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Cancer research in Brazil: Analysis of funding criteria and possible consequences

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ABSTRACT

Cancer has high incidence in both developed and developing countries. Epidemiological data on the rate of cancer incidence in Brazil appears not to have a strong impact on government policies to fund research and innovation in health, particularly in oncology. This study aimed to verify this suspicion by retrospectively analysing data from the Brazilian government's Financier of Studies and Projects (*Financiadora de Estudos e Projetos, FINEP*) and The National Institute of Industrial Property (*Instituto Nacional da Propriedade Industrial, INPI*) on cancer research and innovation in Brazil from 1998 to 2013. Our results indicated that, in the study period, the increased rate of cancer incidence in Brazil was not accompanied by government funding for cancer research since only 9% of the budget approved to health research, and innovation, was spent on cancer research. In addition, the number of projects approved for developing infrastructure to support cancer research was limited, corresponding to 0.46% of the total budget. The number of applications for registration of patents of chemical and biotechnological drugs for cancer showed a reduction, reflecting the low investment in oncology. In conclusion, there are deficits in governmental funding of cancer research and innovation in Brazil. Therefore, effective measures to coordinate funding policies and effective criteria for funding allocation should be implemented to avoid further negative consequences for the population and the public health scenario. Moreover, increased governmental and non-governmental funding could help to improve the current precarious situation that limits the population's access to health goods and services.

1. Introduction

The estimated worldwide incidence of cancer by 2025 is 20 million new cases, of which 16 million cases (80%) are expected to occur in developing countries [1,2]. Data from the National Cancer Institute (*Instituto Nacional do Câncer* - INCA, Brazil) revealed that approximately 600,000 new cases are expected to occur in Brazil in 2018–2019 [1]. To date, diagnosis and treatment of different cancer types involve advanced technology in imaging, surgical procedures, radiotherapy, and drug therapy [3]. In some countries, this scenario may limit the access of the population to health goods and services and have a negative impact on the economy [4]. The health sector is essential for social and economic development by stimulating job creation and improving income distribution and quality of life [5–7]. The results of epidemiological studies on the incidence of new cancer cases both in Brazil and abroad, demonstrate the need for government research funding and innovation in health, particularly in oncology, to meet the population's demands.

In Brazil, two institutions primarily develop government policies that fund projects for technological innovations and implementation of physical infrastructure for health research: The National Council for Scientific and Technological Development (*Conselho Nacional de Desenvolvimento Científico e Tecnológico* – CNPq), and the Financier of Studies and Projects (*Financiadora de Estudos e Projetos* – FINEP). FINEP was created in 1967 as a Brazilian public company affiliated to the federal government to fund science, technology, and innovation in public and private companies in Brazil [20]. The projects are selected based on the public calls for proposals, and the thematic research areas are defined by the *Ministry of Health* and the *Ministry of Science, Technology and Innovation*, which evaluates health demands in federal units (states and municipalities) in the five geographic regions of Brazil: North, Northeast, Central-West, Southeast, and South [8], as priority guide. In this case, the political chief (governor and mayor) becomes the protagonist of the process of selecting diseases eligible to receive financial support for research projects and innovation, which could lead to erroneous decisions regarding funding allocation priorities, as will be discussed later.

For the past 20 years, the trends in cancer research funding by the

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Brazilian government are reflected by political-administrative instruments of incentives to scientific and technological innovation in health [9–11] with the creation of the National Network of Clinical Cancer Research (*Rede Nacional de Pesquisa Clínica em Câncer*) in 2011 and the National Anticancer Drug Development Network (*Rede Nacional de Desenvolvimento de Fármacos Anticâncer*) in 2011. These strategies were supported by the National Policy on Science, Technology and Innovation in Health (*Política Nacional de Ciência, Tecnologia e Inovação em Saúde,* 2004). In addition, cancer is listed as priority theme in the National Agenda of research priorities in Brazil, published in 2006 by the Ministry of Health [12]. Although some political strategies have been implemented, it is of note that the total amount of funds allocated to cancer treatment in Latin America is unknown and the percentage of public health spending in this region (50.2%) is lower than the world average (62.8%) [13]. An increase in the public budget in the area of research and innovation of goods and services in oncology is a necessary measure to contribute to the reduction of the cancer burden and the economic impact on the Brazilian public health system [29].

