

ANALYSIS OF BRAZILIAN FILED PATENTS ON BIOTECHNOLOGY APPLIED TO HEALTH: INFECTIOUS DISEASE PREVENTION AND CONTROL

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Abstract—The advancement of research in the biotechnological area presents solutions for society in different domains and aims to enhance health processes so that they become safer and more efficient. However, there is a lack of information on developing countries' intellectual property concerning the scope of biotechnological health. This study aims to present an analysis of the patents filed in Brazil on biotechnology applied to health that contribute to the prevention and control of infectious diseases. As a complement, the depositor's qualitative profile and the criteria for using the patents deposited to avoid risks of diseases were identified. The research is classified as exploratory and documentary, using a database of patents to provide an overview of the biotechnology area in Brazil. Patents filed to prevent, and control infections accounted for 46% of the sample. The depositor profile with the highest participation were universities, with 38%. The main filers of patents for use in health infections were: 29% from the Federal University of Minas Gerais, 16% from the Oswaldo Cruz Foundation, and 14% from the University of São Paulo. Patents for the use of infections focus on developing prevention and vaccine alternatives, which can be consolidated in public and private sector partnerships.

Keywords—Patent analysis, healthcare sector, Biotechnology, prevention and control, Brazil.

1 INTRODUCTION

Science and technology are two crucial elements of a country's economic and social development (BARRAGÁN-OCAÑA et al., 2019). In Brazil, investments in science and technology are limited and negatively influence global scientific production indicators, which has grown considerably in the last decades (CASTRO, 2017; MARQUES et al., 2020; PERALTA et al., 2020). The Science, Technology, and Innovation (ST&I) actions implemented by the Brazilian government promoted investments in the biotechnology area; however, it is necessary to improve strategic planning and encourage incentive policies for this field.

Another important point that should be prudent is related to the bureaucratic transaction of technological creations related to biotechnology - the processing of intellectual property rights. In Brazil, the backlog (or delay in examining patent applications) is a barrier present in the biotechnology sector. For this reason, the availability of financial resources is one of the pillars for the growth of the bioindustry due to the long product development cycle and the risks inherent to the sector's research and innovation (BARRAGÁN-OCAÑA et al., 2019; CIANI et al., 2020).

Patent applications filed by the BRICS countries (Brazil, Russia, India, China, and South Africa) correspond to 25% of global patent applications in the biotechnology sector. Brazilian biotechnology patents

were filed nationally in 66% of cases and internationally 34% (STRELTSOVA and LINTON, 2018). These are data that characterize the importance of conducting studies on the dynamics of national innovation systems, their actors, relationships, and constituent processes, as well analyzing how biotechnology can converge with other areas of knowledge to contribute to the progress and consolidation of this system (BARRAGÁN-OCAÑA et al., 2019).

Several advances in science and technology for biotechnology are significant for developing alternatives that can be consolidated in the health sector to minimize society's risks (BARCISZEWSKI, CIEMERYCH and TWARDOWSKI, 2019). Technological advances in ST&I for biotechnology also benefit the health sector concerning preventing risks to society (VAISHNAV and DEMAIN, 2017). Biotechnology has a fundamental role in healthcare, specifically for infectious diseases, through the development of products for medicine, such as diagnostics and treatments, in conjunction with other areas, such as engineering and medicine (VAISHNAV and DEMAIN, 2017; STRELTSOVA and LINTON, 2018). Therefore, problem-solving through adopting new biotechnological tools in the health sector is characterized by being a new way of challenging to find the keys to innovation (ACHARYA et al., 2004; DOUILLARD and VOS, 2019).

Infectious diseases are a public health problem in Brazil and cause mortality in all age groups of the population (BARRETO et al., 2011). The globalization process of international exchange and climate change are factors that are characterized by facilitating the development of infectious diseases (LIMA-CAMARA, 2016). Thus, strategies that seek to prevent and control infectious diseases are currently highlighted in scientific research (GRIEF and MILLER, 2019; SMITHA et al., 2019). These are strategic actions in public health that aim to improve the health care delivery system and support services, such as outreach programs that provide specific information on diseases and risk reduction in communities (GRIEF and MILLER, 2019; SMITHA et al., 2019). Concurrently, genetic engineering techniques, new scientific approaches, and technological products in biotechnology are being developed for intervention on infectious diseases (MARQUES, 1995).

