



## HEALTH SCIENCES

# Patentometric analysis of the technological development of biotechnology for health in higher education institutions in Rio Grande do Sul

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**Abstract:** Biotechnology offers solutions and opportunities to meet various societal demands, thereby contributing to significant scientific advancements. This study aimed to characterize the technological development of biotechnology in the healthcare sector in the state of Rio Grande do Sul, Brazil, from 2016 to 2022 by analyzing patents filed by and granted to public and private Higher Education institutions. For data collection, a quantitative exploratory approach was employed using statistical methods and a patent analysis of institutions in the patent database of the Brazilian National Institute of Industrial Property (INPI), focusing on patents related to the healthcare field. Data were collected in October, November, and December. A total of 580 patent records were collected from the INPI, belonging to Sections A and C of the International Patent Classification (IPC) related to educational institutions. Furthermore, this study highlighted that higher education institutions have a higher number of patents in the healthcare field. These results provide an understanding of the strategic areas for technological development in biotechnology in Rio Grande do Sul, Brazil.

**Key words:** Biotechnology, Patents, Health, Industrial Property, Rio Grande do Sul.

## INTRODUCTION

Over the past two decades, the evolution of biotechnology techniques has increased our understanding of biological processes at the molecular level and has allowed the reproduction of processes artificially or in modified forms that were previously restricted to natural models (Pimenta 2017). Significant advancements in biotechnology and high-value-added products have led to a redefinition of the patent system worldwide.

In leading patent-producing countries like the United States, Higher Education Institutions

(HEIs) represent a small fraction of the total patent applicants. In contrast, in Brazil, HEIs compete nearly on a par with companies in patent production. Between 1990 and 2010, universities such as the State University of Campinas (Unicamp), the University of São Paulo (USP), and the Federal University of Minas Gerais (UFMG) were among the top five national institutions in terms of patent applications filed with the Brazilian National Institute of Industrial Property (INPI), alongside companies like Petrobras (Cativelli et al. 2019, Junior & De Almeida 2019).

### Patents

The Brazilian Industrial Property Law (IPL) establishes that the protection of industrial property rights is carried out in various forms, including the granting of patents for invention and utility models (which have a validity of 20 and 15 years, respectively) [Fig. 1], industrial design registration, trademark registration, the repression of false geographical indications, and unfair competition (Brasil 1996, Thambisetty et al. 2021).

A patent grants inventors, authors, other individuals, or legal entities the exclusive right to exploit a specific technology (Amaral et al. 2020, Junior et al. 2020, INPI 2021). It is granted by a government office upon request, and any individual or legal entity can file a patent application. Patents are publicly available and serve as objective sources of data on the innovation activities of companies (Guderian et al. 2021).

The INPI is the Brazilian government agency responsible for examining and granting patents. Documentation related to the patent must be

filed with the patent offices of the country where protection is sought. It is up to the applicant company to determine countries; this decision is usually based on the potential of the market.

It should be emphasized that patent application processing involves filing and maintenance fees (Junior et al. 2020). The accepted request is archived and kept confidential for 18 months from the date of deposit with the INPI. It is also possible to request early publication (Brasil 1996, Thambisetty et al. 2021).

Examination results for both formal and technical requirements can suspend the patent application process until they are met (Junior et al. 2020). After the examination is completed, a decision is made to grant or reject patent applications. If granted, the patent is issued after payment of the corresponding fees is confirmed, and the patent certificate is issued.

The patented technology can only be exploited by third parties with the permission of the holder, as expressed through contracts in which the inventor is compensated for the efforts and costs incurred for their invention (Brasil 1996, Thambisetty et al. 2021). Nogueira

Patents		
Type	Concept	Validity
Invention Patent	Solution to an existing technical problem, in order to meet the requirements of novelty, inventive step and industrial application.	20 years counted from the date of patent filing.
Model Patent Utility	Object of practical use (or part thereof) susceptible to industrial application, in order to present a new form or arrangement, inventive act, which results in functional improvement in its use or in its manufacture.	15 years from the date of patent filing.

