Challenges of Innovation in the Health Economic-Industrial Complex: A Case Study on Implementation of Research Results in a Brazilian Science and Technology Institution

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In addition to advancing scientific knowledge, science and technology institutions (STIs) must translate research outcomes into practical applications, thereby addressing societal needs and challenges. Consequently, this study examines the outcomes produced by a public STI, employing the morphology of the Health Economic-Industrial Complex (HEIC) as an analytical framework. Notably, 77.8% of these outcomes have benefited populations marginalized by public policies. The research underscores a robust correlation between the institution's capacity for technological innovation and the chemical and biotechnological industrial subsystems, particularly in diagnostics and diagnostic services. Significantly, the primary impact of these innovations manifests in formulating and enhancing public health policies, thereby directly influencing governmental initiatives aimed at bolstering the Unified Health System.

Keywords: Innovation; Health Economic-Industrial Complex; Scientific Evidence; Public Health.

The World Health Organization (WHO) defines health innovation as the development of policies, systems, products, technologies, services, and health methodologies aimed at improving the well-being of populations. It emphasizes that such innovations encompass preventive, promotional, therapeutic, rehabilitation, and/or assistive measures [1]. These innovative endeavors are closely intertwined with the scientific sector, as they rely on the flow of information to catalyze breakthroughs in medical practices and healthcare. This encompasses new drugs, equipment, clinical procedures, prophylactic measures, and informational resources [2].

In Brazil, specific challenges hinder health innovation, including difficulties in identifying pertinent research problems, limited engagement of critical stakeholders in scientific research outcomes, lack of collaboration between researchers and knowledge users in the investigative process, and constrained research budgets, particularly for implementing research findings [3]. Against this backdrop, the Health Economic-Industrial Complex (HEIC) concept has gained prominence as a model for scrutinizing the political institutional dynamics underpinning the production and provision of healthcare goods and services.

It is noteworthy that the dynamics of health innovation entail a complex network of institutional arrangements comprising industrial firms, healthcare service providers, academic and scientific institutions, technology and innovation entities, research funding bodies, civil society organizations, and healthcare regulatory agencies, as well as the enactment of industrial, scientific, and technological policies, healthcare policies, and intellectual property regulations [4,5].

Understanding this innovation process within its ecosystem is pivotal for devising organizational strategies and public policies capable of identifying potential barriers to health innovation.

This study aims to analyze the challenges confronting health innovation in Brazil by examining the contextual determinants influencing the adoption of research findings within a public science and technology institution, employing the morphology of the Health Economic-Industrial Complex as an analytical framework.

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Materials and Methods

This study constitutes a case investigation involving a public Science and Technology Institution (STI) in Bahia. Fifteen volunteers were selected from a pool of 25 researchers within the institute, chosen based on their status as laboratory leaders or recipients of research productivity grants from the National Council for Scientific and Technological Development (CNPq). The research adheres to ethical principles governing studies involving human subjects and received approval from the Research Ethics Committee of SENAI CIMATEC - Opinion No. 5,096,148. Primary data collection involved:

We are conducting semi-structured interviews. The content analysis technique is employed as delineated by Bardin [6].

We are adopting the Consolidated Framework for Implementation Research developed by Damschroder and colleagues [7], focusing on intervention characteristics. During the interviews, volunteers were tasked with recounting two research cases: one wherein outcomes were effectively implemented to enhance population health and another where potential innovations had yet to be realized despite being within reach. Furthermore, the morphology of the Health Economic-Industrial Complex served as a model for scrutinizing the locus of implementation for identified innovations and evaluating outcomes with potential for such implementation.

Results and Discussion

Twenty-four instances of scientific research outcomes were identified, wherein the interviewees directly participated. Among these, nine cases (37.5%) saw successful implementation, while 15 (62.5%) held innovation potential. Data analysis in Table 1 reveals that 79.2% of the reported research outcomes pertained to product development projects encompassing diagnostics, drugs, medications, and vaccines alongside clinical investigations. The latter category may encompass endeavors focused on product development, novel treatments, or clinical-epidemiological assessments, all of which hold promise for contributing to enacting public policies aimed at directly or indirectly benefiting the health of the Brazilian populace and fortifying the Unified Health System.

