Robotic-Assisted Surgery in Healthcare Institutions: assessing benefits, obstacles, and implementation success factors

Giada Andriollo

Dissertation written under the supervision of professor
Filipa Lancastre

Dissertation submitted in partial fulfilment of requirements for the MSc in Management with specialization in Strategic Marketing, at the Universidade Católica Portuguesa, 31.05.2024

ABSTRACT

Title: Robotic-Assisted Surgery in Healthcare Institutions: assessing benefits, obstacles, and implementation success factors

Author: Giada Andriollo

This thesis investigates the barriers hindering the further implementation of robotic-assisted surgery (RAS) in healthcare institutions, focusing on benefits and challenges. Analysing this topic is important because it provides critical information on how technological innovations can improve healthcare industry, ultimately leading to improved patient outcomes and effective operations. The Gioia methodology, which provides a systematic and reliable approach to understanding the complex dynamics involved in adopting RAS, has been used for rigorous data analysis. Several key findings were derived through 16 in-depth, qualitative interviews with healthcare professionals.

This study provides novel contributions by highlighting significant barriers related to staff training and education in implementing robotic-assisted surgery (RAS). These bottlenecks lead to inefficiencies within surgical teams and hospital operations, influencing the perception of RAS as complex and difficult to use without adequate training. Additionally, the study identifies financial constraints, logistical challenges, and the need for tailored operating environments as major obstacles. Despite the initial high costs, the long-term economic benefits of RAS can be significant, yet these are often underutilized due to inadequate staff training and resource allocation. Furthermore, the study confirms previous research on the benefits of RAS, such as improved patient outcomes, surgical precision, and operational efficiency.

In summary, the future of robotic surgery depends on addressing training and educational gaps, continuously evolving skills, and effectively integrating new technologies into medical practices. Institutions that are ready to adapt and evolve will likely harness the full potential of RAS, improving patient care and operational efficiency.

Keywords: Robotic-Assisted Surgery, Healthcare, Digital Transformation, Training, Implementation Barriers, Operational Efficiency

SUMÁRIO

Título: Cirurgia Assistida por Robótica em Instituições de Saúde: avaliação dos benefícios, obstáculos e factores de sucesso da implementação.

Esta tese investiga as barreiras que impedem a implementação da cirurgia assistida por robótica nas instituições de saúde, centrando-se nos benefícios e desafios. A análise deste tópico é importante porque fornece informações críticas sobre a forma como as inovações tecnológicas podem melhorar o sector dos cuidados de saúde, conduzindo, em última análise, a melhores resultados para os doentes e a operações eficazes. A metodologia Gioia, que fornece uma abordagem sistemática e fiável para compreender a dinâmica complexa envolvida na adoção desta tecnologia, foi utilizada para uma análise rigorosa dos dados. Foram obtidas várias conclusões importantes através de 16 entrevistas qualitativas aprofundadas com profissionais de saúde.

Este estudo fornece novos contributos ao destacar barreiras significativas relacionadas com a formação e educação da equipa medica na implementação da cirurgia assistida por robótica. Estes obstáculos conduzem a ineficiências nas equipas cirúrgicas e nas operações hospitalares, influenciando a perceção da nova tecnologia como complexas e difíceis de utilizar sem formação adequada. Além disso, o estudo identifica como principais obstáculos os constrangimentos financeiros, os desafios logísticos e a necessidade de ambientes operacionais adaptados. Apesar dos custos iniciais elevados, os benefícios económicos a longo prazo podem ser significativos, mas estes são frequentemente subutilizados devido a uma formação inadequada da equipa medica e à afetação de recursos.

Em resumo, o futuro da cirurgia robótica depende da resolução das lacunas de formação e educação, da evolução contínua das competências e da integração efetiva de novas tecnologias nas práticas médicas.

Palavras-chave: Cirurgia Assistida por Robótica, Cuidados de Saúde, Transformação Digital, Formação, Barreiras à Implementação, Eficiência Operacional

ACKNOWLEDGEMENTS

The completion of this master's thesis marks the end of my academic journey at Católica Lisbon School of Business and Economics. These crucial years have allowed me to grow personally and expand my knowledge, enabling me to have wonderful experiences. I thank everyone who was part of this chapter of my life and made it unforgettable.

I would like to immensely thank my thesis supervisor, Filipa Lancastre. Her brilliant insights have always guided me in the right direction with my research, allowing me not to lose motivation. Thank you for always responding promptly to my doubts and for guiding me on this path.

The most special thanks go to my mom and dad; your love and support are invaluable to me.

I would like to express my deep gratitude to Claudia Colbacchini, Simonetta Peotta, Elisa Gottardo, Stefano Foralosso, Giada Menin, Giusy Pertegato, Matteo Venzi, Laura Lucidi, Camilla Bianciardi, Filippo Cavallier, Marta Villanova, Lorenzo Bochicchio, Isabel Meusel, and two other interviewees, who prefer to remain anonymous. A special thanks go to my sister Giulia who was a key part of my thesis as well as among the 16 experts interviewed. The insights and experiences of all of you were crucial to the success of my thesis, and I am very grateful to each of you.

TABLE OF FIGURES

LIST OF ABBREVIATIONS

DT	Digital Transformation
DOI	Diffusion of Innovation
RAS	Robot Assisted Surgery
TAM	Technology Adoption Model

1. INTRODUCTION

The healthcare industry is leading a digital transformation (DT) in an era of rapid technical progress and robot-assisted surgery (RAS) technology is already revolutionizing modern medicine and represents the promise of DT to change the face of healthcare.

Due to the rapid development of digital technologies and their profound impact on organizational structures and processes, DT is becoming a key topic in both academic research and practical application (Dmitry, Henrik, & Torbjørn, 2023). Technology adoption in the healthcare industry is one of the main factors influencing productivity in this field, and technology is generally regarded as the main source of long-term productivity gains in the overall economy (Horn, Sacarny, & Zhou, 2022). The impact of DT on the healthcare sector is particularly important, as technologies such as electronic health records, big data analytics, and enhanced physical products have been recognized for their potential to radically change medical practice (Burton-Jones, et al., 2020).

A prominent example of the transformation brought about by DT is RAS technology. In surgical procedures, RAS offers increased precision, accuracy, flexibility and control, particularly for minimally invasive surgery. The substantial economic and clinical importance of this technology has been highlighted by the rapid rate of adoption, with the RAS market expected to grow by 21.8% by 2027 (Robotic surgical procedures market size , share & COVID-19 impact analysis , 2022). Despite the clear benefits brought by robotic surgery and the rapid adoption it is experiencing, hospitals are facing challenges to further implement this technology and seem sometimes forced to abandon it after its initial introduction (Compagni, Mele, & Ravasi, 2015 ; Enayati, Momi, & Ferrigno, 2016 ; Abrishami, Boer, & Horstman, 2014)**.** Both internal and external factors influence the adoption of RAS technologies. The adoption is driven by the perception of benefits such as improved operation efficiency, surgeon satisfaction and increased patient outcomes. Externally, competitive pressures and the need to stay at the forefront of medical technology also play crucial roles (Sebastian, et al., 2017). Yet, despite these drivers, there seem to be obstacles preventing the real deployment and continuous use of RAS systems resulting in a paradox where they do not adequately realize the potential or benefits of this technology.

This thesis examines the factors that are preventing wider use of RAS technology in healthcare institutions, with a view to addressing this contradiction.

Specifically, the first research question is:

- *What were the motivations driving the adoption of RAS and to what extent have expected benefits materialized with implementation?*

aims to assess whether the anticipated benefits of RAS, e.g. improved patient outcomes, better precision in surgery and operating effectiveness, have been fulfilled. It is also interested in understanding the impact of these results on the ongoing use and investments in RAS technology.

While the second research question:

- *Which potential challenges are hindering the implementation and continuous use of Robotic-Assisted Surgery (RAS) in healthcare institutions?*

focuses on identifying obstacles that hinder the widespread adoption of RAS. The research will examine aspects such as technological complexity, user acceptance, organizational readiness, and external pressures through the combined use of the technology acceptance model (TAM) and diffusion of innovation theory, putting this research question at the core of a theoretical framework.

This dissertation, structured as an academic research thesis, attempts to add to the existing wealth of knowledge on DT and RAS in the healthcare industry. Starting with the definition of DT and a specific focus on DT in healthcare, the first section of this research evaluates the body of literature on important topics pertinent to the research challenge. The research methodology is explained in the second section of this dissertation, which further elaborates on the selected research technique and clarifies the data collecting, sample plan, and interview process. A full explanation of the findings from the 16 expert interviews was provided by a content analysis of the data that was gathered, which was done using the systematic Gioia technique (Gioia, Corley, & Hamilton, 2013). Thirdly, the findings from the interview are showcased in the Results section and subsequently examined by linking the perspectives to the updated literature. This section identifies the limits of the research, its management importance, its theoretical contributions, and possible directions for future study. In summary, the last section of this study offers important claims and a lesson to be learned.

2. LITERATURE REVIEW

This section of the dissertation provides a thorough literature analysis on the complex topic of digital transformation (DT) and its effects on many different industries, with an emphasis on robot-assisted surgery (RAS) and healthcare. It examines the definition, benefits and challenges associated with DT to highlight its disruptive nature and it explores the significant advances in healthcare achieved by DT. In addition, this section includes the development and growth of RAS technology as well as its benefits and challenges in surgical procedures. The literature review section also includes a reflection on key theoretical models, such as technology acceptance model (TAM) and the diffusion of innovation theory (DOI).

2.1 Digital Transformation

Digital transformation (DT) has been defined as "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies" (Vial, 2019, p. 118). Given the widespread influence of digital technologies on organizational structures and processes, DT is an important theme in the modern literature, with a predominant focus on the organizational context and its role as a facilitator of major changes within entities (Vial, 2019) (Legner, Eymann, Hess, Matt, & Tilo Böhmann, 2017). Despite the above association between digital transformation and organizational transformation, DT involves a broader social and industrial impact, extending its implications beyond organizational boundaries ((Vial, 2019) (Agarwal, Gao, DesRoches, & Jha, 2010) (Majchrzak, Markus, & Wareham, 2016)).

2.2.1 Impact of Digital Transformation in organisations

Considering the organization context, academics recognize the disruptive nature of DT, with digital technologies such as the ones from the SMACIT (Social, Mobile, Analytics, Cloud, and Internet of Things) acting as drivers of change (Sebastian, et al., 2017). In this regard, a timely response to digital disruption is imperative for the survival of organisations, bearing in mind that digital technologies represent both opportunities and threats for companies.

The existing literature diverges between endogenous and exogenous perspectives of digital transformation, with some scholars considering it to be driven by internal initiatives and other academics viewing DT as a reaction to external pressures and competitive trends (Vial, 2019; Tan, Pan, Lu, & Huang, 2015; Li, Liu, Belitski, Ghobadian, & O'Regan, 2016). Furthermore, it is important to highlight that, as traditional boundaries between functional areas blur and new competencies become increasingly important, DT usually requires considerable shifts in organisational patterns and employee roles. At the same time, some challenges such as inertia

(Vial, 2019; Svahn, Mathiassen, Lindgren, & Kane, 2017) and resistance (Vial, 2019; Fitzgerald, Kruschwitz, Bonnet, & Welch, 2014) could slow down and hinder the implementation of DT, emphasising the need to address organisational culture and concerns of employees. For this very reason, organisations need to strategically use digital technologies, and comprehensive planning and execution are required to exploit them successfully. These actions, however, may involve a change in the organisational structure to support cross-functional collaboration and a cultural transformation to foster innovation and agility, which is not always easy to achieve. (Vial, 2019; Duerr, Wagner, Weitzel, & Beimborn, 2017).

Despite the challenges mentioned above, the literature suggest DT holds great potential for organisational benefits, e.g. increased efficiency, innovation and competitiveness. By automating tasks and reducing manual input, DT boosts efficiency significantly, reducing errors and speeding up the processes.

2.2.2 Digital Transformation in healthcare

It has been argued that DT generates a wide range of positive and negative impacts that could be identified and assessed at the organizational level at most (Vial, 2019, p. 130). Despite this consideration, the literature highlights DT impacts at higher levels, including societal and industry. One relevant example is healthcare (Vial, 2019; Agarwal, Gao, DesRoches, & Jha, 2010), in which a wide range of technologies such as electronic health records, augmented physical products, and big data and analytics have been recognised as crucial contributions to an industry that has been a latecomer in technology adoption (Vial, 2019; Henry Lucas, Agarwal, Clemons, Sawy, & Weber, 2013).

