Exploring Factors Influencing Patients Willingness to Consent to (Robotic-Assisted) Total Hip Arthroplasty

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Exploring Factors Influencing Patients Willingness to Consent to (Robotic-Assisted) Total Hip Arthroplasty

by

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Preface

This thesis is the final step in my Master's program in Management of Technology and presents my research on patient willingness to consent to robotic-assisted surgery. The study was conducted using a questionnaire designed to explore factors influencing willingness to consent to robotic surgical procedures. I am deeply grateful to all who have contributed to this work and my development as a researcher.

First and foremost, I would like to express my gratitude towards Dr. Oscar Oviedo-Trespalacios, for his continuous support and insightful guidance throughout this project. I am thankful for the received degree of autonomy and always positive and clear directions. I also extend my appreciation to my second supervisor, Dr. Perla Marang-van de Mheen, for her insightful advice and critical input. Additionally, I am grateful to Prf.dr.mr.ir Neelke Doorn for their oversight and expertise in shaping the direction of this study.

Finally, I would like to acknowledge the participants who took the time to complete the questionnaire, contributing to the findings of this research. Their willingness to participate in this study made this work possible.

I hope that this thesis provides meaningful insights into the willingness to consent to robotic-assisted surgery and contributes to the ongoing discussion on its implementation in healthcare.

Maarten Lemmens
Delft, April 2025

Summary

Robotic-assisted surgical methods are advancing rapidly, offering potential advantages such as improved precision, accuracy, and reduced patient recovery times. However, widespread adoption depends not only on technological advancements but also on patient acceptance and willingness to consent. Informed consent plays a crucial role in the successful integration of robotic-assisted surgery into clinical practice, making it essential to understand the factors influencing patient decision-making.

This study investigates the key factors influencing patient willingness to consent to robotic-assisted total hip replacement surgery in the Netherlands, using a direct-effects model and an extended Technology Acceptance Model (eTAM). A questionnaire-based survey was conducted to assess trust, perceived usefulness (PU), perceived complexity (PC) and willingness to consent across five different surgical scenarios with varying levels of robotic involvement and surgeon presence.

Results indicated that trust and PU showed the strongest association with willingness to consent across all scenarios, emphasizing the need for healthcare providers to prioritize transparency, building trust and discussion risks and benefits. Testing the mediating effect of showed that PU did not act as a consistent mediating variable in any of the scenarios. ANOVA results revealed significant differences between surgical scenarios, with robotic-assisted surgery performed by a surgeon receiving the highest ratings in PU, trust, and willingness to consent. Remote surgery was perceived as the most complex surgical scenario. Participant preferred autonomous robotic surgery over conventional (manual) surgery, despite higher trust and willingness scores for the latter.

Participants also had varying views on the role of technicians in robotic surgery. While many saw their presence as essential for system reliability, others associated it with potential system flaws, emphasizing the need for clear communication about their role. Additionally, most participants mentioned the need for full disclosure regarding surgical methods, reinforcing the importance of patient autonomy.

These findings provide valuable insights for healthcare providers and policymakers to improve informed consent procedures and increase the adoption of robotic-assisted surgery. By addressing patient concerns through education, transparency and building trust, healthcare providers can improve patient comfort and willingness to consent to robotic (assisted) surgery.

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1 Introduction

1.1. Background

Robotic-assisted surgery is a technique which involves usage of specialized robotics during surgical procedures to enhance precision and accuracy. The first robot used in surgery on a human patients was the PUMA 200, employed in 1985 to perform neurosurgical biopsies [1, 2]. Currently, the da Vinci surgical robot (Intuitive Surgical Inc.) is the most widely adopted robotic surgical systems in the world. In 2017, approximately 877,000 procedures were performed worldwide using the da Vinci system [3]. The first da Vinci device received FDA approval for abdominal surgery in the United States in 2000 and became mainly employed in urological surgery [1]. Nowadays, multiple procedures use different robotic surgical systems, including orthopedics, cardiology, urology, endocrinology, metabolic, and bariatric surgery, head and neck surgery, and all intra-abdominal surgery [2, 3].

Robotic-assisted surgical methods can offer both advantages and disadvantages. Significant advantages over conventional techniques can include improved surgical precision, improved accuracy and reduced patient recovery times [4, 5]. Besides possible benefits, robotic surgery can present several disadvantages related to malfunction, alterations in patient positioning and haptic feedback, where loss of accurate haptic feedback might lead to technical errors and increased operative time. In turn, longer operation time leads to increased healthcare cost and risk of infections. Meanwhile, surgical robotic devices require training, additional costs and sufficient operating room [3]. Moreover, consistent observations by Catchpole et al. (2019) found that communication and coordination problems are frequent during surgery using robotic technologies [6].

Currently, robotic-assisted surgery is primarily used as a tool to enhance a surgeon's precision and control, with procedures being performed under direct human supervision. While these systems improve surgical outcomes and reduce invasiveness, they still rely heavily on human expertise and decision-making. The future of robotic surgery might evolve towards increased autonomy and remote capabilities. Advances in artificial intelligence (AI) and machine learning may allow robotic systems to execute increasingly complex procedures with minimal human intervention. AI applications such as image recognition, motion control, and haptic feedback could allow for real-time analysis of surgical images and optimized instrument movement [7]. This could potentially result in increased precision and reduce the risk of human error. Therefore, future robotic technologies could lead to better patient outcomes while minimizing complications such as tissue damage [8]. Another possible future application of robotic technologies in healthcare is remote surgery, where the surgeon performing the operation is remotely located. Remote surgery has the potential to revolutionize healthcare accessibility by allowing medical specialists to perform complex procedures on patients in distant locations. This advancement is particularly crucial for rural and underdeveloped areas, where access to specialized surgical expertise is often limited. By leveraging robotic-assisted systems and high-speed communication networks, remote surgery can bridge this gap, ensuring that patients receive high-quality care. However, for widespread adoption, challenges in communication, cybersecurity and regulatory frameworks must be addressed to ensure safety, reliability, and public acceptance of remote surgical procedures.

Despite these potential advantages and future directions, the widespread adoption of robotic-assisted surgery depends not only on technological advancements but also on social acceptance of the technology. Informed consent and patient acceptance are critical to the successful integration of robotic-assisted surgery into clinical practice. These factors are critical, as even the most advanced robotic systems cannot be integrated without social acceptance. Acceptance, drives adoption of robotic surgery. While the potential benefits might increase acceptance, concerns can hinder acceptance. Acceptance can be defined as the behavioral intention or willingness to use and reflects a patient's general attitude towards a technology [9]. Technical factors influence acceptance through safety, reliability and accuracy of the robotic system, while psychological- and social factors influence acceptance through trust, comfort, perceived risks and attitudes. Simultaneously, willingness to consent is a specific decision to allow robotic-assisted surgery in a patient's own surgical procedure. While acceptance can create a foundation through trust and positive perceptions, willingness to consent can also be shaped through other factors such as risks, understanding and communication during the informed consent process [10]. Informed consent ensures patients understand the benefits, risks, and alternatives of surgical procedures. Given the complexity of robotic surgery, clear communication and transparency are essential to address misconceptions, such as the role of the surgeon and the robot. Transparent discussions should cause patients to make informed decisions, increasing trust in the technology.

There is currently a significant gap in the literature regarding the factors influencing patients' willingness to consent to robotic-assisted surgery. Developing theoretical frameworks to explain willingness to consent is essential, as existing models do not fully capture the complexities of patient decision-making in robotic-assisted surgery. Establishing such frameworks provides a structured approach to identifying key factors, guiding healthcare strategies and help create a more informed and accepting patient population.

In this study, the focus will be on total hip replacement surgery. Hip replacement surgery serves as an ideal case to study willingness to consent to robotic procedures due to its high volume and improved quality of life after the procedure. In 2023, more than 46,000 and 760.000 hip replacement surgeries are performed in The Netherlands and United States, respectively [11, 12]. Moreover, this number is expected to grow with approximately 70% in 2040 [13, 14]. Therefore, advantages of robotic-assisted hip replacement surgery can have a significant impact on a large number of patients.

when using Stryker Mako robotic technologies, an assisting technician might be present in the operating room. This was observed in previous field work and is (often) not disclosed in informed consent. Responsibilities of these technician might include troubleshooting, calibration and managing the robotic systems. However, patients are often unaware of the presence of these technicians and of their influence on the surgical procedure. Therefore, this causes transparency issues as patients are not fully informed about the influence and presence of this technician. Patients might trust the surgeon and expect him/her to solely perform the surgical procedure. This trust might be affected if patients learn that a technician influences the procedure. The effect of the presence of a technician on willingness to consent is currently not explored in literature.

1.1.1. Robotic-assisted Total Hip Arthroplasty (THA)

THA is widely considered an effective and highly successful orthopedic intervention. However, the accuracy of implant placement is a critical determinant of surgical success, as misalignment can lead to complications. Common complications after THA include dislocation, accelerated linear wear, unfavorable mechanics, leg length discrepancy and ultimately the need for revision surgery [15]. Therefore, there is a growing interest among healthcare providers to implement new methods to increase accuracy of implant placement.

One of the most used robotic assistance is the MAKO THA system (Stryker) [5]. It was introduced to provide improved implant positioning and alignment, among others, to improve functional outcomes in the short- and long-term. Using this robotic-assisted technology, the surgeon remains responsible for the appropriate approach, type and size of incisions for an optimal procedure.

Usage of robotic-assisted THA has been shown to have benefits related to enhanced precision, accurate implant positioning, greater operative control, superior visualization, and higher accuracy while maintaining minimal bone resection [5, 16]. This technology might allow for early improvement in functional results which enhances patient recovery. However, definite advantages of robotic-assisted THA are still controversial. Another study showed improved outcomes in safe placement, but no significant difference in immediate postoperative complications compared to conventional (manual) THA [17]. Moreover, robotic-assisted technologies are prone to other limitations regarding standard usage in all hip morphology and pathology, availability and accessibility [5].

Usage of robotic technologies might improve accuracy, reduce complication rates and provide better functional outcomes, but it must be cost-effective and easily accessible as well. This especially holds in the short term [5]. Costs of robotic technologies (and possible increased operation time) might be compensated by saving money on reduced hospital stay and prevention of costly revision surgery.

While robotic systems like the MAKO THA offer potential benefits in precision and functional outcomes, their adoption and integration is influenced by more than just effectiveness. Patients must be willing to consent to these technologies in their healthcare, which can be shaped through understanding, trust and acceptance of robotic-assisted surgery. If they don't consent, hospitals will not be able to compensate the economic investments in acquiring robotic systems. Thus, exploring the factors that drive patient acceptance of robotic-assisted surgery is essential to ensure its broader implementation and integration.

1.2. Literature Review

The literature review explores key themes related to patient acceptance of robotic-assisted surgery, the challenges and considerations in the informed consent process and the role of technology acceptance models.

1.2.1. Acceptance of Robotic-Assisted Surgery

Despite advancements, acceptance of robotic-assisted surgery varies. A study by Boys et al. (2016) on global public perception of robotic surgery shows that over half of survey respondents view hospitals offering robotic-assisted surgery as more favorable than hospitals without, but only a quarter thought that surgeons performing robotic-assisted surgery were better [18]. Additionally, despite the potential of robotic surgery, only a small minority consider robotic-assisted surgery to be safer (22%), less painful (8%), or yielding better outcomes (10%) [19]. At the same time, surveys conducted in Saudi Arabia, Singapore and globally indicate that more than half of respondents express concerns about possible malfunctions that could cause internal damage [18, 19, 20].

Beyond patient perceptions, several obstacles hinder the widespread adoption of robotic-assisted surgery. While technological advancements have improved precision and surgical outcomes, limitations related to patient decision-making, safety concerns, and regulatory challenges persist [21]. Patient hesitation stems from uncertainties about robotic autonomy, potential complications and the role of human oversight during surgery. Existing research on adoption has primarily focused on the benefits and success rates of robotic-assisted surgery, such as post-surgical outcomes, general anesthesia experiences, and patient satisfaction. Yet little is known about patient perceptions of technology in healthcare, trust in robotic-assisted surgery and trust in medical teams [22, 23]. The reasons behind these perceptions and their influence on decision-making during informed consent remain largely unexplored. As robotic-assisted surgery continues to evolve, understanding these perceptions is essential for both acceptance and informed decision-making. Given these challenges, the informed consent process must be adapted to address the unique complexities of robotic-assisted surgery. Enhanced transparency, clear communication, and patient education are essential to bridge the gap between technological innovation and patient acceptance. By addressing these issues, healthcare providers can better support patients in making informed decisions about their care.

1.2.2. Informed Consent in Robotic-Assisted Surgery

Informed consent is a critical process in which a healthcare professional explains a patient the risks, benefits, and alternatives of a given procedure or intervention. It involves assessing the patient's understanding, making clear recommendations, and documenting the process. The patient's active participation in decision-making must be emphasized to ensure autonomy and avoid any sense of coercion [24]. For robotic-assisted surgery, the informed consent process is particularly important due to the complex and often misunderstood nature of the technology. Informed consent requires addressing three key criteria: the patient's capacity to make decisions, the provision of adequate information and the absence of coercion [25]. To ensure patients are well-informed, key topics must be addressed, including patient misconceptions, surgeon experience, robotic availability, and ethical principles such as beneficence, nonmaleficence, and autonomy [26, 27].

Robotic-assisted surgery introduces additional complexity to the informed consent process due to its technical nature and additional factors influencing patient decision-making. Before deciding to undergo robotic-assisted surgery, more than 70% of patients desire a general description of the procedure, acknowledgments of unknown risks, the number of prior procedures performed by the surgeon and the surgeons training for the procedure [28]. However, the technical nature of robotic surgery can make it challenging to communicate this information effectively, particularly when patients have limited understanding of the technology. Below, several challenges in the informed consent process for robotic-assisted surgery are discussed.

Patient Misconceptions and Understanding

Misconceptions about robotic-assisted surgery are common and can influence decision-making. Patients often perceive robotic surgery as the least invasive and most advanced option, driving demand for these technologies [29]. However, current robotic systems act solely as tools controlled by surgeons, with no autonomous functionality [30]. This misunderstanding can lead to unrealistic expectations about the role of the robot and the level of human involvement in the procedure. Furthermore, the proven advantages of robotic surgery remain debated. Therefore, Wightman et al. (2020) argue that choosing for robotic-assisted surgery deserves caution. However, this does not mean that robotic-assisted surgery should not be used [26]. This underscores the importance of providing proper information during the informed consent process to ensure patients make well-informed decisions.

Surgeon Experience and Robotic Availability

The surgeon's experience with robotic systems is a critical factor that should be disclosed during the informed consent process, as it can significantly influence outcomes. Surgical expertise with robots varies, with proficiency typically developing after 15 to 95 procedures [31]. Discussing the number of prior robotic-assisted surgeries performed by the surgeon allows patients to make more informed decisions [32]. Additionally, availability of robotic systems can affect the scheduling of procedures, potentially causing delays [33]. These challenges can impact a patient's decision to choose robotic surgery, particularly when timing is critical.

A recommended surgical approach depends on the surgeon's preferences and likelihood of success. Historically, specific treatments are recommended based on the potential benefits for the patients. However, robotic-assisted surgery might not always be superior to conventional methods. Therefore, some factors can be important in choosing between the two methods. Robotic-assisted surgery is found to cause less muscle fatigue for surgeons [34]. Additionally, surgeon's comfort, preference and skill developments can be reasons for the surgeons to recommend robotic-assisted surgery [35]. Surgeons may recommend robotic-assisted surgery for various reasons. However, true reasons for recommending robotic-assisted surgery should be discussed in the informed consent process.

Ethical Principles: Beneficence, Nonmaleficence, and Autonomy

Ethical principles play a central role in the informed consent process for robotic-assisted surgery. Beneficence emphasizes that interventions should prioritize patient benefits, such as shorter hospital stays, lower complication rates, and increased precision [4]. Nonmaleficence ensures that surgical risks are minimized and balanced against potential benefits [26]. Respect for autonomy ensures that patients are properly informed and free to make their own decisions. While surgeons may provide guidance, patients must be allowed to make autonomous choices, with interventions based on mutual agreement [26].

Challenges in Informed Consent for Robotic Surgery

The complexity of robotic-assisted surgery raises concerns about how to effectively communicate key information, ensuring that patients can make well-informed decisions about their treatment. A major issue is the lack of standardized guidelines regarding what specific details should be disclosed during informed consent. There is no clear consensus on how much technical information patients should receive, which potential complications should be discussed or what the best way is to explain the role of the surgeon [28]. Since patients often struggle to understand complex medical procedures, healthcare providers play a crucial role. Clear, transparent, and accessible communication is essential to ensure patient understanding [36, 37].

Understanding these challenges is crucial for examining how informed consent impacts patient willingness to consent, a key factor in the successful adoption of robotic-assisted surgery.

1.2.3. Willingness to consent

Willingness to consent will be the dependent variable in this research and refers to patients' willingness to undergo robotic surgery in different scenarios. Willingness to consent to robotic-assisted surgery is influenced by various factors, including trust, perceived risks and benefits, and understanding of the technology. Research has primarily focused on clinical outcomes. For example, a study by Ahmad et al. (2017) found that respondents believed that robotic-assisted surgery decreases infection rates (63%) and length of hospital stay (50%) and increases precision and accuracy (85%) [38]. However, little is known about patients' perception on technology in healthcare and willingness to undergo robotic surgery [22]. One study by Abdelaal et al. (2023) showed that patients have limited knowledge and ambiguous understanding of robotic-assisted surgery. Most patients undergoing robotic surgery reported that their understanding of the robot was average to poor (69,9%) and acknowledged that they were not properly informed about the surgical procedure. Therefore, the decision-making and motivation of potential patients may be swayed by misinformation and aggressive advertising [39].

Risk and benefit assessments play a crucial role in shaping willingness to consent. They are rated as the most important category to be discussed prior to medical interventions. The vast majority of individuals considered (un)known risk and known benefits to be essential for deciding whether to undergo (robotic-assisted) surgery, regardless of innovation [28]. Besides, before deciding to undergo robotic-assisted surgery, more than 70% of patients desire a general description of the procedure, acknowledgments of unknown risks, the number of prior procedures performed by the surgeon and the surgeons training for the procedure [28]. This suggests that a well-informed consent process might significantly impact patients' willingness to consent.

Although prior research has largely focused on technical or medical aspects of robotic-assisted surgery, one study by Anania et al. (2021) investigated patient willingness to consent to robotic-assisted surgery in the United States [22]. This research found eight significant predictors of willingness to undergo robotic-assisted surgery, being: familiarity, perceived value, wariness, fear of surgery, openness, happiness, fear and anger. Interestingly, demographics were not significant predictors for willingness to consent to robotic-assisted surgery. This study was done for robotic surgery in general to build a predictive model of people who would be willing to undergo robotic surgery. Therefore, it does not give a description, such as traditional surgery performed solely by a surgeon, robotic-assisted surgery with direct surgeon involvement, remote surgery or fully autonomous robotic surgery. As a results, it is unable to compare willingness to consent between surgical scenarios, which might differ based on factor like surgeon presence, robotic autonomy and remote locations.

1.2.4. Technology Acceptance Model (TAM)

Previous research has shown that the Technology Acceptance Model (TAM) is commonly used to assess user acceptance of technologies [9]. The interest in people's decision-making regarding acceptance or rejection of technologies has resulted in the development of TAM. Significant progress has been made in explaining user acceptance of technology using TAM [40]. The TAM assumes a mediating role of two different variables between external variables and the potential usage of a technology. Those two variables are called perceived ease of use (PEOU) and perceived usefulness (PU).

The concept of the technology acceptance model was first proposed in 1985 [43]. It was assumed that the usage of a system can be explained by a user's motivation, which in turn can be explained through three factors: PEOU, PU and attitude (Fig. 1.1)[41]. The PU is the degree to which a person believes that using a system would increase his/her performance. The PEOU was defined as the degree to which a person believes using a system was free of effort [41]. Both factors could be influenced by the systems design characteristics. In the final model of Davis et al. (1989), attitude was omitted from the model. This was done because of a partial mediation effect and a strong direct link between PU and

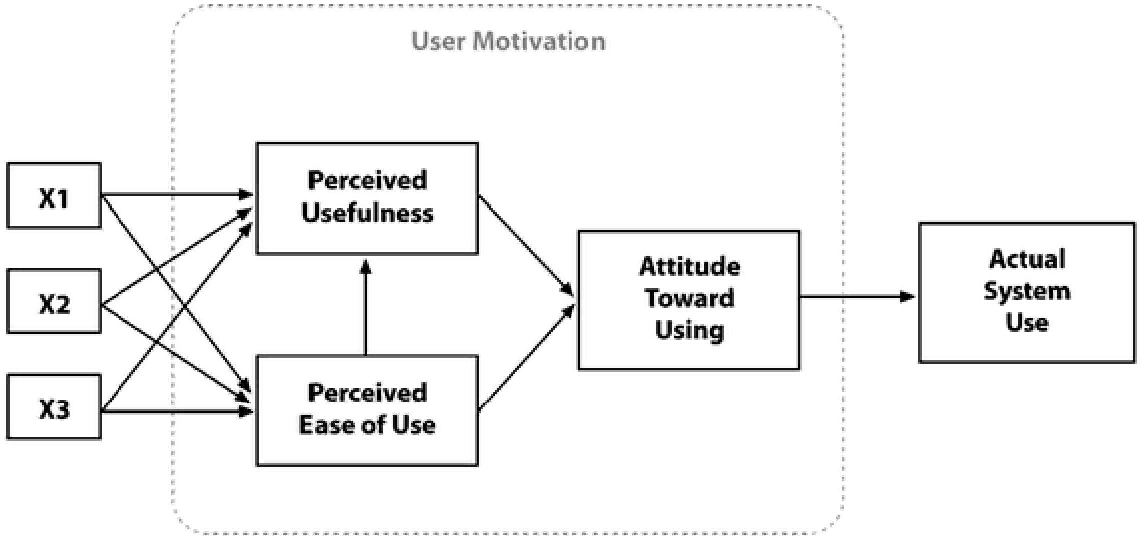

Figure 1.1: Technology Acceptance model including PU PEOU and attitudes towards using [41, 42, 43]

intention. The omission of attitude helps to understand the direct influence of PEOU and PU and the intention to use [40].

TAM in Healthcare

Studies done on acceptance of technology in healthcare do not use a single, uniform model between TAM variables. Most studies begin with TAM as a conceptual framework, after which different variables were either added or removed. Moreover, specific variables can be seen as predictors of either intention to use, PEOU or PU [44]. Added variables include performance of the technology, relevance, personal characteristics and psychological factors such as trust and ownership [44, 45]. Moreover, different studies use different measurement dimension to determine the PU and PEOU.

