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Health Economic-Industrial Complex, digital health in Primary Health Care and the risk of vulnerability 4.0

Complexo Econômico-Industrial da Saúde, saúde digital na APS e o risco da vulnerabilidade 4.0

Carlos Augusto Grabois Gadelha[1,2], Patrícia Seixas da Costa Braga[1], Mírian Miranda Cohen[1], Ana Lúcia Fernandes de Araújo[1], Karla Bernardo Mattoso Montenegro[1,3]

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ABSTRACT We analyze digital health from the perspective of collective health, assuming that technology and connectivity must meet the desires of social control, be at the service of people and improve quality of life. In an approach based on the political economy of health, we discuss the characteristics of the information and connectivity subsystem of the Health Economic-Industrial Complex in the context of Primary Health Care (PHC). We discussed the benefits and risks associated with new digital technologies emerging from the Fourth Technological/Industrial Revolution, which are being integrated into PHC, understood as the communication hub of the Unified Health System (SUS) care network. We highlight the risks of reproducing technological asymmetries, financialization, and economic and social inequalities within the field of digital health. We conclude that, in light of digital transformations, choices may lead to different outcomes, where technology can either become a tool for inclusion or exclusion. It is essential to develop political and institutional strategies that simultaneously foster a local base for innovation and digital health production aimed at meeting the needs of the SUS and universal access, guided by the principles of universality, equity, and comprehensiveness, as a necessary condition to overcome the risk of reproducing vulnerability in the context of the 4.0.

KEYWORDS Health Economic-Industrial Complex. Primary Health Care. Digital health. Unified Health System. Public health.

RESUMO *Analisou-se a saúde digital sob a ótica da saúde coletiva, pressupondo que a tecnologia e a conectividade devem atender aos anseios do controle social, estar a serviço das pessoas e melhorar a qualidade de vida. Em abordagem fundamentada na economia política da saúde, discutiu-se o subsistema de informação e conectividade do Complexo Econômico-Industrial da Saúde no contexto da Atenção Primária à Saúde (APS). Discorreu-se sobre os benefícios e riscos relacionados às novas tecnologias digitais que emergem da 4ª revolução tecnológica/industrial e se inserem na APS, compreendida como o centro de comunicação da rede de atenção do Sistema Único de Saúde (SUS). Alertou-se sobre o risco da reprodução de assimetrias tecnológicas, financeirização e desigualdades econômicas e sociais no campo da saúde digital. Concluiu-se que, diante das transformações digitais, as escolhas poderão levar a diferentes desfechos nos quais a tecnologia poderá ser ferramenta de inclusão ou exclusão. É fundamental construir estratégia política e institucional em que sejam articulados, simultaneamente, uma base local de inovação e produção digital em saúde, direcionada para atender às necessidades do SUS e do acesso universal, orientada pelos princípios de universalidade, equidade e integralidade como condição para superar o risco da reprodução da vulnerabilidade agora no contexto 4.0.*

PALAVRAS-CHAVE *Complexo Econômico-Industrial da Saúde. Atenção Primária à Saúde. Saúde digital. Sistema Único de Saúde. Saúde pública.*

[1] Fundação Oswaldo Cruz (Fiocruz), Centro de Estudos Estratégicos Antonio Ivo de Carvalho (CEE), Rede e Grupo de Pesquisa Desenvolvimento Sustentável, CT&I e Complexo Econômico-Industrial da Saúde (GPCEIS) – Rio de Janeiro (RJ), Brasil.
carlos.gadelha@fiocruz.br

[2] Fundação Oswaldo Cruz (Fiocruz), Escola Nacional de Saúde Sergio Arouca (Ensp) – Rio de Janeiro (RJ), Brasil.

[3] Fundação Oswaldo Cruz (Fiocruz), Instituto de Comunicação e Informação Científica e Tecnológica em Saúde (Icict), Programa de Pós-Graduação em Informação e Comunicação em Saúde (PPGICS) – Rio de Janeiro (RJ), Brasil.

Introduction

Taking a collective health perspective on digital health means recognizing that technology and connectivity must be benefit people in order to improve quality of life. Considering the digital era developments (originated in the third and fourth technological/industrial revolutions), we stand before the opportunity to make choices and decisions that can either positively affect the conditions of access to health or perpetuate inequities.

On the level of Primary Health Care (PHC), digital technologies may be an opportunity to expand and democratize access because they automatize service management, which may reduce waiting time; they help logistics, making health products reach the population with more quality, and more quickly; they promote accessibility, especially for citizens living in remote areas, among other possibilities. However, they also come with challenges, especially if one views citizens as data sets displayed in large bases, thus dehumanizing care and increasing previously existing inequities. Montenegro, Braga and Gadelha[1] describe this phenomenon as 'vulnerability 4.0' and highlight the need for ensuring national sovereignty so that technologies are a means of inclusion, not exclusion.