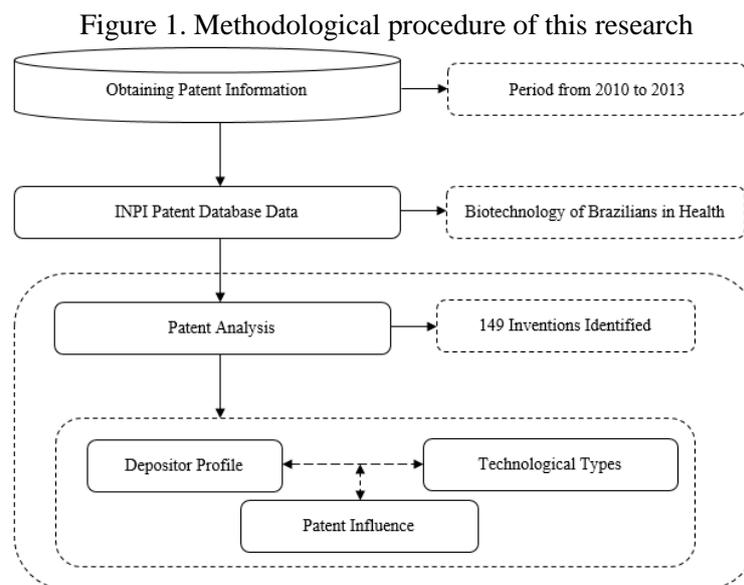
To contribute to current scientific discussions on the characteristics of intellectual property in the health sector in developing countries (ABUDUXIKE and ALJUNID, 2012; FLORÊNCIO et al., 2020), this study aims to present an analysis of the patents filed in Brazil on biotechnology applied to health that contribute to the prevention and control of infectious diseases. As a complement, the applicant's qualitative profile is identified, and the criteria for using the patents filed to avoid risks of diseases. It seeks to group a set of patent documents, specifically on infection, according to the sample patent applications. Despite the synthesis of the factors found in the research on patents dealing with infection, it should be noted that it is not intended to define the semantics and syntax of the methods rigorously. The purpose of the analysis is to demonstrate which procedures are being developed and reflect on a better performance of the patent documents on infectious diseases and facilitate their application.

The research contributes to the discussion on the filing of patents in the biotechnology area that seek to solve problems that are currently being triggered in the world, such as, for example, COVID-19 (SILVEIRA et al., 2019; BERGQUIST, OTTEN and SARICH, 2020; SINGER and REDEKOP, 2020). The Brazilian case is investigated to present an adequate environment for the development of innovative biotechnological products and processes and the progress in the university-company interaction mechanisms (FLORÊNCIO et al., 2020). The propositions and reflections raised in the study also contribute as subsidies for future academic research on the topic, which may continue this initial study. This study was structured in different sections. Following is the methodological approach that was used in the study. Subsequently, the results found, and the research discussions are demonstrated. Finally, the research conclusions, limitations founded, proposals for future studies, and their respective references are exposed.

2 METHODOLOGICAL PROCEDURE

This section presents the methodological procedures adopted to carry out the research. Thus, from the point of view of its nature, the research is primary since it corroborates with new information for the advancement of science on biotechnology without practical application previously determined. In terms of defining its approach, the study is classified as qualitative and quantitative (INPI, 2015a); that is, it

represents a mixed-method approach (VENKATESH, BROWN and BALA, 2013). It is qualitative because it is concerned with investigating and discussing the scientific knowledge of biotechnology applied to health, which favors the understanding of patents aimed at preventing and controlling infectious diseases. It is quantitative because it uses secondary data to represent Brazil's situation in patent applications related to biotechnology applied in health. The collection of information on patents took place at the National Institute of Industrial Property (INPI) database. Patent applications filed by Brazilians in Brazil from 2010 to 2013 were analyzed, the last extract available from the INPI that has 149 patents (INPI, 2015a; INPI, 2015b). Patent analyzes provide useful data that help develop the current ecosystem, with identifications about growth curves and analogies of the topic addressed (DAIM et al., 2006). Figure 1 facilitates the understanding of the steps of the methodological flow selected in the research.



