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Uncovering the potential of innovation ecosystems in the healthcare sector after the COVID-19 crisis

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ABSTRACT

Industry 4.0 technologies are expected to enhance healthcare quality at the minimum cost feasible by using innovative solutions based on a fruitful exchange of knowledge and resources among institutions, firms and academia. These collaborative mechanisms are likely to occur in an innovation ecosystem where different stakeholders and resources interact to provide ground-breaking solutions to the market.

The paper proposes a framework for studying the creation and development of innovation ecosystems in the healthcare sector by using a set of interrelated dimensions including, technology, value, and capabilities within a Triple-Helix model guided by focal actors. The model is applied to an exemplary Italian innovation ecosystem providing cloud and artificial intelligence-based solutions to general practitioners (GPs) under the focal role of the Italian association of GPs.

Primary and secondary data are examined starting from the innovation ecosystem's origins and continuing until the COVID-19 crisis. The findings show that the pandemic represented the turning point that altered the ecosystem's dimensions in order to find immediate solutions for monitoring health conditions and organizing the booking of swabs and vaccines. The data triangulation points out the technical, organizational, and administrative barriers hindering the widespread adoption of these solutions at the national and regional levels, revealing several implications for health policy.

1. Introduction

Industry 4.0 (I4.0) technologies, such as artificial intelligence (AI), are addressing the unmet needs of the healthcare sector [1] by timely addressing patients' health care conditions and performing accurate predictions by examining numerous variables [2].

Immediately after the COVID-19 outbreak, governments, researchers and firms acknowledged the urgency of adopting I4.0 technologies for containing the disease's spread and treating infected cases [3].

Solutions have been introduced by exploiting the capabilities of different stakeholders, including universities and innovative firms, based on the premise that outcomes can be effectively developed through an ecosystem approach [4]. Integrating innovations into the health system is a complex endeavor that requires a well-designed planning process for stakeholders [5,6]. Innovation ecosystems, described as the interrelation between actors and resources, could be an effective framework of reference [7]. These ecosystems usually take place through a triple-helix model (THM), including government, academia, and firms. They may include focal actors, initiating and guiding their evolution [8].

Combining insights from the literature, this paper proposes a conceptual model for examining the origin and evolution of innovation ecosystems in healthcare. The research questions (RQs) we aim to answer are:

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- What are the key dimensions of an innovation ecosystem?
- How can a crisis change its dimensions?

To answer the RQs, the model is applied to an exemplary Italian innovation ecosystem that since 2014 has been providing cloud-based and AI solutions to general practitioners (GPs) under the guidance of the Italian association of GPs. This ecosystem has boosted its impact during the COVID-19 crisis by designing solutions for monitoring patients and organizing the booking of swabs and vaccines.

1.1. AI for healthcare

I4.0 enables the constant exchange of information on health conditions [9], improving the quality of services at the minimum cost [10]. Among I.40 technologies, there are high expectations of AI [11]. AI is the study of algorithms that give machines the ability to reason and perform cognitive functions [12]. Machine Learning (ML) is a branch of computation algorithms that emulates human intelligence by learning directly from the environment [13].

This technology is expanding its footprint in clinical systems ranging from databases to video analysis [11]. Even if Big Data is rich with variables, it is flawed in delivering appropriate clinical context for interpreting data. Instead, thanks to AI, physicians can evaluate predictions in meaningful ways [14] and improve the efficiency of care processes [15]. ML ensures interpretability in terms of being "clinically meaningful" and generalizes on new subjects and different clinical and social conditions. Robustness is guaranteed with a high number of predictors, natural imbalance of classes, and sparsity of predictors and labels.

Recent work has proposed ML methodologies for predicting type 2 diabetes (T2D) [16], risk conditions [17] and complications [18] by using EHR data collected from GPs. These cases prove that ML can represent the core of the clinical decision support system (CDSS). Scholars also proposed an integrated chronic care model based on ML and data sharing between GPs and cloud computing platforms [19]. The quality care evaluation in a clinical use-case scenario demonstrated how empowering GPs using the platform with economic incentives improves care processes [2].