Haddad and Lima[2] voice their concern as they warn that automatizing decisions and processes in health systems may include tendencies to exclusion and discrimination. According to the authors, algorithms reflect social inequalities, and, if there are no compensatory measures, they might perpetuate systemic injustice, thus aggravating problems that they were supposed to mitigate. Consequently, advances in technology must be followed by public policies that shall ensure the fair enforcement of innovations generated according to the paradigm of digital technologies.

This tension between the transformative potential and the risks of exclusion has been discussed by Milton Santos[3]. In 'Toward an Other Globalization: From the Single Thought to Universal Conscience', published in English in 2017, the author warned that the globalization of that historical period was centered in the omnipresent empire of information networks able to create fables such as the 'global village'. Santos argued that the material foundations would not be determining factors to reproduce the perversity of inequity via the new technique; in fact, what would make a difference would be mankind's political availability to use technique at the service of good (or evil)[4].

When reflecting on digital technologies as new ways of promoting health in the contemporary world, Naomar Filho[5] proposes a discussion on metapresentiality, described as an online condition that reterritorializes presence as a virtualized form. In this emerging reality, the relationship between the patient and health professionals would not be limited to the physical-geographical distance. There would be a new intersubjective proximity, promoted by new presence modalities such as telepresence or metapresence[5].

Digital technologies have been making changes in the PHC organization logic, which has impacted the Unified Health System (SUS). While metapresentiality facilitates access and interaction, it also poses challenges to the teams working at the Basic Health Units (UBS), as the territorial bond, among other aspects, includes the observation of socioeconomic, cultural, and environmental conditions that are key to care. As attention is reterritorialized for the digital space, new protocols must be implemented, thus equalizing advantages and disadvantages of this new format.

Regarding the new digital technology, the reproduction of economic and technological mechanisms, which have been defining the asymmetric relations between the Global North and the Global South, is already a

reality, both from a demand perspective and regarding the digital health supply.

In order for SUS to implement the transformations caused by such technologies and make them available to the population in a comprehensive and equitable manner, one must consider the productive activities (displayed in subsystems) that are linked to health within the space of economic and productive development established in Brazil called the Health Economic-Industrial Complex (HEIC). Establishing public interest policies that articulate different actors within this complex associated to the strategic use of the purchasing power of the State is key to strengthening an environment of innovation development based on the ongoing digital revolution paradigm.

Historically, Brazil depends on other countries regarding health products[6], which has been increasing with the advances in technologies related to digital health. In HEIC, digital health in PHC is transversal in all subsystems. Because of its features, digital health in PHC is strongly linked to science and technology, and it has a profound connection with social control, and must be conditioned by it. In this essay, we aim to analyze digital health in Brazil with a particular focus on PHC from the perspective of the political economy of health, as we seek to understand the relations between supply and demand in this field and its consequences to the population.

The HEIC information and connectivity subsystem and the challenges of new digital technologies in the health sector

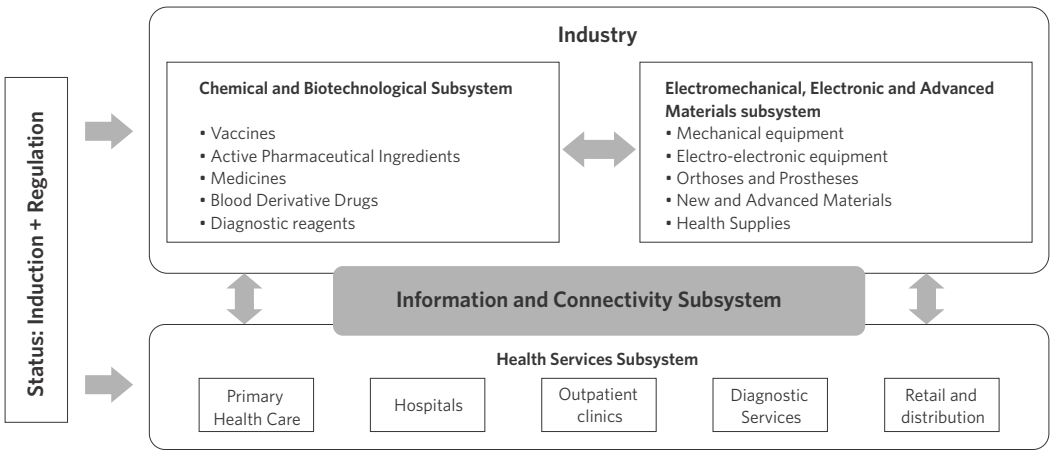
Studies on HEIC date back to the early 2000s, a period when significant technological transformations emerged. Designed as an interdependent systemic space that relates the social and economic sector with the health sector located in the productive environment of health, HEIC provides the structural and material possibilities that are indispensable to ensure sustainable, universal access to health in Brazil[6,7].

According to the Latin-American structuralism tradition, HEIC regards development as argued by Furtado[8(27)]:

> [...] a process of social change through which a growing number of human needs, either pre-existing or created by this very change, are met via differentiation in the productive system, originated from the introduction of technological innovations.

