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Article

The future may repeat the past: A look at successful management and technological development initiatives in the context of health crises – The case of Fiocruz and the AstraZeneca Vaccine

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Abstract

The COVID-19 pandemic, declared in March 2020, marked a global health crisis and triggered emergency actions to combat the disease. These actions included a race for a vaccine to enable collective immunization and the promotion of technology transfer (TT) to accelerate this process. This study describes the TT process within the international partnership between AstraZeneca and Fiocruz, a Brazilian public health institution, to identify potential advances in the use of this tool and the management model adopted. The partnership and agreement, as well as the management model, were examined through secondary document analysis and interviews with managers from the involved institutions. The results identified singularities and dissonances within this partnership, revealing that the critical success factor of the TT process was the management model implemented to guarantee the production of the vaccine.

Keywords: Technology transfer. Technological procurement. Health innovation. Management model. Technological development in health.

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O futuro pode repetir o passado: um olhar a partir de iniciativas bem-sucedidas de gestão e desenvolvimento tecnológico em saúde nos contextos de crises sanitárias – o caso da Fiocruz e a vacina AstraZeneca

Resumo

O início da pandemia da COVID-19, em março de 2020, marcou uma crise sanitária mundial e desencadeou uma ação emergencial no combate à doença e a corrida pela vacina para imunização coletiva, com um estímulo a Transferências de Tecnologia (TT) para acelerar este processo. O objetivo deste estudo é descrever o processo de TT na parceria internacional entre indústria AstraZeneca e Fiocruz com o propósito de identificar potenciais avanços desta ferramenta e do modelo de gestão utilizado. Analisou-se a parceria e o acordo, bem como o modelo de gestão, aplicando-se a metodologia de análise documental secundária e entrevistas com gestores das instituições que fizeram parte do objeto do estudo. Como resultado, foi possível identificar singularidades e dissonâncias nesta parceria e constatar que o processo de TT teve como fator crítico de sucesso o modelo de gestão implementado com a finalidade de garantir a produção do imunobiológico.

Palavras-chave: Transferência de tecnologia. Encomenda tecnológica. Inovação em saúde. Modelo de gestão. Desenvolvimento tecnológico em saúde.

El futuro puede repetir el pasado: Una mirada a partir de iniciativas exitosas de gestión y desarrollo tecnológico en salud en el contexto de crisis sanitarias – El caso de Fiocruz y la vacuna AstraZeneca

Resumen

El inicio de la pandemia de COVID-19, en marzo de 2020, marcó una crisis sanitaria mundial y desencadenó acciones de emergencia para combatir la enfermedad y la carrera por la vacuna para la inmunización colectiva, con un estímulo a la transferencia de tecnología (TT) para acelerar este proceso. El objetivo de este estudio es describir el proceso de TT en la alianza internacional entre la industria AstraZeneca y Fiocruz con el fin de identificar potenciales avances de esta herramienta y del modelo de gestión utilizado. Se analizaron la alianza y el acuerdo, así como el modelo de gestión aplicando la metodología de análisis documental secundario y entrevistas a directivos de las instituciones que formaron parte del objeto de estudio. Como resultado, fue posible identificar singularidades y disonancias en esta alianza y constatar que el proceso de TT tuvo como factor crítico de éxito el modelo de gestión implementado con el objetivo de garantizar la producción del inmunobiológico.

Palabras clave: Transferencia de tecnología. Encomienda tecnológica. Innovación en salud. Modelo de gestión. Desarrollo tecnológico en salud.

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INTRODUCTION

Throughout the 20th and 21st centuries, Brazil has faced several health crises, with particular emphasis on the most recent pandemic, caused by COVID-19, a term used for the clinical disease caused by the virus SARS-CoV-2. Historically, responses to Brazilian public health crises generally involved coordinated actions by the government, healthcare agencies and institutions, healthcare professionals, and civil society, including prevention and treatment measures, awareness campaigns, and strategies to contain disease spread. The effectiveness of these responses varied according to the nature of the crisis, the capacity of the health system, and other contextual factors.

From the historical emergence of Human Immunodeficiency Virus (HIV)/Acquired Immunodeficiency Syndrome (AIDS), through the successive dengue and Zika virus outbreaks, to the resurgence of yellow fever, Brazil has navigated numerous epidemiological challenges. However, the nation had not previously encountered a crisis of such severity as the COVID-19 pandemic, which so unequivocally exposed the chronic structural vulnerabilities of the Brazilian healthcare landscape. These systemic failures include gaps in universal health coverage, profound regional disparities, and critical deficiencies in infrastructure and financing. Most notably, the recent crisis highlighted significant limitations in management capacity and technological development within the national health system.

The World Health Organization (WHO) publicly declared the COVID-19 pandemic in March 2020, prompting global authorities to launch an emergency effort to curb rising case numbers, contain the virus, and implement measures to prevent its spread. After a search for effective treatments, it was found that the most effective way to contain the spread of the virus was to develop a collective vaccination strategy. From this perspective, the rapid development of a vaccine against SARS-CoV-2 became paramount for numerous countries, research institutes, and pharmaceutical laboratories, especially those with prior experience and knowledge in the field, most of which were located in countries with a high capacity for technological development.

