NETWORKS FOR PUBLIC HEALTH IMPROVEMENT: COLLABORATION PATTERNS OF A BRAZILIAN GOVERNMENT PRODUCTION LABORATORY

Bruna de Paula Fonseca e Fonseca[1,2]; Marcus Vinicius de Araújo Fonseca[1]; Elton Fernandes[1]

[1] Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering, Federal University of Rio de Janeiro - UFRJ;
[2]Laboratory of Diagnostics Technology, Bio-Manguinhos, Oswaldo Cruz Foundation – FIOCRUZ, Rio de Janeiro, Brazil.

INTRODUCTION

In the Brazilian public health system (SUS), the government has a significant role in directing the health industry, which ultimately focus the local technological capability in public institutions. In this scenario, collaboration networks become especially important for the development of innovations, as they can contribute to the reduction of government spending, decreasing the balance of trade deficit, stimulating national development and increasing the population access to good quality products, of high technology content. The Oswaldo Cruz Foundation (FIOCRUZ), an organ of Science and Technology of the Brazilian Ministry of Health (MoH), plays a major role in SUS (**Figure 1A**). It consists of a complex of 14 institutes that associate the generation of scientific knowledge and the development of technologies with the production of strategic health inputs and provision of diagnostic services (**Figure 1B**). Within FIOCRUZ, **Bio-Manguinhos** occupies a prominent position in the country as an important innovation agent in SUS by developing and producing biopharmaceutical products, diagnostic reagents and vaccines for the MoH (**Figure 1C**).

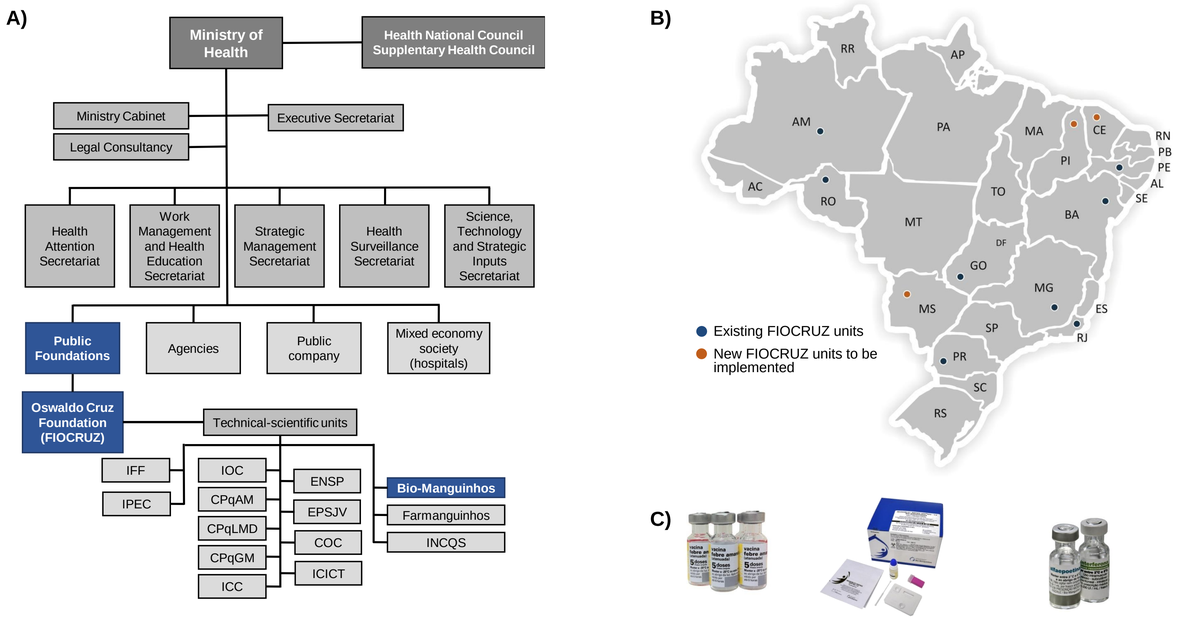

Figure 1: FIOCRUZ and Bio-Manguinhos role in the Brazilian Ministry of Health. A) Structure of the Brazilian Ministry of Health and role of FIOCRUZ as the National Health Foundation and Bio-Manguinhos as one of its technical-scientific units. **B)** Location of the FIOCRUZ units in different Brazilian states and presence of Bio-Manguinhos in the Rio de Janeiro state, southeast region. **C)** Products included in Bio-Manguinho's portfolio.