The ongoing transformations from the digital era demanded updating the HEIC morphology[9] to take on the 21st century challenges emerging from a new information-based, connectivity subsystem, as seen in *figure 1*.

Figure 1. HEIC Morphology: emphasis on the Information and Connectivity Subsystem



Source: Gadelha[9].

Among the HEIC subsystems[9], the information/connectivity one takes central position because of its systemic pervasiveness across all health sectors (it influences the chemical and biotechnological subsystem, the electromechanical, electronic, and advanced materials and the health services subsystems), and because of its innovation potential in industry 4.0. It is transversal not only across the health services subsystem, but across the ones related to the industry, and it is currently strained and fighting over standards.

According to *figure 1*, the dotted lines contouring the HEIC subsystems highlights the lack of rigid boundaries among the fields of knowledge, and it points to the exacerbation of the systemic feature of health[9]. This is because these sectors intertwine in the digital era, thus creating what Belluzo[10(24)] classifies as "the traumas and opportunities of hyperindustrialization 4.0".

Falcón[11] discusses the relation between the HEIC information and connectivity subsystem within the health interface and the data economy, whose market product is the data collected from individuals while receiving medical care or in management activities of medicine delivery, among others. The author believes that these data can be transformed into information of high economic value, and they can be sold in the market depending on their governance level. Such accumulation spaces can cause ruptures in universal systems such as SUS.

As it is a subsystem deeply rooted in the transformations caused by the third and fourth technological/industrial revolutions, it maintains a close relation with PHC. Not only has it been implementing digital products in daily health care, but it has been responding to the demand coming from the health services sector in the form of new business models based on technology and connectivity.

Consolidating a productive, technological health national base that is able to meet the population's needs is a matter of sovereignty and safety, which became even clearer with what happened during the COVID-19 pandemic. At that time, technological dependency exposed structural fragilities of several countries, who were in serious disadvantage compared to the technological resources of the countries who had technology and innovation capabilities, which revealed the so-called 'vulnerability 4.0'[1]. In the health geopolitical scenario, the safeguard mechanisms were not enough to ensure the protection of vulnerable groups regarding products, services, and PHC prevention measures[12].

COVID-19 also led to the consequence of an exponential increase in digital technologies

applied in the health sector, which boosted the information and connectivity subsystem. The advances reached in this sector can also contribute to improve the population's health conditions and SUS' sustainability as a universal system. However, to benefit from these opportunities, one must face the challenges already created by the existing global asymmetries, which are added to the nuances of the characteristics of this HEIC subsystem, as they are linked to the technological dominance that has been seen in this segment[13].

Understanding these challenges can start from analyzing the evolution of the digital technology impact in the health sector. In the 1960s and 1970s, the introduction of the health electronic registration at hospitals and research centers enabled clinical data to be stored digitally. From then on, the first initiatives to create data systems that were able to record results of diagnoses and therapies emerged[14].

In the 1980s, the convergence of information and communication technologies, the creation and expansion of the internet, and the spread of computer technologies had a significant impact on medical interventions[15]. After that, the increase in processing and storage capacity, the development of specialized algorithms and software able to process and interpret large volumes of data, the laboratory automation, the improvement in image quality, digital platforms, and the internet were gradually being implemented in the Research and Development (R&D) processes of health sector industries.

At the start of the millennium, the advance in the sophistication and integration of digital technologies led to the convergence of simultaneous discoveries in the most diverse knowledge fields in an unprecedented level, in the physical, digital, and biological domains, thus inaugurating a new paradigm. Artificial Intelligence (AI), machine learning, the Internet of Things (IoT), quantum computing, advanced robotics, 3D printing, blockchain, self-driving vehicles are among the innovations achieved, just to name a few[16]. In this new context, data stands out as one of the main assets in the generation of innovations, especially demographic, populational, genetic, and personal ones.

In health, it has been found that the industry has been increasingly using digital technologies in their R&D processes as a strategy to reduce costs and optimize outcomes. This is the case for applying computational modeling in the development vaccines[17] or using machine learning in several stages of medicine development[18], which is influenced by the use of data generated in massive quantities[19].

Digital applications such as AI and the processing of large data volumes require the development of sophisticated algorithms, which are not traditionally the target of the health industry. This scenario, alongside the high economic value of this segment, has attracted the interest of companies outside the health sector, especially multinational corporations of the Information and Communication Technology (ICT) industry, and digital services, which are economy giants that concentrate the digital economy infrastructure platforms[20,21].

Traditional companies in the pharmaceutical and biotechnological sectors have been dealing with new actors in the health industry digital revolution. Some examples are Alphabet (Google), Qualcomm, Apple, IBM, Microsoft, and Intel, which have also expanded into the health sector[21]. These corporations have taken a central role in the modern capitalist dynamic, which grants them the ability to compete in several socioeconomic sectors, including health[20].