**Figure 1.** Types of patents. Source: from the authors (2023).

(2018) states that, for companies, the objectives of obtaining a license can be divided into three main classes: access to technology for product or service development, legal assurance to manufacture and sell a product or service and using licensing as an offensive tool to exclude potential competitors in the market. Therefore, technology transfer strengthens the relationship between institutions and companies and plays a crucial role in innovation and competitiveness (Paluma & Teixeira 2019).

### **International Patent Classification**

The International Patent Classification (IPC) is the patent classification system used in Brazil and in more than 100 other countries. The IPC is coordinated by the World Intellectual Property Organization (WIPO).

The IPC consists of four levels: Section, Class, Subclass, and Group. At the highest level, there are eight main sections with 64.000 subdivisions, represented by letters A to H. Each of these sections is further divided into classes, each class into subclasses, and each subclass into groups that can contain subgroups (Cativelli et al. 2019). The eight classes are as follows: A - Human necessities; B - Operations and transport; C - Chemistry; Metallurgy; D - Textiles; Paper; E - Fixed constructions; F - Mechanical engineering; lighting; heating; weapons; blasting; physics; and H, electricity.

By using the IPC, a single invention can receive multiple classifications, which can be indexed according to a function. Once a group of IPCs representing a technological sector, such as biotechnology, is defined, it is possible to conduct various valuable analyses. Among these analyses, technological monitoring of the sector and the creation of a comprehensive overview of patenting in that area during a specific period or in a specific country stand out (Weid et al. 2018).

### **Patents in biotechnology**

According to the Convention on Biological Diversity (CBD) of the United Nations (UN), biotechnology is defined as “any technological application that uses biological systems, living organisms, or their derivatives to manufacture or modify products or processes for specific use” (Amaral et al. 2020). The development of different biotechnology sectors leads to changes and impacts in the research, development, and innovation chain, which reconfigures the organization of companies and interactions in the innovation system in the health field (Gadelha et al. 2019). The result is a sectoral innovation system in which the interaction between heterogeneous agents such as universities, companies in the healthcare sector, and biotechnology-focused companies is essential for generating innovative products. In the healthcare sphere, biotechnology offers promising solutions and perspectives to society and plays a crucial role in scientific advancement (Pimenta 2017).

For Brazilian companies, the incorporation of biotechnology and its derived products into their portfolios is essential for maintaining competitiveness in the medium and long term, especially in the face of increased competition and reduced margins in the generic drug segment. Furthermore, biotechnological products account for a significant portion of the expenses of the Unified Health System because of their high costs.

According to a study on biotechnology sector statistics by the OECD (2009), biotechnology patents accounted for 6.5% of patent portfolios in countries between 2004 and 2006. Denmark is one of the most active countries in biotechnology patenting, with 15.7% of the patents in this area, followed by Belgium, Canada, and Singapore, each with approximately 10% of biotechnology patents. The same study indicated that the

United States contributed 41.5% of all PCT patent filings in biotechnology, followed by Japan and Germany at 12% and 7%, respectively. However, according to statistics from the INPI regarding patent filings by technological fields in Brazil, biotechnology patent applications per Brazilian HEI represent between 3 and 4.5% of the total filings. According to Pimenta (2017), in absolute terms, 38,152 biotechnology patent applications were published in 2004, and 47,012 in 2014.

For scientific and technological knowledge from universities to be disseminated and transformed into innovation, cooperation with the productive sector is necessary, as advocated by the “Triple Helix” model, in which universities, businesses, and governments come together to create an environment conducive to innovation and the technological development of the country (Etzkowitz & Zhou 2017).

Partnerships between universities and businesses aim to generate various benefits, including stimulating scientific and technological research, fostering cooperation among innovation agents, enhancing institutional management, promoting technology-based start-ups, and facilitating technology transfer with a focus on the social impact of innovation processes (Nascimento 2021). However, the interaction between universities and businesses requires a strategic approach to Intellectual Property management, considering interactions with the market and the ability to negotiate them through transfers, generating revenue for Technology Transfer Offices (TTOs) (Simões & Santos 2018). However, what is observed is the technologies developed at Brazilian universities are not primarily implemented in the form of products or processes.

