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Digital transformation in healthcare: Assessing the role of digital technologies for managerial support processes

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ABSTRACT

This study used Porter's value chain model within healthcare organizations and the technology–organization–environment framework to explore the impact of digital technologies on managerial and administrative support processes and identify the determinants of their adoption. We used the Delphi methodology to examine six categories of digital technologies (Internet of Things, artificial intelligence & machine learning, big data & business analytics, cloud storage & computing, social media, and blockchain). The study used an inductive qualitative approach involving 11 experts to gather opinions on the most impactful digital technologies and the factors that hinder or limit digital transformation. We found that the Internet of Things and artificial intelligence & machine learning have the most significant impact on administrative support processes in healthcare organizations. Blockchain was least relevant. The experts identified the skills and competencies of employees as the most crucial determinants for ensuring successful digital transformation. These results contribute to the literature on digital transformation in healthcare, which has previously mainly focused on the impact of technologies on clinical processes. The findings may also be useful to both policymakers and practitioners in determining priorities for investment in digital technologies and delivering successful implementation.

1. Introduction

Digital technologies (DTs) have been important in healthcare organizations since the 1990s, when the term 'e-health' was coined (Aceto et al., 2018). Marques and Ferreira (2020) suggested that digital transformation in healthcare has become steadily more relevant over the last two decades. In a recent study, Ferrigno et al. (2023) identified digital transformation as a future research area relevant to the topic of Industry 4.0. The application of DTs to support existing healthcare processes and treatments or to develop new ones has been termed Healthcare 4.0 (H4.0). This last is characterized by increasing levels of interconnectivity and automation, allowing a recontextualization of health service provision in the cyber-physical environment. This has consequences for both patient care and administrative support processes (Tortorella et al., 2022a). The COVID-19 pandemic accelerated the digital transformation of healthcare organizations (Cobianchi et al., 2020a, 2020b; Tortorella et al., 2021), leading approximately 65 % of healthcare organizations to increase the adoption of DTs as a way to provide enhanced assistance to patients (Deloitte, 2020).

Digitalization in healthcare builds on the assumption that exploiting the potential of these technologies provides advantages for both patients and healthcare professionals, but also organizations, in terms of enhanced efficiency and effectiveness (Marques and Ferreira, 2020; Kraus et al., 2021; Massaro, 2023). DTs allow the interaction and specialization of healthcare services for patients (Alloghani et al., 2018; Tortorella et al., 2020a), and can also completely reshape the decision-making processes of both clinicians and managers supporting the automation of data processes (Secundo et al., 2021; Spanò et al., 2021). This is especially relevant in healthcare, where professionals and managers currently have access to a large amount and variety of information from staff records, electronic patient records, clinical findings, diagnoses, prescription drugs, medical imaging procedures, and mobile health. The use of new DTs might therefore support the collection, processing, analysis, and management of these data to increase understanding and improve decision-making (El Morr and Ali Hassan, 2019; Ilangakoon et al., 2022).

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However, while this topic has been widely studied, there are still some gaps in the literature. First, scholars have tended to adopt a narrow perspective by exploring the use and adoption of specific DTs (Corny et al., 2020; Rolls et al., 2020). Limited attention has been paid to the general level of digital transformation and the drivers and barriers within healthcare (Raimo et al., 2023). Second, most articles exploring DT in healthcare have provided a conceptual analysis and literature review (Lehoux et al., 2017; Aceto et al., 2018). There is little empirical research assessing the impact of new DTs and the related barriers and drivers. Third, most studies have focused on the introduction of DTs to address specific clinical needs and processes (Corny et al., 2020; Rolls et al., 2020). There are very few studies exploring how the introduction of DTs might improve administrative and managerial processes (Behkami and Daim, 2012), also called support processes or support activities, which play a crucial role in healthcare organizations.

According to Porter (2001), 'support processes' support primary organizational activities and each other, providing purchased inputs, technology, human resources, and other organization-wide functions. Some of these may be associated with specific primary activities as well as supporting the entire value chain. Technology is embodied in every value activity within organizations, and technological change can affect competition through its impact on almost any activity (Porter, 1985). Porter's value chain model applied to healthcare organizations (Porter and Teisberg, 2006) divided support activities into 'primary support processes' (e.g., pharmacy, logistics, operations and patient flow logistics, and risk management) and 'secondary processes' (e.g. performance measurement and management, human resource management, information and communication technology, technology development, and procurement).

Both primary support and secondary processes have increasingly been considered crucial parts of the functioning of healthcare organizations. One of the most enduring reforms across western countries, following the wave of New Public Management, is the process of corporatization of public healthcare organizations (Kirkpatrick et al., 2017). Corporatization has increased the autonomy (in terms of decision-making and achievement of financial sustainability) of hospital trusts and local health authorities and therefore their level of accountability (in terms of responsibility for their actions and the requirements for justifying these actions) (Braithwaite et al., 2011). To respond to these increasing needs for autonomy and accountability, healthcare organizations started to strengthen their administrative and managerial capabilities through a process called managerialism (Fattore, 1999). The introduction of managerial systems, methods, and instruments was contraposed to the traditional logic of professional bureaucracies and required the establishment or development of new management and administrative functions (for example, management control, risk management, quality management, operations management, human resource management, information systems, and financial management) (Lega et al., 2013). Healthcare services are also public services (Batley and McLoughlin, 2015) and a crucial phenomenon is the increasing permeability of boundaries and interdependency between public and private sectors (Ferlie et al., 2007). This is especially true in countries where private providers are part of the healthcare system. The changing environment of corporatized public organizations generated increasing demand on management and administration especially where governments had established quasi-market systems (Krachler et al., 2022) and both public and private organizations could be accredited to offer public healthcare services to patients (Fattore, 1999). In these contexts, the increasing complexity of governments' requirements for delivering healthcare services and being reimbursed also required private providers to develop managerial and administrative skills.

The importance of administrative and managerial processes in healthcare organizations is therefore widely recognized. However, there is an internationally common trend in lowering the "administrative intensity", defined as the resources that an organization spends on administrative support functions rather than primary services and production processes (Elston and Dixon, 2020). Lower levels of administrative intensity can be considered a risk in the long term because they may not support primary activities through the development of new services and the improvement of clinical processes (Veronesi et al., 2023). In this context, new digital technologies may sustain administrative and managerial functions (Bilodeau et al., 2007; Veronesi et al., 2023).