OBJECTIVE

To map the science-technology pathway that Bio-Manguinhos has been pursuing in order to comprehend the social context on which the Institute is embedded and provide information on both opportunities and constraints that could have important performance implications for the strategic planning and management of public health policies.

METHODS

Social network analysis was used to construct and analyze patent and scientific publication networks that involve Bio-Manguinhos in order to understand its collaboration pattern and identify its partners. A summary of the methodology used is shown in **Figure 2**.

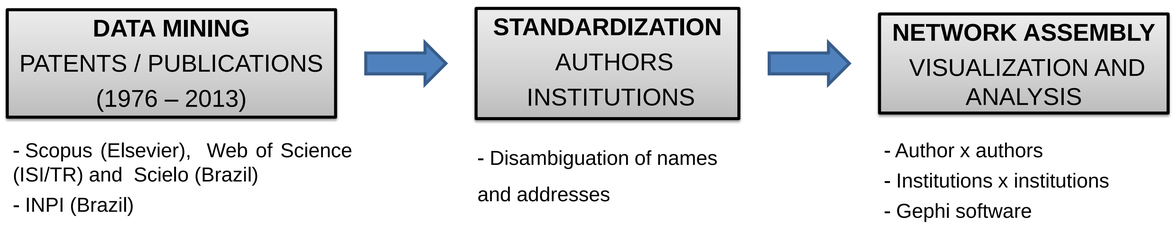

Figure 2: Schematic representation of the methodology used for data collection, standardization and analysis. Publication and patent networks were constructed based on information retrieved from Brazilian and international databases. Upon the compilation of all data, a manual process of standardization was carefully carried out to bring together the various names of a particular author or institution. Data were translated into specific edge lists to map co-authorships between authors and between institutions. Edge lists were built into comma-separated value (CSV) files and imported to the open-source Gephi software to visualize the network graphs and perform statistical analysis of the dataset

RESULTS AND DISCUSSION

Data collection on Bio-Manguinhos scientific publications and patents retrieved 175 and 13 records, respectively. Of the 13 patent applications, nine of them were also filed in other countries and 12 of them were co-titled with other organizations. **Figure 3** shows the number of papers (A) and patents (B) of Bio-Manguinhos authors retrieved per year and the average number of collaborators involved in these activities.

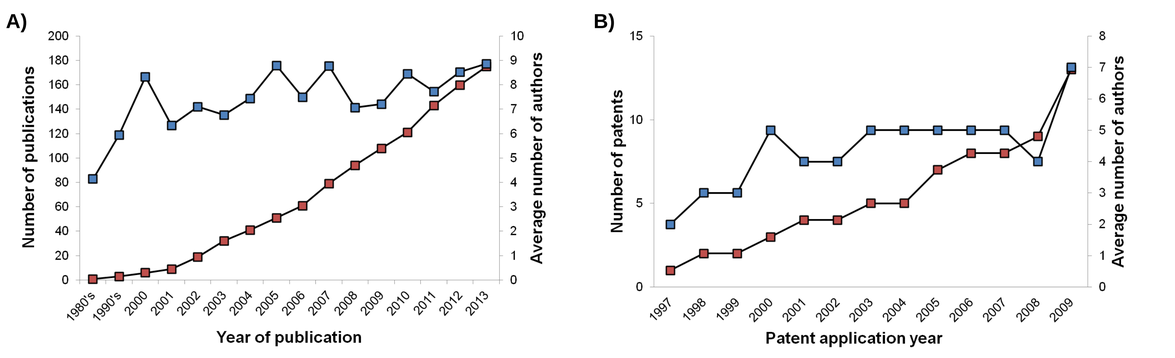

Figure 3: Number of scientific publications (A) and patents (B) of Bio-Manguinhos authors retrieved per year and average number of collaborators. The cumulative number of scientific papers published (A) and patents applied (B) in the period of 1976 to 2013 (left axis) are represented by the red squares and the average number of authors participating in these activities (right axis) are represented by the blue squares.

When comparing the years of 1980's and 1990's with the 2000's, it was observed not only an increase in the number of papers published and patents applied, but also an increase in the average number of co-authors participating in these activities. This fact is in line with the global tendency to collaborate in all areas of science, characterized by intensifying cooperation, especially in the fields of clinical medicine, biosciences and biomedical research.