Such a transformative moment is a reflection of the financialization of the global economy, where the national governments and their policies are progressively captured by the logic of accumulation of big companies[22]. Not only is this process linked to the increase in socioeconomic inequalities, but it can also affect the innovation generation dynamic.

This happens because inasmuch as the financial capital expands its control over the productive sector, it alters the rationality and

priority of the investments in R&D[23,24], thus impacting the resulting technologies. Such a trajectory intensifies the risk of increasing global asymmetries and access inequities, as the big technology companies do not only follow such premises, but they are intrinsically influenced by them. When they expand their domains into the health sector[20,25,26], they favor the process of concentrating the intellectual property within resulting technologies, which may accentuate the existing disparities even more.

In line with this understanding, a study by Vargas et al.[13] found that China and the United States already accumulate 44% of the health sector 4.0 patent families worldwide. It is the technological appropriation that is expressed in the format of protecting knowledge and outlines future dependency.

Besides, other initiatives may contribute to accentuate this process. In 2018, the Food and Drug Administration implemented a fast approval plan for AI proprietary medical algorithms[27], which has been facilitating the expansion and strengthening of the technology monopoly in this sector, thus perpetuating and contributing to increasing asymmetries in the digital health sector.

It is in this context that the HEIC takes a central role not only as the environment where digital health innovations occur, but also as a connector that centers the new ways of knowledge production in health for all levels of care. The algorithms originated in the digital era may be either catalysts for positive transformations in health or pose threats to the health universal system.

Challenges and potentialities in digital health in PHC

PHC is the first level of assistance, the entrance door to the population healthcare, and it is a strategic part of a universal system that is fundamental within the care and communication network of SUS. Organized from a set of actions in the health sector that encompasses assistance processes ranging from the promotion and protection of health, the prevention of conditions, diagnosis, treatment and rehabilitation to damage reduction and maintenance of health, PHC functions as a filter able to drive the service flow organization within health networks, whether they are simple or complex, thus acting as the coordinator of network care. Consequently, it aims to foster full care that can positively impact the health statuses of individuals, families, and collectivities.

Structural obstacles to the efficient use of new digital technologies are part of the PHC reality in Brazil, among which social inequity, low problem-solving capacity of services, and health chronic underfunding[28]. Due to the weakening of the SUS structures, which mostly occurred during 2018 and 2022, there has been a movement of recovery and strengthening, founded in the practice and a discourse of defense of "strengthening as key to the survival of SUS in its universal, equitable, integral, and accessible to the Brazilian population"[28]. Nevertheless, there is a significant structural gap to be filled because of the attack directed at SUS despite the resistance it encountered.

HEIC has played a key role in strengthening PHC because it promotes technological innovation, essential input production locally, and expansion of access to health technologies. Thus, the use of technologies in PHC must be based on strategies that promote universality and equality. Digital tools such as electronic medical records have been used to expand the problem-solving capacity of family health teams and facilitate the access of vulnerable populations to health services in Brazil. Studies show that the technologies applied to primary care may reduce inequities as they decentralize

services, bring specialists closer to frontline professionals, and expand access in remote areas[29,30].

However, adopting technologies must be followed by solid investments in infrastructure, professional training, and health education. The structural fragility of PHC and the lack of connectivity are recurrent challenges that aggravate regional inequalities and limit innovation adoption[31]. Moreover, it is essential to ensure that the solutions are not used in a discriminatory way and that they are accessible to all people as a means to strengthen full care and universal access, thus preserving the SUS principles.

Thinking of PHC beyond the "poor health to the poor"[32(9)] paradigm requires renewing the strength of its strategic role in the health system, consequently, promoting care that combines proximity and innovation. Several authors reflect upon the organization of PHC in SUS focusing on their structure, funding, and its role in reducing inequities[33,34]. Considering these authors' views on the conversation about digital technology in PHC, the need to break from the stigma of primary care as a supply of health services restricted to the most vulnerable populations that requires the lowest investment is highlighted.

In PHC, implementing the concept of digital health and its expansion to health 4.0 point to the transformation of care processes, promoting technologies such as AI, IoT, robotics, and real-time connectivity to include digital consumers with smart devices. These innovations facilitate monitoring and population tracking to increase the response potential of services[31,35].

Digital health in PHC is a facilitator for HEIC's information and connectivity subsystem, as it is an integration link to higher complexity levels of care, such as specialized polyclinics and reference hospitals. The referral management tools and the interoperability between different levels of care are essential to treating several conditions, enabling the development of integrated flows within SUS and ensuring that patients with any suspected disease are quickly referred to specialists.

Digital technologies are increasingly present in several segments and traditional models of service, which requires organizational management that is able to respond to this new reality. Technology is one of the pillars of this stage, directly reflecting on management and performance strategies. Its impacts are especially seen in the patient journey and a health care unit. For this reason, following innovations and adapting to them is a path that one cannot always absorb with the expected speed. Digital transformation requires engagement from all the team: managers, service providers, civil servants, and collaborators, since it requires proactivity and availability to learn new ways of executing routine processes.