This study therefore aimed to fill these gaps by answering the following research questions:

RQ1: *What is the impact of DTs on managerial and administrative support processes in healthcare organizations?*

RQ2: *What are the main determinants of the adoption of DTs for managerial and administrative support processes in healthcare organizations?*

The study used the Delphi methodology to examine six areas of DTs (the Internet of Things [IoT], artificial intelligence [AI] and machine learning, big data & business analytics, cloud computing, social media, and blockchain). These DTs were selected from previous studies as the most relevant for healthcare (Tortorella et al., 2020b, 2021; Robert, 2019; Schiavone et al., 2021; Engelhardt, 2017).

The study used an inductive, qualitative approach involving 11 experts providing opinions on the most impactful DTs and significant factors supporting or limiting digital transformation within the Italian National Health Service (INHS). We chose the Delphi approach for several reasons. First, this methodology has recently been applied to digital transformation issues (Berbel-Vera et al., 2022; Kaartemo and Nyström, 2021), because it has advantages for forecasting and predicting the challenges and dynamics of technology applications (Rowe et al., 1991; Winkler and Moser, 2016). Second, the Delphi methodology has a long tradition as a valid research technique in healthcare-related fields (Keeney et al., 2011). It has been often used to achieve consensus in the development of guidelines, protocols, and indicators in healthcare, especially when there is limited or insufficient available evidence (Noto et al., 2022; Rouse et al., 2024). It has also been used to consider innovation and digitalization (Shinners et al., 2021). We decided to focus on the INHS as the primary beneficiary, in absolute terms, of the two main investment programs of the European Commission, the Recovery and Resilience Facility plans and the REACT-EU plan, which involves several major national-level reforms to modernize and digitize the healthcare system (Cacciatore et al., 2024). Moreover, the context of the INHS retraces the characteristics of corporatization, managerialism, and quasi-market (Fattore, 1999) that influence the importance of administrative and managerial support services in public and private healthcare providers, along with the process of lowering administrative intensity (Vardè and Mennini, 2020).

To define the guideline for the interviews and analyze the determinants of digital transformation, we drew on the technology–organization–environment (TOE) framework (DePietro et al., 1990). This framework was considered suitable because it allows the inclusion of different elements that may influence the adoption of new DTs in an organization. We could therefore include both internal dynamics and the pressures of the external environment, and the specific characteristics of technology adoption. The flexibility of the framework's three dimensions is also useful for engaging experts in a semi-structured interview that allows other interesting elements of their opinions and experience to emerge that may not have been considered in the guideline questions.

In the next section, we review the literature on digital transformation in healthcare by focusing on technologies, impacts, and determinants. Section 3 describes the methodology used in the study. Section 4 presents the main findings and Section 5 discusses the results. Finally, we present the study's contributions and implications for research and practice.

2. Background

2.1. Digital transformation

DTs are revolutionizing how firms and organizations behave and operate, leading to the emerging concept of Industry 4.0 or the so-called 'smart factory' (Lasi et al., 2014; Dal Mas et al., 2020). They are affecting and transforming all industries, from manufacturers to service providers (including healthcare organizations) in both the private and public sectors (Greenstein et al., 2013; Fitzgerald et al., 2014). In 2019, companies around the world spent $2 trillion on DTs, >40 % of the global spend on technology (Appio et al., 2021). This spending was not even limited by the impact of the COVID-19 pandemic: 52 % of companies reported that they planned to limit investment because of the pandemic, but only 9 % cut expenditure on DTs (PwC, 2020).

The importance of digital transformation has also been recognized by academics. Scholars have long acknowledged technology as a major driver of organizational form and structure (Woodward, 1965; Scott, 1992). However, more recently the topic of 'digital transformation' has become very popular in business and management literature (Fitzgerald et al., 2014; Kane et al., 2015). Over the last few decades, several definitions have been provided for the concept of digital transformation, also known as 'digitalization' (Kraus et al., 2021). Fitzgerald et al. (2014, p. 2) defined it as 'the use of new DTs such as social media, mobile technology, analytics, or embedded devices to enable major business improvements including enhanced customer experiences, streamlined operations, or new business models'. Hess et al. (2016, p. 124) suggested that digital transformation is 'concerned with the changes DTs can bring about in a company's business model, […] products or organizational structures'. Vial (2019, p. 118) proposed a working definition of digital transformation as the 'process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies'. Digital transformation is therefore the innovative use of emerging information and communication technologies, which causes organizational change that aims to improve existing processes or initiate new ones (Pihir et al., 2019). Digital transformation concerns both the use of disruptive DTs, and organizational transformation of capabilities, structures, processes and business model components (Ancillai et al., 2023; Dell'Era et al., 2020).

Focusing on the type of DTs, recent reviews of studies on digital transformation (Vial, 2019; Hausberg et al., 2019) suggested that major technological areas enabling digital transformation are diverse and traditionally called 'general purpose technologies'. The most common technologies include social networks (Li et al., 2017), mobile devices (Pousttchi et al., 2015), big data and analytics (Günther et al., 2017), cloud computing (Clohessy et al., 2017), the IoT (Harbert, 2017), the AI (Duan et al., 2019) and platforms (De Reuver et al., 2018). The categories of internet (Lyytinen and Rose, 2003), software (Setia et al., 2013), and blockchain (Glaser, 2017) are seldom involved. These DTs are considered to be inherently disruptive (Karimi and Walter, 2015) because they are 'game changers' that cause disruption in consumer behavior and expectations, the competitive landscape, and the availability of data (Vial, 2019).

Digital transformation is change in how a firm employs DTs to modify key business operations, products, processes, and organizational structures, with the aim to develop management practices to govern the digitalization (Reis et al., 2018; Matt et al., 2015). The challenges for companies therefore include both exploring and exploiting new technologies, and making the necessary organizational changes. This involves a distinction between the terms 'digital transformation' or 'digitalization', and 'digitization'. Digital transformation is the changes and impact on the organization arising from the use of DTs, and digitization is the shift from analog to digital solutions (Hess et al., 2016). The real challenge of digital transformation for firms 'is not to add a digital touch to current practices and products, but to fully exploit DTs' transformative potential' (Steiber et al., 2021, p. 799). Kraus et al. (2021, p. 4) stated that digital transformation 'comprises the understandability to take the required actions when organizations face new technologies'. Digital transformation is therefore a complex issue encompassing both adoption of new technology and digitization of resources, and a shift in thinking, a change in leadership and an acceptance of innovation (Diener and Špaček, 2021). This involves looking at the challenges advanced by digital disruption as an organizational and managerial problem, as well as a technical one (Dell'Era et al., 2020).