Source: Authors (2021)

To carry out the patent analysis, it was necessary to select the system used in the Espacenet base for Cooperative Patent Classification (CPC), which is proposed by the European Patent Office (EPO) and the United States Patent and Trademark Office (USPTO). The CPC includes the same sections as the International Patent Classification (IPC) system, plus a Y section to mark emerging technologies or technologies that span multiple CPC sections (EPO, 2018). Regarding its aim; the research can be classified as exploratory and documentary. Exploratory research provides greater familiarity with the problem, thus enabling new views to make it explicit (GIL, 2017). Concerning the procedures adopted, the research is consistent with bibliographic and documentary research. Documentary research can be used to produce or rework knowledge and create new ways of understanding phenomena. The investigator must interpret and synthesize the information, determine trends, and, as far as possible, infer the data (SÁ-SILVA, ALMEIDA and GUINDANI, 2009). The bibliographic research was selected to represent the relevance and the gap related to the theme. The research uses the scientific deductive method since it starts from general observation, with analysis of the patents of the biotechnology sector applied to health and, afterward, emphasizes the patents that were developed specifically to prevent and control infectious diseases.

It is emphasized that the analysis of patents in biotechnology in research is causally related to the public, private institutions, and companies responsible for developing scientific and technological production in Brazil. The transfer and commercialization of technology in health biotechnology has developed widely in universities and public research centers (MOLOTLA et al., 2017). Researchers analyzed the technological process in Brazil and highlighted that they have transfer channels such as publications and reports, informal exchange of information, training, consulting, and patents (POVOA and RAPINI, 2010). However, there is still a lack of empirical knowledge on this subject in Brazil that presents the depositors' profile and the main importance that is offered by the increase in the deposited patents (COSTA, FLORENCIO and JUNIOR,

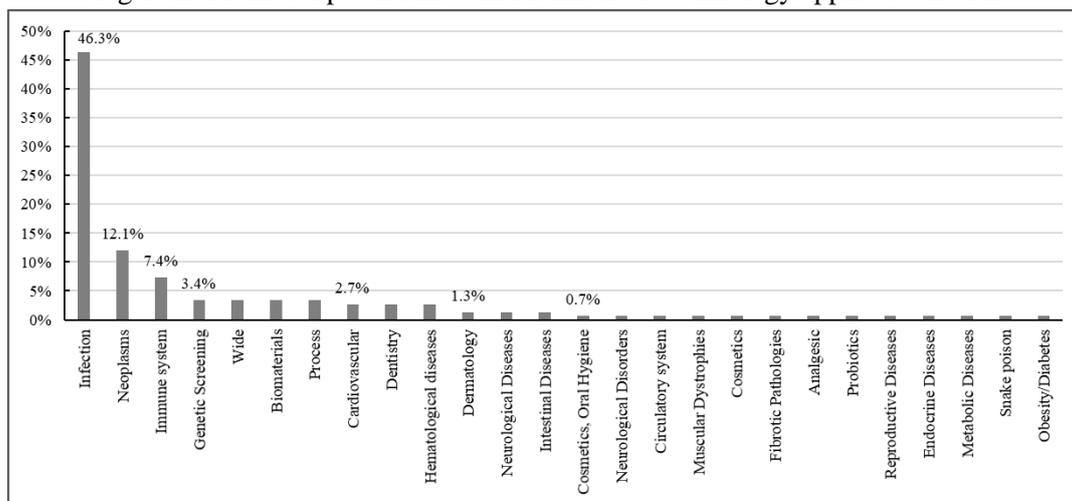
2018).

3 RESULTS

This research started with data generated in consulting the information available in the national patent database of the INPI. The verification of computed data showed the total number of patents available in the database from 2010 to 2013. The 149 patents resulting from the search deposited in Brazil were analyzed to present the scenario in which they are used. Figure 2 showed that 46.3% of patents filed on biotechnology applied to health, 69 patents out of the total were developed to prevent and control risks associated with infectious diseases. The second most significant participation was neoplasms (12.1%), followed by the immune system (7.4%) and genetic screening (3.4%).

