EVALUATING ADOPTION FACTORS FOR ROBOTIC-ASSISTED SURGERY WITH THE ANALYTICAL HIERARCHICAL PROCESS

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ABSTRACT

EVALUATING ADOPTION FACTORS FOR ROBOTIC-ASSISTED SURGERY WITH THE ANALYTICAL HIERARCHICAL PROCESS

The objective of this master's dissertation is to evaluate adoption factors for robotic-assisted surgery (RAS) using the Analytical Hierarchy Process (AHP) as its evaluation methodology. Robotic-assisted surgery is used in various surgical fields. It is mainly used as a tool in numerous disciplines' minimally invasive surgery procedures (MIS). Since it has so many different application areas and actors, the determination of its adoption factors and evaluation process of these factors' priorities for surgeons is a highly complex issue that includes multicriteria of decision-making and numerous surgeons. A comprehensive list of these possible adoption factors recognized by conducting an extensive literature review, was picked and chosen. First, we had 310 factors mentioned in the literature that have a potential impact on the adoption process of the RAS. We have reduced these to 20 factors that are categorized under five different main criteria. By this, a unique AHP tree that is this thesis' contribution to the literature was developed. The research data was collected by an online survey from the surgeons of various disciplines working in Türkiye. Our final sample to evaluate priorities consisted of forty-one surgeon responses in total. The evaluation process consists of three steps: analyzing individual-based pairwise comparison matrices, their consistency rations, and their priority vectors. We executed the same workflow for the aggregated analysis for disciplined-based and all aggregation. Results are examined in detail and concluded with insightful interpretations.

Keywords: Robotic-Assisted Surgery, Adoption Factors, Analytical Hierarchy Process

ÖZET

ROBOTİK DESTEKLİ CERRAHİ ADAPTASYON FAKTÖRLERİNİN ANALİTİK HİYERARŞİK SÜREÇ İLE DEĞERLENDİRİLMESİ

Bu yüksek lisans tezinin amacı, robotik yardımlı cerrahinin (RAS) adaptasyon faktörlerini değerlendirme metodolojisi olarak Analitik Hiyerarşi Sürecini (AHP) kullanarak değerlendirmektir. Robotik yardımlı cerrahi çeşitli cerrahi alanlarında uygulanmaktadır. Esas olarak birçok disiplinin minimal invaziv cerrahi prosedürlerinde (MIS) bir araç olarak kullanılmaktadır. Çok farklı uygulama alanı ve aktörleri olduğundan adaptasyon faktörlerinin belirlenmesi ve bu faktörlerin cerrahlar için önceliklerinin değerlendirilmesi süreci, çok sayıda karar verme kriterini ve çok sayıda cerrahı içeren oldukça karmaşık bir konudur. Kapsamlı bir literatür taraması yapılarak kabul edilen bu olası adaptasyon faktörleri, titizlikle seçilerek kapsamlı bir listesi çıkarılmıştır. İlk listede, literatürde bahsedilen ve RAS'ın adaptasyon süreci üzerinde potansiyel etkisi olan 310 faktör bulunmaktaydı. Biz bunları 5 farklı ana kriter altında kategorize edilen 20 faktöre düşürdük. Bu şekilde, bu tezin literature katkısı olan özgün bir AHP ağacı geliştirildi. Araştırma verileri, Türkiye'de çalışan çeşitli disiplinlerdeki cerrahlardan çevrimiçi anket yoluyla toplandı. Değerlendirmeye uygun veriler toplamda kırk bir tanedir. Değerlendirme süreci; birey bazlı ikili karşılaştırma matrislerinin, bunların öncelik vektörlerinin ve tutarlılık oranlarının sonuçlarının analiz edilmesi, disiplin bazlı toplu değerlendirilmesi ve tüm cerrahların sonuçlarını içeren toplu analizin yapılmasını içeren üç adımdan oluşur. Sonuçlar detaylı bir şekilde incelenerek ufuk açıcı yorumlarla çalışma sonlandırılmıştır.

Anahtar Kelimeler: Robotic Yardımlı Cerrahi, Adaptasyon Faktörleri, Analitik Hiyerarşi Süreci

TABLE OF CONTENTS

LIST OF FIGURES

Figure **Page**

LIST OF TABLES

Table **Page**

LIST OF ABBREVIATIONS

RAS	Robotic-Assisted Surgery
AHP	Analytical Hierarchy Process
EJQ	Expert Judgement Quantification
MIS	Minimally Invasive Surgery
LOS	Length of Stay
RAP	Robotic-Assisted Pyeloplasty
ICR	Intraoperative Complication Rates
PCR	Postoperative Complication Rates
RDL	Risks During Learning
MLT	Multitasking
TA	Tremor Abolition
MS	Motion Scaling
EV	Enhanced Visualization
SI_ICR	Smaller Incisions for Intraoperative Complication Rates
T/HF_ICR	Tactile/Haptic Feedback for Intraoperative Complication Rates
SED_ICR	Surgeon Ergonomics and Dexterity for Intraoperative Complication Rates
SI_PCR	Smaller Incisions for Postoperative Complication Rates
T/HF_PCR	Tactile/Haptic Feedback for Postoperative Complication Rates
SED_PCR	Surgeon Ergonomics and Dexterity for Postoperative Complication Rates
SI_PW	Smaller Incisions for Patient Welfare
SHS	Shorter Hospital Stays
OD_PW	Operation Duration for Patient Welfare
T/HF_EOU	Tactile/Haptic Feedback for Ease of Use
OD_EOU	Operation Duration for Ease of Use
SED_EOU	Surgeon Ergonomics and Dexterity for Ease of Use
EOI	Ease of Installation
TR	Training Requirements
ANP	Attract New Patients

ABS	Attract Better Surgeons
PC	Purchase Costs
OMC	Operational and Maintenance Costs
ECON	Economics
EIA	Ease of Initial Adaption
EOU	Ease of Use
PW	Patient Welfare
OSS	Operation Safety and Success

CHAPTER 1

INTRODUCTION

Understanding technological improvements' adoption process dynamics may contribute to developing a broader and deeper perspective regarding the impacts of these factors on the adoption process. Acquiring this look prevents people who work on developing new technologies from wasting their time. Industrial institutions, both public and private based, high technology institutes, universities, and research and development centers may also benefit from it. To see that the field's strategic importance may help stay in line during the research time.

Robots are becoming more popular daily in many fields of human life. Since they are designed using high technology, the decision mechanisms of people while deciding to adopt these technological products are a very significant issue.

This study focuses on robotic-assisted surgery adoption by surgeons working in different disciplines. A comprehensive literature review was conducted to determine all the relevant factors. At the beginning of the study, 310 factors were mentioned in various studies listed. In a sequence of brainstorming sessions, as suggested by Saaty (Saaty 1980), to eliminate the factors, we eliminated many of them. Then, we decided to keep 20 factors and to make a particular taxonomy including all these factors under the 5 main criteria, 12 sub-criteria and 8 factors in the context of this study.

Executing all these processes is to prepare a convenient infrastructure to find a solution for our research objective. It entails a research question, which consists of three steps.

1. What factors led to the adoption of robotic-assisted surgery (henceforth RAS) technology among surgeons from different disciplines?
2. What is the proper mechanism for evaluating these factors?
3. How can we prioritize these factors to understand their importance from surgeons' perspectives from different disciplines?

In numerous studies, several methods are proposed to analyze adoption factors. In this study, we use the Analytical Hierarchy Process (AHP) developed by Saaty (Saaty 1980). The Analytical Hierarchical Process (AHP) (Saaty 1980, 2013; Saaty and

Varga 2012; Brunelli 2015) is a powerful decision-making tool designed to aid complex decision-making problems, typically involving multiple conflicting criteria and potentially many actors involved in the process. The method aids decision-making at the individual level as well as in group decision-making problems by allowing meaningful aggregates of individual priorities into group preferences. AHP is hence a powerful tool to obtain decision priorities for individual agents as well as for Expert Judgement Quantification (henceforth EJQ), i.e., aggregating the priorities of several experts in a field of practice. A key observation about human decisions and prioritization is that humans typically have difficulty evaluating multiple decision factors at once, but they make much better decisions when decision factors are presented to them in pairs (Saaty 2013). AHP obtains pairwise comparisons of factors along a branch of the decision tree on a scale of preference strength between 1-9, then aggregates them into overall priority weights using standard matrix operations. Aggregating the preferences of multiple actors during deciding is also possible. This methodology is deemed appropriate to answer all our research questions. The data collection process was conducted via an online survey. The ahpsurvey package developed by Frankiecho (Frankiecho 2018) in compliance with Saaty's AHP methodology, was run on R Studio to analyze the data gathered by the survey.

Results are examined in the context of individual-based pairwise comparisons' priority vectors and their consistency ratios, specialty-based aggregations of pairwise comparisons' priority vectors, and the aggregation of all pairwise comparisons' priority vectors. These results are all presented in Chapter 3. Then, the last part is the conclusion, which includes all analyses' interpretations and proposals for future studies.

This study is structured in four separate sections. This section gives brief general information regarding all the research. The following chapter includes a comprehensive literature review that constructs this study's backbone. The third chapter comprises the materials and methodology used during the research. The fourth and last chapter is the conclusion of part of the study, which entails some suggestions for further research.

CHAPTER 2

LITERATURE REVIEW

2.1. Historical Development of Robotic-Assisted Surgery

The usage of robots in medicine is relatively new, having only been around for almost 40 years, even though the idea of building a mechanical robot that could reproduce oneself has been around for 3000 years in human imagination (Ghezzi and Corleta 2016). Robotic-assisted surgery (RAS) has emerged as a significant advancement in medical technology, revolutionizing how surgical procedures are performed. A wish to generate an infrastructure to make teleoperations possible is the main reason for building robotic-assisted surgery devices.

NASA first declared the context in the late 1960s (Bogue 2021; Corliss and Johnsen 1968). In that study, NASA stated what remote robotic surgery is and emphasized the expectation of receiving the touch of sense information even in teleoperation (Bogue 2021; Corliss and Johnsen 1968). At the beginning of the 1970s, numerous studies developed the concept of robotic-assisted surgery to contribute to space studies by providing operational services to astronauts in case they needed them (Alexander 1972; Bogue 2021).

According to Ghezzi and Corleta (Ghezzi and Corleta 2016), the primary motivation for this achievement is telepresence and repetitive and accurate tasks. In compliance with that, Lendvay et al. (Lendvay et al. 2013) state that two main reasons for this development are enhancing surgeons' operation performing dexterity and capability of executing telesurgery.

An illustration of a robotic-assisted surgery device suggested by NASA, in the beginning of the 1970s, and now, several decades later the developed products are the reflection of this drawing (Bogue 2021). Starting in the 1980s, the first applications of robotic-assisted surgery came true (Bogue 2021). In the 1990s, robotic-assisted surgery platforms specialized in performing a particular operation began to be produced and continue (Bogue 2021).

Some robots were developed to achieve these goals. The PUMA 200 was the first robot used in surgery, followed by the development of the 'master-slave' system in the 1990s (Ghezzi and Corleta 2016). NASA's Ames Research Center researchers initiated studies to react to previous President George H. W. Bush's announcement to send humans to Mars (Ghezzi and Corleta 2016). These projects addressed the requirement of performing surgeries on astronauts during long-distance missions (Ghezzi and Corleta 2016).

RAS offers numerous techniques to allow better outcomes compared with other procedures. Some parts are 3D vision, which provides surgeons with a more detailed and immersive view of the surgical field, stable and magnified images that enhance visualization, EndoWrist instruments that mimic human hand movements, physiologic tremor filtering to minimize hand tremors, and motion scaling to improve surgical precision (Ghezzi and Corleta 2016).

The main drawbacks of RAS are higher costs (Bogue 2021; Esen et al. 2018; Fanfani et al. 2015; Ghezzi and Corleta 2016 and Lendvay et al. 2013) and lack of haptic feedback (BenMessaoud et al. 2011; Bogue 2021; Ghezzi and Corleta 2016; Mohammadzadeh and Safdari 2014; Lendvay et al. 2013 and Williams et al. 2014).

In the near future of RAS, a cost decrease, integration of new technologies, and structured training programs are expected to improve the operation quality (Ghezzi and Corleta 2016). Any development in robotic-assisted surgery technology is a promising thing to enhance surgeons' dexterity and ergonomics, and increase the quality of procedures.

2.2. Robotic Assisted Surgery Adoption

The robotic-assisted surgery device market is still a growing one and very dynamic. The products are primarily used in minimally invasive surgery (MIS). The adoption of robotic-assisted surgery has been the focus of numerous studies on various aspects of this technique. Robotic-assisted surgery platforms' technology is quite advanced and inspiring, even if it still has some limitations.

Below, we introduce this literature by organizing studies based on the adoption factors they focus on. The literature for each factor is deeply examined. The factors recognized significantly impacting the adoption of robotic-assisted surgery platforms are selected for our research. These contain all factors that have an essential effect on every phase of acquiring robotic-assisted surgery technology.

2.2.1. Ease of Installation

RAS adoption and implementation are popular topics in medical care services studies. Numerous papers discovered the diverse parameters affecting the adoption of RAS technology as part of installing quickly by making the equipment ready to use in a short while. The vital process of RAS includes installing quickly, making equipment ready to use in a short duration, and the RAS platform extent impressing in adopting RAS. Understanding the drawbacks and difficulties associated with installation may address a plan to adopt and utilize RAS in surgical procedures.

One of the limitations of RAS explored is longer operative time because setting up the RAS platform needs more time than laparoscopic surgeries (BenMessaoud et al. 2011). In compliance with this statement, the RAS platform's physical extent negatively affects its adoption process (BenMessaoud et al. 2011). Taking extended time to install the RAS platform is highlighted as a barrier to its adoption by surgeons and operating room staff (Diana and Marescaux 2015; Vichitkraivin et al. 2020). According to the paper by Abdollah et al. (Abdollah et al. 2017), nursing staff must prepare the RAS platform by ensuring that the patients are not in danger during the operation. Installing quickly regarding setup duration and bulkiness of RAS are vital limitations while performing RAS procedures.

Reducing the installation time and easing the process contribute to RAS adoption. Some answers may involve exploring technological advancements in robotic platforms that are more compact and easier to install. The issue gains a facilitator role in adopting robotic-assisted surgery by designing training programs to provide healthcare professionals with the necessary skills to set up and operate robotic systems efficiently.

2.2.2. Training Requirements

Diana and Marescaux (Diana and Marescaux 2015) highlight the necessity of extensive and ongoing training in minimally invasive surgery due to its demanding features related to images and haptic sensations. Lenihan (Lenihan 2017) emphasizes that handling training requirements is necessary to provide patients with a safe robotic-assisted operation. Additionally, they noted that the training requirements are the barriers in front of to ease the adoption of RAS (BenMessaoud et al. 2011; Krishnan et al. 2018; Vichitkraivin et al. 2020). Langhan et al. (Langhan et al. 2014) and Mandapathil and Meyer (Mandapathil and Meyer 2021) noted that when adequate training is provided to surgeons and operating room staff, this factor facilitates the adoption of robotic-assisted surgery technology. Abdollah et al. (Abdollah et al. 2017), Lendvay et al. (Lendvay et al. 2013), and Lenihan (Lenihan 2017) stated that a surgeon and operation room staff must pass the learning curve to fulfill the training requirements for a robotic-assisted surgery platform competently to make the patient sure about their safety. Resulting in operations with decreased readmission rates, less blood loss, shorter hospitalization time, fewer postoperative complications, reduced operating times, lower cost, and better cancer management is associated with the physicians' competency (Abdollah et al. 2017; Lendvay et al. 2013; Ploussard et al. 2010; Thompson et al. 2014). Prioritizing a structured training program is vital to accomplish this knowledge and skill level. In compliance with that, some studies highlight the significance of establishing a program to teach surgeons using RAS (Abdollah et al. 2017; Aradaib et al. 2018; Lenihan 2017; Moriarty et al. 2016). Considering patients' safety in the period of the surgeons' learning process of RAS, Abdollah et al. (Abdollah et al. 2017) and Lenihan (Lenihan 2017) stress the necessity of creating a well-organized learning journey. Optimizing the benefits of RAS and achieving improved outcomes depend on developing well-structured training programs for physicians and operating room staff.

2.2.3. Surgeon Ergonomics and Dexterity

Robotic-assisted surgery platforms allow surgeons to enhance their dexterity via improved features (Fanfani et al. 2015) and provide better ergonomic conditions during the operation. Some papers refer to the advantages of this technology (Ghezzi and Corleta 2016; Pernar et al. 2017). It offers ergonomic benefits for surgeons and expands the possibilities of minimally invasive procedures.