DT in healthcare is becoming increasingly relevant for practitioners and scholars in the field (Sascha Kraus, 2021) and its characterisation, given by significant changes driven by information, computing, communication, and connectivity technologies (Vial, 2019), has emerged as a crucial aspect in improving healthcare entities. The change brought about by this transformation affects a wide range of areas, including the acquisition of digital resources, development of growth strategies and internal structural changes for healthcare organisations (Verhoef, et al., 2021). Additionally, the healthcare sector has been a key area of DT in recent years, providing new business opportunities and models for addressing medical practice issues and value creation (Sascha Kraus, 2021; Elton & O'riordan, 2016). For example, DT has significantly improved healthcare sectors' operational efficiency, leading to simplified procedures and cost savings, and it has moved healthcare towards a more patient-centered approach through the provision of telehealth services and tailored care portals (Sascha Kraus, 2021; Hong & Lee, 2017). In addition, the introduction of digital training programs has led to a change in working practices, facilitating remote working opportunities and increasing productivity. (Sascha Kraus, 2021; Eden, Burton-Jones, Casey, & Draheim, 2019). Furthermore, the adoption of Electronic Medical Records (EMRs) and Big Data Analytics enables healthcare providers to deliver more timely and accurate medical care. In parallel, concerns about data protection and security have been raised, leading to the need for strong cyber security measures (Reddy & Sharma, 2016).

A crucial role in the adoption of digital technologies was played by the COVID-19 pandemic, which accelerated the adoption phenomenon due to the urgency of addressing its challenges (Dal Mas, Massaro, Rippa, & Secundo, 2023), offering at the same time a great opportunity to achieve more efficient and effective healthcare delivery. In addition, the potential of innovative technologies such as e-health systems, Electronic Health Records, Blockchain, and IoT sensors to manage the complexity of healthcare processes has been highlighted by this crisis ￼ , offering opportunities to improve patient engagement, surgical decision-making, diagnostic procedures, and organizational effectiveness. The adoption of the aforementioned technologies represents a broader trend of DT in healthcare, intending to ensure security and high quality of care (Dal Mas, Massaro, Rippa, & Secundo, 2023; Haggerty, 2017).

2.2 Robot-assisted surgery (RAS) technology

DT in healthcare, as aforementioned, has the potential to optimise production, distribution and use of health staff and infrastructure, improve the allocation of system resources more effectively as well as streamline care delivery processes and supply chains. In this respect, robot-assisted surgery (RAS) technology is a fundamental innovation in healthcare, which is radically transforming surgical methodologies and offering greater precision, accuracy, flexibility, and control (Fosch-Villaronga, Khanna, Drukarch, & Custers, 2022). In particular, this technology is associated with minimally invasive surgery (MIS), which facilitates operations by reducing the number of incisions and resulting in significant benefits for patients such as a quick recovery time, smaller scars, and overall a lower risk of postoperative complications (Sridhar, Briggs, Kelly, & Nathan, 2017). The integration of advanced computing power and imaging modalities such as ultrasound, computed tomography, and robotic systems that are tailored to specific surgical tasks is the essence of RAS or computer-integrated surgery (CIS) (Biswas, Sikander, & Kulkarni, 2023; Taylor & Stoianovici, 2003).

2.2.1 Evolution of RAS

Robotic-assisted surgery, which is characterised by rapid growth and innovation, has become a major player in the healthcare market and thanks to the widespread adoption and integration of robotics systems into a variety of medical fields, the robotics industry's valuation has increased by several billion dollars (Surgical Robotics Market Landscape, 2022).The inception of the Arthrobot, the first robotic system in history designed to assist a human patient, marked the advent of RAS in the early 1980s. Subsequently, there have been significant advancements in the field of laparoscopic surgery, including the FDA's 2000 clearance of Da Vinci's surgical system and its debut and introduction (Biswas, Sikander, & Kulkarni, 2023), setting the standard as the most widely used multiport robotic surgery system in the world (Da Vinci, 2023). The Da Vinci robotic surgery system, with improved precision and control, is able to enhance minimally intrusive surgeries. Its technology is based on the master-slave teleoperation model, which allows surgeons to robotically operate arms that mimic hand movements with greater precision. In addition, key features of the system are high-definition 3D vision and articulated instruments for precise, less invasive procedures (Özgüner, et al., 2020).

Regarding the statistics, it seems that there is a remarkable acceptance and growing expansion of RAS technologies: in 2019, the market size for robotic surgery amounted to 5.23 billion USD and there is a growth forecast of more than 14 billion USD from 2020 to 2027 with a projected market size of USD 19 billion and a CAGR of more than 20% in the 2020-2027 timeframe. The technology's significant economic and clinical impact is highlighted by this growth. (Robotic surgical procedures market size , share & COVID-19 impact analysis , 2022).

RAS is consistent with the broader goals of improving healthcare delivery, optimising resource allocation and improving patient outcomes. The adoption of such technologies is not only a sign of the embracing of more advanced surgical procedures, but also reflects the health sector's commitment to adopting technological innovations that promise higher levels of care, reduced costs and greater operational efficiency.

2.2.2 Benefits and challenges of RAS

RAS has revolutionized the field of surgical procedures by offering a number of compelling benefits related to cost management, operational efficiency, surgeon satisfaction, marketing competitiveness, and reputation and quality of care.

Firstly, in terms of cost management benefit, the initial investment in RAS technology may be high, but the long-term economic benefits can be significant. Robotic surgical systems are known for their precision and efficiency, features that lead to fewer surgical complications and shorter hospital stays for patients (Taylor & Stoianovici, 2003) . These crucial results contribute to reducing the overall cost of care and improving resource utilisation, e.g. by reducing ICU (Intensive Care Unit) days, the need for post-operative treatments and unplanned readmissions that are particularly costly and challenging for the healthcare system (Ben-Assuli & Padman, 2020).

In terms of operational efficiency, RAS provides advanced imaging through high-definition 3D views. This allows surgeons to execute surgical plans integrated with preoperative images, allowing alignment of the procedure with the planned outcomes (Taylor & Stoianovici, 2003). In addition, especially in minimally invasive procedures, RAS improve the surgeon's ability to perform precise dissections and sutures (Sridhar, Briggs, Kelly, & Nathan, 2017). This efficiency can lead to shorter surgery times and, potentially, allow more procedures to be planned which will improve the performance of surgical units.

Advances in robotic system ergonomics reduce the physical strain on surgeons, perceiving this ergonomic advantage in reduced neck or back arthrosis, which may extend their careers and reduce the risk of occupational injuries (Abrishami, Boer, & Horstman, 2014). This aspect is of particular importance from a business point of view, as hospitals can increase their ability to attract top talent, decrease turnover and minimise the costs of recruitment and training new staff.

Offering RAS can enhance the hospital's reputation and contribute to its recognition in the field of modern healthcare. (Abrishami, Boer, & Horstman, 2014). The presence of RAS inside a hospital would attract new patients and, from a management point of view, a hospital's competitiveness in the healthcare market can also be enhanced by being at the forefront of medical technology.

Finally, improved functional outcomes for patients can be achieved by the ability of RAS to maintain healthy tissue in surgical procedures, e.g. prostatectomies or tumour removal (Sridhar, Briggs, Kelly, & Nathan, 2017). Improved patient outcomes are of paramount importance to hospital administration, as they have an impact on ratings and satisfaction scores in many health systems which increasingly depend upon funding.

However, despite these optimistic motivations, the actual deployment and continued use of robotic systems have run into some challenges. The sustainability of the economics and the actual demonstration of improved patient outcomes compared to traditional methods have been the main concerns. Due to high costs and questionable added value to existing surgical techniques, hospitals have reduced or abandoned the use of robotics after its initial introduction (Compagni, Mele, & Ravasi, 2015; Abrishami, Boer, & Horstman, 2014; Enayati, Momi, & Ferrigno, 2016). In addition, the influence of external pressure, competitiveness and patient demand, driven by increased awareness and expectation of RAS, has played a critical role in accelerating its adoption, sometimes without solid evidence to support its superiority.

2.3 Technology acceptance and innovation adoption

The term "creative destruction", introduced by Schumpeter (1970), describes a continuous process of industrial transformation that changes the economic structure from within, constantly dismantling the old and creating the new (Dodgson & Gann, 2010). This phenomenon is essential to competition capitalism because it exemplifies a dynamic system in which innovation continuously modifies the current situation. Innovation is generally defined as an idea, practice or object that has been considered new by a person or entity (Rogers, 1983). In the context of Schumpeter's 1970 concept of creative destruction, various explanations of the drivers of innovation and their diffusion and acceptance have emerged. An example is the diffusion of innovation theory and the technology acceptance model (TAM), both of which have achieved relevance in the management debate.

The adoption, diffusion, and acceptance of new technologies can be explained by the diffusion of innovation and the TAM, introduced by Rogers (1983) and Davis (1989). Davis stresses the cognitive consumer elements of technological acceptance, while Rogers concentrates on the social dimensions of innovation diffusion and adoption. The DOI and TAM rely on the assumption that a particular feature of an innovation, such as perceived value, ease of use or compatibility, is significant in influencing its acceptance (Davis, Bagozzi, & Warshaw, 1989) ((Rogers, 2003). Davis (1989), who notes the limitations of Rogers' model, focuses on psychological aspects in his technological acceptance model. For this reason, the use of TAM and DOI to explore different types of technology adoption has been effective, with studies demonstrating positive results when the models are combined (Lee, Hsieh, & Hsu, 2011).

2.3.1 Technology acceptance model

Technology acceptance describes an individual's intention of using the technology (Davis, Bagozzi, & Warshaw, 1989). Compared to the theory of planned behaviour (TPB), which includes a wider range of behavioural indicators, TAM differs from other models for its simplicity and effectiveness in the literature on information systems (Ma & Liu, 2004). TAM, which takes its name from the theory of reasoned action (TAR), emphasises perceptions of efficiency and ease of use as direct factors that influence whether a technology is adopted. In a range of demographic and cultural contexts, empirical evidence shows that TAM is a reliable indicator of technology acceptance (Ma & Liu, 2004; King & He, 2006).

TAM consists of two main dimensions that together impact a person's state of mind toward using a specific tool (Lee, Thi, & Lin, November 2017). The two dimensions, which reflect the user-centred approach to understanding technology adoption, are perceived usefulness (PU) and perceived ease of use (PEOU). On one hand, PU is defined as how much people believe that using a specific tool will help them to perform their tasks better (Davis, Bagozzi, & Warshaw, 1989). This dimension represents the primary determinant of user conviction and expectations to use innovation. On the other hand, PEOU is characterised by how effortlessly a person uses a specific tool. Past research has shown that PEOU impacts the goal in two ways: direct and indirect impact through the usefulness of the tool. Since PU affects PEOU, the latter does not have a significant impact on the behavioural expectation of use (Davis, Bagozzi, & Warshaw, 1989).

2.3.2 The diffusion of innovation theory

As Rogers explains, diffusion is the process by which innovations are communicated over time to society members (Rogers, 2003). Different factors, including the characteristics of the innovation itself, the communication channels used to disseminate information, the passage of time, and the members of the social system, are involved in the diffusion of innovation. According to Rogers, this procedure lessens uncertainty. In addition, the effectiveness of such communication channels plays a major role in speeding up innovation adoption by social system members (Rogers, 2003). Rogers identifies different categories of adopters based on their readiness to adopt new ideas, classifying them as innovators, early adopters, early majority, late majority, and laggards. The distribution of adopters tends to follow a typical pattern when innovation diffusion has been successful.

Characteristics of innovation help to explain different levels of the adoption of innovation and Rogers defines these as causes for the adoption of innovation at different levels. First, *relative advantage* is the degree to which a particular group of users thinks innovation is better than an idea or practice that it replaces. The faster the level of adoption of innovation is achieved, the greater the perceived relative advantage of the organisation in terms of innovation. *Second, compatibility* is the degree to which innovation is seen as consistent with current values, past experiences and needs of potential adapters. Compatibility depends on whether the innovation can be regarded as being in line with these values or practices. Third*, complexity* is the extent to which people find innovation hard to utilise and comprehend. An innovation will be adopted faster if it is easier to grasp and complex innovations will require adopters to acquire new abilities to comprehend and use them. Fourth, *trialability*, the degree to which an innovation can be validated on scant data before it can truly persuade the majority of potential consumers, is known as its testability. Innovation cannot be expected to succeed if it is not tested. For the person considering adoption, verifiable innovation means less uncertainty because s/he can learn by doing. Finally, *observability* is known as the results' uniqueness and refers to the degree to which the outcomes of innovation are more noticeable than others,. An individual is more likely to adopt an invention if s/he can more easily see the effects of it. Making such a distinction encourages conversation with others, which frequently calls for assessment data on innovation.

