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Smart Hospitals and Digital Innovation: Comparative Insights from Two Italian Case Studies

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Abstract

Purpose: Provide a definition of a smart hospital and identify the key digital technologies that must be adopted to guide hospitals toward e-health 4.0. The concept of a smart hospital has not been rigorously defined in the literature, and there is no widely accepted definition. This research aims to fill this gap by identifying the attributes of a smart hospital and proposing a definition based on these.
Methods: A qualitative case study methodology was used to study smart hospitals. The focus was on two Italian hospitals: one public and one private, considered best performers according to the smart health rankings developed by the international weekly magazine Newsweek, in collaboration with the research firm Statista. Primary data was collected using semi-structured questionnaires aimed at healthcare professionals, while secondary data was obtained from official documentation, websites, press releases and institutional reports.
Findings: Following the review of e-health and smart hospitals, it was found that there is no single model of a smart or intelligent hospital, and that the evolution of these two institutions in this direction is closely linked to the digital technologies used.
Originality: To fully realize the true potential of the smart hospital, it is essential to consider digital technologies not as separate entities, as they must interact to optimize healthcare processes and improve the quality of care. In the light of this, a framework has been developed that highlights the most widespread digital technologies that must be integrated into medical treatments and administrative processes to support the transition from a traditional to a smart hospital.

Keywords: digital transformation, smart health, smart hospitals, case study

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1. Introduction

Healthcare is a social and economic challenge in many countries around the world. The health emergency, addressed to combat the spread of the Coronavirus (CoVid-19), has reawakened the need for more modern and digital healthcare (e-health). Furthermore, it has highlighted the many weaknesses in the healthcare system, prompting a complete reorganization (Alsharif et al., 2020; Raimo et al., 2023). Consequently, the transition to new digital solutions has accelerated significantly. The Smarter Italy plan, first, and the National Recovery and Resilience Plan (PNRR) subsequently, have provided a series of economic measures to finance the digital transformation of hospitals (https://www.agid.gov.it/it/smart-landscape; The European House, 2021), which has also been hampered by the significant digital divide within the country (Mele et al., 2024; Marques and Ferreira, 2020).

The implementation of the fifth industrial revolution has offered traditional hospitals the opportunity to transform into smart healthcare providers. Thanks to new digital healthcare tools—electronic health records, online monitoring systems, telemedicine and telerobotics equipment, and mobile healthcare—it has been possible to improve medical services and simplify access to care for citizens, who can now save time and money by obtaining certain medical services from the comfort of their own homes. Digital healthcare has quickly become a topic of study and has attracted the interest of the academic world (Budd et al., 2020; Chandra et al., 2022; Iyengar et al., 2020). It goes beyond simple process automation and primarily includes smart hospitals, also known as intelligent hospitals, in which innovative management and responsible use of data play a central role. Sharing such data contributes to the creation of an integrated healthcare ecosystem, where clinical information is readily accessible to those who need it.

The study followed a qualitative approach based on case study analysis. Two hospitals were selected, one public and one private, located separately across the country and ranked, albeit differently, in the Best Smart Hospitals ranking, a list of smart hospitals compiled annually by the prestigious international Newsweek ranking in collaboration with Statista. The two hospitals were selected because they are similar in terms of bed capacity and emergency room visits.

The aim of the research is to identify the attributes of an intelligent or smart hospital, to propose a definition for it, based on these and to present a framework to highlight the most widespread digital technologies to integrate into medical treatments and administrative processes, in order to facilitate the transition from a traditional hospital to a smart hospital.

This study specifically aims to address the following research question: *What technological drivers and institutional pressures characterize the transition from a traditional hospital to a smart hospital?*

After a brief theoretical introduction to the topic in the first paragraph, the second paragraph analyses the literature on e-health and smart hospitals. The third paragraph describes the methodology used and the fourth analyses the results obtained; finally, the last paragraph, in addition to the conclusions of the work, explains the theoretical and practical implications, the limitations and possible future developments.