The features that enable surgeons to achieve enhanced ergonomics and dexterity, such as tremor abolition, motion scaling, high-quality 3D vision, zoom-in/out technology, better suturing, and remote-control unit/console, which gives the surgeons to perform operations while sitting down, reusable instruments, the capability of doing different things simultaneously, are summarized in the literature. (BenMessaoud et al. 2011; Diana and Marescaux 2015; Fanfani et al. 2015; Jacobs et al. 2013; Lee et al. 2010; Mohammadzadeh and Safdari 2014; Nasser et al. 2020; Sialulys et al. 2021; Stewart et al. 2018 and Williams et al. 2014).

In this study, we grouped the robotic devices' features into four categories: multitasking, tremor abolition, motion scaling, and enhanced visualization, which are not found in the literature in this way. The reason behind this grouping is to clearly explain the features that impact the adoption of RAS by improving the surgeons' dexterity and ergonomics.

2.2.4. Tactile/Haptic Feedback

Robotic-assisted surgery (RAS) provides various better features compared to traditional laparoscopic surgery; however, its lack of haptic feedback curbs putting RAS into effect worldwide (Ghezzi and Corleta 2016). In some studies, by BenMessaoud et al. (BenMessaoud et al. 2011), Bogue (Bogue 2021), Ghezzi and Corleta (Ghezzi and Corleta 2016), Mohammadzadeh and Safdari (Mohammadzadeh and Safdari 2014), and Williams et al. (Williams et al. 2014), it has been identified that one of the main drawbacks to RAS adoption is the lack of tactile and haptic information, especially for Lendvay et al. (Lendvay et al. 2013) emphasizes that the da Vinci's current technology suffers from the absence of haptic/tactile or force feedback. Having no tactile and haptic input in RAS makes it difficult for surgeons to sense the force being applied to tissues while performing the surgery, which could unintentionally lead to complications (Lendvay et al. 2013). This limitation hampers the surgeons' ability to perceive the force applied to tissues and may lead to unintended tissue damage or ischemia (Lendvay et al. 2013).

By incorporating sensory technologies that can visualize the sense of touch and force feedback, surgeons can have a more comprehensive understanding of tissue characteristics and make more informed decisions during the surgical procedure (Lendvay et al. 2013). Even though the current robotic technology has sensors to capture the forces data applied during the operation to reach this information, it is possible only with a legal arrangement for research intentions regarding intellectual concerns (Lendvay et al. 2013). The development process continues to overcome this limitation, and the first haptic feedback feature design is undergoing clinical trials in some robotic platforms such as The Surgeon's Operating Force-feedback Interface Eindhoven (Sofie) (Lendvay et al. 2013).

2.2.5. Operation Duration

According to the literature, operation duration regarding RAS needs to be handled in two parts: before the learning curve passes and after the learning curve passes. Regarding increased experience and higher surgical volumes, Abdollah et al. (Abdollah et al. 2017), Kim et al. (Kim et al. 2009), and Lim et al. (Lim et al. 2011) reported that RAS results in shorter operation times. Aradaib et al. (Aradaib et al. 2018) state that the RAS operation duration is longer than the open surgery when the surgeon is in his/her beginning of the learning curve. Esen et al. (Esen et al. 2018) noted that prolonged operative time is one of the most significant drawbacks of RAS. BenMessaoud et al. (BenMessaoud et al. 2011) state that a longer operation duration is one of the disadvantages of RAS regarding the more installation time of the robotic platform. Nasser et al. (Nasser et al. 2020) demonstrated that RAS has a longer operation duration than laparoscopic approaches in super-obese patients. The result of a meta-analysis study by Sheth et al. (Sheth et al. 2018), including 17 papers, shows a 27-minute shorter operational time in RAS compared to laparoscopic surgery. Another study by Siaulys et al. (Siaulys et al. 2021) demonstrates that the operation performed through RAS ended in 147 min, while the laparoscopic ones took 80 min.

2.2.6. Multitasking

The multitasking feature of robotic-assisted surgery plays a significant role in adopting and utilizing this technology. Robotic systems offer increased dexterity and precision, allowing surgeons to perform multiple tasks simultaneously by having some features to enable improved visualization, motion scaling, better and quicker suturing, superior instrumentation by the ability to do many different things at the same time, incorporated haptic interaction, more favorable angle of placement, enhanced surgeon ergonomics (BenMessaoud et al. 2011; Fanfani et al. 2015; Mohammadzadeh and Safdari 2014; Nasser et al. 2020; Pernar et al. 2017). Surgeons can do complicated procedures more quickly because they have 7 degrees of flexibility and a 3-dimensional perspective of the operating field with a camera control program that follows the movements of surgeons' eyes, compared to 4 degrees of freedom in standard laparoscopy (Fanfani et al. 2015; Mohammadzadeh and Safdari 2014; Stewart et al. 2018; Williams et al. 2014). Robotic surgery devices are designed to make it easier to suture and improve the surgeon's dexterity by doing many different things at the same time in performing complex movements in a way that is stable and has greater accuracy (Williams et al. 2014; Mohammadzadeh and Safdari 2014; Pernar et al. 2017). The feature of stability and accuracy eliminates the surgeon's tremors. The capability of providing ergonomic benefits like reduced surgeon fatigue, all of which lead to improved surgical performance and decreased weariness for the surgeon (Mohammadzadeh and Safdari 2014; Nasser et al. 2020; Williams et al. 2014; Stewart et al. 2018).

Additionally, the robotic platform records and measures surgical performance data, allowing for the examination of elements like grab forces used, tool path length, and economy of motion (Lendvay et al. 2013). Effective multitasking improves surgical capabilities and helps to enhance patients' outcomes and also the surgeons' dexterity to execute the operation safely during robotically assisted surgery (Siaulys et al. 2021). More accuracy and efficiency in executing complex procedures by surgeons results in shorter surgery times and less trauma to the patient. (Lendvay et al. 2013).

The precise control offered by robotic platforms allows for meticulous suturing and tissue manipulation, which can result in better surgical outcomes. The multitasking feature of robotic-assisted surgery provides surgeons with advanced capabilities and enhances their ability to perform complex procedures. This aspect of the technology and its other technical advantages contribute to the growing acceptance and integration of robotic surgery in various surgical fields.

2.2.7. Tremor Abolition

Abolishing hand tremors is one of the superior functions of RAS compared to laparoscopy (Ghezzi and Corleta 2016). Hand tremors can be a significant challenge for surgeons during minimally invasive procedures, as they can compromise their ability to perform precise movements. However, with robotic devices in surgery, tremor filtration technology is employed, providing surgeons with stable and precise movements that enhance surgeons' dexterity. (Nasser et al. 2020; BenMessaoud et al. 2011; Mohammadzadeh and Safdari 2014). Although Nasser et al. (Nasser et al. 2020) state that Robotic-Assisted Surgery Gastrectomy has no superiority over Laparoscopic Sleeve gastrectomy in super-obese patients BenMessaoud et al. (BenMessaoud et al. 2011) claim that enhancing dexterity and control improves surgical outcomes of RAS.

By eliminating hand tremors, RAS enables surgeons to provide a sensitive treatment for complicated operations more precisely (BenMessaoud et al. 2011; Mohammadzadeh and Safdari 2014; Nasser et al. 2020). With the help of these features, surgeons can navigate tight spaces, manipulate small structures, and suture more accurately, enabling a reduction of the risk of complications and improving patients' postoperative recovery. Additionally, by minimizing errors and improving precision efficiency, robotic surgery can contribute to shorter procedure times, reducing the overall surgical stress on patients (Mohammadzadeh and Safdari 2014).

Tremor abolition enhances the capabilities of surgeons to allow surgeons to show what is possible to achieve in RAS as one of the procedures of minimally invasive surgeries. With stable and precise movements, surgeons can confidently perform sophisticated tasks and explore innovative techniques.

Tremor abolition is a significant advantage of robotic surgery. It enhances the dexterity and control of surgeons, leading to improved surgical outcomes. By enabling precise and stable movements, robotic surgery minimizes the risk of complications and improves both the perioperative process and postoperative recovery for patients.

2.2.8. Motion Scaling

Robotic surgery has completely changed the way of performing minimally invasive surgery by making many technical advantages available to use over traditional laparoscopic procedures. One of the critical advancements in robotic surgery is the implementation of motion scaling. Motion scaling allows surgeons to manipulate robotic instruments with enhanced precision and accuracy by changing the surgeons' large hand movements into more minor forms of the surgical instrument during surgical procedures (source: https://medical-dictionary.thefreedictionary.com/motion+scaling). With these features, motion scaling contributes to the overall efficiency of RAS procedures.

Utilizing motion scaling allows surgeons to overcome human hand and hand-eye coordination limitations, and as Mohammadzadeh and Safdari (Mohammadzadeh and Safdari 2014) emphasize, this feature enhances the surgeons' dexterity. The robotic system provides this dexterity by translating the surgeon's hand movements into smaller, more transparent, and more accurate actions, allowing greater control and precision within the surgical field. This feature is functionality beneficial for procedures that need intricate maneuvers or manipulation of delicate structures (Ghezzi and Corleta 2016).

The ability to scale motion in robotic surgery also provides surgeons with increased flexibility and adaptability. Performing complicated operations, even in very small and narrow areas of the body, with great accuracy is the result of having precisely maneuvered instruments of RAS. The capability of better suturing and enhancing physicians' dexterity is provided to reach improved operation outcomes (BenMessaoud et al. 2011; Ghezzi and Corleta 2016; Mohammadzadeh and Safdari 2014; Nasser et al. 2020).

2.2.9. Enhanced Visualization

Enhanced visualization is one of the features that facilitate surgeons' adoption process of RAS. Some studies support this statement. The research by Diana and Marescaux et al. (Diana and Marescaux 2015) emphasizes that enhanced visualization improves patients' safety by enabling physicians to handle problematic situations through better imaging. Nasser et al. (Nasser et al. 2020) focus on comparing the RAS with laparoscopic surgery and state that three-dimensional (3D) imagining contributes to the superiority of RAS. Entailing high-definition viewing capabilities and modern imaging technology utilize significant ease to the physicians (BenMessaoud et al. 2011; Diana and Marescaux 2015 and Nasser et al. 2020).

RAS' high-quality 3D vision significantly enhances surgeons' dexterity (Mohammadzadeh and Safdari 2014). The research by Fanfani et al. (Fanfani et al. 2015) examines a novel RAS platform named TELELAP ALF-X surgical system. This device involves a remote 3D vision with an eye-tracking camera control system that is investigated to assess this feature's impact, with its all-new specialties (Fanfani et al. 2015). RAS allows surgeons to deal with a complicated situation more precisely via depth perceptiveness and spatial awareness (BenMessaoud et al. 2011; Diana and Marescaux 2015; Mohammadzadeh and Safdari 2014 and Nasser et al. 2020).

Diana and Marescaux (Diana and Marescaux 2015) state that integrating augmented reality features into RAS platforms contributes to performing safer operations by enhancing visualization. Studies by Diana and Marescaux (Diana and Marescaux 2015) and Mohammadzadeh and Safdari (Mohammadzadeh and Safdari 2014) advise that enhanced visualization technology may improve surgical precision and safety, specifically in complex and challenging operations. Nasser et al. (Nasser et al. 2020) highlight the benefits of this feature for both patients and surgeons, which are minimizing surgical trauma and potential complication risks for patients and enhancing surgeons' dexterity.

2.2.10. Intraoperative Complication Rates

Several studies emphasized the contribution of RAS to lower intraoperative complication rates (Aggarwal et al. 2018; Fletcher et al. 2018; Lim et al. 2011; Mohammadzadeh and Safdari 2014; Sivarajan et al. 2015; Thompson et al. 2014). Ghezzi and Corleta (Ghezzi and Corleta 2016) state that the patients who undergo robotic-assisted surgery in general surgery have almost the same oncological and practical results as the ones who have laparoscopic surgery. For some diseases, the treatment with robotic-assisted surgery may cause a rise in intraoperative complications (Bauman et al. 2016). Lim and Kang (Lim and Kang 2017) reported that the patient's position at the operating table during robotic-assisted surgery is vital to prevent unintended intraoperative complications. The study by Kim et al. (Kim et al. 2009) shows that in the comparison of surgical techniques for gastric cancer, the patients who underwent robotic-assisted surgery had no complications, while the two persons treated with open surgery had intraabdominal bleeding and wound infections and the one with the laparoscopic surgery had paralytic ileus. Mendivil et al. (Mendivil et al. 2009) state that patients treated with robotic-assisted surgery have a lower overall complication rate in gynecologic oncology.

The significant competency of a surgeon in RAS provides improved intraoperative results (Barocas et al. 2010; Williams et al. 2014).

2.2.11. Postoperative Complication Rates

In recent years, RAS getting has become famous due to its promising results in reducing postoperative complications. The studies by Abdollah et al. (Abdollah et al. 2017), Diana and Marescaux (Diana and Marescaux 2015), Kim et al. (Kim et al. 2013), Mohammadzadeh and Safdari. (Mohammadzadeh and Safdari 2014), Sheetz et al. (Sheetz et al. 2020), Sheth et al. (Sheth et al. 2018), Siaulys et al. (Siaulys et al. 2021), and Williams et al. (Williams et al. 2014) summarize the benefits of robotic-assisted surgery regarding lower postoperative complication rates while the ones by BenMessaoud et al. (BenMessaoud et al. 2011), Lenvay et al. (Lenvay et al. 2013) and Sivarajan et al. (Sivarajan et al. 2015) and highlight the reduction in postoperative pain. Lim et al. (Lim et al. 2011) noted that a lower postoperative complication rate was observed for significant complications in the patients who had RAS instead of laparoscopic surgery, while the situation was the opposite for the minor complications. Kim et al. (Kim et al. 2009) and Mendivil et al. (Mendivil et al. 2009) focused on the complications in the end-to-end treatment process. They noted a lower complication rate for robotic-assisted surgery. Regarding increased experience and higher surgical volumes, Abdollah et al. (Abdollah et al. 2017) reported that robotic surgery results in lower postoperative complications. Kim et al. (Kim et al. 2013) and Stewart et al. (Stewart et al. 2018) stated that RAS is greater than open surgery regarding postoperative complications. However, Stewart et al. (Stewart et al. 2018) show evidence that it has almost the same results as laparoscopic surgery. Williams et al. (Williams et al. 2014) also proposed that RAS provides improved cancer control.

It is important to note that some studies have raised concerns about the robotic approach. Fletcher et al. (Fletcher et al. 2018) noted that it is not certain that the complication results of RAS compared with open surgery. On the other hand, Garber et al. (Garber et al. 2014) noted that RAS is related to the often-happening postoperative complications such as urinary incontinence, Jacobs et al. (Jacobs et al. 2013) genitourinary complications, and Williams et al. (Williams et al. 2014) erectile dysfunction.

2.2.12. Safety Risks During Learning

The literature highlights the significance of considering the safety risks associated with the learning process. This issue requires excellent attention and objective evaluation by surgeons and the whole operating room staff to be aware of insufficient skills and inadequate experience due to having lower surgical experience and use of RAS during the learning process of robotic-assisted surgery platform usage.

Kim et al. (Kim et al. 2013), Lendvay et al. (Lendvay et al. 2013), and Lenihan (Lenihan 2017) emphasize that following the completion of the learning curve by the surgeons and theatre room staff, patients tend to have shorter hospital stays and mention a reduction in postoperative discomfort. In a supportive manner, Chowdhury et al. (Chowdhury et al. 2007), Esen et al. (Esen et al. 2018), and Lim et al. (Lim et al. 2011) noted that patients operated on by a proficient surgeon may have better results.

Abdollah et al. (Abdollah et al. 2017), Chowdhury et al. (Chowdhury et al. 2007), Esen et al. (Esen et al. 2018), Lenihan (Lenihan 2017), Ploussard et al. (Ploussard et al. 2010), Thompson et al. (Thompson et al. 2014), and Wallenstein et al. (Wallenstein et al. 2012) emphasize incompetent physicians with lower surgical volumes may cause higher patient operation risks. These include higher postoperative complications, longer operation time, increased blood loss, rising readmission rates, and worse cancer control (Abdollah et al. 2017; Ploussard et al. 2010; Thompson et al. 2014).

Green et al. (Green et al. 2018) emphasized that any incompetence may cause significant patients' safety issues. Since the training program includes mostly observational roles, residents may suffer from incompetent dexterity at the end of the program (Green et al. 2018). Green et al. (Green et al. 2018) advise the significance of a structural evidence-based RAS teaching program to avoid any risk from borning lack of skill.

