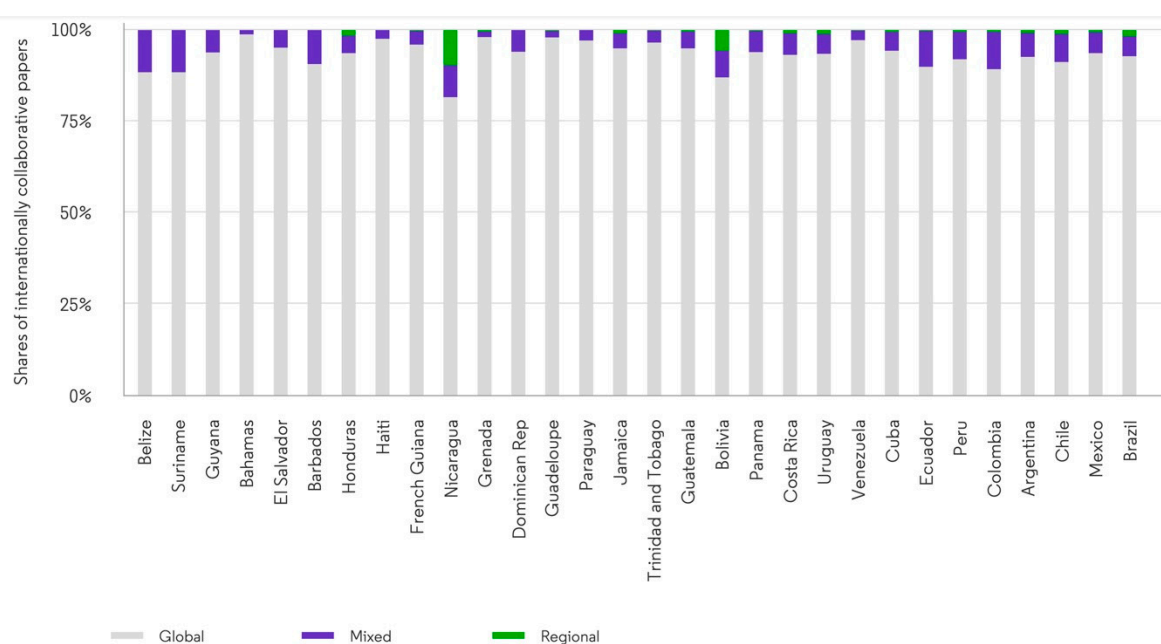


Figure 3. Balance of internationally collaborative output for Latin American countries with more than 100 papers indexed in the Web of Science in the last 10 years. Source: <https://clarivate.com/lp/latin-america-south-and-central-american-mexico-and-the-caribbean/> (accessed on 1 March 2023).

2.4. Systemic Constraints on Development of New Generations of Research Scientists in Latin America

A further problem is that the educational system in Latin America is not geared toward training scholars to be open-minded and question the research concepts and approaches of their mentors [11]. This is evident at the university level, where students need only to memorize information to pass examinations. This tradition does not develop independent

thinking nor the questioning of ideas and dogma. This is remediated to a certain extent in some countries, wherein the undergraduate curriculum requires a form of exercise such as an undergraduate thesis for the completion of a professional degree. Thus, students are obliged to participate in research directed by professors at their institutions. This introduction to research can foment curiosity in young scholars and inspire their enthusiasm to become scientists. Further training can then be acquired in graduate programs both at the national and international level. It is unfortunate that the availability of this potentially valuable pathway is declining in most institutions, as economic pressures to maximize student's enrollment in academic programs demand maximal graduation rates. Graduate training has been replaced by alternatives, such as more in-depth exams and ephemeral study visits to diverse institutions, that require a brief report at most. In addition, the number of publications resulting from undergraduate theses is quite low in Latin America [11]. This superficial approach to the training of young researchers hinders their progress and development as scientists [12]. To make matters worse, the aging of scientists in Latin American institutions has become a serious obstacle to the maintenance of a vibrant professorial corpus and the development of younger colleagues (Figure 4).

