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# Proposal for a digital health platform: Supporting a regional innovation ecosystem from the quadruple helix

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## Abstract

This article proposed a digital health platform for developing and supporting a regional health ecosystem from the perspective of the quadruple helix. This objective was achieved based on studies on innovation ecosystems and the quadruple helix model. The research uses design science research to create two artifacts that emphasize the practical applicability of the study. A field diary was used to collect data further to deepen the understanding of the regional ecosystem; secondary analysis of online documents and interviews were also used. The study developed two artifacts, one of which was a digital health platform, and, as a second artifact, the need for collaborative and constant action between university-business-government-society was also perceived. The creation of a digital health platform based on the quadruple helix model indicates the support and development of mechanisms for identifying parts of a regional innovation ecosystem, where the interaction between the different actors generates synergies for developing practical solutions focused on users' needs.

**Keywords:** Digital health platform, Innovation ecosystem, Performance, Quadruple helix, Regional health ecosystem.

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## 1. Introduction

The analysis of innovation and health is an area of academic and organizational interest, studied from various perspectives due to its impact on societal well-being and health expenditures. This dynamic reflects the relationship between specific industrial sectors and services, creating a so-called health economic-industrial complexGadelha [1] and Brasil [2] that informs the decision-making process of public policies aimed at productive and innovative enhancement, considering the territorial characteristics and specificities within the Brazilian context.

By adopting this perspective, we can identify an approach to the theme of innovation ecosystems. An innovation ecosystem (IE) represents a network of interconnected organizations linked to a focal company or technological platform comprising producers and users capable of creating innovative value [3]. In a recent study, Granstrand and Holgersson [4] identified 21 distinct definitions from an analysis of 120 publications. The study revealed that the three most common components in these definitions were actors, collaboration/complementation, and activities.

Therefore, IE is characterized by the interaction of joint efforts, which can be facilitated by a platform or a set of shared standards acting as a co-alignment system [5-9]. In pursuing value creation, this community or-ganizes itself collaboratively and dynamically, establishing relationships of trust and co-creation while sharing technologies to promote innovation [10].

One can refer to helix models to grasp the importance of interactions among the components of an ecosystem that can lead to innovations. Despite the significant role that the triple helix (TH) has played since its introduction Etzkowitz and Leydesdorff [11] which posits that the university contributes to knowledge development, the company provides an environment that promotes the application of this knowledge, while the government is charged with developing public policies that foster an innovative culture; however, the model is viewed as vulnerable. Criticisms of the model include failures in cooperation among actors and an inability to distribute power equitably Saad and Zawdie [12] conflicting interests and objectives among actors Ruuska and Teigland [13] sensitivity of the model to varying contexts Cai [14] high costs associated with technological innovation development [15]. Furthermore, one of the TH model's primary criticisms is the absence of socially based innovation [16-18].

Thus, the Quadruple Helix (QH) emerges, where civil society plays a significant role in its interactions with other TH actors [19-21]. In this inter-action process, knowledge expands and becomes relevant to the innovative process Cavallini, et al. [22] as academia, business, government, and society connect, promoting economic growth generated by pooling and concentrating productive resources.

Recognizing the need for coordination to develop the ecosystem, the SICT/RS initiated the Inova RS Program, aiming to position the State on the global innovation map. To implement the program, SICT/RS segmented the State of Rio Grande do Sul into eight regions to advance the regional IE by enhancing local potential, with health considered a key strategic area. Consequently, the research problem this study seeks to investigate is: How can the development of the regional health ecosystem, from the perspective of the quadruple helix of Rio Grande do Sul, be promoted?

The research aims to propose a digital health platform for developing and maintaining a regional health ecosystem from the perspective of the quadruple helix. To understand how the ecosystem fosters a strategy focused on harnessing regional potentials, the research begins with the problem of identifying the actors, resources, institutions, and regional health initiatives in Rio Grande do Sul (RS), Brazil. The work involved the participation of seven experts from the Inova RS Project. It was conducted through Design Science Research (DSR), which seeks to empirically address problems based on academic theories [23].

The research led to the presentation of two proposals for artifacts: (a) a digital platform and (b) a method for mapping the regional health ecosystem in collaboration with companies, universities, and government. Thus, the development process of a digital health platform involving interactions among companies, government, universities, and civil society is presented as a condition that can yield benefits for all, along with positive collateral effects on social, economic, environmental, and government policy initiatives.

Furthermore, understanding and developing IEs from the perspective of the QH can guide specific strategies that facilitate interactions and partnerships aimed at combining efforts to achieve economic development [6, 7]. And promote economic recovery during times of crisis or low market dynamism.

## 2. Background

### *2.1. Innovation Ecosystem*

The IE lacks a clear definition and solid theoretical foundation [24, 25]. According to Torlig, et al. [26] the ecosystem approach is conceptually broad and com-plex, as it is examined from various perspectives, including business Iansiti and Levien [27] services Lusch and Nambisan [28] entrepreneurship Autio and Thomas [29] and networks or open innovation [30].