The study by Mills et al. (Mills et al. 2017) discusses the correlation between performance on RAS's surgical simulators and surgical skills. They highlight the potential limitations of simulators in guiding users toward expert performance, noting that transferring skills from simulation to the real-world intraoperative environment may be challenging and unrelated (Mills et al. 2017). Similarly, Lenihan (Lenihan 2017) also state that the simulation could be more beneficial for training the surgeons and operating room staff as the younger surgeons accept that it is an essential component of their professional practice and advancement.

Pernar et al. (Pernar et al. 2017) noted that the robotic-assisted surgery procedure is promising to be a standard approach in general surgery over time under the circumstances of increasing the surgeons' ability to perform it well.

Esen et al. (Esen et al. 2018) critically explained that even though the RAS usage rate is rising in Turkey, only one-fifth of 80 percent of high-volume surgeons who are certified to use the platform can execute the RAS procedure for general surgical operations six times or above during a year. They emphasize that the situation for low-volume surgeons is much worse since they cannot reach enough resources to get proficient in robotic general surgery procedures to exceed the learning curve by pointing out that these are the root causes of the limitation of getting better results.

While robotic surgery offers numerous advantages, it is crucial to acknowledge the higher safety risk during inexperienced use and the learning curve. Mentorship, structured training programs, evidence-based teaching approaches, and opportunities for skill acquisition are essential to ensure patient safety and optimal outcomes in robotic surgery.

2.2.13. Smaller Incisions

One of the significant advantages of robotic-assisted surgery over traditional open surgery is the ability to perform surgeries with smaller incisions, resulting in several positive outcomes.

In the comparison with open surgeries, smaller incisions of RAS' contributions to the patients are summarized in some studies that are reduced postoperative pain, shorter recovery time (Sheth et al. 2018), and hospital length of stay (Sheth et al. 2018; Jacobs et al. 2013; Stewart et al. 2018), and less blood loss (Jacobs et al. 2013).

A dramatic decrease was observed in narcotic use in operations performed by RAS (Mohammadzadeh and Safdari 2014). The capability of executing the operation with micro instruments may reduce surgical trauma, the rate of wound infections and incision-related complications (Stewart et al. 2018) by providing better aesthetic outcomes for patients (BenMessaoud et al. 2011).

The study by Jacobs et al. (Jacobs et al. 2013) draws attention to the possibility of a higher risk for genitourinary complications and salvage therapy for men undergoing robotic prostatectomy.

2.2.14. Hospital Time and Return to Regular Life

The advantages of robotic surgery extend beyond physical outcomes. According to the literature review, robotic surgery has demonstrated significant advantages in shorter hospital stays and earlier patients' return to daily routines. Studies have consistently shown that patients who have treatment with RAS leave the hospital sooner, resulting in a reduced length of stay (Esen et al. 2018; Kim et al. 2009; Lim et al. 2011; Mendivil et al. 2009; Mohammadzadeh and Safdari 2014; Ng et al. 2010; Sivarajan et al. 2015). Lendvay et al. (Lendvay et al. 2013) emphasize that the hospitalization period may be reduced following the surgeon passing the learning curve. Mendivil et al. (Mendivil et al. 2009) also noted that the conclusion of the comparison was the median hospitalization; for open surgery, it was three days, while for robotic surgery was one day.

BenMessaoud et al. (BenMessaoud et al. 2011), Mohammadzadeh and Safdari (Mohammadzadeh and Safdari 2014), Ng et al. (Ng et al. 2010), Pruthi et al. (Pruthi et al. 2010), evidence support that patients undergoing robotic-assistance surgery procedures also tend to experience reduced pain, decreased narcotic use, and faster recovery, allowing them to return to their daily routine activities sooner. These advantages improve patients' overall satisfaction and enhance their postoperative well-being.

Stewart et al. (Stewart et al. 2018) demonstrate that the length of stay (henceforth LOS) of colorectal cancer and pancreatic cancer patients at the hospital after the robotic surgery operation was shorter than the ones who had laparoscopic surgery, about 0.4 and 3.0 days, respectively. Sheth et al. (Sheth et al. 2018) show that the patients who received robotic-assisted pyeloplasty (RAP) had shorter LOS than the ones who had laparoscopy by 1.2 days. Abdollah et al. (Abdollah et al. 2017) claim that returning to regular life after the operation with RAS results in a shorter recovery period, while Pruthi et al. (Pruthi et al. 2010) reported similar results for both laparoscopic and RAS. The significance of operating in small and narrow parts of the body is of higher importance for some patients like super obese; the situation for these patients includes a higher risk of complications and infections, which may result in a longer hospitalization time after RAS (Nasser et al. 2020).

2.2.15. Costs

Higher overall costs of robotic surgical platforms are one of the significant challenges related to the adoption of RAS. Financial constraints need to be removed to boost the adoption of telemedicine apps in healthcare, according to Alanazi and Daim (Alanazi and Daim 2021). While Bogue (Bogue 2021), Fanfani et al. (Fanfani et al. 2015), Goh and Teo (Goh and Teo 2020), and Lendvay et al. (Lendvay et al. 2013) emphasize that expensive costs are one of the main obstacles to using a robotic-assisted surgery platform, Esen et al. (Esen et al. 2018) corroborate this statement in their study, which examines the adoption of RAS in Türkiye. Similarly, Ghezzi and Corleta (Ghezzi and Corleta 2016) point out that higher costs are an essential barrier to bringing RAS into effect as the standard minimally invasive surgery technique in all parts of the world.

Mandapathil and Meyer (Mandapathil and Meyer 2021), and Mohammadzadeh and Safdari (Mohammadzadeh and Safdari 2014) emphasize the negative effect of higher costs of RAS on the adoption, and they also state that lack of cost-covering reimbursement is another element that unfortunately feeds the negative part. Barbash et al. (Barbash et al. 2014) state that distributing the higher fixed price over many patients' reimbursements and maintaining enough receipts to fund robot-assisted surgery are the implementing ways of RAS technology-owned high-volume hospitals. These results emphasize the necessity of addressing the financial aspects of implementing robotic surgery.

The studies by Abdollah et al. (Abdollah et al. 2017), Esen et al. (Esen et al. 2018), Siaulys et al. (Siaulys et al. 2021), and Williams et al. (Williams et al. 2014) highlight the positive outcomes of increased surgeon knowledge in robotic-assisted surgery to lower costs per operation. Williams et al. (2014) also state that to reduce the effects of robotic-assisted surgery technology costs, higher volume hospitals, especially hospitals with reimbursement instructions, and higher volume surgeons have the advantage of having a lower cost because of being capable of the higher standard of perioperative outcomes. Mouraviev et al. (Mouraviev et al. 2007) and Scales et al. (Scales et al. 2005) emphasized that minimizing the cost per robotically assisted approach requires at least 7 times operations in a week, which corroborates that the higher the volume, the less cost per operation. Abdullah et al. (2017) also acknowledge that higher costs of robotically assisted procedures can be a limiting factor considering the situation where the surgeons are less experienced. In this manner, Esen et al. (Esen et al. 2018) address that the main reason for not having cost-efficient and cost-effective national instructions is the scarcity of facilities that lack the surgeons to improve their skills enough to get proficient in RAS.

Current literature suggests that the cost of acquiring and maintaining robotic platforms is substantial, while the technology is still questionable. Due to the high price of the technology and its debatable marginal advantage, the rapid dissemination of surgical robots has generated controversy (Sheth et al., 2018). Garber et al. (Garber et al. 2014) and Jacobs et al. (Jacobs et al. 2013) emphasized that persuading patients, physicians, and hospitals by aggressively advertising robotic-assisted surgery is an important issue to handle. When hospital administrators, policy experts, doctors, and patients weigh the adoption of expensive technological innovations against growing financial restrictions, they should all be aware of the potential for unanticipated advantages from technology diffusion (Sivarajan et al. 2015).

According to Lenihan (Lenihan 2017), the shift towards minimally invasive procedures, including robotic-assisted surgeries, has been significant in gynecologic surgeries. Lenihan (Lenihan 2017) acknowledges controversies around the costs and complications of this approach and suggests that surgeons, hospitals, and medical societies must officially decide on the most cost-efficient and effective use of RAS in gynecologic surgeries by noting that expert surgeons and their operating room staff prefer to perform with robotic-assisted surgery procedures even if it has higher costs.

Despite the general safety and viability of robotic-assisted techniques in bariatric surgery being shown, the role of RAS has yet to be called into question due to longer operating duration and expensive costs without clear advantages over laparoscopic procedures (Nasser et al. 2020). The study by Nasser et al. (Nasser et al. 2020) emphasizes that their research does not concentrate on assessing the cost of RAS. However, it shows that higher operation and hospitalization times are responsible for increased overall costs (Nasser et al. 2020).

Although the patients have some surgical complications such as urinary incontinence, genitourinary complications, and erectile dysfunction, the sudden rise in the number of executed RAS has come at a considerable cost, and a particular procedure's price has increased by approximately 13% (Garber et al. 2014). Barbash and Glied (Barbash and Glied 2010) and Stewart et al. (2018) noted that in comparing the costs of laparoscopic and RAS, RAS was 13% more expensive than laparoscopic approaches. Mouraviev et al. (Mouraviev et al. 2007) and Williams et al. (2014) also noted that RAS is more expensive than the conventional approach. Williams et al. (2014) highlight the need for more comprehensive study designs to evaluate the cost-effectiveness of RAS.

Makarov et al. (Makarov et al. 2010) and Williams et al. (2014) reported that the elements contained in total cost have been characterized according to organizations, medical systems, and place. On the other hand, Hohwü et al. (Hohwü et al. 2009) and Williams et al. (2014) noted that even though there is not enough data to prove the direct impact of RAS, enabling shorter hospitalizations and earlier return to regular life may provide improved financial benefits for society. Lim et al. (Lim et al. 2011) reported that patients stay shorter at the hospital after the robotic-assisted surgery operation compared to laparoscopic one, Martino et al. (Martino et al. 2011) found that patients had less postoperative pain and it caused a 50% drop in consumption of medication; according to Mohammadzadeh et al. (2014) these advantages lead to an immediate effect to decrease cost.

Diana and Marescaux (Diana and Marescaux 2015) and Fanfani et al. (2015) claim that robotic-assisted surgery costs decrease with more market actors. Fanfani et al. (2015) also noted that when robotic-assisted surgery technology starts to offer better quality than it has now, its costs tend to decrease.

The substantial initial investment, high maintenance fees, and cost of instruments contribute to hospitals' financial burden.

2.2.16. Purchase Costs

One of the reasons behind the limitations of widespread adoption of RAS is the higher purchase cost. Jacobs et al. (Jacobs et al. 2013) noted that the initial investment of RAS might exceed $1 million. The amount of money required to acquire and maintain a RAS platform must be handled considering the advantages and disadvantages of having the platform (Jacobs et al. 2013). Despite the financial challenges, the attraction of RAS technology to draw patients and surgeons is found significant by hospitals (Jacobs et al. 2013). In that manner, the study by Jacobs et al. (Jacobs et al. 2013) also emphasizes that getting robotic surgery ready to use shows a rise for all the RAS performed, especially in procedures like radical prostatectomy.

Stewart et al. (Stewart et al. 2018) and Turchetti et al. (Turchetti et al. 2011) show that the expense of robotic surgery compared to laparoscopy is associated with the higher first buying cost and repairing cost of robotic platforms, including the used-up and replacement items.

2.2.17. Operation and Maintenance Costs, Including Materials

Robotic surgery has gained significant attention and adoption in various surgical specialties due to its potential benefits. However, one of the main issues associated with RAS is the high operation and maintenance costs, including materials. Several studies have highlighted the impact of these costs on the widespread adoption of robotic surgical techniques.

Jacobs et al. (Jacobs et al. 2013) handle the issue from the hospitals’ side and emphasize that the decision-makers at the hospitals should consider purchasing robotic surgery technology carefully before making the final decision due to its higher costs for purchasing and maintenance, including pieces of equipment. According to the study, robotic platforms’ annual maintenance costs come to $150,000, and $1,000 is added for each case by seldom used instruments. Nevertheless, hospitals can still find robotic technology to be a valuable investment in addition to drawing in patients and doctors (Jacobs et al. 2013).

Bolenz et al. (Bolenz et al. 2010), Bolenz et al. (Bolenz et al. 2014), and Williams et al. (Williams et al. 2014) suggested the importance of comprehensive studies considering various parameters influencing operation and maintenance costs, emphasizing that the stages of robotic-assisted surgery ended with higher costs. Bolenz et al. (Bolenz et al. 2014) and Williams et al. (Williams et al. 2014) state that case volume and amortization rates affect the robot's purchase and maintenance costs. Barbash and Glied (Barbash and Glied 2010) and Stewart et al. (Stewart et al. 2018) discuss the 13% increase in the costs of robotic surgery compared to laparoscopy. Turchetti et al. (Turchetti et al. 2011) and Stewart et al. (Stewart et al. 2018) stated that these include higher purchase and maintenance costs, while Higgins et al. (Higgins et al. 2016) and Stewart et al. (Stewart et al. 2018) pointed out the more costly consumable surgical supplies. Nonetheless, Stewart et al. (Stewart et al. 2018) stated that the reason for the inevitable adoption of robotic-assisted surgery in general surgical oncology is factors such as enabling enhanced surgeon ergonomics and dexterity.

Since the expenses and difficulties associated with robotic surgery operation and maintenance costs, including materials, have been covered in several publications, the literature suggests that they pose challenges to the widespread adoption of robotic surgery. Addressing these costs through cost-effective solutions and comprehensive studies is crucial to maximizing the benefits of robotic surgical techniques while minimizing the financial burden on healthcare systems.

2.2.18. Benefits and Hospital Quality

Robotic-assisted surgery (RAS) has gained popularity recently due to its numerous advantages and benefits. Factors such as patient demographics and the presence of skilled surgeons influence the adoption of robotic technology. Aggarwal et al. (Aggarwal et al. 2017) emphasize that hospitals try to provide as well-qualified a service to the patients as possible. Hospitals' competition for quality plays a significant role in reaching advanced quality service and may be charming for patients (Aggarwal et al., 2017).

To execute the robotic-assisted surgery procedure, the hospital must acquire the technology. Hospitals may purchase the newest technologies even if they are not the most economical because they compete with one another for patients and providers to provide improved quality (Jacobs et al. 2013). Barbash et al. (Barbash et al. 2014) explored the RAS platforms' adoption elements by hospitals, identifying a correlation between purchasing RAS platforms and wishing to draw physicians and patients. In this manner, hospitals in regions with abundant surgeons and a significant percentage of privately insured patients tend to acquire RAS technology (Barbash et al. 2014). Understanding these factors is crucial regarding competition and people's opinions about RAS.

Some opportunities pop up as a side-effect of having more hospitals in an area providing performing operations more accurately, such as information technology and documentation infrastructure (Williams et al. 2014).

2.2.19. Attract New Patients

Some patients find RAS to be an attractive procedure. Aggarwal et al. (Aggarwal et al. 2017) found that the accessibility of sophisticated surgical procedures, larger operation volume, and the reputation of surgeons and hospitals all significantly impacted patient mobility in the setting of patient choice and hospital rivalry. Barbash et al. (Barbash et al. 2014) reported that the hospitals that compete with other ones are more inclined to invest in technologies to draw in new patients. According to Aggarwal et al. (Aggarwal et al. 2017), the patient decision-making process is also attracted by the patient's age and prosperity, i.e., the younger and wealthier ones are expected to choose hospitals offering RAS with famous surgeons and are willing to travel substantial distances for treatment. Barbash et al. (Barbash et al. 2014) and Stitzenberg et al. (Stitzenberg et al. 2011) also noted that the hospitals applying robotic-assisted surgery tempt the patients to come to the hospital even if it's located in the outground. The result of Makarov et al. (Makarov et al. 2011) paper emphasizes that patients' demand for RAS plays a crucial role in becoming the regions with hospitals that provide RAS. Williams et al. (Williams et al. 2014) and Barbash et al. (Barbash et al. 2014) state that the RAS advertisements aim to attract patients directly and may successfully increase patients’ demand. Jacobs et al. (Jacobs et al. 2013) highlighted that even though the technology of robotic-assisted surgery platform is expensive, hospitals may put up with it, and surgeons desire to provide patients with the best possible treatment so that they may choose the hospitals with the robotic technology.

2.2.20. Attract Better Surgeons

Robotic-assisted surgery (RAS) has become increasingly popular due to its numerous advantages and benefits. RAS, in particular, has been shown to draw better doctors, which enhances patient outcomes and surgical professionals' job satisfaction.