2.2. Digital technologies: impacts and determinants in the healthcare sector

Digital transformation has become increasingly prevalent in healthcare, as the sector faces mounting pressure to improve patient outcomes, reduce costs, and enhance overall efficiency (Marques and Ferreira, 2020; Kraus et al., 2021; Massaro, 2023). In the healthcare environment, digital transformation is the use of technology to automate processes, enhance communication, and improve the delivery of healthcare services. The term is used to describe the adoption of new technologies that enable the shift towards secure and high-quality care (Secundo et al., 2018; Saifudin et al., 2021).

Looking at the specific technologies involved in the digital transformation processes of healthcare organizations, the main tools are big data, the IoT, biomedical/digital sensors, cloud computing, remote control or monitoring, collaborative robots, augmented reality, 3D printing, and AI and machine learning (Tortorella et al., 2020a). Perhaps the most widely used of these are biomedical/digital sensors and cloud computing (Eze et al., 2020; Garai et al., 2017), followed by the IoT and big data (Spanò and Ginesti, 2022; Tortorella et al., 2020a,b; Wehrens et al., 2020).

Studies have explored the possible advantages of using these technologies within healthcare organizations. They have found that the increased use of new technologies in healthcare deeply affected activities from the delivery of care to the management of patient data. Dal Mas et al. (2023) carried out a systematic literature review and identified several types of impact from digital transformation in healthcare. These included significant impacts on: a) patient data management, supported by the use of electronic health records (EHRs) (Häyrinen et al., 2008); b) care delivery (Arpaia et al., 2021; Sageena et al., 2021; Boussif et al., 2020), with improvement in medical diagnosis (medical imaging technologies such as X-rays and CT scans) and treatment (telemedicine or precision medicine); c) healthcare operations, particularly in areas such as supply chain management, inventory management, and patient billing (Moons et al., 2019; Hong and Lee, 2017; Laurenza et al., 2018); d) costs, because technologies can improve efficiency in healthcare operations, reducing costs associated with manual processes (Masuda et al., 2021; Stephanie and Sharma, 2020); and e) communication, because of the improved information exchange between healthcare providers and patients (telemedicine), and between different healthcare providers (Kraus et al., 2021; Garcia Vazquez et al., 2020; Ting et al., 2020).

The literature related to DTs in the healthcare sector also covers the factors influencing their adoption within healthcare organizations. Studies have found a variety of obstacles and incentives that play crucial roles in either promoting or impeding digital transformation (Greenhalgh et al., 2010; Kraus et al., 2021; Thijssen et al., 2023). Following the TOE conceptualization of technology adoption determinants (DePietro et al., 1990), the barriers and determinants of digital transformation in healthcare can be categorized into four main themes: a) organizational, such as leadership commitment, organizational culture, and organizational readiness (Sony et al., 2023; Tortorella et al., 2022b); b) technological, such as IT infrastructure, and interoperability (Kraus et al., 2021); c) regulatory barriers to data use (Kraus et al., 2021; Haggerty, 2017; Imison et al., 2016), and d) environmental determinants, such as the availability of resources (e.g.

finance, skills, information and tools) or the presence of a multi-channel environment that allows continuous interaction among stakeholders through mobile platforms (Thijssen et al., 2023; Kraus et al., 2021). Overall, these studies predominantly concentrated on the use of DTs to enhance the delivery of healthcare services (i.e. primary processes). There is little or no analysis of the determinants related to secondary processes.

2.3. Digital transformation and the healthcare value chain

Digital transformation in healthcare is therefore promising and several articles have explored the potential to use DTs in addressing clinical needs (Corny et al., 2020; Rolls et al., 2020). Scholars have suggested that DTs are mainly used for patient diagnosis, treatment, and follow-up (Tortorella et al., 2022b). In particular, the IoT, big data, and cloud computing are often used to gather and control information about patients' daily life processes and vital parameters, such as blood pressure, heart rate, and body fat (Tortorella et al., 2020a). AI and machine learning are often used to predict patients' conditions, allow early detection, and prevent adverse events (Robert, 2019; Leone et al., 2021; Schiavone et al., 2021).

Tortorella et al. (2020a) stated that in healthcare there are two main distinct domains of digital transformation application: health treatments and hospital support processes. The former is patient treatment and care, including therapy, diagnosis, and surgical practices (Wolf and Scholze, 2017; Ciuti et al., 2016; Malik et al., 2018). The latter includes all managerial back-office processes that support the provision of care, such as financial transactions (Alharbi et al., 2016), equipment maintenance (Gomez and Carnero, 2011), and the management of drugs (Agha, 2014). Studies have shown that introducing digitalization to the administrative core is vitally important, and an essential component of H4.0 (De Sousa Jabbour et al., 2018; Laubengaier et al., 2022; Xu et al., 2018). These emerging DTs can contribute to the improvement of healthcare decision-making by allowing the collection, management and analysis of new and large sets of data (Kamble et al., 2019; Hasselgren et al., 2020; Secundo et al., 2021; Marrone and Hazelton, 2019). However, it is also important to empirically analyze how the introduction of DTs might improve administrative support processes and the related decision-making (Behkami and Daim, 2012). All activities along the care delivery path, including support processes, can generate value for patients (Kaplan and Porter, 2011).

The value chain model developed by Porter (2001) identifies two typologies of activities characterizing production processes of any organization: primary and secondary (or support) activities. This conceptualization was further advanced by Porter and Teisberg (2006) to adapt it to the healthcare sector. There, primary processes can be split into two different categories: i) primary production processes, in which the role of frontline clinicians is fundamental to the delivery of healthcare services along clinical pathways (e.g. diagnosing, preparing, and intervening), and ii) primary support processes (both clinical and management) that mainly concern the internal operations that are relevant to accessing clinical pathways (e.g., pharmacy, logistics, operations and patient flow logistics, and risk management). Secondary processes are mainly managerial and administrative processes (e.g. performance measurement and management, human resource management, information and communication technology, technology development, and procurement) that are instrumental in ensuring the functioning of healthcare organizations (Porter and Teisberg, 2006; Kaplan and Porter, 2011). Porter and Teisberg (2006) identified three macro-categories of support processes (given that accessing was included among primary clinical support processes), i.e. measuring, informing, and knowledge development. They referred to individual patients' conditions, but we believe that this taxonomy can be applied to a broader organizational view, taking into account a population-value perspective (Gray, 2017). As such, measuring concerns both the measurement of patients' medical circumstance (e.g. patient record management), and also individual and population outcomes achieved in terms of quality of care and other relevant performance dimensions. Informing is activities involved in notifying, educating and coaching patients and the wider population, and knowledge development encompasses the empowerment of process improvement activities.