By focusing the analysis on the innovations emanating from the studied STI, Table 2 reveals that 44.5% of the cases targeted diseases categorized as neglected by the World Health Organization (WHO): tuberculosis (1), Chagas disease (1), leprosy (1), and HTLV (1). Furthermore, three cases (33.3%) were dedicated to addressing diseases prevalent among socially vulnerable populations, including leptospirosis (1), hemoglobinopathies (1), and child nutrition (1). Notably, 77.8% of the innovations generated by the STI benefited populations marginalized by governmental public policies and/or investments in research, development, and innovation within the pharmaceutical industry. Additionally, two more cases were reported, one of HPV and another of hepatitis C. Regarding the application sites of these innovations within the Health Economic-Industrial Complex (HEIC), Table 2 underscores the STI's robust technological prowess, particularly within the chemical and biotechnological-based industrial subsystems for diagnostics and diagnostic services, where 5 cases (55.6%) were identified. The nascent Information and Connectivity subsystem accounted for 3 cases (33.3%), while the chemical and biotechnological-based subsystem for vaccines featured in 1 case (11.1%) of research conducted by a multinational pharmaceutical industry in collaboration with an STI researcher serving as the lead investigator in a phase III clinical trial. The STI's capacity to innovate for the betterment of public health is underscored by the impact of its innovations on the formulation and/or enhancement of public health policies, as evidenced by 6 cases (66.6%) directly influencing governmental action in favor of public health at national, regional, and local levels. It is worth

Table 1 . Distribution of research results implemented or with potential for innovation reported by STI researchers.

Research Areas	Incidence (N)	Incidence (%)	Implanted (N)	Implanted (%)	Not Implanted (N)	Not Implanted (%)
Research and Development of Diagnostics	7	29.2%	4	57.1%	3	42.9%
Clinical Research and Clinical Trials	5	20.8%	2	40.0%	3	60.0%
Research and Development of drugs and medicines	4	16.7%	0	0.0%	4	100%
Research and Development of Prophylactic and Therapeutic Vaccines	3	12.5%	1	33.3%	2	66.7%
Genetics and Molecular Epidemiology in Health, Pharmacogenetics	2	8.3%	1	50%	1	50%
Entomology, Biology and Reservoirs of Infectious Agents	1	4.2%	0	0.0%	1	100%
Epidemiology, Statistical and Quantitative Methods	1	4.2%	1	100%	0	0.0%
Public Policies, Planning and Management in Health	1	4.2%	0	0.0%	1	100%
Totals	**24**	**100%**	**9**	**37.5%**	**15**	**62.5%**

noting that being a public health-oriented STI, its outcomes are closely intertwined with the state's role in promoting health. Furthermore, it is pertinent to mention that scientific evidence produced and implemented within the mechanical, electronic, and materials-based industrial subsystem still needs to be identified.

Table 3 showcases 15 research outcomes with the potential to instigate innovation yet remain unimplemented. A notable socio-sanitary inclination is evident within the STI under study, with 66.7% of the cases focusing on neglected diseases as classified by the WHO. Among these, ten cases encompass leishmaniasis (7), Chagas disease (2), and dengue (1). Additionally, two scientific findings pertain to pathologies that, while not categorized as neglected by the WHO, predominantly afflict socially vulnerable populations: leptospirosis (1) and sickle cell disease (1). Combining these two cases with the preceding ten, we observe that 80% of the potentially innovative scientific outcomes target neglected diseases and/or socially vulnerable populations. According to Decit, neglected diseases are those that not only prevail in conditions of poverty but also perpetuate inequality, serving as formidable barriers to a country's development. Moreover, Garcia and colleagues assert that neglected diseases commonly exhibit high endemicity in rural and underprivileged urban areas of developing nations, coupled with a paucity of research endeavors for the development of new drugs, particularly by transnational pharmaceutical corporations [8,9].

About the contextual determinants of health innovation, the interviewed volunteers cited 65 aspects perceived as barriers to the process of implementing the scientific evidence produced. Table 4 shows that 8 categories of barriers were identified, with greater relevance given to the following challenges to be faced: Cooperation

Table 2. Research Results that generated innovation reported by STI researchers studied.

Search Results	Disease	Kind of Innovation	Application Locus at HEIC
Leprosy sub-registration	Leprosy	Service	Information and connectivity subsystem State> promotion + regulation Others: Public Policy with an impact on Public Health
Neonatal screening for hemoglobinopathies	Hemoglobinopathies	Service	Service subsystem: Diagnostics Others: Public Health Policy
Impact of Vitamin A on infant nutrition	Infant Nutrition	Service	Information and connectivity subsystem State> promotion + regulation Others: Public Policy with an impact on Public Health
BCG revaccination	Tuberculosis	Service	Information and connectivity subsystem State> promotion + regulation Others: Public Policy with an impact on Public Health
Rapid Test for the Diagnosis of Leptospirosis	Leptospirose	Product	Subsystem based on chemistry and biotechnology: Reagents for diagnosis Service subsystem: Diagnostics
Molecular diagnostic test for Hepatitis C	Hepatitis C	Service	Subsystem based on chemistry and biotechnology: Reagents for diagnosis Service subsystem: diagnostics
Testing for HTL-V in prenatal care	HTL-V	Service	Subsystem based on chemistry and biotechnology: Reagents for diagnosis Service subsystem: diagnostics Others: Public Health Policy
Diagnostic potential of Trypanosoma cruzi recombinant proteins	Human Chagas disease	Product	Subsystem based on chemistry and biotechnology: Reagents for diagnosis Service subsystem: diagnostics
HPV vaccine	HPV	Product	Chemical and biotechnological base subsystem: Vaccines