In addition to this scenario, the country depends on foreign markets for cancer treatment. It is known that there was a trade imbalance in pharmaceuticals from 1996 to 2003, a tendency of deficit starting in 2014, and a high dependence on the import of chemical and pharmaceutical products [14]. This dependence poses health risks to the population, since the majority of the population use medicines provided by the Unified Health System (*Sistema Único de Saúde* - SUS).

In order to respond to the Brazilian population public health needs, the government has to invest mainly in scientific research and human resources, this choice would enable the technological leap forward (catching-up) [7,10,11]. It is important to highlight that in Europe, Asia and the United States, there are good examples in research, technological innovation, chemical, biotechnology, mechanics, electronics and services sectors that can teach Brazil to boost technological responses in the oncology area [15]. For instance, studies that analysed government research funding for diseases that cause high mortality and disability in the United Kingdom (cardiovascular diseases, cancer, dementia, and stroke) indicated that 64% of the resources were earmarked for cancer research [16], demonstrating the need and importance of allocating funding to this disease. Another example of success is South Korea, which moved from imitation in the 1970s to innovation in the 1990s. The investments started with reverse engineering (imitation), by manufacturing already marketed foreign products [17,18]. In the United States, the innovation system is focused on interactive learning between individuals and companies and among academia, industry, and the government [19,20].

Brazil's behaviour in funding cancer-related research, innovation, and technology needs to be better understood in order to explicit the needs for urgent improvements. Globally, little is known about our cancer research funding and policymaking compared to other countries. Therefore, the objective of this study was to retrospectively analyse the profile and criteria of government research funding for cancer (also comparing to other diseases), using data from FINEP and The National Institute of Industrial Property (*Instituto Nacional da Propriedade Industrial* –INPI). The latter is a federal public institution that manages the provision and guarantee of intellectual property rights, including the registration of trademarks and industrial designs, and the concession of patents in Brazil.

2. Methods

2.1. Study type

This retrospective and descriptive study evaluated activities related to cancer research and innovation in Brazil from 1998 to 2013. The activities were searched in the databases of FINEP, affiliated to the Ministry of Science, Technology and Innovation, and INPI, affiliated to the Ministry of Industry, Foreign Trade and Services.

2.2. Data source

FINEP's database is available online at the agency's website and allows searching by keyword, target audience, funding sources, topic, status, and publication period. The keywords used in the search were: "cancer", "health", "drugs", "biotechnology", "chemistry", "research infrastructure", "diseases", "research investment" and "funding allocation". The funding sources were Inova Health, CT-Infra, CT-Health, Economic Subsidy, and Transversal Actions. The publication period was from January 01, 1998 to December 31, 2013.

INPI manages the provision and guarantee of intellectual property rights, including the registration of trademarks and industrial designs, and the concession of patents [22]. The INPI database is available online at the agency's website and allows searching by order number, date, ranking, keyword, and depositor. The search protocols were developed to identify patent applications in chemical innovations in the treatment of the most common cancers affecting the Brazilian population, including breast, prostate, lung, and cervical cancer. The detailed protocol is available in Avellar [23]. The data presented in Fig. 1 is based on values published annually by the Brazilian National Cancer Institute [1].

2.3. Eligibility

Twenty-five public calls for proposals from FINEP for research and innovation in health were identified, including 23 projects in human health and two projects in animal health and cosmetic research. The proposals selected for analysis were strictly directed to human health and concerned the development or implementation of new products and processes. Moreover, 29 funding bids for developing physical infrastructure and innovation in health were identified, of which 26 bids were selected using the above criteria. The INPI database search retrieved 566 records, of which 503 were selected using the eligibility criteria of this study [23].

The collected data were recorded in an Excel spreadsheet and analysed using descriptive statistics. The content was identified and classified by two researchers independently and blindly. After that, data were analysed by content analysis [24], which is a set of techniques for communication analysis using systematic and objective procedures for the description of the content of messages.

3. Results

3.1. Cancer scenario in Brazil

The comparison between the need for government funding destined to cancer research and the incidence of cancer in Brazil was determined by analysing data from INCA. The results indicated that cancer incidence increased by 10.7% in Brazil from 2008 to 2013 (Fig. 1). In contrast, there was only one FINEP public call for research proposals in cancer treatment and prevention for the same period of time. Data available from FINEP shows that from the overall financial investment proposal of 989 million BRL in research and innovation for diseases, only 12.5 million BRL were effectively applied to cancer research in over 16 years.