The next section assesses the impact of DTs on managerial and administrative support processes in healthcare organizations (RQ1) and its main determinants (RQ2). It describes the development of a Delphi study, a suitable approach for forecasting and predicting the challenges and dynamics of technology applications (Shinners et al., 2021; Berbel-Vera et al., 2022). It explains that we relied on experts' opinions to catch the impact of DTs on both 'primary support processes' focused on managerial and operational issues (e.g., pharmacy, logistics, operations and patient flow logistics, risk management; excluding clinical support services such as radiology or nuclear medicine) and 'secondary processes' (e.g. performance measurement and management, human resource management, information and communication technology, technology development, procurement). We focused on six categories of technology (Table 1) that previous studies have shown are most relevant in the healthcare setting (Tortorella et al., 2020b, 2021; Robert, 2019; Engelhardt, 2017).

3. Method

3.1. Empirical setting

This study's empirical setting is the INHS. This is a regional-based system adopting a Beveridge financing model (De Belvis et al., 2022) and has been described as one of the best performers in terms of spending and outcomes (OECD, 2021). The two next subsections provide an overview of the peculiarities of the service's governance structure and digitalization.

3.1.1. The Italian NHS's governance structure

Since the 1990s, reforms have increased the autonomy of the 21 regions of the INHS at the expense of the central government. Following the New Public Management policies, the INHS has also undergone a

Table 1
Main digital technologies in healthcare.

Digital technologies	Description
Internet of Things (IoT)	The networking of physical objects using embedded sensors and other devices that collect and transmit information about real-time activity within the network (Harbert, 2017)
AI & machine learning	The ability of a machine to learn from experience, adjust to new inputs and perform human-like tasks. AI systems can be used either to support/assist human decision-makers or to replace them (Duan et al., 2019). Within the AI field, machine learning produces predictions that AI technologies can use to take actions.
Big data & analytics	The processing of huge amounts of data coming from different sources in different formats to acquire intelligence. It can be viewed as a sub-process in the overall process of insight extraction from big data (Gandomi and Haider, 2015)
Social media	An umbrella term and a revolutionary trend of online blogs, micro-blogs, social networking, forums, collaborative projects and the sharing of photos and videos (Xu et al., 2019)
Blockchain	A distributed peer-to-peer ledger that provides a way for information to be recorded, secured, aggregated and shared within a heterogeneous community of participants (Felin and Lakhani, 2018)
Cloud storage & computing	An approach to information sharing or services on both Internet and Intranet. Clients can decide what information or services they are going to use, depending on their demands (Gai and Li, 2012). Cloud storage is a service model in which data is transmitted and stored on remote storage systems, where it is maintained, managed, backed up and made available to users over a network.

period of major changes, characterized by: a) corporatization of public healthcare organizations, b) introduction of managerialism, and c) quasi-competition in provision of health services (Fattore, 1999).

Local health authorities and hospital trusts have full responsibility for budgeting, financing, and operations management, as if they were corporate bodies. Local health authorities oversee the delivery and/or commissioning (from other public and private providers) of healthcare services for the residents of their catchment area. Several managerial systems and tools have been introduced by law into both local health authorities and hospital trusts (Fattore, 1999). These include budgeting and managerial control, and new accounting systems. The main emphasis has been on the economic sustainability and accountability of healthcare organizations. Other managerial functions were therefore also expected to be developed, such as quality control, information systems, strategic human resource management, and communications.

The implementation of a prospective payment system in a quasi-market framework reinforced the need for administrative and managerial systems and tools in both public and private healthcare organizations. These organizations have gradually abandoned a bureaucratic style in favor of higher administrative flexibility and greater responsibility for results (Del Vecchio and De Pietro, 2011). At the same time, regional healthcare systems have been challenged by several issues such as financial imbalances, the divide between northern and southern regions, and the slowdown of public financing. Several reforms have been adopted to regain financial sustainability and half of the regional healthcare systems have been subject to financial recovery programs. All these factors have meant that the administrative intensity in healthcare organizations has started to decrease, with several consequences for the reduction of turnover in administrative and managerial roles. From 2001 to 2015, INHS had a reduction of 38.6 % in the heads of administrative functions and 5.9 % among employees (Vardè and Mennini, 2020). Another interesting phenomenon of the past few years in the INHS has been the tendency to centralize some of the administrative functions of healthcare organizations into autonomous regional agencies or organizations, to achieve economies of scale and scope (Fattore et al., 2016). This has increased the need for coordination between the smaller decentralized support processes and these autonomous agencies. Taken together, these two phenomena suggest that the introduction of new digital technologies may be the key to sustaining support processes in healthcare organizations.

3.1.2. The digitalization of the Italian NHS

In the INHS, the path towards digitalization started gradually, with the transformation of paper-based processes into digital formats (such as electronic health records, digital payment systems, e-prescriptions, etc.). It has evolved to include the implementation of advanced DTs like the IoT, AI, virtual reality, and cloud computing (Raimo et al., 2023). The process began in the early 2000s, when the Permanent Committee for political issues between central and regional authorities (Conferenza Stato-Regioni) required the implementation of a national health information system to monitor regions (Domenichiello, 2015). Progress was further driven by the establishment of the eHealth board (Tavolo di Lavoro Permanente per la Sanità Elettronica), where central and regional governments defined e-health development policies to harmonize national and European interventions. In 2005, the board introduced the 'Shared Policy for eHealth', adopting the objectives of the European e-Health Action Plan 2004 to regulate and promote the use of information and communication technologies for prevention, diagnosis, and clinical and service management. Since 2008, the e-health board has promoted the 'Architectural Strategy for e-Health', an initiative that further developed information systems. The board has identified four areas of intervention (access to services, availability of patients' clinical history, innovation in primary care, and redesign of services through telemedicine and remote services). These were subsequently set out through ad hoc regulations established over the years (e.g. the Law 221/2012 and Legislative Degree 179/2012 on electronic health records) (Arena et al., 2020; Domenichiello, 2015).

Beyond the e-health board, digital transformation has also been driven by the introduction in 2012 of the Agency for a Digital Italy and the Italian Digital Agenda (as part of the implementation of the European Digital Agenda and the European eGovernment Action Plans). This agency is responsible for the digital transformation of public organizations (including those operating within the INHS). Since 2012, the Agency has regularly published three-year plans to foster the use of ICT to create a more efficient and transparent public administration (Arena et al., 2020). It has developed guidelines for electronic health records, centralized health services booking systems, and telemedicine services, and focused attention on emerging DTs, such as blockchain (e.g. within the 2017–2019 Plan), AI and machine learning, big data and analytics (e.g. within the 2024–2027 Plan).

