DOI: 10.1590/1413-81232021266.44122020

The relevance a technology ecosystem in the Brazilian National Health Service's Covid-19 response: the case of Rio Grande do Norte, Brazil

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Abstract *Technological advances play an undeniable role in strengthening health systems. With regard to digital technologies, information systems and the analysis of health data are playing a growing role in health surveillance and preparing for and responding to disease outbreaks, the theme addressed by this article within the context of the Covid-19 pandemic in the State of Rio Grande do Norte. This study departs from the assumption that digital health interventions can increase Covid-19 response capacity. We developed a technology ecosystem that integrates different information systems to meet the needs outlined in international regulations governing the response to the pandemic. In addition to the main elements of the ecosystem, this article describes the application of this instrument by different institutional actors. The main decision making tool used in the state government's Covid-19 response, the ecosystem is a model for digital health interventions in Brazil's national health service. This experience in Rio Grande do Norte brings together elements that can contribute to studies investigating the resilience of health systems and analyzing health policies in emergency situations.*

Key words *Coronavirus Infections, Software, Technology, Technological Development and Innovation Projects, Epidemiological Surveillance, Health Care*

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Introduction

Technological advances play an undeniable role in strengthening health systems. The discovery of penicillin and vaccines and the use of magnetic resonance imaging demonstrate just how much science, research and technology have expanded the boundaries of medical knowledge. With regard to digital technologies, information systems and the analysis of health data are playing a growing role in health surveillance and preparing for and responding to disease outbreaks, the theme addressed by this article within the context of the Covid-19 pandemic[1] in the State of Rio Grande do Norte (RN), Brazil, in 2020. The virus that causes Covid-19, the novel coronavirus, was identified in Wuhan, China, after a pneumonia outbreak at the end of December 2019[1].

According to the World Health Organization (WHO)[2], countries should harness the power of digital technologies as a means of promoting universal health coverage and reducing inequities in access to health care, fostering synergies to achieve global goals. However, while constant and relentless, advances in technology can also put strain on the health systems. Studies of the use of digital technologies by health systems during the response to the Covid-19 pandemic can help to answer questions about the capacity of systems to respond to *emergencies of international concern*, while at the same time pointing to pathways to strengthening preparedness, surveillance and response to future emergencies.

On January 30, 2020, the WHO declared the Covid-19 epidemic a Public Health Emergency of International Concern (PHEIC), the highest level of global health alert provided in the International Health Regulations (IHR)[3,4]. It was the sixth time since the approval of the IHR at the 58th World Health Assembly in 2005[5] that the WHO had declared a PHEIC. Eleven days later, it was declared a pandemic. As a result, trading on stock markets halted for a second time since the discovery of the novel coronavirus, a phenomenon that had not been witnessed since the 2007/2008 financial crisis. Wiping trillions of dollars off stock across the globe, this situation clearly demonstrated that the new disease not only kills, but also is capable of paralyzing the economy through mitigation measures such as social distancing, isolation, quarantine and lockdown[6].

In this respect, Lima et al.[7] suggest that the Covid-19 epidemic raises tensions inherent in social organizations in the contemporary world. A world that, despite being "globalized in economic exchanges" and "digitally interconnected", is still quite "vulnerable to the occurrence and global spread of novel diseases". For these authors, modernization and globalization have made the world more prone to epidemics due to the ease of circulation of people and goods between continents and the predatory exploitation of natural resources. In March 2020, countries began to implement the WHO recommendations and address weaknesses as Covid-19 death rates surged. Within this context, and based on the understanding that pandemics are multidimensional phenomena (biological, environmental and social, with both political and economic implications), Lima et al.[7] observed that the global response to Covid-19 is a result of the accumulation of learning along the pathway to tackling diseases, often combining technologies.

The present study departs from the assumption that the development of a customized technology ecosystem guided by integration and interoperability protocols can increase the Covid-19 response capacity of RN's health system. The creation of this enabling ecosystem is in line with the recommendations and observations of the National Health Information Technology Policy (PNIIS, acronym in Portuguese)[8], integrating different information systems and addressing the needs outlined in national and international regulatory instruments. In addition, the ecosystem seeks to promote the production, utilization and synthesis of health information to benefit service users, professionals, managers, health service providers, education and research institutions, and organized civil society[8].

We selected the following guiding questions: 1) How can technology ecosystems help the Covid-19 response in RN, Brazil? 2) What are the criteria for customizing this tool in RN? and 3) What contributions can this experience make to strengthening preparedness, surveillance and response in Brazil's national health service, the "Unified Health System" (SUS, acronym in Portuguese)? The main objectives of the study were to describe and analyze the implementation of a technology ecosystem for controlling the Covid-19 epidemic in RN and discuss how the contribution of digital technologies can go beyond technological aspects and health innovation, in this case resulting in digital health interventions in the SUS.

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Materials and methods

This study effectively began with the publication of the state decree creating the Government Emergency Management Committee[9] as part of RN's Covid-19 response. We used a transdisciplinary research design, including studies, developments, changes and improvements made during the implementation of a technology ecosystem to respond to the Covid-19 pandemic in RN. Given the nature of the object of study and guiding questions and the need for a timely response to the health crisis, we used the action research method as proposed by Tripp[10]. For this author, action research should be undertaken in cycles ("improvement of practice") that depend on the synthesis of the work into two fields: "practice and inquiry into the practice"[10].

Based on the above, the technology ecosystem was developed in four phases: planning, development, evaluation and monitoring. The phases were executed sequentially using cyclical and spiral models, one cycle after the other[11]. Each cycle was executed in one or two weeks, according to needs, which were often changeable and unpredictable, and to urgency and the response deadline. This model permitted the continual improvement of solutions during the ecosystem development process[11,12]. The model was therefore suited to the state's needs at that time of Covid-19 response. Also known as the iterative and incremental model in the area of health information technology[13], the ecosystem enabled the organic development of both practices and research activities.

At the same time, the study object was a multidimensional problem requiring a transdisciplinary approach. It was therefore necessary to apply an agile technology development model that could respond more rapidly to the demands imposed by the Covid-19 pandemic. The development of the ecosystem was therefore centered in the Scrum framework[14,15], which is suited to cyclical and spiral models[16].

In addition to this methodology, we conducted a case study[17,18] to analyze the ecosystem within the context of the health crisis in RN, comprising a cross-sectional social study in the area of public health. For the purposes of this analysis, we adopted the approaches proposed by Goldenberg[17] and Yin[18], which seek to capture the characteristics of a chosen social unit (the case) and present rigorous data collected using precise questions focused on contemporary facts[17,18].

The case study explored and analyzed actions that extend beyond ecosystem planning and development articulated with the action research design through technical cooperation between various institutions in RN. This is because it was necessary to develop the ecosystem and use new technologies that promote effective changes to work processes in the institutions involved. The analysis of the results generated by technical cooperation and the instruments produced during the Covid-19 response was therefore guided by this case study.

Data on the utilization of the ecosystem were analyzed in the light of concepts in the fields of health systems and services and policy analysis, focusing on the "formation of governmental agendas" as proposed by John Kingdon[19], which analyzes decision-making processes and the recognition of a particular topic or problem as a priority on the public agenda[19]. The primary sources were documents, meeting minutes, official state government publications and news about the object of study in the local news media.

Results

RN has a human development Index of 0.684. The most recent census (2010) shows that the state had an estimated population of 3,168,027 people. The state has 167 municipalities divided into eight health regions. The most affected region was the seventh (or metropolitan) region, followed by the second (or west) region, which borders Ceará. These regions have the largest populations and patient flows and most complex health systems in the state.

With regard to Covid-19, the first state epidemiological bulletin (EB) was published by the state health department (SESAP/RN, acronym in Portuguese) on 28 February 2020, when there were eight suspected cases. The EB published on 2 March, still without any confirmed cases, showed that the suspected cases were concentrated in the seventh region, particularly in Natal. This trend continued throughout the course of the pandemic and dictated state and municipal government decision making. The first confirmed case and death were registered on 13 and 29 March, respectively. By the end of July, there were 58,132 confirmed cases and 2,019 deaths across the eight health regions, with prevalence rates being highest in the seventh and second regions[20].