It is observed that the highest occurrence of patent deposits was in the area of infections, as they are associated with health care, given the clinical and economic consequences that it can cause in people. Even with important advances in technology in prevention and control of infections in recent decades, government managers, responsible for incentive programs and the increase in biotechnology in health, demand evidence of their cost benefits. Innovation and health technologies can improve patient outcomes, as in the case of nosocomial infections, for example, but there are also policies and regulations to protect the public interest that can become barriers to improving infection risks in hospitals (MACNEIL et al., 2018). Besides, the prevention of healthcare-associated infections remains an international priority, given the clinical consequences of this largely preventable harm to people's safety (OTTER, 2019; SRINIVASA et al., 2019).

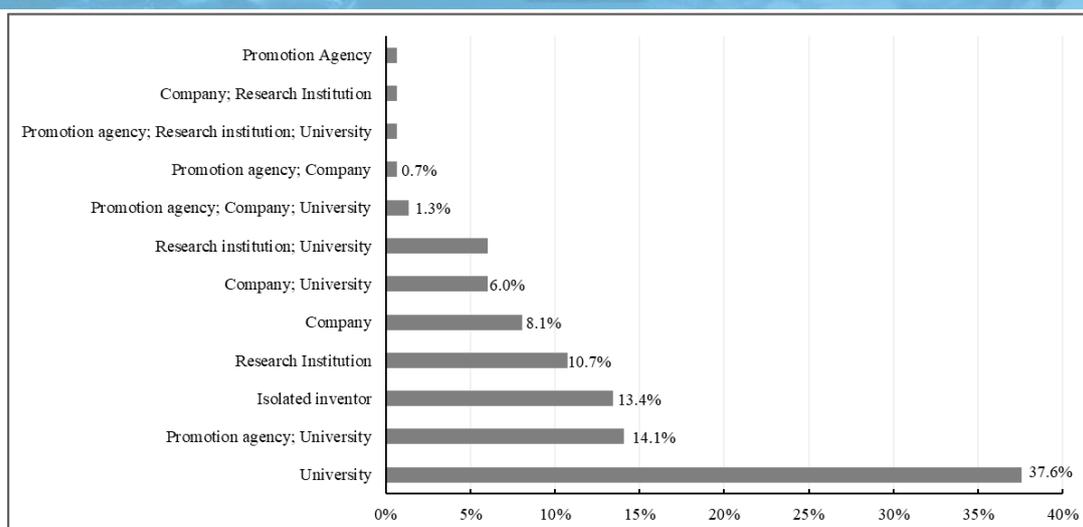
Figure 2. Profile of patents filed in Brazil on biotechnology applied to health



Source: Authors (2021)

Figure 3 shows the profile of the depositors who developed the 149 patents deposited in Brazil. The universities (public and private) were the main responsible (37.6%) for patent applications development. Following, the development agency and university (14.1%), isolated inventors (13.4%), research institutions (10.7%), and companies (8.1%) appear as the largest scale innovative agents in the biotechnology sector applied to health. Brazil has an increasing trend in biotechnology's technological production in all fields in the northeast, south, and southeast regions, with universities and research institutes accounting for the largest number of applications (OTTER, 2019). However, biotechnology in health requires changes in paradigms between technological activity in Brazilian universities and institutions' changes to promote the university's contribution to value chains and technological modernization for the country at an accelerated pace (FISCHER, SCHAEFFER and VONORTAS, 2018).

Figure 3. Profile of the patent applicant



Source: Authors (2021)

The Federal University of Minas Gerais (UFMG) has filed 20 patent applications out of 69 patents developed to prevent infection risks. The Oswaldo Cruz Foundation (FIOCRUZ) filed 11 patent applications, followed by the University of São Paulo (USP) with ten and the State University of Campinas with two. The remaining depositor profiles were responsible for one patent application each, which together a total of 26 patent applications on biotechnology applied to health. There are 4.222 graduate programs in Brazil divided into 1.458 for doctorates, 2.503 for academic master's degrees, and 261 for professional master's degrees. Only 3% of the courses offered are for the biotechnology area (CASTRO, 2017). Even with a small significant portion in the academy, biotechnology in universities has shown a progressive insertion in the national innovation system (FISCHER, SCHAEFFER and VONORTAS, 2018).