Because of the difficulty in obtaining precise information on authors affiliation in the 1980's and 1990's, and to reflect Bio-Manguinhos recent pattern of collaboration in scientific publications, individual and institutional co-authorship networks were constructed based on 2000-2013 records. The patent networks were constructed based on all records retrieved. **Figure 4** shows the co-authorship networks of Bio-Manguinhos individual authors.

The publication network (**Figure 4A**) is composed of 755 nodes, distributed in 16 weakly connected components. The giant component involves the majority of authors (86.7%), which are mostly affiliated to national institutions (60%). Degree distribution within the network follows a power law, suggesting that scientific connectivity is not equally distributed among all authors, but contrastingly, a few very well linked nodes control it.

The patent network (**Figure 4B**) is comprised of 55 nodes, involving 18 Bio-Manguinhos authors distributed in six weakly connected components. This could be explained by the diverse product lines that are produced by Bio-Manguinhos, which may require different specialties and address diverse technology fields.

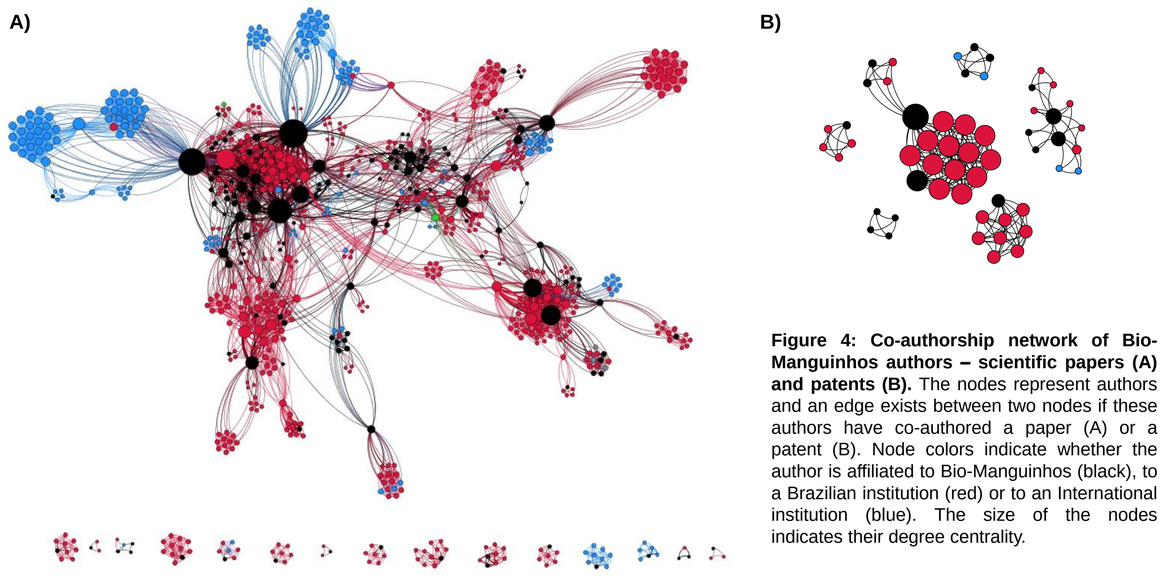

Figure 4: Co-authorship network of Bio-Manguinhos authors – scientific papers (A) and patents (B). The nodes represent authors and an edge exists between two nodes if these authors have co-authored a paper (A) or a patent (B). Node colors indicate whether the author is affiliated to Bio-Manguinhos (black), to a Brazilian institution (red) or to an International institution (blue). The size of the nodes indicates their degree centrality.

Analysis of centrality measures of both networks (**Table 1**) demonstrates that Bio-Manguinhos currently relies on the same individuals to cope with the current challenges of technological innovation and scientific research productivity. This finding indicates that, in Bio-Manguinhos, industrial development is not isolated from the science community as it has been seen in other research settings in Brazil. Nevertheless, this result indicates fragility for the organization. As its scientific productivity and technological development rely on the hands of only a few individuals, the exit of these professionals from the Institute would mean a great loss for its technical-scientific capabilities.

Table 1: Top three authors based on total number of papers or patents and centrality measures.