2. Literature Review

2.1 E-Healthcare 4.0

The digitalization of Industry 4.0 applied to the healthcare sector defines e-Health 4.0; it refers to the use of innovative digital technologies to support the healthcare system (Mathews et al., 2019; Butpheng et al., 2020; Cannavale et al., 2022). With e-health 4.0, the traditional concept of healthcare gives way to a new concept based on a more interconnected, ultra-modern and faster healthcare:

digital healthcare (hereinafter e-health), defined by the European Commission as "digital health and care is the collective term used to refer to tools and services that use information and communication technologies (ICTs) that can improve prevention, diagnosis, treatment, monitoring and management of health and lifestyle (European Commission, 2004). It refers to all self-tracking techniques, shared decision-making processes in diagnosis and e-therapy, telemedicine and teleassistance services (Kostkova, 2015; Haggerty, 2018; Belliger and Krieger, 2018), but also to a series of new digital healthcare tools: the Electronic Health Record (EHR), the dematerialization of medical reports and clinical records (Reina et al., 2012), the introduction of digital prescriptions (e Prescription), online booking systems (CUP), robotic surgery, etc. (Delli Ponti, 2015; Spanò et al., 2021; Cerchione et al., 2022).

Aceto et al. (2018) provided an explanation of e-healthcare and the use of IoT technologies, Big Data, and cloud computing in healthcare. They identified four types of interrelated ICT subsets: those involving ICT integration to support patient healthcare treatments; those that collect and process patient data; those that process and transform data into information; and those that facilitate clinical procedures. Ahsan and Siddique (2022) examined how healthcare and Industry 4.0 came together during the Covid-19 pandemic, addressing complex issues such as data security, resource allocation, and information transparency. Ohannessian et al. (2020) and Ye (2020) argued that the implementation The development of smart health tools based on new digital health applications (artificial intelligence, big data, 5G, Internet of Things, cloud computing technology, telemedicine services, and mobile health applications) have limited the spread of the pandemic.

A study by Cristofaro et al. (2021) assessed the impact of digital technologies on the management and delivery of healthcare services, highlighting that they have improved the efficiency and quality of care. Sakr and Elgamma (2016) analyzed how recent advances in ICT can be leveraged to improve the effectiveness of healthcare services and address new challenges. E-health is an emerging but promising field of study thanks to the intersection of information technology and medicine, with the possibility, as the authors argue, of having intelligent healthcare services at home and on the go, remote access to services, and rapid diagnoses.

Piscopo et al. (2023) and Melina et al. (2024) argue that telemedicine facilitates access to care, service efficiency, and patient well-being.

A study conducted by Tortorella et al. (2020) on a sample of 16 hospitals located in Brazil, India, Mexico and Argentina highlights that the ownership structure of hospitals is an important element in the correct use of e-health: the adoption of digital healthcare by public hospitals appears to be ahead of private facilities. There are also significant differences between university hospitals and those that are not: the former are more research-oriented, have a greater need to innovate processes and adopt new technological solutions, and, consequently, have greater resources to allocate to e-health implementation. Raimo et al. (2020) argue that larger hospitals are more likely to adopt and implement new digital solutions thanks to the availability of greater financial resources and human skills, sometimes more qualified, not only in terms of professional medical staff but also in the field of information technology. It is precisely size, measured in terms of beds and emergency room visits, that is the variable used to select the two hospitals studied in the research; for each of them, the most widespread digital technologies used were identified in order to generate a framework useful for guiding the transition from a traditional hospital to a smart hospital.

2.2 Smart hospital

Traditionally designed to support administrative workflows, increase productivity, reduce errors, and address staffing shortages, smart hospitals, thanks to significant advances in digital technology, now have more ambitious goals: they enable screening, early diagnosis, and remote follow-up. With the activation of nanodevices and the installation of wireless chips that deliver drugs into the body and remotely deliver personalized therapies, they achieve better therapeutic outcomes and enable hospitals to become more resilient in addressing challenges.

Smart hospitals offer healthcare services through functionally connected remote units, including other hospitals, clinics, care centers, and outpatient clinics. They extend to any location where the patient is located: home, work, and any other point of care. Naturally, these connected settings require significant requirements in terms of security and privacy, quality of service, data interoperability, and the availability of specific network infrastructures. In these, a significant amount of work is delegated to intelligent components that operate mostly independently, either inside or outside the facility. Consider electronic medical records, which allow access to patient histories and timely treatment decisions, facilitating diagnosis and treatment processes; devices that track patient location; and those that enable communication flows and interoperability across various spaces: operating rooms, wards, and outpatient clinics (Holland et al., 2021).

Smart hospitals can be defined as an integration of advanced technologies that facilitate interaction between doctors, staff, and patients (Rajaei et al., 2023).

In smart hospitals, precision surgical procedures such as minimally invasive procedures performed by robotic surgery enable complex procedures to be performed with greater accuracy and safety, reducing the risks associated with traditional surgery and offering potential benefits to the patient: shorter hospital stays, mild surgical trauma, minimal postoperative pain with the potential for faster recovery times and a reduced risk of complications from infections or bleeding.