With regard to preparedness, surveillance and response, RN was one of the first states in the Northeast to create a State Contingency Plan (SCP)[21], aimed at organizing the care network and integrating surveillance and response actions. The state followed WHO recommendations, Federal Law Nº 13,979[22] and Ministerial Order Nº 356 issued by the Ministry of Health[23], and created a steering committee, made up of representatives of the state government and coordinated by governor's office, and a scientific committee. The SCP is currently in its fourth edition.

With regard to the main directions taken, the first edition of the SCP allocated hospitals with beds for Covid-19 patients in the three regions (the seventh, fourth and second) considered strategic hubs at a moment when RN was witnessing an upward curve of cases. In parallel with this action, the state also gradually expanded the number of critical care and rearguard beds across the state, focusing on locations where the epidemiological indicators signalled the potential collapse of the local health system. At the time, the plan contemplated the possibility of interiorizing the virus in municipalities in the state's central regions[24]. The number of SUS beds for Covid-19 patients in RN increased from a little over 100 at the end of March, to 655 at the end of July.

At this juncture, it is important to mention the cooperation between certain institutions that worked together to implement the Covid-19 response, essentially in the area of management, transparency and public participation. It can be said that both the ecosystem and the interventions that came about as result of its implementation were outcomes of this interinstitutional cooperation. It is worth highlighting that the following institutions were responsible for the technical and scientific aspects of the ecosystem (conception, elaboration, development and implementation): the Laboratory for Technological Innovation for Health (LAIS), Federal University of Rio Grande do Norte (UFRN); the Center for Public Health Studies, UFRN (NESC); the Advanced Center for Technological Innovation (NAVI), Federal Institute of Education, Science and Technology of Rio Grande do Norte (IFRN); and the executive bodies of the state health department and Natal City Council Health Department (SMS/Natal).

This process promoted the gradual engagement of state authorities (adherence to the use of technologies) and led to an increase in the transparency of and public participation in the dissemination of Covid-19 statistics in the local press media. This is because one of the aims of the ecosystem was to improve the quality of information and mitigate the effects of the infodemic[24]. In this regard, it is important to underline the participation and incorporation of other institutional actors into the cooperation process, such as the federal and state public prosecutor's offices (MPF/RN and MPRN, respectively). These actors participated in the definition of recommendations for the use of technologies in the ecosystem, while at the same time using the data extracted from this device in their analyses and proposals to improve the state health system in response to the Covid-19 pandemic. This technical cooperation produced key results, including effective collaboration in the public health response, the promotion of engagement for the use of the technologies made available by the ecosystem, and public participation. Without this cooperation, it would have been difficult to break the "inertia" caused by the resistance of state and municipal government actors to using new technologies that change work processes.

Ecosystem for the Covid-19 response in Rio Grande do Norte

The technology ecosystem integrates SUS management functionalities with aspects proposed by the WHO, including the public health emergency operations centers management model[25] and global response to the Covid-19 pandemic[26]. In other words, the ecosystem brings together and adapts the main global guidelines in a single management tool designed to support decision making and response planning and coordination. It is also aligned with the PNIIS, addressing the lack of standardization, and consequently integration and interoperability, in part of Brazil's health information systems: "It is important to highlight that achieving interoperability of health information systems is a central element of this Policy, bearing in mind that this integration is essential to support decision making that is consistent with the real needs of the population"[10]. In this regard, the technological architecture of the ecosystem is based around national and international interoperability protocols to ensure a high level of integration with existing and future technologies in RN and Brazil. Thus, in line with the specific demands and needs of RN in relation to the Covid-19 response, the ecosystem is integrated with the following health Ministry of Health information systems: *e-SUS Notifica*, SIVEP-Gripe, *Cartão SUS* and CNES.

The ecosystem consists of 13 subsystems or tools, some of which already existed in the SUS

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and others that were developed by the LAIS to strengthen the integration of the state's response and its alignment with some of the main aspects proposed by the WHO: intersectoral coordination; risk communication and community engagement; case control and prevention; and suppression of transmission and reduction of mortality through the provision of timely quality health services.

Figure 1 is a graphical representation of the ecosystem. A mandala was chosen to illustrate the ecosystem because it best represents the dynamics of the coordination and mobility of the subsystems (internal part of the diagram divided into slices) and the global dimensions operationalized by state Covid-19 response policies (represented on the borders). It is important to highlight that these dimensions are cross-cutting and therefore may be permeated by various technologies and/or processes presented in the mandala. The symbology adopted in Figure 1 can also be seen in the colors defined for each dimension, which are arranged at the base of each respective technology and/or process, emphasizing the cross-cutting nature of and intersection between these stereotypes (dimensions and technologies).

The dimensions of the ecosystem can be described as follows:

Communication and community participation: proactive presentation of information to the public to reduce confusion, prevent an infodemic[27], build more intersectoral confidence, and promote community engagement.

Education: health training for preparedness, surveillance, the state health system Covid-19 response, and to promote resilience.

Comprehensive surveillance: production of data through the integration of different existing systems and health services to promote monitoring, transparency and disease prevention.

*Monitoring***:** indicator panels and integrated analysis of epidemiological and socioeconomic contexts and health service management to support decision making.

Comprehensive health care: strengthening of care networks through technological support for continuity of care, especially primary care, including the hospital network and intensive care.

Contact tracing and management: monitoring of cases and contact, including risk assessment and guidance on public health measures and physical distancing.

Maintenance of essential services: support to health professionals as a measure to prevent spread and risk exposure, recruitment of volunteers, and preservation of essential primary care services.

Planning: strengthening of plans and protocols for managing the state's response to the pandemic.

Regulation: organization of access to technology-mediated intensive care services to increase transparency, improve efficiency, strengthen public participation, and enhance the state response to oversight by control bodies.

*Management and coordination***:** available at the operational, managerial and strategic levels.

Data and information: availability, accessibility and quality, guided by the principles of transparency and quality of data and information at all levels of management.

The systems and/or processes presented in the inner part of the mandala are described in Chart 1. Some of these systems and/or processes are highlighted as anchor technologies.

It can therefore be seen that the ecosystem establishes an organic synergistic process of feedback between the technologies and dimensions set out in the mandala (input and output processes), allowing municipal and state health authorities to activate dynamically fed points. At the same time, the data and information, made available to the public in real time, also allow society, managers and control agencies to act more effectively on more urgent issues.

The multidimensionality of the ecosystem differentiates it from other similar initiatives around the world, because the latter are more centered on monitoring panels or specific care or service applications. Unlike other ecosystems, the development of the ecosystem for the response to Covid-19 in RN and its application within the scope of the SUS adopted an integrated cross-cutting approach[28-37].

Covid-19 Agency

At the beginning of the pandemic, one of the points of agreement in the scientific committee set up by the SESAP was communication[24,38]. In this respect, it was necessary to define a flow of communication to improve the quality of information provided to the public and government in order to avoid an infodemic, which had been witnessed nationally, disarticulating the branches of the government and being used to confuse the population. It was necessary to create a systematic schedule of official government communication strategies and influence the local news agenda.

