The Lancet Regional Health - Americas 3 (2021) 100044

Contents lists available at ScienceDirect

The Lancet Regional Health - Americas

journal homepage: www.elsevier.com/locate/lana

Viewpoint

The evolution of Brazilian Health Sciences and the present situation

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ARTICLE INFO

Article history:
Received 17 June 2021
Revised 28 July 2021
Accepted 5 August 2021
Available online 20 August 2021

Scientific activity in a professional way only started in Brazil in early 1950 by creating the Brazilian National Research Council (CNPq) and the Foundation for the Coordination of Training of Higher Education Personnel (CAPES). However, in medical sciences, important achievements took place at the end of the XIX and the beginning of the XX centuries. During the end of the XIX century, a group of medical doctors dedicated efforts to investigate questions related to some tropical diseases. We mention here classical studies carried out by Otto Wucherer. He found microfilariae in the blood of patients with elephantiasis, showing the existence of a new parasitic disease caused by a nematode nowadays known as *Wuchereria bancrofti*. [1] A second example is a discovery in 1906 of the helminth *Schistosoma mansoni*, one of Brazil's most severe parasitic diseases for many years [2]. A third example is the discovery made by Carlos Chagas in 1909 of the protozoan *Trypanosoma cruzi*, its transmitting vector, and the disease it causes, now known as Chagas disease [3].

The priority and tradition of excellence in tropical diseases persists to the current days. The Web of Science (WOS) shows that between 2015-2020 indexed articles in parasitology and tropical medicine, having at least one author linked to a Brazilian Institution, accounted for 15.5% and 14.3% of the global scientific output. The significant contribution of Brazilian science to these areas can be envisaged by the fact that total Brazilian indexed science output in the WOS during the same period accounted for 3.2% of the global output, placing Brazil at the 13th position in the global rank of indexed scientific articles.

Brazilian scientific output in the health area has doubled its participation in global scientific output in the last two decades [4]. A recent example of the Brazilian scientific competence in infectious diseases can be found in publications related to the ZIKA virus infection and COVID-19 in some of the most prestigious Journals in medical and general science. [5–18] However, other areas besides infectious and parasitic diseases have also projected Brazil in the international scientific scenery. In Odontology, for instance, Brazilian authors participate in 12.9% of all indexed scientific articles, and the relative impact of this output is above the world media. [4] Other areas that deserve mention are public health and primary health care, which occupy the 6th and 13th rank in the global scientific output in Brazil in the last six years, [19] stimulated by the fact that Brazil has the largest public health system in the world (SUS).

An intriguing observation is that although investments in S&T in Brazil have declined sharply since 2015 and even more significantly in the current government, Brazilian scientific output from 2015-2020 has increased by 32.2%, above the world mean of 27.1%. [19] However, this increase in output was not accompanied by an increase in impact. In fact, the percentage of Brazilian articles in the top 1% of the most cited papers in the world continually increased from 2013 through 2016, when it surpassed the world media, reflecting the increasing expenditures in S&T during the period. But since 2016, this percentage has been decreasing, coming again below the world media. Therefore, the increase in scientific output detected during 2015-2020 reflects the fact that by lacking funding, researchers dedicated more effort to writing papers, especially review papers, that increased from almost 8,000 in 2010-2015 (7.8% of the total Brazilian full texts in PubMed) to close to 21,000 (11%) in 2015-2020. In the following paragraphs, we summarize the historical trends in financial support for Brazilian S&T.

From 1950 to the current days, the financial support for research activity varied significantly, depending on how the country's President prioritized such activity. Nevertheless, some important achievements took place during the military government, including creating in 1969 the National Fund for Scientific and Technologic Development, known as FNDCT. For many years FNDCT played an important role in establishing a network of well-equipped scientific institutions, most of them located in public universities, where activities related to the formation of new Masters and PhDs in

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https://doi.org/10.1016/j.lana.2021.100044

graduate courses, always associated with intense research activity, took place. During this period, the fund received the support of new financial resources from loans in international development banks, with the National Treasury's guarantee, to support new initiatives. This financing was used, for example, in creating an innovative Program designated as PADCT (Support Program for Scientific and Technological Development) responsible for establishing well-equipped and active Chemistry, Biotechnology, and New Materials laboratories throughout the country [20]. At about the same time, there was the creation of the Brazilian Agricultural Research Corporation (EMBRAPA) responsible, in association with several Universities and Institutes involved in the Agriculture and Veterinary areas, for a significant advance of Brazil in this area. Together, these agricultural and veterinary Institutions put Brazil in an excellent scientific position nowadays, occupying the world's second or third position in the number of published papers in this area. Therefore, it is not surprising that the country occupies a relevant role in world food production, and agribusiness accounts for around 30% of Brazilian exportation.