Other digital tools of interest to smart hospitals include diagnostic imaging, 3D printing, remote monitoring via videoconferencing and wearable devices, GPS tracking, and health apps; each of these tools aims to put the patient at the center, making them the protagonists of their own well-being, in accordance with the digital healthcare model and reducing the risk of hospitalization (Kaldoudi, 2024).

Leng et al. (2020) analyze the most widely used digital technologies in hospitals, paying particular attention to tools that leverage Radio Frequency Identification (RFID), such as blood sampling and testing equipment and smart bandages capable of providing information on blood pressure, temperature, and other values.

A particularly important key element refers to the use of information and communication technologies (ICT). Consider IoT devices, which can collect patient data and send it to healthcare workers, reducing human interaction and increasing productivity. In traditional hospitals, delays in collecting and processing patient health data negatively impact their already critical conditions. Smart hospitals avoid these problems because the data health data collected in significantly large quantities enables important analyses to support personalized risk prediction, timely and accurate diagnosis, and precision therapy, thus improving overall healthcare (Kwon et al., 2022; Lin et al., 2024; Hu et al., 2022). Automated ICT processes, as Frost and Sullivan (2017) and Taylor (2017) argue, improve patient treatment procedures by continually predicting new ones.

A publication examining the implementation of telemedicine in 53 European countries defines smart hospitals as innovative facilities that get closer to the patient in the most effective way by bridging geo-territorial distances, overcoming the limitations of traditional hospitals thanks to the use of various Industry 4.0-related technologies (Dukhanin et al., 2018). Services delivered via telemedicine have revolutionized healthcare by improving accessibility, effectiveness, and efficiency for both patients and physicians. There is no shortage of obstacles that sometimes prevent its complete implementation: reliable and secure technological infrastructure, high-speed internet, and advanced software.

Composed of various innovative and advanced technologies, the smart hospital is the model of a hospital that, thanks to digitalization, overcomes many of the limitations of traditional hospitals, ensuring quality healthcare services and adequate health standards for citizens. Data is the fuel that drives them, allowing them to function efficiently and effectively with increasingly personalized and high-quality care.

There is no widely agreed-upon definition of the concept of a smart hospital. In the literature, each author analyzes and describes it, taking into account the digital technologies used (Table 1). This research seeks to bridge this gap and defines the smart hospital as an integration of advanced

technologies or as the hospital of the future, without borders, allowing anyone who needs them, including other hospitals, to use services via functionally connected remote units. It is a more data-driven infrastructure than traditional healthcare, as well as one of the areas of development on which many countries are focusing their attention to ensure high-quality healthcare that is efficient, increases patient satisfaction, promotes operational fluidity, and facilitates comprehensive information management within and beyond the hospital, connecting it to a broader healthcare ecosystem (Biancone et al., 2019; Hollander and Carr, 2020; Au-Yong-Oliveira et al., 2021; Kröner et al., 2023).

The literature review, combined with the two case studies analyzed, has allowed us to identify the digital technologies in which smart hospitals are investing. These, summarized in the framework shown in Table 1, are suggested as the main drivers for distinguishing a smart hospital from a traditional hospital

Table 1 – Different definitions of smart hospital

Author	Definition
Frost and Sullivan (2017)	A hospital that improves the patient care process using ICT, optimizes resource management, and utilizes an automation process
Taylor (2017)	A facility that optimizes the ICT environment and establishes an automated process to improve diagnostic and treatment procedures in patient care, continually anticipating new ones.
Dukhanin *et al.* (2018)	A hospital that has revolutionized the way healthcare is delivered with telemedicine, improving accessibility, effectiveness, and efficiency for both patients and physicians
Leng *et al*. (2020)	A facility that, thanks to RFID technologies, ensures safe patient care and efficient hospital management
Holland *et al*. (2021)	A hospital that has the potential to facilitate healthcare delivery from patient admission to discharge, where a significant amount of work is delegated to intelligent components that operate mostly independently within or outside the facility.
Cheng et al. (2022) and Hu et al. (2022)	A facility that uses digital technologies to offer personalized care, real-time patient monitoring, and information based on a significant amount of data
Rajaei *et al*. (2023)	A hospital that integrates advanced technologies that facilitate interaction between physicians, staff, and patients.
Kaldoudi (2024)	A facility that puts the patient at the center, making them the protagonists of their own well-being by reducing the risk of hospitalization
Kwon et al 2022; Lin et al., 2024	A facility capable of collecting significantly large amounts of health data.