This context triggered intense global research and development aimed at creating diverse vaccines, leveraging the latest-generation technology platforms guided by new paradigms (Le *et al.*, 2020) and by technological routes already mastered. Thus, there was a race to create, produce, and distribute vaccines, which required substantial investment and the intensive exploration of projects and technologies (Corey *et al.*, 2020; Gao *et al.*, 2020; Le *et al.*, 2020).

The turbulent and uncertain environment of the pandemic generated a state of emergency that required the vaccine to be developed swiftly, overcoming obstacles and accelerating the stages, while avoiding risks to the population. To make this production feasible, Technology Transfer (TT) emerged as a promising approach that enabled the production of vaccines at an affordable price for developing countries. In this way, these countries were able to meet the urgent demand for vaccination and the respective control of immunization.

While Technology Transfer (TT) remains a preferred strategic pathway, it constitutes an intrinsically complex process. Successful execution necessitates both a supplier committed to the dissemination of critical technical and tacit knowledge, whether in production or development, and a recipient possessing sufficient absorptive capacity to internalize the transferred technology (Battistella; De Toni; Pillon, 2016). This bilateral synergy is essential for ensuring that the technological object is not merely relocated but effectively integrated into the recipient's operational framework.

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In addition to TT, another process aimed at providing autonomy in vaccine production is Technology Commissioning in the Health Care (Encomenda Tecnológica - ETEC). It aims to contract institutions to obtain an innovative product, service, or process in the health area.

As a way to probe the future regarding successful initiatives in management and technological development in health amid health crises, this article proposes highlighting the application of TT in a state of emergency, drawing on Brazil's participation in international partnerships for the development and manufacture of vaccines against SARS-CoV-2.

The partnership established in Brazil in that context was the one concluded between the Fundação Oswaldo Cruz (Fiocruz), the Swedish-British pharmaceutical company AstraZeneca, and researchers at the University of Oxford. This partnership established an agreement that enabled testing in Brazilian volunteers in phase 3 of the study. According to Fonseca, Shadlen and Achcar (2023), despite all the attention given to monitoring and debating the extent of the international transfer of vaccine technology, we know little about what happened, how the partnerships were established, and how they function. In the same vein, Soares *et al.* (2023) suggest that there is a need for more studies assessing the organizational structure and management of megaprojects in emergencies.

Considering the context, the objective of this research is to systematically describe the management models of the organizations involved in TT in international partnerships with Brazil during the exceptional context of the COVID-19 pandemic. Although technology transition and the technology commissioning instrument are central issues for the organizations involved, the focus of this research is on the facts, instruments, processes, and the institutional framework that involved the specific technology transfer between AstraZeneca and Fiocruz to solve the problem in the context of emergency.

This research is structured into five distinct sections. Following this introduction, the second section establishes the theoretical framework, addressing fundamental technical concepts and the extant literature on Technology Transfer (TT) and Etec in the healthcare sector. The third section details the methodological procedures employed to conduct the study. Subsequently, the fourth section presents the core findings and analysis, categorized into several thematic dimensions: the pandemic context, an overview of the Brazilian organizations involved, the managerial aspects of inter-organizational cooperation, and a critical debate regarding the applied management models. This empirical discussion concludes with a multidimensional analysis covering personnel, budgetary and financial frameworks, inventory management, and strategic communication. Finally, the fifth section provides the concluding remarks, synthesizing the primary contributions, identifying research limitations, and offering final considerations.

This research contributes to the literature by summarizing key aspects of the processes and institutional challenges faced by organizations during the COVID-19 pandemic. With this structure, we hope to provide support so that future research can evaluate the institutional framework that encompasses the processes of TT and Etec, and thus develop comparisons and reassessments that expand the available knowledge on the subject. In this way, this research offers academic implications for managerial processes involving TT and Etec, as well as the consequent development of technological management capacity for the manufacture of a vaccine in a state of emergency. Additionally, this study enables practical contributions to the understanding of this process within the scope of the organizational field, with an approach oriented toward the dimensions of innovation and partnerships.

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THEORETICAL FRAMEWORK

Technology transfer is the transmission of scientific and technological knowledge between organizations (Bozeman, 2000) and is a dynamic, complex process that plays a key strategic role in development, accelerating learning (Ávila; Alves; Zawislak, 2018). TT between two distinct entities is a process of intentional, guided, objective, and dynamic interaction, during which technology (and the knowledge related to it) is transferred from one entity to another in order to increase its capabilities (Battistella; De Toni; Pillon, 2016).

It is a collaborative effort in which the supplier and the recipient recognize that TT's success depends on how the technology is operationalized in the recipient's environment. In addition to the actors involved, the relationship between them, and the object to be transferred, other factors inherent to TT are also considered, such as the mechanisms used and the context in which it occurs, which include aspects such as project time and cost, as well as environmental turbulence (Battistella; De Toni; Pillon, 2016).

As presented by Śledzik *et al*. (2023), TT plays an important role in the prevention and treatment of diseases, enabling the rapid transfer of new therapeutic and diagnostic resources to clinics and hospitals, consequently leading to better treatments for patients. The author points out that the TT processes used for COVID-19 reached levels comparable to those for better-known conditions, such as cardiovascular disease, in only 2 years. The author also points to nine types of technology transfer: grant, partnership, asset transaction, acquisition, licensing, private capital, venture financing, debt offering, equity offering, and sum (Śledzik *et al*., 2023).