However, advancements in digital health raised concerns about the reliability of AI tools [20]. To respond to healthcare challenges, algorithms must be integrated with software environments that are already operative in the national scenario. Moreover, AI cannot function without high-quality data. AI models are often powered by clinical data that is generated in the medical system, for which the primary purpose is to support care rather than facilitate subsequent analysis. Many AI approaches use EHR data, which document healthcare delivery and operational needs to understand patient health [21]. However, these are frequently affected by non-uniformity and missing data [22], which may be caused by lack of time to deliver annotations, insufficient IT equipment [23] or lack of standardization in data entry, EHR data interoperability, and clinical and socioeconomic variables [24].

The integration of clinical-medical information, dispersed in many databases, is far from being achieved despite the existence of interoperability protocols. Finally, there are privacy issues [25] since the information managed is identifying and sensitive and must be treated according to regulations on data protection. Thus, solid data frameworks must be proposed within and across countries [26]. In this field, the European General Data Protection Regulation (GDPR, Regulation (EU) 2016/679) established detailed requirements for companies and organisations regarding collecting, storing and managing personal data and recognises data concerning health as a special category. Data concerning health as well as genetic and biometric data are considered highly sensitive. ‘Sensitive data’ are assigned a more protective framework than that applicable to other types of personal data (art. 6, GDPR). In general, processing of all sensitive data is prohibited under GDPR, but a list of exceptions is specified (art 9.2, GDPR).

Indeed, digital transformation in healthcare does not only depend on technical changes but requires an adaptive transformation in legal and financial frameworks [27]. Even if technology played a vital role in COVID-19 control, state policies continue to be one of the driving factors and COVID-19 will likely shape future health data policy [28]. Thus, different stakeholders should find ways to effectively integrate technological change [9].

1.2. Innovation ecosystems

Innovation ecosystems may address the challenges that hinder AI adoption. An innovation ecosystem is a combination of actors, activities, artefacts, institutions and relations that drives innovative performance [29]. These ecosystems specialize in complementary technologies and competencies [30] to turn research and development into profits [31].

Scholars agree that this framework is rooted in interactions among multiple stakeholders. In this context, managers can learn how to establish I4.0 strategies, while policymakers learn how to organize the evolution of ecosystems [32]. These ecosystems can manage regional development [8] and evolve according to needs and circumstances, including new policy initiatives [33].

Innovation ecosystems have been considered in healthcare, reporting positive effects on performance [34]. Within these ecosystems, it is economically beneficial to foster relationships between universities, industry and administrations, favouring a better allocation of budget items and boosting commitments [34]. Governments are acknowledging that for developing innovations it is necessary to establish partnerships with the private sector. Li and Garnsey [35] showed that an ecosystem endorsed by the government can help innovation in the private sector by filling financial gaps and addressing technology and public health issues. Similarly, Dixit et al. [36] discussed the need for interdisciplinary collaboration to foster research diversification, robust regulatory approaches and geographic growth.

Remarkably, professional hierarchies, conflicting interests and lack of awareness make the healthcare ecosystem different from others [37]. The competing interests push for a planned innovation orchestration. Finally, innovation ecosystems can shape firms’ business models [38] to face the occurring complexities, especially from a regulatory and financial standpoint.

Relationships in innovation ecosystems are often unstable and unclear [39] and critical questions need to be addressed to capture their complexity [40]. Even if scholars acknowledged the importance of innovation ecosystems in healthcare, conceptual models analysing their origin and development in the sector are lacking. Thus, it is up to researchers to give meaning and usefulness to this concept [41].

Conceptualizing innovation ecosystems could support researchers in making comparisons and governments to stimulate their emergence. The urgency of the topic has been confirmed during the COVID-19 crisis, which exposed the need for collaboration to exploit technological development. Hence, innovation ecosystems should be based on cooperation between universities, industry and government in a THM [8].

Granstrand and Holgersson [29] specified the elements to be investigated including actors, activities, artefacts, institutions, and relations. Dedehayir et al. [40] discussed that scholars should capture the actions shaping the ecosystem, actors and their roles. Similarly, Oksanen and Hautamaki [8] conceptualized the elements for building an innovation ecosystem, including resources from the THM, organization, actors’ commitment and consensus, and strategic vision. Chen et al. [42] integrated these aspects by looking at the evolution of innovation ecosystems, through the dimensions of technology, value and capability.