3.2. Analysis of FINEP investments by sectors and diseases

In a 16-year period (1998–2013), non-reimbursable funds from FINEP for research and innovation in health totalled 989 million Brazilian Reais (BRL). More than half (68%) were directed to equipment acquisitions, 23% to new drugs and biotechnologies, and 9% to new procedures and methods (Fig. 2A). Data available from FINEP, suggested that the total resources effectively invested in cancer research and innovation were 12.5 million BRL, representing only ˜9% of the total investments approved for health research in the period studied

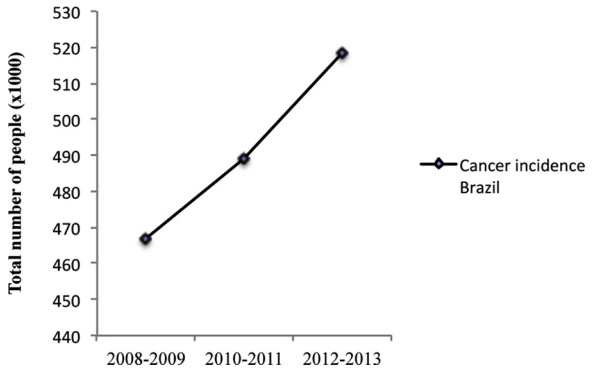

Fig. 1. Cancer incidences in Brazil over time (according to estimates from the National Cancer Institute - INCA).
The estimates correspond to the number of new cancer cases in both men and women following the tumor's primary site.

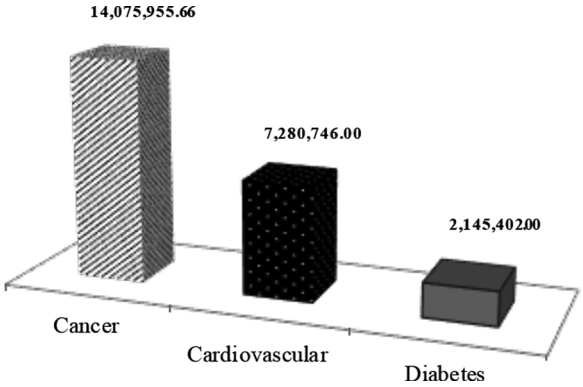

Fig. 3. Description of total funding in infrastructure by FINEP from 1998 to 2013.
Infrastructure funding (currency in Brazilian BRL) for the development of research and innovation in health comparing cancer with other diseases.

(Fig. 2B). For example, cardiovascular diseases which also have a high mortality rate, had a lower investment than cancer (4%, Fig. 2B) and the vast majority, 87%, represents other diseases combined.

3.3. Analysis of FINEP investments in biomedical science infrastructure

The investments to develop physical infrastructure to support health research (including building, extension, modernization, and restoration of buildings) in addition to acquisition and installation of equipment corresponded to a total of 3 billion BRL (from 1998 to 2013). Fig. 3 represents the investments subdivided in the 3 diseases which received most funding. From the total projects approved, support to infrastructure related to cancer research accounted for only 0.46% of the total budget (R$14,075,955.66; Fig. 3).

3.4. Analysis of patent requests scenario over time (INPI)

From 1998 to 2013, 503 patent applications for chemical innovations in cancer prevention and treatment were registered at INPI, distributed in the following categories: breast cancer (208; 41.4%), prostate cancer (194; 38.6%), lung cancer (69; 13.7%), and cervical cancer (32; 6.4%). Brazilian educational and research institutions and the national industry made 48 (9.5%) applications [21]. The evolution of cancer research and innovation at the national and international levels, and the number of cancer patents in Brazil, are shown in Fig. 4. It is of note that from 2009 to 2013, there was a decrease in the numbers of cancer patent registrations in Brazil, perhaps influenced by the economic crisis in the United States.

4. Discussion

The present study analysed the funding profile in cancer research by FINEP in Brazil. Funds could be either reimbursable or non-reimbursable, and they covered all stages and dimensions of the scientific and technological development cycle, including basic research, applied research, product innovation, services, and processes.