Even in typical situations, TT requires a complex structure of understanding between the parties involved, which intensifies in environments of uncertainty, especially when they are dependent on political, economic, environmental, social, and technological factors (Liyanage *et al*., 2009). This is the turbulent context observed in a pandemic and, in this way, greater problems could only be mitigated by the institutional efforts of scientific and research organizations. Medeiros *et al*. (2022a) analyzed the innovations that enabled the Institute of Technology in Immunobiologicals (Bio-Manguinhos) of Fiocruz to participate in the entire production of the Oxford/AstraZeneca vaccine (ChAdOx1 nCov-19) in Brazil. They highlighted several innovations that could be implemented during this process.

Alekseieva *et al*. (2021) point out that the COVID-19 pandemic accelerated the transformation of the technological order of human development and enabled the emergence of new forms of organization and business, and that it may also have accelerated other technological processes, such as the digitalization of the economy and TT processes. Although they may seem like natural efforts of the world's scientific institutions, the cooperative work involved exceeded expectations worldwide.

Gurgula and Hull (2021), in turn, point out that, although some companies overcame the initial challenge of creating a vaccine against COVID-19, the challenge of creating a few billion vaccines in time to avoid inequalities in their distribution requires a greater effort, for which TT, based on transfer channels, proved to be the most suitable solution. However, organizations typically dedicated to scientific development encountered problems precisely in this process. Herder, Gold and Murthy (2022), for example, note that university TT practices were unable to ensure that these products were available in low-income settings, which explains delays in the production of vaccines such as the Pfizer/BioNTech COVID-19 vaccine.

In analyzing key factors in the speed of COVID-19 vaccine dissemination, Fu *et al*. (2022) argue for the importance of cooperation systems and partnerships between global vaccine manufacturers

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and local pharmaceutical companies to create regional production hubs, thereby accelerating TT and global production. The authors maintain that, to be successful, these strategies must be financially supported by the governments involved and by international organizations.

The literature mapped factors that foster or hinder the TT process when transferring medical equipment to countries affected by humanitarian emergencies, a process similar to that observed during the COVID-19 pandemic (Santos *et al.*, 2016). According to the aforementioned study, the most commonly mentioned difficulties fall into three categories: difficulty implementing equipment; uncertainty about the local configuration; and difficulty complying with standards, protocols, and guidelines. Among the most important factors that help in this process are the appropriate selection of equipment, the use of standardized equipment and kits, and, lastly, the establishment of appropriate agreements with suppliers.

Technology transfer and technology commissioning for healthcare in Brazil

TT is subject to political and economic interference, which is especially felt by developing countries (Friede *et al.*, 2011). Oladipo *et al.* (2023) conducted a study examining the challenges of technology transfer of the COVID-19 vaccine to the African continent. According to the authors, there is hesitancy in releasing the intellectual property rights associated with vaccine TT to Africa. For example, although the European Union (EU) was fundamental in global efforts to combat the pandemic, there was reluctance to share valuable knowledge and resources with African countries.

Institutional arrangements in Brazil around the public coordination of health systems have proven to be a relatively adequate institutional organization, since the participation of the public sector in the production of medicines, especially in developing countries, is a preponderant factor for their more equitable distribution (Temprano; Aprea; Dokmetjian, 2017). Intending to reduce the country's external dependence and its productive and technological vulnerabilities through strategic products and services for the Unified Health System (SUS), TT had its regulatory framework updated by the National Policy for Technological Innovation in Health (PNITS) (Brasil, 2017).

PNITS establishes three strategic instruments to be used in selecting the most advantageous proposal: Productive Development Partnerships (PDPs), Etecs, and Compensatory Measures in the Health Area (Mecs). PDPs aim to advance technological development, the transfer and absorption of technology related to strategic products for SUS, as well as to build productive and technological capacity in the country related to these products and their acquisition. Etecs aim at contracting Science and Technology Institutions (ICTs), focused on research activities and with recognized technological capacity in the sector, to carry out research, development, and innovation activities that involve technological risk, aiming at solving a specific technical problem or obtaining an innovative product, service, or process in the health area. Mecs, in turn, prioritize technological development and capacity building in the country related to strategi

Etec is a public procurement instrument for innovation whose characteristic is to stimulate innovation in companies and institutions in order to find a solution to a given problem through technological development (Rauen; Barbosa, 2019), and it can be used for a new material, a new technology, the combination of several technologies into a complex product, a new vaccine, among others. Within the scope of innovation, Etec has been considered a driving force in the pursuit of technological autonomy, capable of fostering the rapprochement of public or private organizations to address complex social demands. More comprehensive and complete than TT, generally limited

to the final processing of the product, Etecs go through stages ranging from basic research and formulation to the product's effective commercial phase, benefiting Brazilian organizations and, consequently, the national innovation system.

METHODOLOGICAL PROCEDURE

This research was conceived and structured around the case of Fiocruz and its initiative aimed at a single purpose: producing the vaccine against COVID-19. The observation of peculiar characteristics of the Brazilian public institution involved and of its respective partner at the international level constituted an object of description and analysis with the purpose of enabling the understanding of how the participation of these institutions can converge toward an effective achievement of results, in view of the processes inherent to TT for manufacturing in Brazil and the consequent autonomy for development.

To achieve the objective of describing the organizational scenario around the TT processes of the case under analysis, it was important to make use of a plurality of information sources whose selection follows a convenience sampling, in which the works and information sources were selected according to their ability to fill the gaps in the processes involved. Such an approach is used to achieve a more complete explanation of the phenomenon under analysis, without prejudice to the fact that future research may refine the perspective around these same processes, whether based on new data or new readings.