According to BenMessaoud et al. (BenMessaoud et al. 2011), the features of robotic technology may attract surgeons to enhance their dexterity while performing, and the system's reliability is the key to improving patient results and job satisfaction. The study addressed that these are the vital elements to facilitate the adoption of robotic-assisted surgery by surgeons (BenMessaoud et al. 2011).

Fanfani et al. (Fanfani et al. 2015) and Siaulys et al. (Siaulys et al. 2021) reported that superior surgeons may quickly adopt robotic-assisted surgery technology to their surgical routine by wishing to increase safety and finding it more feasible.

Jacobs et al. (Jacobs et al. 2013) emphasize that even though robotic technology does not provide the best possible profit, it is charming for surgeons, enabling enhanced patient outcomes.

The literature demonstrates that RAS plays a significant role in attracting better surgeons. The advanced functions and improved patient outcomes associated with robotic technology, along with the competitive landscape and patient preferences, contribute to adopting and utilizing RAS in surgical practice.

2.3. Challenges and Future Perspectives

We also touch on the last two topics by completing the literature review part. The first is RAS’s current challenges because of its present technological limitations. The second one is the future of this technology.

As emphasized in numerous studies, the absence of tactile/haptic feedback is one of the current drawbacks of this technology (BenMessaoud et al. 2011; Mohammadzadeh and Safdari 2014; Ghezzi and Corleta 2016; Williams et al. 2014; and Bogue 2021). Many publications also underline the higher initial purchase and the operational and maintenance cost as current limitations of RAS (Bogue 2021; Esen et al. 2018; Fanfani et al. 2015; Ghezzi and Corleta 2016; Lendvay et al. 2013). The lack of a structurally developed training program creates problems with these devices' current adoption process by hardening the ease of adoption (BenMessaoud et al. 2011; Krishnan et al. 2018; Langhan et al. 2014; Mandapathil and Meyer 2021 and Vichitkraivin et al. 2020). A supportive of this fact is that not having a convenient environment to enable the surgeons to get more experienced with the RAS is also a challenge that requires focus (Esen et al. 2018).

Therefore, any improvements that cause a decrease in all parts of the costs may help to establish proper conditions for the adoption of RAS regarding the affordability side of it. To make this happen, the more players on the market, the more competition and, therefore, the more competitive prices for the customers of these products (Ghezzi and Corleta 2016). Besides this, avoiding all or most of the intellectual property rights of these devices acquired by one or a small number of producers is necessary (Ghezzi and Corleta 2016).

The possibility of receiving touch of sense information may better meet the surgeons’ improved ergonomics and dexterity expectations. Research is currently conducted on that topic. Eindhoven University of Technology is developing a robotic-assisted surgery platform named SOFIE with haptic feedback technology still in testing. (Ghezzi and Corleta 2016; https://www.tue.nl/en/research/research-institutes/robotics-research/projects/sofie/).

Having a well-structured training program to learn how to use this technology may also be expected to be well-received by the surgeons. Providing the conditions that may enable them to perform a massive volume of operations contributes to meeting the surgeons’ expectations. (Esen et al. 2018) Moreover, the improvements in the field of virtual reality may facilitate the escalation of a structured training program, as has already been seen in the da Vinci example (Ghezzi and Corleta 2016).

Diana and Marescaux (Diana and Marescaux 2015) proposed that robotic-assisted surgery technology will be more on the radar of the martial service and space industry. Considering the birth of this technology and the current space research conducted worldwide, the future of this technology may witness a real teleoperation between space and the world.

As the last word in this part of the study, the more detailed research executed focusing on the RAS from various perspectives, such as, both short and long terms costs and benefits for patients, surgeons, hospitals, the healthcare industry as a whole, a particular procedure conduction in a specific field and the differentiated points from the other procedures in that field, may utilize this technology adoption and understand better.

CHAPTER 3

METHODOLOGY

This chapter outlines the research methodology employed in this study to evaluate and prioritize the factors influencing surgeons to adopt the RAS technology in their surgical practice. Considering the complexity of the problem and decision-making process, AHP was chosen as the primary methodology for analysis. With the help of a detailed explanation of the AHP and providing a clear answer to why we chose the AHP as a methodology of this research, the chapter reaches its aim. The following sub-titles include a brief explanation of AHP with its theoretical foundations, priority vector, consistency, consistency index, and consistency ratio, missing comparisons, group decisions, the research design, selection of criteria, sub-criteria, and factors, construction of a unique AHP tree, survey design, data collection, expert panel and data analysis, and results.

The evolution of robotic-assisted surgery is fast, offering healthcare institutions the potential for improved surgical outcomes and patient care. On the opposite side of this development, the adaptation process to use this technology is complicated, involving various elements that impact its success.

The Analytical Hierarchical Process (AHP) is employed as a decision-making tool to prioritize these criteria, allowing healthcare institutions to make informed decisions regarding the integration of robotic-assisted surgery into their practice. By understanding the relative importance of each criterion and its associated sub-criterion and, factors, healthcare decision-makers can better assess the feasibility and benefits of adopting this technology.

3.1. Research Question and Scope, Problem Definition

We evaluate and prioritize factors leading to the adoption of Robotic-Assisted Surgery (henceforth RAS) technology among surgeons from different disciplines. We use an Analytical Hierarchical Process (henceforth AHP) for Expert Judgement

Quantification (henceforth EJQ) for the RAS adoption decision. We study all adoption factors that have been discussed and examined in the previous literature, as well as factors solicited from surgeons, and merge and group these adoption factors under five main criteria, namely, (i) Ease of Initial Adoption (EIA), (ii) Ease of use (EOU), (iii) Patient Well-being/Welfare (PW), (iv) Operation Success and Safety (OSS), and (v) Economics (ECON) in the form of a decision tree with at most two additional levels under each criterion. We separately examine the prioritization of potential future features of robotic assistants. Adoption decisions are evaluated over the decision tree using data collected from a survey of surgeons from various surgical disciplines.

The highest current adoption levels are in: Urology, General Surgery, Gynecology, Thoracic Surgery, and Cardiovascular Surgery.

Table 1: Number of surgeons using robotic surgery in Turkey.

Specialty	Number of Doctors
Urologic Surgery	83
General Surgery	41
Gynecological Surgery	30
Thoracic Surgery	14
Cardiac Surgery	12
Ear, Nose, Throat (ENT) and Head and Neck Surgery	6
Pediatric Surgery	6
Gastroenterology Surgery	4

(Source: https://www.davincicerrahisi.com/robotik-cerrahi-yapan-hastaneler/ as of 22nd of May 2022 at 14:02)

The main aim of the study is to evaluate and prioritize factors leading to adopting Robotic-Assisted Surgery (henceforth RAS) technology among surgeons from different disciplines. It is a very complex problem to analyze statistically and not convenient to solve with a statistical method because of uncertainty about the diffuseness. For these reasons, to assess the priority of the factors regarding the RAS adoption decision, we employ an Analytical Hierarchy Process (AHP) for Expert Judgement Quantification (EJQ).

3.2. The Analytical Hierarchy Process (AHP)

AHP enables individuals to voice their ideas, opinions, and interests on the different alternatives of a multicriteria question. A practical method for assisting with complicated decision-making difficulties, the Analytical Hierarchy Process (AHP) (Brunelli 2015; Saaty 1980, 2013; Saaty and Vargas 2012) often involves numerous competing criteria and maybe many individuals. The technique facilitates individual and group decision-making difficulties by enabling meaningful aggregates of individual priorities into collective preferences. Therefore, expert judgment quantification—that is, combining the priorities of multiple experts in a field of practice—can likewise be accomplished with AHP.

The basic explanation of the AHP is that it is a relative measurement theory or methodology (Brunelli 2015). The researchers adopting AHP in their practice focus on the proportions of the measurements between the alternatives (Brunelli 2015). Their exact measurement is not necessary for the researchers (Brunelli 2015). The application of AHP is to reach an aim with limited choices (Brunelli 2015). Thus, the one who is in charge of deciding is expected to choose the best option for himself/herself (Brunelli 2015). AHP allows the transformation of people's subjective decisions into numerical ratings and then quantitatively calculates a priority for each alternative (Brunelli 2015).

Finding the best possible option among all alternatives is a complex decision-making problem (Brunelli 2015). In the real world, people need to know the relative measurement to decide on the best option (Brunelli 2015). Considering the feature of subjective choices, applying relative measurement makes the analysis more straightforward to execute (Brunelli 2015). Linking the alternatives with criteria allows us to ground the question logically, thinking to provide a greater perspective (Brunelli 2015). Breaking down the complex nature of a problem into smaller and simpler parts makes it more straightforward to reach the solution (Brunelli 2015; Saaty 1980). To make this happen, Saaty (Saaty 1977) advises creating a separate criterion matrix for every criterion the problem has (Brunelli 2015).

Decomposing any problem into its smaller parts while trying to digest it and then reaching a final solution, synthesizing all the granules is the typical approach for each human being (Saaty 1980). Developing a deep thinking and decision-making mechanism to realize why and/or how something happens in this path allows one to improve rational standards as expected (Saaty 1980). In AHP, these stages are called hierarchy and priority. In that kind of architecture, the following two questions needed to be answered (Saaty 1980).

- In which manner can a particular objective be expressed hierarchically?
- In which manner can the effect of each factor be evaluated in that hierarchy?

Keeping this attribute of AHP in mind, considering our problem's complexity and its inconvenience for solving statistically because of uncertainty about the diffuseness. These are the reasons to assess the priority of the factors regarding the RAS adoption decision; we employ an Analytical Hierarchy Process (henceforth AHP) for Expert Judgement Quantification (henceforth EJQ). Saaty (Saaty 1980) emphasizes that AHP entails pairwise comparisons, which provide the decision-maker with the highest possible consistency.

Generally, AHP is used for product or technology preference problems. In our study, we use AHP to evaluate and prioritize factors leading to the adoption of RAS technology among surgeons from different disciplines. The complex nature of our problem needs to be simplified. Since comparison matrices create an environment where the decision-maker can evaluate two alternatives simultaneously (Brunelli 2015), AHP's pairwise comparison makes this problem more straightforward to understand. Thus, in AHP, the reason for creating separate matrices for each criterion is to break down the problem into smaller and essential pieces (Brunelli 2015). By this working principle, Jun and Jian-lian (Jun and Jian-lian 2008) state that a decision-making process may be shortened with the help of AHP. Additionally, Khan et al. (Khan et al. 2022) state that regarding deciding on an issue relevant to health care, generally, two different types of multiple criteria decision analysis methods are applied together. If preferred to use only one approach, then, it is mostly the AHP (Khan et al. 2022).

One crucial finding about human decision-making and prioritization is that people usually find it difficult to consider many options at once. (Brunelli 2015; Saaty 2013). Still, they do significantly better when given options in pairs (Brunelli 2015; Saaty 2013). Pairwise comparisons of the components along a decision tree branch are obtained by AHP using a preference strength scale ranging from 1 to 9 (Brunelli 2015; Saaty 1980; Saaty 2013). The scales and their definition proposed by Saaty (Saaty 1980) are as follows.

Table 2: Saaty’s Scales (Brunelli 2015; Saaty 1980)

Relative Comparison of Factors	**Numerical Ranking**	**Meaning**
Equally Important	1	A pair of alternatives provides equal importance
Moderately More Important	3	Knowledge differs a little between the two factors in preferring one of them
Strongly More Important	5	Knowing to decide firmly about one comparison to another
Very Strongly More Important	7	Deciding on an alternative in a pair by having a severe opinion about
Extremely More Important	9	Judgment of the utmost level when comparing two things
Intermediate Values	2, 4, 6, 8	Knowing limited information or having no sharp opinion to prefer one over another

Using this scale, individuals may decide their preferences for all pairwise comparisons. With the help of these preferences, a pairwise comparison matrix may be created. This matrix includes the one’s subjective choices’ numerical ratings and their reciprocals and the main diagonal combining of 1’s. (Saaty 1980). The factors are then aggregated into overall priority weights using standard matrix operations and suitable techniques to build group preferences from individual data (Brunelli 2015; Saaty 1980; Saaty 2013).

The most significant advantage and disadvantage of applying AHP is its pairwise comparisons (Brunelli 2015; Harker 1987). Advantage because of relaxing and making people more confident by comparing two things simultaneously. The disadvantage of using it for complicated problems is that the number of factors necessary to make pairwise comparisons is high (Brunelli 2015; Harker 1987). Therefore, minimum pairwise comparisons should be made by decision-makers to make them more focused on the main question (Brunelli 2015; Harker 1987). That’s why we selected or combined, in a more general name, the 310 factors to make our research question as clear as possible for the surgeons. In this study, concerning the RAS platforms in a broad concept, we needed to keep the 25 factors as the minimum number.

3.2.1. Priority Vectors

Saaty (Saaty 1980; 2013) states that in determining the priority in hierarchies, the first thing to be done is to create a comparison matrix. The comparison matrices are shown in the following mathematical equations (1.1) and (1.2).

$$A = (a_{ij})_{nxn} \tag{1.1}$$

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} \tag{1.2}$$

Due to the other steps of calculation of the problem highly depending on the priority vector, it is essential to calculate it for each comparison matrix of the AHP problem (Brunelli 2015). In the world of making a decision perfectly rational, the weight vector (w) obtained by using any method gives the same results as A = $(\frac{w_i}{w_j})_{nxn}$ (Brunelli 2015). However, the only possibility to get this result depends on the condition that one's decision for a_{ij}, meets precisely with the ratio of $\frac{w_i}{w_j}$ (Brunelli 2015). Since people are not rational, as is expected, in so many cases, it is observed that they are incapable of deciding between weights (Brunelli 2015). In AHP, a weight vector is necessary to get a priority vector (Brunelli 2015). Considering the irrationality of the individuals, Brunelli (Brunelli 2015) proposed to use other methods to calculate a priority vector $w = (w_1, \dots, w_n)^T$. The standard part of calculating priority vector is combining pairwise comparisons with a scoring, here, its mathematical function $\tau: R_>^{nxn} \to R_>^n$ (Brunelli 2015).

Saaty (Saaty 1980) emphasized that for people who are informed well enough or have limited information while comparing a pair of things by giving a numerical judgment from 1 to 9, the eigenvalue method works more successfully than the other ones. This study uses the eigenvector method – the most accepted and preferred use

(Brunelli 2015) – to obtain the priority vector. Saaty's suggestion regarding the eigenvector was that the principal eigenvector of **A** ought to be the priority vector (Brunelli 2015). To clarify the eigenvector and eigenvalue, reckoning that a $n \times n$ square matrix is equal to **A** (Brunelli 2015). A n-dimensional vector is also shown as **w** (Brunelli 2015). n is our number of alternatives (Brunelli 2015)**.** Only with the condition below, **w** is an eigenvector while the **λ** is an eigenvalue. This is shown mathematically as in the following equation (1.3) (Brunelli 2015).

$$\boldsymbol{Aw} = \boldsymbol{\lambda} w \tag{1.3}$$

Eigenvalues may have minimum and maximum amounts; the maximum value of eigenvalues is represented as $\boldsymbol{\lambda_{max}}$ (Brunelli 2015).

3.2.2. Consistency

Considering one who makes his/her decisions based on the reasons relevant to his/her decision, it is expected that the one ought to articulate his/her pairwise choices precisely as in the following mathematical formulation (1.4) (Brunelli 2015).

$$a_{ij} = \frac{w_i}{w_j} \;\; \forall_{i,j} \tag{1.4}$$

Applying the rule above to get the result of $a_{ij}a_{jk}$, we get the following equation (1.5) (Brunelli 2015).

$$a_{ij}a_{jk} = \frac{w_i}{w_j}\frac{w_j}{w_k} = \frac{w_i}{w_k} = a_{ik} \tag{1.5}$$

In the situation of all the decisions made by a person meet the rule of $a_{ij} = \frac{w_i}{w_j}\ \forall_{i,j}$, the equation (1.6) shown below express the situation only exists if and only if in this condition (Brunelli 2015).

$$a_{ik} = a_{ij}a_{jk}\ \ \forall_{i,j,k} \tag{1.6}$$

The equation above is proof that every pairwise comparison made straight a_{ik} precisely the outcome of the whole indirect pairwise comparisons $a_{ij}a_{jk}\ \ \forall_{i,j,k}$ (Brunelli 2015). In an ideal world, it is expected that any decision-maker is capable of making rationally consistent pairwise comparisons without going against oneself (Brunelli 2015). Therefore, if a matrix meets this rule, it is accepted that it is consistent (Brunelli 2015). Saaty (Saaty 2003) emphasized that a small amount of inconsistency is preferred to a consistent judgement made under pressure. Additionally, Saaty (Saaty 2003) expressed that being very demanding on having a consistent pairwise matrix is the result of seeing the people as machines.