2.4 Researched gap and thesis relevance

The adoption of DT in the healthcare industry, especially regarding technology such as RAS, represents a significant advancement in contemporary medical procedures (Vial, 2019). Even with the wealth of research on DT and its advantages, little is known about RAS' complete potential and ongoing application in healthcare facilities. Many healthcare organisations find it difficult to continue implementing RAS and are frequently compelled to give up on the technology after introduction for a variety of reasons (Compagni, Mele, & Ravasi, 2015; Abrishami, Boer, & Horstman, 2014; Enayati, Momi, & Ferrigno, 2016). By investigating the advantages o, this study fills a significant gap in the literature. The first research question: *what were the motivations driving the adoption of RAS and to what extent have expected benefits materialised with implementation?* aims to access this aspect comprehensively.

This study also investigates the obstacles that prevent RAS technology from being widely adopted and used throughout time. The second research question: *which potential challenges are hindering the broader implementation and continuous use of Robotic-Assisted Surgery (RAS) in healthcare institutions?* focuses on identifying new or overlooked obstacles. Using the diffusion of innovation theory and the TAM, this thesis attempts to offer a thorough grasp of the variables affecting the uptake and integration of RAS. The psychological, social, and organisational factors that affect technology adoption and spread in healthcare settings will be better understood with the application of these theoretical frameworks (Lee, Hsieh, & Hsu, 2011). This research adds to the academic literature by elaborating on the implications of DT in healthcare and providing insights that could guide strategic and policy decisions in medical institutions.

3. METHODS

Research involves the collection, organization and analysis of the data to expand our knowledge and comprehension of problems or a topic (Ussif, Ertugrul, Coskun, & Baycan, 2020). Of the three most common research methods - quantitative, qualitative and mixed (Taherdoost, 2022) - the researcher uses a qualitative approach in this study. By using in-depth and semi-structured interviews, this analysis can delve deeply into the complex experiences and viewpoints of healthcare professionals who are directly impacted by or interacting with this innovative technology. In-depth interviews enable a thorough exploration of the study question and participants' experiences. Simultaneously, semi-structured interviews are characterized by a high level of flexibility and the ability to provide participants with more detailed responses to questions that are posed (Nunan, Birks, & Malhotra, 2020).

There are several reasons behind the choice of a qualitative research method over a quantitative or mixed one that might involve the creation of a standardized survey. Firstly, as aforementioned, qualitative methods are an appropriate choice when the researcher needs to capture specific experiences and emotions of participants (Morse, 2003). Moreover, the high specificity of the researched phenomenon requires a method able to provide a rich contextual understanding of complex issues. Secondly, meticulously planned and executed interviews offer the opportunity to identify and understand the complex interplay of institutional, operational and human factors that influence the implementation of RAS technologies, proving the strengths of qualitative research for examining multifaceted phenomena (Creswell, 2009). Thirdly, the data collection process is further enhanced by the fact that a researcher is directly involved in carrying out these interviews. It gives rise to opportunities for deeper investigation of answers and clarification in real time, thereby enhancing the collection of quality ambiguities and authenticated data, aspects that might be lost with the use of a standardized survey. This approach is in line with the principle of qualitative research, which involves close interaction with a subject to generate meaningful and actionable information based on actual user experiences and institutions' contexts (Maxwell & Reybold, 2015), stressing the importance of direct interactions to generate detailed data reflecting the complexity of real-world situations (Strauss & Corbin, 1998).

Through this method, the complex reasons behind the adoption of RAS technologies have been collected with a view to providing grounds for specific strategies aimed at increasing their use and integration in healthcare facilities. This conclusion is consistent with the view that argues qualitative methods should be used as a primary tool to gain deeper knowledge about human behaviour and organisational dynamics (Denzin & Lincoln, 2005).

3.1 Sample strategy and procedure

The sample for this study consisted of professionals actively involved in the healthcare industry and multiple sampling techniques were used, including purposive, convenience and snowball sampling.

Data that provide an exhaustive, in-depth analysis of the phenomenon being investigated represents a key requirement for any qualitative study and must comply with specific criteria (Holstein & Gubrium, 2003). For this reason, purposive sampling, also known as judgemental sampling, was used as a non-probability sampling technique allowing the selection of participants likely to provide high-quality data (Burns, Veeck, & Bush, 2016). The selection criteria for participants consisted of:

1) Involvement in the healthcare sector, either through professional roles or educational paths.
2) Knowledge of RAS technology gained through practical experience or academic study.
3) Participation in one or more surgeries with RAS, either through active involvement in using the robot or by assisting.

Half of the interviewees currently work at San Bortolo Hospital in Vicenza (Italy), which uses RAS technology. However, many of them have had previous work experiences at other hospitals where they used robotic surgery, such as Sant'Antonio Hospital in Padua (Italy). To obtain a thorough grasp of the effects and integration of RAS technology in healthcare, a purposefully wide sampling technique was used, including medical personnel from different hospitals as well as medical students and medical residents. The sample includes two medical residents working at San Matteo Hospital in Pavia (Italy) and a resident doctor currently specializing at Brigham Hospital in Boston (USA). It also included medical students from various universities, including the University of Milan, the University of Florence, and Charles University in Prague, who have in turn completed internships in various hospital units, also outside Italy. The work led to the identification of 16 professionals with RAS expertise, as detailed in Appendix 1.

Interviewing operating theatre personnel can provide critical insights into the practical aspects of RAS technology. These experts, who work closely with the technology, can discuss their experience from the time it was first introduced to its current application. Medical students can contribute to an understanding of the academic approach to RAS technology. Residents can offer a distinct perspective, seeing firsthand how new doctors adapt and learn in the high-tech surgical environment as they enter established hospital settings.

Some limitations were encountered in assembling a sampling of participants due to the inefficiency of social networks such as LinkedIn for searching for healthcare professionals. Rather, a more individualised strategy was adopted, using word-of-mouth via professional and personal networks, such as friends and family who offered leads to potential candidates. By avoiding the limitations of conventional social networking sites, this strategy succeeded in obtaining a wide-ranging and insightful participant base. After the first interviews, the snowball approach began to be instrumentalised as an additional technique to broaden the pool of potential participants, placing a strong emphasis on networking and referral (Parker, Scott, & Geddes, 2019). In this case, the discovery of previously unidentified experts was facilitated by the initial interviewees' suggestions for other possible participants for follow-up interviews.

3.2 Data collection

Interviews were scheduled and conducted online due to geographical location and convenience. Currently, interviewees are more familiar with different platforms and applications for online communication, which have enhanced their digital skills and competences, making it easier to take part in online research, thanks to increasingly digital societies, especially during the COVID-19 pandemic (Lobe, Morgan, & Hoffman, 2020). All interviews were conducted through Zoom, a videoconferencing platform that has already been extensively applied for research purposes (Archibald, Ambagtsheer, Casey, & M., 2019). The interviews lasted approximately 30 to 45 minutes and were audio recorded with the consent of participants. The interviews were then fully transcribed using Discord, a programme that provides an automatic transcription process by uploading audio files (Appendix 3).

The semi-structured interviews were composed of pre-defined and open-ended questions, avoiding dichotomous choice questions (Nunan, Birks, & Malhotra, 2020). Key thematic issues identified in the literature were addressed by the envisaged open-ended questions included in Appendix 2 and the interview protocol was structured In sic different parts. First, in the introduction, participants were asked to confirm their professional background and share more details about their roles, based on prior research. Then, regarding digital transformation, participants described the impact of introducing new technologies in the healthcare sector. Additionally, participants were asked how familiar they were with the RAS technology and how involved they were. If involved, they discussed the perceived benefits and limitations of

RAS, factors influencing the decision-making process when choosing between RAS and traditional surgical methods, and how these considerations affect the frequency of RAS choice. Moreover, in relation to the diffusion of RAS and the long-term implications, participants shared their views on why hospitals had adopted or did not adopt the technology, examples of RAS having an impact on patient care, lessons learned from integrating RAS into a healthcare establishment, motivations for implementing RAS. Furthermore, participants discussed actions that healthcare entities can take to successfully implement RAS technology. Finally, to conclude the inerview, participants had the opportunity to add other related thoughts.

3.3 Data analysis

Gioia's methodology provides a robust framework for qualitative inquiry, capturing the multifaceted dynamics of innovative surgical techniques and clinical practice in examining RAS. This methodology is designed not only to navigate new concepts but also to provide novel ideas and theories (Gioia & Pitre, 1990). The Gioia methodology presents a chance to give an inductive study "qualitative rigor" while preserving the innovative, revelatory potential that makes these studies famous for producing novel ideas and notions (Gioia, Corley, & Hamilton, 2013). Indeed, one of the main challenges of this analysis is the possibility that the researcher may have subjective opinions and project biases that are not supported by the data. This methodology serves to guarantee that analysis stays grounded in the gathered data and enhances the probability of identifying significant patterns and connections (Gioia, Corley, & Hamilton, 2013).

The analysis based on Gioia's methodology is divided into several key stages which together form the basis for the construction of a data structure. The starting point of the methodology is the first-order analysis, which is considered informant-based because it attempts to carefully stick to informants' terminology as it is based on the belief that dissecting interviews and analyses can lead to artificial results (Langley, 1999; Locke & Golden-Biddle, 2017). For this reason, first-order concepts are deduced directly from the language used by the participants. This stage is essential to maintain a close relationship with the data and make sure the thematic analysis is based on the participants' opinions. However, in this analysis, given the rather limited number of interviews conducted, the initial categorization was simplified by using direct quotes to reflect the first-order categories. This phase is followed by research of differences and similarities comparable to the notion of axial coding (Strauss & Corbin, 1998). The aim of this stage is to group the relationships between the first-order concepts into more general themes (Gioia, Corley, & Hamilton, 2013). For this reason, compared to the first-order concepts, the classification is researcher-based as it reflects the researcher's interpretation of the data more. In the Gioia method's last stage, second-order themes are aggregated into dimensions that serve as the foundational elements for the development of a theoretical model. This last phase offers a more profound comprehension of how the themes contribute to the theory in the literature research.

4. RESULTS

The analysis of qualitative content uncovers numerous significant themes and aspects that arise from 16 semi-structured interviews, which are presented in a well-organized table in Appendix 4. Figure 2 represents an overview of exemplary quotations from the qualitative content analysis using Gioia's methodology by arranging the data in three hierarchical levels. Direct quotes from the interviews are used to illustrate first order concepts since a more straightforward framework was possible due to the volume of material. Several second order themes are identified and consolidated into five aggregated dimensions: Digital transformation impact in healthcare employees and institutions, Potential benefits from adopting RAS, Perception of expectations' achievement: benefits obtained and room for improvement, Challenges hindering further adoption of RAS, Need to revolutionize the training approach to facilitate further adoption of RAS technology.

FIRST ORDER CONCEPTS *Direct quotation*	SECOND ORDER CONCEPTS	AGGREGATED DIMENSIONS
"There are now monitors to try to check the state of anaesthesia, how much a person is anaesthetised and asleep, and there are systems to heat fluids. To monitor movements, in fact. There are various monitoring systems that were not used before." (EG)	*Impact of digital transformation and technological innovation in surgery: patient care and operational efficiency*	**Digital transformation impact in healthcare employees and institutions**
"These devices have significantly eased the surgeon's life." (SP)		
[...]		
"When I arrived, everyone was complaining that they did not know how to operate computers and related software." (LL)	*Training and adaptation challenges to introduce technologies*	
"Introducing new technology can lead to resistance from some staff members, particularly those who are less comfortable with change" (GP)		
[...]		
"By now, apart from small and medium-sized provincial hospitals, however, I think it is catching on a little bit in all hospitals" (FC)	*Institutional and regional disparities in terms of structures' size and funds for technology introduction*	
"In larger hospitals, we usually have the infrastructure to support rapid technological changes but sometimes it's still challenging to adapt quickly to the introduction of an innovation" (LB)		
[...]		

"For the patient, the benefits are as I mentioned before. It's a much less invasive method compared to traditional laparotomies." (EG)	*Perceived patient benefits of RAS: minimally invasive surgery and improved outcomes*	**Potential benefits from adopting RAS**
"And for the patient, the results are much more positive." (IM)		
[...]		
"Compared to traditionally performed surgeries, surgeons have a much wider range of movement using the robot. So they can do many more movements than their hands could do" (AB)	*Perceived surgeon benefits of RAS: reduced physical strain, improved manoeuvrability and better visibility*	
"For urological surgery, and in particular for operations involving the small pelvis, RAS has a significant advantage for the operator. In fact, the robot allows better manoeuvrability of instruments in small spaces and offers better visibility, which allows finer and more precise operations." (PS)		
[...]		
"Some benefits have been met, especially in terms of precision and reduced complications, but the costs are still a significant concern" (LB)	*Partial fulfilment of expectations and superiority of traditional laparoscopic surgery*	**Perception of expectations' achievement: benefits obtained and room for improvement**
"I think partially. I think the initial idea was to apply it to many more fields. Instead, in the end, the number of procedures suitable for robotics isn't that many—there are two or three procedures per specialty, and not all specialties use robotics." (CB)		
[...]		