To characterize partners, initiatives, and the processes involved, dossiers of the organizations were organized through data collection from secondary sources:

a. Websites: institutional information from the institutions involved in the research, namely Fiocruz (bio.fiocruz.br) and AstraZeneca (astrazeneca.com.br; astrazeneca.com). The collection of formal communications on the official websites served to shape an initial perspective, as they offer dynamic, up-to-date information on topics of interest and include multiple data formats and the organization's identity.

b. Contracts: contractual documents are analyzed fundamentally for their formal and binding character, with relevant information on rights, duties, and deadlines. In the case of the contracts, the main focus of analysis was the technological procurement contract signed with AstraZeneca for the production of the COVID-19 vaccine, with the confidential information present in the original document preserved (Fiocruz, 2021a).

c. News published in widely circulated channels, as they present information with relative social validation and, mainly, contextualized information on ancillary events, enabling the identification of narratives and serving as a basis for adequate triangulation with official channels and specialized knowledge. For the news analysis, several references were used, but mainly those linked to other institutions, such as the National Health Surveillance Agency (Brasil, 2021a, 2021b), and widely circulated newspapers, such as *Valor Econômico* (Valor Econômico, 2020).

d. Public institutional documents: these documents, which were widely disseminated with an expression of interest in the partnerships, are a data source whose reliability derives from transparency and legality standards required by law and by good organizational practice. In this classification, legal documents regarding the transfer were analyzed, and they served as the legal basis for the procedures adopted by the two institutions (Brasil, 2017, 2020a, 2021a, 2021b, 2021c, 2021d).

e. Finally, the bibliographic reference framework was also used as a basis, grounded in the analytical structure and theoretical underpinning that serve as structuring axes of the case study, whether through the contextualization of the object of study or for the interpretation of the role represented by the other pieces of information.

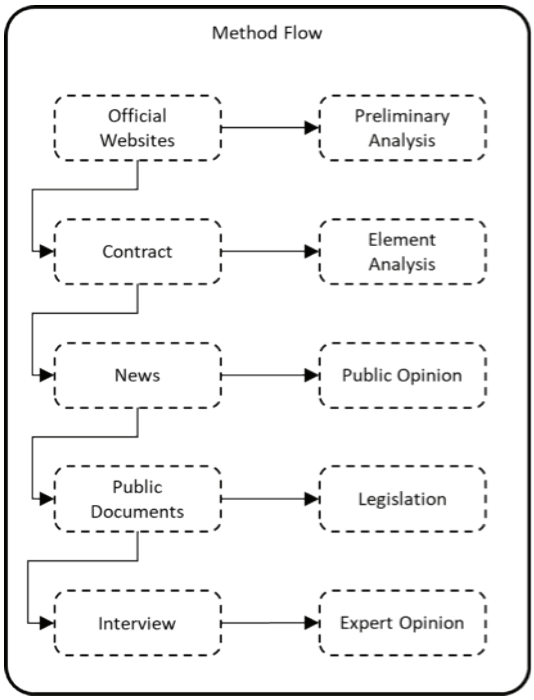
After the documentary and bibliographic assessments, and to deepen the analyses obtained from formal and institutional sources, empirical data were collected from the experiences of key specialists from the technology transfer sectors of the two organizations in question. The perspectives of these professionals were fundamental to increasing the variability of the information sources and to complementing the information gathered from formal sources with more personal and professional perspectives on the procedures adopted by the institutions studied.

To ensure a minimum technical alignment between the perspectives, the profile of the professionals to be interviewed was that of a technology transfer manager, since, in addition to dealing directly with the object, it was also a position available in both organizations. Moreover, these were professionals with qualifications in both the scientific and management and business processes. The professionals were identified with the organizations, and the interviews were conducted in December 2023 via video call. The interviews were semi-structured, following a basic script based on procedural aspects of the technology transfer identified up to that point through the documentary analyses.

Below, in Figure 1, a graphical representation of the research methods:

FIGURE 1

Value chain model of the Oxford/AstraZeneca/Fiocruz vaccine for Brazil



Source: Adapted from Medeiros *et al*. (2022b).

RESULTS AND ANALYSES

Vaccine development in a moment of pandemic and state of emergeny

Although there had already been warnings from the international scientific community about possible risks of a SARS epidemic (Marshall; Enserink, 2004), COVID-19 caused a major impact on society and on health systems. Thus, great attention was given to the development of vaccines to prevent the spread of the disease or its progression to more severe stages (Wang *et al*., 2020), in an unprecedented need for the production and distribution of a sufficiently safe and effective vaccine for an extraordinarily large number of individuals worldwide (Corey *et al*., 2020).

At the same time that the development of several vaccines in a seemingly shorter time than usual brought hope to society, it also came as a surprise, because in a few months, what normally takes years was advanced. According to Lurie *et al*. (2020), the process of developing a vaccine is long and costly, placing great strain on resources, requiring many candidates for clinical trials, and taking years to produce, with high costs and high failure rates. Traditionally, a vaccine goes through five stages: identification of the disease-causing agent; development of the selection standard for which antigen will be used in the vaccine; pre-clinical tests; tests in humans (carried out in three stages); and, finally, production.