The most recent plans (and their updates) have been characterized by the increasingly pervasive presence of the National Recovery and Resilience Plan. This is an extraordinary opportunity to accelerate the digital transformation of public administrations. In response to the COVID-19 pandemic, the European Commission launched the Next Generation EU, a recovery package including the Recovery and Resilience Facility and REACT-EU instruments. These packages have aimed to support European countries towards digital transition, among other goals, and have focused on healthcare organizations through the EU4Health program 2021–2027. Italy has been the main beneficiary, in absolute terms, of both these two instruments. Resources amounting to €191.5 billion from the Recovery and Resilience Facility Plan have been allocated to Italy and been translated by the Italian National Recovery and Resilience Plan into reforms mainly advancing the digital transition of healthcare systems (Cacciatore et al., 2024).

This funding is focused only on capital expenditure and there is also a strong containment of current healthcare spending. Considering the forecasts based on the national budget law, the INHS will be underfinanced compared to similar healthcare systems such as the British NHS, with a decrease in government healthcare expenditure to below 6 % of GDP in the next three years (Longo et al., 2024). One of the main challenges of the INHS will be to balance these two phenomena. Administrative and managerial processes may be the key to managing the trade-offs required, maintaining the responsiveness, efficiency, and effectiveness of healthcare organizations, even as clinicians focus on the primary processes.

3.2. The Delphi approach

The research is based on a Delphi analysis. This is an established information-gathering and forecasting approach developed during the 1950s to obtain the most reliable consensus of opinion from a group of experts (Linstone and Turoff, 1975; Rowe et al., 1991; Winkler and Moser, 2016). It consists of 'a structured, interactive group communication and judgmental forecasting process aiming at systematically exchanging informed opinion concerning an uncertainty-bearing field of interest among a panel of selected experts and developing consensual understanding that reduces uncertainty and finally enhances decision quality' (Winkler and Moser, 2016, p. 64). Delphi analysis requires an iterative process in which experts who are anonymous to others are involved in multiple rounds of controlled feedback until a consensus on the investigated topic is achieved (Linstone and Turoff, 1975; Rowe et al., 1991). Since its development, Delphi analysis has mainly but non-exclusively been used for long-term forecasts of change (Rowe et al., 1991; Winkler and Moser, 2016). It is therefore particularly suitable to address this study's research questions, because they deal with current and future assessments of technology and change in the healthcare sector.

There is no agreement on the required size of the expert panel (Keeney et al., 2011). It depends on the expertise level and the type of involvement (e.g., interviews, focus groups, or online surveys). The modified Delphi approach used in this study drew on interviews instead

of a postal or web-based round (Keeney et al., 2011). This approach allows the use of smaller groups (Linstone and Turoff, 1975). According to Rowe and Wright (2001), the expert group size should be five to 20 experts. Other authors have suggested recruiting between 10 and 20 experts (Huber and Delbecq, 1972; Murphy et al., 1998; Vogel et al., 2019). We therefore approached experts in governance positions using the snowball method. We found 15 experts who were willing to participate. We personally contacted them and decided to include only those who considered themselves to be experts in the field of digital transformation in healthcare. This gave a total of 11 experts. We selected experts from different stakeholders and at varying governance levels to obtain a systemic view of expectations and perspectives related to DTs in supporting health administrative services. Table 2 shows the expert characteristics and governance level.

3.3. Data collection

We chose semi-structured interviews for data collection, because this allowed us to use pre-determined open-ended questions and develop any issues that emerged during the conversation. To formulate our questions and develop an interview guideline, we drew on the literature about DTs in healthcare and the TOE framework (DePietro et al., 1990). We also validated the interview guideline with support from two of the experts on our panel, to guarantee that all relevant topics were covered (Dell'Era et al., 2020).

The first round of interviews was carried out as soon as the final list of questions had been approved (covering items such as impact on processes, uses of information, supporting units involved, barriers, and drivers). Participants were asked to provide their opinion on the current and future use of a set of DTs identified by the literature on the administrative support services of health systems and organizations.

Table 2
Overview of experts.

Expert	Role	Organization type	Years of activity in the organization	Years of activity in the field
Expert 1	Chief Information Officer	Private health provider – Northern Italy	>15	>20
Expert 2	Chief Information Officer	Public health provider – Northern Italy	>20	>20
Expert 3	Chief Executive Officer	Technology provider	>20	>20
Expert 4	Chief Executive Officer	Regional health authority support agency – Southern Italy	>5	>20
Expert 5	Chief Strategy Officer – Partner	Consultancy firm	>5	>15
Expert 6	Chief Information Officer	Public health provider – Southern Italy	>5	>10
Expert 7	Chief Information Officer	Public health provider – Central Italy	<1	>10
Expert 8	Chief Information Officer	Public health provider – Southern Italy	>20	>20
Expert 9	Chief Information Officer	Public health provider – Northern Italy	>5	>20
Expert 10	Chief Information Officer	Private health provider – Southern Italy	>5	>20
Expert 11	Chief Information Officer	Private health provider – Northern Italy	>5	>20

They were able to suggest other DTs that they considered relevant, and were also asked about barriers and determinants of the adoption of each DT. The interviews were carried out using the Microsoft Teams platform in the period from May 2022 to May 2023. On average, each interview lasted for about 2 h and were administered by at least three senior researchers. The interviews were video-recorded, and then listened to and transcribed verbatim by at least two researchers to improve the systematization of the data (Miles and Huberman, 1994).

3.4. Data analysis

We used an inductive and iterative approach to analyze the collected data (Dell'Era et al., 2020). All the authors independently read the verbatim transcripts of the first round of interviews and developed two conceptual frameworks. One was related to the impact of emerging DTs on administrative support processes and the other covered barriers and determinants.

If there was any disagreement, we jointly examined the interviews to resolve the misunderstanding and reach a consensus. The frameworks were then shared in a second round with all the experts to get their opinion and validate the frameworks. Overall, seven of the 11 experts provided specific suggestions, and the others did not add any comments. In the third round, the frameworks were shared again via email with the experts. When no experts provided any further suggestions or comments, we considered that we had reached theoretical saturation and stopped the iteration between theory and expert views (Keeney et al., 2011).