In this context, this study aims to characterize the technological development of biotechnology in the healthcare sector in the State of Rio Grande do Sul from 2016 to 2022

by analyzing patents filed by universities and indexed in the INPI database. The specific objectives focus on identifying areas of the IPC and delineating the locations and sectors that are developing these patents.

## MATERIALS AND METHODS

This study aimed to analyze the technological development of biotechnology for health in the state of Rio Grande do Sul, Brazil, from January 1, 2016, to December 31, 2022, by analyzing patents filed and granted by public and private Higher Education Institutions (HEIs) in Rio Grande do Sul. It is a bibliometric study with a patentometric bias that focuses on patent analysis. This study used the INPI patent database as a source for data collection, and the records were quantitatively analyzed. Search for all patents deposited by universities was done and then filtered for patents related to biotech and health.

The research was divided into three phases: the 1st phase related to the documents to be collected; the 2nd phase related to data collection; and the 3rd phase related to the analysis and presentation of the results. The first phase occurred in January 2023, when the search strategy was decided. Since the database does not allow the retrieval of documents deposited by geographical area, it was decided to analyze the most relevant public and private entities in the state of Rio Grande do Sul. Thus, the search terms were initially based on the name of the institution, followed by its acronym, for example, “Universidade Federal do Rio Grande do Sul” OR “UFRGS,” considering that many institutions are also known by their acronyms. The 2nd phase involved data collection, which took place throughout February and March 2023. The advanced search option was selected, in

which the fields of 'Dates,' 'Classification,' and 'Applicant/holder/inventor' were combined.

In the 'Dates' field, the subfield 'date of deposit' was used, entering the period from 01/01/2016 to 12/31/2022. In the 'Classification' field, the subfield 'IPC Classification' was selected, where the subclasses of IPC related to Patents in Biotechnology in health were entered. In the 'Applicant/holder/inventor' field, the subfield 'Name of applicant/holder' was used, where the acronyms of the universities and the Boolean operators OR and AND were used to include the search for the full name of the institutions. The 3rd phase began in early April 2023, when all patent records were obtained. During this phase, the type of patent registered (invention or utility model patent) and the technological subdomain to which the registered patent belongs were analyzed. The SPSS v29.0 Software was used to construct graphs and tables to facilitate data analysis.

## RESULTS

A search of the INPI Database retrieved 788 patent documents related to biotechnology in human health. Based on this query, an analysis of the mentioned variables was conducted,

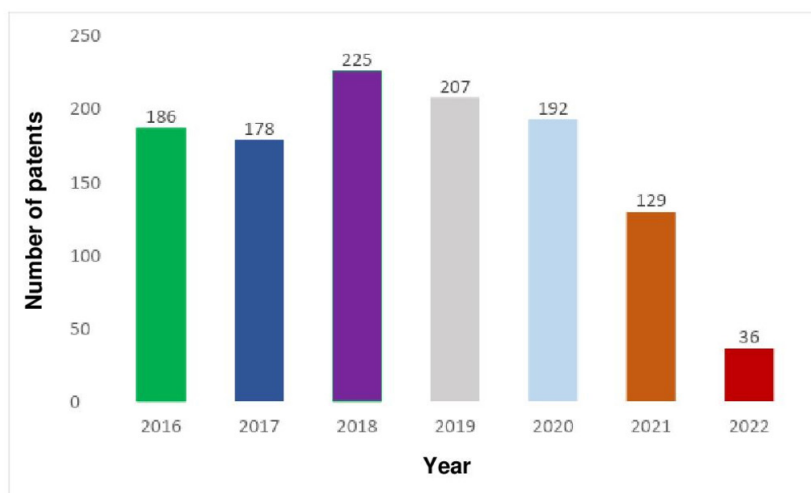
and the results are described below. Table I shows the total number of records deposited by education institutions in Rio Grande do Sul from 2016 to 2022. The overall average over the last 6 years was 161.71 deposits per year.