In addition to this variation in protocols and processes, another change to rapidly meet the global need for a vaccine is the establishment of partnerships, whether between pharmaceutical and

biotechnology companies, or even a broader one involving industry, government, and academia, in collaboration, with each contributing its strengths (Corey *et al.*, 2020). An example cited by the aforementioned authors is the public–private partnership Accelerating COVID-19 Therapeutics and Vaccines (ACT|IV), led by the United States National Institutes of Health (NIH) and bringing together efforts from all sectors.

This type of partnership enables the creation of collaborative platforms to conduct harmonized, randomized, and controlled vaccine efficacy trials and aims to generate essential safety and efficacy data for multiple vaccine candidates in parallel, thereby accelerating the licensing and distribution of multiple vaccine platforms. Similarly, in the next sections, the management model for the technological advancement of the Brazilian research institute that partnered with foreign actors to accelerate vaccine development will be explored.

Brazilian Organization Involved

One of the pioneering public entities in establishing partnership agreements for testing vaccines against SARS-CoV-2, Fiocruz was responsible for concluding the partnership with the Swedish British company AstraZeneca, which, in turn, developed its vaccine together with the University of Oxford. Other national-level partnerships were also established to confront COVID-19, such as the one between the government of São Paulo and the Instituto Butantan (2020a, 2020b); however, it was the cooperation agreement between Fiocruz and AstraZeneca that enabled coordination among federal institutions around a national plan to confront COVID-19.

Fiocruz is an integral part of the Brazilian Ministry of Health. The institution was founded in 1900 with the objective of integrating emergency action in combating an epidemic of bubonic plague. From 1970 onward, it came to be considered a foundation and, as a public law institution, it developed several coordinated initiatives, such as the creation of Bio-Manguinhos with the objective of supplying the National Immunization Program (NIP) (Barbosa *et al.*, 2014); since then, its production of studies on vaccines has been a function carried out by the Institute. In addition to this activity, Bio-Manguinhos is also responsible for partnerships with public and private institutions (Fiocruz; Bio-Manguinhos, 2020), such as the one with AstraZeneca.

Brazil's Ministry of Health signed an agreement at the end of June 2020 to produce the COVID-19 vaccine locally in partnership with the AstraZeneca laboratory. Established in Brazil since 1999, AstraZeneca is based in São Paulo, where it concentrates its administrative headquarters and manufacturing unit. This vaccine, produced by AstraZeneca, was developed by the Jenner Institute at the University of Oxford and is the same one used in the trial with the United Kingdom and South Africa. The Oxford Vaccine Group, founded in 1994, conducts studies of new and improved vaccines for children and adults and is part of the University of Oxford.

For this partnership, a memorandum of understanding was drawn up that provided for an agreement on TT and the production of 100 million doses of the vaccine (Fiocruz, 2021b), if its efficacy and safety were proven after the clinical trials. With experience in vaccine production, Bio-Manguinhos also made its technical capacity available to accelerate the industrial-scale up of vaccine production with other partners (Valor Econômico, 2020).

Managerial aspects of cooperation in the Brazilian public institution involved

Regarding the conclusion of the partnership with international institutions, it is important to note that the decision-making process for this agreement fell to the senior positions within the organizations. Specifically, Fiocruz, as provided for in its Internal Regulations, had partnerships concluded through its presidency, the vice-presidency for production and innovation in health, and, in the case of vaccines, the unit directorate, Bio-Manguinhos.

In the context of urgency, the identified obstacles could be minimized through action by the Brazilian federal government. In this regard, due to the public interest, vaccines produced by the institution are acquired by the Ministry of Health via the National Immunization Program (PNI). As both a client and an overseer of vaccine development, the Brazilian state, through agencies such as Anvisa, holds prerogatives of urgency and social interest to address some of the disadvantages presented and streamline processes.

Management model applicable to technological development in health: the case of Fiocruz in the COVID-19 pandemic

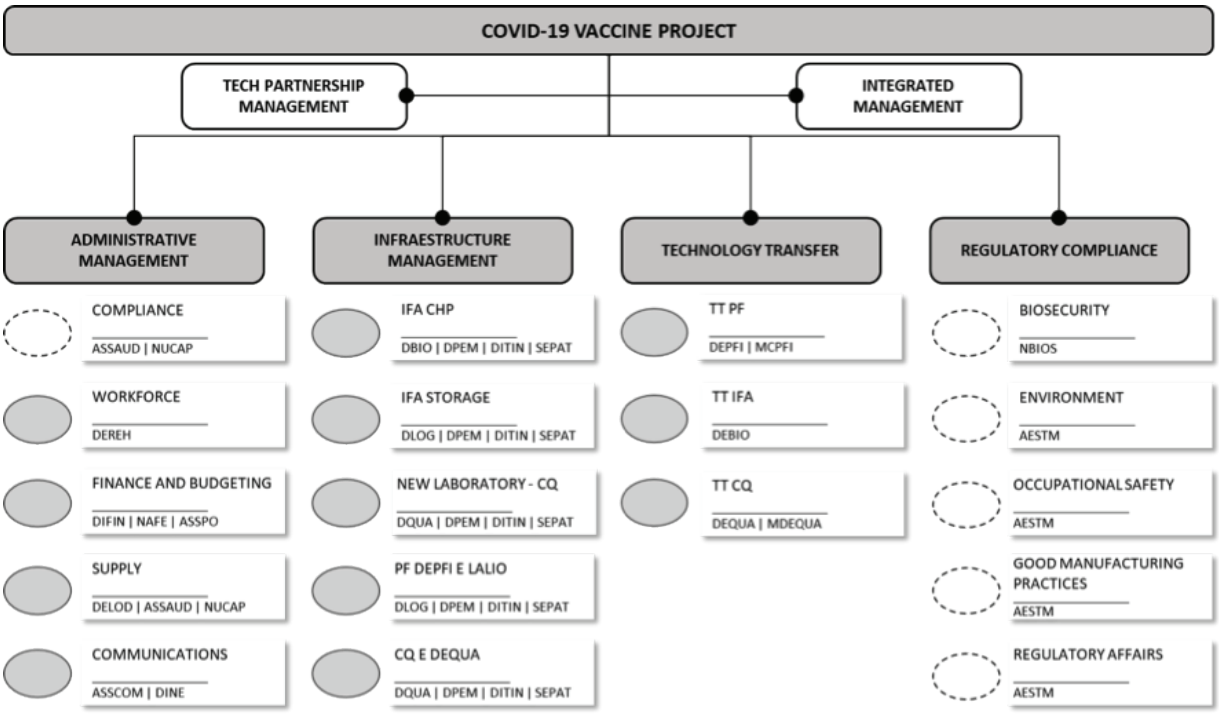
About the management model applied during the pandemic, the situation demanded that Bio-Manguinhos/Fiocruz provide a differentiated response in terms of the time required to achieve the project results. Such challenges required a differentiated management structure for the COVID-19 Vaccine Project, as a megaproject (Flyvbjerg, 2017). From there, the management structure was organized into six pillars (Abreu *et al.*, 2021):