Table 1 summarizes each of the patents identified in the database that specifically deal with an infection. After analyzing the title and summary of 69 patents, the following categories of use were developed: diagnosis, treatment, prevention, medication, vaccines, and kit (method for diagnosis). To prioritize patents responsible for the largest number of categories of use, it was necessary to develop the indicative factor. The code has the number of categories that the patent presents when used. Three priority factors were adopted according to the categories of use of the patents analyzed: a) Low (1-2); b) Medium (3-4); and c) High (5-6).

Table 1. Distribution of patent documents on infection according to their applications

Order Number	Diagnosis	Treatment	Prevention	Medicines	Vaccines	Kit *	Indicative
102012001876	X					X	Low
102012005556	X					X	Low
102012005567	X					X	Low
PI0703559		X		X			Low
PI0704730			X		X		Low
PI0704860			X		X		Low
PI0704995		X		X			Low
PI0705414	X	X	X	X	X		High
PI0705535			X		X		Low
PI0705874			X		X		Low
PI0705880			X		X		Low
PI0705990			X		X		Low
PI0706003			X		X		Low
PI0706004			X		X		Low
PI0800357			X		X		Low
PI0800601			X		X		Low
PI0800612	X					X	Low
PI0801906			X		X		Low
PI0802282			X				Low
PI0802371		X		X			Low
PI0803008			X		X		Low

PI0803047			X		X		Low
PI0803262			X		X		Low
PI0804859	X		X		X	X	Medium
PI0804889		X		X			Low
PI0805203	X					X	Low
PI0805321	X					X	Low
PI0806054	X					X	Low
PI0806285			X		X		Low
PI0900896		X		X	X		Medium
PI0900961	X	X	X		X		Medium
PI0902443		X	X		X		Medium
PI0902944		X	X		X		Medium
PI0903460	X	X		X		X	Medium
PI0903616		X		X			Low
PI0904020			X		X		Low
PI0905645			X		X		Low
PI0911827		X		X			Low
PI0914507			X		X		Low
PI0914508	X	X	X	X			Medium
PI1000443	X		X		X	X	Medium
PI1000664	X					X	Low
PI1000870		X	X		X		Medium
PI1002842			X			X	Low
PI1003192		X		X			Low
PI1003744	X					X	Low
PI1003747	X					X	Low
PI1003749		X	X		X		Medium
PI1003750	X	X	X		X	X	High
PI1003753			X		X		Low
PI1003755	X					X	Low
PI1005033	X					X	Low
PI1005054			X		X		Low
PI1005056	X					X	Low
PI1005855		X	X		X		Medium
PI1006638	X					X	Low
PI1006646	X		X		X	X	Medium
PI1006647		X			X		Low
PI1100532			X		X		Low
PI1100855	X					X	Low
PI1102019		X	X		X		Medium
PI1102223			X				Low
PI1103275	X		X			X	Medium
PI1103325		X	X		X		Medium
PI1103869	X		X		X	X	Medium
PI1105460	X		X			X	Medium
PI1105654	X					X	Low
PI1106037			X		X		Low
PI1106627		X		X			Low

Note: * Diagnosis method.

Source: Authors (2021)

Patent documents dealing with infections can be classified into more than one category, so the total numbers of information presented in Table 1 are more comprehensive for prevention (40), vaccines (38), diagnosis (27), kit (25), treatment (22), and medication (12). These are alternatives that can be consolidated in Brazil in partnerships between the private and public sectors to enable improvements in the prevention and control of infectious diseases, without accounting for the advantages in biotechnology. However, through the technological advances already achieved, service delivery environments, in particular hospitals, are not free from contamination and infections (GOMES and MORAES, 2018). At the regional level, collaborations between both sectors provide the potential for the development of research, innovation, and business growth opportunities and increase technologies that enable improvements in the health sector (GARTLAND and GARTLAND, 2018), particularly for preventing and controlling infectious diseases (VAISHNAV and DEMAIN, 2017; STRELTSOVA and LINTON, 2018).