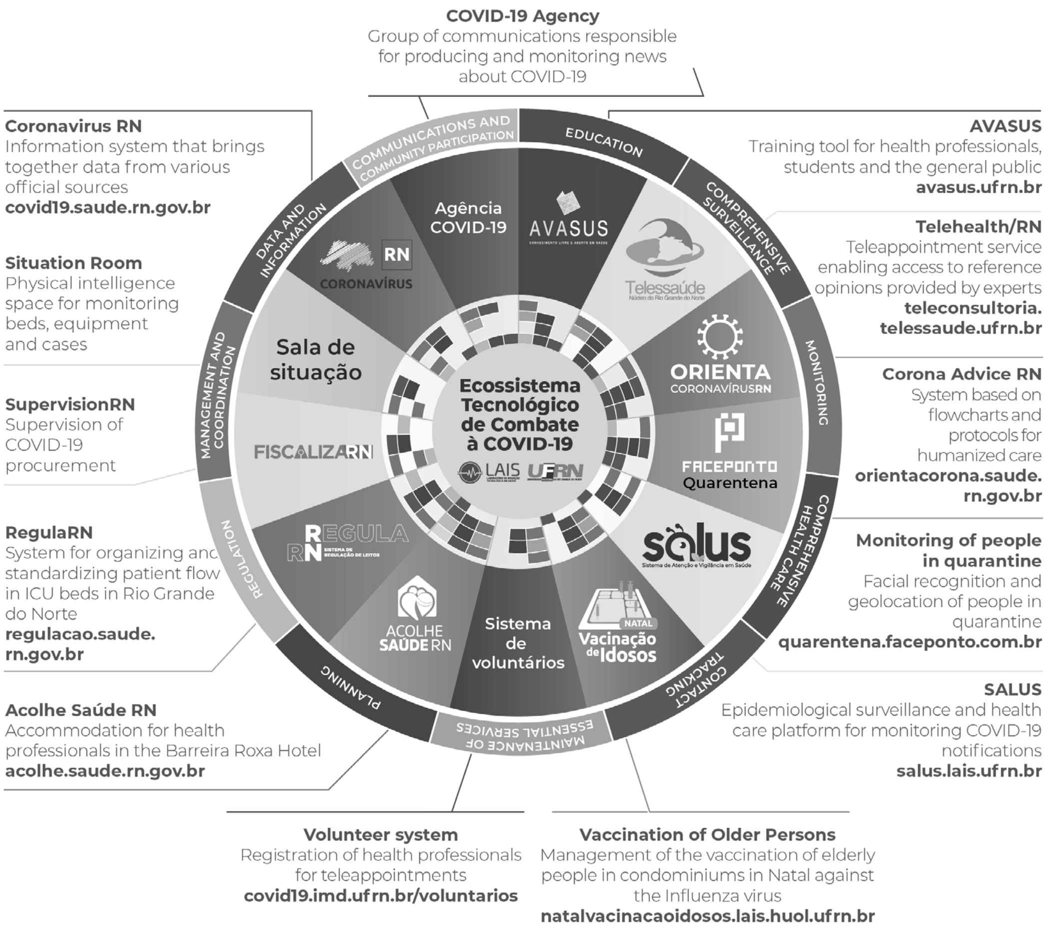

Figure 1. Ecosystem for the response to Covid-19 in Rio Grande do Norte.

Source: Elaborated by authors.

A number of examples in this field gained notoriety in the national and international news media, including: denialism, where the novel coronavirus was depicted as "a little flu"; "miracles" solutions, such as the use of ivermectin or chloroquine; and negligence in relation to the use of face masks, where it was common to see political leaders promoting gatherings and failing to use a mask in various places, including closed commercial spaces.

However, the governor of RN did not manage to hire an advertising agency that was able to execute a communications plan capable of reaching all levels of society[39]. It was within this context that the LAIS and state government created the Covid-19 Agency, made up of more than 20 communicators from RN, including journalists, researchers, PhD and master's media students, and journalism, publicity and audiovisual undergraduates. This action was coordinated by the LAIS and researchers from UFRN's Department of Communication and the Hyperlab at the Rio Grande do Norte State University. The objective of the Covid-19 Agency is to influence the local media agenda in the search for quality content about issues related to the pandemic that are of real public concern and mitigate the effects of fake news.

In addition to press conferences, the agency produced various materials, including interviews, story suggestions, reports, infographics, podcasts, video broadcasts, and social media cards. Up to July, the Covid-19 Agency had developed more than 50 communication actions in

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Chart 1. Description of the technologies and/or processes that make up the ecosystem.

Title	Description
Covid-19 Agency*	Work process instituted by communicators to strengthen health sector communication during the response to the pandemic. Core actions: tackling the infodemic, informing the population, producing special reports, organizing press conferences, influencing press agendas to include topics of public concern, and strengthening autonomous and crosscutting public and governmental communication.
Situation Room https://portalcovid19.saude.rn.gov.br/	Intelligence room implemented in the SESAP in partnership with the LAIS to monitor data and produce analyses and information from the ecosystem to support state management and decision making.
AVASUS* https://avasus.ufrn.br/	Part of a cooperation effort between the LAIS and Ministry of Health, AVASUS is an online platform that was added to the ecosystem to rapidly scale up and increase the capillarity of the training process in RN. This process was applied to both health workers (workforce training) and the general population, which needs quality information on the SARS-Cov 2 virus and Covid-19.
Telehealth RN http://www.telessaude.ufrn.br/	State platform that joined forces with the Covid-19 response. The platform focuses on primary care in the following core areas: clinical management of patients, care, diagnosis, welcoming and care networks.
Coronavirus Guidance RN https://orientacorona.saude.rn.gov.br/	Teleappointment system aimed primarily at providing guidance and information on Covid-19 to promote self-care and avoid overburdening health services.
Facepoint Quarantine https://quarentena.faceponto.com.br/	Information system integrated into the Coronavirus Guidance platform aimed at monitoring adherence to physical distancing measures.
Salus https://salus.lais.ufrn.br	System developed to enhance integration between epidemiological surveillance and health care. Implemented by the Natal City Council Department of Health Surveillance, the objective of the system is to address and correct errors generated by Ministry of Health notification systems such as the *e-SUS VE*. The system supports monitoring and care delivery in primary care services and care networks in Natal. It is important to highlight that Natal accounts for more than 48% of Covid-19 cases in the state. The system is essential for promoting the automation of previously manual work, increasing the time teams have to dedicate to comprehensive surveillance actions.
Vaccination of older persons https://natalvacinacaoidosos.lais.huol.ufrn.br/	The platform was developed to strengthen the Natal City Council Health Department's older person protection policy. It registers older persons living in vertical condominiums for home flu vaccination, enabling the vaccination of more than 6,034 older people living in 384 condominiums.
Volunteer system https://covid19.imd.ufrn.br/voluntarios/	Information system for health workforce recruitment in response to the pandemic.
Acolhe RN https://acolhe.saude.rn.gov.br/	Project implemented in partnership with the Rio Grande do Norte Federation of Trade in Goods, Services and Tourism (FECOMÉRCIO). The Hotel Barreira Roxa was used to provide accommodation for health staff who live with people in risk groups or infected persons. The system was developed to manage triage and the amount of time spent by staff in the project.
RegulaRN* https://regulacao.lais.ufrn.br/sala-situacao/sala_publica/	Fully integrated into the *e-SUS Notifica*, this platform was developed to manage the regulation of beds for Covid-19 patients in the state. This platform resolved the problem of reworking, improving the quality of information and maintaining data integrity. Totally transparent, the platform increased public participation, strengthens oversight, disciplines the state regulation process, and played a decisive role in decision making about the number of beds for Covid-19 patients.
Oversight RN https://fiscalizarn.lais.ufrn.br/login	Platform developed jointly by the LAIS and Federal Prosecutor's Office (Covid-19 Working Group) to oversee state and municipal government spending on Covid-19.
CoronavirusRN* https://covid.lais.ufrn.br/	Platform developed to work as an online monitoring panel for 149 Covid-19 indicators in RN; the indicators are updated at least three-times a day.

*Anchor technologies or processes.

Source: Elaborated by the author.

the following core areas: vaccination and protection of older persons; physical distancing; use of medicines with no scientific evidence to support their use; epidemiological data; clarifications about the virus; presentation of the technology ecosystem and its respective applications and platforms; and organization of press conferences focused on science journalism. Part of the material produced is available at: https://lais.huol.ufrn.br/categoria/noticias/coronavirus/.

AVASUS: SUS's Virtual Learning Environment

AVASUS, a product of ongoing technical cooperation between the LAIS and Ministry of Health since 2015, was included in the ecosystem to mediate health training and drive the response process in the state. The use of AVASUS meant that the Covid-19 training process was completely technology-mediated, improving the scalability of training and reducing the exposure of course participants to the virus. Twenty courses were offered in the specific Covid-19 training pathway: https://avasus.ufrn.br/local/avasplugin/cursos/covid.php. All courses were developed according to the specific needs in the region, except for the first course, which was developed by the Pan American Health Organization (PAHO) in partnership with the Ministry of Health.