The estimates of new cancer cases when compared with the FINEP research funding in Brazil indicated that the coordination between these two variables was insufficient, *i.e.,* the increase in cancer incidence in Brazil (Fig. 1) did not lead to a constant increase in FINEP funding for cancer research since from the overall financial investment proposal of 989 million BRL in research and innovation for diseases, only 12.5 million BRL were effectively applied to cancer research in over 16 years. These data indicate the limited influence of cancer growing incidence in funding research and innovation, and also suggest dissociation among health policies, industrial policies, and technological policies [7]. Although some health policies are known not to meet health demands, as demonstrated by studies that compared European countries with different economic levels [25], our results indicate the need for higher funding in cancer research and innovation since there is a high demand for cancer treatment in Brazil. This need is highlighted by the fact that cancer incidence is also increasing, due to several factors, including higher life expectancy, industrialization, and lifestyle

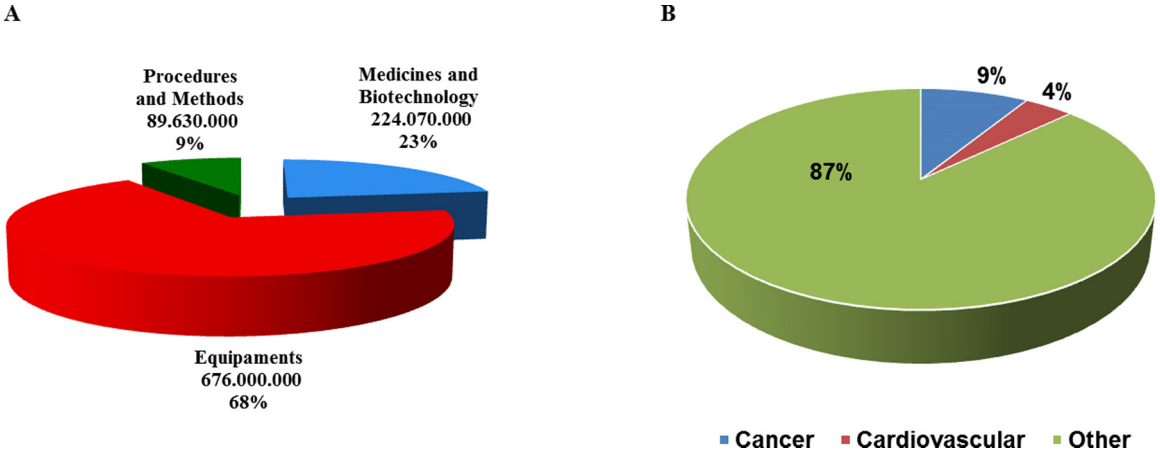

Fig. 2. Distribution of FINEP funding according to different sectors end diseases (1998–2013).
Funding obtained for projects in biomedical research distributed by sectors. **B)** Funding destined to cancer research (˜12.5 million or 9% of the total) projects versus other diseases (˜123.7 million or 87% of the total) and cardiovascular disease (˜5.8 million or 4% of the total). Currency in Brazilian Reais (BRL).

Fig. 4. Profile of Brazilian patent requests in cancer deposited at INPI from 1998 to 2013.

changes [26]. Performing diagnostic and therapeutic care with reduced domestic funding in cancer research consequently increases the volume of chemical and biotechnological product imports in Brazil and increases the trade deficit in the health sector [27,28]. Furthermore, limited funding prevents the development of effective public health policies, as demonstrated in studies on cancer policy in countries with similar economic situations [29–31].

In the scenario in which this study compared the funding of the development of products and processes to thematic research areas and priority diseases (Fig. 2A and B), it was possible to deduce that policy makers responsible for establishing priorities in health research recognise the physical infrastructure bottlenecks in the health sector's production, as they allocated 68% of the budget for acquiring new equipment, but only 23% for promoting drug and biotechnology research, development, and innovation. Health research is essential for producing knowledge and fostering the development of novel technologies for disease treatment and prevention; it has multiple interdependent positive effects on the transforming processes of the economic–industrial complex of health [15]. Therefore, stimulating research activity can generate a positive impact by increasing Brazil's competitiveness in scientific production and education.