1.3. Knowledge Gap

In the field of robotic-assisted surgery, much attention has been on the technological advancements, acceptance and role and view of surgeons. However, little is known about the factors influencing patients' willingness to consent to robotic-assisted surgery. Additionally, the relative importance of different factors on willingness to consent remains unknown. While robotic surgery holds great potential, it also introduces unique challenges, including misconceptions about robotic autonomy and its impacts on patients' willingness to consent. Multiple factors might influence a patient's willingness to consent, including psychological factors, demographic factors, familiarity and trust in medical procedures. The influence of these factors might depend on the level of robotic autonomy, the surgeon's location, and the presence of an assisting technician. Particularly, little is known about the influence of an assisting technician present in the operating room, who is a non-clinician with significant influence on the procedure, on patient trust and willingness to consent. These technicians are important for smooth functioning of robotic systems, yet their involvement is rarely discussed with patients or disclosed in an informed consent process.

The identified knowledge gap highlights the need for research exploring how different surgical scenarios affect patient decision-making. Addressing this gap will ensure that informed consent processes are ethical, transparent, and patient-centered, ultimately increasing willingness to consent to robotic-assisted surgery.

1.4. Research Objective

The successful integration of robotic-assisted surgery depends not only on technological advancements but also on patient acceptance and willingness to consent. While robotic-assisted surgery offers benefits such as improved precision and reduced recovery times, concerns about trust, risks and the complexity of informed consent remain barriers to adoption. Understanding the factors influencing willingness to consent is crucial for improving communication and transparency, addressing misconceptions and increasing acceptance.

This study examines how trust in the medical procedure, familiarity, PU and perceived complexity (PC) influence patients' willingness to consent to total hip replacement surgery across different surgical scenarios. By testing a direct-effects model and the mediating effect of PU in an extended Technology Acceptance Model (eTAM), it assesses the relative importance of these factors.

The findings aim to enhance informed consent procedures, guide hospitals in implementing robotic technologies and support policymakers in developing regulations that increase trust. Additionally, insights from this study could help shape patient perceptions through education, training and awareness initiatives, ultimately benefiting the entire healthcare system [23].

1.5. Research Question and Research Aim

Understanding the factors that influence patients' willingness to consent to robotic surgery remains crucial. This research aims to identify the key factors influencing patients' willingness to consent to robotic-assisted THA, with a particular focus on the role of the assisting technician. This study explores a number of influencing factors, guided by the following main research question:

Research Question: *What factors are associated with patients' willingness to consent to different (robotic-assisted) surgical scenarios for total hip replacement in The Netherlands?*

The primary research question address the lack of understanding of how different factors influence willingness to consent in robotic-assisted surgery. Specifically focusing on total hip replacement as a surgical scenario. Five different surgical scenarios will be used: Surgery performed manually by the surgeon without assistance of a robotic system, Surgery performed by a surgeon assisted by a robotic system, Surgery performed by a surgeon assisted by a robotic system and a technician who is involved in the procedure, Surgery autonomously performed by a robotic system under close supervision of a surgeon and Surgery performed by a remotely located surgeon assisted by a robotic system. Additionally, the following research aims were formed to structure the study:

Research aim 1: *Test the utility of a direct-effects model and relative importance of different variables in explaining patients' willingness to consent across five surgical scenarios for total hip replacement.*

The increasing role of robotic technologies in surgery requires the development of theoretical frameworks which can help healthcare providers understand and address factors which influence willingness to consent. By evaluating the relative importance of different factors in a direct-effects model, this study seeks to provide a model that healthcare providers can use to improve communication, informed consent and adoption of robotic technologies in healthcare.

Research aim 2: *Test the mediating effect of PU in an eTAM model on willingness to consent in five surgical scenarios for total hip replacement.*

PU is an important construct of TAM and has been widely recognized as a key predictor of technology adoption. In the context of robotic-assisted surgery, PU might not only directly influence willingness to consent but also act as a mediator between other factors, such as trust, familiarity, and PC.

Research aim 3: *Compare the relative importance of different constructs and their influence on willingness to consent across five surgical scenarios for total hip replacement.*

Besides the utility of conceptual frameworks, the relative impact of different factors across different scenarios remains unknown. The third research aim seeks to compare these constructs across five surgical scenarios. This helps to identify key factors influencing willingness to consent in different scenarios, varying in degree of robotic autonomy and surgeon location. Any differences in the patterns of the constructs predicting willingness to consent to robotic-assisted surgery for five different scenarios will be identified.

Research aim 4: *Explore participants preferences for different surgical scenarios in robotic-assisted THA by analyzing stated preferences and qualitative insights.*

This aim seeks to identify which scenario participants prefer most, uncover the underlying reasoning and provide a deeper understanding of the factors that shape patient willingness to consent. The findings will help refine informed consent procedures and support the development of patient-centered surgical approaches.

2

Conceptual Framework and Research Approach

2.1. Theoretical Background of Key Variables

Patient willingness to consent to robotic-assisted surgery is influenced by various factors, including demographic characteristics, trust, familiarity, and perceptions of risks and benefits. These factors are particularly important in the context of robotic-assisted surgery, where the complexity of the technology can lead to misunderstandings and unrealistic expectations.

2.1.1. Demographic Factors

Variables such as age, gender, ethnicity and education levels play predictive roles in the establishment of trust in robotic assisted surgery and have been shown to influence decision making in technology acceptance [46, 47, 48]. Compared to American and European studies, a study from the middle east reports lower trust in robotic-assisted surgical technologies, where only 6% of respondents trust surgeons using robotic techniques [49]. This might be explained through cultural differences, differences in access to robotic assisted surgery and public knowledge.

Age

Age is included as a predictor of willingness to consent as changes in decision making may come with increased age. For example, older people are found to make more risk-averse decisions compared to younger people. Additionally, younger people are found to take emotional and social factors into account more than older people [23]. In the context of technology adoption, older people take longer to adjust to changing automation and have different reasons for technology adoption. Technology adoption in younger people is influenced by attitudes toward technology, while the adoption of technology in older people is influenced by the perceived control they had and social norms [23, 50].

Gender

Gender is a potential predictor due to differences in decision making between males and females, who tend to respond differently to risky-, social- and competitive situations. In general, males are more willing to undergo robotic-assisted surgery, whereas females report increase fear and lower trust in technology [22, 51]. Moreover women are shown to make more risk averse decisions and are less willing to adopt new automated technologies [23]. Males and females are also shown to have different reasons for adoption of new technologies, where females are more concerned with perceived control and males with attitudes [50].

Education level

Education level refers to the highest level of education which a participant has completed. This is included as participants with a differing level of education might make different decisions. Studies found that education level can be a predictive factor for the usage of new technologies. In this case, higher educated individuals were found to use more types of technology and were more willing to undergo robotic-assisted surgery [22, 23, 51]. In the context of this research, differences in level of education might be associated with the level of understanding of robotic-assisted surgical procedures, which in turn affects the perceived complexity of different procedures.

2.1.2. Familiarity

Familiarity indicates how familiar a participant is with robotic surgery. In the context of joint replacement, those who were less familiar with joint replacement expected longer hospital stays and more pain [23]. This suggests that familiarity plays a crucial role in shaping perceptions of surgical procedures, which may in turn influence willingness to consent. Individuals who are more familiar with robotic-assisted surgery may perceive it as safer, more effective, and less risky, making them more inclined to consent to such procedures.

Pre-existing attitudes, often shaped by familiarity, are significant explanatory factors influencing both trust and willingness to consent. A lack of understanding and fear of robotic-assisted surgery frequently contribute to lower acceptance rates [46]. Similarly, a study by Anania et al. (2021) found that individuals who are wary of new technologies or fearful of surgery were less likely to consent to robotic-assisted surgery [22]. This highlights that pre-existing attitudes affect the willingness to consent.

Individuals who are more familiar with robotic-assisted surgical procedures were found to have more accurate and positive perceptions and were more willing to undergo these procedures [22]. This indicates the positive effect of familiarity with willingness to consent. This can be best explained through understanding of the used technologies or procedures. Additionally, previous experiences with robotic surgery play a crucial role in shaping willingness. Positive experiences may enhance trust and acceptance, whereas negative encounters with robotic technology or surgical procedures can reduced willingness to consent [10].

2.1.3. Trust in medical procedure

Trust in the medical procedure plays a crucial role in patients' willingness to consent to robotic-assisted surgery. Trust influences how patients perceive the risks and benefits of a procedure, shaping their confidence in both the technology and the medical team. A review by Kelly et al. (2023) identified trust as a significant predictor of behavioral intention, highlighting its role in decision-making [9]. In this research, trust is measured as trust in the described surgical procedure. This includes trust in the possible usage of robotic technology, trust in medical personnel and trust in the described surgical procedure.

Trust as a Barrier to Adoption

A lack of trust is one of the primary barriers to adopting new medical technologies [52]. Robotic-assisted surgery represents an uncertain environment for patients, as it relies heavily on human-robot interaction and teamwork, where errors can have severe consequences [53]. Given this uncertain environment, trust becomes a critical factor in whether patients consent to robotic-assisted surgery. Several factors influence trust, and therefore, willingness to consent to robotic-assisted surgery. Understanding how trust is built and maintained in this context is crucial for improving decision-making processes and technology acceptance [53].

Trust is not only shaped by the technology itself but also by the human elements involved in surgery. A study by Boys et al. (2016) found that when patients were given the choice between remote robotic surgery performed by an expert they had never met and a local surgery performed by a less experienced but familiar surgeon, many preferred the latter [18]. This illustrates how interpersonal trust, familiarity with the surgeon, and personal connection influence willingness to consent.

Trust in Medical Professionals and the Impact on Willingness

Surgeons' trust in robotic-assisted surgery also affects patient confidence. Many surgeons remain reluctant to recommend robotic-assisted surgery, often due to extensive training in traditional methods and a reluctance to adopt a new learning curve [49]. Moreover, trust in robotic surgery is closely linked to perceived patient outcomes. When robotic-assisted surgery does not provide substantial benefits for both surgeons and patients, trust in the technology declines, reducing both surgeon adoption and patient willingness to consent [53, 54].

Beyond surgeons, trust in the surgical process itself plays a major role. Research has shown that patients trust human surgeons significantly more than robotic systems. Pradeep et al. (2023) found that 71% of patients placed greater trust in a human surgeon compared to just 6% for robotic systems [53]. This gap in trust can significantly impact willingness to consent, as patients may feel uncertain about a procedure where direct human control is reduced.

The Role of Experience in Trust Development

Experience with robotic-assisted surgery strongly influences trust and, by extension, willingness to consent. Increased experience with robotic-assisted surgery often correlates with greater trust, acceptance and belief of superiority of the technology [51, 55]. However, negative prior experiences can have the opposite effect, reducing trust in robotic procedures. Concerns about malfunctions, inadequate surgeon training, increased costs, longer operation times and potential errors can all contribute to decreased willingness to consent [18].

One of the key determinants of trust is reliability. Highly reliable and precise robotic systems can significantly enhance trust [46, 53]. Misconceptions also play a role. Many patients incorrectly assume that robotic systems operate independently, unaware that surgeons maintain full control [19]. Clarifying these misconceptions through education and transparent communication can significantly improve trust and increase willingness to consent.

Design and Team Integration

Trust is not only influenced by knowledge and experience but also by the design of robotic systems. Studies suggest that surgical robots with anthropomorphic design elements, such as human-like features, can enhance trust, making the technology appear more intuitive and approachable [53]. In contrast, an overly mechanical or intimidating appearance might reduce trust and acceptance.

For healthcare professionals, trust in robotic surgery is closely tied to teamwork and workflow integration. Effective training and collaboration establish clear roles and mutual trust [53]. Coordinated roles and strong team dynamics are essential for reducing concerns about role awareness and enhancing trust and acceptance [56, 57]. However, task division and physical separation can lead to misunderstandings about responsibilities and mental models within the team [58]. An important factors is whether surgical teams have adapted their workflow to integrate robotic technologies or if the technology was simply introduced in existing practices. The latter could lead to inefficiencies and role communication. Therefore, positive communication and trust within surgical teams are critical for fostering trust in robotic-assisted surgery.

2.1.4. Perceived Complexity (PC)

PC refers to the participants' perception of the complexity of the medical procedure. In healthcare, there is a constant need to keep patients well informed about the care they receive, which includes treatment planning. However, the integration of advanced robotic systems into healthcare may introduce additional layers of complexity, potentially increasing patient confusion in an already intricate decision-making process [23]. Consequently, it is crucial to examine how patients perceive the complexity of different surgical procedures and determine whether these perceptions influence their willingness to consent to such procedures.

2.1.5. Perceived Usefulness

PU refers to the participants' perception of the usefulness or added value of robotic surgery. This factor is crucial because there is a strong link between PU and the acceptance of new technologies, with greater perceived value increasing the likelihood of adoption and willingness to consent [40]. The more value or increase in utility one receives from a new technology, the more likely one is to adopt this technology. Therefore, robotic surgical procedures should add value to the patient through, for example, reduced cost, shorter hospital stay, reduced post-operative complications or better surgical outcomes.

2.2. Conceptual Frameworks

This study utilizes two different conceptual frameworks to explain willingness to consent. First a direct-effects model to understand the factors influencing willingness to consent was tested. Secondly, the mediating effect of PU was tested between independent variables and willingness to consent. In robotic-assisted surgery, patients are not using the technology themselves, which is a critical distinction from traditional TAM. Therefore, PEOU is replaced with PC in both frameworks [22]. For patients undergoing robotic surgery, the emphasis shifts from their own ability to use a technology to their perception of how complex the technology is. PC measures how clearly patients can understand the medical procedure (using robotic technologies), the mental effort required and the difficulty and complexity of the procedure (using robotic technologies). By shifting the focus to complexity, the frameworks remains relevant for patient's decision making.

Compared to the TAM described by Davis (1985), patients' attitude is removed from both frameworks. Instead, the proposed constructs from the model by Venkatesh (2000) are used [40, 43]. In this model, attitudes are omitted to help better understand the influence of PC and PU on willingness to consent (or intention to use). Additionally, since trust and familiarity are considered to be important factors influencing willingness to consent, those variables were added in both frameworks. Trust is often adopted in TAM to predict behavioral intentions and found to be a frequent significant predictor [9]. This highlights the relevance of the inclusion of trust in the model. The additions of trust and familiarity ensures that the frameworks captures unique factors factors influencing willingness to consent.

2.2.1. Conceptual Framework 1: Direct-Effects Model

The first framework adopts the constructs from TAM as a starting point for building a framework to identify the factors influencing patients' willingness to consent to robotic-assisted surgery. While TAM provides a robust framework to understand technology adoption and acceptance, it might not be fully applicable to the context of robotic-assisted surgery due to the passive role of patients in the usage of robotic technologies. Instead of mediating effects proposed in TAM models, the first framework tested in this study identifies the relative importance of several independent variables on willingness to consent (dependent variable) directly. This approach allows for initial assessment of the importance of each variable in explaining variance in willingness to consent and provide a broad overview of individual contributions. This framework is shown in Fig.2.1

2.2.2. Conceptual Framework 2: eTAM

Theoretical models such as TAM suggest that PU acts as a mediating variable in technology acceptance. As previously described, no single uniform TAM model is used to identify the influence of specific factors in healthcare. Previous research by Kelly et al. (2023) on the usage of TAM on AI acceptance also found that TAM is frequently extended or changed to incorporate additional constructs [9]. Moreover, they also demonstrated that key independent variables in TAM, consistently predict different dependent variables such as behavioral intention, willingness and actual usage behavior. In the context of robotic surgery, willingness to consent closely aligns with behavioral intentions or willingness. Therefore, the eTAM in this study is adjusted towards the research objective of this study (Fig. 2.2). Since, PU is often the strongest positive predictors of behavioral intention, the mediating effect of PU was tested in the eTAM model [9]. Given that robotic surgery represents a novel and potentially complex healthcare technology, it is essential to test whether the effects of trust and familiarity on willingness were mediated through PU.

By integrating both a direct-effects model and a mediation model (eTAM), this study ensures a comprehensive evaluation of the willingness to consent to robotic-assisted surgery. The initial direct-effects model provides a broad exploratory foundation, while the mediation analysis aligns the findings more closely with established technology acceptance theories.

2.2.3. Surgical Scenarios

In this study, the conceptual frameworks are used in five different surgical scenarios. In all five hypothetical scenarios there has been a traffic accident, after which the patient has to undergo THA because of a hip fracture. In all five cases, the surgeon is highly experienced and proficient in both conventional (manual) and robotic techniques, which is uniformly communicated with patients across all scenarios. Last, in all five cases, the surgeon will provide the patient with detailed explanations of the procedure, benefits and risks. The case of THA after a traffic accident is used to help participants imagine a hypothetical surgical scenario. Through this approach, the factors influencing willingness to consent within each scenario can be identified, as well as the differences between each scenarios. The following five

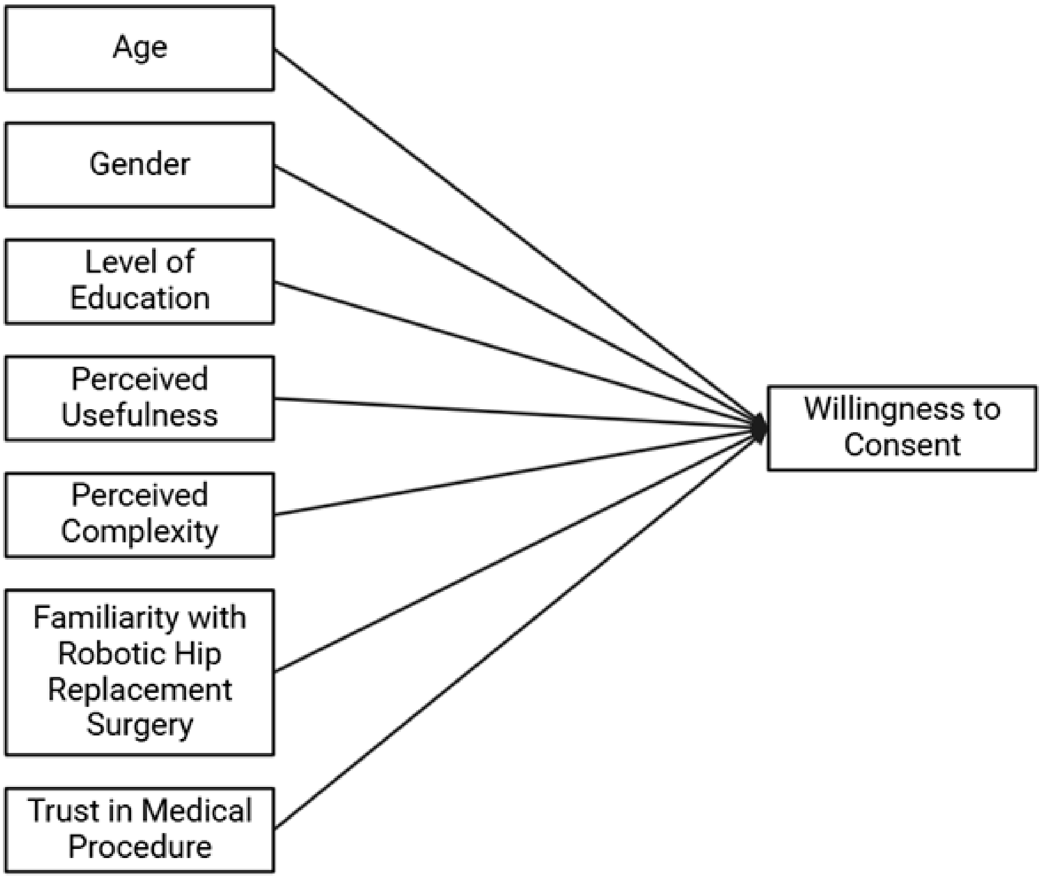

Figure 2.1: Conceptual framework 1: Direct-effects model. Perceived ease of use is changed with Perceived Complexity. Familiarity with robotic hip replacement surgery, trust in the medical procedure and demographic factors are added in the framework. In the analysis, the independent variables are divided in three groups: demographic variables (age, gender and education level), TAM constructs (PU and PC) and additional variables (familiarity and trust).

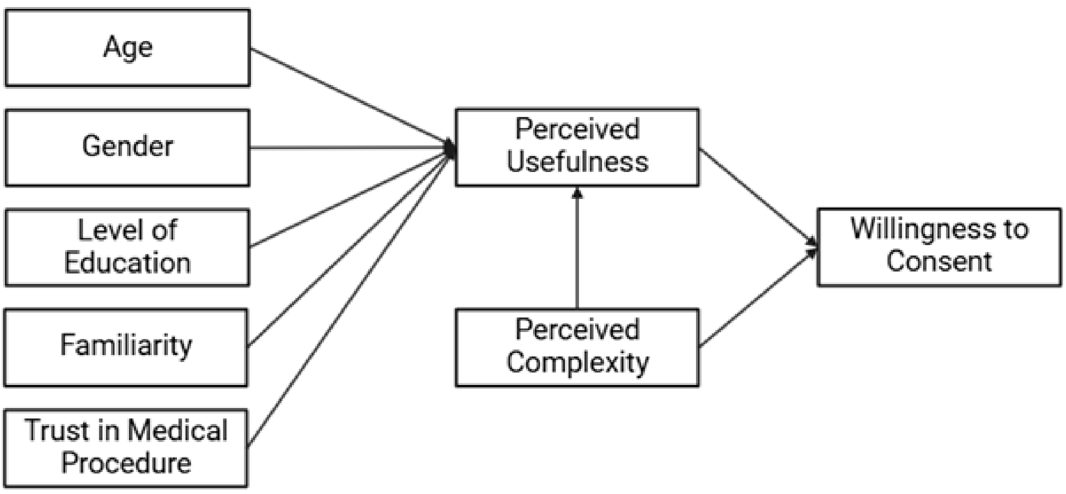

Figure 2.2: Conceptual Framework 2: eTAM. Perceived ease of use is changed with Perceived Complexity. Familiarity with robotic hip replacement surgery, trust in the medical procedure and demographic factors are added in the framework

scenarios were used:

Scenario 1: Surgery performed manually by the surgeon without assistance of a robotic system
This scenario serves as the baseline for understanding perceptions of conventional surgery. It represents a familiar and established surgical method, allowing comparison with robotic-assisted alternatives. The scenario is crucial for understanding the level of trust patients have in traditional surgical methods and helps to determine how much value they place on technological advancements. Moreover, this scenario offers a clear understanding of the patient's confidence in the surgeon, as no technological assistance is present.

Scenario 2: Surgery performed by a surgeon assisted by a robotic system
The implementation of robotic THA systems worldwide has increased exponentially in recent years. The MAKO robotic-arm-assisted system is the most widely adopted robotic arthroplasty system worldwide and currently dominates the market [59]. This scenario represents a currently used method with technological involvement where the surgeon maintains full control and oversight. It allows for assessment of how robotic assistance impacts the other construct and ultimately willingness to consent compared to non-robotic methods.

Scenario 3: Surgery performed by a surgeon assisted by a robotic system and a technician who is involved in the procedure
This scenario introduces an additional layer of complexity by including a technician who actively participates in the surgical process. It is designed to assess how patients perceive the involvement of a technician, especially in terms of trust, transparency, and decision-making. This scenario can also address potential concerns about the presence of this technician. It allows for investigation of patient comfort with non-clinical individuals in the operating room.