The patient as an active subject who is connected to technology is a reality that must reach SUS. In Brazil, technologies must be adapted to regional specificities, considering their inequities regarding access to digital infrastructure and differences between local capacities. Because of the strengthening of SUS digitalization and the use of emerging technologies, it is possible to significantly expand the PHC capacity in facing chronic, infectious diseases and other health conditions, especially in early diagnosis and quick, longitudinal patient follow-up.

From a HEIC perspective, the health 4.0 technology is focused on strengthening the community's and people's needs. Technology is implemented into PHC in order to achieve the best results for the user citizen. To improve diagnosis, treatment, and prevention of diseases and make changes in the capacity and technological efficiency in PHC, it is essential that managers and health professionals qualify themselves to use the implemented technologies, thus placing the user in the center of the system

and seeking a holistic, integrated approach. There must be a movement articulated with the segments of users, suppliers, and partners to translate this technological evolution also as how the human relationship is perceived and valued within health assistance.

Digital technologies in PHC must be fully integrated into the health system in order to allow professionals to develop treatment plans that are more precise and personalized, considering the context and specificities of each user segment. In this case, technology serves as a bridge to facilitate the incorporation of individuals' needs into the collective context in order to ensure that human and territory potential is valued and applied to the improvement of quality of life.

However, there are obstacles for the users to benefit from digital technologies. A systematic review by Alvarado et al.[36] on e-health mentions obstacles such as: technology illiteracy (24%); low literacy in health (12%), and little formal education (10%). The difficulty in adherence to health through these technologies was described by authors who found discomfort in several patients who, despite having access to computers and the internet, preferred phone calls.

In order to ensure that local communities and patients are at the center of public policies and engage with the digital transformation in health, technologies must meet the social control requirements that are highlighted in the discussions and recommendations from the National Health Councils (NHC) and other social control instances.

Public policies in digital health interfacing with social control to strengthen PHC

The 17th NHC (Brazilian National Health Conference), carried out in 2023, addressing the topic 'Ensuring Rights and Defending Sus, Life, and Democracy'[37], presents recommendations for both digital health in the 4th technological revolution and the adaptation of HEIC in a context of social, economic, and technological changes regarding the supply and demand for digital technologies.

The choice of PHC technologies must strengthen the coordinating and continuity-assuring role of care, promoting a safe, inclusive, and equitable approach for all people, and facilitating connectivity towards higher complexity levels within the health system.

Despite the notable trajectory of digital technologies in health, which evokes the creation of DataSUS, and the actions already taken towards responding to the needs of social control, such as 'e-SUS PHC', 'My Digital SUS', the 'National Network of Health Data' (NNHD), and 'Digital PHC' in 2023 and 2024, the Ministry of Health (HM) has increased the execution of health policies digitally to make health care more accessible, equitable, resilient, and aligned, especially with the guidelines proposed by 17th NHC.

As an example of this alignment, we mention an excerpt of the NHC Resolution 719/2023:

> [...] establishing a technical committee of information and digital health in NHC [...] to assess and monitor public policies in digital health, with digital technologies that meet the needs of users and SUS[37(79)].

In fact, this committee was established in July 2024[37] and named 'Digital Health and Communication Technical Committee' with the expectation that it would become a qualified forum for social control and discussion on both digital technologies and the key role of the health communication sector, considering health as a fundamental human right and an expression of citizenship[38].

One of the actions executed at the time is the 'Digital SUS Program', structured into

three axes: digital health culture and continuous education of professionals, development, and implementation of technological solutions and services in SUS; interoperability, analysis, and dissemination of data and information of health, thus ensuring the integral problem-solving capacity of health care.