Source: *Our elaboration*

2.3 Theoretical Framework

To better understand the adoption of digital technologies in different healthcare contexts, this study adopts Institutional Theory as a theoretical lens. According to this theory, organizational decisions are influenced not only by considerations of technical efficiency but also by the need for legitimacy within their institutional context (DiMaggio & Powell, 1983).

Within the healthcare sector, the transition to a "smart" model is affected by various institutional pressures. This perspective is particularly pertinent to our comparative analysis: public hospitals typically respond to "coercive" pressures arising from government regulations, regional health policies, and national digitalization initiatives. In contrast, private organizations may be more susceptible to "mimetic" and "normative" pressures, aiming to align with international best practices and global standards of excellence, such as Newsweek's "World's Best Smart Hospitals" ranking, to maintain a competitive advantage and enhance professional prestige.

Therefore, applying this theoretical framework, the research goes beyond a simple technical description of the digital tools most used by the two facilities and focuses on the different institutional characteristics they have. It shows how their regulation varies according to their public or private nature, thus influencing their respective paths toward the "smart hospital" model.

3. Methodology

In order to ensure a holistic understanding of the digital technologies used by the two hospitals, the methodology adopted follows the case study approach (Stake, 1995; Yin, 2018), combining primary data, secondary data and documentary sources. This qualitative approach is particularly suitable for investigating complex phenomena within their real-life context, where the boundaries between phenomenon and context are not clearly evident (Yin, 2009; Harrison et al., 2017). This methodology combines various data collection methods, including questionnaires, interviews, and observations (Eisenhardt, 1989).

Specifically, the study employs a multiple case study design, focusing on two prominent Italian healthcare facilities: a public hospital and a private hospital.

The research opted for multiple case studies because they are considered more reliable than single-case studies and because they are more appropriate for the purpose of the study. They allow for the comparison of contextual variables, which adds value to the literature and allows for a more complete and rigorous view of the observed phenomenon (Urbinati et al., 2019; Mele et al., 2024). This helps develop more robust and testable theories (Tortorella et al., 2022).

The focus was on two Italian hospitals considered best performers according to the smart health ranking developed by the international weekly magazine Newsweek, in collaboration with the research firm Statista. This international ranking, in this case, comprises 350 hospitals from 28 different countries worldwide, ranked as the best smart hospitals that have distinguished themselves in the use of advanced digital technologies.

The two hospitals were selected because they had similar bed capacities and emergency room visits, and the most widely used digital technologies were identified for each (Biancone et al., 2023). To protect the confidentiality of the information collected, the two hospitals were designated Private Smart Hospital and Public Smart Hospital.

The Private Smart Hospital is a facility affiliated with the National Health Service. Located in northern Italy, it offers over 50 clinical specialties and approximately 800 beds. It admits approximately 40,000 patients annually, with an average of 200 patients visiting the emergency room each day. It is a highly specialized hospital, a research center, and a university teaching facility; it invests heavily in digital soft skills to drive innovation and digital transformation. The Private Smart Hospital is a global benchmark for research into immune system diseases. The Private Smart Hospital

also hosts a Foundation whose primary goal is to promote the quality of life of patients and their families. The National Agency for Regional Health Services (Agenas) has named the Private Smart Hospital one of the best accredited private hospitals in Italy, thanks to its ongoing commitment to providing digital healthcare services that enhance prevention, diagnosis, and treatment processes. The Private Smart Hospital houses an Artificial Intelligence Center staffed by a multidisciplinary team of engineers, data scientists, bioinformaticians, and physicians. Through data analysis and machine learning, they are able to provide personalized patient care, rapid diagnoses, precise and effective interventions, and effective management of patient flows entering and exiting the facility. The Private Smart Hospital has specialized centers for the treatment of cancer, cardiovascular, neurological, and orthopedic diseases, as well as an eye care center and a fertility center. During the pandemic, the Private Smart Hospital expanded its telemedicine services, ensuring continuity of care remotely. It is present on major social media networks, and some services can be accessed simply via a mobile app.

The Public Smart Hospital is a public facility located in central and southern Italy. It operates within the Italian National Health Service as a highly specialized hospital and is recognized as an Institute for Research, Hospitalization and Treatment (IRCCS). It has approximately 900 beds and over 50 clinical specialties; it is one of the largest and most important hospitals in Italy. On average, it records 50,000 hospitalizations each year, with nearly 200 emergency room visits per day. It is a key player in healthcare both nationally and internationally. Since 2010, the Public Smart Hospital has been using a robotic platform used by several functionally connected operating units. It also conducts clinical research, focusing in particular on genetics and hereditary-familial diseases. It is considered one of the smartest hospitals in central and southern Italy, where technological and digital innovation applied to clinical practice, research, and patient services represent a key value, a fundamental resource for improving the quality and safety of prevention, diagnosis, and treatment processes. The Public Smart Hospital also stands out for its commitment to environmental and local sustainability. It has long implemented a series of initiatives to optimize and reduce energy consumption and efficiently manage waste

3.1 Data Collection and Analysis

The research used primary data and secondary sources (Eisenhardt, 1989). Primary data were collected using a semi-structured questionnaire. To avoid some anomalies that typically occur when questionnaires are administered over extended periods (Raimo et al., 2023), the research was conducted over a short time frame from January 2025 to March 2025.