Scenario 4: Surgery autonomously performed by a robotic system under close supervision of a surgeon
This scenario explores a higher level of robotic autonomy, where the robotic system performs the surgery autonomously with direct supervision of the surgeon. It assesses how patients view the concept of robotic autonomy and whether they trust robotic technologies to perform a surgical procedure. This scenarios also help to elevate potential concerns people have with robotic technologies.

Theoretically, an autonomous model could increase the precision and accuracy of surgeries. Robotic technologies can potentially make highly accurate movements without the fatigue or human error. Although, most autonomous robotic systems are still experimental, preliminary results have shown that autonomous procedures can outperform surgeons in efficacy and consistency showing the potential of improved surgical outcomes and accessibility [8].

Scenario 5: Surgery performed by a remotely located surgeon assisted by a robotic system
This scenario investigates perceptions of telemedicine in surgery, where the surgeon's physical absence might influence trust and willingness to consent. The advantage of remote surgery lies in the possibility to overcome geographical limitations. This allows patients in rural areas to have access to highly specialized healthcare from surgeons anywhere on the planet. However, the reliance on communication and internet is a severe limitation. Any interruption in communication could seriously affect the surgical outcomes and patient safety. Additionally, for patients, the surgeons not being present in the operating room might increase feelings of fear and insecurity. Currently, telemedicine in orthopedics is use fore diagnosis, monitoring and follow-up with high patient satisfaction, showing a promising future for remote robotic surgery [60].

2.3. Research Hypotheses

Based on the literature research and developed research questions and aims, several hypotheses were formulated. The first two hypotheses reflect on the first research aim and focus on the utility of the direct-effects model. The last four hypotheses reflect on the second research aim and focus on differences of construct across five scenarios.

Hypothesis 1: *The direct-effects model will significantly explain variance in patients' willingness to consent across all five surgical scenarios.*

The first hypothesis tests whether the direct-effects model effectively explains variance in willingness to consent across different surgical scenarios. By evaluating this model, the study whether the used construct in the model results in a sufficient predictive accuracy.

Hypothesis 2: *Trust and familiarity will be positively associated with willingness to consent in the direct-effects model in all scenarios and will explain additional variance beyond the TAM constructs of PU and PC.*

Previous research shows that trust and familiarity could have a notable effect. The second hypothesis tests if the additional constructs of trust and familiarity provide an additional explanation in variance of willingness to consent when accounted for the TAM constructs of PU and PC.

Hypothesis 3: *Perceived complexity will be significantly higher for autonomous and remote surgical scenarios compared to (a) surgery performed manually by the surgeon and robotic-assisted surgery (b) with and (c) without an assisting technician.*

The third hypothesis is based on the assumption that people perceive higher levels of autonomy as more complex. Simultaneously, previous research showed that patients prefer direct human involvement in medical procedures and remote surgery can increase concerns about communicative reliability and control.

Hypothesis 4: *The presence of an assisting technician will increase patient willingness to consent to robotic-assisted surgery compared to robotic-assisted surgery without an assisting technician.*

When a technician is present, patient might feel reassured due to the additional layer of oversight and intervention if needed. The fourth hypothesis focuses on the presence of a technician and suggests that including a technician could lower concerns and increase willingness to consent. This hypothesis only focuses on the difference of an additional technician to test the direct effect of his/her presence. Therefore, this scenario is not compared to the other scenarios.

Hypothesis 5: *The remote location of the surgeon will decrease willingness to consent to robotic-assisted surgery compared to both (a) surgery performed manually by the surgeon and robotic-assisted surgery (b) with and (c) without an assisting technician.*

This hypothesis explores whether the presence of a surgeon influences willingness to consent. Previous research indicated that patients prefer direct human involvement in medical procedures. Therefore, willingness to consent in remote surgery should be lower compared to other scenarios.

Hypothesis 6: *Autonomous functioning of the robot will decrease willingness to consent to robotic surgery compared to both (a) surgery performed manually by the surgeon and robotic-assisted surgery (b) with and (c) without an assisting technician.*

The last hypothesis reflect on possible concerns that people might be uncomfortable with a robot performing surgery.

3

Methodology

3.1. Participants and Recruitment

A convenience sample of 305 participants aged 16-88 years (M age = 40.17 years, SD = 16.733) was recruited from the Dutch population. Participants were recruited through LinkedIn, University recruitment and word-of-mouth. The questionnaire was open from December 24, 2024 to February 6, 2025. Personal characteristics on gender and education level are shown in Tab.3.1. The majority of respondents were male. None of the respondents answered ”Other” or ”Prefer not to say” when asked what their gender was. For education level, the majority of the respondents had either an HBO-,WO-bachelor or master degree.

Although the sample included 305 participants, 35 participants did not mention their age. Therefore, the sample size for regression and correlation was 270. Tabachnik and Fidell (2007) indicate that for multiple regression, a rule of thumb for sample size follows the formula N > 50 + 8m. Where m is the number of independent variables, in this case seven. This results in a minimum sample size of 106 participants [61].

Additionally, a priori sample size calculation was conducted in order to ensure validity of the results. The program G*Power 3.1.9.7 was used to perform this analysis. With an effect size of 0.05, power of 0.8 and level of significance of 0.05, it was determined that a minimal sample size of 223 was required for regression. This effect size is between small (0.02) and medium (0.15). Because the actual effect was unknown a smaller effect size was chosen, which increases the sample size. Effect sizes of 0.15 are considered medium and 0.35 large [62]. For the within-subjects repeated measures ANOVA, the lowest partial η^2 was 0.023. Using G*Power this was calculated to result in an effect size of 0.15. Because the actual effect size was unknown a lower effect size was chosen. With an effect size of 0.1, power of 0.8 and level of significance of 0.05, a minimal sample size of 121 was required for ANOVA. In all calculation, the obtained sample size was higher than the required sample size.

3.2. Measures

A series of 5-point Likert Scale questions (1 = Strongly disagree, 5 = Strongly agree) was used to assess *familiarity*, *trust*, *PU*, *PC* and *willingness to consent*. The items used for *PU* were adapted from Nayak et al. (2024) and Kao et al. (2022). For this construct an additional question was added to measure if participants believed that the described surgical scenario would completely restore the function of their hip. This question was added as it was argued that completely restoring hip function would increase the usefulness of the surgical procedure. the items for *trust* were adapted from Pavlou et al. (2003). For this construct, two questions were added on the perceived trust in accuracy and safety as it was shown that reliability and performance expectancy are critical components for building trust [53]. The items for *PC*, *familiarity* and *willingness to consent* were adapted from Anania (2021) [22, 52, 63, 64]. For perceived complexity, two questions were added regarding difficulty to carry out the procedure and the effort to perform. The first question was added as a control question for the first question on PC. The second question was added as it was argued that additional effort to perform the procedure would

Table 3.1: Demographic Frequencies of the Study Sample

Variable		N	%
Gender	Female	120	39.3
	Male	185	60.7
	Other	0	0
	Prefer not to say	0	0
Education level	Primary education	1	0.3
	Vmbo, havo-, vwo-onderbouw, mbo1 (junior secondary education)	13	4.3
	Havo, vwo, mbo2-4 (senior secondary education)	54	17.7
	Hbo-, wo-bachelor	107	35.1
	Hbo-, wo-master	119	39.0
	Doctor	11	3.6

increase PC.

All original and adapted measures are listed in App. A. For all constructs Cronbach's alpha was used to determine the internal consistency within each scenario. A threshold of 0.7 was used to indicate acceptable reliability [65]. Constructs with an value above 0.7 were considered to have sufficient internal consistency for further analysis.

3.3. Procedure

The study was approved by the Human Research Ethics Committee (HREC) (Application number: 4938) of TU Delft before the distribution of the questionnaire. Participants' informed consent was first obtained through an informed consent opening statement before starting the questionnaire. Afterwards, participants were asked if they were currently residing in the Netherlands. If this condition was true, participants were directed to complete the online questionnaire.

The questionnaire first asked for the participants' demographic information including age, gender and educational level. They were then provided with six Likert Scale question to determine their familiarity with robotic-assisted surgery and total hip replacement surgery. Next, participants had to read an introductory text. This included an hypothetical scenario following a traffic accident after which total hip replacement surgery was necessary. This text also included the conditions which accounted for each of the following scenarios.

After the introductory text, participants were shown five different scenarios, which were randomized in between participants, so that the order of scenarios differed for each participant. The five included scenarios were: *Surgery performed manually by the surgeon without assistance of a robotic system*, *Surgery performed by a surgeon assisted by a robotic system*, *Surgery performed by a surgeon assisted by a robotic system and a technician who is involved in the procedure*, *Surgery autonomously performed by a robotic system under close supervision of a surgeon* and *Surgery performed by a remotely located surgeon assisted by a robotic system*. Each of these scenarios included an assisting figure and a brief introductory text to explain the scenario, conditions and possible advantages (App.B). Afterwards, all the Likert Scale items for *PU*, *PC*, *trust* and *willingness to consent* were shown. These items were in the same order for every scenario and for every participants to improve the completion time of the questionnaire.

Finally, after completing the five scenarios, participants were asked to choose their preferred type of surgery if they would every have to undergo total hip replacement surgery and were asked about their opinion about the presence of an assisting technician in the operating room. The final question was as follows: "*In some robotic-assisted surgeries, there is a technician present alongside the surgeon, providing technical support to ensure the procedure runs smoothly. What are your thoughts on the involvement of a technician in these surgeries? Do you feel that patients should be informed about this additional team member and involvement in the procedure as part of the consent process? Why or why not?*".

The complete questionnaire was translated into Dutch to allow non-English speakers to participate in the study and therefore increase inclusivity.

3.4. Data Analyses

In this study, only completed responses to the questionnaire were used in the data analysis. This was done to improve validity and reliability. While this approach helps to maintain data consistency, it does not entirely eliminate the risk of biases caused by missing data. Each construct in the conceptual frameworks was measured using several Likert Scale questions. From these items, mean scores were calculated to create scores which represent the underlying construct. Missing responses for one or more items within a construct can compromise the accuracy of theses scores. Moreover, the statistical methods used in this study, require complete data to provide valid results. By focusing on completed questionnaire only, this study ensured that each response accurately reflects the participants perception. For the ANOVA test between scenarios, 305 responses were complete (all questions in each scenario were answered). For regression and correlation analysis, 270 complete responses were used, since 35 people preferred not to mention their age.

The Statistical Package for the Social Sciences (SPSS) Version 29 was used to perform all analyses. The input values for age were all string variables and were converted to a scale measure, gender (1 = male, 2 = female) to nominal and education level to ordinal. Additionally, the output values from the Likert scale questions were used as a scale measure. All significance values were assessed at $p < .05$. Bivariate relationships were measured for all variables in each construct using correlation tables. This was done to identify highly correlated independent variables, indicating potential multicollinearity. Additionally, understanding how constructs relate allows for a more informed model building process.

Three statistical methods were used to address specific aspects of the study and to test the hypotheses. Stepwise regression was used to test the utility of the direct-effects model to explain patients' willingness to consent in all five surgical scenarios (Research Aim 1), a mediation analysis was used to test the mediating effect of PU in the eTAM model (Research Aim 2) and repeated measures ANOVA was used to compare willingness to consent and TAM constructs across the five surgical scenarios (Research Aim 3). Research Aim 4 will be answered using qualitative data analysis shown in Sec.3.4.5.

3.4.1. Stepwise Regression

Stepwise regression allows for examination of independent contribution of each of the construct in the model on the dependent variable (willingness to consent). Choosing stepwise regression analysis is supported by similar studies testing the influence of eTAM predictors [66, 67]. The regression analysis was done in a stepwise manner. Demographic variables were entered in the first step to control for demographic influences before adding in other constructs. The TAM constructs (PU and PC) were added in the second step. Those are the fundamental constructs in technology acceptance models and were tested first to asses their influence on willingness to consent. The additional constructs of trust and familiarity were entered in the third step. These factors might account for additional variance beyond the core constructs of PU and PC. By adding variables step by step, it was possible to assess additional variance explained by each set of variables. By entering the TAM constructs first, it was possible to evaluate how much variance is explained by these constructs in the model. Through this order of implementation, the first step assessed the influence of personal characteristics, the second on the perception of the technology and the third step added a layer building on trust and familiarity. The results from stepwise regression were used to test hypotheses 1 and 2. Standardized coefficients and significance values were used to assess the contribution of individual variables to explain the variance in willingness to consent (H2). Additionally, R^2 values were used to analyze the overall variance explained by the complete model and additional variance explained in each step (H1).

3.4.2. Mediation Analysis

Possible mediation effects of PU on willingness to consent were tested. This was done using linear regression and PROCESS macro for SPSS, using model 4 to test the indirect effects [68]. Fig.3.1 shows mediating pathways between independent, dependent and mediating variables. Results from linear stepwise regression and correlation were used to identify potential pathways between constructs. Path A and C were tested by performing linear regression from the independent variable to the mediating variable and from the independent variable to the dependent variable, respectively. Path B and C' were tested by multiple linear regression from the independent variable and the mediating variable to the dependent variable. This allows to test the direct effect (C') of the independent variable on the dependent variable after accounting for the mediating variable.

A mediating relation requires four steps. First, a significant relation of the independent variable to the dependent variable (Path C). Second, a significant relation of the independent variable to the mediating variable (Path A). Third, a significant relation of the mediating variable to the dependent variable (Path B). Fourth, the coefficient relating the independent variable to the dependent variable (Path C) must have a larger coefficient compared to the relation between the independent variable to the dependent variable in the regression model with both the independent variable and the mediating variable predicting the dependent variable (Path C') [69]. The significance of the indirect effect was tested using bootstrapped confidence intervals (95% CI). An indirect effect was considered significant if the confidence interval did not include zero [70]. Effect sizes were used to assess the magnitude of mediation. All models were tested using 5,000 bootstrap samples for confidence intervals. The correlation results were used to identify potential mediating pathways by identifying significant correlations of different independent variables with PU. These were the only models tested as the predictive relationship between the independent variables and between the independent and dependent variables should be significant.

3.4.3. Regression assumptions

This research utilized stepwise regression for the data analysis within each scenario to create a predictive model. The data must fit assumptions listed below in order for the analysis to be appropriate. The assumptions are as follows:

1. There is a linear relationship between the dependent variable and each of the independent variables. This will be tested by inspection of scatterplots of dependent against independent variables.
2. There is independence of observations. Specifically, the error of each observation should not be correlated, to ensure that they are not linked. This will be tested through the Durbin-Watson statistic. Value <1.5 were considered to have positive autocorrelation, values >2.5 were considered to have negative autocorrelation. Values of approximately 2 were considered to be completely independent [71].
3. There is homoscedasticity in the data. Homoscedasticity refers to the fact that the variance and standard deviation of the residuals (error) should be the same for predicted dependent variable scores [23]. This will be tested by inspection of scatterplots of dependent against independent variables.
4. There is no multicollinearity in the data. This indicates that independent variables should not be highly correlated. This will be tested using tolerance values, VIF values and correlation tables. The tolerance values were considered acceptable if above 0.1, VIF was considered acceptable if lower than 10 and multicollinearity using correlation tables was not considered a problem if significant correlation values were below 0.7 [72].
5. The residuals (errors) are normally distributed. This will be tested through visual inspection of histograms and QQ-plots of residuals. Histograms give an overview of the distribution shape, while QQ-plots help to detect deviations from normality. Additionally, skewness of mean values was checked to quantify asymmetry of the residual distribution. Skewness values of +/- 2 were considered acceptable [72].

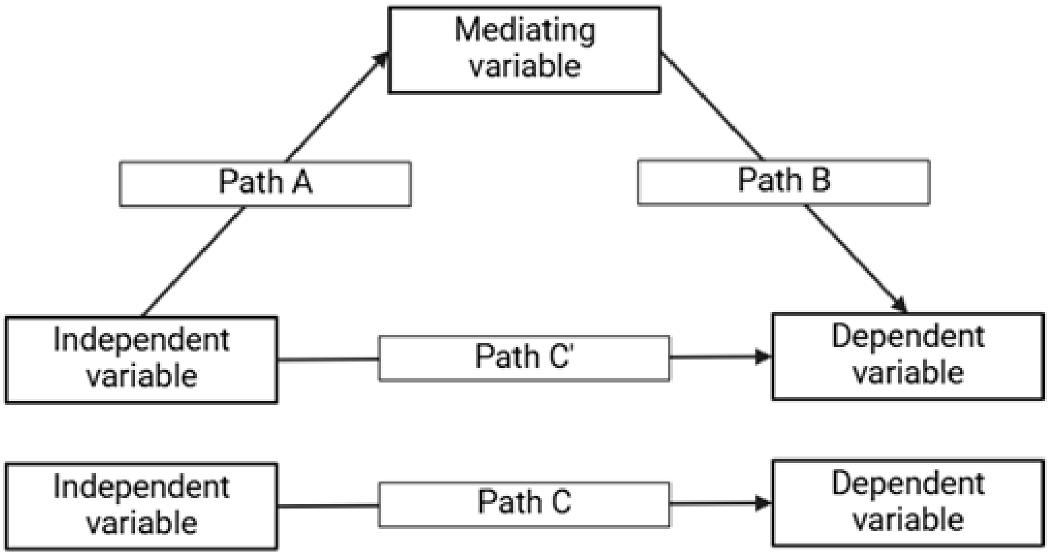

Figure 3.1: The mediation analysis pathways. Path A, Path B and Path C should be significant. Path C should have a larger coefficient compared to Path C'.

3.4.4. Repeated Measures ANOVA

Repeated measures ANOVA (within-subjects ANOVA) was used to compare willingness to consent and eTAM constructs across the five surgical scenarios. This method allows for analyzing within-subject differences, since all participants answered questions of all five scenarios. The repeated measures ANOVA can be used to detect significant differences in mean scores across the five scenarios. Mean scores for the four constructs (PU, PC, trust and willingness) were compared. Additionally, if the results were significant, a Post-Hoc analysis was done to determine which scenarios differed significantly from each other.

The results from the repeated measures ANOVA were used to test hypotheses 3-6. The effects of different scenarios on willingness to consent were used to determine the influence of a technician present (H4), remote location of surgeon (H5) and autonomous functioning of the robot (H6). Last, differences across scenarios in mean values for PC were used to test H3.

3.4.5. Qualitative Data Analysis

To analyze responses to the open-ended question on the involvement of a technician in robotic-assisted surgery and its relevance to the informed consent process, a schematic coding approach was applied (Research Aim 4). Responses were categorized based on a coding scheme, allowing for the identification of recurring themes and variations in participant perspectives. Only the responses from participants who filled in the open question were used, as those explicitly stated their perceptions on technician involvement and disclosure preferences.

The coding scheme was developed inductively, emerging from participant responses. The responses were analyzed using the following thematic categories:

- **Perceptions of technician involvement:** exploring views on the necessity and role of the technician in robotic-assisted procedures.
- **Views on informed consent and disclosure:** identifying whether participants believe patients should be informed about the technician's role.
- **Reasoning behind disclosure preferences:** examining participants' justifications for their view on technician disclosure.

All the codes with descriptions and example answers are shown in App. G.

Additionally, it was tested if those who answered the open question are a selection of participants who differ in demographic or other variables. The open question was transformed to a binary output, where a value of 1 indicated that the open question was answered and a value of 0 indicated that it was not answered. For the categorical variables, the Chi-Square test was used. For all the other variables, an independent-samples T-test was done to check if the means of variables differ between participants who filled in the open question and those who did not. First, it was checked if Levene's test was significant. If this was the case, two-sided significance ($p < 0.05$) was used to determine relationships between variables.

4

Results

4.1. Descriptive Statistics

The descriptive statistics of the construct familiarity, PU, PC, trust and willingness for all five scenarios are shown in Tab.4.1. Besides familiarity, all constructs show mean scores in between 3.0 and 4.2, which is approximately around the midpoint of the range. Cronbách's alpha values were acceptable for all construct, with every construct having a score above 0.7 [65]. Skewness values were between the recommended +/- 2 [72].

4.2. Stepwise Regression

Stepwise regression and correlations were conducted for every scenario. The correlation tables are shown in App. C. In scenario 1,2,4 & 5, there were no significant multicollinearity between the independent variables. In scenario 3 PU correlated significantly with trust. However, in all scenarios all VIF values were < 10 and all tolerance values were > 0.1. Therefore, multicollinearity was not considered an issue. QQ-plots and histograms for the regression assumption of normality are shown in App. D. The residuals all follow an approximately bell-shaped curve. Therefore normality assumptions was met. Residual scatterplots for the regression assumptions of linearity and homoscedasticity are shown in App. E. All residuals are randomly scattered around y = 0, ensuring linearity. The spread of the residuals is also approximately constant across all predicted values, without any pattern. Therefore, the homoscedasticity assumption was met. Last, the Durbin-Watson statistic for scenario 3 (1.499) was just below the required 1.5. However, this deviation was not considered a problem. For all other scenarios the Durbin-watson statistic was approximately 2. Therefore, the independence assumption was met.