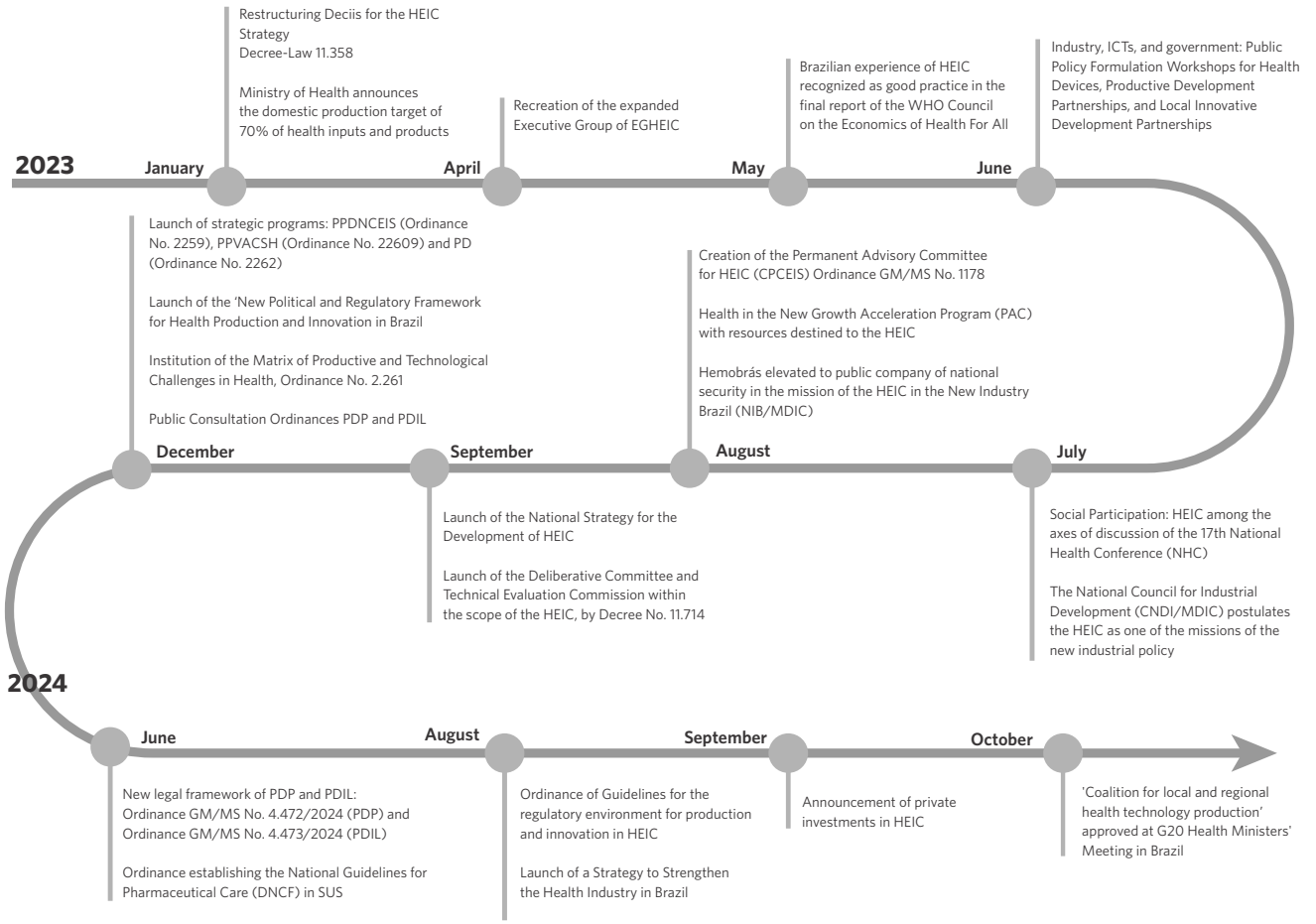
We must also highlight the standardization in 2023 to record vaccination doses in the Health Information Systems (HIS) on vaccines and the posterior integration of data with the NNHD. The HIS interoperability work has been positively impacting the understanding of the real vaccination coverage of Brazilians and created an opportunity to develop 'My Digital SUS', an interface between the citizen and the health system, as well as a contribution to research and the continuous monitoring of vaccination coverage in Brazil[39].

Other significant initiatives were as follows: 'e-SUS Regulation', which optimized care in regulation centrals, facilitates coordination between levels of care and promotes efficient access to health services; the 'Innovate Digital SUS Laboratory', which promotes digital innovation and transformation in SUS via a collaborative network; and 'Digital SUS Strategic Action – Telehealth', which aims to expand telehealth to overcome geographic and access barriers. All these actions are found in the 2024-2027 National Health Plan (NHP).

For innovation in digital health to become consolidated in accordance with the principles of social control, the HEIC perspective was widely debated at the 17th NHC, particularly in relation with the challenges of strengthening healthcare. This included the use of the state's purchasing power to drive a new generation of policies and innovations for the expected development of SUS through a strengthened HEIC.

HEIC was mentioned in the 2024-2027 NHP and the 17th NHC. In the first event, the term appears more than 10 times, while in the second event, it appears more than 24 times across the axes, which demonstrates how transversal this perspective is in relation to the guidelines and proposals of the NHC on the relevance of strengthening HEIC in accordance with the interests of social control. Among the HEIC public policies, *figure 2* presents examples of actions implemented between 2023 and 2024.

Figure 2. Institutionalities, actions, and strategies to strengthen the HEIC (2023-2024 period)



Source: Prepared by the authors.

The efforts for HEIC to advance towards social and economic development, presenting health as a vector of development that we want for SUS are described by the frameworks that were either created or reformed. Among them, it is important to mention the 'National strategy for the development of HEIC' as discussed in the 17th HEIC, a public policy designed with the participation of social movements that, according to Lima[40], represents the Brazilian society demands.