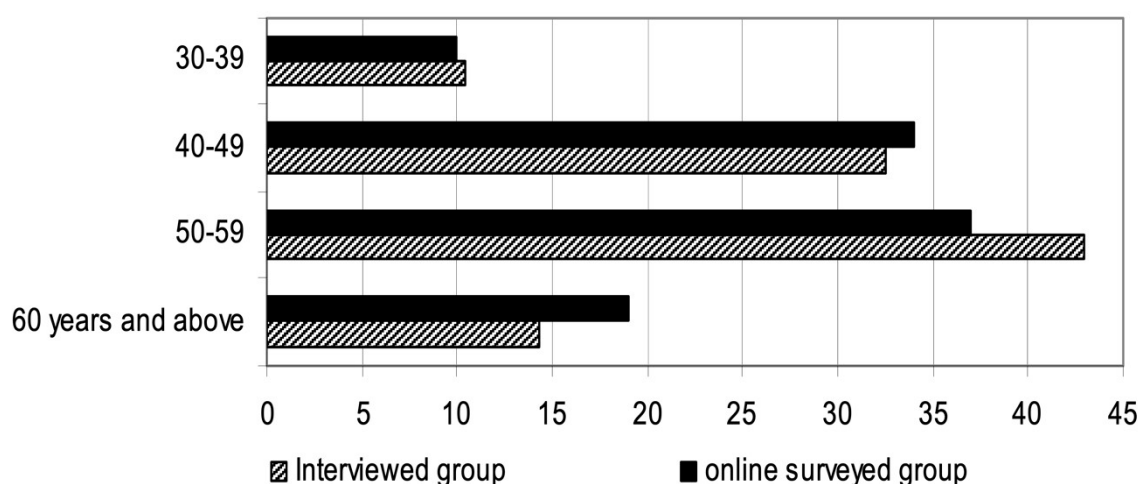


Figure 4. Age profiles of the scientists in Latin America. Source: [8].

2.5. Heavy Teaching and Administrative Loads Interfere with the Research Productivity of Latin American Scientists

In Latin America, research activities are most commonly carried out at establishments of higher education. There are very few organizations exclusively dedicated to investigations. Given the predominant focus on teaching in Latin American institutions, researchers are confronted with burden classroom and individual laboratory activities, which frequently involve large groups of students. New faculty members are often burdened with greater teaching loads than their experienced peers. This is particularly deleterious to the development of research programs by young investigators, who often find it difficult to distribute their time productively. In addition to problems related to heavy teaching loads, academics are obliged to participate in committees and occupy posts in the administration of an institution, further compromising their research productivity [13]. In an informal survey undertaken with respect to researchers working in academic institutions in Costa Rica and México, it was found that due to contractual conditions, researchers must spend at least eight hours per week in the classroom and another ten hours per week engaging in practical exercises. The main complaint of the researchers interviewed was the imposition of an additional administrative load, which added as much as another ten hours per week.

3. Resource and Cultural Constraints on Research

3.1. Shortages of Tutors and Mentors with Sufficient Insight and Experience

Another serious hindrance to the development and execution of research programs in Latin America is the lack of a critical mass of peers for collaboration and consultation [13]. The interactions in developed countries that provide researchers with critical feedback and advice about experimental design, the interpretation of results, and the preparation of scientific communications range from being rare to absent in Latin America. This is of particular significance to novice researchers who lack the benefits of having been mentored by experienced scientists. Gaining experience in research, and particularly in seeking external funding, is greatly enhanced by participation in active and interactive research centers. The absence of this practice is reflected in this region's deficient undergraduate or graduate training that does not place sufficient emphasis on rigorously conducting research. Thus, scientists and academics in Latin America may have difficulty formulating valid hypotheses, developing sound experimental designs, and interpreting results. This problem is more acute for new researchers that need to establish their research programs and laboratories at institutions that are vastly different from those in which they were trained [14].

3.2. Recognition of Researchers at the Local and National Level in Latin America

A common shortcoming of research activities in Latin America countries is that the most productive and successful laboratories are those situated in large urban areas [7]. This situation leaves laboratories in the provinces at a clear disadvantage; using Brazil as an example, (Figure 5), it can be observed that universities located in urban areas are more productive than those in the provinces. However, this situation can be overcome, as indicated by Lopez-Olmedo et al. [15], when working in Mexico, analyzed several government policies to increase the participation of laboratories outside urban centers. These policies have had some success, as, in 1950, 90 percent of the publications emerged from the capital, Mexico City. Today, only 50 percent are produced in this metropolis.



Figure 5. Number of publications of Brazilian universities. Search using beef cattle as a topic in the Web of Sciences—Clarivate database. Source: <https://www.webofscience.com/wos/woscc/analyze-results/b1a86c8c-18e7-4c4db37f-f7a0d0d1bca5-762b9dde> (accessed on 1 March 2023).