Saaty 1977, suggest the Consistency Index to evaluate a pairwise comparison matrix result (Brunelli 2015). The Consistency Index is formulated as follows in the equation (1.7) (Brunelli 2015).

$$\mathrm{CI}(\boldsymbol{A}) = \frac{\lambda_{max} - n}{n-1} \tag{1.7}$$

After this proposal of Saaty (Saaty 1977), it is recognized in the relevant research that this index needs to be redesigned (Brunelli 2015). The new version of Consistency Index (CI) is named as Consistency Ratio (CR) (Brunelli 2015). It is calculated by dividing CI to RI_n (Random Index) (Brunelli 2015). RI_n is a certain number acquired by forecasting the average CI regarding a sufficiently big collection of n-dimensional randomly generated matrices (Brunelli 2015). In the following equation (1.8) the formula stated.

$$\mathrm{CR}(\boldsymbol{A}) = \frac{\mathrm{CI}(\boldsymbol{A})}{\mathbf{RI}_n} \tag{1.8}$$

Saaty (Saaty 1980) states that if a pairwise comparison matrix is consistent its CR value ought to smaller than or equal to 0.1($\mathrm{CR} \leq 0.1$), if it is higher than 0.1 then, the matrix is inconsistent ($\mathrm{CR} > 0.1$) (Brunelli 2015). More detailed, for the values equal to 0.1 ($\mathrm{CR} = 0.1$) indicate that the decision's is inconsistent in 10% (Brunelli 2015).

Predicted numbers of $\mathrm{RI_n}$ are in Table 3 as follows (Alonso and Lamata 2006; Brunelli 2015). These are calculated by randomly generating from a dataset entails n-dimensioned matrices which are big enough to give an opinion about average CI (Alonso and Lamata 2006; Brunelli 2015):

Table 3: Randomly generated RI_n values

$\boldsymbol{n}$	3	4	5	6	7	8	9	10
$\boldsymbol{RI_n}$	0.5247	0.8816	11.086	12.479	13.417	14.057	14.499	14.854

3.2.3 Missing Comparisons

AHP becomes prominent in multi-criteria decision-making methods because of its two features that provide much better solutions (Harker 1987). These are mentioned in the following (Harker 1987).

- The easiness of use,
- Capability to manage inconsistencies in decisions.

Decision-makers find AHP to be easy to use because of its allowance to compare a pair of things at once (Harker 1987; Saaty 1980). It makes them feel more relaxed and confident when deciding something (Harker 1987; Saaty 1980). Moreover, AHP does not compel the decision-makers to make their decisions consistently (Harker

1987). As relevant to this, Saaty (Saaty 2003) stated that since people's choices are normally inconsistent, AHP has room for inconsistency.

Harker (Harker 1987) assumed that decision-makers have some redundancy while making their decisions. Thus, they do not necessarily complete all parts of a pairwise comparison matrix (Harker 1987). Considering this reason, there could be some incomplete pairwise comparisons (Harker 1987).

Ideally, obtaining a complete and consistent pairwise comparison matrix from a decision-maker is the expected situation when working with AHP (Brunelli 2015). The importance of a completed pairwise comparison matrix is to provide an official acceptance (Saaty 2003). Since the decision-makers do not always make a decision between all pairwise alternatives, some missing values for some comparisons may exist (Brunelli 2015). Especially for complicated problems, like having limited time, any reason may cause this (Brunelli et al. 2007; Brunelli 2015). For these reasons, the pairwise comparison matrices with some missing values are also acceptable (Brunelli 2015). Regarding human-focusing nature and trying to maximize its utility, demanding a few pairwise comparisons from them may work in a better way (Brunelli 2015; Carmone et al. 1997). The missing values are unsuitable while executing an AHP study because they make it difficult to derive the priority vector. (Brunelli 2015). Even if the decision-maker completed the whole pairwise comparisons, the one may have slightly focused mostly on the last part of the comparisons (Brunelli 2015; Carmone et al. 1997). The main reason why the missing values are problematic is that in this kind of circumstance, obtaining the priority vector process gets harder (Brunelli 2015).

To solve this problem, in this study, we prefer to use the geometric mean method developed by Harker (Brunelli 2015; Harker 1987). His reference to creating this algorithm is Saaty's eigenvector approach. Harker (Harker 1987) widened the limitations of the eigenvector approach by making it also useful for non-negative quasi-reciprocal matrices with the aim of calculating the results of incomplete comparison matrices (Brunelli 2015).

For the inconsistent pairwise comparison matrices, the eigenvector method is the only one capable of successfully obtaining the right positions of data in line that has been intrinsic (Harker 1987; Saat and Vargas 1984). The eigenvector method's working principle is based on taking averages, so Harker (Harker 1987) noted that the eigenvector method is more logical and found the other ways not as good as the eigenvector method. It is required to execute the Eigen method when there are some missing values in pairwise comparisons (Harker 1987). Harker (Harker 1987) emphasized that the expected way to complete the missing values of an incomplete pairwise matrix is to average all the strengths of all potential basic routes linking i and j. In other words, the evaluation a_{ij} refers to all the conceivable methods through which i and j may be assessed by considering their connections with something that has good enough features or intersects (Harker 1987). Harker (Harker 1987) stated that a pairwise comparison matrix with missing values is consistent regarding all judgements that already exist, then, all the missing values must have identical strengths. In inconsistent circumstances, the connection from every i to every j may become different (Harker 1987). In that kind of situation, it is necessary to take the geometric mean of the values that are already known (Aczél and Saaty 1983; Harker 1987).

3.2.4. Group Decisions

Here, in this section, we explain whether a result could be obtained for each particular field using AHP. This question requires combining all the individuals' decisions and getting a group priority vector ($w^{G} = (w_1^G, \dots, w_n^G)^T$) (Brunelli 2015). For two or more decision-makers deciding on a specific thing (i.e. m is a number of decision-makers, m ≥ 2), we can treat them as a group (Brunelli 2015). More clearly, shown in the mathematical symbols (1.9) below.

$$\underbrace{\left(a_{ij}^{(1)}\right)_{nxn}}_{A_1}, \dots, \underbrace{\left(a_{ij}^{(m)}\right)_{nxn}}_{A_m} \quad (1.9)$$

To obtain a group's decision result two ways were proposed as follows (Brunelli 2015; Forman and Peniwati 1998).

- The Aggregation of Individual Judgements (AIJ) method is supposed that putting all individuals' comparison matrix together into one, shown as $A^G =$

$(a_{ij})^G$, to reach the group's priority vector (Brunelli 2015; Forman and Peniwati 1998).

- Aggregation of Individual Priorities (AIP) method proposed that after the calculation of all single decisions' priority vectors, which are shown as, $w_1, \ldots, w_m$, to obtain the group's priority vector we need to combine all of them into one, w^G (Brunelli 2015; Forman and Peniwati 1998).

The combination process is the main discrepancy between these two methods (Brunelli 2015). Group decision priority vector does not include reciprocals because of being not able to maintain the reciprocal characteristics and this may arise some problems considering the synthesizing the group's decision, if the weighted arithmetic mean is used. (Brunelli 2015; Harker 1987). That's why the weighted arithmetic mean way is not recommended (Brunelli 2015; Harker 1987). However, some studies presented evidence that using the weighted geometric mean gives group priority vector results with an insignificant difference (Aczél and Alsina 1986; Aczél and Saaty 1983; Brunelli 2015; Saaty 2013). In the concept of AIJ, the weighted geometric mean is formulated as in the following equation (1.10) (Brunelli 2015).

$$a_{ij}^{G} = \prod_{h=1}^{m} a_{ij}^{(h)^{\lambda_h}} \tag{1.10}$$

Taking the importance of everyone's decision into account to obtain a group priority vector, we handle the typical understanding that it is not necessary to give different importance to different people; we take the weights as 1 (Brunelli 2015). Thus, everyone is of equal importance (Brunelli 2015).

Regarding AIP, both weighted geometric mean and weighted arithmetic, have general opinion as being convenient to be used, but the geometric mean method has a bit more popularity (Bernasconi et al. 2014; Brunelli 2015). The geometric mean functional formats are shown, as follows in the equations (1.11) and (1.12) (Brunelli 2015).

$$w_i^G = \prod_{h=1}^{m} w_i^{(h)^{\lambda_i}} \quad (1.11)$$

which simplifies to

$$w_i^G = \prod_{h=1}^{m} w_i^{(h)} \quad (1.12)$$

when there is no reason to differentiate between respondents.

Additionally, Brunelli (Brunelli 2015) states that weighted geometric mean aggregation method gives the same result while calculating a group decision priority vector regardless of the choice of AIJ or AIP.

3.3. The Research Design

AHP hierarchy includes the following steps to calculate the best option according to decision makers' priority preferences (Brunelli 2015):

- Determining a goal,
- Setting of alternatives,
- Setting of criteria and sub-criteria if required
- Mapping the relation of criteria with the alternatives regarding the goal.

Keeping these steps in mind, this study is designed to comply with the AHP methodology. Firstly, the objective was determined by the research question of the study, which evaluates and prioritizes factors leading to the adoption of RAS technology among surgeons from different disciplines. Then, a comprehensive literature review process was executed to determine all the factors that may have an impact on surgeons' decision-making to adopt the RAS platform in their own practice. Since the research context is very complicated, reviewing the literature, 310 factors that may affect the adoption of RAS have been observed. After a careful selection process, the factors that have similar meanings are named in the most precise way, and they are considered as one under the same title. In the end, we have 25 of the total factors. They comprise 5 main criteria, 12 sub-criteria, and 8 factors. They all comprise a unique AHP tree design, explained in detail below. An online survey in compliance with the AHP approach was created to gather the data. The survey was designed in a careful and logical mindset that emphasizes the surgeons' eye and orders the questions regarding this. To analyze data R software's R studio was utilized to run the ahpsurvey package developed by Frankiecho (Frankiecho 2018). Since there were some missing values in the responses, they were completed using the imputation. Obtaining the results after the former parts are completed, the interpretation part of the findings comes. The last part of the study design entails the conclusions and recommendations for future studies.

3.4. Construction of A Unique AHP Tree

To construct the hierarchy of our research question, we deeply considered all factors that may impact RAS adoption. Brainstorming sessions helped us decide on the final version of the hierarchy, as Saaty (Saaty 1980) advised. The main contribution of this study to the literature is the taxonomy of all these factors and the development of an AHP tree for the study. All criteria were arranged in a unique form of sequence (Saaty, 1980). The AHP tree was created in a way that simplifies this complicated problem as much as it could be. To do this, reducing the criteria was a fundamental process. At the end of this, 5 main criteria and clusters named, Operation Safety and Success, Patient Well-Being and Welfare, Ease of Use, Ease of Initial Adoption and Economics. First Sub-Criteria entails 12 elements, which are Ease of Installation, Training Requirements, Enhanced Surgeon Ergonomics and Dexterity, Tactile / Haptic Feedback, Operation Duration, Intraoperative Complication Rates, Postoperative Complication Rates, Safety Risks During Inexperienced Use and Learning, Smaller Incisions, Shorter Hospital Stays and Earlier Return to Human Activity, Costs, and Benefits, Hospital Quality (Including Quality Procedures). The second Sub-Criteria includes 8 factors: Multitasking, Tremor Abolition, Motion Scaling, Enhanced Visualization, Purchase Costs, Operation and Maintenance Costs, Attract New Patients and Attract Better

Surgeons. Each criterion cluster and the logical background behind them were explained in detail in the following paragraphs.

Operation Safety and Success (henceforth OSS) cluster was considered may be the highest priority for a surgeon's decision-making process. Thus, it was placed at the top of the tree while being the first pairwise comparison part of the survey. OSS criterion combines the sub-criteria: Intraoperative (henceforth ICR), Postoperative Complications (henceforth PCR) and Safety Risks During Inexperienced Use and Learning (henceforth RDL). It deals with factors that lead to higher success and reduced operation risk, leading to successful completion of the surgery. RAS is found to reduce ICR and PCR (Abdollah et al. 2017; Aggarwal et al. 2018; Diana and Marescaux 2015; Fletcher et al. 2018; Kim et al. 2013; Lim et al. 2011; Mohammadzadeh and Safdari 2014; Sheetz et al. 2020; Sheth et al. 2018; Siaulys et al. 2021; Sivarajan et al. 2015; Thompson et al. 2014 and Williams et al. 2014) though may present additional risks during Inexperienced Use and Learning. RAS platforms offer Enhanced Surgeon Ergonomics and Dexterity (henceforth SED). Multitasking, Tremor Abolition, Motion Scaling, and Enhanced Visualization are the factors that contribute to Surgeon Ergonomics and Dexterity. Since surgeon ergonomics and dexterity positively reduce operation complications, both intraoperative and postoperative complications rates include surgeon ergonomics and dexterity. RAS is claimed to reduce both intraoperative and postoperative complication rates. Hence, Smaller Incisions, Tactile / Haptic Feedback, and Surgeon Ergonomics and Dexterity are the factors considered related to fewer complications.

In compliance with this logic, Patient Well-Being and Welfare (henceforth PW) group was located as the second. PW was defined as all factors that improve the well-being of the patient, other than factors that directly relate to OSS. The main factors that contribute to PW are: Smaller Incisions, Shorter Hospital Stays and Earlier Return to Human Activity, and Operation Duration.

Ease of Use (henceforth EOU) is the third cluster. EOU criterion refers to factors that make the platform more straightforward to use. Current RAS platforms are known to enhance Surgeon Ergonomics and Dexterity and reduce Operation Duration with higher surgical volume (Abdollah et al. 2017; Kim et al. 2009; and Lim et al. 2011). However, the absence of Tactile / Haptic Feedback is noted as a significant drawback. Therefore, EOU consists of the factors that are named Surgeon Ergonomics and Dexterity, Operation Duration, and Tactile / Haptic Feedback.

For Ease of Initial Adoption (henceforth EIA), the factors facilitating or inhibiting the accessibility of the RAS platform for the hospitals are considered: Ease of Installation and Training Requirements. This group comes fourth.

All factors related to monetary costs and benefits for the surgeon, or the hospital are handled under the name of Economics (henceforth ECON) as the fifth criteria cluster of the study. Initial Costs (Initial Purchase Cost) and Operation Costs are considered separately, under a sub-criterion of Costs, as well as Benefits (Including Quality Procedures). Potential benefits of RAS platforms include Attracting New Patients, and Attracting Better Surgeons, for the hospital or practice.

The reason for having the same sub-criterion and factors for two separate criteria may be explained by the fact that they both cover similar and close criteria. The exact cause is valid for the sub-criteria: Intraoperative and Postoperative Complication Rates. For these both, we considered combining them and taking them as just complications but, reviewing the literature, it was recognized that they were handled separately. That's why, in this study, there are two different factors namely Intraoperative Complication Rates and Postoperative Complication Rates.

Other factors that are focused on technology adoption with a broader perspective are left out of the study. These are peer-effects, and leadership effects. Additionally, these are factors that are studied by previous literature on RAS adoption (Makarov et al. 2011; Lenihan 2017) as well as in technology adoption at large and are understood as critical technology adoption factors in general. We leave them outside our investigation to focus on factors specifically important for the RAS adoption decisions of surgeons and hospitals.

3.4.1. Adoption Factors and Criteria

We collect all 20 critical adoption factors to be evaluated under five main criteria with an AHP tree consisting of at most three levels: (i) Ease of Initial Adoption (EIA), (ii) Ease of use (EOU), (iii) Patient Well-being/Welfare (PW), (iv) Operation Success and Safety (OSS), and (v) Economics (ECON). The decision tree with the sub-branches and factors is shown in Figure 1. A description and further details for each factor are given in Table 4.