4.2.1. Scenario 1: Surgery performed manually by the surgeon without assistance of a robotic system

The stepwise regression table of the first scenarios is shown in Tab.4.2. In the first step, age, gender and education level did not significantly account for any variance in the willingness to consent to surgery, F(3, 266) = 2.396, p=0.069. In the second step, PU and PC were entered in the model. There is an increase in the variance of willingness, R^2_{change} = 0.372, F_{change}(2, 264) = 81.676 p=<0.001, and the model became significant,F(5, 264) = 34.980, P<0.001. Within the second step, age and PC has a significant negative association with willingness to consent, meaning that older participants and those who perceived the surgical procedure as more complex were less willing to consent. Simultaneously, PU had a significant positive association and explained the most unique variance in willingness to consent. This suggests that participants who found the system more useful were more willing to consent. In the third step, trust and familiarity were entered in the model. The variance significantly increased, R^2_{change} = 0.139, F(2, 262) = 39.037 p=<0.001, and remained significant, F(7, 262) = 43.339, p <0.001. This confirms that these variables further improve the explanation of variance in willingness to consent. Age en PC were still had a significant negative association. PU and trust had a significant positive

Table 4.1: Descriptive and Reliability Statistics

Scale	N	M(SD)	95% CI	α	Range	Skewness
Familiarity	305	2.453(0.053)	[2.35-2.56]	0.870	1-5	0.533
Scenario 1: Surgery performed manually by the surgeon without assistance of a robotic system						
PU	305	3.572(0.031)	[3.52-3.64]	0.767	1-5	-0.241
PC	305	3.195(0.044)	[3.11-3.28]	0.824	1-5	-0.221
Trust	305	3.942(0.029)	[3.89-4.00]	0.764	1-5	-0.191
Willingness	305	3.937(0.038)	[3.86-4.01]	0.902	1-5	-0.385
Scenario 2: Surgery performed by a surgeon assisted by a robotic system						
PU	305	3.887(0.031)	[3.83-3.95]	0.754	1-5	0.129
PC	305	3.137(0.044)	[3.05-3.22]	0.859	1-5	-0.154
Trust	305	4.117(0.029)	[4.06-4.17]	0.834	1-5	-0.319
Willingness	305	4.003(0.038)	[3.93-4.08]	0.909	1-5	-0.933
Scenario 3: Surgery performed by a surgeon assisted by a robotic system and a technician who is involved in the procedure						
PU	305	3.894(0.032)	[3.83-3.96]	0.735	1-5	-0.042
PC	305	3.147(0.045)	[3.06-3.24]	0.852	1-5	-0.115
Trust	305	4.099(0.035)	[4.03-4.17]	0.885	1-5	-0.839
Willingness	305	3.971(0.047)	[3.88-4.06]	0.944	1-5	-1.176
Scenario 4: Surgery autonomously performed by a robotic system under close supervision of a surgeon						
PU	305	3.606(0.031)	[3.54-3.67]	0.751	1-5	-0.404
PC	305	3.167(0.044)	[3.08-3.25]	0.825	1-5	-0.114
Trust	305	3.728(0.043)	[3.64-3.81]	0.901	1-5	-0.722
Willingness	305	3.370(0.060)	[3.25-3.49]	0.957	1-5	-0.446
Scenario 5: Surgery performed by a remotely located surgeon assisted by a robotic system						
PU	305	3.476(0.035)	[3.41-3.54]	0.812	1-5	-0.481
PC	305	3.320(0.045)	[3.23-3.41]	0.852	1-5	-0.391
Trust	305	3.501(0.046)	[3.41-3.59]	0.896	1-5	-0.611
Willingness	305	3.021(0.062)	[2.90-3.14]	0.950	1-5	-0.164

N = Valid sample size, M = Mean, SD = Standard Deviation, CI = Confidence Interval, α = Cronbach's alpha. Scales: 1 = Strongly disagree, 5 = Strongly agree. PU = Perceived Usefulness, PC = Perceived Complexity

Table 4.2: Stepwise Regressions explaining Willingness to Consent for Scenario 1: Surgery performed manually by the surgeon without assistance of a robotic system

Step		Adj. R^2	B	SE B	Sig	95% CI		β
						Lower bound	Upper bound	
1		0.015						
	Age		**-0.005**	**0.002**	**0.038**	**-0.010**	**0.000**	**-0.127**
	Gender		-0.071	0.082	0.389	-0.232	0.091	0.082
	Education level		0.044	0.044	0.312	-0.042	0.130	0.044
2		0.387						
	Age		**-0.007**	**0.002**	**<0.001**	**-0.011**	**-0.003**	**-0.175**
	Gender		-0.097	0.065	0.137	-0.224	0.031	-0.072
	Education level		0.013	0.035	0.712	-0.055	0.081	0.035
	PU		**0.680**	**0.058**	**<0.001**	**0.566**	**0.794**	**1.027**
	PC		**-0.144**	**0.041**	**<0.001**	**-0.225**	**-0.062**	**-0.168**
3		0.524						
	Age		**-0.006**	**0.002**	**<0.001**	**-0.009**	**-0.003**	**-0.150**
	Gender		-0.074	0.057	0.198	-0.186	0.039	-0.055
	Education level		0.003	0.031	0.933	-0.059	0.064	0.004
	PU		**0.386**	**0.061**	**<0.001**	**0.265**	**0.506**	**0.322**
	PC		**-0.110**	**0.038**	**0.005**	**-0.186**	**-0.034**	**-0.129**
	Trust		**0.575**	**0.065**	**<0.001**	**0.447**	**0.703**	**0.451**
	Familiarity		0.002	0.033	0.951	-0.062	0.066	0.003

N = 270, B = Unstandardised coefficients, SE = Standard Error, β = Standardised coefficients, CI = Confidence Interval, PU = Perceived Usefulness, PC = Perceived Complexity. Bold items are significant. Durbin-Watson statistic = 2.088

association and were also the two constructs which explain the most variance, as can be seen from the standardized coefficients. The significant effect of trust suggests that a higher trust in the surgical procedure is associated with an increase in willingness to consent. This model significantly accounts for 52.4% of the variance in willingness to consent.

4.2.2. Scenario 2: Surgery performed by a surgeon assisted by a robotic system

The stepwise regression table of the second scenario is shown in Tab.4.3. In the first step, age, gender and education level were added to the model. These variables did not significancy account for any variance in willingness to consent, F(3, 266) = 1.1415, p=0.239. In the second step, PU and PC were added to the model. There was a significant change in the variance of willingness to consent, R^2_{change} = 0.321, F_{change}(2, 264) = 63.924 p=<0.001 and the model became significant, F(5, 264) = 26.821, P<0.001. PC had a negative association, while PU had positive association with willingness to consent. This suggest that participants who perceived the surgical procedure as more complex were less willing to consent. Simultaneously, participants who perceived the surgical procedure as more useful were more willing to consent. In the third step, trust and familiarity were added to the model. The variance significantly increased, R^2_{change} = 0.232, F_{change}(2, 264) = 70.462 p=<0.001, and the model remained significant F(5, 264) = 49.371, P<0.001. In this step, PC was not significant anymore. Instead, PU and trust both had a significant positive association, where trust explained the most unique variance, indicated by a higher coefficient values. These results suggest that the effect of PC diminishes when trust is added into the model. In this scenario the model accounts for 55.7% of the variance in willingness to consent.

Table 4.3: Stepwise Regressions explaining Willingness to Consent for Scenario 2: Surgery performed by a surgeon assisted by a robotic system

Step		Adj. R^2	B	SE B	Sig	95% CI Lower bound	95% CI Upper bound	β
1		0.016						
	Age		-0.001	0.002	-0.631	-0.006	0.004	-0.029
	Gender		-0.101	0.084	0.229	-0.266	0.064	-0.074
	Education level		0.060	0.045	0.183	-0.028	0.148	0.082
2		0.324						
	Age		-0.002	0.002	0.305	-0.006	0.002	-0.052
	Gender		-0.106	0.069	0.126	-0.242	0.030	-0.078
	Education level		0.065	0.037	0.080	-0.008	0.137	0.089
	PU		**0.665**	**0.061**	**<0.001**	**0.545**	**0.785**	**0.546**
	PC		**-0.133**	**0.044**	**0.003**	**-0.220**	**-0.047**	**-0.153**
3		0.557						
	Age		-0.001	0.002	0.429	-0.005	0.002	-0.033
	Gender		-0.042	0.056	0.460	-0.152	0.069	-0.031
	Education level		0.053	0.031	0.085	-0.007	0.113	0.073
	PU		**0.161**	**0.066**	**0.015**	**0.032**	**0.290**	**0.132**
	PC		-0.069	0.037	0.062	-0.141	0.004	-0.079
	Trust		**0.853**	**0.072**	**<0.001**	**0.712**	**0.995**	**0.646**
	Familiarity		-0.024	0.031	0.437	-0.085	0.037	-0.034

N = 270, B = Unstandardised coefficients, SE = Standard Error, β = Standardised coefficients, CI = Confidence Interval, PU = Perceived Usefulness, PC = Perceived Complexity. Bold items are significant. Durbin-Watson statistic = 2.163

4.2.3. Scenario 3: Surgery performed by a surgeon assisted by a robotic system and a technician who is involved in the procedure

The stepwise regression table of the second scenario is shown in Tab.4.4. In the first step, age, gender and education level were added to the model. These variables did not significantly account for any variance in willingness to consent, F(3, 266) = 1.749, p=0.157. In the second step, PU and PC were added to the mode. There was a significant increase in the variance of willingness to consent, R^2_{change} = 0.351, F_{change}(2, 264) = 73.612 p=<0.001, and the model became significant, F(5, 264) = 31.067, P<0.001. In this step PU was the only significant variable on willingness to consent. In the third step, trust and familiarity were added to the model. The variance of willingness to consent increased, R^2_{change} = 0.255, F_{change}(2, 264) = 87.094 p=<0.001, and the model remained significant, F(5, 264) = 61.528, P<0.001. In the last step, PU was not significant anymore. Instead trust was the only variable with a significant association with willingness to consent. This suggest that trust in the surgical procedure played a dominant role in explaining variance in willingness to consent. This model accounts for 61.2% of the variance in willingness to consent.

4.2.4. Scenario 4: Surgery autonomously performed by a robotic system under close supervision of a surgeon

The stepwise regression table of the fourth scenario is shown in Tab.4.5. In the first step, age, gender and education level were added to the model. these variables significantly accounted for variance in willingness to consent, F(3, 266) = 4.411, p=0.005. Age had a significant positive association, while gender had a significant negative association with willingness to consent. This means that older patients and males were more willing to consent. In the second step, PU and PC were added to the model. There was a significant increase in the variance of willingness to consent, R^2_{change} = 0.377, F_{change}(2,

Table 4.4: Stepwise Regressions explaining Willingness to Consent for Scenario 3: Surgery performed by a surgeon assisted by a robotic system and a technician who is involved in the procedure

Step		Adj. R^2	B	SE B	Sig	95% CI Lower bound	95% CI Upper bound	β
1		0.008						
	Age		-0.004	0.003	0.175	-0.010	0.002	-0.083
	Gender		-0.119	0.103	0.252	-0.322	0.085	-0.071
	Education level		0.058	0.055	0.295	-0.051	0.166	0.065
2		0.359						
	Age		-0.003	0.002	0.165	-0.008	0.001	-0.069
	Gender		-0.096	0.083	0.249	-0.260	0.068	-0.057
	Education level		0.006	0.045	0.888	-0.082	0.095	0.007
	PU		**0.877**	**0.074**	**<0.001**	**0.730**	**1.023**	**0.582**
	PC		-0.102	0.053	0.057	-0.207	0.003	-0.094
3		0.612						
	Age		-0.002	0.002	0.279	-0.006	0.002	-0.042
	Gender		-0.029	0.065	0.652	-0.157	0.098	-0.017
	Education level		-0.024	0.036	0.501	-0.095	0.047	-0.027
	PU		0.137	0.081	0.090	-0.022	0.296	0.091
	PC		-0.006	0.043	0.896	-0.091	0.080	-0.005
	Trust		**0.934**	**0.072**	**<0.001**	**0.793**	**1.076**	**0.707**
	Familiarity		0.046	0.036	0.208	-0.026	0.117	0.052

N = 270, B = Unstandardised coefficients, SE = Standard Error, β = Standardised coefficients, CI = Confidence Interval, PU = Perceived Usefulness, PC = Perceived Complexity. Bold items are significant. Durbin-Watson statistic = 1.499

264) = 85.630, p=<0.001, while the model remained significant, F(5, 264) = 38.582, P<0.001. In this step age was not significant anymore. Instead, gender was still significant and PU had a significant positive association. In the last step, trust and familiarity were added. There was again a significant increase in the variance of willingness to consent R^2_{change} = 0.299, F_{change}(2, 264) = 140.464 p=<0.001, and the model remained significant F(5, 264) = 96.809, P<0.001. In this step, gender, PC and familiarity had a significant negative association, suggesting that a higher perceived complexity and greater familiarity are associated with a lower willingness to consent. PU and trust had a significant positive association, where PU explained the most unique variance in willingness to consent. This model accounts for 71.4% of the variance in willingness to consent in this scenario.

4.2.5. Scenario 5: Surgery performed by a remotely located surgeon assisted by a robotic system

The stepwise regression table of the second scenario is shown in Tab.4.6. In the first step, age, gender and education level were added to the model. These variables significantly accounted for variance in willingness to consent, F(3, 266) = 5.597, p=<0.001. In this step gender was the only (negative) significant variable, meaning that for this scenario, males were more willing to consent. In the second step, PU and PC were entered into the mode. There was a significant increase in the variance of willingness to consent, R^2_{change} = 0.433, F_{change}(2, 264) = 113.416 p=<0.001, and the model remained significant, F(5, 264) = 51.962, P<0.001. In this step gender and PC had a significant negative association, while PU had a significant positive association. In the last step, trust and familiarity were entered in the mode. There was again a significant increase in the variance, R^2_{change} = 0.171, F_{change}(2, 264) = 67.439 p=<0.00, and the model remained significant, F(5, 264) = 75.065, P<0.001. In the last step, gender and PC were still significant variables. Trust and PU had a significant positive association, where

Table 4.5: Stepwise Regressions explaining Willingness to Consent for Scenario 4: Surgery autonomously performed by a robotic system under close supervision of a surgeon

Step		Adj. R^2	B	SE B	Sig	95% CI Lower bound	95% CI Upper bound	β
1		0.037						
	Age		**0.009**	**0.004**	**0.015**	**0.002**	**0.017**	**0.147**
	Gender		**-0.348**	**0.130**	**0.008**	**-0.604**	**-0.092**	**-0.162**
	Education level		-0.077	0.069	0.267	-0.214	0.059	-0.068
2		0.411						
	Age		0.004	0.003	0.212	-0.002	0.010	0.059
	Gender		**-0.370**	**0.102**	**<0.001**	**-0.570**	**-0.169**	**-0.172**
	Education level		-0.065	0.054	0.235	-0.172	0.042	-0.057
	PU		**1.152**	**0.090**	**<0.001**	**0.975**	**1.329**	**0.607**
	PC		-0.118	0.064	0.065	-0.244	0.007	-0.088
3		0.714						
	Age		0.001	0.002	0.586	-0.003	0.005	0.018
	Gender		**-0.241**	**0.072**	**<0.001**	**-0.382**	**-0.099**	**-0.112**
	Education level		-0.038	0.039	0.333	-0.115	0.039	-0.033
	PU		**0.293**	**0.082**	**<0.001**	**0.132**	**0.455**	**0.115**
	PC		**-0.106**	**0.046**	**0.020**	**-0.196**	**-0.017**	**-0.079**
	Trust		**0.997**	**0.061**	**<0.001**	**0.877**	**1.116**	**0.710**
	Familiarity		**-0.105**	**0.039**	**0.008**	**-0.181**	**-0.028**	**-0.093**

N = 270, B = Unstandardised coefficients, SE = Standard Error, β = Standardised coefficients, CI = Confidence Interval, PU = Perceived Usefulness, PC = Perceived Complexity. Bold items are significant. Durbin-Watson statistic = 1.600

PU explained the most unique variance in willingness to consent. This model significantly accounts for 65.8% of the variance in willingness to consent.

4.2.6. Hypothesis Testing and Evaluation

The results of the stepwise regression analysis support Hypothesis 1. In all five surgical scenarios, the research model significantly explained variance in patients' willingness to consent, as shown by the high explanatory power of the models (R^2 values ranging from 0.524 to 0.714) and the significant F-statistics (all p < 0.001). These findings demonstrate that the direct-effects model, which includes PU, PC, trust, and familiarity, is strong in explaining patients' willingness to consent across different surgical contexts.

The results partially support Hypothesis 2. Trust had a significant positive association with willingness to consent in all five surgical scenarios (all p < .001), with standardized regression coefficients ranging from β = 0.061 to 0.072. This indicates that higher levels of trust consistently increased patients' willingness to consent, regardless of the surgical scenario. Familiarity only had a significant association in Scenario 4 (β = 0.039, p = 0.008). This suggests that familiarity plays a more limited role in influencing patients' willingness to consent, except in the context of autonomous robotic surgery.

When compared to the traditional TAM constructs, trust had a stronger and more consistent association with willingness to consent than PU and PC in the first three scenarios. However, in scenario 4 and 5, PU had a stronger association. This suggests that, in the context of autonomous- and remote surgery, patients' perceptions of the technology's usefulness play a more important role in explaining willingness to consent than trust. Additionally, in the last two scenarios (autonomous and remote surgery) the effect of PC and gender became more pronounced. This suggest that for the more advanced robotic surgery technique, participants who perceived the procedure as more complex were less willing to consent.

Table 4.6: Stepwise Regressions explaining Willingness to Consent for Scenario 5: Surgery performed by a remotely located surgeon assisted by a robotic system

Step		Adj. R^2	B	SE B	Sig	95% CI Lower bound	95% CI Upper bound	β
1		0.052						
	Age		0.004	0.004	0.337	-0.004	0.011	0.058
	Gender		**-0.557**	**0.134**	**<0.001**	**-0.820**	**-0.293**	**-0.250**
	Education level		-0.010	0.071	0.893	-0.150	0.131	-0.008
2		0.486						
	Age		0.002	0.003	0.553	-0.004	0.007	0.026
	Gender		**-0.374**	**0.099**	**<0.001**	**-0.570**	**-0.179**	**-0.168**
	Education level		0.004	0.053	0.938	-0.100	0.108	0.003
	PU		**1.135**	**0.800**	**<0.001**	**0.979**	**1.291**	**0.631**
	PC		**-0.224**	**0.061**	**<0.001**	**-0.344**	**-0.103**	**-0.162**
3		0.658						
	Age		0.000	0.002	0.979	-0.005	0.005	-0.001
	Gender		**-0.263**	**0.082**	**0.001**	**-0.424**	**-0.103**	**-0.118**
	Education level		0.031	0.044	0.481	-0.056	0.119	0.026
	PU		**0.421**	**0.090**	**<0.001**	**0.244**	**0.597**	**0.234**
	PC		**-0.154**	**0.051**	**0.003**	**-0.254**	**-0.054**	**-0.111**
	Trust		**0.804**	**0.069**	**<0.001**	**0.668**	**0.941**	**0.591**
	Familiarity		-0.046	0.044	0.301	-0.133	0.041	-0.039

N = 270, B = Unstandardised coefficients, SE = Standard Error, β = Standardised coefficients, CI = Confidence Interval, PU = Perceived Usefulness, PC = Perceived Complexity. Bold items are significant. Durbin-Watson statistic = 1.871

Additionally, females were less willing to consent.

4.3. Bivariate Relationships

The Pearson correlation tables in Tab.**??** highlight key relationships between the independent variables. Across all scenarios, education level was negatively correlated with gender and positively correlated with familiarity, indicating that from these participants, males had higher education levels and that individuals with higher education were more familiar with robotic-assisted surgery. Additionally, trust, familiarity, PU, and PC were consistently interrelated, with higher trust and familiarity associated with greater PU and lower PC. This suggests a fundamental relationship between these constructs regardless of the specific surgical scenario.

In scenario 3, education level correlated positively with PU and trust, suggesting that higher education was linked to perceiving the procedure as more useful and trustworthy. In scenario 4, age was positively correlated with PU and trust, indicating that older participants found the procedure more useful and reliable. In scenario 5, gender was negatively correlated with trust, meaning that females had lower trust in robotic-assisted surgery compared to males.

4.4. Mediation Analysis

In the first conceptual framework (direct-effect model), all independent variables were tested directly on willingness to consent using stepwise regression. This provided an assessment of which variables had a direct impact on willingness to consent, allowing for a broad understanding of the relative importance of different variables. However, TAM based models emphasize the mediating role of PU. Therefore, the influence of PU as mediator was tested. The results from the mediation analyses build upon the

Table 4.7: Results of Mediation Analysis with PU as Mediator and Willingness to Consent as dependent variable

IV	Path A	Path B	Path C	Path C'	Effect	95% CI
Scenario 1: Surgery performed manually by the surgeon without assistance of a robotic system						
Familiarity	0.109 (0.001)	0.667 (<0.001)	0.130 (0.001)	0.057 (0.098)	0.073	[0.024 - 0.121]
PC	-0.103 (0.011)	0.660 (<0.001)	-0.190 (<0.001)	-0.122 (0.032)	-0.068	[-0.124 - -0.013]
Scenario 2: Surgery performed by a surgeon assisted by a robotic system						
Familiarity	0.073 (0.030)	0.689 (<0.001)	0.090 (0.031)	0.040 (0.256)	0.050	[0.001 - 0.098]
Trust	0.693 (<0.001)	0.167 (0.008)	0.981 (<0.001)	0.865 (<0.001)	0.110	[0.020 - 0.210]
Scenario 3: Surgery performed by a surgeon assisted by a robotic system and a technician who is involved in the procedure						
Familiarity	0.094 (0.006)	0.903 (<0.001)	0.177 (<0.001)	0.092 (0.025)	0.085	[0.021 - 0.154]
Scenario 4: Surgery autonomously performed by a robotic system under close supervision of a surgeon						
Age	0.005 (0.018)	1.161 (<0.001)	0.009 (0.021)	0.003 (0.282)	0.006	[0.001 - 0.010]
Trust	0.481 (<0.001)	0.275 (0.006)	1.156 (<0.001)	1.024 (<0.001)	0.133	[0.048 - 0.214]
Scenario 5: Surgery performed by a remotely located surgeon assisted by a robotic system						
Trust	0.538 (<0.001)	0.423 (<0.001)	1.077 (<0.001)	0.849 (<0.001)	0.228	[0.133 - 0.323]
PC	-0.095 (0.032)	1.183 (<0.001)	-0.333 (<0.001)	-0.221 (0.001)	-0.112	[-0.236 - 0.020]

IV = Independent Variable, CI = Confidence Interval. Significance in brackets.

earlier results from correlation analyses, which highlight the significant correlation of other constructs with PU.

Tab.4.7 shows the significant mediating effects of PU on different independent variables. PU significantly mediated the relation for several variables in all five scenarios. PU mediated the relationship between familiarity and willingness to consent in the first three scenarios, on trust and willingness to consent in the second, fourth and fifth scenario, on PC and willingness to consent in the first and last scenario and on age and willingness to consent in the fourth scenario. These findings suggest that in different surgical scenarios, PU plays a role in linking both patient characteristics and constructs to willingness to consent. The strongest mediation effects of PU were found with trust. However, a reverse mediation analysis (not shown) indicated that trust also mediates the relationship between PU and willingness to consent. These bidirectional findings align with the stepwise regression results, where trust and PU consistently emerged as the variables explaining the most variance in willingness to consent. These results suggest that both variables reinforce each other. However, the mediation analysis did not confirm the assumption that PU acts as a mediator for all independent variables. Instead, only a subset of independent variables significantly influence willingness to consent through PU. Additionally, a scenario-specific variation emerged. These findings suggest that PU does not act as an universal mediator in the context of robotic-assisted surgery.

4.5. Comparison Between Surgical Scenarios

This section explores the differences across the five surgical scenarios by firstly, a repeated measures ANOVA to compare the mean differences of the four eTAM constructs (PU, PC, trust and willingness) between scenarios, and secondly, results of the preferred scenario by participants.

4.5.1. ANOVA for Constructs Between Scenarios

To examine differences for PU, PC, trust and willingness across the five surgical scenarios, a one-way repeated measures ANOVA was conducted. Mauchly's test indicated that the assumption of sphericity was violated for all four constructs, suggesting that the variances of the differences between scenarios were not equal. Therefore, the Greenhouse-Geisser correction was used to adjust the degrees of freedom. The results of the ANOVA, including post hoc comparisons, are presented in Tab.4.8. The complete post hoc comparisons for each construct are shown in App.F.