Among the actors involved, there may be focal actors, who manage the mix of identities, which may create a faultline and have a negative impact on the outcome [43]. A faultline is a dividing line [43] that separates components of teams and generates subgroups that cannot communicate. Differences in scientific cultures among individuals could lead to difficulties in teamwork [44,45].

Combining these studies, we provide a conceptual model (Fig. 1), as described in Table 1. This model is applied to an exemplary healthcare innovation ecosystem. The model is designed to capture the key variables shaping the creation of innovation ecosystems in healthcare (RQ1) as well as their development in response to a crisis (RQ2). The model looks into how these variables interact within a THM investigating the emergence and evolution of focal actors and relationships among governmental institutions, academia and firms.

2. Material and methods

The paper illustrates the case study [46] of an exemplary healthcare innovation ecosystem that acted responsively to the pandemic's challenges by broadening its activities and networks in a THM. The case study methodology is well suited to healthcare service research because it can track and examine complex relationships, contexts, and systems as they evolve [47].

The selected innovation ecosystem is guided by the Italian association of GPs, called FIMMG (Federazione Italiana Medici di Medicina Generale), which launched an innovative cloud-based platform called Net Medica Italia in 2014. The case is exemplary for the attention that FIMMG placed on improving their cloud-based platform with AI-based techniques and for the recognition gained by their solutions during the COVID-19 outbreak in the national and regional areas. This case is revelatory also for its context. Italy was the first European country dramatically hit by COVID-19 in early 2020. It is of interest to note that the Italian National Healthcare System (NHS) has been increasingly decentralized, with many powers devolved to regions. This has progressively translated the Italian NHS into uneven regional health services [48], potentially limiting a harmonized adoption of technical and structural standards. Data was gathered from several sources (Table 2). Semi-structured interviews were used to allow greater flexibility and provide a wider description of the phenomenon [49]. Interviews were addressed to the doctor responsible for the ICT activities of FIMMG and the ICT expect that followed the launch and development of the platform.

The data collection consisted of two rounds of face-to-face interviews (January – March 2021). The interviews were audio-recorded and transcribed. Four interviews were conducted for a total time of 4 h. Subsequently, the interview transcripts were sent back to the interviewees for confirmation before we continued developing the case study. E-mails were exchanged to compare and contrast findings. Additional data and documents were used to complement the transcripts through triangulation to support the reliability of our study [50]. Thus, we cross-checked interview data with publicly available information and internal documents. Moreover, three of the authors were directly involved in the platform's technical development. The triangulation of data aimed at uncovering the selected variables for describing both the emergence and evolution of the innovation ecosystem after the crisis

Table 1
innovation ecosystem dimensions.

Variables	Key aspects to address	References
Actors	• Presence of focal actors • Actors involved in the ecosystem's introduction and/or development. • Actors' roles in building the ecosystem's dimensions. • Reasons for involving the actors	Oksanen and Hautamäki [8]; Granstrand and Holgersson [29]; Dedehayir et al. [40]
Technology	• Technologies addressed by the ecosystem	Granstrand and Holgersson [29]; Chen et al. [42]
Value	• Tangible value: economic value and added value of the solutions offered • Intangible value: credibility and diffusion of technologies among users	Chen et al. [42]; Granstrand and Holgersson [29];
Capability	• Internal and external resources, skills and knowledge	Chen et al. [42]; Oksanen and Hautamaki [8]
Interactions among dimensions	• Coordination of activities among actors and dimensions	Chen et al. [42]; Oksanen and Hautamaki [8]

Table 2
Data.