Table 4. Contextual determinants for health innovation: barriers.

Categorization	Definition	Examples of Reports	Nº	%
Cooperation and Restricted Partnerships	Refers to the need to strengthen institutional dialogues with public and private entities to expand strategic collaborations, formal and informal, intra and extramural, in support of the implementation of the results of the scientific evidence produced by the STI	"It is not understood that these public-private partnerships are important. There is a crooked look at researchers who seek private initiative to develop their projects"	13	20%
Lack of Training and Development of Skills for Innovation in STI	Refers to the need to improve the process of recruiting, developing and retaining human resources to act in the implementation of research results	"We researchers do not have training for innovation, so it is very difficult today to be a researcher in Brazil"	12	18.46%
Financing in Limited ST&I	Refers to insufficient financial resources for research, development and innovation.	"There is a need for new funding to implement research results"	10	15.38%
Low Institutional Competence to Deal with Regulatory Bodies	Refers to limited institutional competence to deal with the complexity of normative and legal requirements by regulatory bodies, which would facilitate KT	"It needs a lot more resources, it needs people who understand regulatory issues, lack of trained staff"	10	15.38%
Insufficient Technical Support for innovation	Refers to the need for human resources with specialized technical knowledge to support innovation in STI	"Lack of support from a group that spoke look we identified a series of potential products or potential ideas to be translated and sold"	8	12.31%
Culture of Insufficient Creativity and Innovation	Refers to the need to encourage a culture of creativity and innovation among STI managers and researchers, as well as to strengthen closer ties with government, industry, society and other stakeholders to promote the generation of ideas, knowledge, products and services, expanding the ability to innovate	"You have to take a deeper look at innovation"; "there is no culture of entrepreneurship"	6	9.23%
Little technical-scientific criteria in the definition regarding the vocation of physical spaces	Refers to the need for definition regarding the vocation and use of equipment and physical spaces, according to technical criteria that ensure greater quality to scientific experiments	"There is no proper culture room to work in. There is no division by viruses, bacteria, parasites, etc. segmented culture rooms"	3	4.62%
Conflict between Research and Management Macroprocesses	It is about the incompatibility of the national public management model with the specificities of scientific research institutions, in addition to a misaligned culture between management and research that is not always able to respond with agility and efficiency to the strategic demands of middle and end activities	"We have many restrictions within the public environment. It was not in vain that foundations were created"	3	4.62%
	Totals		**65**	**100%**

and Partnerships 13 (20%), Lack of Training and Development of Skills for Innovation in STI 12 (18.46%), Limited ST&I Financing 10 (15.38%), Low Institutional Competence to Deal with Regulatory Bodies 10 (15.38%) and Insufficient.

Conclusion

The potential of the STI to foster innovations benefiting socially vulnerable populations is evident, given its primary focus on neglected diseases in its scientific investigations. There exists a palpable necessity for heightened political-institutional collaboration among the State, STIs, and various subsystems within the health productive sector, as delineated in the morphology of the Health Economic-Industrial Complex (HEIC). This imperative stems from the interconnectedness and interdependence of these stakeholders in the health innovation process, characterized by a pronounced degree of innovation and intensity in producing and disseminating scientific and technological knowledge. The recent enactment of Brazil's new legal framework for science and technology (Law 13.243/2016) and its accompanying Decree 9.283/2018 mark significant strides by the Brazilian state in promoting and regulating research and development (R&D) activities within the country, with a particular emphasis on fostering collaboration and interaction between the public and private sectors. These legislative measures provide legal clarity for fostering strategic partnerships among key players involved in the innovation process within the Health Economic-Industrial Complex. These partnerships can be facilitated through technology transfer agreements, research and development partnership agreements, and technological procurement arrangements, among other formal mechanisms to incentivize public-private collaboration for health innovation in Brazil. However, it is imperative to cultivate technical expertise to bolster innovation capabilities and capitalize on successes in addressing the challenges.

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