There is considerable variation among countries in Latin America with respect to the degree of development of, or emphasis on, research. Whereas some countries have established programs, such as a national system of researchers, others have none. These programs were usually created as schemes to prevent the intellectual migration of productive or potentially capable scientists to industrialized countries where research opportunities are more abundant. Although this is a laudable initiative, it only occurs in countries with robust economies. Further, this system has several pitfalls. Perhaps the foremost mem-

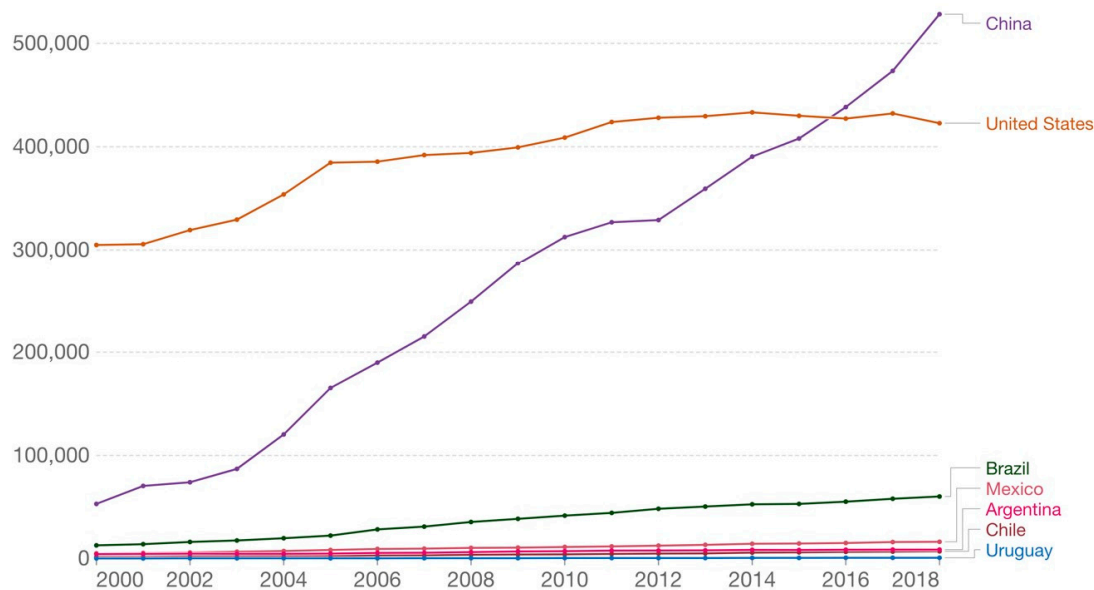
ber of these pitfalls is that success in national systems is often based on the frequency of publication in “reputable journals with a high impact factor”. This requisite most often fails to recognize the excellent local research that may not meet the stringent evaluation of international journals. This is of particular significance for researchers working on, for example, long-term problems such as the development of new varieties of crops or new techniques for management of food producing animals. These topics are often out of the mainstream of international science, and the principal metric for evaluation, the number of citations, ignores the local or national importance of these studies. Likewise, this research is a long-term investment that often does not yield frequent publications. Nonetheless, Adams and Pendlebury [9], in an extensive study using several databases, it was found that researchers from Latin American countries with larger economies are increasingly being cited in the mainstream literature. Cuba is a good example, as its researchers have had scarce visibility in the past but have increased their number of citations considerably [16].

3.3. Lack of Trained Technical Support

Science, and the technology that supports it, evolves rapidly. Laboratory or even field methods are in a state of constant flux, with better versions emerging frequently. New and superior laboratory equipment becomes available regularly. Exploiting the rapid change in technical expertise is hindered by the absence of trained technicians in the developing world. This problem is heightened in Latin America, where universities have not sufficiently developed programs to train technical staff, particularly in biological sciences, when compared to laboratories in the USA or China (Figure 6). Researchers in Latin America, who are distant from the sites where they were trained, depend heavily on their previous experience to train their collaborators and students. As technology evolves, their capability to impart state-of-the-art methods and approaches declines. This problem is aggravated by the lack of qualified and experienced technical staff that can serve to maintain the continuity of research projects.

Scientific and technical journal articles, 2000 to 2018

This is counted by the country of the author's institution. Includes scientific articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.



Source: National Science Foundation (via World Bank)

OurWorldInData.org/research-and-development • CC BY

Figure 6. Scientific and technical journal articles from 2000 to 2018. Source: <https://ourworldindata.org/research-and-development> (accessed on 1 March 2023).

3.4. Weakness in or Absence of Supportive Peer Networks

After returning home from training in more developed countries, researchers often experience a lack of supportive peer networks with whose support they can be advised and assisted in their research activities in their new academic environment. This usually has a pronounced negative effect on their progress as researchers. Physical facilities, such as equipment and laboratory and animal resources, are often woefully insufficient. Perhaps the most critical obstacle these researchers face is isolation from a supportive collegial network. This is often reflected in the inability to receive honest and critical judgement from experienced colleagues on scientific questions such as the design and interpretation of experiments. This deficiency is often accompanied by a lack of valid and supportive criticism of scientific manuscripts.