Within the variety of concepts, two general views guide the under-standing of the IE: (a) ecosystem as an affiliation, resulting from a community of actors that connect through their networks and platform affiliations to capture value; (b) ecosystem as a structure, which emphasizes value creation as a defining factor of actors and their interactions [5, 6]. Concerning this distinction, Ritala, et al. [31] consider value creation as the collective action of actors through collaborative activities and processes designed to create value for customers and stakeholders, while value capture refers to the individual pursuits of organizations seeking to achieve their profitability goals.

When considering the ecosystem as a structure, four elements define the model regarding the value created through interdependent collaboration. First, there is the identification of activities necessary to implement the value proposition, the presence of actors performing these activities, the roles that outline the system's activity flows, and finally, the connections that delineate the types of exchanges established between the actors [5].

Knowledge sharing among focal actors, components, and complements can influence the strength of relationships between actors, the development of the ecosystem, and its sustainability [32-34]. The essential ecosystem trait emerges through coordinating organizations with considerable autonomy interacting with one another [8]. This is facilitated by a modular architecture that enables the coordination of independent organizations throughout the ecosystem [35].

To better understand complementarities, Jacobides, et al. [8] identified two types that characterize relationships between ecosystem actors. The first type is unique complementarity, where one offering depends on the preexistence of another. The second type is super modular or Edgeworth complementarity, which states that the greater the number of complements, the more value is generated for another complement [8, 35, 36].

From this perspective, it is possible to verify that, viewing unique complementarity, the ecosystem's survival may be jeopardized since the absence of an actor can lead to the loss of demand. Conversely, super modularity can enhance the attractiveness from the ecosystem's actors, as including more actors expands the collective value proposition [8, 36]. Additionally, the modularity of tasks and the engagement of multiple actors contribute to knowledge distribution, decomposability, the ease of regrouping tasks, and the intrinsic motivation of the actors[35].

Regarding the coordination of these complements, Jacobides, et al. [8] argue that actors' participation in the ecosystem does not require a formal alliance but takes place through adherence to certain specifications. In this context, a defining characteristic of the ecosystem is the presence of standardized rules for each type of actor, without the binding nature of employment contracts or hierarchical distribution, nor connection through a formal authority structure [35-38].

The ecosystem forms through the multilateral alignment of partners who must interact to realize the core value proposition. This alignment structure is established through mutual agreements among participants regarding positions and flows, which employ the ecosystem strategy to achieve a shared goal [5].

Supporting actors are the components that provide the foundation for ecosystems and are generally leveraged by a core institution that gives vision, financial resources, technological assets, and coordination mechanisms, including common standards [38]. Even if this core institution does not have formal authority or employment contract, it may have informal influence or authority, based on experience, reputation, status, privileges, or control over resources or technologies [35, 39].

The core institution is responsible for recognizing and strategically organizing actors to direct collective action while considering the necessary flexibility for this process to function. Consequently, assigning these roles resembles an ecology where some processes are deliberate and others emerge organically, respecting the dynamics and maintaining the foundational initiative [35, 40].

### *2.2. Quadruple Helix*

In the mid-1990s Etzkowitz and Zhou [41]coined the term “triple helix” (TH) to describe the innovation model based on the relationship between government, universities, and industry. Each participant engages in bilateral and trilateral relationships, occasionally taking on each other's roles. When bilateral interactions fail to satisfy stakeholders' needs, trilateral inter-actions can create opportunities for developing new secondary institutions known as hybrids, such as incubators and technology parks [41, 42].

The cooperation triad has evolved and is shaped by the global landscape and regional economic development conditions [43-45]. This evolution has also increased government pressure on universities to actively contribute to the socioeconomic advancement of their regions [46]. However, this process involves significant costs related to growth and innovation cycle times [15]. Other authors, includingAsheim and Coenen [16]; Edvardsson, et al. [17] and McAdam, et al. [18] argue that this model does not produce the expected outcomes in terms of innovation, gross domestic product (GDP), and job creation due to inadequate user involvement (socially based innovation) in the process.

Thus, the QH underscores innovative collaboration and signifies a shift toward a systemic, open, and user-centered innovation policy. Linear innovation, previously driven by experts in development, production, and ser-vices, now presents itself in various forms and levels of co-production within the context of the QH, relying on interactions with consumers, customers, and citizens. Consequently, scientific knowledge is increasingly assessed based on its inclusivity and social resilience [19, 20].

From this perspective, QH is founded on four pillars: academia, business, government, and society, thereby promoting economic growth through the gathering and concentration of talented and productive individuals. With the backing of technological infrastructures, academia and business stakeholders contribute to an integrated IE, facilitating the emergence of various forms of innovation. Meanwhile, the government sector provides financial support and regulation for the execution of innovative activities, which can subsequently fulfill civil society's demand for innovative products and services [47].

While the TH innovation model emphasizes high-tech innovative pro-duction and is particularly suited for high-tech companies MacGregor, et al. [48] according to Arnkil, et al. [20] the QH model enables the production of a wider variety of innovations, including the application of user knowledge to existing technologies. Small and medium-sized enterprises (SMEs) can also take advantage of the QH model through an increase in user-oriented innovations, which opens up opportunities for innovation that contribute to the development of other SMEs, thereby fueling a virtuous cycle of knowledge, entrepreneurship, and innovation.