There are several different models in the literature to explain technology adoption. These include the technology acceptance model (Davis, 1985), the diffusion of innovations model (Rogers et al., 2014), and the unified theory of technology acceptance and use (Venkatesh et al., 2003). However, the TOE model is considered particularly appropriate for classifying the determinants of adoption of DTs in healthcare for various reasons (Damali et al., 2021). First, TOE, unlike the diffusion of innovations theory, takes into account the environmental context by providing a more comprehensive perspective to understand the motivations behind the decision to adopt or not to adopt a new technology (Oliveira and Martins, 2011). It also emphasizes the importance of the organizational context in which technology adoption occurs, by highlighting the role of organizational culture, resources, and internal competencies (Aboelmaged, 2014). It therefore provides a useful conceptual framework for understanding the complex interactions between technological, organizational, and environmental factors in the adoption of new technologies (Yeh et al., 2015; Zhu et al., 2004).

4. Results

This section is separated into two sub-sections, one per research question. The first sub-section focuses on the actual and potential impact of DTs on administrative support processes in healthcare. The second focuses on the drivers and barriers to adoption of DTs.

4.1. The impact of DTs on administrative support processes

We asked the experts to provide their opinion on the actual and potential impact of each of the selected DTs on the administrative support services of organizations providing healthcare. We also asked whether they could suggest other DTs to be considered in the analysis. For each DT, we noted whether they considered the impact to be low, medium, or high. If they suggested that the DTs were not emerging or not relevant, we noted "not applicable" (N/A). To assign a score to each DT, we converted the answers using a Likert-type scale ranging from 1 to 3, where "low" impact corresponds to a score of "1", "medium" impact to "2" and "high" impact to "3". The final score, which represents the actual and potential impact of the DT on administrative support

processes in healthcare, is given by the sum of the experts' answers using this scoring system. DTs with higher scores are those considered to have the biggest impact on healthcare administrative processes.

Table 3 shows the ranking and scores for each DT. It reports experts' opinions of the impact of new technologies on managerial and support processes.

The DTs with the highest score were the IoT and AI and machine learning. Experts stated that IoT has, or may have, a high impact on administrative support processes of healthcare organizations. They highlighted their belief that this technology can provide support for clinical engineering, equipment maintenance, operations management and patient flow logistics, and risk management. Expert 2 commented:

> "*The IoT is critical because it has an immediate potential to automate processes by enabling certain data to be captured continuously from devices. In a scenario where less and less data is entered at the keyboard by people, but can be transmitted from devices, IoT has very important potential.*"

The impact of AI and machine learning was mainly considered in improving interaction with patients through chatbots, case mix planning at the healthcare system level, operations management at the healthcare organization level (such as supply chain management and inventory management), maximization of revenues in diagnosis-related group systems (i.e. analysis of invoicing), and clustering of patients. Expert 4 commented:

> "*With AI, you will be able to do more accurate simulations, because you can use administrative flows to plan the utilization of operating rooms. For example, if our organization governs the data flows and also does data analysis, our operations management function may foster case mix planning and operating room planning at the health system level.*"

The second-highest score was attributed to cloud storage and computing, followed by big data and business analytics. Some experts suggested that cloud storage and computing could not be considered an emerging DT anymore. Instead, it is simply a tool to store data and software as a service. Some experts also highlighted the risks of using cloud storage such as the loss of an internet connection—which requires the simultaneous presence of one or more physical servers—and hacker attacks. Expert 11 commented:

> "*The use of cloud storage is already considered in different guidelines,* […] *cloud computing will change the way we do analytics even for support services.*"

Some experts believed that a single healthcare organization could not generate the required volume and variety of data to obtain advantages from big data and analytics. They therefore preferred the term business analytics. Despite this debate, four experts believed that data analytics was already having and would continue to have an important impact in supporting performance management, planning and control, and marketing functions. Expert 7 commented:

> "[*These*] *are useful tools in contexts where a large amount of data is available. They are useful tools for strategic management, because you can act and take preventive actions and anticipate actions that are important to the organization itself.*"

Table 3
Impact of different DTs.

DTs	Low	Medium	High	N/A	Score
IoT	1	6	4		25
AI & machine learning	1	6	4		25
Cloud storage & computing			8	3	24
Big data & business analytics		1	7	3	23
Social media	1	8	1	1	20
Blockchain	6	2	2	1	16

Lower scores were achieved by both social media and blockchain. Only two experts maintained that blockchain may have, or was already having, a high impact on administrative support services in healthcare. They identified its support in the management of medical records, cybersecurity, and certification of balance sheets. However, Expert 1 said:

> "*I believe that what can be done with blockchain can also be done with other technologies*".

Finally, social media may have a medium impact on marketing and customer relationship functions through reputational and sentiment analysis. Expert 10 commented:

> "*It is used a lot; it is a tool that puts citizens in direct contact with the facility. We have a team of people who spend 12 hours a day responding to users asking for information through social media.*"

4.2. Drivers and barriers affecting the adoption of DTs

The second research question focused on the identification of drivers and barriers affecting the adoption of DTs and improving the efficiency and effectiveness of administrative support services. Drivers can be perceived as barriers in certain circumstances and vice versa, and we therefore refer to "determinants" of DT adoption. Table 4 shows the determinants identified and discussed with the experts. These were grouped into three main categories based on the TOE model. Next to each determinant, we noted the number of experts mentioning them.

Table 4 shows that skills and competencies (within the category 'Organization') were the most commonly-mentioned determinant. Lack of skills and competencies to support the selection and introduction of DTs may be an important barrier in the introduction of these technologies. Skills and competencies include both digital literacy among clinicians and specific digital skills among administrative employees. The ability to interact with IT developers is a key factor. Training in digital skills and competencies can therefore be an important driver of the adoption of DTs. An open mind and change management culture within the organization is also key to successful implementation. The experts suggested that older generations may be more resistant to change. Having an internal sponsor, especially a charismatic clinician, was identified as an important driver. This was linked to the strategic apex perspective on DTs. The experts commented that proactive top management is pivotal to provide the strategic direction for the introduction of DTs to the organization. However, some believed that clinicians could be even better sponsors. Another important determinant within the 'Organization' category was related to the economic resources for investment in DTs. Several experts suggested that the Italian Recovery and

Table 4
Determinants of use of DTs.

TOE	Determinants	No. of experts
Organization	Skills and competencies	11
	Strategic apex perspective on DTs	9
	Economic resources for investment in DTs	8
	Needs and objectives for DTs	8
	Open-mindedness and change management culture	8
	Internal sponsor/s	7
	Employee headcount	5
	Incentives	3
	Internal: level of digitalization of the health authority	3
Technology	External: DT developers	8
	Internal and external: level of connectivity	6
	Internal and external: level of interoperability of the digital tools and data	5
	External: DT solutions	5
Environment	Actions from higher institutional levels	8
	External sponsors	4

Resilience Plan could accelerate the adoption of DTs in the healthcare sector and support administrative services.