Table 4.8: Comparisons of constructs Across all Scenarios

Construct	df	F	Sig	η^2	Post-hoc
PU	3.561	63.386	<0.001	0.173	S2 > S1 & S4 & S5,
					S3 > S1 & S4 & S5,
					S4 > S5
PC	3.699	7.232	<0.001	0.023	S5 > S2 & S3 & S4
Trust	3.503	74.821	<0.001	0.198	S1 > S4 & S5,
					S2 > S1 & S4 & S5,
					S3 > S1 & S4 & S5,
					S4 > S5
Willingness	3.333	113.744	<0.001	0.272	S1 & S2 & S3 > S4 & S5,
					S4 > S5

N = 305, df = degrees of freedom, F = F-statistic, η^2 = Partial Eta Squared, PU = Perceived Usefulness, PC = Perceived Complexity

Perceived Usefulness

The repeated measures ANOVA shows a significant difference in PU between the five scenarios F(3.561, 300) = 63.386, p <.001. 17.3% of the variance in PU is explained through the differences in the five scenarios. Post hoc analysis of all scenarios shows that PU for scenario 2 and scenario 3 was significantly higher than the PU in the other three scenarios. This suggests that participants perceive robotic-assisted surgery with a surgeon present as more useful than other types of surgery. Additionally, the PU of scenario 4 was significantly higher than PU is scenario 5, indicating the participants perceive fully autonomous robotic surgery as more useful that remote robotic surgery.

Perceived Complexity

The repeated measures ANOVA shows a significant difference in PC between the five scenarios F(3.699, 300) = 7.232, p <.001. 2.3% of the variance in PC is explained through the differences in the five scenarios. Post hoc analysis of all scenarios shows that PC for scenario 5 was significantly higher than PC for scenario 2, scenario 3 and scenario 4. However, there was no significant difference between scenario 5 and scenario 1. These results partially support Hypothesis 3. PC was significantly higher for remote robotic surgery (Scenario 5) compared to the first three scenarios. This suggests that patients perceive remote surgery as more complex. However, autonomous robotic surgery (Scenario 4) did not show significantly higher PC compared to the first three scenarios. This indicates that patients may not view autonomous surgery as more complex than manual or robotic-assisted procedures.

Trust

The repeated measures ANOVA shows a significant difference in trust between the five scenarios F(3.503, 300) = 74.821, p <.001. 19.8% of the variance in trust is explained through the differences in the five scenarios. Post hoc analysis shows that trust was significantly higher for scenario 2 and scenario 3 compared to the other three scenarios. This suggests that participants have higher trust in robotic-assisted surgery with a surgeon present compared to other types of surgery. Additionally, trust in scenario 1 was significantly higher than scenario 4 and scenario 5. This indicates that conventional (manual) surgery is perceived as more trustworthy than fully autonomous or remote surgery. For the last

Table 4.9: Participant Preferences of Surgical method

Scenario	Frequency	Percentage(%)
Scenario 1: Surgery performed manually by the surgeon without assistance of a robotic system	17	5.6
Scenario 2: Surgery performed by a surgeon assisted by a robotic system	58	19.0
Scenario 3: Surgery performed by a surgeon assisted by a robotic system and a technician who is involved in the procedure	189	62.0
Scenario 4: Surgery autonomously performed by a robotic system under close supervision of a surgeon	39	12.8
Scenario 5: Surgery performed by a remotely located surgeon assisted by a robotic system	2	0.7

N = 305

two scenarios, trust was significantly higher for scenario 4 than scenario 5, indicating that participants place more trust in autonomous surgery than in remote surgery.

Willingness
The repeated measures ANOVA shows a significant difference in Willingness to consent between the five scenarios $F(3.333, 300) = 113.744$, $p < .001$. 27.2% of the variance in willingness is explained through the differences in the five scenarios. Post hoc analysis shows that the Willingness to consent for scenario 1, scenario 2 and scenario 3 was significantly higher than scenario 4 and scenario 5. Additionally, willingness to consent for scenario 4 was significantly higher than scenario 5.

The results do not support Hypothesis 4. Willingness to consent in scenario 3 (robotic-assisted surgery with a technician) was not significantly higher compared to scenario 2 (robotic-assisted surgery without a technician). This suggests that the presence of an assisting technician does not significantly influence patients' willingness to consent to robotic-assisted surgery. However, the results support Hypothesis 5 and 6. Willingness to consent for remote robotic surgery (Scenario 5) and autonomous robotic surgery (Scenario 4) was significantly lower compared to manual (conventional) surgery (Scenario 1), robotic-assisted surgery without a technician (Scenario 2), and robotic-assisted surgery with a technician (Scenario 3). This suggests that patients are less willing to consent to remote surgery or autonomous surgery.

4.5.2. Participants Preferred Scenario

At the end of the questionnaire, participants were asked to indicate their preferred surgical scenario should they ever need to undergo surgery themselves. The distribution of preferences across the five scenarios is shown in Tab.4.9. Scenario 3 was clearly the most preferred, with the majority of participants (62%) choosing this option. This suggest a strong preference for robotic-assisted surgery with a technician present. Scenario 5 was the least favored option, with only 0.7% of participants indicating a preference for this scenario.

4.6. Qualitative Data Analysis

Qualitative data was collected through open-ended survey responses to obtain a deeper insights into participants' perceptions of technician involvement during robotic surgery and the importance of disclosure regarding their role. The coding of these responses aimed to identify recurring themes, concerns, and attitudes. This section presents the findings from the qualitative coding, highlighting patterns in the responses. The coded responses are shown in Tab.4.10. 108 respondents included their perception of the involvement of a technician in their answer, 172 included their views on informed consent disclosure and 99 included their reasoning behind their disclosure preferences. In total, 231 participants left a comment (75,7% of total participants). The percentages in Tab.4.10 are based on the number of responses for that category. Since some people gave multiple answers, the sum of percentages can exceed 100%. All codes and example answers are shown in App.G. None of the other variables had a significant influence ($p < 0.05$) on whether the open question was filled in or not. This indicates no statistically significant difference between groups.

Perception of Technician Involvement

A small majority of participants who gave their perception on technician involvement reported that having a technician involved was essential or beneficial, particularly focusing on technical support and oversight. Some respondents mentioned potential flaws in technology or the necessity for a technician when something goes wrong. Multiple responses argued that the technician's presence is not essential but supportive. These responses mostly focused on the necessity to have a technician on standby in the hospital, but not necessarily present in the operating room. A notable number of respondents expressed concerns about the safety and reliability of robotic surgery. Several responses highlighted that the presence of a technician could raise doubts about the technology safety. For instance, some participants felt that the technician's involvement might imply that the robot was prone to failure, which in turn could reduce their trust in the procedure. Other responses highlighted increased trust and comfort when a technician was present. A small minority reported that they preferred surgeons control. These responses indicated that either the surgeon should be able to operate the robot independently or that they preferred no robotic interaction at all. Last, a small number of participants expressed indifference in the presence of a technician.

Views on Informed Consent and Disclosure

A large majority of participants who gave their opinion felt that full disclosure about the technician's presence was essential. Those responses highlighted the importance of full transparency. Others, however, suggested that it should not be a mandatory disclosure, as the technician is part of the team and their role is expected to be essential in the procedure. They also highlighted that all people in the operating room are bound to confidentiality agreements. A small number of respondents expressed that limited disclosure was acceptable, mentioning that it might be good to mention but should never be mandatory. Some of those responses also highlighted that they thought is should be mandatory to inform about the usage of a robot, but no explicitly about the presence of a technician. Last, two respondents had concerns about overloading the patient with information, indicating that people are already occupied enough with surgery itself.

Reasoning Behind Disclosure Preferences

The reasoning behind disclosure preferences differed a lot between respondents. Most respondents argued that patients had the right to know the roles of everyone involved in their surgery, as it was a matter of personal choice and trust in the surgical process. They mostly highlighted importance of full transparency on the surgical procedure. Other respondents felt that knowing a technician would be present could provide reassurance, increased trust or increased the perception of safety. A minority of respondents thought that I was necessary to disclose the presence of a technician because of it's influence on the surgical procedure, highlighting that the technician could influence the surgeons decisions. Last, several respondents emphasized the importance of informing patients about who would be involved in their surgery, not only for transparency's sake but also for privacy and ethical reasons.

Table 4.10: Coded Responses on Technician Involvement in Robotic Surgery

Code Category	Frequency	Percentage	Example Quote
Perceptions of technician involvement (N = 108)			
Essential for procedure	40	37.0%	*Necessary, because there must be someone present during the surgery who has full knowledge of the technology*
Supportive but Non-essential	18	16.7%	*Having the ability to call a technician if needed would be nice, but having seems a bit excessive*
Concerns about role	23	21.3%	*It is deeply worrying that a technician is needed, it shows the immaturity of the technology*
Trust in technician's expertise	32	29.6%	*I would find it comforting and feel a greater sense of reliability if a technician were present*
Prefers surgeon control	5	4.6%	*The surgeon should be able to operate the equipment without technical assistance*
Indifference to technician's presence	6	5.6%	
Views on Informed Consent and Disclosure (N = 172)			
Full disclosure required	135	78.5%	*It should be mandatory to inform the patient*
Limited disclosure acceptable	16	9.3%	*Patients should be informed about the robot, but not necessarily about the technician*
No need for disclosure	23	13.4%	*It's not necessary for the patient to know*
Concerns about overload of information	2	1.2%	*People are already occupied enough with the surgery itself*
Reasoning Behind Disclosure Preferences (N = 99)			
Right to know	48	48.5%	*I do think that a patient has the right to know the roles of every person that will be involved in the surgery*
Impact on trust	34	34.3%	*I think it is good to inform patients about this, as it will likely increase trust in robotic surgery*
Relevant to surgical outcome	23	23.2%	*Yes, because the technician's advice could potentially influence the surgeon's decisions*
Legal and ethical considerations	10	10.1%	*I think they should be informed of their involvement, purely on a privacy and autonomy level*

5 Discussion

This research investigated the factors influencing patient willingness to consent to total hip replacement surgery in different surgical scenarios in the Netherlands, using two conceptual frameworks. The research aimed to test the utility of a direct-effects model in explaining willingness to consent, test the mediating effects of PU and to compare the importance of different constructs across fives different surgical scenarios. The combination of five different surgical scenarios in a single study offers a comprehensive understanding of how the degree of robotic involvement and robotic autonomy influences patients' willingness to consent. By comparing various levels of robotic surgery with manual (conventional) surgery, differences in willingness to consent compared to conventional methods could be determined. This allows for a better understanding of how willingness to consent can change depending on the level of technological autonomy and surgeon involvement.

The findings provide insight in the role of PU, PC, trust and familiarity in explaining willingness to consent. While the construct often explained significant variance, their importance varied across the five scenarios. This indicates that different levels of robotic involvement can influence the importance of these factors in patient decision making.

Research examining patient willingness to consent are increasingly important in society as medical technology continues to evolve. Advancements in robotic systems could revolutionize surgery. Understanding factors that influence willingness is crucial for successful adoption of robotic technologies in healthcare. This study helps healthcare providers and policymakers to improve communication and increase trust in- and adoption of new technologies. Additionally, be examining important factors such as trust and PC, more effective informed consent processes can be designed. Ultimately, this research contributes to more efficient, accessible and patient-centered healthcare.

The obtained sample size was sufficiently large to ensure the reliability and validity of the findings. For multiple regression analyses, the sample size of 270 exceeded the required minimum of 106 participants, as determined by Tabachnick and Fidell's (2007) formula [61]. Additionally, an a priori sample size calculation using G*Power indicated that a minimum of 223 participants was needed to detect small effects (0.05) with a power of 0.8 and a significance level of 0.05. The collected sample size exceeded this threshold, ensuring that even small effect sizes could be detected [62]. Similarly, for the within-subjects repeated measures ANOVA, the lowest observed partial η^2 was 0.023, corresponding to an effect size of approximately 0.15. Based on G*Power calculations, the minimum required sample size for an effect size of 0.1 was 121 participants. The sample size of 270 was more than double this requirement, further supporting the robustness of the statistical analyses. In addition, the internal consistency of the constructs was confirmed through Cronbach's alpha, which was above the commonly accepted threshold of 0.7 for all measured variables. This indicates strong reliability and suggests that the constructs were measured consistently across participants [65]. The sample size calculations and reliability analysis confirm that the study had sufficient statistical power to detect meaningful effects. These findings support the validity of the conclusions drawn from the data.

5.1. Evaluation of Regression Models

The stepwise regression analyses provided insight in the utility of the direct-effects model in explaining variance in willingness to consent in (robotic-assisted) total hip replacement surgery in five different scenarios. The overall model explained a substantial proportion of the variance of willingness to consent in all scenarios. However, the relative importance of constructs varied across the scenarios.

The findings support the utility of the direct-effects model in explaining variance in willingness to consent (H1). In all scenarios the model explained between 52% and 72% of the variance. The high R^2 values indicate that PU, PC, trust, and familiarity collectively provide a strong explanation. Across all scenarios, trust, PC and PU were the most significant and dominant factors. This suggests that integrating trust alongside traditional TAM constructs is essential in understanding patients' willingness to consent to robotic-assisted surgery. Additionally, the alteration from Perceived Ease of Use to PC proved to be useful. The Cronbach's alpha values for PC were consistently acceptable and the construct proved to be significant in several scenarios. However, education level was not found to be significant in any of the scenarios. Therefore, it might be suitable to omit this independent variable from the model.

The findings only partially support Hypothesis 2. Trust emerged as an important variable of willingness to consent across all scenarios, emphasizing its central role. This aligns with prior research highlighting trust as a key determinant in the adoption of new technologies [52]. The consistently high impact of trust suggests that patients' willingness is not solely based on the technical aspects of the procedure but also on their trust and comfort with the medical procedure. In contrast, familiarity was only significant in Scenario 4 (autonomous surgery). This suggests that familiarity becomes particularly relevant when human involvement is minimized. One possible explanation is that patients who are more familiar with robotic surgery have a better understanding of autonomous systems. In other scenarios, where the surgeon is directly involved, familiarity may be less important, as patients might rely more on the expertise of the medical team rather than their knowledge of robotic systems.

5.2. Mediation Analysis

The eTAM assumed that all independent variables influenced willingness to consent indirectly through PU. However, the mediation analysis results challenge this assumption, highlighting the need for a more flexible conceptual model.

First, the results indicate that PU did not mediate all independent variables, suggesting that PU is not always the primary variable to explain willingness to consent. Notably, gender and level of education were never mediated through PU, meaning that these factors either influence willingness to consent directly, through other variables such as trust, or not at all. Additionally, in Scenario 3, PU was not significant in the stepwise regression model, yet mediation analysis was still conducted. This raises concerns about the validity of PU's role as a mediator in this scenario, as mediation typically requires a significant relationship between the mediator and the dependent variable. The lack of significance suggests that other factors, such as trust, may play a more important role in influencing willingness to consent in this scenario. Alternatively, the effect of PU on willingness to consent might be mediated by trust. Once trust was added in the model, the effect of PU became insignificant. This might suggest that the an indirect effect (through trust) accounted for most of the variance explained by PU, resulting in a weaker direct effect.

The stepwise regression analyses further revealed that PC often did not have a significantly association with willingness to consent when controlling for other variables. This suggests that PC may not have a strong direct influence on willingness. This questions whether PC should be included in the eTAM as a directly linked variable. Instead, its role as an indirect variable, potentially influencing PU or trust should be further explored. If PC primarily affects willingness to consent through other mediating variables, future models should account for this by removing PC as a direct variable and testing alternative pathways.

5.3. Comparison Between Surgical Scenarios

The following section will investigate differences and patterns in regression and correlation results, the outcomes from the ANOVA analysis and participants' preferred surgical scenarios.

5.3.1. Regression and Correlation

The regression and correlation analyses provide a comprehensive understanding of the variables influencing willingness to consent. A number of interesting patterns emerged.

The regression results showed that PU and trust were the most frequent significant variables, emphasizing their central role. Trust explained the most variance in the first two scenarios and remained an important variable in the last three, highlighting the importance of trust in the creation of comfort with robotic surgery. This align with previous research indicating the importance of building trust for the adoption of new technologies [52]. The strong influence of trust suggests that patients prioritize emotional and relational factors over purely technical aspects of robotic technologies. This might be caused by the high-risk nature of medical procedures [53]. When patients lack direct experience, they could rely more on trust to assess safety and effectiveness.

PU was also significant in many scenarios, explicitly in scenario 4 and 5, where it had a higher coefficient than trust. This suggests that when the level of robotic involvement increases, patients rely more on their perception of the technologies utility than on trust. In these scenarios, patients may evaluate robotic surgery based on expected efficiency, precision, or potential benefits rather than on their trust in the surgeon or medical team. However, even in these cases, trust remained a significant variable. These findings highlight the importance of considering both technical and psychological factors. Building trust remained important in all scenarios, while emphasizing benefits and reliability of robotic systems might become more important in scenarios where robotic involvement increases.

PC had a negative effect, this suggest that patients who perceived the surgery as more complex are less willing to consent. Interestingly, PC was a significant variable in scenario 1, 4 and 5. Especially the significance in the last two scenarios indicates that perceived complexity becomes more important as the technology behind the surgical procedure become more advanced (i.e. fully autonomous and remote surgery). This suggests that to increase willingness to consent, healthcare managers should improve patient understanding of the robotic technologies, as patients will not instantly accept complex technologies.

Age was only significant in scenario 1 (Surgery performed manually by the surgeon without assistance of a robotic system). This suggests that older patients can be less willing to consent to surgery in general. Although age does not significantly explain variance in willingness to consent in the other surgical scenarios after taking other factors into account, it might be an important factors to keep in mind in informed consent processes.

Interestingly, gender emerged as a significant variable of willingness to consent in scenario 4 (fully autonomous) and 5 (remote location), where males were more likely to consent. This suggest that gender can become an important factors as robotic surgery becomes more advanced. These results indicate that an increase in robotic autonomy or a surgeons remote location would decrease the willingness to consent amongst females. These results align with data found in literature, where females report increased fear and lower trust in robotic assisted surgery [22, 51].

Scenario 4 was the only scenario in which familiarity had significant negative association with willingness to consent. This suggest that in this particularly scenario, familiarity directly influences patient willingness to consent. Participants who are more familiar with robotic surgery might be more aware of its limitations or ethical concerns, leading to skepticism and lower willingness to consent. The idea of removing the surgeon altogether (scenario 4) might feel like a step too far. In scenarios with less autonomy and more surgeon involvement, the role of familiarity was not significant. Previous results from Anania et al. (2021) showed that familiarity was a significant predictor of willingness to consent [22]. However, in this research trust, PU and PC were used. This indicate that using these constructs, the sole effect of familiarity on willingness to consent become lower.

5.3.2. ANOVA for Constructs Between Scenarios

The repeated measures ANOVA revealed significant differences across the five surgical scenarios. The significant variation in PU indicates that the level of robotic involvement influence how useful patients perceive the surgery to be. Surgical scenarios involving robotic-assisted technologies performed by a surgeon (with- or without a technician) were seen as significantly more useful than other the other three scenarios. This indicates that participant believe that robotic-assisted surgery is more useful than manual surgery. These findings are contradictory with previous findings reported by Boys et al. (2016) and Chan et al. (2022). Boys et al. concluded that only a quarter of survey respondents thought robotic-assisted surgery was better. Chan et al. reported that small minorities considered robotic-assisted surgery to be safer or have better outcomes. [18, 19]. However, another study by Ahmad et al. (2017) found that a majority of respondents believed that robotic surgery decreases infection rates, length of hospital say and increase precision and accuracy [38]. These findings align with the results of this study, where participants report increased PU for robotic-assisted surgery. Additionally, robotic-assisted surgery performed by a surgeon was seen as more useful compared to fully autonomous (scenario 4) and remote surgery (scenario 5). This might be explained through a decrease in comfort, concerns about safety and lower familiarity with the technology. Participants might see the surgeon as a critical decision-makers, where their presence ensures adaptability.

PC was significantly higher for scenario 5 compared to scenario 2, 3 and 4. This indicate that participants perceived remote surgery as more complex than other types of robotic surgery. These perceptions might by caused by concerns about communication or potential failures. The partial support for Hypothesis 3 indicates that perceived complexity is not uniformly high across the advanced robotic scenarios. While PC was significantly higher in remote robotic surgery (Scenario 5), autonomous surgery (Scenario 4) did not show significantly higher PC compared to other scenarios. A possible reason for this is that remote surgery could introduce concerns about surgeon control and response time, making it appear more complex. This finding also suggests that the PC of remote surgery might be caused by logistical and communication concerns rather than technological complexity alone.

Similar to PU, trust in surgical scenarios involving robotic-assisted technologies performed by a surgeon (with- or without a technician) was significantly higher than the other scenarios. This might be explained through the direct involvement of the surgeon in the surgery. In these scenarios, the surgeon has an active role in controlling the robot compared to scenario 4 and 5, where the surgeon is either located remotely or surgery is performed autonomously. These results align with results from a previous study by Boys et al. (2016). They also reported that survey respondents preferred non-expert local surgeons over remotely located expert surgeons [18]. Additionally, finding from a study by Pradeep et al. (2013 reported that patients show more trust in surgeons, compared to robots [53]. These findings also align with the results from this study, where all the scenarios directly involving a surgeon had higher values for trust. Interestingly, trust is also significantly higher in scenario 2 and 3 compared to scenario 1 (surgery performed manually by the surgeon without assistance of a robotic system). This indicate that participants have greater trust in robotic-assisted surgical technologies compared to a surgeon performing the surgery manually.

Willingness to consent was significantly higher for all scenarios with direct involvement of a surgeon (scenario 1, 2 and 3) compared to the scenarios with higher robotic autonomy or remote surgery (scenario 4 and 5). This implies that the presence and involvement of human surgeons during surgery is a key factor to increase the willingness to consent. In contrast, scenarios which involve fully autonomous robots or remote surgeons likely raise concerns about safety or reliability. This suggest that a significant degree of human involvement remains necessary to assure safety and increase willingness to consent.

The lack of support for Hypothesis 4 suggests that the presence of an assisting technician does not significantly impact willingness to consent. This contradicts the expectation that additional human oversight would increase willingness. One possible explanation is that patients might assume that the surgeon remains the primary decision-maker regardless of technician involvement, making the additional presence of a technician less important. Alternatively, the role of the technician may not be well understood by patients, leading to indifference regarding their presence. The significantly lower willingness to consent in scenario 4 (autonomous) and 5 (remote) provided strong support for Hypotheses 5 and 6. This suggests that patients might have concerns about safety. Remote surgery may introduce fears about communication delays, while autonomous surgery may raise concerns about the lack of human involvement.

Interestingly, PU, trust and willingness were significantly higher for autonomous robotic surgery compared to remote surgery. This also relates to the previous findings, that patients prefer a direct human oversight in the operating room. In the autonomous surgical scenario, the surgeon was still present in the room. Whereas in remote surgery, this is not the case.