The significance of stakeholders in the QH model for socioeconomic development and recommend that local policymakers foster and support this collaboration to drive innovation [49]. This perspective is reinforced by Kon [50] and Matos, et al. [51] who assert that the collaborative efforts of QH actors are essential for promoting innovation and can help address challenges arising from economic crises, as well as contribute to job creation and local-regional socioeconomic development.

## 3. Method

This research is guided by the Design Science Research (DSR) methodLacerda, et al. [52] and Dresch, et al. [53]and follows the guidelines of the DSR model by Vaishnavi and Kuechler [23] in which the construction of the research artifact

occurs in five stages: 1) Problem Definition; 2) Suggestion; 3) Development; 4) Evaluation; and 5) Conclusion. The presentation of this conclusion stage adheres to the definitions of March and Smith [54] for characterizing the artifact, which in this study yields two results (artifacts): the method and instantiation. Table 1 illustrates the research stages.

**Table 1.**
Research steps.

| **Design Science Research Steps** | | | |
|---|---|---|---|
| **DSR Process Step** | **Activity Developed** | | **Date** |
| 1. Problem Identification: lack of identification of actors, resources, institutions and regional health initiatives in the state of Rio Grande do Sul, Brazil. | > Identification of strategic ecosystem actors.<br>> Unstructured interviews with ecosystem actors and field diary.<br>> Identification of ecosystem gaps through active methodologies.<br>> Focus Group with representatives of key sectors of the health ecosystem.<br>> Meetings with the government actor responsible for designing the proposal to present the ecosystem gaps.<br>> Literature review on IE and the QH. | | Between 05/20/2020 and 05/27/2021 |
| 2. Suggestion: create a digital health platform for the development and support of a regional health ecosystem. | > Unstructured interview with experts and field diary.<br>> Focus group with ecosystem actors using a semi-structured instrument to capture component elements for a mapping platform. | | Between 01/26/2021 and 05/27/2021 |
| 3. Development: feasibility study of the platform creation structure | > Hiring a company to create the platform.<br>> Meetings to align the platform's needs.<br>> Interviews with ecosystem stakeholders by the platform company.<br>> Benchmarking of IE structures. | | Between 03/20/2022 and 06/15/2022 |
| 4. Assessment: expert interviews | > Presentation of the digital platform prototype to the experts.<br>> Semi-structured interview with the experts to evaluate the digital platform.<br>> Content analysis of the interview transcripts. | | Between 08/18/2022 and 09/26/2022 |
| 5. Conclusion: results presented in the form of an academic article | > Presentation of research results through the artifact, which is a digital platform developed based on IE and QH (Instanciation). | > Presentation of the results of the interview with experts and the development artifact of the health IE from the perspective of the QH (Method). | 04/26/2023 |

SICT/RS initiated the development of the Inova RS Program to place Rio Grande do Sul (RS) on the global innovation map. The objective was to foster strategic partnerships among organized civil society, business, academic, and government sectors. Consequently, the state was divided into eight regions: Metropolitan and North Coast; South; Western Border and Campanha; Central; Northwest and Missões; Production and North; Serra and Hortênsias; and Vales, as illustrated in Figure 1.

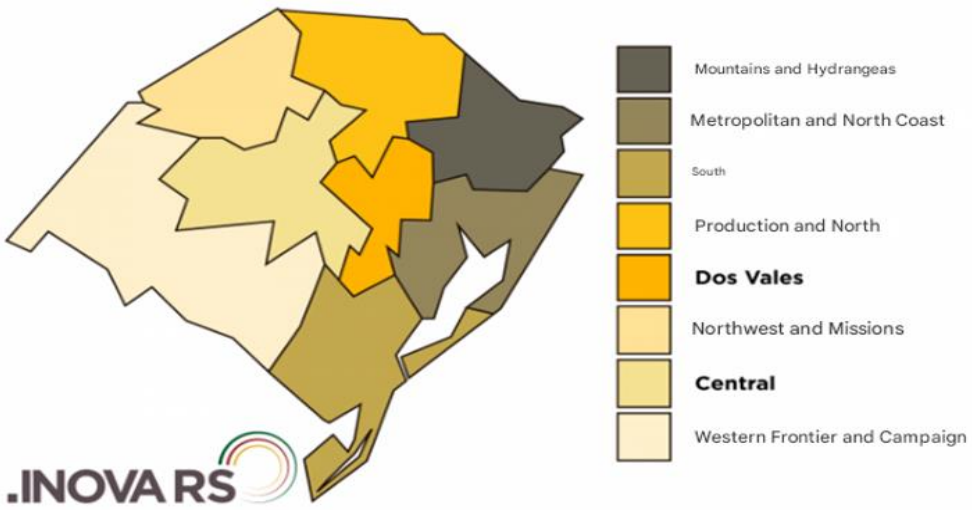


**Figure 1.**
Map of Inova RS regions.
**Source:** SICT/RS (2022).

The Metropolitan and North Coast macroregion (RMLN) has articulated its vision for the future. It aspires to become a global leader in innovation by implementing a smart specialization strategy in health, information and communication

technologies (ICT), education, and the creative economy. This vision fosters entrepreneurship to develop and attract talent and utilizes research capacity and digital technologies to advance economic and social development.