A number of milestones were reached during this period, not only in RN, but also nationally and in other parts of the world. The indicators shown in Chart 2 show the scalability of technological mediation (AVASUS) for promoting health training. It is worth mentioning that the scalability achieved by the AVASUS, which is part of the ecosystem, would have been practically impossible with face-to-face training. The results shown in Chart 2 demonstrate the importance of this training model during health crises such as the Covid-19 pandemic.

RegulaRN

At the beginning of the pandemic, strains on intensive care beds for patients infected with Covid-19 were common in health systems around the world and in some states in Brazil. In RN, an urgent review of planning and the logistics of bed distribution across the state was needed.

The *RegulaRN* platform was developed to manage the operationalization of the previously manual State Regulation Complex (CER/RN). At the time, data – such as bed needs and availability, including forecasting the availability of new beds – were essential.

The first version of the platform began to operate at the end of April with the support of the federal and state public prosecutor's offices, which recommended that the state and municipal governments and service providers used the platform, promoting data integration. This recommendation resulted in the engagement of all actors and speeded up the subsystem implementation process.

One of the most important functionalities of the *RegulaRN* platform is the Situation Room. Illustrated in Figure 2, the aim of the Situation Room is to give wide publicity to and ensure the transparency of the regulatory process[40]. The data area presented and updated in real time throughout the day.

In a little over 60 days, the platform enabled the CER/RN to refer more than 3,700 Covid-19 patients to critical or clinical care beds. Of the regulated patients up to 22 July 2020, 1,932 were cured and discharged. The platform also records the implementation and monitoring of SUS Covid-19 beds in RN, including 301 intensive care beds and 343 clinical care beds, and enables the management of ventilator use.

CoronavirusRN

The CoronavirusRN platform (available at: https://covid.lais.ufrn.br/) is an integrated intersectoral smart environment designed in accordance with SUS guidelines and the principles set out in the PNIIS[41]. The information management panel consists of 149 indicators presented in graphs, tables, maps, scenarios and forecasts, as shown in Figure 3.

The CoronavirusRN platform collects information from various municipal, state and national sources[42], and social media, providing data on indicators to the government, public, press and control agencies in an agile, centralized, targeted and open manner. The tool helped RN obtain second place in the national ranking of transparency in the Covid-19 response, with 98 points (see Open Knowledge Brasil and the website *Transparência Covid-19*[43]).

Salus

Salus is a primary care epidemiological surveillance and monitoring platform. Developed in partnership with the Natal City Council Health Department, its aim is to improve data quality,

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Chart 2. Number of AVASUS training processes in response to Covid-19.

Number of students reached*	121,193
Number of subscriptions*	241,238
Average number of students per course	12,064
Number of municipalities reached in RN	111
Number of students reached in RN	24,315
Number of states reached in Brazil	27
Number of students reached in Brazil	131,396
Number of countries reached	55
Number of foreign students reached	2,014
Number of Covid-19 response courses offered	20

Notes: *The difference between the number of students reached (AVASUS Covid-19 users) and subscriptions (number of subscriptions to AVASUS courses in the Covid-19 training pathway) is due to the fact that students can do more than one course, meaning the number of subscriptions is higher than the number of students.

Source: Coronavirus RN Platform (accessed on 29 November 2020. Available at: https://covid.lais.ufrn.br/#capacitados-em-covid19).

correcting inconsistencies using smart algorithms, and integrate surveillance and primary care actions.

The platform was adapted to local needs, such as the division of the state into health districts, so that primary care facilities are able to directly monitor notified patients living within their sphere of operation. With regard to surveillance, the platform generates local indicators and automates the consolidation of epidemiological bulletins. Figure 4 shows part of the Salus indicators, including heat maps in neighborhoods in Natal. In addition to being an important decision making tool, Salus promotes the integration of surveillance and primary care, a unique innovation in health given that these are traditionally separate areas in Brazil[44].

Vaccination of older persons

The vaccination of older people against the H1N1 virus was managed using a system developed by the UFRN and Natal City Council Health Department. Considering that this group is high-risk, it was necessary to plan the vaccination in a way that prevented gatherings, thus ensuring the protection of older persons against Covid-19. The solution consisted of mapping and registering older persons living in residential condominiums, permitting the implementation of a home vaccination campaign[45-49]: "The flu vaccination campaign in condominiums in Natal, the capital of Rio Grande do Norte, ended on Friday (24 March). According to the Natal City Council Health Department, a total of 3,439 older persons in 390 condominiums were vaccinated against flu. The initiative [...] was developed to avoid older people gathering in vaccination centers"[45].

However, the vaccination system records show that 607 condominiums and 7,344 older adults were registered. These data differ from those cited by the health department[49] because condominiums and individuals from other municipalities in the metropolitan region outside the Natal vaccination area were also registered.

Coronavirus Guidance RN

The Coronavirus Guidance RN system is a tool designed to promote self-care, multiplying individual and collective preventive actions in homes, neighborhoods and communities, and reducing the burden on health services. This tool provides two levels of service: self-care and tele-appointments[50]. Service users can also be monitored when recommended by health teams, using the Facepoint Quarantine or Salus monitoring module. A total of 7,000 appointments were provided through the Coronavirus Guidance RN system across the state. However, 15,000 patients were monitored using the Salus monitoring module because the module has been incorporated into health service work processes, resulting in an increased preference for and adherence to this technology.

Use and application of the ecosystem in the Covid-19 response in RN

The results of the use of the ecosystem related to preparedness, surveillance and the Covid-19 response, particularly in relation to government decision making, were already evident at the end of May. The repository of the CoronavirusRN platform (https://covid.lais.ufrn.br/#documentos) synthesizes some technical documents provided by the ecosystem and documents related to decisions taken by the state government organized by date of publication, topic, and the institutions and departments that participated in decision making.