Source	Details
Primary	• First round of interviews (2 h) • Second round of interviews (2 h) • Transcript of interviews (20 pages) • E-mail interaction to integrate the findings (20 e-mails)
Secondary	• Statistics on Net Medica Italia usage among doctors • Guide on the web services offered by Net Medica Italia • Videos of presentation of Net Medica Italia (tot. length 1 h) • Description of Net Medica Italia implementation in Campania • N. 4 Scientific articles published on Net Medica Italia • N. 15 Press articles on Net Medica Italia

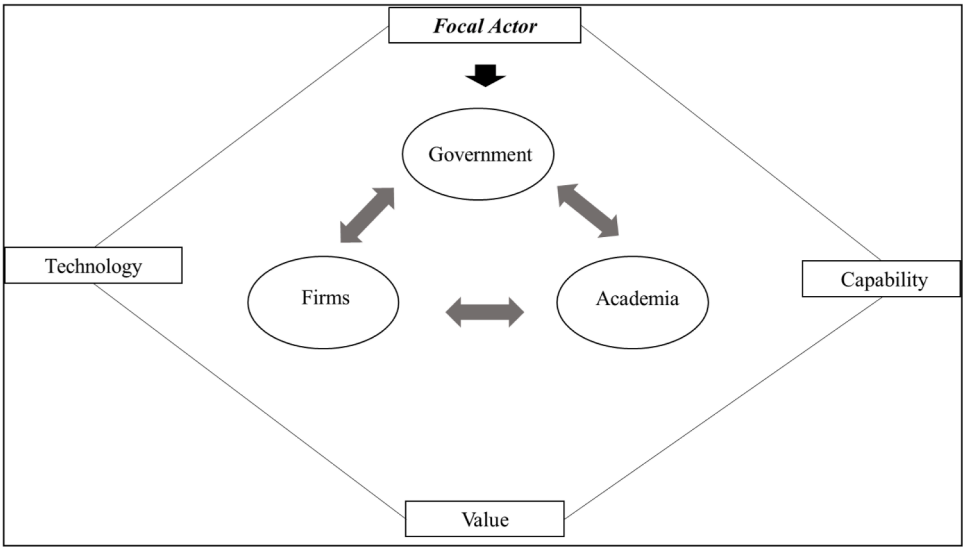

Fig. 1. Conceptualizing innovation ecosystems.

within a THM guided by focal actors.

3. Results

The findings illustrate the evolution of Net Medica Italia before and after COVID-19 by presenting technological, value, and capability dimensions within the THM dynamics.

3.1. The technology dimension

Since its introduction, the Net Medica Italia platform has focused on replication in the cloud of EHR data, according to a standardized language. The platform enables GPs to access the database (DB) remotely, using the PC or mobile devices. The DB allows sharing of data, even between professionals who use different management systems. The application, which is a Web resource, ensures complete interoperability to the data shared. From the Net Medica Italia portal, GPs can access a store area where additional applications are available. This area includes:

- Training – this section can be used to test and integrate the offered Web services.
- NMI Privacy - In line with GDPR, doctors can register their activities by answering a questionnaire available on the platform. The questionnaire examines the activities and procedures of which the doctor is in charge.
- NMI Cloud for sharing, analysing and monitoring clinical records. The platform provides key performance indicators (KPIs) measuring GPs' performance. Based on the KPI, training activities can be organized.
- NMI e-HEALTH, from which the doctor can provide online consultancy to patients, who download the app "Ciao Dottore".
- NMI CARE3, including data sharing among GPs for chronic care management. A set of indicators are included for monitoring and evaluating treatment responses. A pilot case on ML techniques was examined for the chronic case of diabetes to classify chronic care quality [2].
- My Net Medica Italia, from which it is possible to share medical records at the territorial level.

Patients can access a part of the GPs records in the Cloud through an authentication system that generates personal credentials. This area collects medical reports uploaded by the doctor and notes and health documents uploaded by patients.

The EHR data collected on the platform enables GPs to trace their patients' conditions, including rare and chronic diseases, disabilities and medical prescriptions. The heterogeneity of EHR fields and the presence of longitudinal observations represent the basis for undertaking a detailed analysis of health conditions over time. AI-based techniques are integrated to analyze the multifactorial temporal data stored in the Cloud to discover complex patterns and set up advanced ML models that forecast clinical outcomes and interpret patterns that physicians sometimes miss. These ML models can help physicians to predict early-stage diseases but also detect the relevant clinical factors associated with a risk condition profile.

ML techniques have been used to extract information from a large amount of data and have proven helpful in improving the diagnosis, predictions and management of chronic diseases. Based on these models, Net Medica Italia identifies high-risk profiles such as the transition into another disease state for example, the progression from pre-diabetes to T2D.