In the first stage, where the research problem in the RMLN was identified, an initial approach involving unstructured interviews was carried out with over 30 experts from various organizations within the health ecosystem and participants in the quadruple helix. To facilitate this, invitations were sent to members for working group meetings with agendas designed to develop the proposal. During these meetings, records were kept as a field diary to compile initial information for the research [55]. This initial engagement with the experts revealed concerns about the inadequate identification of actors, resources, institutions, and regional health initiatives in Rio Grande do Sul, Brazil. The first guiding principle centered on recognizing the existing vocation in the region by mapping the health sector to highlight the potential within the RMLN. The following data was collected for the field diary: i) Number of hospitals: The region has a total of 54 hospitals; ii) Health establishments: This indicator included any organization providing health services, such as clinics and laboratories, totaling 4,045 institutions; iii) Health professionals: This measure assessed the number of professionals working in the region across various health fields, finding a total of 42,496 professional records for those operating in the area; iv) Doctor index per thousand inhabitants: Based on the average number of doctors for every thousand inhabitants in the region, there are 61.5 doctors per 1,000 inhabitants; v) Public health investment: The region invests approximately R$ 1.32 billion annually in this sector [56].

Thus, based on the collected indicators and utilizing the smart specialization strategy, it was possible to identify that RMLN focuses on the health sector. As part of the problem identification process, the theoretical framework was also consulted, emphasizing IEs and the QH [5, 7-9, 19-21].

The second stage refers to when a potential solution to the problem is proposed, such as when the project “RS: Digital Health” was introduced. During this stage, in-depth unstructured interviews were conducted using the Microsoft Teams application, and meetings were held to update the field diary for a digital health platform focused on developing and maintaining a regional health ecosystem. Experts compiled observations and information gathered during these efforts. Additionally, secondary data on events, seminars, congresses, and hackathons in the state's health sector were identified and collected. This secondary data primarily includes a survey of courses, publications of best practices, guidelines on population health data, and products and services provided to the community, among others, related to the state of Rio Grande do Sul.

The third stage, called development, encompassed the steps for conducting the operational feasibility study to establish the digital health platform. This feasibility process was carried out by seven members of the QH who supported the proposal and committed to participating Yin [55] (Table 2). These activities aim to improve understanding of the health environment and specialists' roles. This perspective is examined in studies on IE and the interactions of the QH [9, 30].

In the fourth stage of the research, which focuses on evaluating the digital platform and development model based on health ecosystems and the quadruple helix, the process of conducting semi-structured interviews with experts began to present and assess the results. The interview script included semi-structured questions derived from the theoretical framework and previous stages of information collection. Recordings were made using Microsoft Teams in August 2022 during this interview phase. Seven experts participated in identifying problems, making suggestions, developing solutions, and evaluating outcomes. Table 2 outlines the seven experts' positions and their experience levels.

**Table 2.**
Description of experts in the regional health ecosystem.

| Expert/Representative | Occupation | Years of Experience |
|---|---|---|
| Specialist 1 / Organization | Product Development Manager | 42 years |
| Specialist 2 / Organization | Technical Modeler - Product Development Supervisor | 32 years |
| Expert 3 / Society | Administration Manager (Human Resources and Costs) | 30 years |
| Specialist 4 / University | Professor | 45 years |
| Expert 5 / Government | Technological Innovation Manager | 34 years |
| Specialist 6 / Organization | Senior Designer | 35 years |
| Expert 7 / Organization | Doctor | 55 years |

The experts were chosen based on their healthcare experience and involvement with one of the propellers. The questions posed to the experts were as follows: “1. Are there other opportunities on the platform?”; “2. Do you see a need for a change in communication?”; “3. Does the platform meet the needs of customers and society?”; “4. What do you think of this RS: Digital Health project?”; “5. How do you perceive the role of the actors and resources available on the platform?”; “6. What are your thoughts on the ongoing interaction between universities and companies?”; “7. What is your opinion on the innovation behind developing this project’s platform?”; “8. What criticisms can be made of this project?”

Still, in stage 4 research and evaluation, the content analysis process continued. This content analysis stage adhered to Bardin's method Bardin [57] encompassing the sequence from data collection and organization (keeping the implicit guiding assumption of developing and sustaining a regional health ecosystem) to coding and presenting the inferential interpretation. The data gathered through fieldwork Yin [55] participation in events, secondary data, and semi-structured interviews were analyzed using the following categories: 1. Elements of the IE (focal actor, components, complements, and customers); 2—academia-business-government-society interactions.

The fifth and final stage, the conclusion, refers to presenting the results of this research. This section aims to provide the reader with an overview of the strategic actions undertaken in the RS: Digital Health project. Additionally, two

proposals for inseparable artifacts are introduced, as the method developed for this research led to and validated a product for a digital health platform. Consequently, they are presented together as the result of this study.