Between 1998 and 2002, 14 funds tied to FNDCT were created. Most of them obtained financing linked to economic segments, such as oil & gas, energy generation, mineral exploration, biotechnology, health, informatics, internalization of new technologies by the industry, among others, to mention some of them. Two of the funds are cross-cutting, focusing on establishing and maintaining a scientific structure (CT-Infra) and promoting the interaction between Universities and companies. Together, all these funds collect around US$1.3 billion annually. For only a few years (2006 to 2014), most of these resources were applied to support research activities both at the Universities and in some enterprises, using non-refundable as well as refundable money. Altogether, this effort allowed a significant increase in the publication of scientific papers in international journals, which reached 55.437 articles in 2017, with Brazil occupying the thirteen position in the world. Also, papers coming from scientific institutions and the industry started to appear, indicating the beginning of a necessary association between these two partners, fundamental for generating patents and new processes and products to reach society. However, since 2015 the government decided to limit the amount of money from the FNDCT to science and technology. For instance, only about 20% of the funds became available for use by the two federal Brazilian agencies that support research activity: CNPq and FINEP. It is now a consensus that research activity would be drastically reduced if state agencies, known as State Foundations for Research Support (FAPs), now present in most states, did not fill the gap. Altogether, the FAPS released around US$660 million per year since 2015.

With the appearance of the Covid-19 pandemic, significant changes took place in Brazilian society. The continuous increase in the number of infected and dead people (which reached today (August 16 , 2021) 20,378,986 and 569,581, respectively) has shown that science is the effective instrument to fight against the Sars-Cov-2 dissemination. The necessity of new vaccines and the identification of new truly effective drugs active against the virus and the various pathologies it induces in humans require the support of fundamental and applied science in several areas. With a tremendous mobilization of the Brazilian society, the approval of the Congress was obtained, even with the opposition of the Federal Government, to pass new legislation for funding S&T. All Brazilian Academic Institutions and the National Industry Confederation, among others, worked hard to establish direct contact with each member of Congress, to approve a new law, known as PL 135/2020 that forbids the federal government to limit the use of the budget that constitutes the FNDCT. At the end of 2020, the Senate and the Chamber of Deputies approved the project. To our surprise, given the tremendous support by Congress, some of the Law Project articles were vetoed by President Jair Bolsonaro. However, Congress voted against the presidential vetoes and maintained the original version of the project. In the end, the interests of Brazilian society prevailed, and the FNDCT will become a fundamental element for the advancement of science and technology in the following years. Immediately after the approval of the law, the National Treasury Secretariat transferred to the FNDCT account, maintained at FINEP, the Executive Secretary of the FNDCT, the amount of US$ 5.4 billion, correspondent to all money collected since 2001 by the various economic funds that were not transferred to FNDCT. In addition, the FNDCT budget for 2021 will be around US$ 1.4 billion. Significantly, the FNDCT budget should not suffer discontinuities, and money not spent in one fiscal year can be used in subsequent years. This perennial apport of significant funds increases the responsibility of the Brazilian scientific and technological community, in association with the Brazilian federal scientific agencies and the Ministry of Science, Technology, and Innovation, to properly use these funds to develop our country. Unfortunately, the government has found ways to postpone the use of the FNDCT funds this year, and only the States Agencies in São Paulo and Rio de Janeiro have awarded a significant amount of grants to the research community. This continued lack of federal and state funding for over six years is responsible for the lower impact of Brazilian science, as mentioned above. Research infrastructure has also been adversely affected by the lack of funding. Maintenance contracts were canceled, and the number of single and multi-user pieces of equipment out of order has peaked. Patents deposited at the National Institute for Industrial Property (INPI) followed the trend and have decreased from 2013 through 2019. We recognize the limitations of bibliometric indicators to evaluate the impact of funding in S&T progress. To include detailed data on the effect of the financing in patents, international cooperation, research infrastructure, and graduate courses would require more than a Viewpoint article.

In conclusion, although the current scenery is bleak for Brazilian science, the new law approved by Congress will be enforced next year, and we will have funds to increase science and technology activity in the country for the next decades, generating the conditions to create a knowledge-based society in Brazil that will reduce the social inequalities that plague our country since its discovery.

Contributors

Antonio Carlos Campos de Carvalho performed literature searches and wrote the manuscript. Wanderley de Souza performed literature searches and wrote the manuscript. Both authors verified the data.

Declaration of interests

The authors declared no conflicts of interest.

Funding

Authors declared grants from CNPq and FAPERJ for unrelated projects. The funding sources had no role in the writing of the manuscript or the decision to submit it for publication.

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