In some cases, early-career scientists continue to engage in collaborative programs with their former tutors, a strategy that is beneficial to both parties. Successful interactions at a distance can include study visits by the former mentor to address strategies for local experimental approaches, the provision of facilities for the students of the new researcher so that they may learn techniques in their laboratory, or, in some cases, the processing and evaluation of samples. In addition, there are exchange programs allowing students from a university of an industrialized nation to assist in the implementation of a research project. While these solutions to academic isolation are often productive and useful, they do not address the core problem of a shortage of a critical mass of researchers together with the lack of policies that support local mentoring and interaction. It has been proposed by Song and Gan [17], that opportunities for international mobility predict research output. As noted above, this is not judged to be a comprehensive solution to the lack of local mentorship.

3.5. Difficulties in Responding to Rapid Changes in Research Methods and Focus

All aspects of science, particularly biological research, are undergoing constant and rapid evolution. Methods are now available in this field to investigate topics in unprecedented depth and breadth. Laboratories in the developed world adapt quickly and adopt new technology. Two factors impede Latin American scientists from keeping abreast of the rapidly changing technological landscape. The first of these is training, as modern methods are technically complex and learning them is usually not intuitive. The second is the cost of equipment and reagents. Modern molecular technology requires expensive instrumentation, which is often quite sensitive to the conditions of a laboratory environment. Repairs are costly, as are service contracts. Both new and experienced researchers struggle to find funding for the technical aspects of their projects. This leaves them at an even greater disadvantage when competing with scientists in more affluent societies to produce high-quality and high-impact research. Technological issues greatly influence publication, as reviewers can question the validity of studies where the latest equipment or technology has not been employed. There does not appear to be an easy solution to this problem, and the best approach to coping with this constraint seems to be through cooperative programs, national or international, that may, in part, alleviate the economic crisis in Latin American institutions.

4. Constraints on Publication of Research in Developing Countries

4.1. Inadequate Library Facilities and Information Access due to High Subscription Rates and Financial Constraints of Researchers including Page and Open Access Charges

Print journals are becoming obsolete for several reasons, including issues related to cost, availability, and convenience. Library subscriptions are rapidly disappearing as space and cost have precluded universities from continuing this practice. Indeed, most publishers now provide only electronic versions of journal issues. Despite the progress of the open access movement, subscription to scientific journals has remained expensive [1]. Many journals, including the most prestigious, maintain articles behind a paywall for long periods. Hybrid journals, which offer some articles in an open access mode, provide greater accessibility of scientific research to researchers, but their impact is often limited. To

exacerbate the problem, some universities, even in industrialized countries, have decided to cancel their subscriptions to some of the most reputable journals. This decision is often based on the frequency with which the journal is consulted. There has been some progress in improving access. For example, the organization Research4life is a nonprofit with the aim of improving online access for scientists from lower-income countries to journals with a paywall (<https://www.research4life.org/about/>—accessed on 1 March 2023). Much of Latin America is not included in this program, but some regions can benefit from low-cost access. Further, the open access system moves the cost of publishing from journal subscriptions to the researcher, often rendering article publishing charges far that are too expensive for many researchers in the developing world [18,19]. At the upper end of the open access cost spectrum is the journal *Nature*, which charges USD 10,500 per article. Other journals are less expensive, but costs from USD 1500–3000 are quite common (Figure 7).