As Raimo et al. (2023) suggest, the digital transformation of hospitals is a broad and complex phenomenon, and as such, it cannot be described or circumscribed by a single element, but rather by identifying multiple elements. Therefore, to understand the digital technologies integrated into medical treatments and administrative processes at the two selected hospitals, we drew inspiration from a Deloitte study (2020) analyzing the main digital technologies adopted by Italian hospitals and from research by Aceto et al. (2018) and Tortorella et al. (2022) which analyze healthcare paradigms based on the most widespread ICT technologies. The technologies thus identified have been listed and grouped into four thematic areas (Table 2).

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Table 2 - Most widespread digital technologies

Patient Follow-up	1	Electronic medical records	Deloitte (2020); Tortorella *et al.* (2022)
	2	On line booking	Our elaboration
	3	On line reports	Our elaboration
	4	Tele monitoring	Tortorella *et al.* (2022)
	5	Wireless Body Area Network	Aceto *et al.* (2018); Tortorella *et al.* (2022)
Diagnosis Patient	6	Voice recognition tools	Deloitte (2020)
	7	On line emergency room monitoring system	Our elaboration
	8	Digital symptom screening	Tortorella *et al.* (2022)
	9	Diagnostic imaging	Our elaboration
	10	Virtual reality	Deloitte (2020)
	11	Tele visit-teleconsultation	Our elaboration
	12	Test al point-of-care	Deloitte (2020); Tortorella *et al.* (2022)
	13	Digital genomic data analysis	Deloitte (2020)
Patient Treatment	14	Digital prescription	Deloitte (2020); Tortorella *et al.* (2022)
	15	Virtual reality diagnostics	Deloitte (2020)
	16	Non invasive digital medical techniques	Tortorella *et al.* (2022)
	17	Health apps	Deloitte (2020)
	18	Telesurgery	Our elaboration
	19	Robotic surgery	Deloitte (2020); Aceto *et al.* (2018)
	20	Wireless Body Area Network	Aceto *et al.* (2018); Tortorella *et al.* (2022)
	21	3D printing	Aceto *et al.* (2018)
	22	Drug delivery automation systems	Deloitte (2020)
Supply Chain	23	Digital platforms for managing medical supply procurement	Tortorella *et al.* (2022)
	24	Radio frequency identification technology for material and product traceability	Deloitte (2020)
	25	Cloud computing	Aceto *et al.* (2018)
	26	Wireless sensor network technologies	Aceto *et al.* (2018)
	27	Online platforms	Deloitte (2020)

Source: *Our elaboration*

The semi-structured questionnaire included a question for each digital technology rated on a scale of 0 to 5, where 0 indicates the absence of digital technology and 5 represents its complete and continuous use.

Secondary sources analyzed websites, press releases, and, where available, service charters, codes of ethics, impact reports, and documents relating to collaboration with universities and/or research centers. The analysis of these documents yielded information that, as the literature maintains, provides insights that are difficult to access quickly (Stake, 1995).

The different data sources were collected to ensure effective triangulation and to obtain results that are reliable, accurate, and valid for the research (Carter et al., 2014; Patton, 1999).

4. Results

An analysis of the sources analyzed shows that in both the Private and Public smart hospitals, the pandemic has accelerated the opportunity for a digital transformation already underway, aimed at improving the quality and effectiveness of services provided and patient well-being. The digital technologies present in the two hospitals are largely similar in all four thematic areas, with some peculiarities regarding certain medical treatments and/or administrative processes. Both facilities employ innovative technologies ranging from telemedicine, teleconsultations for remote prescriptions, telemonitoring, robotic surgery systems, IoT sensors, virtual information desks, contact centers, and digital assistants. Digital platforms and mobile applications are widely used, simplifying access to healthcare information and allowing patients to interact with the facility quickly and securely. Particular emphasis is placed on follow-up services. Additionally, the strong emphasis on technological innovation in both hospitals confirms that the digital technologies utilized are largely consistent with those identified by the primary sources.