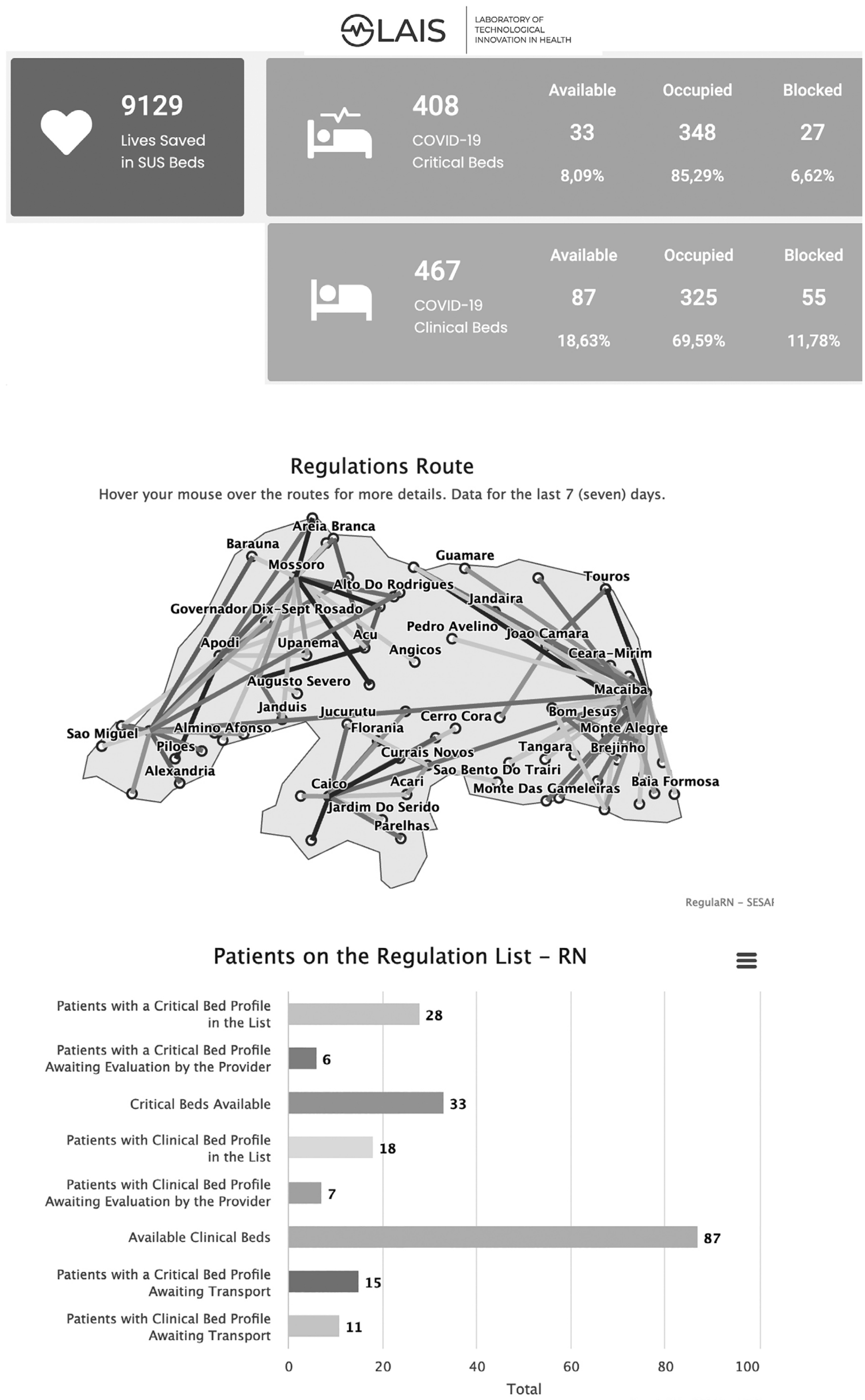

Figure 2. RegulaRN's Situation Room.

Source: Elaborated by authors.

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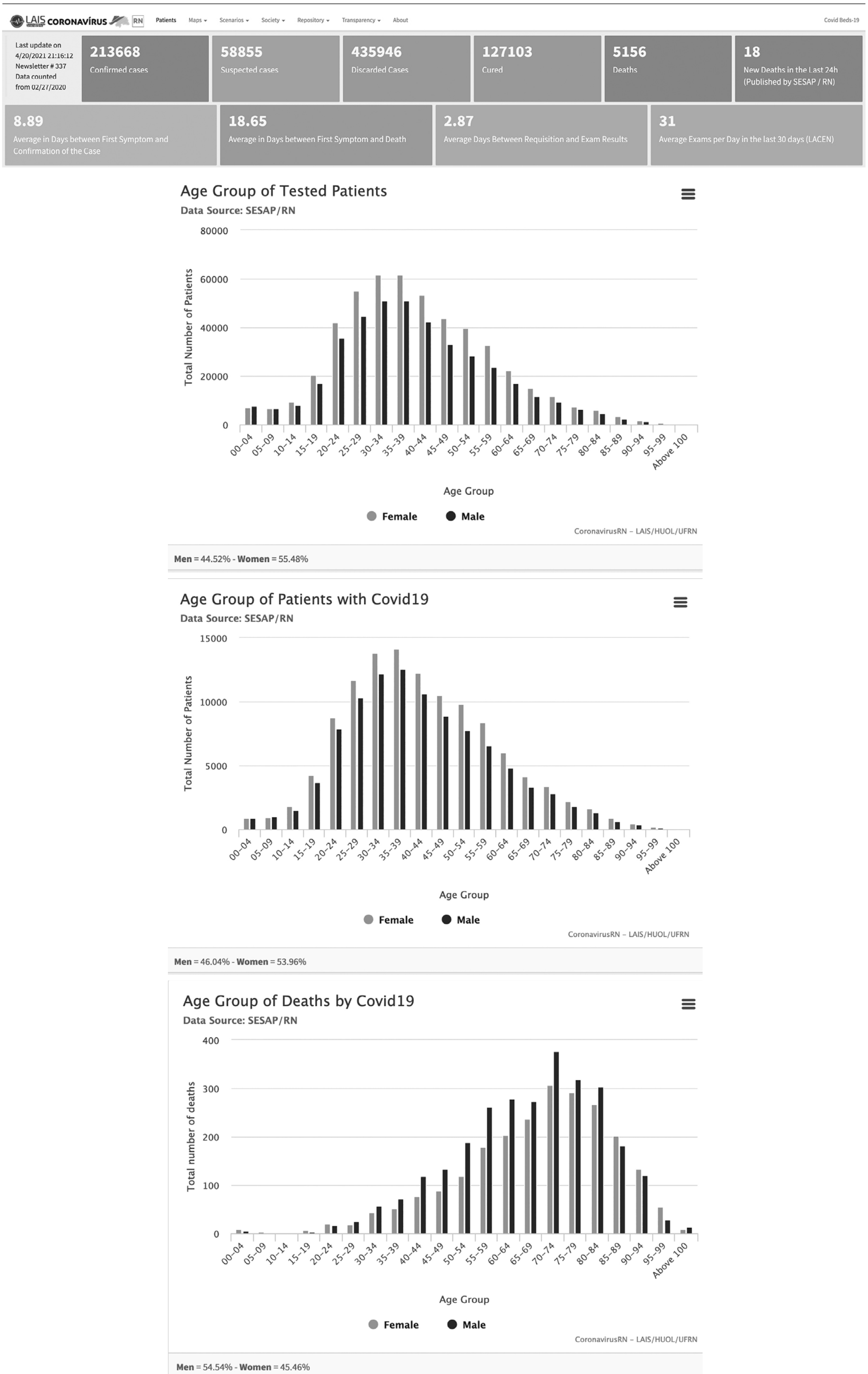

Figure 3. Data from the Situation Room shown on the CoronavirusRN platform.

Source: Elaborated by authors.