Rank	Author	Number of papers	Author	Degree centrality	Author	Betweeness centrality
1	Akira Homma	27	Akira Homma	129	Marcos Freire	59,563
2	Marcos Freire	24	Reinaldo Martins	122	Akira Homma	46,504
3	Antonio Gomes	21	Marcos Freire	110	Edimilson Domingos	36,125
Rank	**Author**	**Number of patents**	**Author**	**Degree centrality**	**Author**	**Betweeness centrality**
1	Ricardo Galler	6	Antonio Gomes	18	Antonio Gomes	56
2	Marcos Freire	5	Edimilson Domingos	14	Marcos Freire	33
3	Antonio Gomes	2	Marcos Freire	10	Ricardo Galler	19

Network analysis was also carried out at the institutional level. Analysis of the publication network (**Figure 5A**) indicates that both national (53%) and international (47%) institutions are equally present as Bio-Manguinhos collaborators. The participation of foreign organizations suggests that national interactions are not broad enough to satisfy the collaborative needs of the Institute. In the institutional patent network (**Figure 5B**), national organizations play a leading role in the partnerships with 66% of all cooperation.

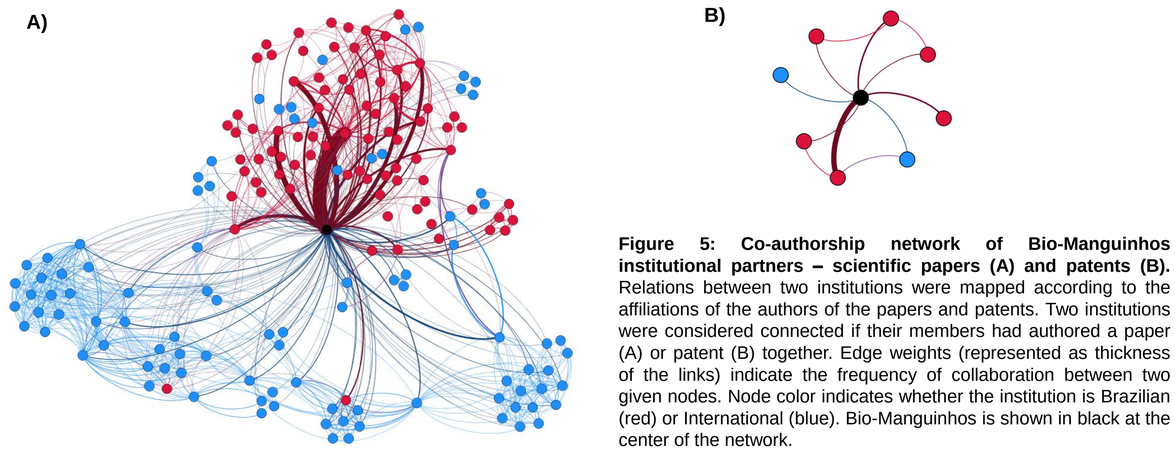

Figure 5: Co-authorship network of Bio-Manguinhos institutional partners – scientific papers (A) and patents (B). Relations between two institutions were mapped according to the affiliations of the authors of the papers and patents. Two institutions were considered connected if their members had authored a paper (A) or patent (B) together. Edge weights (represented as thickness of the links) indicate the frequency of collaboration between two given nodes. Node color indicates whether the institution is Brazilian (red) or International (blue). Bio-Manguinhos is shown in black at the center of the network.

Analysis of the type of institutions that collaborate with Bio-Manguinhos, revealed that cooperation is mostly restricted to universities, government-related institutions and other FIOCRUZ units (**Table 2**). There is lack of participation by industry, especially in patent applications, and the most frequent Bio-Manguinhos partners is a FIOCRUZ unit. Despite several technology transfer agreements between Bio-Manguinhos and private companies, this result demonstrates an absence of cooperation with regard to product development. Additionally, it shows the Institute's frequent engagement in multiple same-type alliances, which may hinder access to diverse pools of information and complementary assets necessary for successful growth.

Table 2: Type of institution participating in the collaboration networks.

Type of institution	Participation in publication network	Participation in patent network
Universities	35%	50%
Government-related institutions	25%	12,5%
Hospitals and healthcare centers	14%	0%
Private companies/industry	10%	0%
Other FIOCRUZ units	8%	37,5%
International organs and agencies	5%	0%
Research institutes	2%	0%

CONCLUSION

Social network analysis generated valuable information on Bio-Manguinhos network patterns and processes. The comparison of publishing and patenting networks showed a marked difference between both, suggesting that their articulation could be the key to consolidate Bio-Manguinhos scientific research productivity into patents and ultimately products. Most importantly, it also revealed fragility in the Institute's innovation chain, which relies on only a few key individuals to cope with scientific productivity and product development. Further analysis of the publications and patenting networks that are related to Bio-Manguinhos sphere of action could provide insights into the most adequate partnerships for improving public health in Brazil

Contact: bruna.fonseca@pep.ufrj.br