In the 'Technology' category, the most cited items were related to the availability of DT developers and solutions. A fiduciary relationship may improve the healthcare organization's ability to introduce new DTs. However, the current DT offer in the marketplace might be a barrier if solutions were not yet suited to organizational needs. On 'Environment', action from higher institutional levels could represent barriers when these are formulated as new rules, e.g. for data protection and privacy. However, they could also be drivers when regional or national governments formulate strategies and plans for the introduction of DTs, or provide shared tools (such as cloud computing) at national or regional levels.

5. Discussion

The management literature on digitalization and DTs has generally focused on the impact and process of technology adoption in organizations (Fitzgerald et al., 2014; Dal Mas et al., 2020; Vial, 2019). Scholars focusing on the healthcare sector have not escaped this emerging research trend (Marques and Ferreira, 2020; Kraus et al., 2021; Massaro, 2023). However, most of the literature on the topic has exclusively focused on what Porter (2001) called primary processes (in the case of healthcare, clinical support services), and neglected the potential impact and contribution of DTs on administrative support processes (both primary and secondary). The latter, although not directly delivered to service users, have a considerable impact on the management and overall performance of healthcare organizations (Lega et al., 2013). This study aimed to fill this gap.

The findings provide interesting insights into the research questions underlying this study. In response to RQ1 (*What is the impact of DTs on managerial and administrative support processes in healthcare organizations?*), the study suggested that the IoT and AI and machine learning have the biggest impact on managerial and support processes, followed by cloud computing & storage and big data and business analytics. Comparing our findings with previous studies on diagnostic–therapeutic processes, our results are semi-consistent. Articles on clinical processes found that cloud computing & storage, IoT, and big data analytics (Garai et al., 2017; Tortorella et al., 2020a, 2020b; Ilangakoon et al., 2022) were the most relevant DTs, and were usually employed to gather and control information about patients' everyday lives (Tortorella et al., 2020a). Our experts reported that AI had the highest impact on administrative processes. This was different from other empirical studies on diagnosis and treatment activities in healthcare organizations. In the case of clinical services, physicians are still apprehensive of the potential biases and clinical risks of adopting AI to support their decision-making (Sibbald et al., 2024).

Looking at the support functions using the DTs with the highest impact, our findings are in line with previous studies on specific technologies. This suggests that these technologies are mainly adopted to improve sales program optimization (i.e. strategic planning function), medical devices and pharma supply chain management (i.e. procurement and maintenance functions), people management (i.e. human resource management functions) and people evaluation (i.e. management control functions) (Sousa et al., 2019; Yang et al., 2021; Tortorella et al., 2022a).

Turning our attention to the DTs with the lowest impact, it may be surprising that social media and blockchain were considered to have little impact on healthcare administrative functions. The use of social media in healthcare organizations is less pronounced, probably because of the specificities of the service (i.e. care) compared to organizations in other industries that use a business-to-consumer (B2C) model where these DTs are widely used, especially in marketing processes (Swani et al., 2014). Other studies in different contexts (such as financial services and the agrifood sector) have found that blockchain seems to break industry processes because of its improved transaction transparency or product monitoring and traceability (Chang et al., 2019; Dal Mas et al., 2023). However, its contribution to healthcare processes is limited to low-value-added activities, such as medical records management, cybersecurity management, and certification of balance sheets (Engelhardt, 2017; Jarwal, 2019; Shi et al., 2019).

Using these results, we developed a framework to support researchers and practitioners in advancing knowledge and practice on implementing DTs. For each DT, Table 5 shows the macro-category of support processes it acts on from Porter and Teisberg's (2006) taxonomy covering measuring, informing, and knowledge development. It also provides some examples of administrative processes that may be improved by the adoption of the DT.

These new DTs foster measuring and informing processes and enable knowledge development at a higher level than traditional information technology such as that supporting medical records. Porter and Teisberg (2006) suggested that IT could be considered a driver to make the healthcare value chain more efficient. Our expert views suggest that new DTs could also foster its effectiveness and responsiveness.

Shifting the focus to RQ2 (*What are the main determinants of adoption of DTs in managerial and administrative support processes in healthcare organizations?*), our findings contribute to the literature by identifying the most important determinants of adoption of DTs in administrative processes in healthcare. Scholars have previously identified several barriers and drivers that can foster or hinder the digitalization of healthcare organizations (Greenhalgh et al., 2010; Kraus et al., 2021; Thijssen et al., 2023). Our results, in line with previous studies focused on care delivery, emphasized the significance of fostering a supportive organizational culture, effective leadership, proactive top management, and skilled employees for successful digital transformation (Sony et al., 2023; Beaulieu and Bentahar, 2021; Mlakar et al., 2022). There is ongoing research in the field of digital transformation that explores the question of who is responsible for guiding and driving initiatives (Kraus et al., 2021; Singh and Hess, 2017; Hansen et al., 2011). Strong support from the top management team is crucial for the successful implementation, security, and communication of digital transformation (Andriole, 2017). Our results suggested that in healthcare, employees' skills and competencies are key determinants to the successful implementation of DTs to support managerial and administrative processes. Similarly, Thijssen et al. (2023) explored the obstacles and enablers associated with implementing radical innovations in secondary healthcare. They found that the primary barriers were insufficient human, material, and financial resources, and a lack of integration and organizational readiness. The key facilitators included fostering a supportive culture, providing adequate training, education, and knowledge, and acknowledging the anticipated added value.

Many studies have examined the impact of healthcare information

Table 5
The impact of DTs on macro-categories.