"From a business perspective, RAS has successfully attracted top talent and new patients, enhancing our hospital's competitiveness and reputation in the healthcare market." (FC)	*Fulfilled expectations and need for little to no improvement*	
"In the hospital where I did my internship, they told me that each year they had a certain number of operations to perform with the robot to effectively recoup the implementation costs, and each year up to that point, that number had been reached. So, I would say that the expectations have been met." (IM)		
[...]		
"In my opinion, managing the robot is more complex for the team." (CC)	*Complex dynamics and logistical challenges*	**Challenges hindering further adoption of RAS**
"One potential issue is the extended operative time, not the actual time spent operating, but all the preparation time: setting up the room, assembling and disassembling the robot, especially if the team hasn't undergone specific robotic training" (PS)		
[...]		
"Using robots certainly requires a financial outlay, because special procedural packages are opened and cost a lot of money" (GP)	*Financial constraints: personnel training, maintenance and robot's replacement costs*	
"I also think the costs of training personnel are significant." (EG)		
[...]		
"While it becomes more convenient once you've learned it, the learning process is very difficult. In our case, those who use it have done years and years of training on that robot." (LL)	*Training and role adjustments*	

"Unlike normal surgery, robotic surgery requires a longer preparation and process, especially for operations on small structures" (LB)		
[...]		
"During my time at university I never heard of robotic surgery." (AB)	*Educational gaps in robotic surgery training*	**Need to revolutionize the training approach to facilitate further adoption of RAS technology**
"There are no specific courses at university on the application of artificial intelligence or robotic surgery." (MV)		
[...]		
"A person who arrives in the operating theatre does not start using the robot if he is not trained on standard surgeries." (AB)	*Initial training challenges*	
[...]		
"There is a lot of inconsistency within the operating room team, both among operators and nurses, in terms of familiarity with robotic instrumentation. However, I see that young staff members adapt quickly, but to become proficient in robotic surgery, they need to practice more frequently." (LB)	*Need for cross-disciplinary and ongoing training*	
[...]		

Figure 1: Overview of exemplary quotations from the qualitative content analysis using Gioia's methodology – selection of quotes
Source: Own illustration based on qualitative analysis using Gioia's methodology (2013).

4.1 Digital transformation impact in healthcare employees and institutions

In general, interviewees agree that the use of digital technologies in healthcare is significantly increasing surgeon efficiency and patient satisfaction, as evidenced by the many testimonies from medical professionals.

The introduction of new technologies reduces the duration and invasiveness of surgeries and "by reducing the duration of surgeries, the related complications, including pain and infections, also decrease because shorter surgery times reduce the likelihood of infections" (SP). In addition, healthcare professionals point out that these technologies make it easier for surgeons to carry out their tasks and improve patients' outcomes by improving visual clarity and precision in surgical procedures. Indeed, "the surgeon has a three-dimensional view of the operating field, so they can see every tiny vessel. The precision is meticulously maintained, and there's reduced blood loss because everything is coagulated" (SP). Furthermore, digital change is also revolutionising the way patients are treated and monitored. New monitoring equipment is making anaesthesia and emergency treatment more innovative, which is helping to improve patient safety and comfort after surgery and, compared to the past, "there are now monitors to try to check the state of anaesthesia, how much a person is anesthetized and asleep, and there are systems to heat fluids and to monitor movements, in fact" (EG). Moreover, the inaccuracies that come with manual record-keeping are eliminated by digitising patient records and treatment protocols, resulting in more accurate and effective patient information management. This approach brings several advantages, “the first is that it cuts down on the most trivial error is the doctors' handwriting, which is often incomprehensible. Instead with computerised therapy, the patient has a bracelet with a QR code, and the nurse scans it with a reader and out comes all the medication he or she has to do at that moment" (CB), thus transforming the management of daily therapies and complex medical data.

However, interviewees also acknowledge there are still challenges in the transition to digital health care. Particularly for older professionals accustomed to traditional methods, training and adaptation to new technology are major obstacles. To this point, LL explains that "the big problem with technology is that there has to be someone who knows how to use it, and so precisely, especially for people with somewhat older schooling who may have always done everything on paper, saying 'by tomorrow you have to do everything online' becomes a challenge". In addition, a hospital's size and location can have a significant impact on how quickly these technologies are implemented. Smaller hospitals might be dealing with additional difficulties, which could result in slower adoption rates and potential differences in the standard of service. For example, "in smaller hospitals, the introduction of new technology can take much longer because probably they don’t have the same level of funding or access to training programs as larger entities" (GP).

4.2 Potential benefits from adopting RAS

Interviewees have identified two important groups of benefits, those e related to patients and others regarding healthcare professionals. Considering the former, the advantages of RAS are several and “primarily in terms of postoperative recovery and wound management, the benefits for the patient are evident" (CC). Indeed, thanks to this innovative and less invasive surgery method, patients benefit from faster recovery times, less pain post-surgery, and decreased risk of infections. As PS notes, “for the patient, not working through a large skin opening, but using laparoscopy, has significant advantages. It allows a faster recovery and a reduction in postoperative pain”. In addition, VB emphasises that “the advantages are mainly for the patient, I would say almost exclusively. These advantages include better surgical results because the movement of the robot arm is a hundred times finer than that of a human hand, and also much finer than that of a laparoscopic arm”. Another important aspect regards hospitalization time as highlighted by LL: “All those procedures that were traumatic for the patient, where they had to stay in the hospital for two or three weeks because they couldn’t move and felt severe pain with every breath, have been reduced to practically three days of hospitalization”.

In regard to healthcare professional, interviewees have also noted that the ergonomic advantages for surgeons are considerable. The use of RAS reduces the surgeon's workload, as "RAS is less demanding for the surgeon than traditional surgery. The surgeon can work sitting in an ergonomic position, whereas with traditional laparoscopy he is forced to work standing with his arms in suspension for long hours" (SL). Additionally, RAS' increased control and precision have contributed to an improvement in surgical performance, as a matter of fact, "[c]ompared to traditionally performed surgeries, surgeons have a much wider range of movement using the robot. So, they can do many more movements than their hands could do" (AB). At the same time, the healthcare professionals recognise that there are still potential benefits for the surgery staff and the operators that have not been realised, especially in specific geographic areas, emphasising that “the theoretical advantage, which at least in Italy is not fully exploited, is that the primary surgeon can be miles away from the operation site and still actively participate without needing to travel" (CC).

4.3 Perception of expectations' achievement: benefits obtained and room for improvement

This finding highlights the fact that several reasons are behind the decision of a hospital to introduce RAS technology. On the one hand, there is a matter of prestige and competitiveness arising from external pressures because "not having a robot means being significantly less competitive" (CC), highlighting the fact that "is both an evolution from a surgical point of view, and also a prestige that allows the hospital to say 'yes, we have the robot too' and in this way remain competitive". Indeed, "if a medical institution does not keep up to date, it risks losing prestige and not being chosen by patients who are informed about the available options" (SL) because "patients come in and ask 'Will the surgery be done using the robot?'. Because it's something that attract patients" (SF) and at the same time "it is unthinkable to continue operating as twenty years ago" (MC). On the other hand, there is also internal pressure from the staff as "when there is a team of surgeons in a hospital who specialize in this area and strongly believe in it, they will do everything possible to get it purchased and used" (CB).

Further, evidence shows that RAS has overall lived up to promises, improving surgical accuracy, efficiency, and hospital competitiveness. To this point, IM claims that "[i]n the hospital where I did my internship, they told me that each year they had a certain number of surgical operations to perform with the robot to effectively recoup the implementation costs, and each year up to that point, that number had been reached. So, I would say that the expectations have been met". Furthermore, as stated by FC, the robot "allows for surgical techniques that were possible with colonoscopy but with greater difficulty. Let's say the procedures are done better. It has indeed been a gain and a positive development".

However, some evidence suggests that there were also several unmet expectations. As CB said, "the number of procedures suitable for robotics isn't that many—there are two or three procedures per speciality, and not all specialities use robotics". In addition, highlighting the challenges of underutilization, some other practical challenges were mentioned "but not because of any shortcomings on the part of the robot or the technology, but because other factors lead to having a robot and keeping it unused for four out of eight or out of ten sessions per week and that is stupid, so its use should be maximised and it should be used every day all the time. Furthermore, increasing its volume brings down the cost per procedure so the benefit in economic terms is increased" (PS). Moreover, healthcare staff "found that many procedures are still more advantageous with laparoscopy, which limits the full potential of RAS" (GP).

4.4 Challenges hindering further adoption of RAS

The information gathered reveals several major obstacles related to the implementation of RAS, which mainly affects medical staff rather than patients. Among the challenges is the change in staff dynamics following the introduction of the robot which creates a more complex dynamic in the operating room, complicating the coordination and communication of the team, according to some respondents. For instance, there is a major change as “the primary surgeon works at the console, while the assistants are a bit distant. So, there’s no gathered team, and the distance can make communication a bit difficult at times” (EG). In addition, some logistical issues, such as space and equipment constraints prevent a hypothetical further adoption of the RAS technology because as mentioned by EG “the robot is bulky, heavy and large. They had to calibrate a specific surgery room for it. And that room is now used only for robotic surgeries”

The financial constraints associated with the RAS, covering personnel training, maintenance and tool replacement costs, are another major issue, along with the fact that the initial investment in RAS technology is substantial and continues to be expensive. For instance, “The costs associated with robot instruments can therefore be very high, compared to those of traditional laparoscopy. For example, while laparoscopic instruments can be used several times until they are damaged, the instruments of the Da Vinci robot have a limited lifespan, usually between ten and fifteen procedures. Once the usage limit is reached, the system warns and the device has to be replaced, with costs ranging from a few hundred to several thousand euros per instrument" (SL). These financial pressures may hinder further adoption of RAS, especially in hospitals with small budgets.

4.5 Need to revolutionize the training approach to facilitate further adoption of RAS technology

The data collected demonstrates the crucial role of training in successfully integrating RAS technology, highlighting the fact that major training and educational gaps prevent further adoption of the technology. Unfamiliarity with the robot and its instruments among surgeons and operating room staff can further prolong the overall surgery times. To this argument, PS notes that “one potential issue is the extended operative time, not the actual time spent operating, but all the preparation time: setting up the room, assembling and disassembling the robot, especially if the team hasn't undergone specific robotic training”. This statement “highlights the necessity of having a team that knows how to use the equipment and is familiar with it to avoid excessively prolonging the surgery times" (PS).

Unfortunately, a notable lack of proper training starts from university curricula, as mentioned by AB: “During my time at university I never heard of robotic surgery" and emphasised by MV, who states the fact that “there are no specific courses at university on the application of artificial intelligence or robotic surgery”. Furthermore, the operating room presents initial training problems for novice surgeons since they must gain proficiency in normal surgeries before receiving robotic system training, which “requires a significant amount of time and additional staff” (PS). Expert assistance at the outset is essential, as demonstrated by the regular attendance of specialists at early interventions to guarantee thorough training. Furthermore, the problem of knowledge bottlenecks—where a facility's few qualified personnel can execute robotic surgeries—highlights the necessity of continuous, cross-disciplinary training and calls for further training because as stated by CB “If only one person does it, they must teach someone else. The robotic technique cannot die with them, but unfortunately, this happens in many places.".

5. DISCUSSION

5.1 Theoretical and managerial contributions

This study aims to shed light on the barriers to further adoption of robotic-assisted surgery in healthcare institutions. All in all, the comparison of the study results with the analysed literature review reveals not only a confirmation of previous research but also new, insightful and overlooked insights, which represent valid contributions of the study and provide an interesting starting point for hypothetical further research.

Firstly, there are two critical reasons hindering the further acquisition of RAS that have not been acknowledged in the literature yet: logistical challenges together with financial constraints of some healthcare institutions and internal dynamics (namely training of healthcare professionals) that prevent internal dissemination. Indeed, the dynamics of the operating room are altered with the introduction of RAS, making it more difficult for the surgical team to coordinate and communicate. In addition, because of its size, weight, and bulk, the robot requires a tailored room for its utilization. This results in a limitation of the flexibility of hospital resources as there is the need for a room exclusively dedicated to robotic surgeries. Furthermore, there are considerable costs concerning the maintenance of the robot and the surgical instruments that are attached to the robot arms. In fact, the instruments that are to be used with the robot have much higher costs than and a shorter service life than the instruments that are used during traditional operations. Regarding internal dynamics, a major barrier is the need for specialised training, which is most often not offered. In fact, the learning curve to be able to operate the robotic system effectively is steep, which is why staff require extensive training periods. At the same time, some surgical staff members play a less active role as a result of the robot automating some surgical duties, which lowers engagement and lowers job satisfaction.