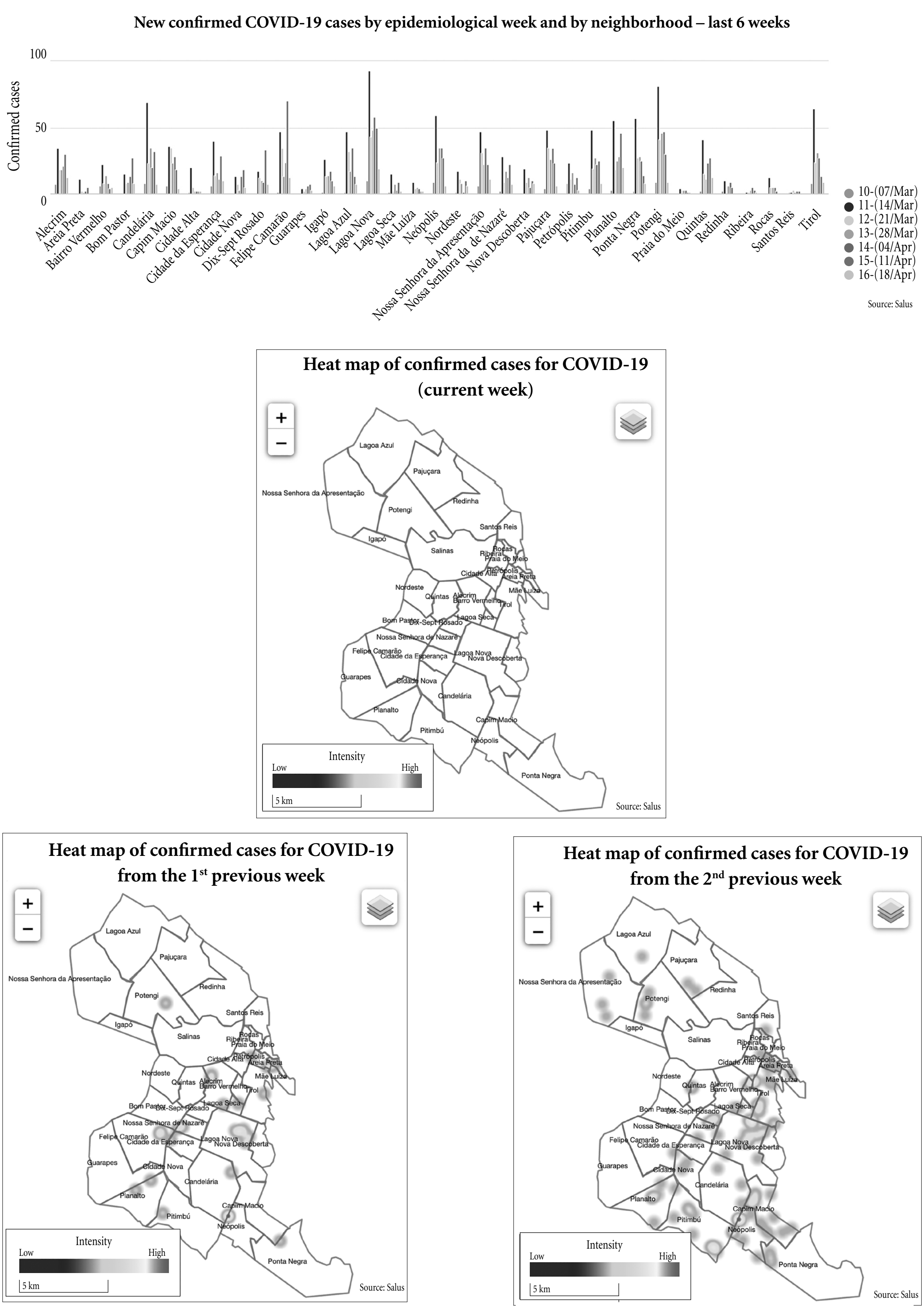

Figure 4. Indicators presented on the Salus platform.

Source: Elaborated by authors.

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Discussion

The study shows that the technology ecosystem for the Covid-19 response in Rio Grande guided local and state government decision making and recommendations made by other authorities such as the judiciary and public prosecutor's offices to other sectors involved in the response in a transparent manner. This is best shown by the use of technical reports produced by the ecosystem to inform recommendations made by public prosecutor's offices, state policy directives and government decrees governing the gradual resumption of economic and school activities.

The transdisciplinarity inherent in the ecosystem meant that its impact went beyond the technological dimension. The ecosystem served as a tool to articulate and bring together synergies for decision making in the field of management, health work processes, engagement of social actors and public participation, and technical cooperation. In addition, the use of this technology reinforces the importance of digital health interventions for advancing responses to public health emergencies, especially in relation to timely access to information and quality health services.

In the field of health information and communications, it is known that "against a backdrop of exponential growth of doubt, uncertainty and anxiety, combined with conflicting narratives that lead to misgovernment and the lack of central references, the problem of controlling epidemics and fake news is exacerbated"[51]. In this regard, the ecosystem promoted important initiatives to mitigate the harmful effects of disinformation, including the production of quality information and development of strategies to disseminate scientifically validated content using language that is accessible to opinion makers, particularly the general public. In other words, the ecosystem combined technological innovation and communication and information processes to control both the pandemic and infodemic at local level, with repercussions at the national and international level.

Health crises like the Covid-19 pandemic test health system resilience because they put a strain on services[52] (provision and distribution of key supplies and hospital beds) and the capacity for dialogue and negotiation between government entities, including the private sector. The studies and forecasts conducted at the beginning of the pandemic in Brazil were pessimistic for a state like RN, especially in relation to the capacity of the SUS. However, the use of the ecosystem highlights the potential role digital health technologies can play in decision making and strengthening the response to the pandemic in the state. Examples include the expansion of the number of beds for Covid-19 patients and growth in the fleet of medical vehicles. The ecosystem strengthened responsiveness and resilience to the strains placed on health services by the pandemic by mobilizing different resources and promoting institutional elasticity. These concepts are reinforced in studies undertaken by Barlach et al.[53], Massuda et al.[54], Nuzzo et al.[55], and Ammar et al.[56] about health system resilience.

In the field of innovation in health, the ecosystem enabled the government to develop analyses and make decisions based on an integrated view of surveillance and primary care, which are often treated separately in Brazil[57]. In addition, the ecosystem's global view of surveillance and care and emphasis on information technology helped integrate decision making with the participation of representatives from different areas. This possibility articulated dialogue between the actors involved, albeit not without conflict, and improved decision making in the response to the public health emergency.

Furthermore, the technologies developed and applied in the ecosystem formed a health care value chain consisting of products and processes for RN and all the institutions involved. In addition to the technologies, the ecosystem promoted interinstitutional cooperation in decision making, becoming a driver of equity, social justice and the democratization of access health services. This cooperation was therefore a major driver the state's pandemic response policy. This factor is of major relevance for future analyses of what is called the "post-pandemic legacy" in Brazil.

The coverage and intensity of use of health technologies by countries suggest that industrial capacity, wealth, social adaptability and capacity for political management are important assets that need to be mobilized in the face of multi-dimensional global shocks[2,58]. In the case of a PHEIC, it may be assumed that these assets influence to a greater or lesser extent the capacity of health systems to respond to the demands of the IHR (2005)[2], such as mobilizing resources to this end[3].

National, state and municipal governments and organizations that have the capacity to mobilize human, technological and biological resources around the same cause tend to be more effective in tackling diseases. In this respect, this study shows that technical solutions that help analyze scenarios have a double effect during adversity: 1) providing a prompt response to the problem; and 2) renewing the skills and competences that are needed for personal development; a factor that provides new momentum and motivation to cope with the everyday activities in health services, which have become that much harder during the crisis.

The pandemic has shown the world that the availability of digital health solutions may be inversely related to the real health needs of populations; perhaps that is why the virus has caused so much damage to global health. Even in rich countries, where the use of technologies is widespread, the virus has been contained "organically". This aspect is aggravated in poorer countries, which lack medicines and basic equipment. Therefore, "a combined global effort is needed to encourage the development and use of health technologies that can benefit the world's poorest people"[58].

Aligned with the concept of democratization of access to health services and the promotion of equity and social justice, the technology ecosystem for the response to the Covid-19 "enlightened" decision making in RN, ensuring that the government did not "fly blind" and permitting the rational expansion of care integrated with a health surveillance model and informed by the provision of transparent data and information to the entire population, thus facilitating public participation.

With regard to the democratization of access to health and production of new knowledge, the technology ecosystem provided a significant set of open data, ensuring greater transparency and serving as a valuable source of research for the scientific community[59-64].

Finally, considering that it "is the most human aspect of man"[16], technology should serve humanity, particularly in the face of such a vital present day issue: tackling pandemics and strengthening health systems to respond in a resilient, agile, ethical and transparent manner.

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Collaborations

RAM Valentim and LR Cortez conceived, supervised and managed the development of the research project, articulated and organized technical cooperation for project development and implementation, defined the project methodology, analyzed and interpreted the data, and contributed to the discussion. They also critically revised the manuscript, contributed to the entire article development process and approved the final version to be published. TS Lima defined the project methodology, analyzed and interpreted the data and contributed to the discussion. She also critically revised the manuscript, contributed to the entire article development process and approved the final version to be published. DMS Barros participated in the definition of the project methodology, analyzed and interpreted the data, contributed to the discussion, critically revised the manuscript, contributed to the entire article development process, and approved the final version to be published. RD Silva participated in project development, analyzed and interpreted the data, critically revised the manuscript, partially contributed to the article development process and approved the final version to be published. JC Paiva was responsible for study conception and management of the development of the research project, partially contributed to the article development process and approved the final version to be published. KD Coutinho conceived, supervised and partially managed the development of the research project, partially contributed to the article development process and approved the final version to be published. PSG Morais participated in project development, analyzed and interpreted the data, critically revised the manuscript, partially contributed to the article development process, and approved the final version to be published; the article is part of his doctoral research. JS Lacerda critically revised the manuscript, partially contributed to the article development process, and approved the final version to be published. FR André revised the manuscript, partially contributed to the article development process, and approved the final version to be published.