We observed a slight decrease between 2016 and 2017 and a significant decrease between 2020 and 2022. This factor can be explained by budget cuts for Science and Technology promoted by the Federal Government and the COVID-19 pandemic that occurred during this period.

A survey of the number of patent filings made by Gaúchas Higher Education Institutions (Fig. 2) demonstrates that Public Universities will stand out in the number of patent filings made between 2016 and 2022.

Analysis of the typology of patent applications revealed the predominance of invention patents, accounting for 98.43% of filings in this category, compared to only 1.57% of utility model applications (Table II).

Among the 253 university patents related to biotechnology in health deposited by HEIs in Rio Grande do Sul, 86 belonged to Class A and 46 belonged to Class C of the IPC. Among the identified patents, 121 remained confidential during the data collection phase. Patents related



**Figure 2.** Graph of total patents filed per year (period from 2016 to 2022) by HEI in RS. Source: From the authors, 2023.

to the health sector were also found in the G-physics classes. However, they are not patent deposits for biotechnological products (Table III).

In Class A, patents mainly belong to subclasses 61–medical or veterinary science; hygiene; 23–food or food products; their treatment, not covered by other classes; and 47–health, rescue, and recreation. In Class C, the patents belong to classes C07–organic chemistry, C12–biochemistry, beer, alcohol, wine, vinegar,

microbiology, enzymology, genetic engineering, or mutation.

Table IV shows the relationship between Postgraduate Programs and Patent Applications. In the analyzed period, the institution with the highest number of programs with research lines related to the health biotechnology theme was UFRGS, with seven programs, followed by UFPEL with five programs. Together, these two institutions submitted 403 patent applications in the analyzed area.

**Table I. Survey of patent filings by university from 2016 to 2022.**

University	Total patent filings per year*							Total
	2016	2017	2018	2019	2020	2021	2022	
UFPEL	45	25	26	27	40	26	15	204
UFRGS	31	40	47	42	24	14	1	199
UCS / FUCS	13	17	18	17	22	14	2	103
UFSM	14	16	14	16	13	16	6	95
FURG	5	6	8	12	11	12	2	56
IFSUL	2	0	14	6	8	0	0	30
PUCRS	5	5	5	4	3	4	0	26
UNISC	8	7	3	1	3	0	0	22
UNIPAMPA	0	2	3	2	10	0	0	17
UNIVATES / FUVATES	9	1	1	2	0	1	2	16
SLMANDIC	0	0	0	0	6	4	1	11
IFRS	1	0	3	4	2	0	0	10
UNISINOS	4	0	0	2	1	3	0	10
IFFAR	1	2	2	4	0	0	0	9
UFCSPA	0	0	4	3	1	0	0	8
FEEVALE	0	0	0	0	2	2	0	4
UNIFRA	0	0	0	0	1	2	0	3
URI (FURI)	0	1	0	1	0	1	0	3
FSP	1	0	0	0	0	0	0	1
ULBRA	0	0	1	0	0	0	0	1
FDN	0	0	1	0	0	0	0	1
UERGS	0	0	0	0	0	0	0	0

\* Patent documents related to biotechnology in human health.