Secondly, the study further emphasizes the crucial role played by training and education in facilitating the continued implementation of RAS technology. Indeed, most respondents highlighted the importance of comprehensive training, not just in the workplace but also at the university level, when asked what advice they would give to facilitate the further implementation of robotic surgery. Managerial contributions emphasize the necessity for surgical departments and hospital management to fund formal training initiatives. To reduce the risks associated with knowledge bottlenecks, it is essential to ensure that every member of the surgical staff – not just a small number of them – is knowledgeable about RAS technology. Moreover, incorporating RAS technology training into university curricula would prepare future healthcare professionals from the outset, creating a well-prepared workforce ready to embrace robotic surgery. Additionally, dedication to continual interdisciplinary training helps promote a cooperative atmosphere where information is updated and shared on a regular basis. Healthcare organisations may increase operational effectiveness, shorten surgical times, and ultimately improve patient care by filling in these training gaps and guaranteeing general proficiency with RAS technology.

Thirdly, the analysis also highlights the fact that, while the benefits for the patients – such as reduced recovery time, decreased pain after surgery, and decreased likelihood of infection – are widely recognized, the benefits for healthcare personnel are less considered. Highlighting the fact that healthcare staff have a perception of a larger overall benefit for patients than for medical personnel. The study does, however, highlight the significant benefits that RAS has been shown to provide to healthcare professionals, including decreased physical strain during procedures and improved accuracy that results in less stress and fewer mistakes. Additionally, the possibility of remote surgery for surgeons is a significant untapped value. This capacity could help spread medical knowledge more widely and alleviate personnel shortages. The report highlights the fact that this specific benefit has not been applied in many regions, suggesting a significant chance for additional RAS technology adoption and advancement.

The findings of this study corroborate several aspects of the existing literature review. Firstly, general medical practices, surgical efficiency, and patient outcomes have all greatly improved as a result of digital transformation (DT) (Sascha Kraus, 2021; Hong & Lee, 2017). Medical professionals attest to the significant advantages that DT offers, in line with previous research findings. Secondly, the study supports the literature on the benefits of RAS regarding hospital reputation, cost management, and operational effectiveness (Taylor & Stoianovici, 2003). Furthermore, the study demonstrates that the desire for competition and status, which is impacted by outside forces and patient demand, is a significant factor that promotes the use of RAS technology (Compagni, Mele, & Ravasi, 2015; Abrishami, Boer, & Horstman, 2014; Enayati, Momi, & Ferrigno, 2016). In addition, despite initial concerns about living up to promises, RAS has improved surgical precision, efficiency, and hospital competitiveness, hence satisfying long-term expectations in general. These results support the insights found in the literature on the important role and adoption factors of DT and RAS in healthcare environments.

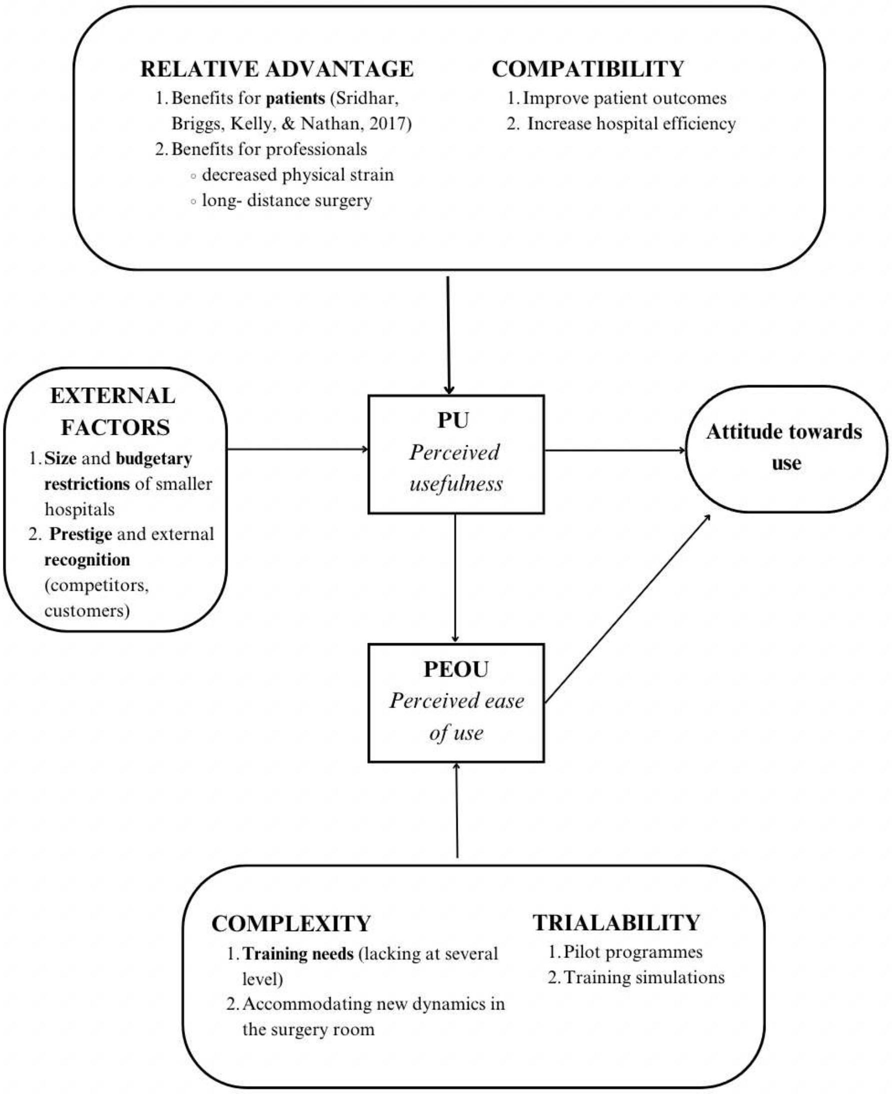

Figure 2: TAM and diffusion of innovation model combination
Source: own illustration

Figure 2 offers an overview on how the application of both the technology adoption model and the diffusion of innovation theory provides an extensive framework for comprehending the uptake of robotic surgery technology. According to the diffusion of innovation theory, five characteristics influence the adoption of an innovation: relative advantage, compatibility, complexity, trialability and observability (Rogers, Diffusion of Innovations 5th Edition, 2003). When these five attributes are integrated with TAM's perceived usefulness and perceived ease of use it is possible to draw more sophisticated results.

On the one hand, combining the TAM and the diffusion of innovation theory demonstrates that RAS technology has significant perceived usefulness (PU) through its relative advantage and compatibility. The relative advantage is clear since robotic surgery, as previously mentioned, provides enhanced precision and capabilities, which could result in better surgical outcomes and significant benefits for patients. Furthermore, the ergonomic design of RAS systems lessens the physical strain on surgeons, a recognized benefit. Additionally, there are significant advantages for healthcare professionals that have not been fully realized, such as the potential for long-distance surgeries. Compatibility is demonstrated by robotic surgery's alignment with the primary objective of improving patient outcomes and overall hospital efficiency, reinforcing its adherence to healthcare values. However, the necessity for intensive training and modification suggests that present surgical skills and practices may not be aligned properly.

On the other hand, the perceived ease of use of robotic surgery is significantly impacted by its complexity, trialability, and compatibility. One of the main obstacles to the widespread acceptance of this technology is its complexity, which includes the difficult setup, calibration, and operation. This intricacy is increased even further by the significant training needs that is lacking at several level, which detract from its usability. However, the trialability component—introducing robotic surgery through pilot programmes and training simulations, for example—can give staff members practical experience and gradually lessen perceived complexity. Finally, compatibility has a dual effect on perceived utility and usability. The objectives of the technology are in line with healthcare values, however the surgical team may be reluctant to switch from conventional methods because of the considerable lack of manoeuvrability of technology and learning opportunities.

In conclusion, the need to offer training is a fundamental element to facilitate the further implementation of robotic surgery thus representing an essential external variable in the TAM model. It has a direct impact on perceived ease of use (PEOU), making technology more accessible and less complex. It also affects perceived usefulness (PU), improving users' ability to use the technology effectively, thus improving performance and results. Addressing training needs is critical to the successful adoption and integration of new technologies such as robotic assisted surgery in healthcare.

5.2 Limitations and further research

Although this study provides novel and insightful information about the barriers to further implementation of robotic-assisted surgery in healthcare institutions, it is important to acknowledge its limitations and highlight areas that require further investigation.

Firstly, the nature of this study is qualitative and while this method offers detailed insights, it restricts the findings' applicability to larger groups. In addition, due to the study's reliance on semi-structured interviews, which represent the individual experiences and opinions of a sample of 16 healthcare professionals, the potential for researcher bias may be introduced during the analysis of the interviews. This highlights the importance of using a rigorous qualitative analytical method to mitigate such biases. Furthermore, the sample size, limited to individuals from particular hospitals – mainly San Bortolo Hospital in Vicenza (Italy) - and geographic areas, may prevent the researcher from collecting different perspectives that could enrich the study and yield theoretical saturations of the categories. To improve the validity and application of the results, future studies should increase the sample size and incorporate a wider variety of healthcare settings and job roles of the respondents. For example, it would be useful to compare scenarios of public and private healthcare institutions and include interviews with hospital management alongside surgical room staff and medicine students.

Furthermore, as the RAS technology is developing relatively quickly, the results could become dated very soon, as they provide a snapshot of the situation dated April-May 2024, necessitating an ongoing study to keep up with advances in the technology.

Finally, further research should also examine how sophisticated training programs can be integrated and how well they work to alleviate the obstacles that have been found, such as a steep learning curve and cost issues related to RAS technology. Examining the function of cross-disciplinary training and ongoing professional development may yield important insights on how to assist medical professionals in adjusting to new surgical technologies.

6. CONCLUSION

The countless benefits and improvements brought by robotic surgery are obvious, yet something is blocking its further implementation by also limiting the achievement of its full potential. Therefore, the central idea of this thesis is straightforward but impactful: to research what forces are blocking the greater implementation of RAS technology.

The study provides fresh and intriguing insights while confirming previous literature research. Several bottlenecks were found, with the lack of personnel education and training being the main focus. Inefficiencies arise in the surgical team and the hospital overall as a result of this circumstance. Furthermore, if insufficient training is combined with poor education, people may perceive technology as being difficult to use.

In summary, resolving issues with education and training, constantly developing skill sets, and skilfully incorporating new technologies into medical procedures will be key to the future of robotic surgery. While the journey is still ongoing, institutions that are prepared to change and grow will surely prosper.

REFERENCES

Özgüner, O., Shkurti, T., Huang, S., Hao, R., Jackson, R. C., Newman, W. S., & Çavusoglu, M. C. (2020). Camera-Robot Calibration for the Da Vinci Robotic Surgery System. *IEEE TRANSACTIONS ON AUTOMATION SCIENCE AND ENGINEERING*, 2154 - 2161.

Abrishami, P., Boer, A., & Horstman, K. (2014). Understanding the adoption dynamics of medical innovations: Affordances of the da Vinci robot in the Netherlands. *Social Science & Medicine*, 125-133.

Agarwal, R., Gao, G. (., DesRoches, C., & Jha, A. K. (2010). The Digital Transformation of Healthcare: Current Status and the Road Ahead. *Information System Research*, 796-809.

Archibald, M. M., Ambagtsheer, R. C., Casey, M. G., & M. (2019). Using zoom videoconferencing for qualitative data collection: Perceptions and experiences of researchers and participants. *International Journal of Qualitative Methods*.

Ben-Assuli, O., & Padman, R. (2020). TRAJECTORIES OF REPEATED READMISSIONS OF CHRONIC DISEASE PATIENTS: RISK STRATIFICATION, PROFILING, AND PREDICTION. *Mis Quarterly* , 201-226.

Biswas, P., Sikander, S., & Kulkarni, P. (2023). Recent advances in robot-assisted surgical systems. *Biomedical Engineering Advances*.

Burns, A. C., Veeck, A., & Bush, R. F. (2016). *Marketing research.* Pearson Education.

Burton-Jones, A., Akhlaghpour, S., Ayre, S., Barde, P., Staib, A., & Sullivan, C. (2020). Changing the conversation on evaluating digital transformation in healthcare: Insights from an institutional analysis. *Information and Organization*.

C., P., S, S., & A, G. (2019). Snowball Sampling. *SAGE Research Methods Foundations*.

Christian, M., Thomas, H., & Alexander, B. (2015). Digital Transformation Strategies. *Business & Information Systems Engineering*, 339-343.

Compagni, A., Mele, V., & Ravasi, D. (2015). HOW EARLY IMPLEMENTATIONS INFLUENCE LATER ADOPTIONS OF INNOVATION: SOCIAL POSITIONING AND SKILL REPRODUCTION IN THE DIFFUSION OF ROBOTIC SURGERY. *The Academy of Management Journal*, 242-278.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches.* Thousand Oaks, California: SAGE Publications.