This policy was proposed by the Executive Group of the Health Economic-Industrial Complex (EGHEIC), which was expanded and relaunched in April 2023. Led by the HM and receiving support from the Ministry of Development, Industry, Trade and Services (MDIC), this group gathers over 20 ministries and government institutions, as well as over 30 company associations, unions, representatives from the productive sector and the civil society; it has been thoroughly discussing the challenges and solutions to strengthen all levels of care within SUS. This initiative is articulated with the 'New Industry Brazil' policy[41], aimed at making 'a resilient HEIC in order to reduce the SUS vulnerabilities and expand access to health,' and it depends on funds from 'The New Growth Acceleration Program'.

To implement the national strategy to develop HEIC, HM has created the six programs that are described in *figure 3*.

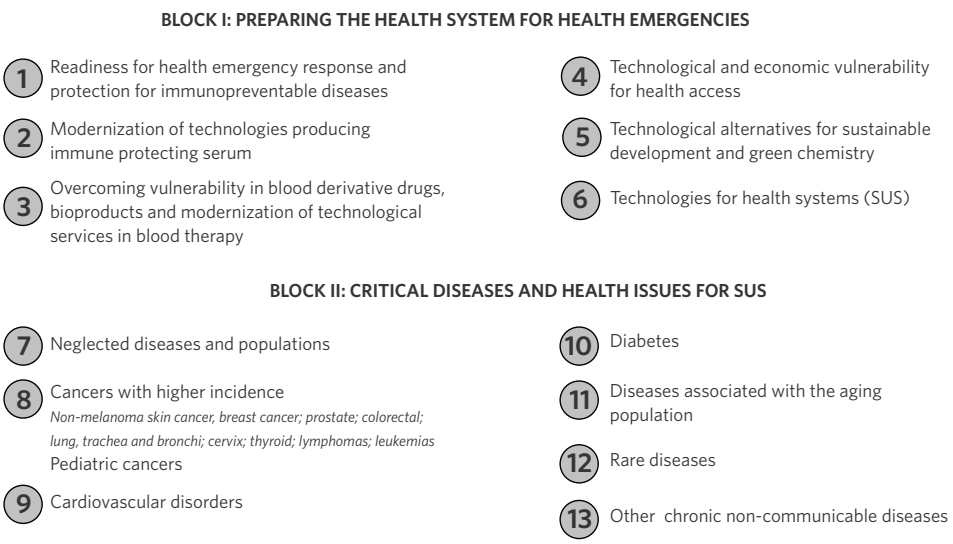
Figure 3. HEIC National Strategy Programs

Source: Prepared by the authors based on Ordinance GM/MS No 1354/2023[42].

The strategic programs, which constitute the HEIC public policies, gather public and private investments, seek to stimulate local production and the capacity of national innovation and sustainability of SUS.

Another highlight is the 'Matrix of productive and technological challenges in health'. It is one of the structuring aspects of the national structure of HEIC because it signals to the society and the economic agents about the priorities of production and innovation in health and the critical gaps that need to be fulfilled to improve SUS resilience and expand access to health in Brazil. *Figure 4* describes the aforementioned challenges.

Figure 4. Matrix of productive and technological challenges in health



Source: Prepared by the authors based on Ordinance GM/MS No. 2.261/2023[43].

Nonetheless, the understanding of the importance and resilience of SUS must be deepened, as argued by Jatobá and Carvalho[44]. This is because in the current scenario in which the SUS action capacity is put to the test daily, the resilience of all SUS components is demanded "both for dealing with extraordinary events and everyday stressful [situations]"[44(131)]. Thus, digital health, transversal to the HEIC public policies, presents itself as a measure for the needed resilience.

One must identify progress in the development of HEIC between 2023 and 2024 regarding investments to decrease the Brazilian dependence on health products as exemplified by the allocation of public funds that was carried out to equip and modernize the Public Health Central Laboratories (LACEN)[45]; the update and expansion of laboratory production plants such Farmanguinhos/Fiocruz and Butantan; and the inauguration of the blood product plant of State-owned company Hemobrás[46].

Regarding the private sector at that time, there was an announcement of new production plants of companies such as Bionovis, for biotechnological products such as monoclonal antibodies; Biomm, for the production of insulin; and EMS, focused on products for obesity and type 2 diabetes[47]. These are examples of how public policies can influence private investments to drive innovations of public interest by manufacturing products in Brazil; consequently, this stimulates job creation locally and generates a virtuous cycle of investments and public-private partnerships in the health sector.

According to Sabbatini[48], there is a window of technological opportunity associated to digital innovations regarding the growth of small technology-based companies that gravitate around HEIC. This author argues that health techs are among the most dynamic startups in the world, and there would be room for expansion, consolidation, and development of these companies, "which would threaten, to a certain degree, the market power of the big companies that dominate HEIC"[48(111)]. Finally, public policies that would coordinate and finance these companies, associated to the SUS purchasing power, would ensure the demand that enables scale-up to develop digital technologies within the Brazilian territory.

The international cooperation towards worldwide health equality is also part of the HEIC strategy, and there have already been some results, as it can be noted in the agreed resolutions during the Brazilian presidency of G20 in 2024: i) construction of sustainable and resilient health systems; and ii) global coalition for local and regional production to facilitate access to vaccines and treatments in low-income countries, focusing on technical cooperation and transfer of technology. One of the statements is about how important digital health is in promoting access to health services[49].