Moreover, AI-based techniques integrated into the Net Medica Italia Cloud play a fundamental role in the development of learning healthcare systems. These systems may combine multi-source data with ML techniques, including data collected by territorial aggregations and national providers. The result consists of a continuous source of data-driven insights to optimize biomedical research, public health, and healthcare quality.

3.2. The value dimension

The value proposition is articulated in tangible and intangible layers. The tangible part includes the added value of the platform compared to existing solutions and its economic value. Instead, intangible aspects are linked to the GPs' loyalty.

3.2.1. Tangible aspects

Family medicine was already the most computerized field among national health contexts. Since the 1980s, GPs were sending information and making prescriptions using databases. However, relying on these generic systems, GPs were not able to assign value to the information recorded.

Current management systems allow the treatment of patient data but do not enable data sharing from the perspective of integrated teamwork. Net Medica Italia wanted to exceed these limits by proposing a cloud computing system for GPs, with an interface available for interoperability with the rest of the healthcare system, including interactions with specialists. The idea was to bring together the DB of GPs in a cloud structure where the data could be stored in a standard way.

Differently from the state-of-the-art on EHR, the FIMMG Net Medica Italia Cloud Platform is based on the GPs' daily activities. Moreover, the heterogeneity of the data collected, and the presence of longitudinal observations allow analysing of the evolution of the subjects in each community. Net Medica Italia, beyond the typical demographic and primary care attributes, contains information on allergies, intolerances, smoking, alcohol, and physical activity.

The timely observation of health status data in primary care, even in association with a prolonged lifestyle, is promising for predictive purposes. The multi-modal temporal information could lay the foundation for a CDSS.

Net Medica Italia emerged as a limited liability company for members, who pay a fee of 50 euros including VAT per year. However, this model is not sustainable in the long term, considering the high investments behind the platform's development. Before investing in a new initiative, FIMMG has to be very selective when asking for funds. Net Medica Italia will continue working on the intangible aspects by offering services for which GPs will be willing to pay, thereby recognizing the value of innovation.

3.2.2. Intangible aspects

Building loyalty among GPs by acting on their territorial aggregations is recognized as crucial by FIMMG. Net Medica Italia was established as a turning point for GPs. In 2012 a law ("Balduzzi Law"), required doctors to be organized in territorial aggregations with a number not below 20. In their aggregation, GPs have to ensure continuity of care to patients in that area. To start spreading awareness on the platform, Net Medica Italia emerged as a practical tool used to comply with the procedures required by GDPR. Using the Net Medica Italia platform, the doctor realized they had more time to focus on the clinical activity.

The doctors appreciated this outcome, also because dashboards were made available to assess their operational performances. The goal is to prove to doctors that it is possible to achieve improvements in time management and economic value by changing aspects of their activity. Net Medica Italia is the only platform that manages to combine different data to monitor KPIs, including administrative ones.

Another novelty is the possibility of having a complete web-based medical record, resulting in a cloud software for data as well as interfaces. The medical record can be reached from any device, including mobile. To date, this solution has been made available in the regions of Piedmont, Campania, Calabria, Basilicata, Marche, Lazio, Sicily and Puglia. Net Medica Italia showed a growth trend from its launch.

Currently, FIMMG manages more than 5000 GPs and 11 million medical records.

However, its diffusion is taking place in a chaotic manner on the national territory even if Net Medica Italia could potentially cover most of the Italian territory, being compatible with many software systems. The first success was achieved in the Campania region. In this region, all of the GPs joined Net Medica Italia because of a regional agreement (Regional Law 9/2009), seeking to guarantee continuity of care for patients with diabetes. The region recognized that this was possible by implementing a chronic care model. Net Medica Italia ensured access to a database that contained data subject to the agreement, on which four million health cards were uploaded to be aggregated and shared with colleagues. Data can be viewed at the individual level but also at the territorial one to compare aggregations.

Nevertheless, Campania is an exception. To continue creating awareness of the added value of Net Medica Italia it is necessary to gain trust among other territorial aggregations. Coordinators have been appointed to create awareness, and GPs are becoming promotors among others.