References

1. Epidemiology Working Group for NCIP Epidemic Response. The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) in China. *Zhonghua Liu Xing Bing Xue Za Zhi* 2020; 41(2): 145-151.
2. World Health Organization (WHO). *Recommendations on digital interventions for health system strengthening. Guideline*. Geneva: WHO; 2019.
3. World Health Organization (WHO). *International health regulations-2005*. Geneva: WHO; 2009.
4. Agência Nacional de Vigilância Sanitária (Anvisa). *Regulamento Sanitário Internacional RSI - 2005*. Brasília: Anvisa; 2009.
5. Brasil. Decreto nº 10.212, de 30 de janeiro de 2020. Promulga o texto revisado do Regulamento Sanitário Internacional, acordado na 58ª Assembleia Geral da Organização Mundial de Saúde, em 23 de maio de 2005. *Diário Oficial da União* 2020; 30 jan.
6. Buss PM, Alcázar S, Galvão LA. Pandemia pela Covid-19 e multilateralismo: reflexões a meio do caminho. *Estud Av* 2020, 34(99):45-64.
7. Lima NT, Buss PM, Paes-Sousa R. A pandemia de COVID-19: uma crise sanitária e humanitária. *Cad Saude Publica* 2020; 36(7):1-4.
8. Brasil. Ministério da Saúde (MS). *Política Nacional de Informação e Informática em Saúde (PNIIS)*. Brasília: MS; 2016.
9. Rio Grande do Norte. Decreto nº 29.541, de 20 de março de 2020. Define medidas restritivas temporárias adicionais para o enfrentamento da Emergência de Saúde Pública de Importância Internacional decorrente do novo coronavírus (COVID-19). *Diário Oficial do Estado* 2020; 20 mar.
10. Tripp D. Pesquisa-ação: uma introdução metodológica. *Educ Pesquisa* 2005; 31(3):443-466.
11. Rani SBASU. A detailed study of Software Development Life Cycle (SDLC) models. *Int J Eng Computer Sci* 2017; 6:7.
12. George MS, Richard LH. A systems engineering perspective on the human-centered design of health information systems. *J Biomed Inform* 2005; 38(1):61-74.
13. Sousa TL. *Uso do Scrum na Contratação de Fábrica de Software: Uma Pesquisa-Ação em um Órgão Público Federal Brasileiro* [monografia]. Brasília: Universidade de Brasília; 2014.
14. Nidagundi P, Novickis L. Introducing lean canvas model adaptation in the Scrum Software Testing. *Procedia Computer Science* 2017; 104:97-103.
15. Schwaber K. Scrum development process. In: *Business object design and implementation*. Londres: Springer; 1997. p. 117-134.
16. McLuhan M. *McLuhan por McLuhan*: *conferências e entrevistas*. Rio de Janeiro: Ediouro; 2005.
17. Goldenberg M. *A arte de pesquisar*: *como fazer pesquisa qualitativa em Ciências Sociais*. 8ª ed. Rio de Janeiro: Editora Record; 2004.
18. Yin RK. *Estudo de caso*: *planejamento e métodos*. Porto Alegre: Bookman; 2010.
19. Kingdon JW. *Agendas, alternatives, and public policies*. New York: HarperCollins College Publishers; 1995.
20. Laboratório de Inovação Tecnológica em Saúde (LAIS), Universidade Federal do Rio Grande do Norte (UFRN). *Plataforma Coronavírus RN. Versão 1.0* [programa de computador]. Natal: LAIS, UFRN; 2020 [acessado 2020 ago 01]. Disponível em: https://covid.lais.ufrn.br.
21. Rio Grande do Norte. Secretaria de Estado de Saúde Pública. *Plano de Contingência Estadual para Infecção Humana pelo novo Coronavírus* [Internet]. 2020 [acessado 2020 ago 08]. Disponível em: https://www.saude.gov.br/images/pdf/2020/fevereiro/13/PLANO-DE-CONTINGENCIA-novo-coronavirus-RIO-GRANDE-DO-NORTE-EM-REVIS--O.pdf.
22. Brasil. Lei nº 13.979, de 06 de fevereiro de 2020. Dispõe sobre as medidas para enfrentamento da emergência de saúde pública de importância internacional decorrente do coronavírus responsável pelo surto de 2019. Presidência da República, Secretaria-Geral, Subchefia para Assuntos Jurídicos. *Diário Oficial da União* 2020; 06 fev.
23. Brasil. Portaria nº 356, de 11 de março de 2020. Dispõe sobre a regulamentação e operacionalização do disposto na Lei nº 13.979, de 6 de fevereiro de 2020, que estabelece as medidas para enfrentamento da emergência de saúde pública de importância internacional decorrente do coronavírus (COVID-19). *Diário Oficial da União* 2020; 11 mar.
24. Rio Grande do Norte. Secretaria de Estado de Saúde Pública. Governo do Rio Grande do Norte. *Recomendação nº 04/2020* [Internet]. 2020 [acessado 2020 ago 01]. Disponível em: https://covid.lais.ufrn.br/publicacoes/recomendacao_comite_n04_2020.pdf.
25. World Health Organization (WHO). *Marco para um Centro de Operações de Emergências. Framework de 2015*. Genebra: WHO; 2017.
26. World Health Organization (WHO). *COVID-19 Strategy Update*. Genebra: WHO; 2020.
27. Organização Pan-Americana de Saúde (OPAS). Departamento de Evidência e Inteligência para Ação em Saúde. *Entenda a Infodemia e a desinformação na luta contra a COVID-19* [Internet]. [acessado 2020 ago 10]. Disponível em: https://iris.paho.org/bitstream/handle/10665.2/52054/Factsheet-Infodemic_por.pdf?sequence=14.
28. Gianicolo E, Riccetti N, Blettner M, Karch A. Epidemiological Measures in the Context of the COVID-19 Pandemic. *Dtsch Arztebl Int* 2020; 117(19):336-342.
29. Raju V, Mohd J, Ibrahim HK, Abid H. Artificial Intelligence (AI) applications for COVID-19 pandemic. *Diabetes Metab Syndr* 2020; 14(4):337-339.
30. Hart OE, Halden RU. Computational analysis of SARS-CoV-2/COVID-19 surveillance by wastewater-based epidemiology locally and globally: Feasibility, economy, opportunities and challenges. *Sci Total Environ* 2020; 730:138875.
31. Foddai A, Lindberg A, Lubroth J, Ellis-Iversen J. Surveillance to improve evidence for community control decisions during the COVID-19 pandemic. *One Health* 2020; 9:100130.