However, it is clear that private smart hospitals are more advanced in the use of certain digital technologies that are part of the supply chain and patient diagnosis, whereas public smart hospitals are more advanced in those that are part of patient treatment and follow-up.

Therefore, consistent with what the literature suggests, we can say that private smart hospitals offer a greater opportunity to reduce waste by improving efficiency, thus enhancing the resilience of the facilities (Tortorella et al., 2022; Chatterjee et al., 2023; Islam and Habib, 2024). Furthermore, the ability to provide timely, accurate, and personalized solutions, overcoming the barriers of traditional hospitals, fosters predictive medicine, improves patient well-being, and improves overall health management (Hah and Goldin, 2021; Tilahun et al., 2021).

In smart public hospitals, the focus on continuous care theoretically aims to ensure more effective, safe, and faster care through interdisciplinary teamwork (Ayo-Farai et al., 2024; Shaik et al., 2023). However, the research findings reveal a more complex reality: despite the adoption of similar technologies, the public sector shows lower operational efficiency and speed of integration than the private sector.

This discrepancy confirms what institutional theory suggests. In public hospitals, digitization is predominantly driven by coercive pressures, such as regulatory obligations and national mandates, which often lead to purely “formal” and slower integration, aimed at meeting transparency and standardization requirements rather than process optimization (Meyer & Rowan, 1977; Westphal et al., 1997). In contrast, the private sector responds to strategic mimetic and regulatory pressures. Aligning themselves with international standards such as the “Newsweek World’s Best Smart Hospitals” ranking, private institutions are adopting more “agile” and systematic digitization. This approach, geared toward competitive differentiation and clinical resilience, enables private facilities to be more efficient, flexible and high-performing in the global healthcare market (Liang et al., 2007; Tortorella et al., 2020).

The findings reveal that both public and private hospitals have adopted a diverse array of similar “smart” technologies, including AI-driven diagnostics, robotic surgery, and electronic medical records. However, the underlying motivations and outcomes of these implementations are shaped by distinct institutional pressures, leading to different patterns of digital maturity.

The private hospital, ranked at the top of the national assessment, demonstrates a “Digital Ubiquity” model. In this case, technology adoption appears as a strategic response to mimetic and

normative pressures. By aligning with internationally established standards, such as the Newsweek World's Best Smart Hospitals ranking, the private institution aims to maintain its status and legitimacy as a center of excellence. Consequently, its digital transformation is deeply oriented towards process efficiency and service personalization. By leveraging cloud computing and AI-based diagnostics, the private hospital offers timely, accurate, and highly personalized solutions for each patient, allowing the facility to reduce waste and optimize patient flow.

On the other hand, the public hospital demonstrates a different but equally vital strategic focus, predominantly influenced by coercive pressures. In this context, digitization is driven by the necessity to comply with national mandates and public policy frameworks. Rather than focusing solely on market differentiation, the public hospital uses digital innovation to ensure continuity of care and clinical resilience, overcoming structural barriers to reach a broader and more diverse patient population.

This confirms that, while the private sector leads in personalization and high operational performance, the public sector achieves excellence through clinical innovation aimed at managing long-term patient health, where digital innovation is deeply embedded in specialized medical care and post-acute care. Ultimately, the analysis of primary and secondary sources leads to the conclusion that there is no single smart hospital model; rather, each institution develops specific digital strengths based on its institutional mission and the external pressures it faces.

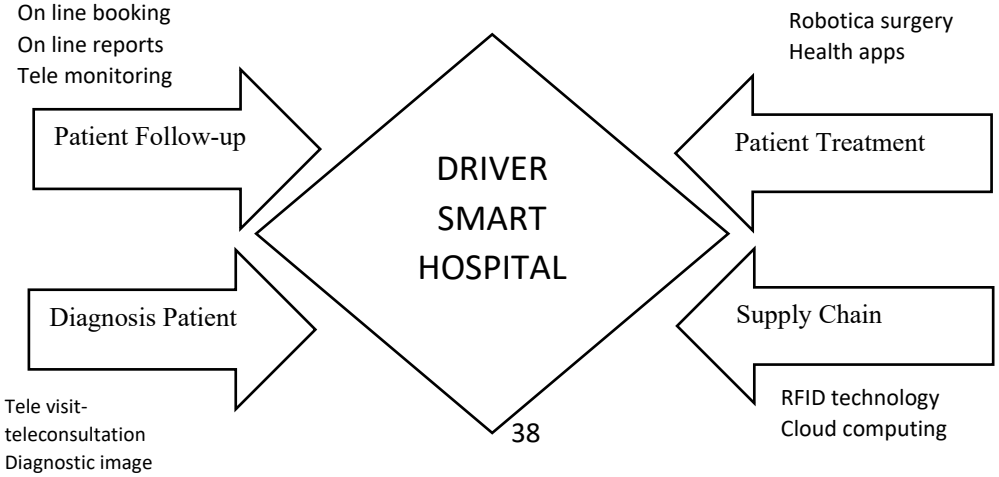
In both selected facilities, to fully realize the true potential of the smart hospital, it is advisable not to consider the digital technologies identified from time to time as separate entities; rather, they should interact to optimize healthcare processes and improve the quality of care. This does not mean using multiple technologies in a single hospital, but rather allowing them to interact to achieve synergistic benefits. By addressing the challenges and exploiting the opportunities this brings, smart hospitals will contribute to creating a more efficient, equitable, and patient-centered healthcare system.