3.3. The capability dimension

The value proposition of Net Medica Italia results from the successful integration of multidisciplinary capabilities. The integration of internal and external resources acted as the driver for its development. Collaboration was fostered from the beginning between doctors of FIMMG, ICT and legal experts, software companies, and researchers.

As for the internal resources, Net Medica Italia has 11 employees, including ICT experts, lawyers and different collaborators. Heterogeneous teams were organized to create a virtuous mechanism: *"Doctors tried to understand the language of computer scientists and computer scientists tried to understand the needs of doctors" (doctor FIMMG)*.

In general, when the teams are heterogeneous, there is the risk that they will not create value due to inefficient communication. Net Medica Italia is an example where the faultline theory did not occur [43]: the medical skills integrated with the technical and managerial skills and contributed to the value dimension.

The ICT experts worked on enabling interoperability between the DBs of GPs, and then with other DBs and operators of the NHS to ensure continuity of care. Legal experts were needed to ensure that data was managed in compliance with regulations and laws. Legal experts collaborated in building a strong security system based on encrypted data. The data encryption algorithm was developed in collaboration with the Polytechnic University of Marche in Italy.

Moreover, there have been collaborations with software houses to share some additional operations for enabling doctors to use data stored on the Cloud and using other software. Net Medica Italia does not replace the software that doctors use and hopes that software houses will become more cooperative. Then, to work in connection for the continuity of care, sharing data between professional levels was ensured by a partnership with Federsanità, which is the institutional actor representing the Local Health Agencies in different municipalities. Through this partnership, the sharing of specific areas of the cloud was enabled for managing chronic diseases. Furthermore, Net Medica Italia has worked with a leading Italian company managing patients with diabetes mellitus, making it possible to share data between diabetic centres.

3.4. Dimensions after the pandemic

After the COVID-19 outbreak, Net Medica Italia upgraded its dimensions in a new stage of development that increased the borders of the healthcare innovation ecosystem, in which FIMMG continues to be the focal actor.

As for the technological dimension, it included NMI CARE COVID-19. This section offers telemedicine services to guarantee continuity of care for patients with COVID-19. Doctors use the platform to monitor patients in the disease course, even daily. The section includes an agenda of appointments and teleconsultation services. Bluetooth devices were introduced to remotely monitor vital parameters. Doctors can access their patients' data in the Cloud and share the data with the emergency medical service, which is unaware of each patient's conditions.

In addition, a COVID-swab booking system was proposed for supporting the local health service and health companies in managing bookings and reporting the result to the doctor.

Net Medica Italia also proposed an algorithm that supports doctors in managing priorities for the COVID-19 vaccine [51], considering the characteristics of the patient in line with the national priorities.

Therefore, Net Medica Italia was able to react to the needs led by the pandemic generating value in the innovation ecosystem for doctors and the local community. COVID-19 boosted the solutions proposed. The new solutions created awareness of the services that Net Medica Italia offered at the local and national levels. The subscriptions on the platform increased and the experience recorded in Campania is repeating itself in other regions, such as Calabria and Puglia.

The new services made Net Medica Italia rethink its business model by recognizing that economic sustainability is essential. In 2021, Net Medica Italia became a benefit company, therefore, a company that maintains profit objectives with a mission in favor of societal goals.

External resources supported the new technological and value dimensions. Thanks to the collaboration with the Polytechnic University of Marche and experts from different universities, the algorithm was created for managing priorities in the vaccine booking [51]. The algorithm collects data from the GPs and establishes priorities based on the characteristics of a vulnerable person. The algorithm identifies profiles based on the data the GPs collected, which is not included in regional and national healthcare platforms. The algorithm could consider certain side effects deriving from the vaccine's administration based on the patient's health conditions.

The algorithm would be at the disposal of GPs and institutions for free, but the GPs databases need to be connected with regional and national healthcare platforms in order to work. This means that regional administrations must authorize the connection between platforms. Up until now, the algorithm has only been implemented in Puglia and Calabria. The FIMMG's involvement in the mass vaccination against COVID-19 was necessary, considering the widespread distribution of GPs in the territory and their knowledge about the clinical history of individual patients.

Moreover, to exploit the platform's new functionalities, collaborations with Local Health Centres increased. A new collaboration emerged with IBM, a leading ICT company, and Novartis, a global health company, to advance the platform's functionalities. In collaboration with IBM, Watson's query of AI was integrated for managing unstructured text.