- Integrated Management: sponsorship and methodological support for project management, in addition to the coordination and continuous monitoring of all ongoing activities.
- Management of Technological Partnerships: management of the technological partnership between Bio-Manguinhos/Fiocruz and AstraZeneca, including negotiations and legal instruments.
- Infrastructure Management: construction of new areas and adaptation of existing ones to incorporate the technology in its various stages, production of the Active Pharmaceutical Ingredient (API), final processing, and quality control.
- Technology Transfer Management: internalization of technologies, knowledge, and processes necessary for the entire production chain of the vaccine against COVID-19, including inputs, intermediate products, and the final product.
- Administrative Management: coordination of all resources necessary for the internalization of the technology and vaccine production, including people, inputs, equipment, budgetary and financial resources, as well as the management of communication aspects of the process.
- Regulatory Compliance: ensuring compliance with all legal and regulatory requirements across the various stages of the project.

Figure 2 represents the structure of the project organization.

FIGURE 2

Project organization structure



Source: Adapted from Medeiros *et al*. (2022b).

To make execution and operation feasible, the model established for the project's administrative management was responsible for coordinating the provision of the resources necessary for TT, production and making the vaccine available to Brazilian society, which involved supply activities, management of financial and human resources, communication, and marketing of the product, in alignment with administrative compliance requirements. Based on the institution's project operations and the matrix coordination of its activities, the administrative stream was organized into the following work areas: people management, supply, budgeting and finance, communication, and marketing.

The urgency in contracting and the scarcity of inputs in national and international markets were evident challenges for the supply area. The intricate struggle on social networks and in other communication channels, which promoted crises of reliability and credibility in the project and the product even before their production and availability, intensified the challenges for the communication area.

Considering the public logic as the locus of action for this project, it is necessary to highlight, as an additional challenge, the need to observe the legal parameters governing acquisitions and contracting, as well as the use of public resources.

People Management

The main objective of the people management area was to provide a workforce capable of meeting the project's demands. To that end, this area was responsible for defining staffing levels to achieve the project's strategic objectives, including the selection, hiring, and training of employees, aligned with the defined profile and within the required time frames.

The main challenges on this area involved the processes of sizing and recruiting staff within a short time frame and adapting to the conditions imposed by the pandemic, which required a differentiated functioning of the work environment in accordance with the Bio-Manguinhos/ Fiocruz contingency plan.

Recruitment to compose the project team and to expand teams in routine activities involved not only external selection processes, but also the use of internal staff. This created the need to manage different recruitment processes, including internal movement, new hires for positions vacated by moved employees, and external selection processes.

Due to its nature, this was configured as one of the areas with the greatest interaction with the others in the project and with the various functional areas, including the requesting areas and the Human Resources (HR) area. The following results were identified: hiring employees with an average time of 15 days; assessment of the suitability/justification for temporary positions; close operation to the functional areas to address possible deviations (work hours, urgency of hiring, unplanned increases in headcount, etc.); mapping of profiles and performance for the internal utilization of employees added to the project; training of employees in equipment and processes fundamental to the operation of production, quality, and support activities.

Budget and finance

The main objectives of the budget and finance area were to plan the execution of the project budget in accordance with the budget execution guidelines, to consider different revenue sources, to monitor and control the budget, and to coordinate the execution of the project's economic feasibility study. Among the most significant challenges on this area was the use of resources released by the Ministry of Health across different budgetary sources, each with distinct time restrictions, given the nature of the so-called 'war budget'. Also, the main resources for this project originated from provisional measures issued by the federal government and resources from donor companies.

The deadline for executing the resources from the provisional measures was approximately four months. Considering the usual procurement and contracting timeframes in the Brazilian federal public administration, which were extended due to the pandemic, this deadline proved very challenging. This legal condition, characteristic of the origin of this resource, necessitated mobilizing several areas of the institution to define the strategy for executing this budget, even though much technical information from the technological partner was still pending.