## 4. Results and Discussion

### *4.1. Environmental Actors*

Based on the guiding elements of the QH Carayannis and Campbell [19] and Arnkil, et al. [20] we sought, through secondary data, to map the leading actors in the market. In other words, users, institutions, or programs (representatives of society) can develop innovations, propose innovations, and connect with the actors in the quadruple relationship of academia-industry-government-society. Thus, the actors Fundmed, iCoLab, Método Dutra, Parque Zenit, Sindihospa, and Toth Lifecare are involved. Additionally, synergies were identified with programs and initiatives such as Minha Saúde Digital, Pacto Alegre, Hub Saúde - Gabinete Inovação de Porto Alegre (RS), and an Ecosystem Mapping Project conducted by the Micro and Small Business Support Service (SEBRAE) of RS. Regarding university involvement, Feevale University (FEEVALE), Pontifical Catholic University of Rio Grande do Sul (PUCRS), Federal University of Rio Grande do Sul (UFRGS), and The Federal University of Health Sciences of Porto Alegre (UFCSPA) stand out for their articulation. Lastly, invitations were extended to societal actors characterized as health system users (Public or private).

From the perspective of IE, we can observe the dynamics where various organizations are systematically engaged in a process of cooperation and mutual learning among local institutions, universities, research institutes, technology transfer offices, and funding sources Cooke, et al. [58] as well as science and technology parks, hubs, smart cities, incubators, and accelerators, among others [59].

SEBRAE plays a crucial role as a training partner, and spin-off companies collaborating with laboratories and the City Hall in the health sector are identified as key partners. Interviewee 1 notes: "*Any partner interested in innovating and collaborating with our researchers will always be significant.*" Fundmed is vital, as it can bring together various stakeholders and is recognized as essential for innovative development (interviewee 7).

Conversely, researchers play a crucial role in driving innovations at the university (interviewee 4 and interviewee 5). Supporting his report, interviewee 4 points out that when researchers pay closer attention to market demands, they can cultivate more successful partnerships. Therefore, he believes researchers are the most vital partners in innovation activities.

Research Support Foundations and Development Agencies, such as the Rio Grande do Sul Research Support Foundation (FAPERGS), the National Council for Scientific and Technological Development (CNPq), and Studies and Projects Funding (FINEP), are identified as essential partners by Interviewee 1. From Interviewee 6's response, it can be inferred that the university's Information and Communication Technology (ICT) area is well-structured and has important innovation partners, including Toth Lifecare and IcoLab.

The report regarding interviewee 7 noted that three institutions are considered key partners in innovation efforts: the Research Support Foundation, SCIT/RS, and the Union of Hospitals and Clinics of Porto Alegre (Sindihospa). It is noted that most of the university's partners are primarily public entities, including Development Agencies, state-owned companies, and businesses in the ICT sector, which illustrates the predominance of the TH model. This aligns with Etzkowitz and Leydesdorff [11] which asserts that collaboration between universities, governments, and industries fosters technology-based innovation.

This demonstrates that despite the increasing discussion about including society as a fourth actor essential to the innovation process, the triple relationship among university, government, and industry remains the most prominent [60]. This points to the need for synergy more directly with open innovation activities involving industry, government, and end users to enhance innovation and commercialization processes.

One support emphasized by interviewee 5 is the effective involvement of private sector partners in innovation activities. This viewpoint is echoed by Interviewee 1, who underscores the importance of partners articulating their wants and needs, as this helps to "*create showcases of skills, technological showcases, and showcases of startups or SMEs.*" These demands can contribute to developing solutions and expertise through helical relationships. In this context, interviewee 4 notes that research projects have been aimed at addressing societal needs.

Reviewing the reports, it is evident that partnerships can be formal or informal, involving public entities or public-private collaborations. They are established through minutes, partnership agreements, conventions, technical cooperation agreements, collaboration terms, and contracts (interviewees 1, 3, 4, and 5). Additionally, there are accounts of partnerships through industrial property registrations (interviewee 7) and funding announcements (interviewee 4). The university can also promote partnerships by identifying potential partners. However, an important consideration emphasized by various interviewees is the necessity for user-friendliness for the end user (interviewees 3, 4, 5, and 6).

### *4.2. Artifacts for the Regional Health Ecosystem*

With the launch of the RS: Digital Health Project, the development and implementation of innovative digital solutions for the health sector commenced in the RMLN. Therefore, the proposed artifact pertains to the study method used in this research (Table 3) and the artifact itself. It is recommended that these studies occur every semester with working groups formed from the stakeholders of the quadruple helix, enhancing the tool and, in turn, expanding the relationships and interactions between academia, business, government, and society in creating solutions.

In the *Problem and Opportunity Identification* stage, the need to develop a digital platform capable of mapping and connecting the key players and initiatives in the healthcare ecosystem of Rio Grande do Sul was recognized. Due to their high concentration of hospitals, healthcare professionals, and healthcare facilities, the RMLN were identified as strategic

hubs. The activities identified gaps in interactions among startups, academic institutions, government, and society, as well as planning actions to promote innovation and interoperability in the sector. On May 25, 2022, the mapping of the healthcare startup ecosystem commenced, along with organizing a work plan and recruiting scholarship holders to support the project. Simultaneously, introductory courses were planned to prepare the stakeholders involved for the digital transformation in healthcare.