Mazzucato[50] corroborates the perception that HEIC is a sustainable development opportunity in the health sector. According to her, this is a good example of how to leverage industrial investment and innovation to achieve social goals. This is because transforming health challenges into opportunities for investment, innovation, and growth, as promoted by HEIC, has contributed to achieving aims such as universal access to health in Brazil while it has boosted job generation and gross domestic product growth. However, Mazzucato[50] also alerts that the dependency of the HEIC subsystems on imports raises concerns regarding the economic frailty and the reproduction of practices of exclusion.

This author[50] also argues that the digital era provides opportunities to transform HEIC. In an approach focused on public missions, Mazzucato emphasizes the importance of integrating digital technologies to improve efficiency and equity in the access to health services, and she also believes that the collaboration between the government and the private sector may be an option of strategic use and incentive for innovations to be accessible and beneficial to all citizens, especially the most vulnerable ones[50].

Final remarks

The advance of digital technologies is an opportunity to transform PHC in Brazil. Resulting from technological innovations provided by the market or requested by users, these technologies can provide greater efficiency, accessibility, mobility, and resilience to SUS; nonetheless, such changes do not happen neutrally or without challenges. From the viewpoint of the political economy of health and public health, they should be centered on people and be applied to solve problems and needs of the population. For this reason, we must use institutional mechanisms and public policies to align the productive system with the digital needs of the population. Following this line of reasoning, technological innovation must follow social needs, not the opposite.

In a context of changes promoted by digital technologies that are associated to contemporary global economy characteristics, the growing influence of big corporations in the development and control of these technologies imposes additional risks to the Brazilian technological sovereignty; this may affect access to health will be ensured in Brazil. It is essential that SUS will overcome the structural and economical obstacles, and innovations in SUS will be fostered to ensure that the right to health is truly universal.

Consolidating HEIC in order to strengthen national innovation and promote productive independence in Brazil is an opportunity where the information and connectivity subsystem stands as the main axis of this discussion, considering how transversal it is and the potential it has to drive digital innovations for health care.

Recent public policies have highlighted efforts from HM and other ministries to face these challenges. The implementation of digital technologies in PHC still requires institutional and political maturity to achieve the ideal established in the Declaration of Alma-Ata[51] and highlighted in the Declaration of Astana[52]. Thus, Haddad and Lima[2] stress that it is essential to strengthen solidarity, expand connectivity, and qualify health data as public assets.

The book 'Knowledge Management in the Digital Transition and Health[1]: reflections on the scientific and technological evolution against digital convergence', the three scenarios that compose the HEIC digital health sector are: i) unequal and dependent subordination, with technology dependency that renders universal access impractical and makes it unable to respond to crises and sanitary emergencies, configuring vulnerability 4.0 in health; ii) exclusionary modernization, where there is an effort for modernization driven by consumption only, with no local production capacity and fragilities in implementation of technologies by the unified health system; this may cause difficulties in access and reproducing inequalities; iii) innovative, equitable, and universal, a daring, necessary scenario to leverage innovation and local production with universal access, where digital health takes a transversal dimension, and the HEIC strategy is focused on combating vulnerabilities 4.0 in health[1].

The digital transformation in PHC is regarded as a process that goes beyond technological adoption. It requires a political, social and economic commitment, where a more inclusive and democratic, sustainable and innovative unified health system is built, and digital innovations are used as instruments to promote social justice and the right to health.

A deep transformation in public management is essential, where transdisciplinarity and the focus on real society's problems overcome old paradigms and are organized into static, bureaucratic department structures. Finally, digital health associated to a universal system poses the challenge of providing constant professional qualification that will enable a coordinate action between public managers and other SUS actors to apply technology in humanized, problem-solving care service across all the health care network. The success of this venture shall depend on Brazil's ability to leverage robust public

policies, strengthen HEIC, and face the challenges posed by financialization and global technology concentration.

The perspective outlined in this essay places digital health in a production, innovation system that shapes the material basis of SUS[7]. It describes an integration where care, social and life needs must be the drivers of a social policy framed by the needs of SUS as an integral, equitable, and universal system.

Collaborators

Gadelha CAG (0000-0002-9148-8819)* collaborated with the coordination of this study, its methodological definition, discussion, critical analysis, and manuscript review. Braga PSC (0000-0002-3444-1651)* and Cohen MM (0000-0003-1765-0280)* collaborated with study conception, its conceptual analysis, writing and work structure, executive coordination, critical analysis, and manuscript review. Araújo ALF (0009-0002-0468-4924)* collaborated with study conduction, writing, and manuscript critical analysis. Montenegro KBM (0000-0003-1773-7781)* collaborated with this study initial conception, conceptual analysis, writing and work structure, executive coordination, critical analysis, and manuscript review. ■

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*Orcid (Open Researcher and Contributor ID).

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