Table 2 shows the patents with a high priority factor. From the analysis of the title and summary of patents, it is possible to verify the scope that leads certain patents to exert a more decisive influence on

subsequent technological developments (patents classified as a medium and low priority factor) (PETRUZZELLI, ROTOLO and ALBINO, 2015). The two high priority patents were developed and filed by USP, which is configured as a modern university characterized by being a central agent in the system of innovation and dynamics in the field of technological updates. Because they can create and disseminate knowledge, universities in Brazil are responsible for a substantial portion of technological activity in the country and assist in the development of health biotechnology, which helps health systems meet the needs of the population (ABUDUXIKE and ALJUNID, 2012; FISCHER, SCHAEFFER and VONORTAS, 2018).

Table 2. Patents with a high priority factor

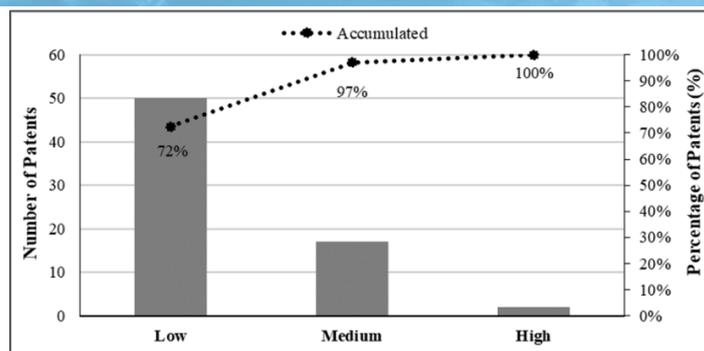
Request Number	Title	Abstract
PI0705414	Immunoadjuvant, the process for obtaining immunoadjuvant, pharmaceutical composition, and medication and use of the immunoadjuvant	The present invention is applied in the pharmaceutical, veterinary, biotechnological, pharmacotherapeutic, immunotherapeutic, immunodiagnostic, or preventive areas referring to new immunoadjuvant systems capable of immobilizing antigens, the immunoadjuvant is characterized by comprising a lipid bilayer fragment covered by antigenic biomolecules. of opposite charges immobilized on the system
PI1003750	Recombinant microorganisms, methods of preparing vaccine strains, antigens, vectorized vaccine compositions, their uses, antibodies, diagnostic kit and methods of treatment and / or prophylaxis	The present invention provides live recombinant microorganisms, such as prokaryotic organisms, in particular enterobacteria, preferably salmonella enterica, containing SEQ. ID. No. 1 and SEQ. ID. No. 2, capable of expressing VapG and/or VapA/VapG lipoproteins (SEQ. ID. No. 3 and SEQ. ID. No., optionally associated with other assets, methods of preparing vaccine strains, antigens (SEQ. ID. No. 3 and SEQ. ID. No.), and vaccine compositions, preferably vectorized vaccines. Also, the present patent application is intended for the use of vaccine vectors in the preparation of pharmaceutical compositions, in particular, vaccines indicated for the prevention and/or treatment of infections by <i>Rhodococcus equi</i> , its antibodies and/or antisera, diagnostic kits and methods of prophylaxis and/or treatment of infections by <i>R. equi</i> infections.

Source: Authors (2021)

The strategies that must be adopted by biotechnology in health must take into account the cost-benefit analysis of innovation. Continuing to improve health services, in general, requires observations that promote an understanding of the relationship and balance between biotechnological innovation and healthcare spending while promoting an environment that encourages health reforms concurrently and considering technologies that have a broader scope of applications (CINAROGLU and BASER, 2018). New technologies present additional costs that require reallocation of existing resources. Therefore, adequate resource planning is necessary to not deny health innovations to people and can be offered on a larger scale (MASON and DRUMMOND, 1997).