5.3.3. Participants Preferred Scenario

The preference of surgical scenario provides valuable insight into how patients perceive the various levels or robotic involvement and surgeon presence. Scenario 3, where surgery is performed by a surgeon assisted by both a robotic system and a technician, received the highest number. These findings align with the findings from the repeated measures ANOVA, where scenario 2 and 3 had the highest PU, trust and willingness to consent. Also consistent with ANOVA, is the higher number for scenario 4 (autonomous) compared to scenario 5 (remotely), with 39 and 2 participants preferring these scenarios respectively. In ANOVA, PU, trust and willingness for scenario 4 were higher than scenario 5. Contradictory with ANOVA scenario 1 (manual surgery), had fewer participants preferring that scenario compared to scenario 4 (autonomous), with 17 and 39 responses respectively. Although, participant reported higher PU, trust and willingness to consent in scenario 1, more participants actually preferred scenario 4.

Ultimately, the results from the preferred scenario of participants emphasized the preference for robotic-assisted surgery performed by a surgeon assisted by a robotic system (with- or without a technician).

5.4. Interpretation of Qualitative Data

A substantial portion of participants who left a comment reported that the presence of technician in the operating room was essential, supportive or beneficial. Many participants reported that the technicians was useful to assist in the event of failures, ensuring correct functioning of the robotic systems. These findings emphasized the idea of having additional human oversight as a reassuring factor. However, although a majority reported surgery with a technician present as their preferred scenario, the reason behind their perception of technician involvement differs. Some respondents thought it was necessary to have a technician present, others reported that a standby function would be sufficient and other reported an increase in trust when a technician was present. From these, the latter also align with previous findings about the influence of trust on willingness to consent.

Several participants expressed indifference in the presence of a technician. An important consideration in the interpretation of open-ended questions is whether people who did not respond should be categorized as ”indifferent”. In this research, people who did not fill in the open question were not counted as indifferent. This was done because non-responses do not necessarily indicate indifference. It can also be cause by survey fatigue, lack of motivation or simply choosing not to engage. On the other hand, those who explicitly stated that they were indifferent made a conscious choice to express this. Therefore, non-responses should remain separated from explicit expressions to ensure the findings accurately reflect participants’ perspectives. Categorizing non-responses as indifferent could introduce biases.

A notable number of participants also expressed concerns regarding the role of the technician. These participants mostly noted that the presence of a technician implies potentials flaws in the robotic system. These findings align with previous results indicating that respondents express concerns about possible malfunctioning of robotic systems [18, 19, 20]. Therefore, it is important to educate and inform people about potential risk, benefits and the exact role of the technician in the procedure.

The fast majority of participants who filled in the open question reported that full disclosure was necessary. Some argued that full transparency was essential to build trust, which in turn aligns with previous finding on the importance of trust. Others reported that disclosure was necessary to ensure autonomy. This align with previous statements that patients should actively participate in decision-making of their healthcare to ensure autonomy and avoid coercion [24].

5.5. Theoretical Implications

This study extended existing theoretical frameworks on technology acceptance and decision-making in medical contexts by introducing key modifications to improve their applicability to patient willingness to consent to robotic-assisted surgery. These adjustments contribute to the development of more useful frameworks for understanding how patients perceive and respond to robotic-assisted surgical methods.

One of the primary modifications is the use of willingness to consent as the dependent variable instead of acceptance. While acceptance models focus on the user’s intention to adopt and use a technology, willingness to consent is more relevant in healthcare settings where patients are not active users but decision-makers regarding their treatment. This changes the scope of existing models and provides a more accurate reflection of patient decision-making processes.

Additionally, this study provided insights into the mechanisms underlying willingness to consent by applying and adapting established frameworks. Notably, PEOU, a key construct in TAM, was replaced with PC. This adjustment aligns with the passive role of patients, who do not use robotic surgical systems directly but are passive receivers. This modification enhances the framework's relevance in medical decision-making scenarios.

The study also found that PU was not a consistent mediator influencing willingness to consent. This finding challenges traditional technology acceptance models that assume PU plays a central role in determining user adoption. In contrast, trust emerged as a more important variable explaining willingness to consent, underscoring its crucial role in healthcare decision-making. Trust in the medical procedure strongly influenced patient willingness. A study by Kelly et al. (2023) also found trust is frequently included and significant in technology acceptance models across different industries [9]. Given the importance of trust, future research should further explore its influence within technology acceptance models, especially when focusing on willingness to consent. Understanding whether trust operates as a direct variable, a mediator, or a moderator in different contexts could refine theoretical frameworks and improve strategies for increasing patient confidence in robotic-assisted surgery.

The importance of trust in willingness to consent may be explained by several factors. First, patients rely heavily on medical professionals to ensure their safety, making trust in the surgical team a key determinant of their decision-making. Second, the uncertainties associated with robotic-assisted surgery lead patients to rely on trust in technology and the institutions overseeing its implementation. Lastly, the complexity of surgical procedures reinforces patients' dependence on trust, as they may feel unable to assess the technology themselves.

Overall, this study advances theoretical models of technology acceptance by adapting them to the healthcare context and emphasizing the critical role of trust in patient decision-making. Future research should further investigate willingness to consent as a dependent variable using refined frameworks that account for trust, perceived complexity, and other psychological and contextual factors that influence patient decisions.

5.6. Implications for Policy and Clinical Practice

Trust and PU were found the be the most important variables in explaining willingness to consent. The importance of trust in this study highlights the need for healthcare providers to build trust with patients. Given that trust was consistently a major variable, it is necessary for healthcare provider to increase transparency and improve open communication. Ensuring that patients feel informed can significantly increase a patients trust and willingness to consent. Moreover, since PU was also an important variable, patients should reassured about safety and reliability of robotic surgery. Previous results from Char et al. (2013) also indicated that risk and benefits are rated as the most import factors to be discussed prior to medical intervention [28]. Combined with the results from this study, clear communication and highlighting risk and benefits is found to be essential for healthcare providers to increase willingness to consent.

PC emerged as a key factor in several scenarios. This suggest that patient understanding of the procedure can influence willingness to consent. Healthcare providers should invest efforts to explain robotic system functioning to patients. Simplifying information and focusing on benefits such as enhanced precision and reduced risks might reduce PC, especially amongst patients who perceived the technology as difficult or intimidating. This highlights the importance of tailored communication strategies based on patient demographic or familiarity.

This study highlights the role of a technician in robotic-assisted surgery as a factor which could influence trust and willingness to consent. The presence of a technician can enhance confidence by providing additional oversight and human expertise. Patients may perceive the technician as an added layer of safety. However, concerns about the role of the technician were another important finding. Many respondents who left a comment expressed the necessity for clear communication about everyone present in the operating room. To overcome these problems, healthcare providers should emphasize the role of all individuals involved in surgery. Transparency about the technician involvement in robotic surgery should be part of a standardized informed consent process. This should ensure that all patients received clear, consistent communication prior to surgery. This relates to previous data obtained by Char et al. (2013), who mentioned that 70% of patients desire a general description of the procedure, acknowledgments of unknown risks, the number of prior procedures performed by the surgeon and the surgeons training for the procedure [28].

In conclusion, healthcare providers should focus on trust-building measures, simplify explanations and ensure transparent communication about technician involvement. This strategy should be incorporated in policy and practice to enhance willingness to consent in robotic surgery,

5.7. Limitations and Future Research

While this study provides valuable insights into the factors influencing patient willingness to consent to robotic-assisted surgery, several areas require further investigation. The cross-sectional design of the study captures responses at a single point in time. As a result, it does not account for potential changes in responses due to increased familiarity or trust over time as exposure to or experience with robotic-assisted surgery increases. Moreover, the study investigates participants' willingness to consent to robotic-assisted surgery, it does not measure actual behavior. There may be a gap between participants' stated willingness and the decisions they would make in real-life, particularly when facing high-stakes surgical scenarios. Therefore, the impact of real-world exposure to robotic-assisted surgery on patient willingness to consent should be examined. While this study relied on hypothetical scenarios, longitudinal studies tracking patients before and after undergoing robotic-assisted procedures could provide deeper insights into how familiarity, trust, PC, PU and willingness evolve over time. This would also help identify whether initial concerns about robotic autonomy or remote surgery diminish with experience.

Since trust was often found to be a more important variable than PU, future research should consider modifying the eTAM frameworks to include trust as a central mediating factor. This adjustment could provide a more accurate model of patient decision-making in robotic surgery. Furthermore, the fact that PU was not a significant variable in Scenario 3 and did not mediate gender or education level suggests that mediating role of PU might not be as distinct as initially assumed. Similarly, given that PC did not consistently influence willingness to consent, future research should assess whether PC should be removed as a direct varialbe and instead analyzed as an indirect factor influencing other variables.

The role of assisting technicians in robotic-assisted surgery should be further explored. Although this study found that the presence of a technician did not significantly influence willingness to consent, qualitative feedback suggested that patients value transparency about their role. Future research could investigate how detailed explanations of the technician's responsibilities influence patient trust and willingness to consent.

The observed variations across scenarios indicate that willingness to consent is context-dependent. Future studies could further investigate whether specific patient characteristics influence these perceptions in different surgical scenarios. Understanding these dynamics can help improve informed consent procedures and increase the adoption of robotic-assisted surgery in different healthcare settings. Additionally, this study evaluates five distinct surgical scenarios, each varying in the degree of robotic and human involvement. While using these scenarios aimed to include a wide range of possibilities, they may not represent all possible setups in robotic-assisted surgery. Therefore, the study can be expanded to other surgical scenarios.

This study was conducted in the Netherlands. Therefore, the findings may not be fully applicable to populations in countries with different healthcare systems or cultural attitudes toward technology. Expanding the study to include an international sample could increase the generalizability of the results.

In this research, the construct of Perceived Ease of Use from the Technology Acceptance Model (TAM) was replaced with Perceived Complexity. This adjustment reflects the target population of patients, who are not using the robotic surgical systems themselves and may lack the expertise to assess ease of use directly. Instead, perceived complexity captures how complex or challenging the surgical procedure appears to them. While this change aligns well with the context of the study, it limits the comparability of the results with other studies using similar frameworks. Future research should validate this adapted construct and explore its robustness across similar contexts.

Statistical analyses were conducted using stepwise regression, which assumes that key conditions, such as linearity, independence of observations, and homoscedasticity, are met. Despite thorough efforts to verify these assumptions, any deviations could impact the validity of the results. For example, correlation values where not considered a problem. However, PU and trust highly significantly correlated in each scenario. This creates the possibility of overlap between constructs. As a results, distinct effect of these separate constructs on willingness may be less clear. The overlap is probably best explained through similarity in the questions regarding safety in both constructs (see App.A). However, it was previously shown that reliability and performance expectancy were key factors influencing trust in robotic surgery [46, 53]. Therefore, it might very well be plausible that trust and PU should highly correlate. Additionally, the high correlation could also suggest mediating role of one of the two constructs. Further research will be necessary to investigate this.

Lastly, the study focuses on specific variables, such as perceived usefulness, perceived complexity, trust, familiarity, and demographics. While these factors are critical, other influences such as costs, insurance coverage, or recommendations from healthcare professionals were not included but may also play a significant influence participants' willingness to consent. Additionally, previous findings from Anania et al. (2021) found that wariness, fear, openness, happiness and anger were also important factors influencing willingness to consent [22]. Future research could include these factors in the framework to determine their influence in combination with the variables used in this study.

5.7.1. Biases

Every research faces the risk of biases that could affect the reliability or validity of the results. A key limitation of this study is the potential bias in the sample of respondents who completed the questionnaire. Since participation was voluntary, individuals with an interest in technology, healthcare innovation or robotic-assisted surgery may have been more inclined to complete the survey. This could lead to an over representation of participants with favorable attitudes toward robotic surgery, potentially skewing the results toward higher willingness to consent. Additionally, participants who took part in the questionnaire might have chosen it themselves because of an interest in engineering or healthcare. This also leads to an over-representation of a specific group. Future studies should aim for a diverse and representative sample, including individuals with varying levels of familiarity and interest in robotic-assisted surgery.

The study was also prone to sampling bias. Sampling bias occurs when the participants do not represent the target population. This can be a happen when the questionnaire is distributed through a singly uniform channel. This results in an over-represented group of the population. This questionnaire was distributed through Linkedin, Whatsapp, flyering in universities, printed papers in neighborhoods and word of mouth. Although, the targeted groups are still familiar people, there is no single over-represented group.

Last, the reliance on self-reported data introduces subjectivity, which could affect the accuracy of the responses. Factors such as social desirability bias or misunderstandings of the questions may have influenced participants' answers. For instance, participants might overstate their willingness to consent to align with perceived societal norms or technological trends. In this questionnaire the chance of this bias are minimal, due to ensured anonymity and confidentiality.

6 Conclusion

This research investigated the factors influencing patient willingness to consent to robotic-assisted total hip replacement surgery in the Netherlands. Using a direct-effects model and an eTAM, the research demonstrated that trust, PU and PC are the most important variables explaining willingness to consent, with trust and PU being the most significant variables across all surgical scenarios. The adapted conceptual framework explained between 52% and 72% of the variance in willingness in all scenarios. This emphasizes its suitability for understanding patient acceptance of robotic surgery. Moreover, the eTAM framework assumed that PU would mediate all independent variables, the results show that this is not the case. PU was not a consistent mediating variable for other independent variables in any of the scenarios.

Results from ANOVA revealed significant differences across surgical scenarios. Robotic-assisted surgery performed by a surgeon was rated higher in PU, trust, and willingness compared to manual, autonomous or remote surgery. Remote surgery was perceived as the most complex surgical scenario. While autonomous surgery was viewed more favorably than remote surgery, direct surgeon involvement remained the strongest factor in increasing willingness to consent.

Data from participants preferred scenario aligned with these results, showing the highest support for surgery performed by a surgeon assisted by both a robotic system and a technician. Interestingly, autonomous robotic surgery was preferred over manual surgery, despite the latter receiving higher scores for trust and willingness to consent. Remote surgery had the lowest preference, further emphasizing the importance of physical surgeon presence.

The role of the technician also played a significant role in patient perceptions. Many participants of those leaving a comment viewed the presence of a technician as essential for ensuring system reliability and handling potential failures. However, others saw technician involvement as an indication of system flaws. This emphasizes the need for clear communication regarding their role. Additionally, most participants mentioned the importance of full disclosure, which was mostly necessary to build trust and maintain patient autonomy.

These findings offer valuable insights for healthcare providers and policymakers, who wish to improve informed consent procedures and increase the adoption of robotic-assisted surgery. By prioritizing transparency and trust-building initiatives, healthcare provider can improve patient confidence and increase willingness to consent. The eTAM framework developed in this study provides a useful tool for guiding future research and policy development in robotic surgery acceptance.

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A

eTAM Measures

Table A.1: Original and adjusted measures used in eTAM model

Original statement	Adjusted statement	Source
Perceived Usefulness		
	In this surgical procedure, it is likely that the function of my hip is completely restored	
Da Vinci surgery will allow me to recover quickly after surgery	In this surgical procedure, it is likely that I recover quickly after the procedure	[63, 64]
Da Vinci surgery can relieve my pain	In this surgical procedure, it is likely that my pain is relieved after the surgery	[63, 64]
Da Vinci surgery is safer than other surgical treatments	This surgical procedure is safer than other forms of surgery	[63, 64]
Perceived Complexity		
The automation that controls robotic surgery is very complex	It is complex to carry out this surgical procedure	[22]
	It is difficult to carry out this surgical procedure	
I do not understand the automation that controls robotic surgery	It is difficult to understand how this surgical procedure is carried out	[22]
It is difficult to know how the automation that controls robotic surgery works	It is challenging to comprehend how this surgical procedure is carried out	[22]
	This surgical procedure requires significant effort	
Trust		
I trust this Web retailer because they keep my best interests in mind	I trust that this surgical procedure was chosen to be in my best interest	[52]
	I trust this surgical procedure to be accurate	
This Web retailer is trustworthy	This surgical procedure is trustworthy	[52]
	This surgical procedure is safe	
Familiarity		
I am familiar with robotic surgery	I am familiar with total hip replacement surgery	[22]
I have a lot of knowledge about robotic surgery	I have a lot of knowledge about total hip replacement surgery	[22]
I know more about robotic surgery than the average person	I know more about total hip replacement surgery than the average person	[22]
I am familiar with robotic surgery	I am familiar with robotic surgery	[22]
I have a lot of knowledge about robotic surgery	I have a lot of knowledge about robotic surgery	[22]
I know more about robotic surgery than the average person	I know more about robotic surgery than the average person	[22]
Willingness to consent		
I would be willing to undergo surgery in this situation	I would be willing to undergo surgery in this situation	[22]
I would be comfortable undergoing surgery in this situation	I would be comfortable undergoing surgery in this situation	[22]
I would feel safe undergoing surgery in this situation	I would feel safe undergoing surgery in this situation	[22]

B

Introductory Texts and Figures of Questionnaire

B.1. Intro text

The following cases describe total hip replacement surgery after a serious bike accident. Imagine that falling off your bike caused a severe hip fracture, leaving you in significant pain and unable to move your leg properly. Medical specialists recommend total hip replacement to restore mobility and improve your quality of life.

Total hip replacement involves replacing the damaged hip joint with an artificial implant to relieve pain, restore function, and allow a return to daily activities.

The following five scenarios illustrate different ways to carry out the surgical procedure, varying in the location of the surgeon, use of robotic technology, and the composition of the team. In every case you can assume that:

- The surgeon is highly experienced and has performed numerous similar procedures.
- The surgery is performed in a state-of-the-art medical facility.
- An anesthesiologist and nurses with sufficient experience supporting the procedure to ensure safety and precision.

Please read each scenario carefully and imagine yourself in the described situation before answering the accompanying questions.

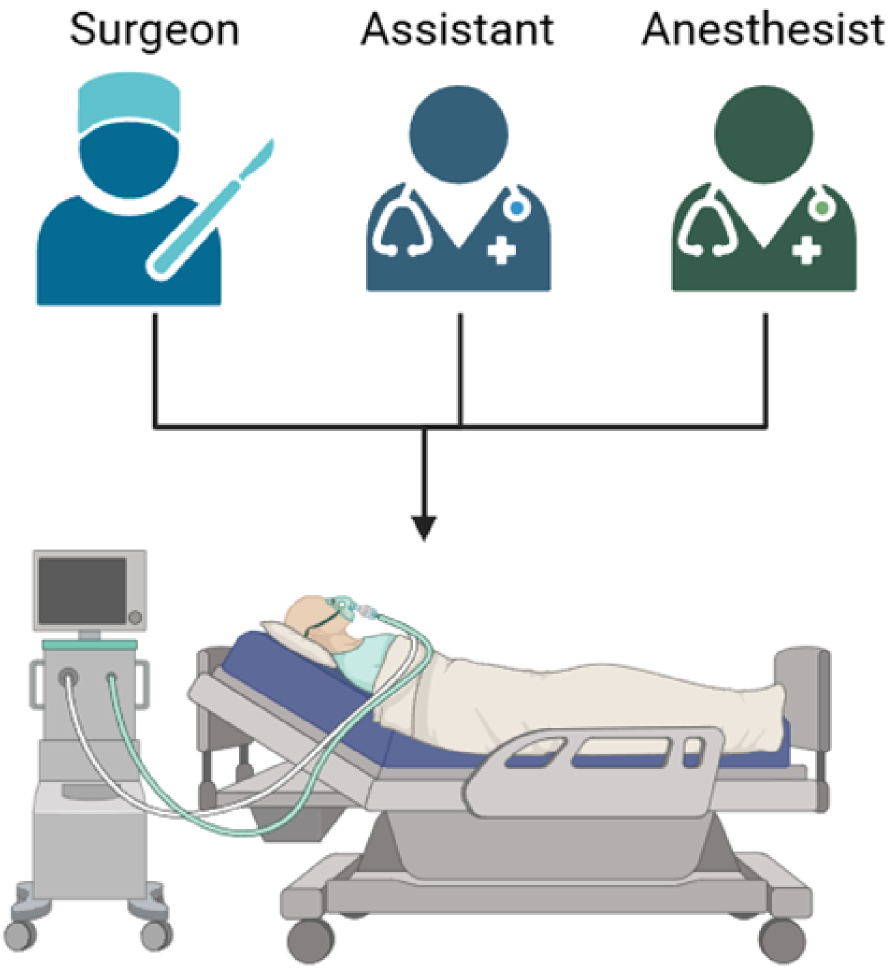


Figure B.1: Illustration of scenario 1: Surgery performed manually by the surgeon without assistance of a robotic system

B.2. Scenario 1: Surgery performed manually by the surgeon without assistance of a robotic system

In this scenario, the total hip replacement is performed manually by the surgeon without the assistance of robotic systems. The surgeon is physically present in the operating room and carries out every step of the procedure, relying solely on expertise, skill, and standard surgical tools.

The surgeon manually accesses the hip joint, removes damaged bone and cartilage, and positions the artificial implant with precision. The success of the surgery depends entirely on the surgeon's experience and judgment, without any robotic assistance or advanced technology.

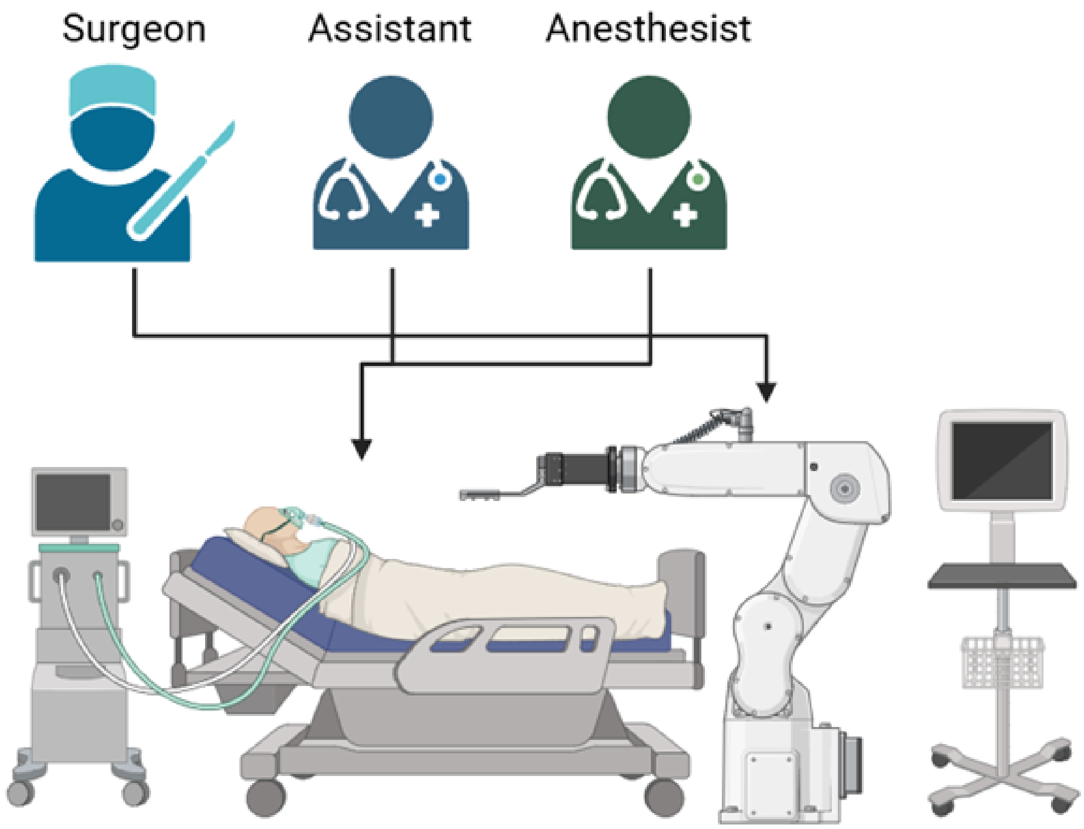


Figure B.2: Illustration of scenario 2: Surgery performed by a surgeon assisted by a robotic system

B.3. Scenario 2: Surgery performed by a surgeon assisted by a robotic system

In this scenario, the total hip replacement is performed with the assistance of advanced robotic technology. The surgeon operates the robotic system directly, using it to enhance precision and accuracy of the procedure.