4. Discussion

The conceptual model suggested and its validation through the exploratory case of Net Medica Italia contributes to the literature on innovation ecosystems by suggesting a set of variables to be explored in a THM. Indeed, the model enabled the uncovering of factors and critical relationships that determined the creation of an innovation ecosystem in healthcare (RQ1) as well as its development during a crisis (RQ2). The case shows that the capability dimension contributed to creating the technological dimension. The FIMMG, as the focal actor, gave rise to the innovation ecosystem by combining external capabilities with internal ones through partnerships with multiple actors.

The case confirms that innovation ecosystems are rooted in interactions between stakeholders. Indeed, agreeing with Oksanen and Hautamaki [8], a THM was built by including the institutional role of FIMMG, academia and firms. In addition, the case supports the use of multidisciplinary teams to encourage technological change as Dixit et al. [36] and Aceto et al. [9] both suggested.

Net Medica Italia integrates the findings of Vlaisavljevic et al. [34] by showing that fostering relationships in a THM is beneficial when developing initiatives, even if the same cannot be said for the economic aspect, which is still a big challenge.

Instead, the pandemic represented a turning point towards providing new technologies and value dimensions by leveraging new capabilities. The urgency of managing COVID-19 led to introducing telemedicine services that are extendable to all chronic cases. In this stage, partnerships within the health innovation ecosystem resulted crucial in providing a timely response. Moreover, thanks to its algorithm for managing vaccines, Net Medica Italia is expected to increase awareness in the territory and continue driving new partnerships that could open the way for its national diffusion.

However, the extension of Net Medica Italia's capabilities required a structural change. This stage of development consolidates the assumption of Banda et al. [38] since an innovation ecosystem influences firms' business models. The business model of Net Medica Italia is meant to change based on AI and ML developments. While the platform and the functionalities offered were considered an accessory before COVID-19, they are now becoming central for local health agencies. *"The objective is to become the center of innovation in healthcare thanks to AI" (ICT expert)*. Even if technology plays an important role in COVID-19 control, it is not the only factor affecting the results, as state policies continue to be a driver in achieving a better outcome by filling financial resources.

5. Conclusions

The case of Net Medica Italia shows how an innovation ecosystem guided by trusted focal actors and built on multidisciplinary teams can provide advanced technological solutions that are tailored to the doctors' needs, offering a new value proposition in the sector. The findings underlined that innovation ecosystems built on a strong capability dimension can create technological and value propositions only if they are guided by committed focal actors able to match different competences and interests. Theoretically, the paper contributes to the literature on innovation ecosystems by defining and applying a set of dimensions for analysing their creation and evolution. In this sense, a conceptual model is proposed to study key dimensions including, technology, value, and capabilities in a THM guided by focal actors.

As for managerial implications, the paper shows how AI can improve the quality of healthcare services in the territory and provide predictive capabilities that would benefit the sector in terms of efficiency and costs. Furthermore, this case indicates that technological developments and external factors, such as the pandemic, require a revision of the existing business models to balance new costs and users' needs. In terms of policy implications, the case underlines the need for more substantial governmental support for ensuring the widespread adoption of the solution in the territory. Specifically, policy programs at the national and regional levels should provide conditions for overcoming administrative, financial and technical challenges in experimenting and adopting innovative solutions in healthcare. This case highlights the need to identify structural and technological standards which should be uniform in the territory. Furthermore, it shows that measuring GPs' performances should encourage them to improve their performances through targeted training programmes. These aspects are crucial for implementing the Italian National Recovery and Resilience Plan (NRRP) whose mission dedicated to healthcare aims at modernizing the healthcare system, reducing territorial fragmentation and favouring research activity. Nevertheless, results cannot be generalized. Thus, studies should compare other experiences to understand how the dimensions evolve after a crisis. The proposed model may be applied in different sectors and countries to favor comparative analysis. It would be useful to investigate different types of focal actors, thereby understanding how they coordinated multiple actors and resources. Longitudinal cases are suggested for following up on the collaboration in the THM.

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Declaration of interest statement

The Authors declare there is no conflict of interest

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