Elsevier Article Publishing Charges

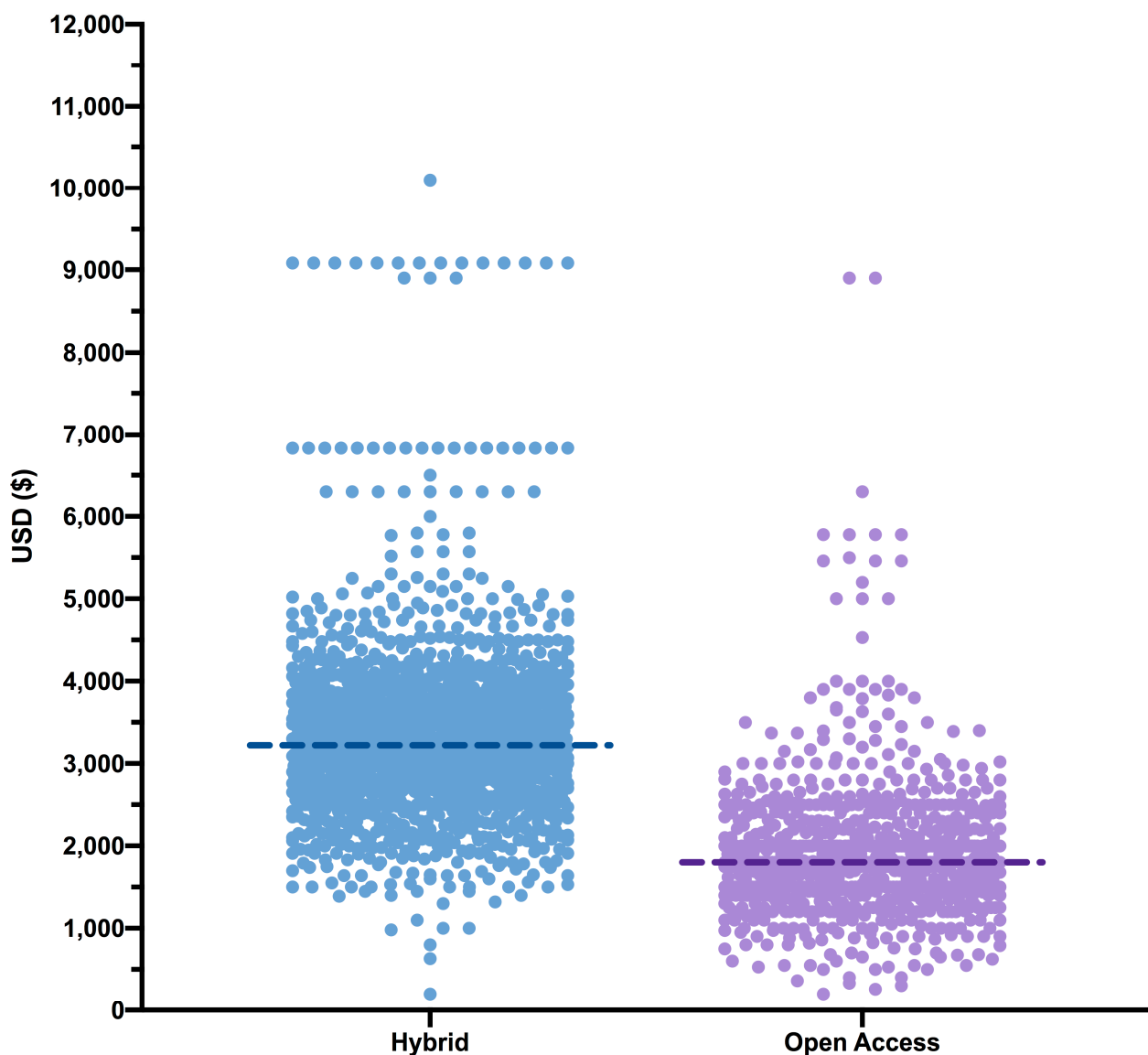


Figure 7. Article-publishing charges taken from Elsevier as an example in open access or hybrid journals. Individual points (Article-publishing charges of Elsevier Journals) and dotted lines (Mean). Source: <https://www.elsevier.com/about/policies/pricing> (accessed on 1 March 2023).

Countries, particularly in Latin America, most frequently do not benefit from reductions in publishing costs, and usually neither the country nor the institution can collaborate to meet the expense. Scientists depend on grants, and the costs of publication compete with personnel and operating costs in the management of a research program. Overall, the costs of acquiring published information from, and of publishing in, recognized journals are often prohibitive to researchers in Latin America, providing yet another constraint to their scientific progress. Remarkably, some investigators in Mexico split the cost of publication among the authors, who pay from their personal funds [4]. Two recent communications address this issue. Rodrigues et al. [19] suggests that article-processing charges should be modified in order to give equal opportunities to scientists in developing countries. Cabrerizo [18] in a letter to the journal *Nature*, likewise identifies a need for equal opportunities in open access journals so that scientists in developing countries can have a fairer chance to publish.

4.2. Infrequent Presence of Scientists from Developing Countries on Editorial Boards of International Journals

Traditionally, editors and editorial boards are composed of scientists working in industrialized nations. This tradition frequently extends to the reviewers chosen by editorial boards. Therefore, the perspective of traditional journals is often limited and does not recognize the significance of region-specific research to the conditions where experimentation was performed [20]. There has been some progress over the last few years, as the number of scientists from developing countries on editorial boards has increased. To date, these advances are not sufficient, but publishers and editorial committees have at least become sensitized to the need for more scientists from less-developed nations to be included in the decision-making aspects of publication.

Most scientists who publish have experienced the discouraging response from editors indicating that their manuscript has been triaged, that is, not sent for review. The consequence is that without peer review, no comments from reviewers are provided. The lack of criticism and feedback from peer reviewers does not aid inexperienced researchers' ability to recognize the weak points in their manuscripts and, crucially, does not permit revision and resubmission. Thus, this important benefit of a learning experience is lost to researchers from Latin America. The appointment of editors from this region has the potential to reduce triaging and thus provide authors with a greater chance to receive feedback on their manuscripts.