Table 4: RAS Adoption Decision Criteria and Factors

Category or Factor Name	**Description and Short Discussion**
Operation Success and Safety	Level 1 Criteria {Factors: Lower Intraoperative Complication Rates, Lower Postoperative Complication Rates, Higher Safety Risk During Inexperienced Use and Learning}
Lower Intraoperative Complication Rates \ F with Subfactors	Many studies show that patients who have an operation with RAS have lower Intraoperative Complication Rates (Aggarwal et al. 2018; Bauman et al. 2016; Barocas et al. 2010; Fletcher et al. 2018; Ghezzi and Corleta 2016; Kim et al. 2009; Lim et al. 2011; Lim and Kang 2017; Mendivil et al. 2009; Mohammadzadeh and Safdari 2014; Sivarajan et al. 2015; Thompson et al. 2014; Williams et al. 2014).
Lower Postoperative Complication Rates \F with Subfactors	Many studies show that patients who have an operation with RAS have lower Postoperative Complication Rates as well (Abdollah et al. 2017; Diana and Marescaux 2015; Fletcher et al. 2018; Garber et al. 2014; Jacobs et al. 2013 Kim et al. 2013; Mohammadzadeh and Safdari 2014; Sheetz et al. 2020; Sheth et al. 2018; Siaulys et al. 2021; Williams et al. 2014 BenMessaoud et al. 2011; Lenvay et al. 2013; Sivarajan et al. 2015; Lim et al. 2011; Kim et al. 2009; Mendivil et al. 2009; Kim et al. 2013; Stewart et al. 2018; Williams et al. 2014). Subfactors for all complications are {Enhanced Surgeon Ergonomics and Dexterity (see below as its own branch with subfactors), Smaller Incisions and related factors, Absence of tactile / haptic feedback}, all explained above.
Higher Safety Risks During Inexperienced Use & Learning \F	In many studies these risks are explained. (Abdollah et al. 2017; Chowdhury et al. 2007; Esen et al. 2018; Green et al. 2018; Kim et al. 2013; Lendvay et al. 2013; Lenihan 2017; Lim et al. 2011; Mills et al. 2017; Pernar et al. 2017; Ploussard et al. 2010; Thompson et al. 2014; Wallenstein et al. 2012).
Patient Well-Being and Welfare [Non-Safety Related]	Level 1 Criterion {Smaller Incisions & Related Factors, Shorter Hospital Stays & Earlier Return to Regular Human Activities, Operation Duration}

(cont. on the next page)

Table 4 (cont.)

Category or Factor Name	Description and Short Discussion
Smaller Incisions & Related Factors \F	Reduction in surgical trauma and incision-related complications, suturing advantages. Reduced postoperative pain, lower incidence of wound infections, shorter recovery time, less blood loss compared to open surgeries, fewer readmission rates, aesthetic concerns, and less complication rate during the operation and after the operation. Many studies show that patients who have an operation with RAS have the advantage of smaller incisions and its related positive effects during the perioperative and postoperative time (BenMessaoud et al. 2011; Jacobs et al. 2013; Sheth et al. 2018; Mohammadzadeh and Safdari 2014; Stewart et al. 2018). There are also some studies that draw attention to the possibility of a higher risk for genitourinary complications and salvage therapy for men undergoing robotic prostatectomy (Jacobs et al. 2013).
Shorter Hospital Stays & Earlier Return to Regular Human Activities \F	Many studies show that patients who have an operation with RAS may stay at the hospital for a shorter period and return to regular human activities earlier (Abdollah et al. 2017; BenMessaoud et al. 2011; Esen et al. 2018; Kim et al. 2009; Lendvay et al. 2013; Lim et al. 2011; Mendivil et al. 2009; Mohammadzadeh and Safdari 2014; Nasser et al. 2020; Ng et al. 2010; Sivarajan et al. 2015; Mendivil et al. 2009; Mohammadzadeh and Safdari 2014; Ng et al. 2010; Pruthi et al. 2010; Stewart et al. 2018; Nasser et al. 2020).
Operation Duration \F	While some studies show that robotic-assisted surgery operation duration is 27 minutes shorter compared to the others (Sheth et al. 2018), some of them show that it may be longer because of lacking haptic feedback (Abdollah et al., 2017). In addition, some studies state that surgeons get more experience, and the operation duration gets shorter (Abdollah et al., 2017). (Abdollah et al. 2017; Aradaib et al. 2018; BenMessaoud et al. 2011; Esen et al. 2018; Kim et al. 2009; Lim et al. 2011; Nasser et al. 2020; Sheth et al. 2018; Siaulys et al. 2021).
Ease of Initial Adoption (EIA)	Level 1 Criterion Main Factors are {Ease of Installation, Training Requirements}.

(cont. on the next page)

Table 4 (cont.)

Category or Factor Name	Description and Short Discussion
Ease of Installation \F	Robotic platforms are complex devices and require a large number of instruments to be installed. Some studies show that this is a barrier or disadvantage to the adaptation of RAS by surgeons and nurses. (Abdollah et al. 2017; BenMessaoud et al. 2011; Diana and Marescaux 2015; Vichitkraivin et al. 2020).
Training Requirements \F	These include training for all the procedures and operating practices that the surgeon and operating room staff need to perform the operation. It is extra training that specifically focuses on how to use the robotic surgery platform during the operation. Many studies show that it costs additional time and money, for the surgeons and operating room nurses, and this may be a barrier to adaptation (Abdollah et al. 2017; Aradaib et al. 2018; BenMessaoud et al. 2011; Diana and Marescaux 2015; Krishnan et al. 2018; Langhan et al. 2014; Lenihan 2017; Lendvay et al. 2013; Lenihan 2017; Lendvay et al. 2013; Mandapathil and Meyer 2021; Moriarty et al. 2016; Ploussard et al. 2010; Thompson et al. 2014; Vichitkraivin et al. 2020)
Ease of Use (EOU)	Level 1 Criterion Factors are {Tactile/Haptic feedback, Operation Duration, Enhanced Surgeon Ergonomics and Dexterity}
Tactile / Haptic Feedback \F	Haptic or tactile feedback relates to or involves the sense of touch. Many studies show that the absence of tactile/haptic feedback is a barrier or disadvantage to the adaptation of RAS by surgeons (BenMessaoud et al. 2011; Bogue 2021; Ghezzi and Corleta 2016; Lendvay et al. 2013; Mohammadzadeh and Safdari 2014; Williams et al. 2014).
Operation Duration\F	(Above)

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Table 4 (cont.)

Category or Factor Name	Description and Short Discussion
Enhanced Surgeon Ergonomics and Dexterity \F with Subfactors	Subfactors are {Multitasking, Tremor Abolition, Motion Scaling, Enhanced Visualization}
Multitasking \F	This technology enables surgeons to perform more than one process simultaneously. Many studies show that this is an important factor in the decision to adopt robotic-assisted surgery by increasing the accuracy of the operation (BenMessaoud et al. 2011; Fanfani et al. 2015; Lendvay et al. 2013; Mohammadzadeh and Safdari 2014; Nasser et al. 2020; Pernar et al. 2017; Siaulys et al. 2021; Stewart et al. 2018; Williams et al. 2014).
Tremor Abolition \F	Many studies show that this is an important factor in the decision to adopt robotic-assisted surgery by eliminating the hand tremor of the surgeon during the operation. Studies state that it enhances the surgeons' dexterity and facilitates complex procedures (BenMessaoud et al. 2011; Ghezzi and Corleta 2016; Nasser et al. 2020; Mohammadzadeh and Safdari 2014).
Motion Scaling \F	Motion Scaling, in robotic surgery, is the conversion of the surgeon's large hand movements into smaller movements of the surgical instrument in the operative field. (medical-dictionary.thefreedictionary.com) Many studies show that this is an important factor in the decision to adopt robotic-assisted surgery by enhancing the surgeons' dexterity and facilitating complex procedures (BenMessaoud et al. 2011; Ghezzi and Corleta 2016; Mohammadzadeh and Safdari 2014; Nasser et al. 2020).
Enhanced Visualization \F	Many studies show that this is an important factor in the users' (surgeons') decision to adopt robotic-assisted surgery by attracting them to many enhanced functions including high-quality 3D vision, enhanced depth of vision, stable and magnified image, and remote 3-dimensional vision with an eye-tracking camera control system. (BenMessaoud et al. 2011; Diana and Marescaux 2015; Fanfani et al. 2015; Mohammadzadeh and Safdari 2014; Nasser et al. 2020)

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Table 4 (cont.)

Category or Factor Name	Description and Short Discussion
Economics	Level 1 Criterion {Costs, Benefits and Hospital Quality Procedures}
Costs	It is an umbrella term that states how expensive robotic surgery technology/platform is – purchasing cost, maintenance fee per year, and instruments that have limited use, and almost no incentives for hospitals and surgeons. Many studies show that RAS is more expensive compared to traditional laparoscopy and open surgery.
\F with Subfactors	(Abdollah et al. 2017; Alanazi and Daim 2021; Barbash and Glied 2010; Barbash et al. 2014; Bogue 2021; Diana and Marescaux 2015; Esen et al. 2018; Fanfani et al. 2015; Garber et al. 2014; Ghezzi and Corleta 2016; Goh and Teo 2020; Hohwü et al. 2009; Jacobs et al. 2013; Lendvay et al. 2013; Lenihan 2017; Lim et al. 2011; Makarov et al. 2010; Mandapathil and Meyer 2021, Martino et al. 2011; Mohammadzadeh and Safdari 2014; Mouraviev et al. 2007; Nasser et al. 2020; Scales et al. 2005; Sheth et al., 2018; Siaulys et al. 2021; Sivarajan et al. 2015; Stewart et al. 2018; ; Williams et al. 2014). On the other hand, some studies state that robotic-assisted surgery has lower costs (Abdollah et al. 2017). Some studies state that higher costs of robotic-assisted surgery procedures may tend to decrease by entering the new producers of robotic platforms into the market (Diana and Marescaux et al. 2015).
Purchase Cost \F	The initial cost of the RAS platform. (Jacobs et al. 2013; Stewart et al. 2018; Turchetti et al. 2011)
Operation and Maintenance Costs, Including Materials \F	As named. (Barbash and Glied 2010; Bolenz et al. 2010; Bolenz et al. 2014; Higgins et al. 2016; Jacobs et al. 2013; Stewart et al. 201; Turchetti et al. 2011; Williams et al. 2014)

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Table 4 (cont.)

Category or Factor Name	**Description and Short Discussion**
Benefits & Hospital Quality Procedures \F with Subfactors	The infrastructure and the surgeons' dexterity of the hospitals. Some studies show that the area, including the hospitals in competition that acquired robotic surgery platforms are more likely to attract new patients through their technology. In addition, studies state that larger hospitals, teaching hospitals, and hospitals are chosen by patients who have private insurance coverage, and hospitals with more surgical specialists are more likely to acquire robotic surgery technology/platform (Aggarwal et al. 2017; Barbash et al. 2014; Jacobs et al. 2013; Williams et al. 2014).
RAS Helps Attract New Patients \F	Some studies show that the shorter recovery time, less complication rate during the operation and after it, small incisions, less blood loss compared to open surgeries, fewer readmission rates, aesthetic concerns, reduced postoperative pain, lower incidence of wound infections, etc. are the determinants to attract new patients (BenMessaoud et al. 2011). Some studies show that the areas, including the hospitals in competition that acquired robotic surgery platforms are more likely to attract new patients through their technology. In addition, studies state that larger hospitals, teaching hospitals, and hospitals are chosen by patients who have private insurance coverage, and hospitals with more surgical specialists are more likely to acquire robotic surgery technology/platform (Aggarwal et al. 2017; Barbash et al. 2014; Jacobs et al. 2013; Stitzenberg et al. 2011; Makarov et al. 2011; Williams et al. 2014).
RAS Helps Attract Better Surgeons \F	Many studies show that RAS platforms have many features to help to improve surgeons' dexterity and ergonomics during the operation. (BenMessaoud et al. 2011; Fanfani et al. 2015; Jacobs et al. 2013; Siaulys et al. 2021)

(cont. on the next page)

Table 4 (cont.)

Category or Factor Name	**Description and Short Discussion**
Factors that are left out of the study	Some adoption factors that are of interest to the larger literature on technology adoption are left out, such as having colleagues or competitors who have adopted RAS (peer effects) or having a supporting managerial environment (leadership effects). These are factors that are studied by previous literature on RAS adoption (Makarov et al. 2011; Lenihan 2017) as well as in technology adoption at large and are understood as critical technology adoption factors in general. We leave them outside our investigation to focus on factors specifically important for the RAS adoption decisions of surgeons and hospitals.

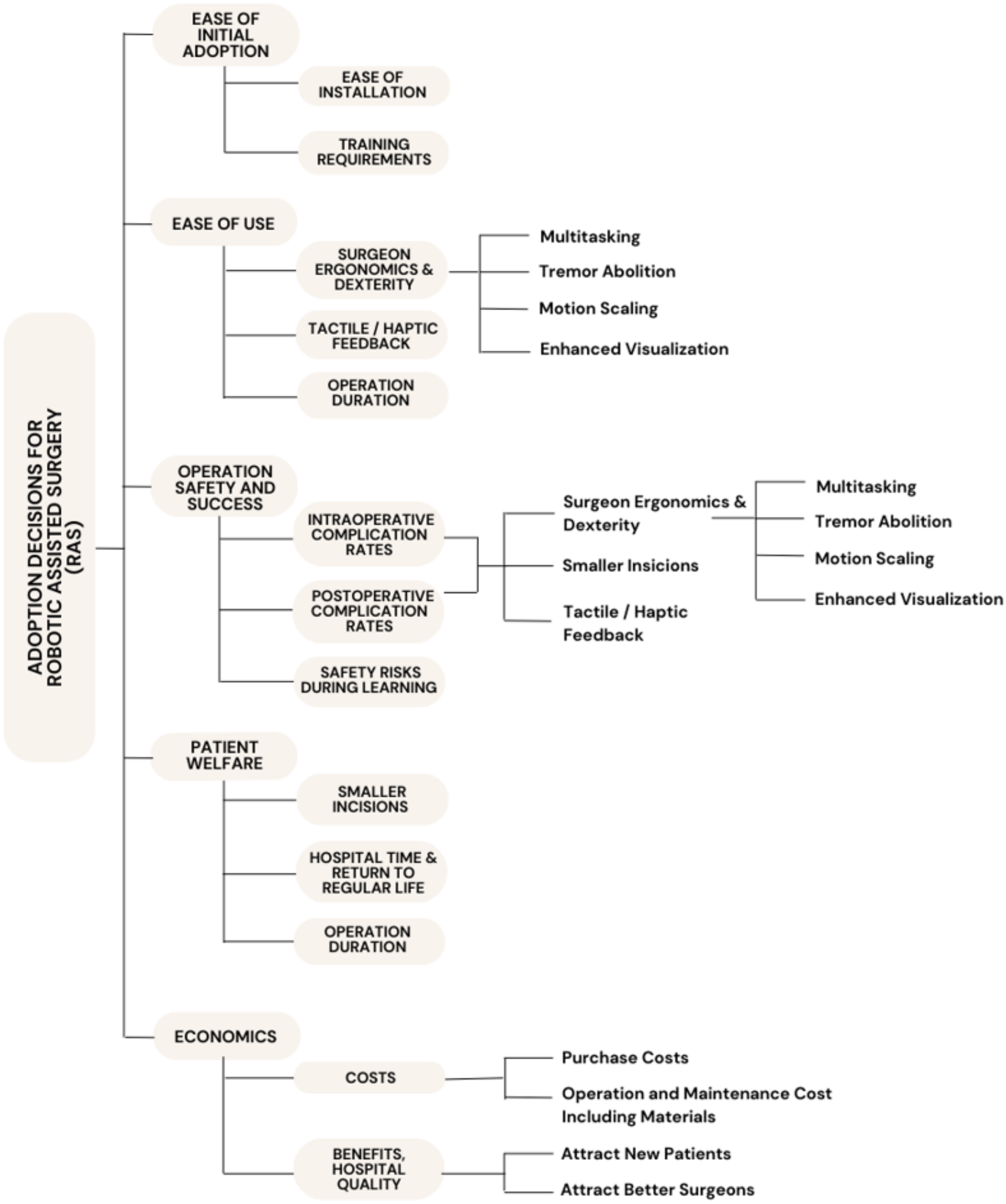

Figure 1: Robotic-Assisted Surgery Adoption AHP Tree

3.4.1.2. Adoption Criteria, Sub-Criteria, and Factors of Robotic-Assisted Surgery

A comprehensive literature review investigates the factors influencing surgeons' adoption of robotic-assisted surgery. After examining all the factors, a careful taxonomy was developed based on the Analytical Hierarchical Process (AHP). Finally, a unique AHP Tree for this study was created. The impacts of these factors in the existing literature are discussed to understand each classification better.

3.4.1.2.1. Ease of Initial Adoption

The AHP branch of Ease of Initial Adoption involves Ease of Installation and Training Requirements. As explained above, both factors have primarily adverse effects on the adoption process of RAS by surgeons and operation room staff. The reason for creating this branch is a standard part of these factors, which provide the required infrastructure to start and perform an RAS operation.