**Table II. Survey of patent filings by type in the period from 2016 to 2022\*.**

University	Innovation Patents							Utility Model						
	2016	2017	2018	2019	2020	2021	2022	2016	2017	2018	2019	2020	2021	2022
UFPEL	45	25	26	27	40	26	15	0	0	0	0	0	0	0
UFRGS	31	38	47	41	18	2	1	0	1	0	0	2	0	0
UFSM	14	16	14	16	2	16	5	0	0	0	0	0	0	1
UCS / FUCS	13	17	18	17	22	14	2	0	0	0	0	0	0	0
FURG	5	5	7	12	9	12	2	0	1	1	2	0	0	0
IFSUL	2	0	14	6	8	0	0	0	0	0	0	0	0	0
PUCRS	5	5	3	3	3	4	0	0	0	1	0	0	0	0
UNISC	8	5	3	1	3	0	0	0	2	0	0	1	2	0
UNIVATES / FUVATES	9	1	1	2	0	1	2	0	0	0	0	0	0	0
UNIPAMPA	0	2	2	1	7	0	0	0	0	1	1	2	0	0
IFRS	1	0	3	4	2	0	0	0	0	0	0	0	0	0
IFFAR	1	2	2	4	0	0	0	0	0	0	0	0	0	0
UFCSPA	0	0	4	3	1	0	0	0	0	0	0	0	0	0
UNISINOS	0	0	0	1	1	3	0	0	0	0	0	0	0	0
SLMANDIC	0	0	0	0	2	3	0	0	0	0	0	4	1	0
FEEVALE	0	0	0	0	2	2	0	0	0	0	0	0	0	0
UNIFRA	0	0	0	0	1	2	0	0	0	0	0	0	0	0
URI (FURI)	0	1	0	1	0	1	0	0	0	0	0	0	0	0
UERGS	0	0	2	1	0	0	0	0	0	0	0	0	0	0
ULBRA	0	0	1	0	0	0	0	0	0	0	0	0	0	0
FSP	1	0	0	0	0	0	0	0	0	0	0	0	0	0
FDN	0	0	1	0	0	0	0	0	0	0	0	0	0	0

\* Patent documents related to biotechnology in human health

**Table III. Distribution of patent deposits by class and period of secrecy of universities from 2016 to 2022.**

University	Class		Secrecy Period (months)
	A	C	
UFPEL	34	28	40
UCS	12	0	22
UFRGS	24	13	21
UFSM	4	2	13
FURG	3	0	11
IFSUL	0	0	8
PUCRS	6	1	3
UNIVATES	1	0	0
UNISC	2	2	3
UNISINOS	0	0	0
<b>Total</b>	<b>86</b>	<b>46</b>	<b>121</b>

## DISCUSSION

The data shows that UFPel leads the ranking of patent application submissions, followed by UFRGS and UCS. The patent submissions from other universities are significantly less prominent when compared to the numbers from UFRGS and UFPel, but they are no less important. Since 2005, UFPel has had an office dedicated to supporting the development and implementation of technologies, known as the Intellectual Property, Technology Transfer, and Entrepreneurship Office of UFPel. This office also provides support to research groups and their interactions with companies and business arrangements, assists in the creation of scientific,

technological, and business development plans. Its primary purpose is to manage the university's innovation policy.

UFRGS has an Office of Interaction and Technology Transfer (EITT), whose mission is to facilitate the UFRGS interaction with society and to serve as the institutional authority responsible for implementing procedures related to intellectual property protection. Furthermore, UFRGS's technological production shows a significant number of collaborations. Collaborating institutions included educational and research institutions such as the Hospital de Clínicas de Porto Alegre (HCPA) and the University of São Paulo (USP). However, only a few companies such as Biolab, Braskem, and Petrobras are linked to this university.

The private university with the highest number of IP assets was UCS, which has its own Technology Transfer Office (TTO) linked to the Pro-Rector for Research and Postgraduate Studies (PPPG). The TTO was created to promote and facilitate negotiations between the Institution and the Community in knowledge transfer actions generated by the university as well as to manage the UCS's set of intangible assets. The Technology Transfer Office is involved in the entire process related to Intellectual Property, from supporting students and faculty to registering with relevant authorities, and plays a role in transferring or commercializing the results of scientific research at UCS.

Indeed, the presence of TTOs in Higher Education and Research Institutions plays a crucial role in bridging the gap between scientific

**Table IV. Survey of patent deposits filed and granted to public and private in Rio Grande do Sul and numbers of postgraduate programs.**

IES	Total deposits	Number of programs	
		Master	Doctorate degree
UFPEL	204	5	5
UFRGS	199	7	7
UCS (FUCS)	103	2	2
UFSM	95	4	4
FURG	56	2	2
IFSUL	30	0	0
PUCRS	26	4	4
UNISC	22	1	1
UNIPAMPA	17	3	2
UNIVATES (FUVATES)	16	2	1
SLMANDIC	11	1	0
IFRS	10	0	0
UNISINOS	10	1	0
IFFAR	9	0	0
UFCSPA	8	5	5
FEEVALE	4	2	0
UNIFRA (UFN)	3	2	1
URI (FURI)	3	1	1
FSP	1	0	0
ULBRA	1	2	1
FDN	1	0	0

\* Patent documents related to biotechnology in human health.



production and technological innovation in a country. Well-structured TTOs capable of performing fundamental activities also serve as information support centers for technological innovation. They are accessible to both internal and external communities affiliated with the institution and significantly contribute to the overall innovation ecosystem.