4.3. Tyranny of the Impact Factor

There are no unequivocal or non-subjective criteria with which to judge the quality of research publications. Bibliometrics, the science of the study of publications, has given us a number of measures, the most frequently used of which is the impact factor. This metric is based on a calculation of the number of citations in a journal over a two-year period, and it was created in 1955 [21] to give a coarse estimate of the frequency with which a journal is cited. It was not meant to be applied as it is today, as an indication of the quality of a journal or an article, based on an evaluation of a researcher's productivity or a tool to be used in hiring and advancement decisions. Generally, impact factors vary with the popularity of the subject, the novelty of the article, the nature of the study, and the size of the scientific community. Judgment using only the impact factor has introduced serious distortions, which have affected creativity and precipitated a preoccupation with catering to popular topics and the social relevance of science [22–24] (Figure 8). Fortunately, there are new bibliometric measures in the developing field of altmetrics, such as the number of times an article is consulted online or the number of times it was downloaded, which have the potential to provide a better indication of interest in research articles. Their adoption in place of the classic impact factor would be beneficial to the worldwide scientific community.

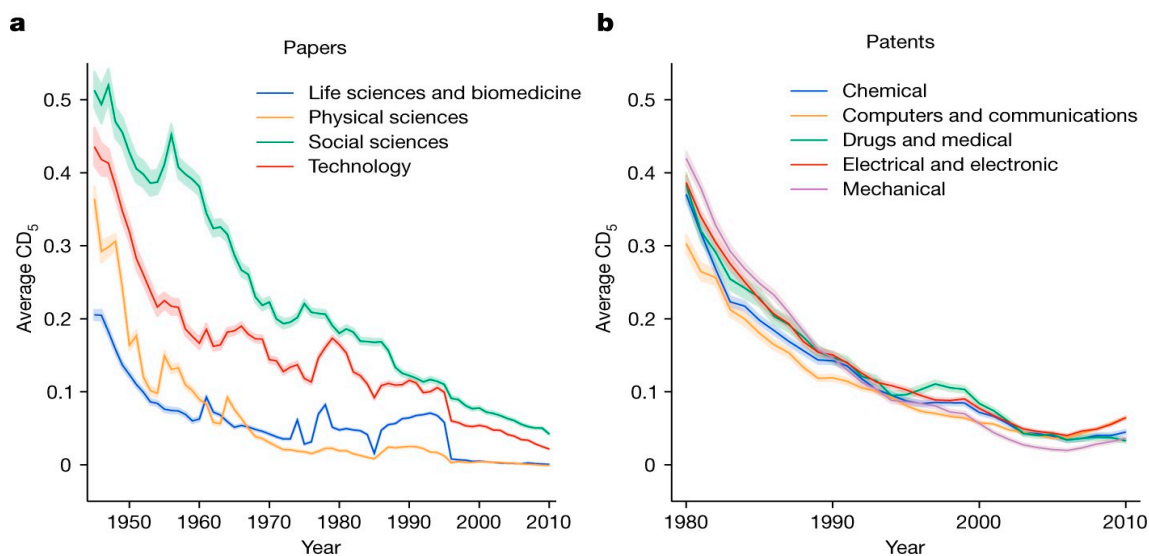


Figure 8. (a,b) Decline in the CD₅ index over time, segregated according to papers ((a), $n = 24,659,076$) and patents ((b), $n = 3,912,353$). Shaded bands correspond to 95% confidence intervals. Source: <https://www.nature.com/articles/s41586-022-05543-x#Sec9> (accessed on 1 March 2023).

4.4. Insufficient or Absent Culture of Publication at the Institutional Level

In general terms, the academic promotion system in Latin America is based on the number of years a professional has been employed by an institution as well as other issues, such as the number of hours that the academic spends on teaching activities. Very few academic institutions, particularly those in less-developed sectors in Latin America, provide accreditation towards the advancement, based on research and publishing.

Conversely, in the more developed nations in Latin America, there has been a tendency for committees evaluating academic progress to imitate the procedures and standards of institutions in the industrialized world, with the aim of establishing high standards for their institutions. Time will tell whether this idea is good or bad, but for now, it seems to be an unfair process as it insists that the most important criterion is that researchers publish in journals with elevated impact factors. The out-of-hand dismissal of publications in regional or less prestigious journals discourages research. Bosman et al. [25] have analyzed the problems of Latin American journals. They found that these journals lack professionalism, as editing is often left for completion by a member of the academic staff, engendering only small budgets and little commitment from the editor. In addition, regional journals are generally not included in the mainstream literature; thus, the information suffers from lack of visibility [10]. Further, and as noted above, it is essential that investigators be provided with a supportive and sufficiently funded research environment if there is to be an expectation of publication in high-impact journals. Generally, evaluating committees do not recognize that even publishing a young researcher's work in a local or specific journal gives them the opportunity to cite his/her published work in future manuscripts submitted to more recognized journals.