In implementing the budget and finance routines and processes, another challenge arose: the constant monitoring of balances across the project budget's different sources, including provisional measures and resources from donations, and the appropriate allocation of project demands to each of these sources. As an additional opportunity and challenge, in addition to the cited sources, a group of companies approached the institution to add value, as a donation, to support the production

and technology transfer of the COVID-19 vaccine. In this partnership, approximately R$ 106 million was allocated and operationalized by the Support Foundation through the Unidos Fiocruz Program (Fiocruz, 2021b).

Supply

The main objective of the supply area was to contract services and acquire inputs and equipment for the project, as a result of the logistical operation that comprises the supply chain for the production and provision of the vaccine in question. Therefore, the supply area encompassed a wide variety of items necessary for the internalization of the production process for the vaccine against COVID-19, both in the project phase, where the imported Active Pharmaceutical Ingredient (API) is processed, and in the production of API entirely within the unit. This area involved processing a significant volume, including around 700 items and approximately 150 service contracts.

Given the pandemic scenario and the emergency nature of the context of vaccine production to confront this crisis in Brazil, this area had as its central requirement maximum speed in the processes so that, in record time, the resources and services would be available to enable the production and provision of the vaccine. However, as prescribed by the legislation on procurement and contracting in the public service, the current Law No. 14.133/2021 (Brasil, 2021d), (which repeals Law No. 8.666 of 1993), these contracts require a bureaucratic formality to be observed to ensure the efficiency of public procurement. However, this did not align with the pandemic context, which, as mentioned above, required speed and the prompt availability of items for the technology's internalization and production.

In order to reduce the time required for procurement procedures under public-sector rules, while considering the integrity of the bidding processes, the Pandemic Law (Law No. 13.979/2020), (Brasil, 2020b) was issued by the federal government, in which one of the guidelines is the temporary debureaucratization of the administrative processes for purchasing items related to confronting the pandemic. With the publication of this regulation, it became possible to carry out the logistics for a substantial share of inputs to be used in the vaccine production process in a time shorter than the legal flow normally established. Reinforcing this need for flexibility, in March 2021, the government issued a second law, No. 14.124/2021 (Brasil, 2021e), whose main objective was to waive bidding procedures, on an exceptional basis, for all acquisitions directly related to vaccination against COVID-19.

As a way to support procurement for items intended for vaccine production, in April 2021, Provisional Measure No. 1.047/2021 (Brasil, 2021f), was issued, in support of Law No. 14.121/2021 in the flexibilization of procurement processes for inputs, services, or any other contracting related to vaccine production in confronting the pandemic.

The supply area interacted with the functional areas to identify process needs, describe items for procurement and contracting services, align expectations regarding the arrival of materials and compliance with the schedule, and, consequently, with the project milestones.

Communication and marketing

The main objective of this area was to identify pandemic-related opportunities and needs that the project could explore in relation to communication and marketing. This area was inserted into a complex context of combating fake news, misinformation, and the politicization of the discussion around vaccine production, which required strategies for alignment and the use of communication tools of the PNI and other institutions, such as medical societies like the Brazilian Society of Immunizations (SBIm), the National Council of Health Secretaries (Conass), and the National Council of Municipal Health Secretariats (Conasems), in addition to sector specialists.

It was also sought to position the vaccine as one of the main pillars of Bio-Manguinhos/Fiocruz's strategy to combat the pandemic, in alignment with the Ministry of Health, and to highlight Fiocruz's participation in studies of other COVID-19 vaccines (Fiocruz; Ministério da Saúde, 2021). This aspect helped reinforce Bio-Manguinhos as a key actor in the Oxford/AstraZeneca/Fiocruz vaccine process, while other initiatives exemplified strategies to create opportunities for its objectives.

The area actively participated in the construction of the vaccine's marketing plan and, in parallel, developed a communication plan, considering the main project milestones and analyzing distinct scenarios at each milestone to plan the actions to be carried out.

This area produced the following results: participation in the development of the marketing plan, a document used to design other studies in the project's dynamics; development of the communication plan with actions related to combating the pandemic; development of the FAQ about the vaccine and the creation of a dynamic for updating and sharing the information.

Regarding social media (up to June 10, 2021): more than 70 posts made; on average, more than one thousand likes and 15 thousand people reached per post (in the first 7 days); creation of content categories for better public understanding (News, Questions and Answers, Statement, Dose Deliveries, and Did You Know?); collaboration in the growth of the profile's follower base (from 17 thousand followers at the beginning of the project to 53,400 on June 10, 2021); and the creation of a new visual identity for vaccine communications. Finally, regarding the press (up to May 15, 2021): the beginning of media training with the unit's official spokespersons; support for data collection for press statements; and more than R$ 20 million in earned media value.

Analyses

Taken together, the data analyzed in this study, including interviews, news reports, and the memorandum of understanding, indicated the distinct features of the Fiocruz/AstraZeneca partnership and how the organization produced COVID-19 vaccines in Brazil. Concerning the contract, a dissonance was observed in the cultural aspects and legal frameworks that guided the partners' actions; in other words, while unrestricted access to knowledge is a requirement of the TT process, it also constitutes a barrier to the incorporation of methods and processes.