3.4.1.2.2. Ease of Use

The Ease of Use cluster consists of three sub-criteria named Enhanced Surgeon Ergonomics and Dexterity, Tactile/Haptic feedback, Operation Duration, and the factors that affect Enhanced Surgeon Ergonomics and Dexterity, which are Multitasking, Tremor Abolition, Motion Scaling, and Enhanced Visualization. In this study, the name Ease of Use is the preferred use for one of the main criteria of our study's AHP hierarchy; it has a name resemblance but is not related to the context of the study by Davis (Davis 1989).

3.4.1.2.3. Operation Safety and Success

This branch of our AHP tree entails three layers. The first one includes Intraoperative Complication Rates, Postoperative Complication Rates, and Safety Risks During Learning. The second consists of Surgeon Ergonomics and Dexterity, Smaller Incisions, and Tactile/Haptic Feedback. The third comprises Multitasking, Tremor Abolition, Motion Scaling, and Enhanced Visualization. These are all grouped under the name of Operation Safety and Success because, with all these factors, the objective is to provide a more accurate operation.

3.4.1.2.4. Patient Welfare

Patient welfare is vital, and some factors have an impact on this issue. In this study, Smaller Incisions, Hospital Time and Return to Regular Life, and Operation Time are considered as related to patient welfare and grouped under that name.

3.4.1.2.5. Economics

Considering RAS adoption by surgeons and operating room staff, economics is a topic to handle carefully. We separate the economics branch into two sub-branches: Costs and Benefits and Hospital Quality. Costs group includes Purchase Costs and Attract New Patients and Attract Better Surgeons.

3.5. Survey Design

Survey Monkey online survey platform was chosen to create a questionnaire to gather data for our study. We decided to design the pairwise comparison questions in Matrix of Dropdown Menu format. To gather data, an online survey was created in two languages, Turkish and English. The order of all information and questions is the same in both languages. Since there are two language options, two separate web links for each survey have been created. The design of the survey depends on a logical foundation. It starts with a general and brief explanation of the research aim and methodology. Our questionnaire includes forty-five questions in total. 35 out of 45 questions ask respondents to make pairwise comparisons. Firstly, we ask about the surgeons' age intervals. Then, it continues with an open-ended question asking about the specializations of physicians. In the third question, we would like to learn which procedures the surgeon applies in his/her surgical practice. The fourth question is to understand the surgeons' practicing intention in considering RAS. The reason for asking for the title of surgeon is to understand their competence. Right after this question, we are trying to understand surgeons' managerial competence with the sixth question. Questioning the workplace also provides important information for our research, so the seventh question concerns this. Question eight asks for information related to where they live. 9th and 10th questions attempt to receive surgeons’ email addresses and ask permission to contact them for further inquiries.

Pairwise comparisons of the survey start with the 11th question regarding Operation Safety and Success. The reason for starting the survey by considering this criterion is that it is vital to lead to the successful completion of the surgery by lowering intraoperative and postoperative complication rates after the learning curve has passed, and paying great attention to safety risks during learning refers to time learning curve not passed yet. Intraoperative and postoperative complications groups have the same factors because of the nature of the operation. These factors may affect these criterion results. To keep the survey as lean as possible and to prepare it in the most compact way for helping to take the surgeons’ time as little as possible, we avoid creating the same questions for the same branches and groups of the AHP Tree of our research. A good example of this is the Surgeon Ergonomics and Dexterity group. The Surgeon Ergonomics and Dexterity group includes Multitasking, Tremor Abolition, Motion Scaling, and Enhanced Visualization. All factors facilitate the surgeons’ operational skills and allow them to work more efficiently, providing more comfortable working conditions. The components of both Intraoperative and Postoperative Complication Rates are Surgeon Ergonomics and Dexterity, Smaller Incisions, and Tactile/Haptic Feedback. All these factors have some impact on the complications of the operations, as mentioned in the literature. While Surgeon Ergonomics and Dexterity and Smaller Incisions allow to lower the complication processes, lack of Tactile/Haptic Feedback is an obstacle to feeling resistance during operation. In total, fifteen pairwise questions are prepared to learn from surgeons' experience considering this criterion. The section includes three sub-criteria: Intraoperative Complication Rates, Postoperative Complication Rates, and Safety Risks During Learning. These sub-criteria consist of the first three pairwise comparison questions of the survey. Then, a four-question pairwise comparison helps us understand which factors – multitasking, tremor abolition, motion scaling, and enhanced visualization – prioritize surgeon ergonomics and dexterity the most. After that, for both Intraoperative and Postoperative Complication Rates, pairwise comparison questions were created separately to evaluate Surgeon Ergonomics and Dexterity, Smaller Incisions, and Tactile/Haptic Feedback priorities for surgeons in these two separate time processes.

After completing all questions regarding the Operation Safety and Success criterion, the second one in our survey is Patient Well-Being and Welfare. This category is defined as all factors that improve the well-being of the patient. Since there is a separate category for Operation Safety and Success, here it is preferred to avoid focusing on the factors that directly relate to Operation Safety and Success. For these reasons, the Patient Well-Being and Welfare group consists of Smaller Incisions, Hospital Time and Return to Regular Life/Shorter Hospital Stays, and Operation Duration. Three pairwise questions are created to ask the physicians regarding this criterion.

The third criterion is called Ease of Use. This category refers to factors that make the platform more straightforward to use. It comprises Surgeon Ergonomics and Dexterity, Operation Duration, and Tactile/Haptic Feedback. Current RAS platforms are known to enhance Surgeon Ergonomics and Dexterity and reduce Operation Duration. However, the absence of Tactile/Haptic Feedback is noted as a significant drawback. Surgeons find three pairwise questions to be answered in this section.

Criterion four is Ease of Initial Adoption, which refers to factors facilitating or inhibiting the accessibility of the RAS platform for the hospital. Two factors for this category are considered: Ease of Installation and Training Requirements. This criterion includes one pairwise question to be asked to participants.

Economics is the fifth and last criterion of the survey. This criterion describes all factors related to monetary costs and benefits for the surgeon or the hospital. We consider Initial Purchase Costs and Operation Costs separately, as well as Benefits (Including Quality Procedures). Potential benefits of the RAS platform include Attracting New Patients and Attracting Better Surgeons for the hospital or practice. Under this criterion, three pairwise comparison questions were asked of participants. Additionally, the survey design allows the participants to skip this section if they are unfamiliar with Economic considerations such as a hospital’s unit making the purchase decision.

The last pairwise comparison questions comprised the main criteria for the adoption decision of RAS. The surgeons’ decisions to adopt a RAS platform and the relative importance of each of the five main criteria were asked of the physicians in this part of the survey, including ten questions in total. These five main criteria are

Operational Safety and Success, Patient Well-Being and Welfare, Ease of Use, Ease of Initial Adoption, and Economics.

Then, as the last part of the survey, we thank the surgeons who contributed to our study. The survey is given in Appendix A in Turkish and English.

3.6. Data Collection

Data are gathered via an online questionnaire tailored to the hierarchical structure of the criteria and underlying factors to be examined for RAS. In this study, we present the results of the data we obtained until the 15th of February 2024. We plan to keep the survey open till the end of March/April 2024 for further paper research. AHP does not require (though definitely benefits from) a great number of survey responses to generate meaningful results since the process is not statistical but is based on the quantification of individual (expert) priorities.

On the 20th of January 2024, we started to conduct the survey. Since that day, to all the robotic surgeons in Turkey, whose names are found on https://www.davincicerrahisi.com/robotik-cerrahi-yapan-hastaneler/ this link on the 22nd of May 2022, at 14:02 in the GMT+3 time zone, the survey links sent by email to 154 surgeons out of 196. 42 surgeons' information out of 196 could not be found on the internet, and unfortunately, for this reason, we could not send the web links of our survey to them. Some social media platforms were also used to reach the surgeons. These platforms are Instagram and LinkedIn. While 14 surgeons out of 154 were sent a message on Instagram, 4 physicians out of 154 were reached by LinkedIn. Both language versions' web links of the survey were shared with some specialization associations such as Türk Üroloji Derneği, Jinekolojik Cerrahi Derneği, Türk Cerrahi Derneği, Robotik Ortopedi Cerrahi Derneği via sending email to its chairman, Transoral Robotik Cerrahi Derneği by sending email to its founding chairman, Türkiye Endoskopik ve Laparoskopik Cerrahi Derneği through sending email to its chairman. Additionally, we have used our private and individual connections to undertake a pilot study that tested the survey as well as checked the appropriateness of the AHP tree and classification, and to obtain survey responses. We have added a professional surgeon working in the field of General Surgery in Turkey, who helped distribute the survey within Turkish and international Surgeon communities.

While analyzing the first received data, some missing values were recognized. Then, both survey links were sent to the physicians who had already attempted to complete the survey and shared their email addresses, allowing them to contact them for further information to avoid missing values. This process was executed two times in a row.

After all that endeavor, 74 surgeons participated in the survey in total. 59 surgeons preferred the Turkish version of the survey while 15 surgeons took it in English. 41 responses had useful data to be analyzed. 33 out of 41 were Turkish version of the survey and the rest of 8 were English. Among them 15 surveys were responded to completely. 14 out of 15 were chosen in Turkish but only 1 was in English.

The details of the survey participants' demography are shown in Table 5.

Table 5: Demographic Information of the Surgeons.

Surgeon ID	Age	Specialty	Procedure	Title	Administrative Duties	Working Place
1	45-54	Bariatric Surgery	Laparoscopy	Professor	None	Runs own surgical practice
2	55-64	Brain and Nerve Surgery	Open Surgery	Attending Physician	None	Works for a hospital and university
3	55-64	Cardiac Surgery	Open Surgery RAS	Professor	Director of the Surgical Department	Works for a hospital
4	25-34	Cardiac Surgery	Open Surgery Laparoscopy RAS	Attending Physician	None	Works for a university
5	45-54	Cardiac Surgery	Open Surgery RAS	Professor	Vice-Dean	Works for a hospital and university
6	25-34	Colorectal Surgery	Open Surgery Laparoscopy	Attending Physician	None	Works for a hospital
7	35-44	Colorectal Surgery	Open Surgery Laparoscopy	Professor	Colleague	Runs own surgical practice
8	45-54	Colorectal Surgery	Open Surgery Laparoscopy RAS	Professor	Director of the Surgical Department	Works for a hospital

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Table 5 (cont.)

Surgeon ID	Age	Specialty	Procedure	Title	Administrative Duties	Working Place
9	45-54	Endourology	Open Surgery Laparoscopy	Attending Physician	None	Works for a hospital
10	55-64	Gastrointestinal Surgery	Open Surgery Laparoscopy	Associate Professor	None	Works for a university
11	45-54	General Surgery	Open Surgery Laparoscopy RAS	Professor	Director of the Surgical Department	Works for a university
12	35-44	General Surgery	Open Surgery Laparoscopy RAS	Associate Professor	Chief Executive Officer / Chief Physician for the Hospital Director of the Surgical Department	Works for a university
13	35-44	General Surgery	Open Surgery Laparoscopy	Associate Professor	Director of the Surgical Department	Works for a hospital and university
14	35-44	General Surgery	Open Surgery Laparoscopy RAS	Associate Professor	None	Works for a hospital
15	45-54	General Surgery	Open Surgery Laparoscopy	Attending Physician	None	Works for a hospital
16	35-44	General Surgery	Open Surgery Laparoscopy RAS	Attending Physician	None	Works for a hospital
17	35-44	General Surgery	Open Surgery Laparoscopy RAS	Associate Professor	None	Works for a university
18	35-44	General Surgery	Open Surgery Laparoscopy	Attending Physician	None	Works for a hospital

(cont. on the next page)

Table 5 (cont.)

Surgeon ID	Age	Specialty	Procedure	Title	Administrative Duties	Working Place
19	35-44	General Surgery	Open Surgery Laparoscopy	Assistant Professor	Deputy of Liver Transplantation	Works for a university
20	65-plus	General Surgery	Open Surgery Laparoscopy RAS	Professor	None	Works for a hospital
21	45-54	General Surgery Gynecology	Open Surgery Laparoscopy	Attending Physician	None	Runs own surgical practice
22	45-54	Gynecologic Laparoscopic Surgery	Laparoscopy RAS	Associate Professor	Director of the Surgical Department	Works for a hospital and university
23	35-44	Gynecological Oncology	Open Surgery Laparoscopy RAS	Associate Professor	Director of the Surgical Department	Works for a hospital
24	35-44	Gynecological Oncology	Open Surgery Laparoscopy RAS	Associate Professor	None	Runs own surgical practice
25	45-54	Gynecology	Open Surgery Laparoscopy RAS	Professor	None	Works for a university
26	25-34	Maxillofacial Surgery	Open Surgery RAS	Attending Physician	None	Works for a hospital
27	55-64	Orthopedics and Traumatology	Open Surgery Laparoscopy	Attending Physician	None	Works for a hospital
28	45-54	Orthopedics and Traumatology	Open Surgery Laparoscopy	Attending Physician	None	Works for a hospital
29	45-54	Pediatric Surgery	Open Surgery Laparoscopy RAS	Associate Professor	None	Works for a university
30	55-64	Thoracic Surgery	Open Surgery Laparoscopy RAS	Professor	Director of the Surgical Department	Works for a hospital

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Table 5 (cont.)

Surgeon ID	Age	Specialty	Procedure	Title	Administrative Duties	Working Place
31	45-54	Urology	Open Surgery Laparoscopy RAS	Professor	None	Works for a hospital and university
32	45-54	Urology	Laparoscopy RAS	Professor	Urology Director	Runs own surgical practice
33	55-64	Urology	Open Surgery Laparoscopy RAS	Professor	None	Works for a university
34	45-54	Urology	Open Surgery Laparoscopy RAS	Professor	Director of the Surgical Department	Works for a hospital and university
35	55-64	Urology	Open Surgery Laparoscopy RAS	Professor	None	Works for a hospital and university
36	45-54	Urology	Open Surgery Laparoscopy RAS	Professor	Head of Urology Department	Works for a hospital
37	35-44	Urology	Open Surgery Laparoscopy	Attending Physician	None	Works for a hospital
38	55-64	Urology	Open Surgery Laparoscopy	Associate Professor	None	Runs own surgical practice
39	45-54	Urology	Open Surgery Laparoscopy RAS	Professor	None	Runs own surgical practice
40	35-44	Urology	Open Surgery Laparoscopy	Professor	None	Works for a hospital and university Runs own surgical practice
41	25-34	Urology	Open Surgery Laparoscopy RAS	Attending Physician	None	Works for a hospital

Note: Surgeon ID is randomly given for easier reference to individual surgeons while presenting results.

3.7. Data Analysis

We use an R package named the ahpsurvey developed by Frankiecho (Frankiecho 2018) to analyze our sample data from an online survey. This package provides a convenient working process that is adequately established for the AHP methodology. It was run on RStudio, which is an integrated development environment.

The ahpsurvey package has an appropriate infrastructure to run all the functions needed to execute an AHP method. It is also capable of working with a relatively big sample size. Including necessary codes to create an aggregated group decision matrix depends on the individual's preferences. In addition to all these properties, this package enables us to figure out the most inconsistent pairs that are the root cause of a decision-maker's confusion.

The first step of our data analysis is to create a pairwise comparison matrix for each respondent regarding their responses. Then, to obtain each individual's priority vectors, the eigenmethod was applied. After that, the consistency ratio was calculated for each decision-making matrix. Executing this process, a small number of missing values recognized in 26 responses were completed by imputations (Harker 1987).

The aggregated pairwise comparison matrices were produced to obtain the aggregated priority matrices and consistency ratios of the individuals who are consistent in their decisions, all decision-makers regardless of consistency situation, and the consistent surgeons from a particular discipline. The all aggregations result calculated by the geometric mean method. Then, we examined all results carefully and interpreted them.

3.8. Results

We now turn to the analysis of our survey responses. We use survey responses to construct decision matrices for all 11 branches of the AHP tree for all surgeons in our sample. We first obtain consistency ratios for all matrices larger than dimension 2x2, then obtain priority weights and interpret them individually, with respect to specific surgical disciplines, as well as the totality of all responses. Then, we conclude our analysis with aggregated priority vectors results and its interpretation for urology. The last part of the analysis of the survey responses examines the relation between the discipline-based aggregated priority vectors and the total aggregated priority vectors of all responses.

Before diving into the analysis recalling the relevant literature may help to develop an infrastructure to our interpretation. According to Saaty (Saaty 1980), inconsistency may exist if there are alternatives that are not easily differentiated from each other. Brunelli (Brunelli 2015) also states that consistent situations are rare due to the dynamics of real life and that there are various sudden and unexpected circumstances to deal with immediately. From another point of view, it is possible that survey respondents found AHP complicated and hard to understand its working mechanism (Cho and Kim 2003). Having many alternatives for this kind of problem makes the evaluation process dull and much harder (Cho and Kim 2003).