Da Vinci. (2023). Retrieved from Intuitive: https://www.intuitive.com/en-us/products-and-services/da-vinci

Dal Mas, F., Massaro, M., Rippa, P., & Secundo, G. (2023). The challenges of digital transformation in healthcare: An interdisciplinary literature review, framework, and future research agenda. *Technovation*.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management science* , vol. 35 pp. 982-1003 .

Denzin, N. K., & Lincoln, Y. S. (2005). *The SAGE handbook of qualitative research.* Thousand Oaks: Sage Publications.

Dmitry, P., Henrik, F., & Torbjørn, H. N. (2023). Digital transformation: A review and research agenda. *European Management Journal*, 821 - 844.

Dodgson, M., & Gann, D. (2010). 'Joseph Schumpeter's Gales of Creative Destruction',. In M. Dodgson, & D. Gann, *Innovation: A Very Short Introduction, 1st edn* (p. 12). Oxford: Oxford Academic.

Duerr, S., Wagner, H.-T., Weitzel, T., & Beimborn, D. (2017). Navigating Digital Innovation - The Complementary Effect of Organizational and Knowledge Recombination. *Wirtschaftsinformatik Conference, St. Gallen, Switzerland: AIS Electronic Library* (pp. 1363–1377). St. Gallen : AIS Electronic Library,.

Eden, R., Burton-Jones, A., Casey, V., & Draheim, M. (2019). Digital Transformation Requires Workforce Transformation. *MIS Quarterly Executive*, 1540-1960.

Elton, J., & O'riordan, A. (2016). *Healthcare disrupted: next generation business models and strategies* . New Jersey: John Wiley and Sons.

Enayati, N., Momi, E. D., & Ferrigno, G. (2016). Haptics in Robot-Assisted Surgery: Challenges and Benefits. *IEEE REVIEWS IN BIOMEDICAL ENGINEERING*.

Fassin, Y. (2012). Stakeholder Management, Reciprocity and Stakeholder Responsibility. *Journal of Business Ethics*, 83-96.

Fitzgerald, M., Kruschwitz, N., Bonnet, D., & Welch, M. (2014). EMBRACING DIGITAL TECHNOLOGY A New Strategic Imperative. *MIT Sloan Management Review*, 1-12.

Fosch-Villaronga, E., Khanna, P., Drukarch, H., & Custers, B. (2022). The role of humans in surgery automation. *International Journal of Social Robotics* .

Frooman, J. (1999). Stakeholder Influence Strategies. *The Academy of Management Review*, 191-205.

Gioia, D. (2021). A Systematic Methodology for Doing Qualitative Research. *The Journal of Applied Behavioral Science*, 20-29.

Gioia, D. A., & Pitre, E. (1990). Multiparadigm Perspectives on Theory Building. *Academy of Management Review*, 584-602.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. *ORGANIZATIONAL RESEARCH METHODS*, 16-31.

Haggerty, E. (2017). Healthcare and digital transformation Author links open overlay panel. *Network Security*.

Henry Lucas, J., Agarwal, R., Clemons, E. K., Sawy, O. A., & Weber, B. (2013). Impactful Research on Transformational Information Technology: An Opportunity to Inform New Audiences. *Management Information Systems Research Center, University of Minnesota*, 371-382.

Holstein, J. A., & Gubrium, J. F. (2003). *Inside interviewing : new lenses, new concerns.* Thousand Oaks: Sage Publications.

Hong, K. S., & Lee, D. (2017). Impact of operational innovations on customer loyalty in the healthcare sector. *Service Business*, 575-600.

Horn, D., Sacarny, A., & Zhou, A. (2022). Technology adoption and market allocation: The case of robotic surgery. *Journal of Health Economics*.

Khan, T. H., & MacEachen, E. (2022). An alternative method of interviewing: critical reflections of Videoconference Interviews for Qualitative Data Collection. *Journal of Qualitative Methods*.

King, W. R., & He, J. (2006). A meta-analysis of the technology acceptance model. *Information & Management*, 740 - 755.

Langley, A. (1999). Strategies for Theorizing from Process Data. *Academy of Management Review*, 691-710.

Lee, A. S., Thi, L.-S., & Lin, M.-H. (November 2017). Affective Technology Acceptance Model: Extending Technology Acceptance Model with Positive and Negative Affec. In M. Mohiuddin, N. Halilem, S. A. Kobir, & C. Yuliang, *Knowledge Management Strategies and Applications* (pp. 148-161). Intech (EU).

Lee, Y.-H., Hsieh, Y.-C., & Hsu, C.-N. (2011). Adding Innovation Diffusion Theory to the Technology Acceptance Model: Supporting Employees' Intentions to use E-Learning Systems. *Journal of Educational Technology & Society* , 124-137.

Legner, C., Eymann, T., Hess, T., Matt, C., & Tilo Böhmann, P. D. (2017). Digitalization: Opportunity and Challenge for the Business and Information Systems Engineering Community. *Business & Information Systems Engineering*, 301-308.

Li, W., Liu, K., Belitski, M., Ghobadian, A., & O'Regan, N. (2016). E-Leadership through Strategic Alignment: An Empirical Study of Small- and Medium-sized Enterprises in the Digital Age. *Journal of Information Technology*, 185-206.

Lobe, B., Morgan, D., & Hoffman, K. A. (2020). Qualitative Data Collection in an Era of Social Distancing. *International Journal of Qualitative Methods*, 1-8.

Locke, K., & Golden-Biddle, K. (2017). Constructing Opportunities for Contribution: Structuring Intertextual Coherence and "Problematizing" in Organizational Studies. *Academy of Management Journal*, 1023-1062.

Ma, Q., & Liu, L. (2004). The Technology Acceptance Model: A Meta-Analysis of Empirical Findings. *Journal of Organization and End User Computing* , 59-72.

Majchrzak, A., Markus, M. L., & Wareham, J. (2016). Designing for Digital Transformation: lessons for information systems research from the study of ICT and societal challenges. *Management Information Systems Research Center, University of Minnesota*, 267-278.

Massaro, M. (2023). Digital transformation in the healthcare sector through blockchain technology. Insights from academic research and business developments. *Technovation*.

Maxwell, J., & Reybold, L. (2015). Qualitative Research. In J. D. Wright, *International Encyclopedia of the Social & Behavioral Sciences 2nd edition, Vol 19* (pp. 685-689). Oxford: Elsevier.

Morse, J. M. (2003). Principles of Mixed Methods and Multimethod Research Design. In *Handbook of Mixed Methods In Social and Behavioral Research.* Sage.

Nunan, D., Birks, D., & Malhotra, M. (2020). *Marketing Research (6th ed.).* Retrieved from https://www.perlego.com/book/1388475/marketing-research-pdf : Pearson.

Reddy, P., & Sharma, B. (2016). DIGITALISATION: THE FUTURE OF HEALTH CARE. *Journal of Business Management*, 126-135.

Robotic surgical procedures market size , share & COVID-19 impact analysis . (2022). Retrieved from Fortune Business Insights: https://www.fortunebusinessinsights.com/industry-reports/robotic-surgical-procedures-market-100124

Rogers, E. M. (1983). *Diffusion of Innovation 3rd Edition* . New York,: The Free Press A Division of Macmillan Publishing Co., Inc.

Rogers, E. M. (2003). *Diffusion of Innovations 5th Edition.* New York : FREE PRESS.

Sascha Kraus, F. S. (2021). Digital transformation in healthcare: Analyzing the current state-of-research. *Journal of Business Research*, 557-567.

Sebastian, I. M., Ross, J. W., Beath, C., Mocker, M., Moloney, K. G., & Fonstad, N. O. (2017). How Big Old Companies Navigate Digital Transformation. *MIS Quarterly Executive*.

Sridhar, A. N., Briggs, T. P., Kelly, J. D., & Nathan, S. (2017). Training in Robotic Surgery—an Overview. *Current Urology Reports*.

Strauss, A., & Corbin, J. (1998). *Basics of Qualitative Research : Techniques and Procedures for Developing Grounded Theory.* Thousand Oaks: Sage Publications, Inc.

Surgical Robotics Market Landscape. (2022, May 23). Retrieved from Global Data: https://www.globaldata.com/reports/surgical-robotics-market-landscape/

Svahn, F., Mathiassen, L., Lindgren, R., & Kane, G. C. (2017). Mastering the Digital Innovation Challenge. *MIT Sloan Management Review* , 239-253.

Taherdoost, H. (2022). What are Different Research Approaches? Comprehensive Review of Qualitative, Quantitative, and Mixed Method Research, Their Applications, Types, and Limitations. *Journal of Management Science & Engineering Research*, 53-63.

Tan, B., Pan, S. L., Lu, X., & Huang, L. (2015). The Role of IS Capabilities in the Development of Multi-Sided Platforms: The Digital Ecosystem Strategy of Alibaba.com. *Journal of the Association for Information Systems*, 248-280.

Taylor, R. H., & Stoianovici, D. (2003). Medical Robotics in Computer-Integrated Surgery. *IEEE TRANSACTIONS ON ROBOTICS AND AUTOMATION*.

Taylor, R. H., & Stoianovici, D. (2003). Medical Robotics in Computer-Integrated Surgery. *IEEE TRANSACTIONS ON ROBOTICS AND AUTOMATION*, 765 - 781.

Ussif, R., Ertugrul, M., Coskun, M., & Baycan, I. O. (2020). Research Methodologies: Qualitative Quantitative and Mixed Research Method in Social Sciences. *International Journal of Academic Multidisciplinary Research*, 83-91.

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattachary, A., Dong, J. Q., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, 889-901.

Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *Journal of Strategic Information Systems*, 118-144.

APPENDIX

Appendix 1: Interview participants

INTERVIEW PARTICIPANTS					
#	**Participant**	**Role**	**Specialization**	**Years of experience**	**RAS involvement**
1	G.A.	Registered nurse (*San Bortolo hospital, Vicenza)*	Operating theatre *(all specialties)*	12	Experience with RAS in different surgical specialities
2	A.C.	Scrub nurse (*San Bortolo hospital, Vicenza)*	Operating theatre *(general surgery senology plastic surgery)*	2	Experience with RAS in different surgical specialities
3	L.B.	Medicine student *(Università degli studi di Firenze)*	-	6 (academic years)	Experience with RAS during apprenticeship
4	S.P.	Scrub nurse (*San Bortolo hospital, Vicenza)*	Operating theatre *(urology, genecology)*	32	Experience with RAS in different surgical specialities
5	E.G.	Scrub nurse (*San Bortolo hospital, Vicenza)*	Operating theatre *(urology, genecology)*	10	Experience with RAS in different surgical specialities
6	G.P.	Registered nurse (*San Bortolo hospital, Vicenza)*	Operating theatre *(all specialties)*	10	Experience with RAS in different surgical specialities
7	C.B.	Anestheseology and critical care resident (*San Matteo Hospital, Pavia)*	Operating theatre *(all specialties)*	4	Experience with RAS in different surgical specialities
8	M.V.	Endocrinology resident (*Brigham hospital, Boston)*	Endocrinology department	2	Experience with RAS during apprenticeship

9	C.C.	Surgeon *(Sant'Antonio hospital, Padova)*	Operating theatre *(urology)*	7	Second operator of RAS in urology
10	G.M.	Registered nurse (*San Bortolo hospital, Vicenza)*	Operating theatre *(all specialties)*	6	Experience with RAS in different surgical specialities
11	L.L.	Medicine student *(Università degli studi di Milano)*	-	6 (academic years)	Experience with RAS during apprenticeship
12	I.M.	Medicine student *(Charles university Prague)*	-	6 (academic years)	Experience with RAS during apprenticeship
13	S.F.	Scrub nurse (*San Bortolo hospital, Vicenza)*	Operating theatre *(general surgery, cardiovascular surgery senology)*	30	Experience with RAS in different surgical specialities
14	F.C.	Cardiology resident (*San Matteo hospital, Pavia)*	Cardiology department	4	Experience with RAS during apprenticeship
15	M.V.	Nurse anesthetist *(Sant'Antonio hospital, Padova)*	Operating theatre *(all specialties)*	16	Experience with RAS in different surgical specialities
16	P.S.	Surgeon (*San Bortolo hospital, Vicenza)*	Operating theatre *(urology)*	8	Second operator of RAS in urology

Appendix 2: Semi-structured interview protocol

INTERVIEW QUESTIONS	
1. Introduction	• Based on my research, I understand that you have been working/studying [ ] at [ ] for [X] years. Could you please confirm this information and share a bit more about your role?
2. Digital Transformation	• Can you describe what has been the impact of introducing new technologies in the healthcare sector?
3. Robot- Assisted Surgery (RAS) technology	• Are you familiar with the use of Robot-Assisted Surgery technology? Have you been somehow involved with this technology? If so, how?
(If the answer is yes, there are a couple of questions more)	• What are the perceived benefits and limitations of robot-assisted surgery compared to traditional methods, according to your experience? • What factors influence the decision-making process for you when choosing between RAS and traditional surgical methods for specific procedures? • How these considerations, influence the frequency and circumstances under which RAS is chosen over traditional methods?
4. The diffusion of RAS and the long-term implications	• What do you think are the main reasons why the hospital adopted/did not adopt RAS technology? How did this decision happen? • Can you give me an example of how RAS impacted the treatment for a patient? • What lessons learned can you share about the integration process of RAS in your healthcare institution? What do you think were key success factors for its implementation, what were the challenges, what have you learned with the process, what would you make different? • What were the motivations to implement RAS in your opinion? Do you feel that the initial expectation has been met so far? If not, why?
5. Outlook	• In your opinion, which actions can healthcare entities take in order to positively implement RAS technology?
6. Conclusion	• Is there anything else you would like to add?