4.5. Lack of Understanding of Publication Processes and Journal Options

The movement of scholarly journals from print to digital format has engendered changes in publication procedures and created a serious burden for reviewers and editors alike. The volume of articles sent for consideration to be published has increased exponentially in the last few years [25]. In addition, online publications have no page budgets or costs related to printing; therefore, the authors are able to submit long manuscripts [26]. These changes have decidedly modified the process of publication for authors from Latin America.

There are some alternatives for scientists in developing countries. One approach has been to publish locally in journals; unfortunately, as indicated earlier, some of these lacks

sufficient periodicity and/or scientific rigor [10]. Another alternative is to publish in open access journals, which are increasing in number. Many of these journals require accuracy and validity in an article but not originality or significance [26]. Moreover, papers are often assigned to reviewers who are not experts in a given area and who have the required technical ability to evaluate methods and results but lack the expertise to evaluate the totality of a manuscript, particularly the overall significance of the work. These reviewers often lack the capacity to determine whether authors are quoting the right literature to support their rationale, data, and conclusions. This is a serious problem, as the citation of obsolete or inappropriate studies can lead to invalid conclusions. Figure 9 summarizes the differences between publishing in journals covered by Web of Science versus those in SciELO. As can be seen, the volume of articles in English is overwhelmingly high.

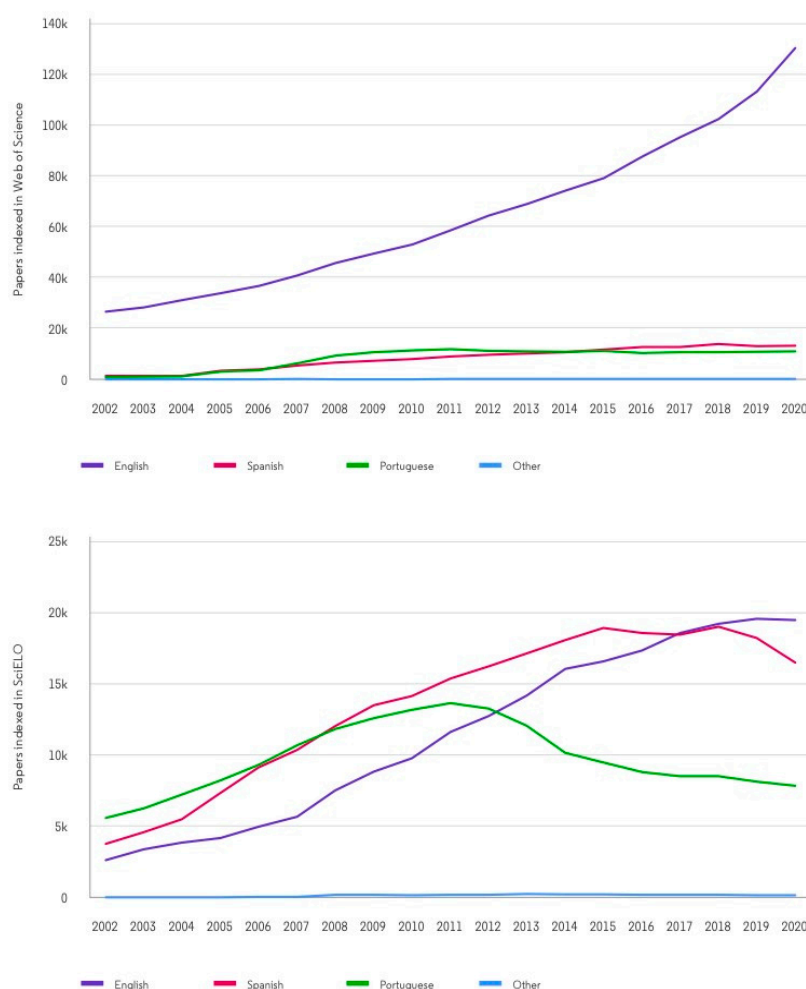


Figure 9. The language coverage of Web of Science (top) and SciELO (bottom). Source: <https://clarivate.com/lp/latin-america-south-and-central-american-mexico-and-the-caribbean/> (accessed on 1 March 2023).

4.6. English Language Difficulties

Most high-impact journals require publication in English. Papers written by non-English speakers have the additional burden of convincing reviewers and editors that their material is worth publishing [14,27]. There is a clear difference between writing in English, particularly scientific English, a language precise and not so eloquent, and languages such as Spanish or Portuguese, where the vocabulary is rich, and the tradition is to carry on with long sentences and cumbersome paragraphs. It is not uncommon that a scientific article written in the latter two Romance languages is difficult to accurately translate into a sound document in English. The alternative, writing in English, may be a better approach for

Latin American academics, but it takes time to master. Scientists trained in industrialized countries, where there is more of a tradition to write in English, will have an advantage over those trained locally. In a survey of Brazilian scientists, Vasconcelos et al. [27] found that researchers with good writing skills are considerably more productive, as measured by the number of publications, as opposed to those with reasonable or poor writing skills (Figure 10).