Other studies on cancer treatment in Brazil (and other Latin American and Caribbean countries) indicated that total funding of the health sector in Brazil from 2007 to 2009 represented 8.5% of the Gross Domestic Product (GDP), and a similar percentage was found in other Latin American countries [13]. The private sector contributed with 4.8% and the Brazilian Unified Health System (SUS) contributed with 3%; the latter serves at least 70% of the population [13,32]. These data help to identify the factors that limit access to treatments, medications, and diagnostic tests provided by public health services and indicate the need for public investment in physical infrastructure to support cancer research. In addition, the analysis of applications for registration of patents of chemical and biotechnological products in the Brazilian patent office from 1998 to 2013 (Fig. 4) reflects the limited overall government funding of cancer research in Brazil and an unstable trajectory of growth, with a small annual growth rate. Furthermore, the number of patents filed by national companies represented only 9.5% of the total registered patents.

As mentioned in the introduction section, projects are selected following the health demands in federal units (states and municipalities). However, if the criteria of allocating resources are in accordance with the need and priority of public health of each federative unit, the political chief (governor and mayor) becomes the protagonist of the process of selecting diseases eligible to receive financial support for research projects and innovation. The hypothesis of project selection supported by the economic impact of treatment and disease prevention without evaluating, for example, epidemiological indicators, scientific capacity and infrastructure, can produce erroneous decisions regarding investment priorities.

Although the economic impact or the health demands in different federal units are still relevant criteria of resources allocation, it should not be considered solely, since studies [33–36] showed that the use of one variable in isolation could lead to unjustified neglect of investments. In the literature, there are five criterions listed as priorities on resources allocation: public health needs, the scientific quality of research, the potential for scientific progress (the existence of promising pathways and qualified investigators), the portfolio diversification along the broad and expanding frontiers of research, and the adequate support of infrastructure (human capital, equipment and instrumentation, and facilities) [34]. These variables are considered important for public health and scientific progress [34].

The analysis of public calls for proposals for developing physical infrastructure to support biomedical research indicated that there have been 26 public calls in this area over a 16-year period, with a total budget of ˜3 billion BRL. The oncology area received 14 million BRL, corresponding to 0.46% of the total budget (Fig. 3). This limited funding for cancer research denotes the urge for better coordinating the different sectors to increase the production of health goods and services in order to meet the demands of the population [28]. Considering these gaps in FINEP funding for cancer research in Brazil, there are opportunities to expand the sector's agenda with partnerships and inflow of funds from non-governmental organizations, philanthropic institutions, and the pharmaceutical industry [29], as it occurs in European countries and the United States [37,38]. Such funds, despite involving conflicts of interest in some cases, allow partnerships with the private sector to stimulate research in cancer and other strategic areas [39].

Unfortunately, it is important to point out that access to certain relevant information was limited by the lack of Brazilian publications on this topic and also by the lack of detailed information from the funding agency analysed. We observed that some information regarding public grants and results, only specified the institutions which received the funding without indicating the financial resources effectively applied (*i.e.* funding amounts). Therefore, some FINEP information was not available for the public analysis, which was a limitation of this study. In addition, this article focused on FINEP funding rather than global Brazilian research funding, which could also be interesting to evaluate in the future.

Financial support for cancer research through the government

agencies as based on the public health needs is only one of the variables necessary to meet the demands of the Brazilian population and Brazil seems to fail in the assessment of this criterion. The lingering dissociation between funding policy and disease incidence, combined with political and economic instability associated with the absence of other criterion for technological catching-up, reduces the chance to overcome the health sector deficit. This can increase the use of courts of law to obtain access to the otherwise unavailable cancer treatment, increase public deficit, and breach the social pact established by the Brazilian Constitution for free, universal, and equal access to health services for all citizens.

5. Conclusion

The Brazilian population average age is rising, a fact that has impacts on lifestyle and also in socioeconomic conditions throughout the country. These changes can collectively influence the access to diagnosis and treatment of certain diseases such as cancer. The present study suggested that to face these scenarios, it is not only necessary to expand the government budget for cancer care but is also important to identify strategies to develop more effective treatments through research and technological innovation. Although an important investment in infrastructure was identified, it does not match all required criteria such as scientific quality of research, potential for scientific progress, and diverse portfolio which collectively should also be considered to develop policies in Brazil. We consider it could be strategic to have a system for evaluating the performance and execution of government projects related to health research and technological innovation in order to employ public money more effectively. Therefore, we conclude that Brazil behaviour within the context of funding research and technological innovation in cancer seems to be inadequate and requires a transformation in the criteria of resources allocation. In addition, demand and production should be synchronized to stimulate scientific and technological innovation in health.

Disclosure

We acknowledge that there are no known conflicts of interest associated with this publication.

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