Appendix 3: Interview transcript

Link to OneDrive document: Interviews transcripts_EN version_RAS technology

Appendix 4: Analysis of interview series based on Gioia's method

FIRST ORDER CONCEPT - Direct Quotations	**SECOND ORDER THEMES**	**AGGREGATE DIMENSIONS**
"Well, with the introduction of new technologies and instruments, it's clear that they have decreased the duration of surgeries." (SP)	*Impact of digital transformation and technological innovation in surgery, patient care and operational efficiency*	**Digital transformation impact in healthcare employees and institutions**
"These devices have significantly eased the surgeon's life." (SP)		
"By reducing the duration of surgeries, the related complications, including pain and infections, also decrease because shorter surgery times reduce the likelihood of infections." (SP)		
"The surgeon has a three-dimensional view of the operating field, so they can see every tiny vessel. The precision is meticulously maintained, and there's reduced blood loss because everything is coagulated. This allows for a perfect visualization of all anatomical structures." (SP)		
"From a surgical, but also anaesthesiological point of view. We have seen the advent of so many machines that were not there before. It occurs to me that there is so much monitoring now, whereas when I arrived, patient preparation was much more basic." (EG)		
"There are now monitors to try to check the state of anaesthesia, how much a person is anaesthetised and asleep, and there are systems to heat fluids. To monitor movements, in fact. There are various monitoring systems that were not used before." (EG)		
"The biggest impact I saw was on the patients' therapy. That is, every patient has a daily therapy that also changes from day to day often. And when I was a student, almost every department had a huge A3 sheet where the doctors would handwrite the therapy with all the changes and the nurses would write down when they had administered it. And now it's all computerised." (CB)		
"There are also applications for managing treatments allowing every doctor, including those in specialist training, to have an account they can use to access any computer in the hospital." (FC)		
"When I think back fifteen years ago, there has been a remarkable change brought about by the digital transformation. Many anaesthesia and patient care techniques have developed, bringing great benefits, especially for post-operative pain control." (MV)		
"I think surgery is the area of medicine in which artificial intelligence or, in any case, the whole area of technological development and innovation has had the greatest impact." (MV)		
"Well, in general, in surgery, it has certainly improved certain performances. It has allowed us to reduce the invasiveness of many treatments, which is definitely optimal." (PS)		
"I have noticed a significant impact of digitisation, especially in areas where control over the person is required, with the introduction, for example, of wireless devices that make it possible to record, say, an electrocardiogram for twenty-four hours, and the person does not have to go to the hospital every day, thanks to this little gadget that communicates directly for twenty-four hours everything that happens." (LB)		
"There are technologies that precisely allow you to evaluate the genetics of the patient in a time rate that is really low, you can immediately see all the different types of mutations that are very complicated mutations where you would have to evaluate panels of hundreds and hundreds of genes." (LL)		

"In just a few years, let's say since I was in my first year of specialisation, I'm now in my last, and we have moved from the paper folder where both therapies and the medical and nursing diary were written manually on a sheet of paper to basically fully computerised systems" (FC)		
"As far as cardiology is concerned, artificial intelligence has been implemented in the field of imaging, hence the automatic recognition of echocardiography machines, which can directly make calculations by taking the image and then make an automatic or semi-automatic analysis of certain parameters" (FC)		
"This has a lot of advantages. The first is that it cuts down on the most trivial error is the doctors' handwriting, which is often incomprehensible. Instead with computerised therapy the patient has a bracelet with a qr code and the nurse scans it with a reader and out comes all the medication he or she has to do at that moment" (CB)		
"There is also a double check. That is, when the doctor enters the therapy, the computer detects anomalies and signals them to you like 'look this medication is usually ten milligrams because you are doing three times the dose" ". (CB)		
"Entering instead into the more surgical sphere, let's say more operative, there are certainly new technologies and in fact the objective is still to perform the same treatment but with new instruments, so mainly the use of lasers or precisely new energy sources to try to reduce side effects" (CC)		
"The big problem with technology is that there has to be someone who knows how to use it, and so precisely, especially for people with somewhat older schooling who may have always done everything on paper, saying 'by tomorrow you have to do everything online' becomes a challenge." (LL)	*Training and adaptation challenges to introduce technologies*	
"I arrived that yes, everyone was complaining that they did not know how to operate computers and related software." (LL)		
"This thing happened quite recently, in the sense that when I was a student there were no computerised therapy prescription systems. And even computerised chart systems were reserved for a few departments that acted a bit as a pilot study. Now almost all the big hospitals have adopted this type of technology and computerisation." (FC)		
"Previously everything was much more tied to print, to paper. Although I have to say that we haven't got rid of it but it continues to be, in my opinion, a fifty-fifty as far as composition is concerned, in the sense that one would like to digitise so much but on the other hand sometimes the system doesn't work" (CC)		
"The biggest challenge with new technology is ensuring that everyone is on the same page. Miscommunication or lack of familiarity can lead to mistakes". (GA)		
"In the hospital where I did my internship there were still departments that transcribed patient data by hand and some hybrids where they were half digitised. There was a tendency not to trust technology completely" (IM)		
"I tell you, there are hospitals that are still a bit behind in terms of technological organisation, but not because they don't use software, but because they may still prefer to use paper in some situations" (LL)		
"Introducing new technology can lead to resistance from some staff members, particularly those who are less comfortable with change" (GP)		

"It's not just about understanding how to use the new equipment but also integrating it seamlessly into our existing protocols" (IM)		
"Definitely like implementation for all the different types of analysis. Because, trivially, now the analyses come to us really quickly, especially in certain hospitals, obviously the bigger ones." (LL)	*Institutional and regional disparities in terms of structures' size and funds for technology introduction*	
"it is certainly more common to find a digitised hospital, but it is also likely to find hospitals that use paper, especially in smaller settings" (IM)		
"By now, apart from small and medium-sized provincial hospitals, however, I think it is catching on a little bit in all hospitals" (FC)		
"This thing happened quite recently, in the sense that when I was a student there were no computerised therapy prescription systems. And even computerised chart systems were reserved for a few departments that acted a bit as a pilot study. Now almost all the big hospitals have adopted this type of technology and computerisation" (FC)		
"There's a clear disparity in how quickly hospitals can innovate based on their location and size. Smaller hospitals often lack the infrastructure and funding needed to adopt new technologies promptly, which can affect the qulaity of care provided to patients."(GA)		
"In smaller hospitals, the introduction of new technology can take much longer because maybe let's say they don't have the same level of funding or access to training programs as larger entities. This can lead to significant delays in providing the best possible care to patients" (GP)		
"In larger hospitals, we usually have the infrastructure to support rapid technological changes but sometimes it's still challenging to adapt quickly to the introduction of an innovation" (LB)		
"Robotic surgery is extremely precise and reduces complications for patients. Hospital stay times are short and incisions are minimal, but it requires specific training and specialisation" (L.B.)	*Perceived patient benefits of RAS: minimally invasive surgery and improved outcomes*	**Potential benefits from adopting RAS**
"When they opt for RAS, they make five holes in your belly and you realise that from a wound starting from your sternum and reaching below your navel to four small holes the difference, in short, is substantial even for an after concept of healing infections" (G.A.)		
"I have observed that it seems to shorten time and be less invasive than traditional methods" (M.V.)		
"In a surgery with a robot, the patient's recovery is much, much faster than in a classic operation" (G.P.)		
"For me, robotic surgery is less impactful and invasive for the patient, reducing the risk of infection and ensuring a faster recovery" (M.C.)		
"For the patient, the benefits are as I mentioned before. It's a much less invasive method compared to traditional laparotomies." (EG)		
"This means less trauma to the tissues, resulting in less bleeding, less postoperative pain, and less nausea and vomiting when the intestines are touched, etc. So the patient definitely benefits greatly." (CB)		

"For the patient, not working through a large cutaneous opening but rather using laparoscopy has significant advantages. It allows for faster recovery and reduced postoperative pain." (PS)		
"Certainly, not having a 15 cm incision is beneficial. It's not just about the incision itself. Sometimes, it's still necessary to make a cut to extract the specimen, like in nephrectomies. However, not working for three hours with retractors is advantageous. Avoiding strain on muscle tissues definitely allows for better recovery of the abdominal wall, mobilization of the patient, and reduced postoperative pain." (PS)		
"Well, as I mentioned, the procedure is less invasive, so it causes less pain for the patient. Otherwise, the alternative is to open up, which is a completely different scenario." (GM)		
"The benefits are primarily for the patient, I would say almost exclusively. These benefits include better surgical outcomes because the movement of the robot's arm is a hundred times finer than that of a human hand, and even much finer than that of a laparoscopic arm." (CB)		
"As I was saying, for thoracic surgery, it's incredibly easy to access. You only need to widen the ribs, so you don't break anything, whereas before, you had to cut through all the ribs to get in. You understand it's not the same thing." (LL)		
"All those procedures that were traumatic for the patient, where they had to stay in the hospital for two or three weeks because they couldn't move and felt severe pain with every breath, have been reduced to practically three days of hospitalization." (LL)		
"Well, for the patient, it's definitely much less invasive. So, they don't have all these issues." (IM)		
"The risk of something going wrong is much lower; it's much more controlled." (IM)		
"And for the patient, the results are much more positive." (IM)		
"The robot, from what they say, combines the advantage of having only a few accesses, or rather only a very small access, with therefore a, how should I say, less trauma for the patient" (FC)		
"As for benefits for the patient, being a minimally invasive surgery, it has a significant impact on the postoperative course. A traditional long surgical wound entails a whole series of implications." (CC)		
"I think, for instance, about the fact that a patient can only get up when they have a compression band. The band has to be measured, ordered, and in the meantime, the patient can't get up. This makes early postoperative rehabilitation much more complex. So yes, primarily in terms of postoperative recovery and wound management, the benefits for the patient are evident" (CC)		
"Studies, as far as I know, are still being reviewed in terms of oncological or functional outcomes. However, the impression is that it offers an advantage in these terms for the patient. For instance, in robotic prostatectomies, there is an impression of better erectile function rates and better continence rates, among other evaluations." (PS)		
"Compared to traditionally performed surgeries, surgeons have a much wider range of movement using the robot. So they can do many more movements than their hands could do" (A.B.)		