Moreover, barriers arose from linguistic differences and translation complexities, especially regarding contractual clauses, their approaches, and negotiation elements. Notably, due to its control over technological inputs and the associated knowledge to be transferred, the technology transferor (AstraZeneca) maintained a greater bargaining power relative to the recipient (Fiocruz).

However, it is necessary to note that the transferor also relied on the positive results of TT for the vaccine to reach the market successfully, a preponderant factor at the time of high demand, which

put pressure on the production system's capacity. Therefore, as indicated in the literature (Battistella; De Toni; Pillon, 2016), it was expected that foreign companies would want national organizations to be able to increase their capabilities in vaccine production with the transferred technology. However, the same did not occur with the development of the stages before manufacturing; that is, it was not possible to know whether the commitment of the technology-holding companies would be the same for TT related to the manufacture of the API. Consequently, little is known about whether the technological capacity installed in the recipient institute after these partnerships would be sufficient to bring autonomy in the development of vaccines for new strains.

There was also a visible concern about communicating vaccine efficacy to break the myth of competitiveness among the formulations under research. Because we were in a context of insecurity inherent to political and ideological aspects, as well as social instability, this initiative seemed to face an additional strain: the instability arising from the then political and ideological rivalry of the period. However, this vector did not have a significant impact on the formulation of the AstraZeneca vaccine, which was developed in collaboration with British partners, even though they were developing vaccines for the first time.

The TT process for such an extreme product already faced sufficient barriers at that point; therefore, it was necessary to minimize unnecessary noise and difficulties. At the organizational level, however, there was promising news for Brazilian institutions. In that state of emergency, when the priority was to optimize vaccine manufacturing, investments in infrastructure and the streamlining of bureaucratic processes were the fruits of the partnership that must be maintained in the long term. Thus, we observed that Fiocruz benefited from the acceleration of the vaccine development process and critical investments in manufacturing and infrastructure

However, as a point of attention raised by this study, it is important to reinforce that the actions that resulted from this partnership - and the consequent contract - were limited to transferring the technology for producing the API for final processing, leaving the country still dependent on the molecules produced from basic research and the technological development of the vaccine - which are the intellectual property of the transferring country.

It is understood that the determination of towers for specific activities contributed to the management structure of the vaccine project. In addition, the support and decision committees were relevant for better monitoring of the project. The committees had an overall view, enabling integration between the internal management structure and the external issues that could impact the project's outcome.

CONCLUSION

In this article, we address the topic of technology transfer in the context of the SARS-CoV-2 pandemic, with emphasis on events in Brazil and on the technological partnerships concluded between Sinovac Biotech and the Butantan Institute, and between the biopharmaceutical company AstraZeneca and the national institution Fiocruz.

In general terms, it is necessary to warn that it was not possible to devise peremptory conclusions in such an unprecedented and dynamic scenario in the history of the world and of humanity. What is presented here were final considerations regarding the limits of our research work, carried out in a space in which there is still much to study and learn. This is an inductive theoretical study, and, naturally, it does not offer definitive answers about how TT processes should be, but it records, in a

systematic way, the TT processes in such a sensitive and emblematic phase in the history not only of these institutions but of humanity. Despite these limitations, this study opens lines of analysis that future studies can use to compare the processes reported here and formulate theoretical propositions about factors that contribute to or hinder the TT process in similar situations.

First, we concluded that the TT process within the partnership was viewed positively. Although there was a considerable number of obstacles related to cultural and legal aspects, with those of a political and ideological nature being the ones that most hindered the development of a vaccination strategy in Brazilian territory, it was undeniable that Brazilian institutions benefited from the partnerships, since through them they were able to rapidly advance their knowledge bases in the manufacture of vaccines against SARS-CoV-2, even if along technological routes already mastered.

The main learning from assessments such as those in this article is the idea that, although vaccine development, and research and development, strictly speaking, are a very important aspect for minimizing problems in health crises, and states of emergency, the TT process is fundamental to achieve the necessary scale and prevent distribution problems from deepening inequalities in access to health care. Other important lessons include the fact that the factors that energize institutional cooperation agreements, facilitating processes for TT, must be structured and developed. Future studies should continue to address these management and cooperation structures, analyze them comparatively, and assess their quality, success factors, and main barriers.

Regarding the management model used for this purpose, the project's success highlights that the management and governance structure was appropriate for TT and vaccine production. This structure enabled the simultaneous performance of concomitant activities, accelerating the TT vaccine process. Among the most evident theoretical implications that our results point to is the fact that the entire accelerated TT process, motivated by efforts to curb the advance and effects of COVID-19, occurred through a broad effort to improve processes and communications, with the potential to influence the development of countries in the medium and long term, according to capital transfer theories (Wang, 1990). However, the durability of the benefits and the particularity of technology flows after the emergency situation ends should be evaluated by future studies.

The idea that the future may repeat the past, especially when it comes to successful initiatives in management and technological development in health during health crises, is an interesting and important perspective. Although we cannot predict the future with certainty, we can learn from the past and apply valuable lessons to face future challenges.

In sum, although the future is uncertain, we can draw valuable lessons from the past to prepare ourselves for future health crises. Technology, preparedness, global collaboration, flexibility, and innovation are key elements for effective health management in times of crisis. Continuous learning and adaptation to constantly changing circumstances are crucial to ensure resilience and the capacity to respond effectively in the future.

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DATA AVAILABILITY

The entire dataset supporting the results of this study was published in the article itself.