**Table 3.**
Practical research method for semiannual application.

| **Research Proposal Artifact in Regional Health Ecosystem**<br>**Permanent/sustainable study (biannual) from the perspective of the Quadruple Helix** | | |
|---|---|---|
| **Phase** | **Description** | **Detailing** |
| 1 | Problem and Opportunity Identification | 1. IE are characterized as a network of interconnected organizations, linked to a focal company or technological platform, incorporated by producers and users, capable of creating values of an innovative nature<br>2. As academia-business-government-society begin to interact, they favor economic growth generated from the grouping and concentration of productive resources. |
| 2 | Selection of representatives for the study of regional ecosystems in health | 1. At this stage, the core institution organizes other institutions/actors that have experience in the affected area.<br>2. During the research, other representatives from other areas may be invited, as necessary, where dialogue is essential to guarantee relationships. |
| 3 | Contact with partners to resolve problems/opportunities | 1. Contact with complements and components refers to the first moment of presentation of the problem to be solved.<br>2. Support actors are responsible for academic-scientific dissemination for researchers to produce articles. |
| 4 | Beginning of the study through a practical resolution method. | 1. At this stage, researchers choose the research method to be used, such as Design Science Research or Design Thinking.<br>2. Other methods can be applied, as long as they meet the objective of seeking practical solutions for the context of the ecosystem. |
| 5 | Presentation of Results | 1. The result presented to the environment is a suggestion for solving the problem.<br>2. The result for supporting actors is the production of academic and technological articles focusing on IE from the perspective of the QH. |

The stakeholders involved in this phase were notable for their strategic contributions. Universities such as UFCSPA, PUCRS, and UFRGS provided technical support, while Feevale University distinguished itself with its essential infrastructure. Fundmed served as a key foundation, delivering financial and logistical support, and companies like iCoLab and Toth Lifecare offered technological expertise. Governments, including the SICT/RS and the City of Novo Hamburgo, played a vital role in regional coordination and data sharing. Other partners, including Sindihospa, SEBRAE, and initiatives like Pacto Alegre, strengthened connections within the ecosystem. These collaborations established the groundwork for an innovative network focused on the sustainable development of the health sector in the state.

In the *Representative Selection* stage of the Regional Health Ecosystems Study, strategic stakeholders from academia, government, business, and society were mobilized to ensure diversity and representation in the project. This stage included organizing meetings with partner institutions, such as FEEVALE, Fundmed, and South Collab Lab, on June 13, 2022, promoting ongoing dialogue among participants. Additionally, a detailed development schedule was created on July 21, 2022, incorporating contributions from various sectors, and experts from complementary areas were invited to enrich discussions and align collective strategies. The formation of representative working groups ensured the identification of the ecosystem's needs and the collaborative development of proposed solutions.

The actors involved played key roles in this phase. Universities such as Feevale, UFCSPA, PUCRS, and Unisinos offered technical and intellectual support, integrating professors, researchers, and students into the process. Fundmed stood out in facilitating collaboration among health institutions and local startups, while companies like South Collab Lab served as a bridge to connect startups, hospitals, and other key stakeholders in the health innovation sector. Representatives from civil society and public managers also participated actively, enhancing interactions between the sectors and fostering a cooperative environment essential for advancing the project.

In the *Contact with Partners for Problem/Opportunity Resolution* stage, a collaborative network was established to validate project ideas and create practical solutions aimed at developing the healthcare ecosystem. This phase involved meetings with partners to align expectations and objectives and discussions about events, such as the Healthcare Innovation Journey and the hackathon, designed to engage the community and foster innovation. Held on June 29, 2022, these efforts also included defining courses and training focused on qualifying ecosystem participants, covering topics like General Data Protection Law (LGPD), blockchain, and interoperability. The partnerships led to technical, financial, and logistical support, enabling collaborative actions and reinforcing the project.

Feevale University, in collaboration with Fundmed, organized events such as Innovation Day and hackathons. Companies like South Collab Lab, Sindihospa, and Toth Lifecare helped define strategies and structure training initiatives.

The Inova RS program played a key role in designing the hackathon and engaging in discussions about regional innovation. Other organizations, including FINEP, FAPERGS, SEBRAE, and the City of Novo Hamburgo, also participated, fostering regional coordination and contributing to the establishment of a collaborative and innovative ecosystem in the health sector.

In the *Initiation of the Study through the Practical Resolution Method* stage, researchers began implementing practical solutions for the platform's development, employing methods such as Design Science Research and Design Thinking, which aligned with the project's objectives. The first action taken was conducting usability tests on August 12, 2022, with various groups, including healthcare professionals and startup representatives, to identify necessary improvements to the platform's interface and functionalities. The analysis of the collected feedback enabled technical and functional adjustments, such as enhancing search filters and clarifying menu nomenclature, which were implemented on September 1, 2022. This process involved benchmarking similar ecosystem structures and holding validation meetings to ensure that the platform's design and functionalities met the ecosystem's expectations.