The surgeon remains in full control at all times, overseeing every movement of the robotic system and making all key decisions to ensure the best outcome. The robotic system creates a detailed 3D model of your hip joint using advanced imaging and sensors. This model helps the surgeon plan the implant placement and the robotic arm helps the surgeon with precise execution and placement of the implant.

This method combines the surgeon's expertise with robotic precision to optimize the success of your hip replacement.

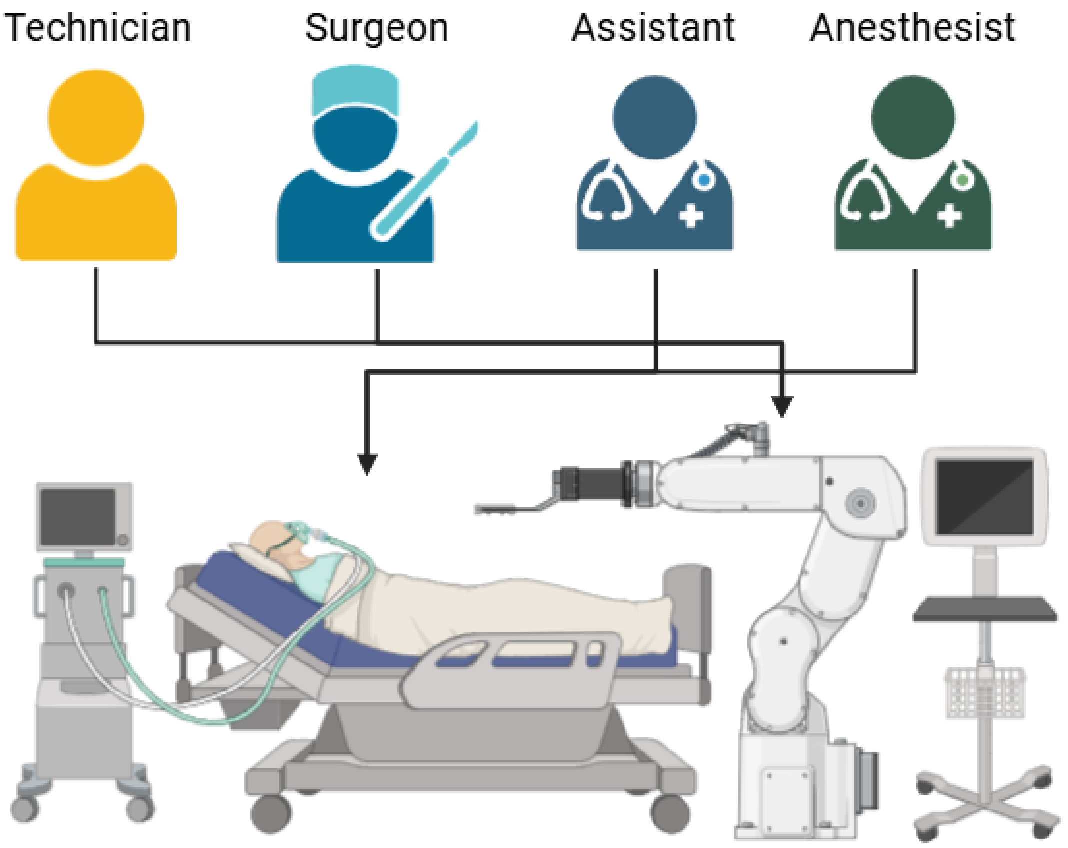


Figure B.3: Illustration of scenario 3: Surgery performed by a surgeon assisted by a robotic system and a technician who is involved in the procedure

B.4. Scenario 3: Surgery performed by a surgeon assisted by a robotic system and a technician who is involved in the procedure

In this scenario, the total hip replacement is performed using robotic-assisted technology, combining the surgeon's expertise with the precision of robotics and the support of a trained technician.

The surgeon remains in full control of the robotic system, which provides a 3D model of your hip joint and guides the implant placement with high precision. A technician is present to manage the robotic system, troubleshoot technical issues, and adjust the system as needed to support the surgeon's instructions.

This collaboration allows the surgeon to focus on the critical aspects of the procedure while leveraging the robotic system and the technician's expertise to enhance the accuracy and success of your hip replacement.

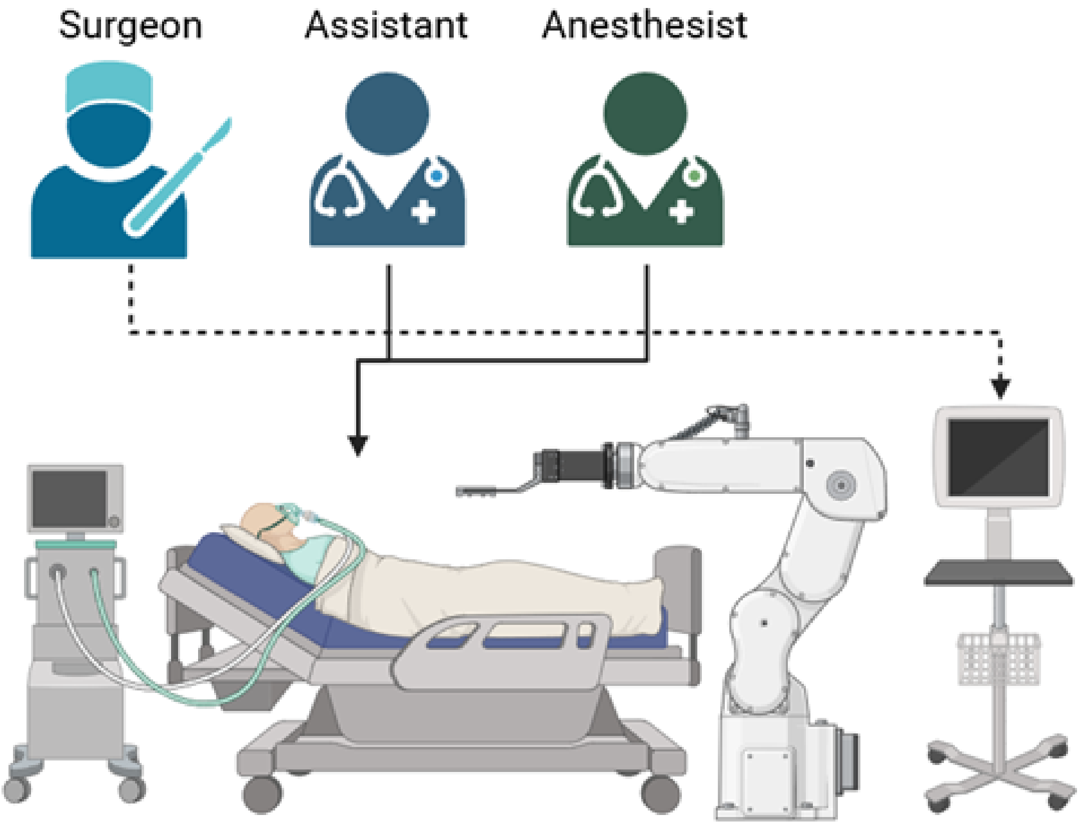


Figure B.4: Illustration of scenario 4: Surgery autonomously performed by a robotic system under close supervision of a surgeon

B.5. Scenario 4: Surgery autonomously performed by a robotic system under close supervision of a surgeon

In this scenario, the total hip replacement is performed autonomously by a robotic system. The system is programmed to carry out the entire procedure, including removing damaged bone and cartilage, preparing the joint, and positioning the artificial implant.

The surgeon is present in the operating room to supervise the robotic system closely. Although the surgeon does not operate the system directly, they are ready to intervene if needed to ensure safety and optimal outcomes.

The robotic system uses a 3D model of your hip joint and real-time imaging to guide the surgery with precision, relying on advanced technology while maintaining human oversight for safety.

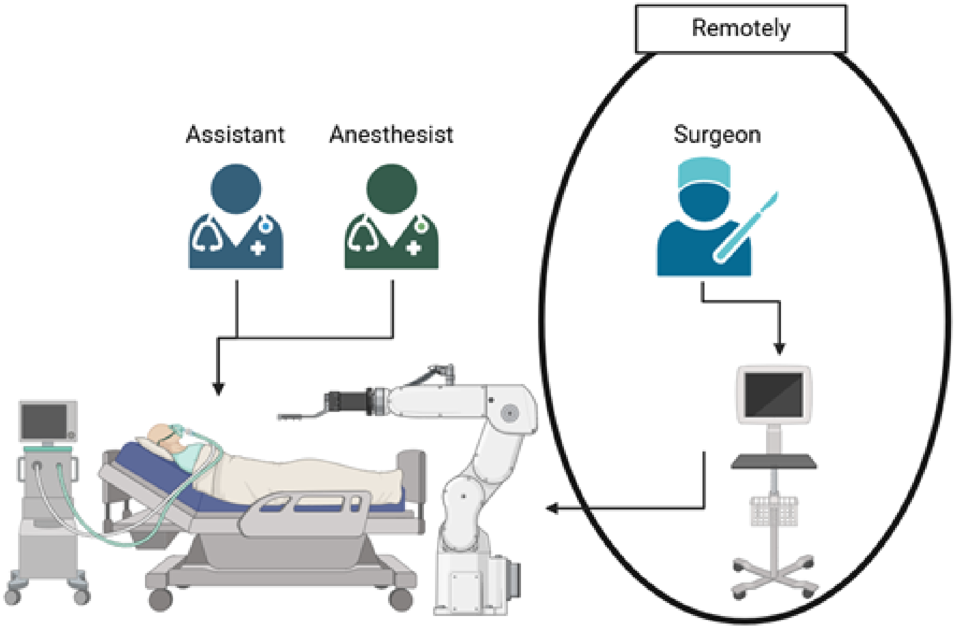


Figure B.5: Illustration of scenario 5: Surgery performed by a remotely located surgeon assisted by a robotic system

B.6. Scenario 5: Surgery performed by a remotely located surgeon assisted by a robotic system

In this scenario, the total hip replacement surgery is performed using robotic-assisted technology, with the surgeon controlling the robotic system remotely from a different location. Despite not being physically present in the operating room, the surgeon directs the robotic system with precision using advanced communication and imaging tools.

The robotic system is equipped with sensors and robotic arms, which the surgeon controls in real-time from a remote workstation. A skilled medical team is present in the operating room to ensure the procedure runs smoothly.

The surgeon maintains full control over the robotic system, ensuring the precise placement of the artificial hip implant. This approach enables the surgical procedure being carried out by a highly experienced specialist from a remote location.

C

Pearson Correlation Coefficients

Table C.1: Pearson correlation coefficients for Scenario 1: Surgery performed manually by the surgeon without assistance of a robotic system

	1	2	3	4	5	6	7	8
1. Age	1	0.083	-0.094	-0.114	0.050	-0.024	-0.099	-0.137*
2. Gender		1	-0.149**	-0.66	0.014	-0.037	-0.076	-0.067
3. Education level			1	0.224**	0.070	0.070	0.034	0.066
4. Familiarity				1	0.186**	0.158**	-0.282***	0.182**
5. PU					1	0.549***	-0.145**	0.563***
6. Trust						1	-0.156**	0.641***
7. PC							1	-0.219***
8. Willingness								1

N = 270 *. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed). *** Correlation is significant at the <.001 level (2-tailed). Pu = Perceived Usefulness, PC = Perceived Complexity

Table C.2: Pearson correlation coefficients for Scenario 2: Surgery performed by a surgeon assisted by a robotic system

	1	2	3	4	5	6	7	8
1. Age	1	0.083	-0.094	-0.114	0.017	-0.023	-0.092	-0.043
2. Gender		1	-0.149**	-0.066	0.007	-0.057	-0.054	-0.064
3. Education level			1	0.224***	0.004	0.060	0.063	0.098
4. Familiarity				1	0.124*	0.174**	-0.182**	0.123*
5. PU					1	0.652***	-0.024	0.560***
6. Trust						1	-0.150**	0.741***
7. PC							1	-0.165**
8. Willingness								1

N = 270 *. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed). *** Correlation is significant at the <.001 level (2-tailed). Pu = Perceived Usefulness, PC = Perceived Complexity

Table C.3: Pearson correlation coefficients for Scenario 3: Surgery performed by a surgeon assisted by a robotic system and a technician who is involved in the procedure

	1	2	3	4	5	6	7	8
1. Age	1	0.083	-0.094	-0.114	-0.037	-0.064	-0.004	-0.095
2. Gender		1	-0.149**	-0.066	-0.022	-0.065	-0.027	-0.069
3. Education level			1	0.224***	0.129*	0.123*	0.090	0.094
4. Familiarity				1	0.157**	0.192***	-0.245***	0.197***
5. PU					1	0.717***	-0.87	0.620***
6. Trust						1	-0.130*	0.797***
7. PC							1	-0.122*
8. Willingness								1

N = 270 *. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed). *** Correlation is significant at the <.001 level (2-tailed). Pu = Perceived Usefulness, PC = Perceived Complexity

Table C.4: Pearson correlation coefficients for Scenario 4: Surgery autonomously performed by a robotic system under close supervision of a surgeon

	1	2	3	4	5	6	7	8
1. Age	1	0.083	-0.094	-0.114	0.144*	0.131*	-0.027	0.140*
2. Gender		1	-0.149**	-0.066	0.025	-0.055	-0.102	-0.114*
3. Education level			1	0.224***	-0.029	-0.014	0.085	-0.078
4. Familiarity				1	0.010	0.006	-0.166**	-0.067
5. PU					1	0.658***	-0.098	0.629***
6. Trust						1	-0.126*	0.831***
7. PC							1	-0.160**
8. Willingness								1

N = 270 *. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed). *** Correlation is significant at the <.001 level (2-tailed). Pu = Perceived Usefulness, PC = Perceived Complexity

Table C.5: Pearson correlation coefficients for Scenario 5: Surgery performed by a remotely located surgeon assisted by a robotic system

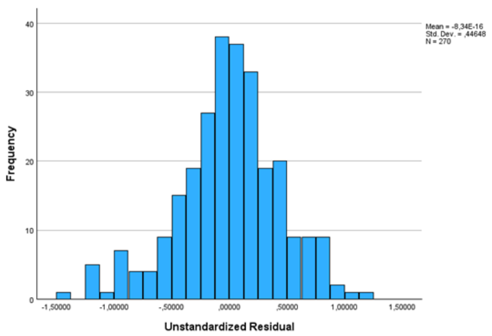
	1	2	3	4	5	6	7	8
1. Age	1	0.083	-0.094	-0.114	0.026	0.057	-0.057	0.037
2. Gender		1	-0.149**	-0.066	-0.098	-0.136*	-0.006	-0.214***
3. Education level			1	0.224***	0.014	-0.020	0.075	0.017
4. Familiarity				1	0.092	0.150**	-0.152**	0.118*
5. PU					1	0.710***	-0.123*	0.682***
6. Trust						1	-0.183**	0.795***
7. PC							1	-0.242***
8. Willingness								1

N = 270 *. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed). *** Correlation is significant at the <.001 level (2-tailed). Pu = Perceived Usefulness, PC = Perceived Complexity

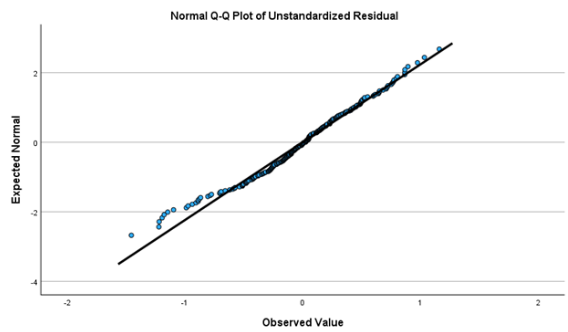
D

Regression Assumptions: Normality of Residuals

This appendix includes the histograms and Q-Q plots used to assess the normality of residuals in the regression analysis. The histograms display the distribution of unstandardized residuals, providing a visual check for the approximate symmetry and bell-shaped curve expected in a normally distributed dataset. The Q-Q plots further confirm normality by comparing the distribution of residuals to a theoretical normal distribution.

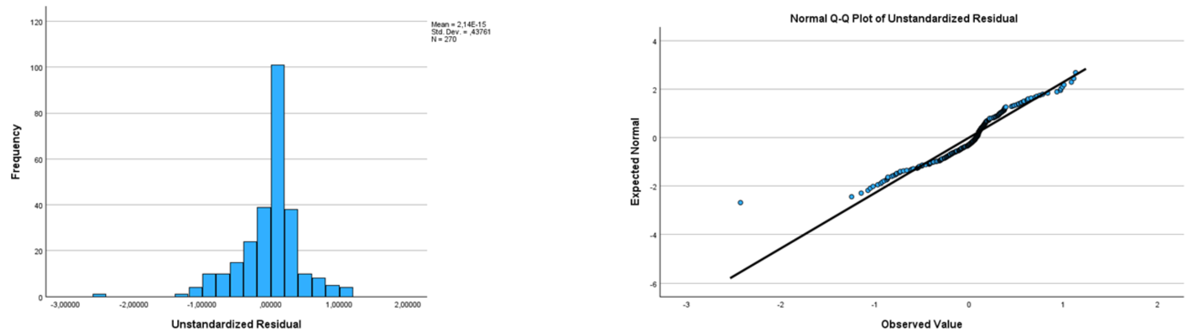


(a)



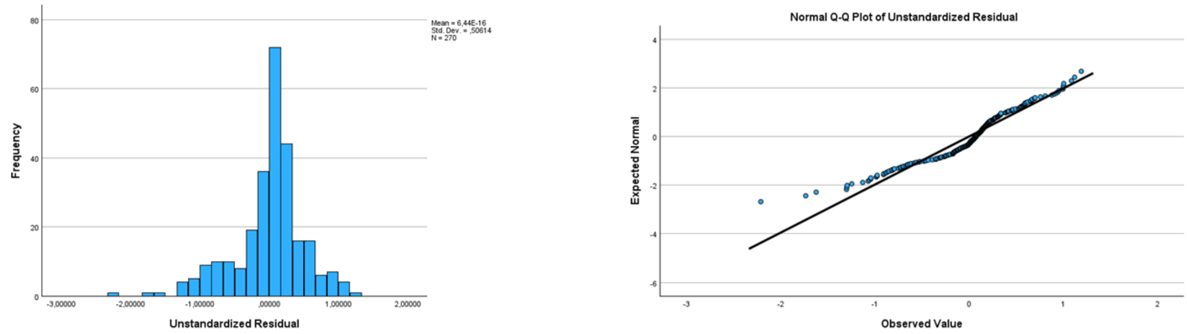
(b)

Figure D.1: Histogram of unstandardized residuals and Q-Q plot of unstandardized residuals of scenario 1. The histogram shows the distribution of residuals, which appears approximately normal. The Q-Q plot visually assesses normality, with most points following the diagonal line, indicating that the assumption of normally distributed residuals is largely met.



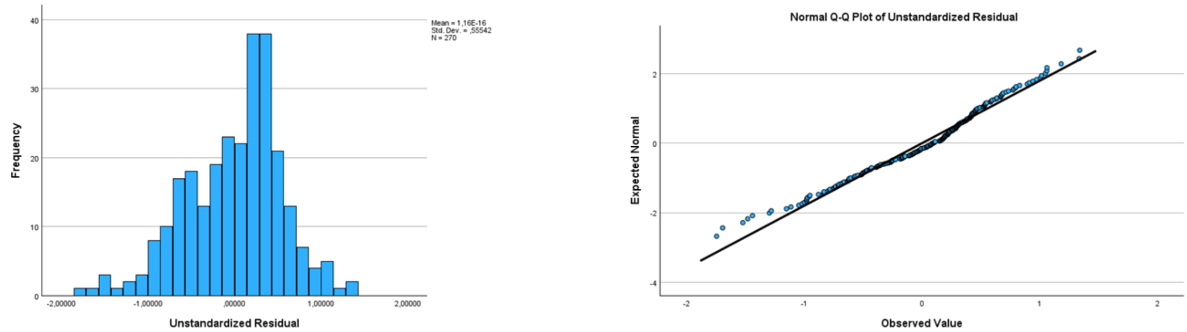
(a) (b)

Figure D.2: Histogram of unstandardized residuals and Q-Q plot of unstandardized residuals of scenario 2. The histogram shows the distribution of residuals, which appears approximately normal. The Q-Q plot visually assesses normality, with most points following the diagonal line, indicating that the assumption of normally distributed residuals is largely met.



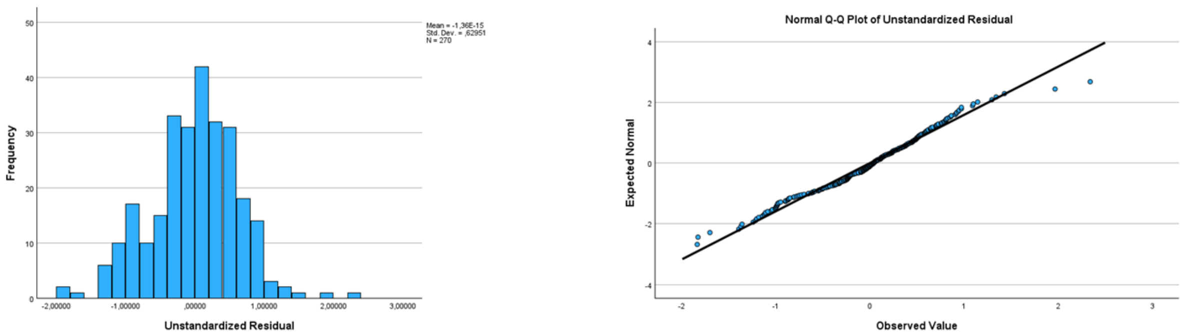
(a) (b)

Figure D.3: Histogram of unstandardized residuals and Q-Q plot of unstandardized residuals of scenario 3. The histogram shows the distribution of residuals, which appears approximately normal. The Q-Q plot visually assesses normality, with most points following the diagonal line, indicating that the assumption of normally distributed residuals is largely met.