The framework developed in Figure 1 summarizes the digital technologies included in the four most widespread thematic areas between the two hospitals, which the research suggests should be considered the main drivers for identifying a smart hospital versus a traditional hospital.

Specifically, the patient follow-up area includes digital technologies aimed at ensuring effective continuity of care, such as remote monitoring, online booking, and online reporting. The patient diagnosis area includes technologies that support the assessment of clinical conditions through advanced tools, such as diagnostic imaging and teleconsultations. The patient treatment category encompasses innovations in care delivery, including robotic surgery and medical applications. Finally, the supply chain area involves digital technologies that optimize hospital procurement and logistics, such as RFID for traceability and cloud computing for data management.

The framework is intended to be a valuable tool for both those in leadership positions, to guide them in their hospitals' digitalization decisions, defining priorities in e-health 4.0 and investing in certain technologies over others, and for citizens, who can choose where to seek treatment, taking into account the characteristics that make one hospital smarter than another.

Figure 1 – Smart hospital



Source: *Our elaboration*

6. Conclusions, implications and future developments

While the process of digital transformation has made hospitals more responsive to the crisis, it has also exposed a significant socio-digital divide, where the isolated technological initiative of some leading and cutting-edge countries in digital healthcare has contrasted with the widespread, endemic delays of others. The digital transformation in healthcare has opened the door to a more equitable, accessible, and humanized future of healthcare, where individuals travel less, while data and expertise travel. This is a primary social and economic challenge aimed at providing patients with a superior patient experience, limiting access to facilities to only the most complex cases that cannot be managed online with a more rational use of resources.

The convergence of technology and healthcare has created a new dimension of healthcare 4.0, namely e-health, within which a new definition of hospital is taking shape: the smart hospital.

In the literature, the concept of smart hospital has not been rigorously defined and there is no widely shared definition for it. Research has contributed to filling this gap by identifying the attributes of an intelligent or smart hospital to propose a definition for it on the basis of these. In agreement with some studies Arora and Sharma (2022), Rajaei et al. (2023), Kaldoudi, (2024), Dadkhah et al. (2022), Cheng et al. (2022) who have referred to the importance of digital technologies in the definition of a smart hospital, we define smart hospitals as the hospitals of the future that use cutting-edge innovative solutions to provide increasingly personalized and high-quality healthcare where data exchange takes place via remote units functionally connected quickly and in significantly broader size, enabling preventive healthcare management beyond the physical confines of existing hospitals. Smart hospitals are not limited to the implementation of new technologies; they usher in a structural revolution, redefining the relationship between patients and healthcare facilities.

To study smart hospitals and identify the most widely used digital technologies, the research adopted a qualitative case study methodology. The focus was on two Italian hospitals, one public and one private, considered best performers according to the Newsweek smart health rankings.

The data collection and analysis process yields information that, consistent with the literature, allows us to affirm that there is no single smart hospital model, as each facility reinforces the idea of a smart hospital by focusing on certain technologies rather than others. True potential is achieved when the adopted technologies, rather than being treated as separate entities, interact with each other, creating an ecosystem of digital solutions that maximize healthcare benefits. The future of smart hospitals is promising. Digital technologies are expected to continue to evolve rapidly. Telemedicine, robotic surgery, and remote digital services will become increasingly widespread.

The developed framework summarizes the most widespread digital technologies at the two hospitals, which the research suggests should be considered the primary drivers for guiding hospitals toward e-health 4.0.