Feevale University led the usability tests, providing both technical and academic analyses. Fundmed coordinated the technical adjustments and validated the methods used, while companies like iCoLab and Toth Lifecare contributed technological expertise to the platform's development. Startups within the ecosystem offered feedback on features and design, ensuring that test users from diverse backgrounds contributed to both the diversity and relevance of the evaluations. This extensive and strategic collaboration was vital for enhancing the platform and aligning it with the practical needs of the healthcare ecosystem in Rio Grande do Sul.

It is important to note that the test groups were expanded, with invitations sent to targeted audiences, including public health managers, researchers, startup representatives, and users. This diversification aimed to validate the new features and make the platform more user-friendly for individuals who are less experienced with complex digital tools. Ideas gathered during the tests were integrated into ongoing development, and the feasibility of creating tailored versions of the platform for different audiences was evaluated. Adjustments to the visual identity were also planned, which included logos, colors, and more responsive layouts for various devices, ensuring enhanced accessibility and visual impact.

These technical and strategic enhancements led to a significant boost in the user experience, lowering barriers for new audiences and raising expectations for greater engagement from the health and innovation community. The second round of testing, with adjustments made, was carefully organized to include personalized invitations for the initial test users, along with validation of the final functionalities.

During the *Results Presentation* stage, results were shared with various audiences, ranging from representatives of the healthcare ecosystem to the scientific community. The official platform launch occurred during Health Innovation Day on November 10, 2022, where functionalities like ecosystem mapping were demonstrated. Subsequently, on April 27, 2023, a formal presentation was held at the Fundmed space, showcasing the platform's interactive dashboards and other technological tools. Additionally, the production of academic and technological articles reinforced the concept of IEs from the perspective of the quadruple helix, promoting knowledge dissemination and consolidating the project's impact. From the perspective of the final stage proposed by the Design Science Research method, the conclusion of the research process is anticipated with the presentation of results to the experts involved in solving the problem and its implications.

The lack of clear identification of actors, resources, institutions, and regional health initiatives in Rio Grande do Sul, Brazil, hinders the promotion of a regional ecosystem. The access link to the platform is active and can be viewed at https://rssaudedigital.com.br. Currently, the platform features the following indicators: 109 startups in the health sector of the RMLN; 48 public and private hospitals; 9,432 available beds; 202 undergraduate and stricto sensu graduate courses in the health field; and 19 registered innovation initiatives (Figure 2).

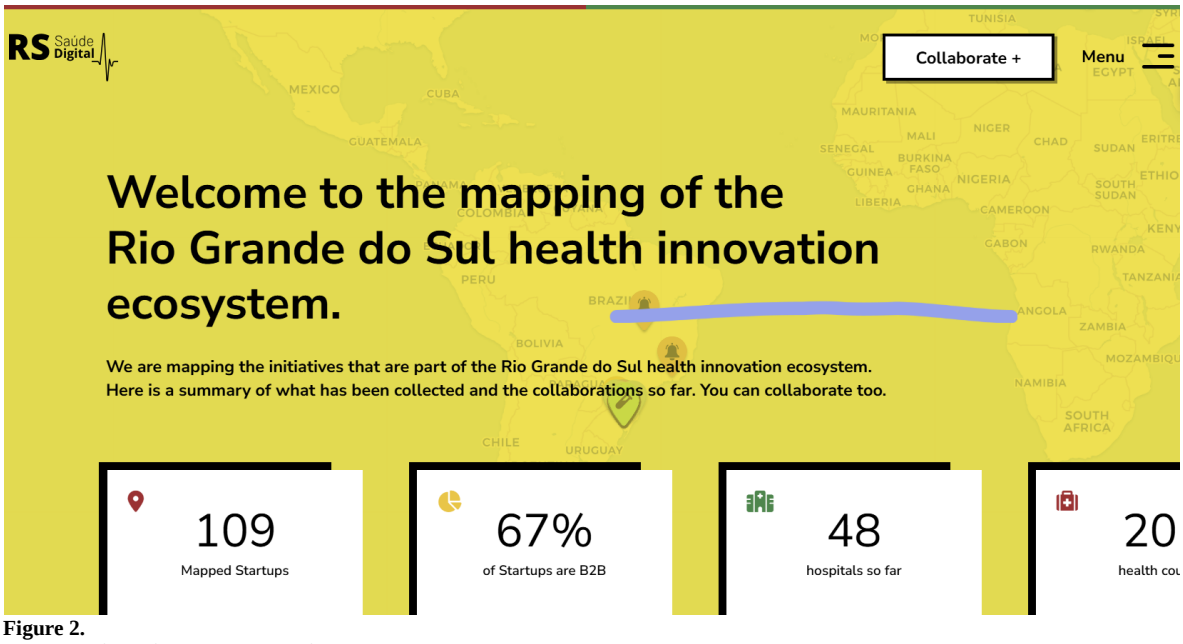


**Figure 2.**
Initial interface of the mapping platform
**Source:** RS Saúde Digital (2025).

Experts indicate an apparent increase in cooperation between the university and various stakeholders, emphasizing the need to enhance institutional communication with the external public and market. In this regard, Ferreira and Rocha [61] caution that research groups can serve as strategic connectors between the university, the productive environment, and society as they unite professors, students, and external stakeholders. These interactions foster a beneficial exchange of knowledge for research purposes and can significantly contribute to socioeconomic development. Notably, the interaction between the university and other key stakeholders in implementing innovation can be a gradual process and demands creating and strengthening an entrepreneurial culture geared toward the external context [62].