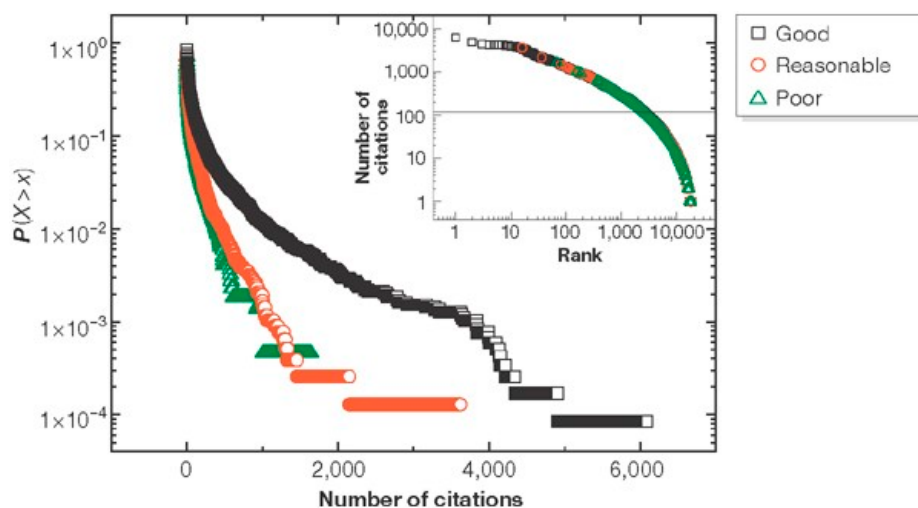


Figure 10. Cumulative distribution of researchers with different writing skills, judged as good (black squares), reasonable (red circles), and poor (green triangles), according to the number of citations. Source: <https://www.embopress.org/doi/full/10.1038/embor.2008.143> (accessed on 1 March 2023).

4.7. Lack of Confidence and Fear of Rejection

Early-career researchers that require their results to be published often find it difficult to synthesize their information into a cogent manuscript. Some have the tendency to attempt to write the perfect manuscript but at a great cost in terms of time and effort. Writing difficulties are further compounded by lack of confidence and a fear of rejection; cultural features common among Latin American scientists. Inflexible approaches to article preparation and an inability to accept criticism can further impede the development of publishable manuscripts. When receiving an array of comments, many researchers tend to see the negative part of the equation, i.e., that the paper is not acceptable in its present form. However, they fail to see that the reviewer(s) has spent considerable time assessing the scientific value of the manuscript and that, if the authors of the paper address the comments carefully, the revised manuscript will convey its message more clearly and thus more judiciously convey its data.

5. Final Remarks and Recommendations

In summary, Latin American scientists face several barriers to success that are not experienced by their counterparts in more developed countries. Many of these are the by-product of economic issues, while others are based on cultural differences. Recognizing these constraints is the first step toward bettering the conditions to enable high-quality output from scientists in Latin American and other less-developed regions. The following is a list of recommendations for the short- and long-term improvement of the scientific and publishing environment in Latin America.

5.1. Government and Institutional Strategies

- a. Recognize the breadth of research priorities and provide sufficient funding.
- b. Fund in-country and overseas training to provide young investigators with experience in emerging technology.
- c. Support interactive clusters of researchers to increase critical mass at the local level.

- d. Favor group rather than individual projects.
- e. Support cutting-edge research.
- f. Fund core facilities in advanced technology, such as imaging, gene sequencing, and molecular biology.
- g. Encourage international collaboration.
- h. Subsidize libraries, library subscriptions, and publication costs.
- i. Provide equipment to libraries to assist online access.
- j. Institute and maintain courses in scientific writing.
- k. Create writing fellowships for researchers in developing countries.

5.2. Changes in Publishing Policies

- l. Subsidize subscription rates and page charges.
- m. Market key journals to libraries in developing countries.
- n. Create regional editorial offices and networks to assist would-be authors.
- o. Broaden the geographical reach of editorial boards and reviewer panels.
- p. Increase the priority of research submitted from less-developed countries.
- q. Publish less expensive local editions (e.g., quarterly).
- r. Prepare and distribute information describing a range of the qualities of primary research journals.
- s. Hold publication workshops to train prospective researchers.
- t. Create a core group of journal editor mentors.
- u. Invest in manuscript editors to assist non-English speakers.

5.3. Transformation of Editorial Procedures

- v. Appoint scientists from developing countries to editorial boards.
- w. Seek primary research for publication from developing countries.
- x. Commission work from authors in less-developed nations.
- y. Review more papers from less-developed countries.
- z. Write editorials to raise awareness about these issues.

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