From the perspective of institutional theory, the “Smart Hospital” model cannot be regarded as a universally applicable solution; rather, it is shaped by management practices and regulatory frameworks that vary according to the public or private status of hospitals. The distinct characteristics of public hospitals indicate that their digital transformation is primarily driven by coercive pressures, thereby serving as a mechanism to enhance public service efficiency and ensure compliance with national policies. Conversely, the attributes of private hospitals allow for a more market-oriented approach to innovation, wherein digital technologies are employed as a strategic competitive differentiator.

These divergent pathways underscore the significant impact of institutional environments on the prioritization of smart attributes, shifting the focus from mere technical efficiency toward a broader pursuit of organizational legitimacy. The originality of this work lies in both the proposed

comprehensive definition of smart hospitals and the development of an accessible framework for digital transition. By bridging the gap between technical implementation and institutional theory, these findings expand the existing knowledge of the phenomenon, offering significant theoretical and practical implications for healthcare managers and policymakers in navigating the complexities of Healthcare 4.0.

Theoretically, smart hospital combines the definition of healthcare excellence with the dissemination and implementation of digital tools and technologies, with the primary objective of ensuring patient health care in a universal and supportive manner. In this sense, digital healthcare and the smart hospital are the key to achieving the economic sustainability of healthcare.

Second, the findings contribute to the ongoing debate on the literature on smart hospitals, which remains underexplored. Finally, the results demonstrate that the development of digital healthcare is not limited to a specific, well-defined technological area, but involves various digital technologies. Indeed, the research highlights that there is no single smart hospital model, but rather a set of digital technologies that can be integrated into different hospital settings to improve the efficiency and quality of care.

On a practical level, smart hospitals represent the digital evolution of the healthcare sector; they streamline processes, reduce human errors, and improve efficiency thanks to a hyper-connected environment. Furthermore, they enhance diagnosis and treatment processes, significantly impacting patient health.

From a managerial and policy perspective, the analysis suggests that while private sector management should continue to leverage digital innovation as a primary driver for competitive differentiation, it is imperative for policymakers to reconfigure the regulatory frameworks governing public healthcare institutions. Such a transition necessitates a mitigation of bureaucratic and coercive pressures, fostering a more agile organizational environment that prioritizes operational efficiency and the systematic integration of performance-oriented technologies.

The digital technologies that research suggests should be considered as the main drivers of a smart hospital are useful for those in leadership positions to define priorities in e-health 4.0 and invest in some technologies rather than others.

While all of the above is sufficient to reinforce the idea of a smart hospital, it is not enough to support, promote, and facilitate it. To ensure effective implementation, it is essential to invest in training, digital security, and technology integration, avoiding a fragmented approach. The availability of adequate financial resources is the prerequisite and priority for the digital transformation of hospitals. Equally important is human capital, without whose contribution a smart hospital cannot be considered. In this context, it is necessary to develop ongoing training programs to improve staff skills and knowledge in relevant areas. Another issue requiring attention is data security, which emphasizes the need for solid digital skills (Kwon et al., 2022).

This work presents some limitations that could be addressed in the future. Specifically, it is difficult to generalise the findings due to the adoption of a qualitative methodology that uses an approach based on multiple exploratory case studies. Furthermore, it focuses exclusively on the Italian context, so the results may only be generalisable to other organizations located in similar socioeconomic contexts. In the future, it would also be useful to investigate the main barriers faced by less digitally advanced hospitals and the strategies to implement to foster a smart healthcare environment. Also, the comparative analysis is bounded by the specific institutional and regulatory frameworks of the Italian healthcare system. Future research should investigate if these institutional pressures operate similarly in different national contexts. Finally, it is essential to recognize an inherent limitation of this research: the comparison is drawn between a public hospital and a private hospital. This distinction is significant, as institutional and regulatory contexts can substantially influence organizational performance and behavior. Therefore, it is essential to investigate the impact of various regional and national regulatory reforms on the capacity of public hospitals to navigate coercive pressures, thereby facilitating a transition towards more agile and performance-oriented digitization comparable to that of the private sector.

In conclusion, the adoption of digital technologies in hospitals is a great opportunity to revolutionize the healthcare sector, and failing to seize it would be a strategic mistake for the future of patients and healthcare providers. Given the undeniable difficulties and complexities of e-health 4.0, we must not be discouraged, always keeping in mind that the benefits far outweigh the initial costs. The key to success lies in the ability to integrate new technologies into clinical and administrative processes, promoting a culture of technological and organizational innovation to redesign a more economically and socially sustainable healthcare system that can lead our country toward a new, higher-performing healthcare model. The time is ripe, but a change in mentality is needed to overcome ideological conflicts and particularisms by embracing the opportunities offered by smart hospitals, understood as a key determinant of citizens' health and well-being.

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