According to reports from most experts, universities recognize the importance of welcoming user participation to develop solutions that address the actual needs of society, including legal support and integration into institutional innovation policy. However, it is essential to emphasize that simply acknowledging this importance or implementing specific citizen interaction initiatives is insufficient; users must be at the center of the QH model to foster the development of innovations pertinent to their needs [44].

In other words, QH initiatives must be strategically planned because the university plays a crucial role in providing support (information, tools, forums) and other subsidies to assist users in developing innovative, value-generating activities that can strengthen the IE [44, 63-65].

Experts also highlight that society can play a role within an ecosystem from four perspectives: as a beneficiary of the innovative process, as an active participant in the innovation development process, as an initiator of the innovation process that generates demand for new products, and as a participant in innovation programs. In this context, supporting Carayannis and Rakhmatullin [63] users representing society can engage in the development process and suggest new types of innovations, along with the possibility of connecting with the actors within the industry-academia-government relationship triad.

QH brings together the public, academic, industrial, and civil society sectors, emphasizing the importance of dynamic and collaborative partnerships. Each helix contributes unique resources, including scientific expertise from universities, financial and strategic support from the public sector, practical skills from the industrial sector, and citizen insights. Experts have underscored that this integration is essential for catalyzing the digital platform, where development policies, advanced technologies, and user demands intersect [30, 66]. Additionally, civil society provides perspectives from end users and represents public interest organizations. In the context of a digital health platform, as noted by one expert, this might involve the participation of patient groups and NGOs, helping to shape development based on actual needs and promoting the adoption of innovation through more direct involvement.

Another aspect emphasized by experts was the governance of IEs within QH, which have structures that promote both formal coordination and informal networks. For the digital platform, seminars, and dialogue days were organized to integrate participants and align their interests, ensuring that various stakeholders are involved in the design process and that innovation remains user centered. Co-creation and knowledge transfer among QH actors was another point highlighted by experts in developing the digital health platform. This collaboration helps transform tangible and intangible resources into practical and viable solutions[5, 8, 9]. Concerning the health platform, exchanging ideas and skills among academics, public health managers, technology developers, and end users can accelerate the development and implementation of practical solutions.

Thus, the university conducting the study benefits scientific production by generating knowledge that aligns with the practical problems of the external environment [41]. Meanwhile, organizations and society benefit from the opportunity to rely on the university's support in generating ideas and solutions to their challenges. In this regard, this study reveals that the external environment requires guidance, in this instance from the university, to initiate projects that benefit the regional context. It becomes challenging for organizations and society to keep pace with the evolution of theories and social demands for solutions, particularly concerning collaboration and pooling efforts for the common good. Organizations encounter difficulties related to technological interoperability, scalability of solutions, and cultural resistance to change. At the same time, universities often operate in isolated disciplinary structures, impeding the transdisciplinarity essential for addressing health issues comprehensively.

The reason for this article proposing two artifacts is justified by the fact that they are inseparable, as generating the digital platform artifact is required following the research method utilized here. Once completed, this method produced observations and insights that highlight the need for and importance of continuing this type of study involving the university, business, government, and civil society. Ultimately, the digital health platform catalyzed new practical approaches that integrate disciplines such as public health, data science, engineering, and social sciences.

## 5. Conclusions

Creating a digital health platform based on the QH model signifies support and development of mechanisms for identifying components of a regional IE, where the interaction among various actors creates synergies for developing practical solutions tailored to users' needs.

The digital health platform benefits from co-creation and collaborative governance structures. Universities contribute to the research and development of emerging technologies, while the government provides regulatory and financial support. The industry implements and commercializes the solutions, and civil society plays an essential role in validating their functionalities and adapting them to health demands. This integrated process promotes transdisciplinarity, ensuring that the platform is a technical product and socially relevant, distinguishing itself as a method within the DSR perspective.

As a result, implementing this digital health platform can promote access to health information, enhance the efficiency of services, and consequently improve the quality of patient care. The platform also fosters citizen engagement, enabling

them to serve as co-creators and active users of digital health solutions. Besides the municipalities in the region, the project has affected the following groups: health professionals, educational institutions, including teachers and students in the health field, information technology experts, health managers, hospitals and outpatient facilities, health insurance companies, as well as users and beneficiaries of health services.

As a limitation of the study, even though the research focused on a regional context, which may restrict the generalizability of the results to other settings, a development model utilizing the DSR method is straightforward. Additionally, coordination among various stakeholders is emphasized as intricate, with communication barriers and difficulties aligning expectations.

As an opportunity for future work, it is essential to highlight that collaborative research among universities and other stakeholders presents opportunities for developing new artificial intelligence technologies and predictive algorithms. Furthermore, digital platforms allow studies to expand through analyses and create more agile and resilient organizational models, fostering open innovation and forming collaborative networks. From a social perspective, one factor to consider is that by involving civil society as an active partner in the co-creation of solutions, future research can better demonstrate user adherence and satisfaction.

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