32. Yuan J, Li M, Lv G, Lu ZK. Monitoring transmissibility and mortality of COVID-19 in Europe. *Int J Infect Dis* 2020; 95:311-315.
33. Bokolo AJ. Exploring the adoption of telemedicine and virtual software for care of outpatients during and after COVID-19 pandemic. *Ir J Med Sci* 2020; 190(1):1-10.
34. Gozes O, Frid-Adar M, Greenspan H, Browning PD, Zhang H, Ji W, Bernheim A, Siegel E. Rapid AI development cycle for the coronavirus (covid-19) pandemic: initial results for automated detection & patient monitoring using deep learning CT image analysis. *arXiv* 2020 [preprint]. Disponível em: https://ui.adsabs.harvard.edu/abs/2020arXiv200305037G.
35. Kumar A, Gupta PK, Srivastava A. A review of modern technologies for tackling COVID-19 pandemic. *Diabetes Metab Syndr* 2020; 14(4):569-573.
36. Kittel B, Kritzinger S, Boomgaarden H, Prainsack B, Eberl JM, Kalleitner F, Schlogl L. The Austrian Corona Panel Project: monitoring individual and societal dynamics amidst the COVID-19 crisis. *Eur Polit Sci* 2020; 1-27.
37. Javaid M, Haleem A, Vaishya R, Bahl S, Suman R, Vaish A. Industry 4.0 technologies and their applications in fighting COVID-19 pandemic. *Diabetes Metab Syndr* 2020; 14(4):419-422.
38. Wiener N. *Cibernética e sociedade*: *O uso humano de seres humanos*. São Paulo: Cultrix; 1968.
39. Agora RN. *Fátima cancela campanha publicitária sobre coronavírus; verba era de R$ 3 milhões* [Internet]. 2020 [acessado 2020 abr 4]. Disponível em: https://agorarn.com.br/politica/fatima-cancela-campanha-publicitaria-sobre-coronavirus-verba-era-de-r-3-milhoes/.
40. Laboratório de Inovação Tecnológica em Saúde (LAIS), Universidade Federal do Rio Grande do Norte (UFRN). *Plataforma RegulaRN. Sala de Situação. Versão 1.0* [programa de computador]. Natal: LAIS, UFRN; 2020 [acessado 2020 ago 01]. Disponível em: https://regulacao.lais.ufrn.br/sala-situacao/sala_publica/.
41. Brasil. Ministério da Saúde (MS). *Política Nacional de Informação e Informática em Saúde* [Internet]. Brasília: MS; 2016 [acessado 2020 ago 08]. Disponível em: https://www.conasems.org.br/wp-content/uploads/2019/02/politica_nacional_infor_informatica_ saude _2016.pdf.
42. Governo Federal. Coronavírus Brasil. *Painel Coronavírus* [Internet]. [acessado 2020 ago 01]. Disponível em: https://covid.saude.gov.br/.
43. Transparência COVID-19 2.0. *Dados abertos podem salvar vidas* [Internet]. [acessado 2020 ago 01]. Disponível em: https://transparenciacovid19.ok.org.br/.
44. Laboratório de Inovação Tecnológica em Saúde (LAIS). Universidade Federal do Rio Grande do Norte (UFRN). Secretaria de Saúde do Município do Natal (SMS/Natal-RN). *Plataforma Salus - Dados abertos do Salus. Versão 1.0* [programa de computador]. Natal: UFRN, LAIS, SMS/Natal-RN; 2020 [acessado 2020 ago 01]. Disponível em: https://salus.lais.ufrn.br/indicadores/painel_publico.
45. Globo G1 RN. *Idosos poderão ser vacinados contra a gripe dentro de condomínios em Natal: Cerca de 71 mil idosos já foram vacinados na capital potiguar* [Internet]. Natal; 2020 [acessado 2020 mar 27]. Disponível em: https://g1.globo.com/rn/rio-grande-do-norte/noticia/2020/03/27/idosos-poderao-ser-vacinados- contra-a-gripe-dentro-de-condominios-em-natal. ghtml.
46. Agora RN. *Idosos de Natal vão poder receber a vacina da gripe nos condomínios onde residem: A partir deste sábado (28) até 05 de abril, o síndico pode acessar o sistema e preencher o formulário* [Internet]. Natal; 2020 [acessado 2020 mar 27]. Disponível em: https://agorarn.com.br/geral/idosos-de-natal-vao-poder-receber-a-vacina-da-gripe-nos-condominios-onde-residem/.
47. Laboratório de Inovação Tecnológica em Saúde (LAIS). *Projeto da UFRN vai ajudar na vacinação de idosos em condomínios de Natal durante a pandemia* [Internet]. Natal; 2020 [acessado 2020 mar 30]. Disponível em: https://lais.huol.ufrn.br/projeto-da-ufrn-vai-ajudar-vacinacao-de-idosos-em-condominios-de-natal-durante-a-pandemia.
48. Tribuna do Norte. *UFRN cadastra condomínios que terão serviços de vacinação a idosos* [Internet]. Natal; 2020 [acessado 2020 mar 24]. Disponível em: http://www.tribunadonorte.com.br/noticia/ufrn-cadastra-condoma-nios-que-tera-o-servia-o-de-vacinaa-a-o-a-idosos/475639.
49. Tropical. *Mais de 3 mil idosos são vacinados contra gripe em condomínios de Natal* [Internet]. Natal; 2020 [acessado 2020 abr 24]. Disponível em: https://www.portaldatropical.com.br/news/mais-de-3-mil-idosos-sao-vacinados-contra-gripe-em-condominios-de-natal.
50. Laboratório de Inovação Tecnológica em Saúde (LAIS). *Orienta Corona RN possibilita fácil acesso à informação sobre a Covid-19* [Internet]. Natal; 2020 [acessado 2020 abr 24]. Disponível em: https://lais.huol.ufrn.br/orienta-corona-rn-possibilita-facil-acesso-a-informacao-sobre-a-covid-19.
51. Vasconcellos-Silva PR, Castiel LD. COVID-19, às fake news e o sono da razão comunicativa gerando monstros: a narrativa dos riscos e os riscos das narrativas. *Cad Saude Publica* 2020; 36(7):e00101920.
52. Rache B, Rocha R, Nunes L, Spinola P, Malik AM, Massuda A. Necessidades de infraestrutura do SUS em preparo à COVID-19: leitos de UTI, respiradores e ocupação hospitalar. *IEPS* 2020; 3:1-5. [Nota Técnica].
53. Barlach L, Limongi-França AC, Malvezzi S. O conceito de resiliência aplicado ao trabalho nas organizações. *Interam J Psychol* 2018; 42(1):101-112.
54. Massuda A, Hone T, Leles FAG, de Castro MC, Atun R. The Brazilian health system at crossroads: progress, crisis and resilience. *BMJ Global Health* 2018; 3:e000829.
55. Nuzzo JB, Meyer D, Snyder M, Ravi SJ, Lapascu A, Souleles J, Bishai, D. What makes health systems resilient against infectious disease outbreaks and natural hazards? Results from a scoping review. *BMC Public Health* 2019; 19(1):1310.

56. Ammar W, Kdouh O, Hammoud R, Hamadeh R, Harb H, Ammar Z, Zalloua PA. Health system resilience: Lebanon and the Syrian refugee crisis. *J Global Health* 2016; 6:2.
57. Howitt P, Darzi A, Yang GZ, Ashrafian H, Atun R, Barlow J, Cooke GS. Technologies for global health. *Lancet* 2012; 380(9840):507-535.
58. Coelho Neto GC. *Integração entre Sistemas de Informação em Saúde: o caso do e-SUS Atenção Básica* [dissertação]. São Paulo: Universidade Federal de São Paulo; 2019.
59. Valentim RAM, Coutinho KD, Morais AHF, Lima TS, Guimarães MCS, Silva Neto JHV. Conectividade e digitalização no contexto da saúde global: um olhar para o futuro inspirado na saúde 4.0. In: Departamento do Complexo Industrial e Inovação em Saúde, Secretaria de Ciência, Tecnologia e Insumos Estratégicos, Ministério da Saúde (MS), organizador. *Avanços, desafios e oportunidades no Complexo Industrial da Saúde em serviços tecnológicos*. Brasília: MS; 2018. p. 254-273.
60. Plataforma Coronavírus RN. *Dados abertos epidemiológicos e laboratoriais* [Internet]. Natal: UFRN; 2020 [acessado 2020 out 14]. Disponível em: https://covid.lais.ufrn.br/#dados.
61. Plataforma Coronavírus RN. *Documentos do repositório do LAIS/UFRN durante a covid-19* [Internet]. Natal: UFRN; 2020 [acessado 2020 out 14]. Disponível em: https://covid.lais.ufrn.br/#documentos
62. Plataforma Coronavírus RN. *Dados abertos capacitados em covid-19* [Internet]. Natal: UFRN; 2020 [acessado 2020 out 14]. Disponível em: https://covid.lais.ufrn.br/#capacitados-em-covid19
63. Plataforma RegulaRN. *Dados abertos regulação de leitos covid-19 no RN* [Internet]. Natal: UFRN; 2020 [acessado 2020 out 14]. Disponível em: https://regulacao.lais.ufrn.br/sala-situacao/sala_publica/.
64. Portal covid-19 RN. *Documentos do Comitê Científico do RN produzidos durante a covid-19* [Internet]. 2020 [acessado 2020 out 14]. Disponível em: https://portalcovid19.saude.rn.gov.br/medidas/comite-cientifico-do-rio-grande-do-norte/.

Article submitted 13/09/2020
Approved 15/01/2021
Final version submitted 17/01/2021