"RAS has led to an advantage both in terms of vision, because the robot works in three dimensions (3D), and in terms of manuality, because the manuality given by the Robot with respect to traditional laparoscopy is greater because the articulation of the instruments is not only on the two to three axes, but on many axes, especially in the tips, because it allows you to equip the tips and instruments in a way that you cannot do in traditional laparoscopy" (S.L.)	*Perceived surgeon benefits of RAS: reduced physical strain, improved manoeuvrability and better visibility*	
"The introduction of the robot has made work much easier" (G.P.)		
"As for the team, I'm not sure if we can really identify clear advantages. The theoretical advantage, which at least in Italy is not fully exploited, is that the primary surgeon can be miles away from the operation site and still actively participate without needing to travel." (CC)		
"Even on a physical level, the Da Vinci is less demanding for the surgeon than traditional surgery. The surgeon can work sitting in an ergonomic position, whereas with traditional laparoscopy he is forced to work standing with his arms in suspension for long hours." (S.L.)		
"For us, operating room instrumentalists, robotic surgery is easier to manage" (A.B.)		
"The robot is however very user-friendly, the interface is very intuitive and this is something that is very noticeable when using it" (A.B.)		
"For the surgeon, it's a surgery where they can sit comfortably in a chair and operate using two joysticks, making it less tiring and more ergonomic." (EG)		
"It also reduces the surgeon's hand tremors. Unlike laparoscopy, where you still hold the instruments in your hands and don't have the tactile perception of the organs, with the robot, you move through joysticks but don't physically touch the organs. This requires some getting used to and can be seen as a disadvantage." (EG)		
"For urological surgery, and in particular for operations involving the small pelvis, RAS has a significant advantage for the operator. In fact, the robot allows better manoeuvrability of instruments in small spaces and offers better visibility, which allows finer and more precise operations." (PS)		
"In my opinion, it is important for the hospital to keep up with technological developments. In the global context of medicine, we cannot afford to lag behind in surgical techniques. If a medical institution does not keep up to date, it risks losing prestige and not being chosen by patients who are informed about the available options" (SL)	*The enhanced competitiveness and prestige given by RAS to hospitals*	
"With regard to external pressures and competition between hospitals, it is possible that there was some influence in the decision to adopt RAS" G.P.		
"So I see both an evolution from a surgical point of view, and also a prestige that allows the hospital to say 'yes we have the robot too' and in this way remain competitive" (SL)		
"Demand from surgeons themselves also seems to be an important factor" (MC)		

"There are a series of advantages for the patient that are crucial in 2024 in the civilized world where the resource is available. It wouldn't even be acceptable for certain procedures to be performed in some peripheral hospitals when, instead, the patient could be sent to Vicenza and have the procedure done properly there. The guideline would be that this is the right thing to do." (PS)		
"So, it is unthinkable not to have it in HUB hospital like Vicenza."		
"My personal opinion is that, you know, people come in and ask, 'Will I be operated on with the robot? Will they use the laser?' It's something that attracts patients. Having robots and being equipped with these technologies adds a bit of prestige. However, I'm not sure if there are other reasons driving a facility to have these technologies. I think that's mostly it." (SF)		
"Nowadays, the traditional open technique is practically no longer performed, so any patient I see and who is a candidate for radical prostatectomy, when I tell them that I can only do it with the open approach, it's a moment of hesitation, because the patient has a thousand other options even nearby to have the surgery with a minimally invasive approach." (CC)		
"It is unthinkable to continue operating as twenty years ago" (MC)		
"So, now I believe that any hospital, not necessarily a third or second level hospital, but even smaller hospitals, are all trying to acquire a robot because not having a robot means being significantly less competitive." (CC)		
"The need to keep up with the times and provide an adequate service to patients have been key reasons for the adoption of robotic technology" (MC)		
"Well, it depends a bit on the surgeons. When there is a team of surgeons in a hospital who specialize in this area and strongly believe in it, they will do everything possible to get it purchased and used." (CB)		
"There are certainly surgeries that can only be done with robotics. Or rather, they could be done in other ways, but the advantage of using robotics is much higher. This allows you to attract a series of patients who otherwise would not come to your hospital and might go elsewhere". (CB)		
"I can confidently answer that they probably expected something more because in Padua they are now trying to further implement it. But even when I was in residency, there were two robots, one exclusively for urology and another shared one, but the shared one was used very little, not so much by urology, but each specialty had its own time slots and days in which it could be used. The urological time slot was occupied, but the others not all. So, they probably expected more." (CC)	*Partial fulfilment of expectations and superiority of traditional laparoscopic surgery*	**Perception of expectations' achievement: benefits obtained and room for improvement**
"I would say that they have not been fully satisfied, but not because of any shortcomings on the part of the robot or the technology, but because other factors lead to having a robot and keeping it unused four out of eight out of ten sessions per week and that is stupid, so its use should be maximised and it should be used every day all the time. In addition, increasing its volume brings down the cost so the benefit in economic terms is increased" (PS)		

"I think partially. I think the initial idea was to apply it to many more fields. Instead, in the end, the number of procedures suitable for robotics isn't that many—there are two or three procedures per specialty, and not all specialties use robotics." (CB)		
"Okay, so maybe they thought they could convert many more procedures to robotics, but then they realized that many are still more advantageous with laparoscopy." (CB)		
"While there are benefits, we found that many procedures are still more advantageous with laparoscopy, which limits the full potential of RAS." (GP)		
"Some benefits have been met, especially in terms of precision and reduced complications, but the costs are still a significant concern" (LB)		
"That's a good question. I'm very practical, so I would say yes, for certain types of procedures it is very effective. As I mentioned before, it allows for surgical techniques that were possible with colonoscopy but with greater difficulty. Let's say the procedures are done better. It has indeed been a gain and a positive development. If we exclude that aspect, then yes, let's define it this way: it has been positive for certain procedures and has allowed them to be performed better" (SF)	*Fulfilled expectations and need for little to no improvement*	
"In the hospital where I did my internship, they told me that each year they had a certain number of operations to perform with the robot to effectively recoup the implementation costs, and each year up to that point, that number had been reached. So, I would say that the expectations have been met." (IM)		
"In my opinion, the expectations have been met, but there is room for improvement. I believe they can still improve. Right now, they have reached a certain level, but there is potential to take it a step further." (GM)		
"From a business perspective, RAS has successfully attracted top talent and new patients, enhancing our hospital's competitiveness and reputation in the healthcare market." (FC)		
"Yes, I believe the benefits of RAS have been realized. The advanced imaging and precise execution have greatly improved our operational efficiency, resulting in better surgical outcomes and shorter surgery times." (FC)		
"You don't have the tactile perception of the organs with the robot. You move using joysticks, but you don't physically touch the organs. So, it's a bit different and takes some getting used to. This aspect is missing." (EG)	*Complex dynamics and logistical challenges in robotic surgery Implementation"*	**Challenges hindering further adoption of RAS**
"Another disadvantage is that the primary surgeon works at the console, while the assistants are a bit distant. So, there's no gathered team, and the distance can make communication a bit more difficult at times." (EG)		
"In reality, the robot creates a much more complex dynamic in the operating room for the team. When everyone is in the surgical field, they all see the same things, making it easier to manage and more orderly." (CC)		
"With the robot, there are different perspectives. The primary operator sees through the console with a highly magnified view, which can prevent them from evaluating certain aspects." (CC)		

"At the operating table, there's the second operator and the scrub nurse, who try to manage the situation, but sometimes there are issues with the robot that affect the primary operator but need to be managed by the second operator." (CC)		
"In my opinion, managing the robot is more complex for the team." (CC)		
"The costs of training personnel are significant." (EG)		
"For an hospital, investing in RAS is a big step, and they might not have enough resources to financially sustain it" (M.V.)		
"The Da Vinci is a machine that requires a lot of space. First of all, you need a room that is specially calibrated for its weight and everything else. And just to get it in, you need the right doors. I mean, everything has to be in place." (EG)		
"Yes, it's bulky, heavy, and large. They had to calibrate a specific room for it. That room is used only for the robot. So, in my opinion, it's also a logistical issue of space and everything else. Aside from that, which I think is fundamental because if you have to use another of our operating rooms just for the robot, it means taking away operating slots from other specialties that might not use the robot. Currently, there are three specialties that use it." (EG)		
"And the robot is very bulky. For example, in our operating block in Pavia, the problem is that it's so bulky that it physically fits in only two out of eleven rooms." (CB)		
"A limitation of robotic surgery is the many connections that need to be set up. If you don't do them correctly, you have to reset everything and start over." (GM)		
"Another limitation is that the instruments are quite large. So, it can happen that in the operating room, while the surgeon is working, the robot's arms might touch each other, triggering an error signal. You then have to disconnect and reconnect everything again. That can be quite problematic." (GM)		
"The robot requires longer setup times. Just mounting and aligning the robot's arms with the machine takes an hour." (CB)		
"The surgical times are slightly longer. Perhaps this is the only real disadvantage for the patient, meaning that a procedure that might take two hours laparoscopically might take three to three and a half hours with the robot." (CB)		
"That was an advantage and a disadvantage, in the sense that especially in the beginning the surgery duration was much longer, because a traditional surgery that took a couple of hours almost doubled the time using robotics, obviously because of manual dexterity and habit." (S.L.)		
"One potential issue is the extended operative time, not the actual time spent operating, but all the preparation time: setting up the room, assembling and disassembling the robot, especially if the team hasn't undergone specific robotic training" (PS)		
"I also include, for example, surgeons and operating room nurses who are not familiar with the robot and its instruments. How do you manage and maneuver the robot in the operating room? How do you adjust the gas levels, etc.? These tasks extend the overall time, highlighting the necessity of having a team that knows how to use the equipment and is familiar with it to avoid excessively prolonging the surgery times." (PS)		

"In laparoscopy, you have a much smaller range of motion, but with the robot, you can move a lot. You need to be much more adept at maneuvering." (LL)		
"And then, there are the costs, as you mentioned earlier. The instruments have limited lifespans. In addition to being single-use, the instruments also have a limited number of uses and are quite expensive." (EG)	*Financial constraints: personnel training, maintenance and tool replacement costs related to the robot*	
"The costs associated with robot instruments can therefore be very high, compared to those of traditional laparoscopy. For example, while laparoscopic instruments can be used several times until they are damaged, the instruments of the Da Vinci robot have a limited lifespan, usually between ten and fifteen procedures. Once the usage limit is reached, the system warns and the device has to be replaced, with costs ranging from a few hundred to several thousand euros per instrument" (S.L.)		
"I also think the costs of training personnel are significant." (EG)		
"For an hospital, investing in RAS is a big step, and they might not have enough resources to financially sustain it" (M.V.)		
"Maintenance and replacement costs of instruments represent a significant part of the budget required to use the Da Vinci in the operating room" (S.L.)		
"Then again, the robot is insanely expensive as a machine. Why? To tell you just the camera they put in to inspect whether you can actually proceed with the operation with the robot costs as much as a flat" (G.A.)		
"Using robots certainly requires a financial outlay, because special procedural packages are opened and cost a lot of money" (G.P.)		
"The major limitation is definitely that there needs to be an operator who knows how to use the robot because it is much more challenging." (LL)	*Training and role adjustment's challenges*	
"So, obviously, in big cities, you find surgeons who can use it. But in more remote areas, you simply don't find surgeons who know how to operate it. That's a significant limitation because it's completely different from traditional surgery." (LL)		
"While it becomes more convenient once you've learned it, the learning process is very difficult. In our case, those who use it have done years and years of training on that robot." (LL)		
"I actually prefer non-robotic surgery. Unfortunately, the robot, by replacing many human maneuvers, makes us less active and important in the team. The main surgeon has the primary role, then there's an assistant with a secondary role. We are quite marginal; we prepare things and assist. But it's a bit boring as a type of surgery. You're not very active. With laparoscopic or open surgeries, we were definitely more active and engaged. So, unfortunately, the answer is that robotic surgery isn't as enjoyable for a nurse, but it is certainly fascinating and interesting. The point is that after you've done many, many of them, it becomes a bit tedious." (EG)		
"Our role as operating room instrumentalists during robotic surgery is a bit more secondary. My role becomes a mere passing of instruments, whereas in traditional surgery we usually have a more active role" (A.B.)		

"Unlike normal surgery, robotic surgery requires a longer preparation and process, especially for operations on small structures" (L.B.)		
"During my time at university I never heard of robotic surgery." (A.B.)	*Educational gaps in robotic surgery training*	**Need to revolutionize the training approach to facilitate the further implementation of RAS technology**
"There are no specific courses at university on the application of artificial intelligence or robotic surgery." (M.V.)		
"Robotic surgery training is still niche at university." (L.B.)		
"I have not seen a trainee using the robot directly for training purposes." (M.V.)		
"A person who arrives in the operating theatre does not start using the robot if he is not trained on standard surgeries." (A.B.)	*Initial training challenges*	
"Training requires time and additional personnel in the operating room." (PS)		
"At the beginning, when the Da Vinci arrived, the specialists were there very often, i.e., at every intervention. So all the colleagues were able to get training. Obviously afterwards, the new ones who arrive build on the training of colleagues who have already experienced it." (G.P.)		
"Should training be more cross-disciplinary? It can't be that, for example, only one gynecologist performs robotic hysterectomies in our facility. That's not enough and it's not acceptable. If only one person does it, they must teach someone else. The robotic technique cannot die with them, but unfortunately, this happens in many places." (CB)	*Need for cross-disciplinary and ongoing training*	
"From what I've seen, it's primarily a training problem. If a person in a certain field isn't trained, maybe the head of the department isn't either, then the rest of the team won't be trained. As a result, certain procedures won't be performed with the robot but with another approach. I believe this is a significant limitation." (CC)		
"There is a lot of inconsistency within the operating room team, both among operators and nurses, in terms of familiarity with robotic instrumentation. However, I see that young staff members adapt quickly, but to become proficient in robotic surgery, they need to practice more frequently." (LB)		
"One potential issue is the extended operative time, not the actual time spent operating, but all the preparation time: setting up the room, assembling and disassembling the robot, especially if the team hasn't undergone specific robotic training" (PS)		
"I also include, for example, surgeons and operating room nurses who are not familiar with the robot and its instruments. How do you manage and maneuver the robot in the operating room? How do you adjust the gas levels, etc.? These tasks extend the overall time, highlighting the necessity of having a team that knows how to use the equipment and is familiar with it to avoid excessively prolonging the surgery times." (PS)		
"I have seen specialists present during robotic operating sessions, but I do not know the details of the instrumentalists' training. However, it seems that new instrumentalists are joined by more experienced colleagues to gain experience." (M.C.)		