It is possible to identify that the technological production of UFRGS is growing, but this is not an isolated fact. University patents have grown throughout Brazil due to the enactment of the Innovation Access Law of 2004, Law N° 10.973/2004, which provides legal guarantees for inventions developed in universities, encourages the development of innovations and monitors technological records (Pojo 2019). This enacted legislation aims to promote the production of new technologies by legalizing the relationship between TTOs and companies based on the Triple Helix model (Junior & Almeida 2019).

In 2016, the Information Law was reinforced by Law N°. 13.243/2016, which defined new elements for creating innovative environments, in which public universities are included. This includes the provision of specific legal instruments for intellectual property ownership and participation in the exploitation of creations resulting from partnerships. This legislative change reflected a clear political concern regarding the use and treatment of industrial property developed within universities. Furthermore, the new legislation promotes greater interactions between TTOs and private companies. It allows for the sharing of equipment, university laboratories, and research teams by companies. It also authorizes universities to hold intellectual property rights over the results of research in which they participate, turning universities into organizations that produce and provide services (Costa & Silva 2016).

Another contributing factor was the strengthening of National Innovation Systems, which promoted greater interaction among TTOs, companies, and the government. According to Ziomkowski et al. (2021), in Brazil, from 2000 to 2012, there was a 15% increase in intellectual property protection requests through patenting by TTOs, while individual inventors experienced a 21% decline, and companies showed a 7% increase.

According to Scartassini & Moura (2020), universities tend to develop patents classified in Sections A and C, which refer to medical and chemical áreas, in general. In the case of the UFRGS, there is a predominance of products in Sections A, B, and C, which encompass medical fields, drug development, and chemical and biochemical processes, as supported by studies by various authors (Cativelli & Lucas 2016, Scartassini & Moura 2020).

Another inference that can be made based on the analyzed data is that universities with a higher volume of *stricto sensu* postgraduate programs with research lines focused on biotechnology do not always obtain a larger number of patent applications.

## CONCLUSIONS

The UFPEL is the university with the highest number of IP assets has its own Technology Transfer Office linked to the Pro-Rectorate for Research and Postgraduate Studies. The TTO was created to promote and facilitate negotiations between the Institution and the Community in knowledge transfer actions generated by the university as well as to manage the UFPEL set of intangible assets. Public universities deposit the highest number of patents in the healthcare field. This study provides a deeper understanding of technological developments in biotechnology in Rio Grande do Sul through patent indicators

and allows for an understanding of this dynamic in relation to the sectoral context involving the healthcare sector.

It should be noted that although there is some resistance within the academic environment regarding the strategy of protecting inventions through patenting, many of them are based on the Brazilian patent system, which is restrictive and slow compared to other countries. Additionally, it is important to remember that patents are valuable intangible assets that serve as sources of technological information of great relevance in the context of knowledge dissemination and institutional competitiveness, with recognized implications for a country's performance in the global scientific and technological landscape. However, although INPI is the country's main filing office, other offices have attracted the interest of inventors in Rio Grande do Sul for patent filing. One is the WIPO, which handles filings through the PCT route, providing an alternative way for applicants to obtain patents for their inventions.

For an invention to be considered an innovation, it must reach the market through intellectual property mechanisms or management. There has not been an effective transformation of inventions resulting from research conducted in universities into patents, nor has there been an effective transformation of these inventions into new products or services for the market. Unfortunately, there is still a gap between what is done in terms of Research, Development, and Innovation in Science and Technology Institutions, especially when analyzing inventions developed, and the generation of technological innovation that meets the real needs of the productive sector.

### Ethical Approval

Ethical approval is not applicable for this study, because it is a patentometric analysis.

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