(a) (b)

Figure D.4: Histogram of unstandardized residuals and Q-Q plot of unstandardized residuals of scenario 4. The histogram shows the distribution of residuals, which appears approximately normal. The Q-Q plot visually assesses normality, with most points following the diagonal line, indicating that the assumption of normally distributed residuals is largely met.



(a) **(b)**

Figure D.5: Histogram of unstandardized residuals and Q-Q plot of unstandardized residuals of scenario 5. The histogram shows the distribution of residuals, which appears approximately normal. The Q-Q plot visually assesses normality, with most points following the diagonal line, indicating that the assumption of normally distributed residuals is largely met.

E

Regression Assumptions: Linearity and Homoscedasticity

The following scatterplots are used to assess both linearity and homoscedasticity. Linearity is evaluated by checking if the residuals are randomly scattered around the horizontal axis, while homoscedasticity is assessed by ensuring the spread of residuals remains constant across all levels of predicted values, with no distinct patterns or trends.

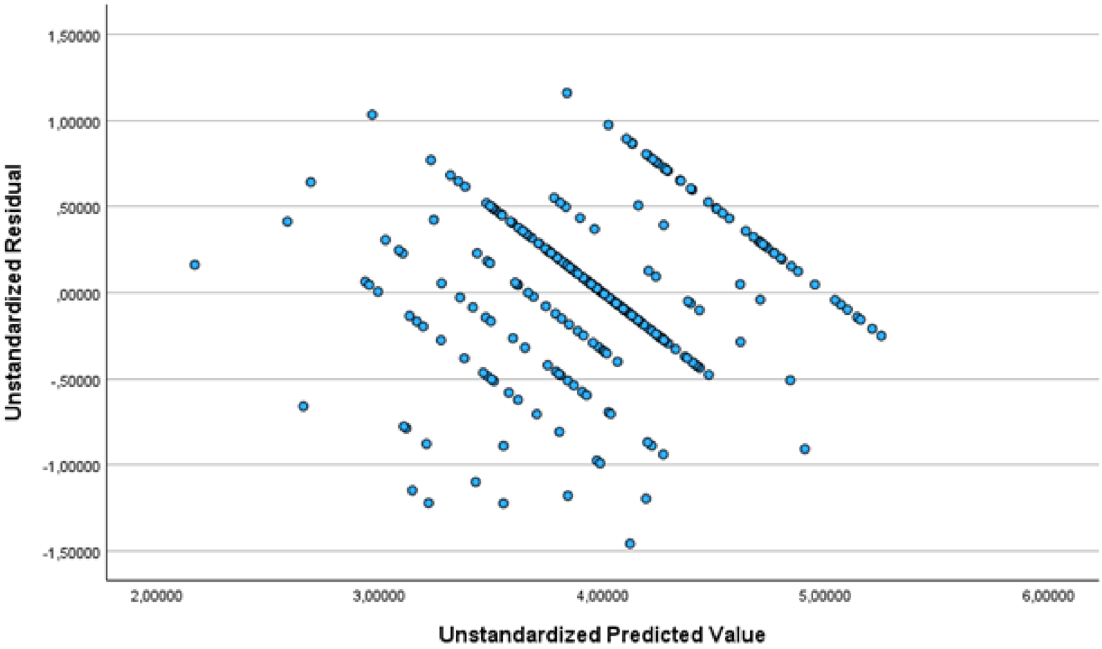


Figure E.1: Scatterplots of unstandardised residuals versus unstandardised predicted values for scenario 1. The residuals are randomly scattered around the horizontal (y=0) axis. The spread of residuals remains constant accross all predicted values.

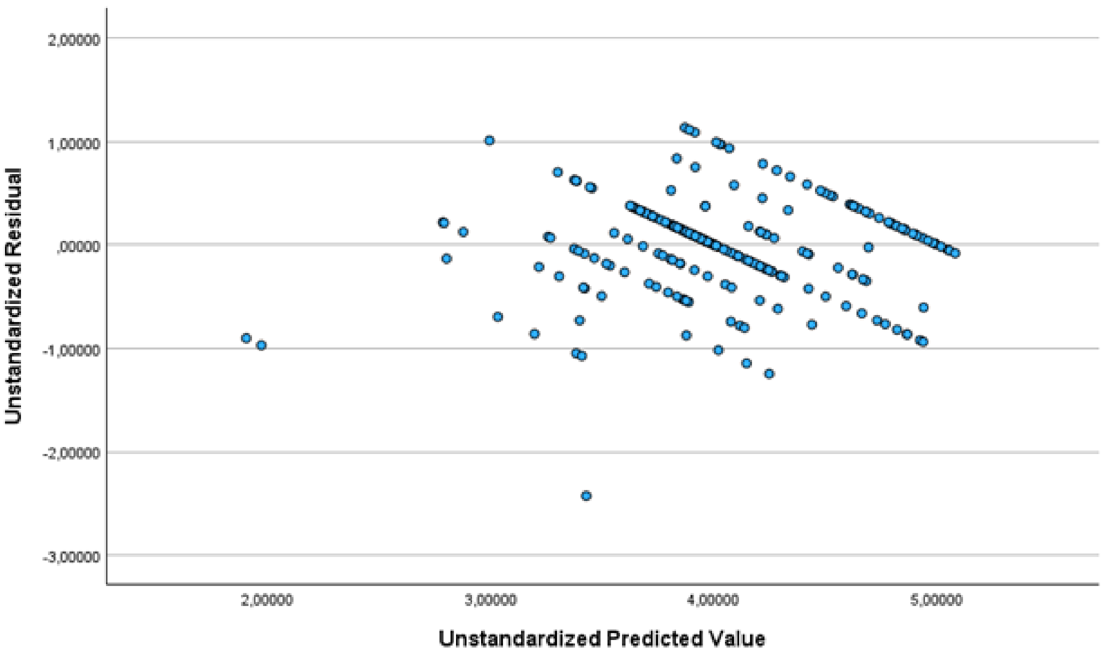


Figure E.2: Scatterplots of unstandardised residuals versus unstandardised predicted values for scenario 2. The residuals are randomly scattered around the horizontal (y=0) axis. The spread of residuals remains constant accross all predicted values.

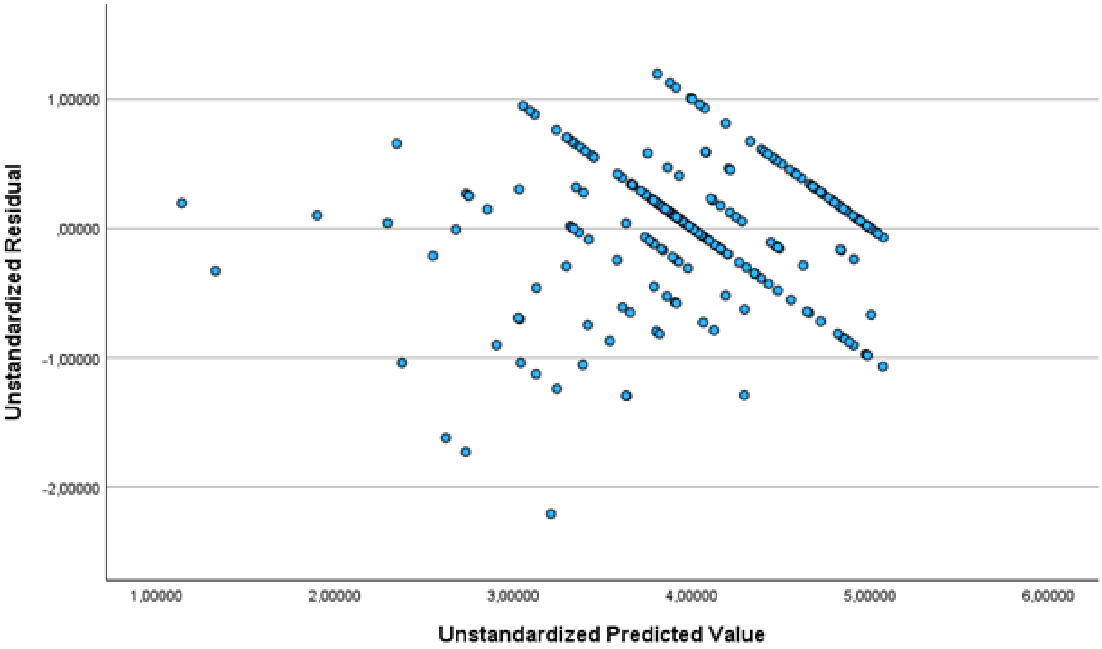


Figure E.3: Scatterplots of unstandardised residuals versus unstandardised predicted values for scenario 3. The residuals are randomly scattered around the horizontal (y=0) axis. The spread of residuals remains constant accross all predicted values.

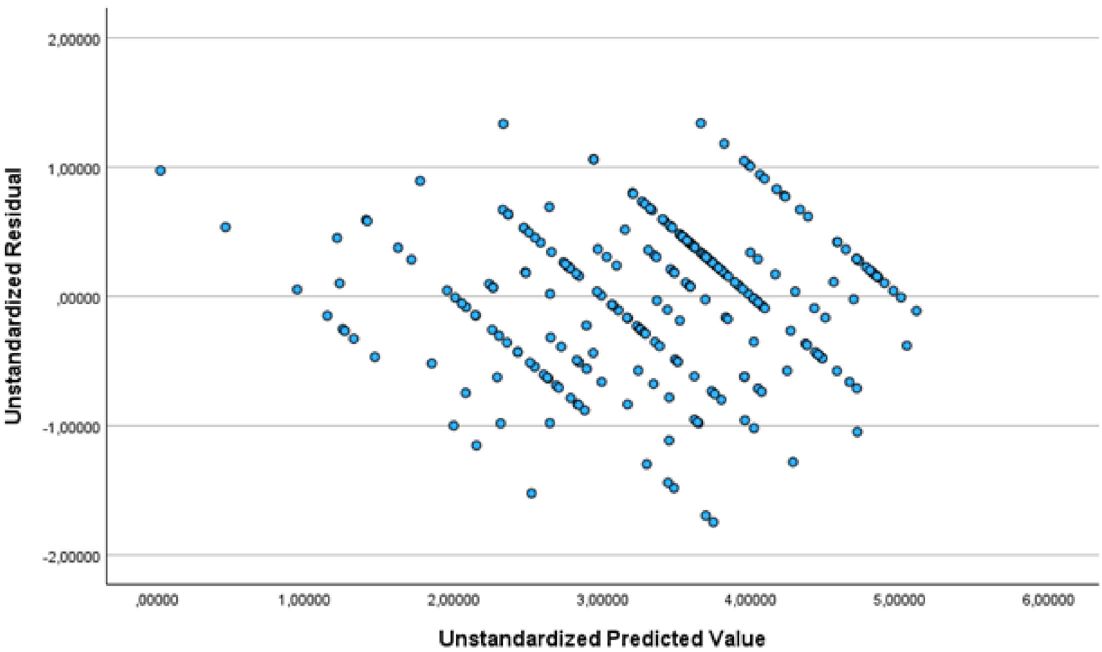


Figure E.4: Scatterplots of unstandardised residuals versus unstandardised predicted values for scenario 4. The residuals are randomly scattered around the horizontal (y=0) axis. The spread of residuals remains constant accross all predicted values.

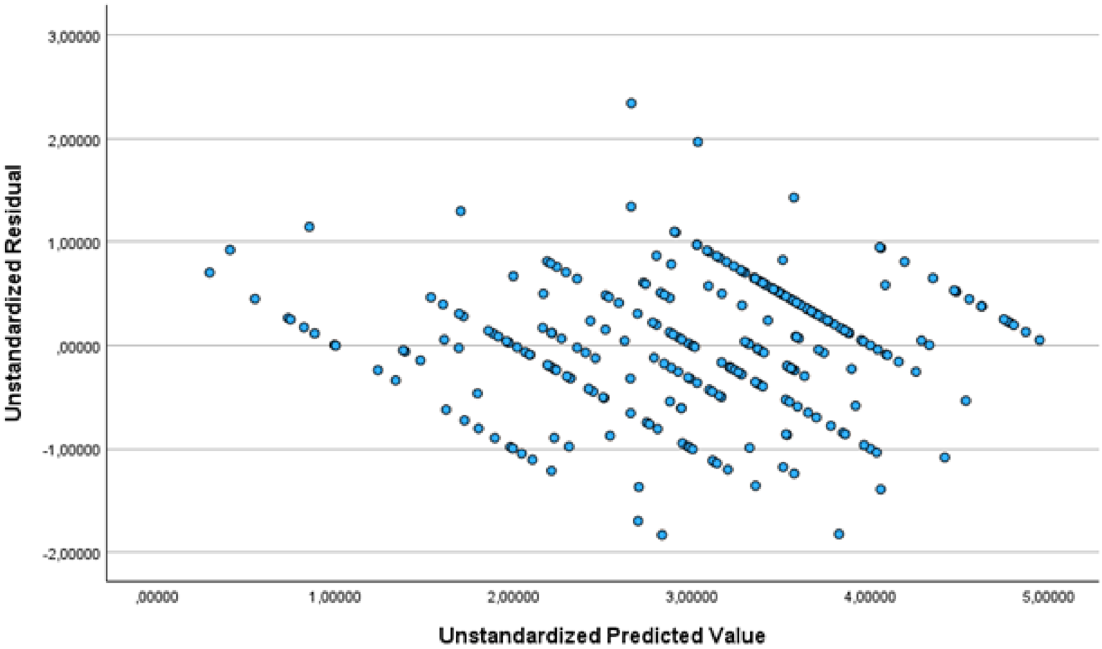


Figure E.5: Scatterplots of unstandardised residuals versus unstandardised predicted values for scenario 5. The residuals are randomly scattered around the horizontal (y=0) axis. The spread of residuals remains constant accross all predicted values.

F

ANOVA Post-Hoc analysis

Table F.1: Comparisons of Perceived Usefulness Across all Scenarios

Comparison	Mean difference	SE	Sig.	95% CI Lower bound	95% CI Upper bound
S1 vs. S2	-0.311	0.034	<0.001	-0.407	-0.214
S1 vs. S3	-0.318	0.039	<0.001	-0.428	-0.208
S1 vs. S4	-0.030	0.038	1.000	-0.136	0.076
S1 vs. S5	0.100	0.40	0.125	-0.012	0.212
S2 vs. S3	-0.007	0.027	1.000	-0.082	0.068
S2 vs. S4	0.281	0.031	<0.001	0.195	0.367
S2 vs. S5	0.411	0.033	<0.001	0.319	0.503
S3 vs. S4	0.288	0.032	<0.001	0.198	0.379
S3 vs. S5	0.418	0.034	<0.001	0.321	0.515
S4 vs. S5	0.130	0.031	<0.001	0.042	0.218

N = 305, SE = Standard Error, CI = Confidence Interval

Table F.2: Comparisons of Perceived Complexity Across all Scenarios

Comparison	Mean difference	SE	Sig.	95% CI	
				Lower bound	Upper bound
S1 vs. S2	0.058	0.039	1.000	-0.051	0.167
S1 vs. S3	0.048	0.04	1.000	-0.066	0.162
S1 vs. S4	0.028	0.045	1.000	-0.099	0.155
S1 vs. S5	-0.125	0.044	0.051	-0.250	0.000
S2 vs. S3	-0.010	0.031	1.000	-0.097	0.077
S2 vs. S4	-0.030	0.037	1.000	-0.135	0.075
S2 vs. S5	-0.183	0.037	<0.001	-0.288	-0.078
S3 vs. S4	-0.020	0.039	1.000	-0.130	0.090
S3 vs. S5	-0.173	0.039	<0.001	-0.282	0.064
S4 vs. S5	-0.153	0.038	<0.001	-0.261	-0.045

N = 305, SE = Standard Error, CI = Confidence Interval

Table F.3: Comparisons of Trust Across all Scenarios

Comparison	Mean difference	SE	Sig.	95% CI Lower bound	95% CI Upper bound
S1 vs. S2	-0.175	0.035	<0.001	-0.270	-0.079
S1 vs. S3	-0.157	0.041	0.002	-0.273	-0.040
S1 vs. S4	0.214	0.048	<0.001	0.078	0.351
S1 vs. S5	0.441	0.048	<0.001	0.305	0.577
S2 vs. S3	0.018	0.031	1.000	-0.071	0.107
S2 vs. S4	0.389	0.041	<0.001	0.273	0.505
S2 vs. S5	0.616	0.044	<0.001	0.491	0.741
S3 vs. S4	0.371	0.044	<0.001	0.248	0.494
S3 vs. S5	0.598	0.046	<0.001	0.466	0.729
S4 vs. S5	0.227	0.047	<0.001	0.094	0.360

N = 305, SE = Standard Error, CI = Confidence Interval

Table F.4: Comparisons of Willingness to consent Across all Scenarios

Comparison	Mean difference	SE	Sig.	95% CI	
				Lower bound	Upper bound
S1 vs. S2	-0.066	0.043	1.000	-0.187	0.055
S1 vs. S3	-0.034	0.056	1.000	-0.192	0.125
S1 vs. S4	0.567	0.68	<0.001	0.374	0.760
S1 vs. S5	0.916	0.065	<0.001	0.732	1.100
S2 vs. S3	0.032	0.042	1.000	-0.087	0.152
S2 vs. S4	0.633	0.056	<0.001	0.474	0.793
S2 vs. S5	0.982	0.057	<0.001	0.822	1.142
S3 vs. S4	0.601	0.0663	<0.001	0.424	0.778
S3 vs. S5	0.950	0.067	<0.001	0.760	1.139
S4 vs. S5	0.349	0.063	<0.001	0.171	0.525

N = 305, SE = Standard Error, CI = Confidence Interval

G

Qualitative Analysis: Coding Scheme

Perceptions of Technician Involvement

- **Essential for procedure:** Respondent believes the technician plays a crucial role in ensuring the surgery runs smoothly. Example answers: *"I find it important that a technician is present.", "I think it is good if, in addition to the surgeon, a technician is present to oversee the technical aspects of robotic surgery. This allows the surgeon to fully focus on performing the surgery and preventing operative complications.", "Robots are more accurate and rarely go wrong, but IF something does go wrong, human supervision is needed to prevent worse outcomes.", "Necessary, because there must be someone present during the surgery who has full knowledge of the technology.", "Technology has its flaws and should be under supervision in these circumstances."*
- **Supportive but Non-Essential:** Respondent sees the technician as helpful but not strictly necessary. Example answers: *"Would be nice to have someone, but not essential.", "A technician should be on standby anyway. They don't necessarily need to be present in the operating room.", "Having the ability to call a technician if needed would be nice, but having them in the room seems a bit excessive.", "Maybe there should be a technician on standby in the hospital for emergencies, but not necessarily present in the operating room."*
- **Concerns About Role:** Respondent expresses doubts or concerns about the technician's role in surgery. Example answers: *"A technician being present would make me doubt whether the robot is truly safe. It would give me more confidence if their presence was not necessary.", "Although at the same time, a technician being present might suggest that the technology is error-prone.", "I cannot imagine that a technician would make a meaningful contribution.", "If the robot needs troubleshooting during surgery, it might not be safe enough to use in the first place.", "It is deeply worrying that a technician is needed—it shows the immaturity of the technology."*
- **Trust in Technician's Expertise:** Respondent states confidence in the technician's abilities and knowledge or an increase in comfort or trust when technician is present. Example answers: *"I think it's good, and I actually believe that it might increase confidence if an "expert" is observing.", "I would find it comforting and feel a greater sense of reliability if a technician were present to resolve potential issues with the robotics.", "An additional safety measure."*
- **Prefers Surgeon Control:** Respondent prefers the surgeon to have sole responsibility rather than relying on a technician. Example answers: *"Not necessary if the surgeon is trained in using the robot.", "I have nothing with robots and want the surgeon to operate.'", "The surgeon should be able to operate the equipment without technical assistance.", "I personally would rather not have a robot cutting into me."*
- **Indifference to Technician's Presence:** Respondent states that the technician's involvement does not matter to them.

Views on Informed Consent and Disclosure

- **Full Disclosure Required:** Respondent believes all team members involved, including the technician, should be disclosed in the consent process. Example answers: *"It should be mandatory to inform the patient", "But I do think that a patient has the right to know the roles of every person involved in the surgery. So they should be informed of their involvement, purely from a privacy/autonomy perspective.", "There should be complete transparency between medical staff and the patient."*
- **Limited Disclosure Acceptable:** Respondent thinks only key roles (e.g., surgeon, robotic system) need to be disclosed. Example answers: *"No obligation, but an explanation would be appreciated.", "Involvement is good, but I don't think it is necessary to require explicit consent. It would be useful to include this in general information and to clarify that the technician is trustworthy.", "Patients should be informed about the robot, but not necessarily about the technician.", "I think that if a technician is part of the procedure, it is good to mention it, but it should not be mandatory."*
- **No Need for Disclosure:** Respondent sees the technician's role as purely technical and not necessary to mention. Example answers: *"Patients do not need to be informed. They are often unaware of the presence of assistants and students in the operating room.", "No, as long as the technician is part of the team and bound by the same confidentiality obligations.", "It's not necessary for the patient to know.", "Everyone in the operating room is bound by confidentiality."*
- **Concern About Overloading Patients with Information:** Respondent worries that too much information might overwhelm patients. Example answers: *"It might be intimidating.", "People are already occupied enough with the surgery itself."*

Reasoning Behind Disclosure Preference

- **Patient Right to Know:** Respondent argues that patients should be fully informed about everyone involved in their care. Example answers: *"Patients always need to know who is present and has which responsibility in the procedure.", "Yes. Transparency is, as far as I'm concerned, vital in a situation where it concerns a patient's health.", "I cannot imagine how a patient can give consent if not fully informed.", "I do think that a patient has the right to know the roles of every person that will be involved in the surgery."*
- **Impact on Trust:** Respondent believes transparency increases trust in the medical team and procedure. Example answers: *"I think it is good to inform patients about this, as it will likely increase trust in robotic surgery. People are often hesitant because there is a lack of knowledge.", "I believe that mentioning the presence of a technician helps; patients would be more likely to give consent.", "It could help build trust.", "Can influence the perception of safety."*
- **Relevance to Surgical Outcome:** Respondent sees disclosure of technician involvement as relevant if it directly affects patient safety or outcomes. Example answers: *"Yes, because the technician's advice could potentially influence the surgeon's decisions. In that way, the technician also affects how the surgery proceeds. Since this impacts the outcome, I believe the patient should be informed.", "This is because it concerns an adjustment to their body.", "Technician has influence on the operation.", "Yes, it is important that the patient is as well-informed and complete as possible about the procedure and the risks."*
- **Legal and Ethical Considerations:** Respondent highlights the importance of ethical and legal obligations in informed consent. Example answers: *"I think they should be informed of their involvement, purely on a privacy/autonomy level.", "Information and guarantees regarding privacy.", "In case of a mishap, there will be litigation.", "It would be ethical to explain the involvement of the additional team member."*