Figure 4 shows the participation of the high, medium, and low needs of the 69 patents found that deal with an infection. The low need factor represents 72% (50) of the total (69). Subsequently, the average need factor is 25% (17), and the high need factor is 3% (2). Through the delineation of the need factors, it is realized that it is possible to contemplate a new bias to prevent and control infectious diseases, which according to the analyzed patents, presents an indication of high need for some particularities and low for others; however, all necessary to provide better conditions in the public health sector.

Figure 4. Needs of patents on infection



Source: Authors (2021)

From the analysis of Figure 4, it is also noticed that there is a lack in the development and improvement of technologies that effectively exercise greater weight concerning the broad applications of patents, confirming the results found in the research of the article that lack information regarding factors of high and medium need.

4 DISCUSSION

Biotechnology is vital to improving and helping health systems meet patients' needs efficiently and effectively. Through advances in the development of biotechnological innovations, it is possible to properly prevent and control infectious diseases. However, the success of biotechnology in Brazil results from the role of each innovative sector and its respective links. Fostering the dispersion of biotechnology patents in the health field requires significant integration among all actors involved so that the information, research, resources, and relationships between stakeholders can guarantee the development of new commercial products and innovative processes. Besides, increasing investors' participation in biotechnology companies may be a key factor for Brazil to take advantage of its biodiversity's full potential, recognized worldwide (TENÓRIO, MELLO and VIANA, 2017).

Even though the private sector is recognized and emphasized by governments, agencies, and international organizations on a larger scale, it is noted that Brazilian federal universities are playing the role of driving agents in filing patent applications on biotechnology applied to health. To leverage the Brazilian potential in the number of patent filings, it is necessary to establish more partnerships between the public and private sectors since biotechnology is a significant trend for its economic development. However, the production of patents in Brazil on biotechnology in health remains underdeveloped, as new investment strategies in research and development have not undergone significant changes.

Biotechnological patents in the health field should be further explored. They present in their scope new compounds and formulations, technologies for treatment or diagnosis, vaccines, among other information that may be necessary to prevent and control infectious diseases and improve people's quality of life. Despite the patent's importance as a source of information for biotechnological research in health, academic research uses little of the primary patent data. It is a necessary change that must be adopted so that biotechnology in health can present increasingly dense interconnections between systems-actors in different dimensions (scientific-technological, social, and economic) that help develop and file patents (SINGH, HALLIHOSUR and RANGAN, 2009; MATOS and IPIRANGA, 2017).

5 CONCLUSION

The study presented the main characteristics of biotechnological patents in the health area, to be a facilitating agent that helps and directs the people involved in the process since it seeks to compare the information presented. The research's central aim, which consists of broadening the discussion and the

theoretical basis surrounding the theme of the patents filed in Brazil on biotechnology applied to health, has been achieved. Assessing the context, it is relevant to mention that with the constant evolution of technology, new changes in theories, behaviors, and ways of determining the new doctrine of management in public health based on reliable technical elements that seek to facilitate activities and processes are refurbished.

The research contributed to those who seek to better understand the definitions and concepts related to the patent in the health sector, thus providing researchers and interested parties with a study on the subject. As a limitation of this paper, it is possible to say that, since the relationship between the theme of patents and biotechnology is recent, there is not a significant number of technical articles that fit the research criteria. Thus, only the primary references are located.

The description of the results was focused and critical, structured, as far as possible, to expand knowledge on the topic, given its current and relevance in the health sector. Finally, in the absence of a profusion of scientific research on new approaches that link patents and the management of the development of biotechnologies in health, it is suggested that future studies be carried out to deepen this field of knowledge in order to identify ways to contribute to new concepts of health patent information that can be absorbed in the Brazilian context and what are the legal aspects of this use. Future research is suggested to verify the operational interaction between patents and the economic and technical advantages resulting from these actions for the different business segments of the health sector, both in the Research & Development sector and in the public health management part. It is also considered relevant to identify the perspectives of the various member members of the value flow involved in the adoption of biotechnologies applied to health, systematically structuring the lessons learned during the management of projects that seek to prevent and control infectious diseases.

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