DT	Macro-category	Examples of administrative processes that can be improved
IoT	Measuring	Clinical engineering, Equipment maintenance, Risk management, Operation management, Patient flow logistic
AI and machine learning	Knowledge development	Forecasting; Case-mix planning; Operations management; Patient clustering
Cloud storage & computing	Measuring	Data storage; Software as a service
Big data & business analytics	Knowledge development	Performance management; Marketing; Strategic planning
Social media	Informing	Marketing; Customer relationships
Blockchain	Measuring	Patient record management; Cybersecurity; Certification of balance sheet

technologies on various aspects of health services (Agarwal et al., 2010), exploring factors influencing the digital evolution of healthcare institutions. Tortorella et al. (2020a) investigated 16 hospitals across Brazil, India, Mexico, and Argentina, and found that ownership type and operational functionality significantly influenced the adoption of digital technologies. The age of hospitals was also important, with newer establishments having a stronger inclination towards digital integration than their older counterparts. However, findings on the influence of hospital size on digital implementation were inconclusive, varying with the metrics employed. Preko and Boateng (2020) studied Ghanaian hospitals and identified five key drivers of digital transformation: standardization, financial transparency, storage systems, convergence and connectivity, and data security. Raimo et al. (2023) sought to assess how hospitals' attributes influenced the extent of digital transformation. Their findings underscored the relevance of hospitals' size, age, and teaching status, and suggested that hospital complexity might also play a role in the digital transformation journey. Previous studies also identified the lack of skills in information and communication technologies as a key determinant in implementing digital technologies in healthcare (Ali et al., 2018; Manogaran et al., 2018; Mutlag et al., 2019).

Our findings are not completely consistent with previous studies in other sectors. Tangi et al. (2020) explored barriers and drivers affecting technology-driven public sector transformation. They suggested that external drivers were the main motivation for organizational transformation, and that internal barriers did not necessarily affect digital transformation. Ghobakhloo and Iranmanesh (2021) focused on digital transformation success among small and medium entities, and came to the same conclusion: external support for digitalization (mostly supportive governmental policies for Industry 4.0 transformation) was the primary and most crucial determinant of success. Jones et al. (2021) analyzed the barriers to digitalization in manufacturing industries, classifying them into three main categories of logistical, strategic, and competency. Liere-Netheler et al. (2018) carried out qualitative interviews among sixteen participants across various manufacturing subindustries, such as automotive and engineering, and found that there were 12 drivers mentioned. However, two primary drivers of digital transformation emerged: process enhancement within the organization and meeting customer demands.

Contrarily, however, and in line with our study, Laubengaier et al. (2022) considered Industry 4.0, and found that skills and competencies were fundamental, especially skill development. The need to increase existing competencies and develop new skills applies to both the operational (i.e., employees, operators, and workers) and managerial levels. Diener and Špaček (2021) also identified employees' flexibility, acceptance, qualification, and availability as a major barrier to digital transformation in banking.

In general, the identification of different drivers able to guide digital transformation and the focus on internal determinants could be ascribed to the peculiarities of healthcare organizations that offer knowledge-intensive expert services to create public value (Bos Nehles et al., 2017). Knowledge-intensive organizations need to process data and information more effectively than other types of organizations, to create knowledge (Richards and Duxbury, 2015; Grossi et al., 2020). In line with our study, Xu et al. (2018) reviewed recent research on Industry 4.0, and identified the following technologies as the most relevant: cyber-physical systems, IoT, cloud computing, blockchain, industrial information integration and other related technologies.

6. Conclusions

This study used a Delphi-based inductive qualitative approach, focusing on the Italian NHS to consider the introduction of novel digital technologies. It provides a number of contributions to academics and practitioners.

From a scholarly standpoint, the results contribute to the emerging field of H4.0. Unlike previous studies, which mainly focused on clinical aspects (e.g. Garai et al., 2017; Ilangakoon et al., 2022; Tortorella et al., 2020a), we explored the adoption of DTs within administrative and managerial processes in healthcare, and looked at drivers and barriers to this. To the best of our knowledge, this is the first study to examine these issues. It contributes to the debate on determinants of digital transformation, by discussing how drivers and barriers of digital technologies in healthcare administrative and support processes compare with those in other industries and settings (e.g. Thijssen et al., 2023), and particularly with those related to clinical processes (e.g. Sony et al., 2023; Beaulieu and Bentahar, 2021; Mlakar et al., 2022). The study also makes a contribution through the methodological approach. Previous studies have mainly developed literature reviews (e.g. Tortorella et al., 2020b), but we drew on the views of experts to provide a picture of the current situation in healthcare organizations, and the impact of particular DTs. Our research also adds to the literature on Porter's value chain model in healthcare by exploring the role of digital transformation in 'primary support processes' and 'secondary processes' (Porter and Teisberg, 2006). This shows how new digital technologies have a different impact from previous technologies. Finally, the study contributes to the literature on digital transformation in healthcare (Tortorella et al., 2020b) because we used experts' opinions to classify the DTs employed within administrative and managerial processes by macro-category of function: measuring, informing, and knowledge development.

Our findings also have practical implications for healthcare service providers, policymakers, and other stakeholders. They highlight the crucial factors that contribute to the successful implementation of digital transformation in healthcare, which will enable organizations to identify strategies that will actively promote digitalization. This study provides valuable insights for healthcare service providers to enable them to assess progress towards digital transformation and take the necessary action in each critical dimension to ensure success.

Of course, when drawing these conclusions and contributions, it is useful to enlighten a number of limitations as well as directions for future research. Additional lines of research might start from the focus of our paper. The DTs used emerged from a comprehensive review of the literature, but we are also conscious that this is a relatively recent topic and other DTs may not yet have been discussed in the literature even if they are being adopted by pioneer organizations. We asked the experts if there were other DTs to add, and none emerged, but future studies might check for additional DTs. The paper also focused only on determinants of digital technologies, and future studies might explore the effect of DTs, for example by assessing whether their adoption within administrative processes adds value for healthcare organizations. Our method also had implications. The Delphi approach was considered appropriate to answer our research questions, but the findings are based on the subjective opinions of experts. Future studies might use additional methodological techniques that might further validate our findings (e.g. confirmatory factor analysis of survey data) (Rezaei et al., 2021). We also involved a limited number of participants (Keil et al., 2013). The Delphi methodology does not require a statistically representative sample of experts (Okoli and Pawlowski, 2004) and our panel of experts' experience covered a broad range of healthcare providers and DTs. However, caution is needed in generalizing our findings. Future studies might adopt additional qualitative methods, such as online surveys, to expand the sample size. This might also be useful to improve the robustness of the findings on drivers and barriers of DTs. Alternative quantitative methods such as structural equation modeling could be useful to investigate the causal relationship among barriers/drivers and the level of intensity of DT adoption. The choice of the INHS as a case study also has implications. In some ways, this was an ideal setting because of the strong investment in digital transformation (Cacciatore et al., 2024), but the specific institutional and socio-economic context might restrict the generalization of our findings to other countries. Future studies might extend the analysis to other healthcare systems and compare different institutional and socio-economic scenarios.

CRediT authorship contribution statement

Marianna Mauro: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. **Guido Noto:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. **Anna Prenestini:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. **Fabrizia Sarto:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

None.

Data availability

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