Saaty (Saaty 1980) emphasized that in reality, it is hard to obtain complete consistency although there are factors that may be compared easily between each other. Measuring their impact on the objective is the main issue that requires handling carefully (Saaty 1980). Saaty (Saaty 1980) accepted that the decisions made by individuals are frequently inconsistent, however, the main thing to be executed here is that the values of priorities must be determined, and the requirements fulfilled in spite of the inconsistency. Inconsistency causes a break in the fundamentals of proportionality, and it might also affect transitivity negatively (Saaty 1980).

In this study, we use the geometric mean method found by Aull-Hyde et al. (Aull-Hyde et al. 2006). The working principle of that method is that when the geometric mean method is used to aggregate the individuals' judgements, the group judgement can be taken as a separate person's decision considering the whole group as one person (Aull-Hyde et al. 2006). In that case, the group decision result could be consistent, even if the individuals' comparison results are inconsistent (Aull-Hyde et al. 2006). The study emphasized two mains, which are pairwise comparison matrices dimension and group extension, parameters that may affect this situation (Aull-Hyde et al. 2006). The study shows these are inversely related (Aull-Hyde et al. 2006). The working principle of the geometric mean method, having low sensitivity to great degrees compared to arithmetic mean, is the root cause (Aull-Hyde et al. 2006).

We note that many responses were indeed inconsistent. Therefore, we begin with an analysis of consistency and inconsistency in our responses.

3.8.1. Analysis of Consistency and Inconsistency

Considering all comparison matrices in the context of this study, each of them, except (2x2) matrices, needed to be examined at their consistency ratio results. The following figures show the result of each comparison matrices' consistency ratio compliance for all observations according to their original consistency ratio calculations in compliance with the original consistency ratio ($CR \leq 0.10$). The following table shows the definitions of the matrices and factor keys used in the figures.

Table 6: Matrices and Factors Keys Definitions.

Matrix' Keys	Factor' Names	Factor' Keys
OSS	Operation Safety and Success	OSS
OSS	Intraoperative Complication Rates	ICR
OSS	Postoperative Complication Rates	PCR
OSS	Safety Risks During Learning	RDL
SED	Surgeon Ergonomics and Dexterity	SED
SED	Multitasking	MLT
SED	Tremor Abolition	TR
SED	Motion Scaling	MS
SED	Enhanced Visualization	EV
ICR	Intraoperative Complication Rates	SI_ICR
ICR	Tactile/Haptic Feedback	T/HF_ICR
ICR	Surgeon Ergonomics and Dexterity	SED_ICR
PCR	Smaller Incisions	SI_PCR
PCR	Tactile/Haptic Feedback	T/HF_PCR
PCR	Surgeon Ergonomics and Dexterity	SED_PCR
PW	Smaller Incisions	SI_PW
PW	Shorter Hospital Stays	SHS
PW	Operation Duration	OD_PW
EOU	Tactile/Haptic Feedback	T/HF_EOU
EOU	Operation Duration	OD_EOU
EOU	Surgeon Ergonomics and Dexterity	SED_EOU

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Table 6 (cont)

Matrix' Keys	Factor' Names	Factor' Keys
EIA	Ease Of Installation	EOI
EIA	Training Requirements	TR
ECON_B	Attract New Patients	ANP
ECON_B	Attract Better Surgeons	ABS
ECON_C	Initial Purchase Cost	PC
ECON_C	Operation and Maintenance Cost	OMC
ECON	Costs	Cost
ECON	Benefits for the Hospital/Practice	Benefit
MAIN	Economic Considerations/Economics	ECON
MAIN	Ease of Initial Adoption	EIA
MAIN	Ease of Use	EOU
MAIN	Patient Well-Being	PW
MAIN	Operational Safety and Success	OSS

3.8.1.1. Consistency of Operation Safety and Success (OSS) Matrices

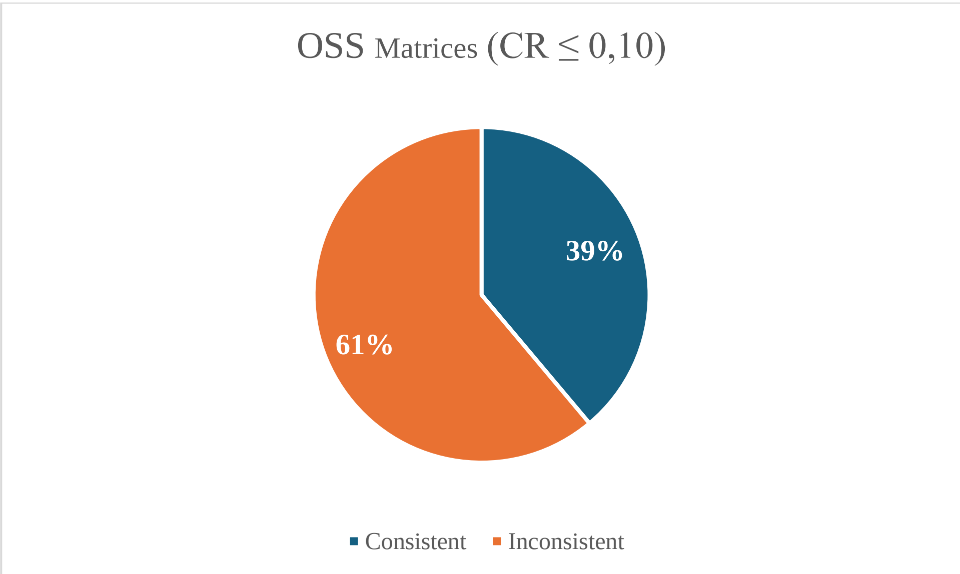
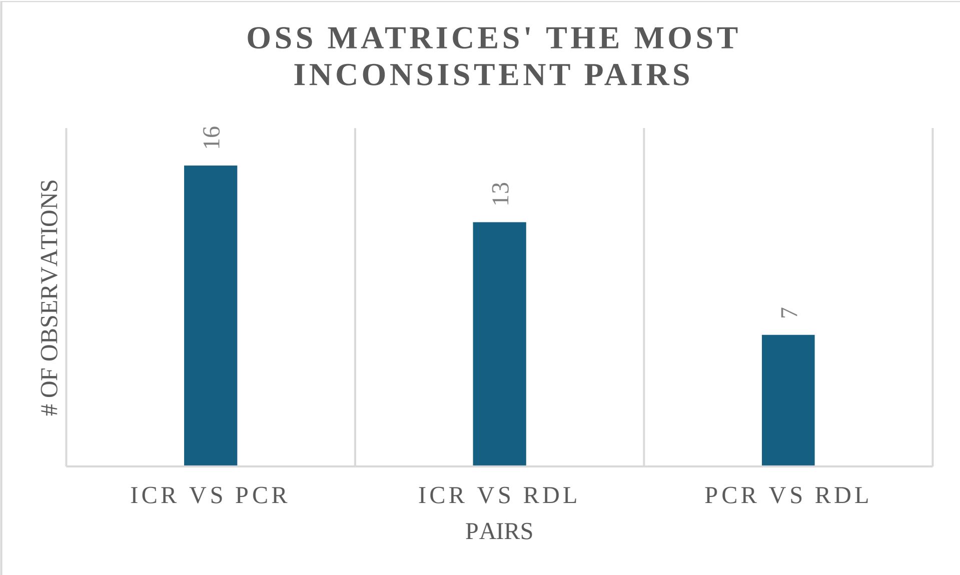


Figure 2: Operation Safety and Success (OSS) Matrices Consistency Ratio Results for All Observations

Operation Safety and Success (OSS) Matrices ($CR \leq 0.10$) Figure 2 shows that 39% of all surgeons who completed the Operation Safety and Success (OSS) matrices made consistent decisions. The rest's decisions were inconsistent. In total, 36 surgeons have completed the Operation Safety and Success (OSS) matrices. Thus, 39% equals 14 surgeons, while 61% equals 22. They compared the Intraoperative Complication Rates (ICR), Postoperative Complication Rates (PCR), and Safety Risks During Learning (RDL) sub-criterions of each other in pairs.



Abbreviations: OSS: Operation Safety and Success, ICR: Intraoperative Complication Rates, PCR: Postoperative Complication Rates, RDL: Risks During Learning

Figure 3: OSS Matrices Pairs Inconsistency

Figure 3 above shows the inconsistent number of observations in pairs. Considering the Operation Safety and Success (OSS) criterion, comparing the Intraoperative Complications Rates (ICR) and Postoperative Complication Rates (PCR) pair is the most inconsistent with the 16 observations out of 36. According to the result, handling separately the complications as intraoperative and postoperative seem significant in the literature (Abdollah et al. 2017; Aggarwal et al. 2018; Diana and Marescaux 2015; Fletcher et al. 2018; Kim et al. 2013; Lim et al. 2011; Mohammadzadeh and Safdari 2014; Sheetz et al., 2020; Sheth et al. 2018; ; Siaulys et al. 2021; Sivarajan et al. 2015; Thompson et al. 2014; Williams et al. 2014), however, their differences cannot be clearly separated by the surgeons. They had difficulty evaluating the Intraoperative Complication Rates (ICR) versus Postoperative Complication Rates (PCR) pair. Combining the Intraoperative Complication Rates

(ICR) and Postoperative Complication Rates (PCR) under the name of complication rates regarding the whole procedure duration, from beginning to the end and after the operation, may help to decide more straightforwardly.

3.8.1.2. Consistency of Surgeon Ergonomics and Dexterity (SED) Matrices

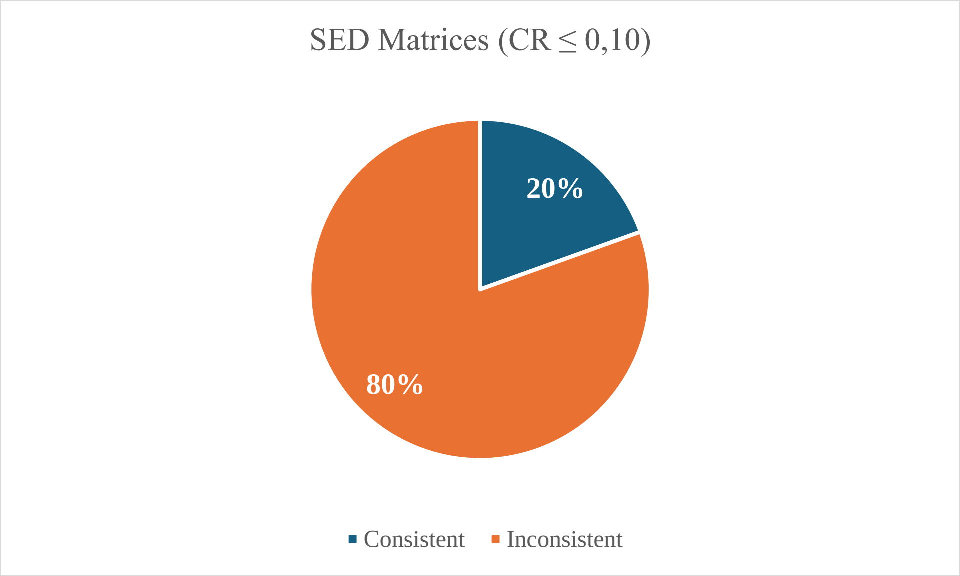
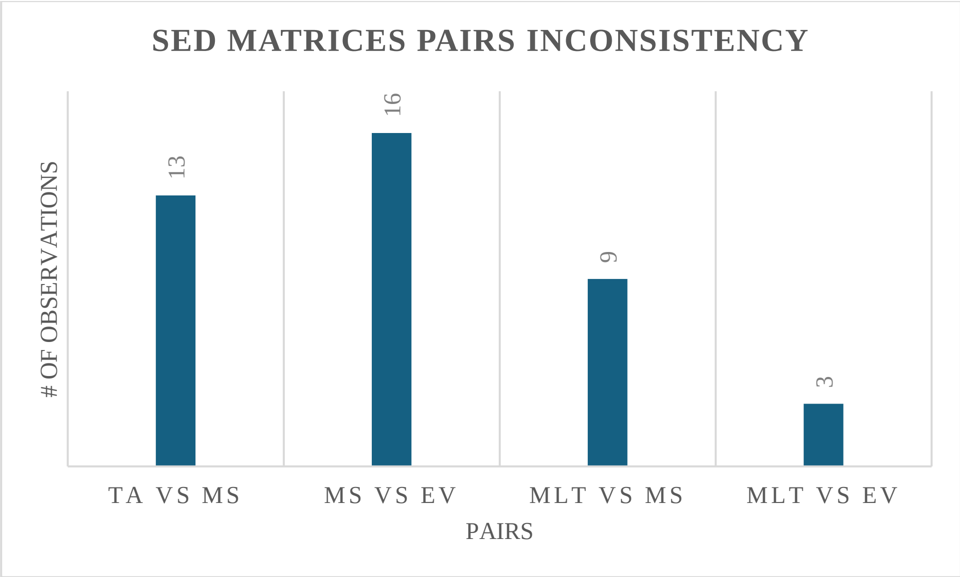


Figure 4: Surgeon Ergonomics and Dexterity (SED) Matrices Consistency Ratio Results for All Observations

Surgeon Ergonomics and Dexterity (SED) Matrices $(CR \leq 0.10)$ Figure 4 shows that 20% of all surgeons who completed the Surgeon Ergonomics and Dexterity (SED) matrices made consistent decisions by comparing the Multitasking (MLT), Tremor Abolition (TA), Motion Scaling (MS), and Enhanced Visualization (EV) factors against each other. The decisions of the rest are inconsistent with the situation of $(CR \leq 0.10)$. Forty-one surgeons completed the Surgeon Ergonomics and Dexterity (SED) matrix. Of these, 20% equals eight surgeons, and 80% equals 33 surgeons.



Abbreviations: SED: Surgeon Ergonomics and Dexterity

TA: Tremor Abolition, MS: Motion Scaling, MLT: Multitasking, EV: Enhanced Visualization

Figure 5: Surgeon Ergonomics and Dexterity (SED) Matrices Pairs Inconsistency

Figure 5 shows the inconsistent number of observations in pairs. Considering the Surgeon Ergonomics and Dexterity (SED) criterion, comparing the Motion Scaling (MS) vs Enhanced Visualization (EV) pair is the most inconsistent, with 16 observations out of 41. According to the result of this, the Motion Scaling (MS) and Enhanced Visualization (EV) pair found that it is hard to compare surgeons' Ergonomics and Dexterity (SED) during their practice.

3.8.1.3. Consistency of Intraoperative Complication Rates (ICR) Matrices

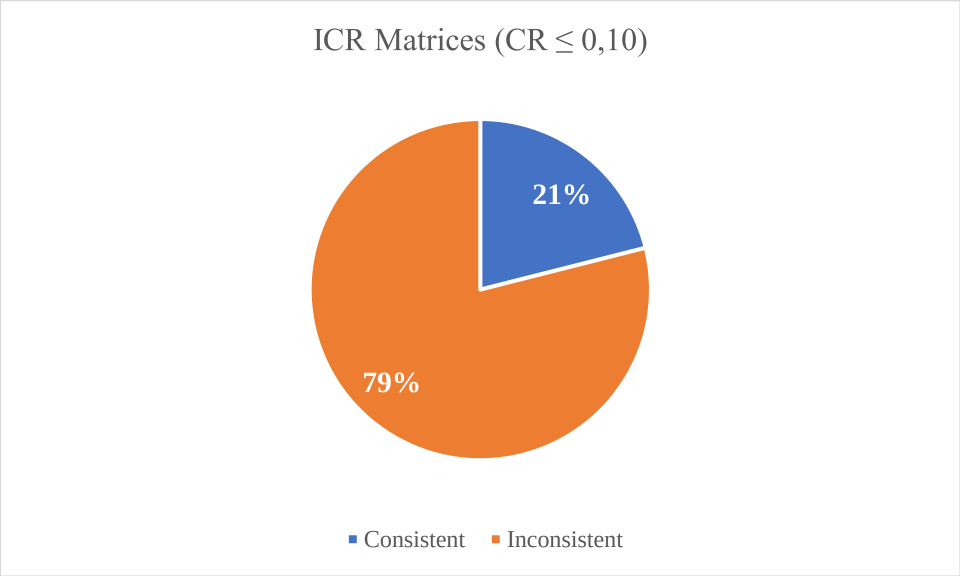
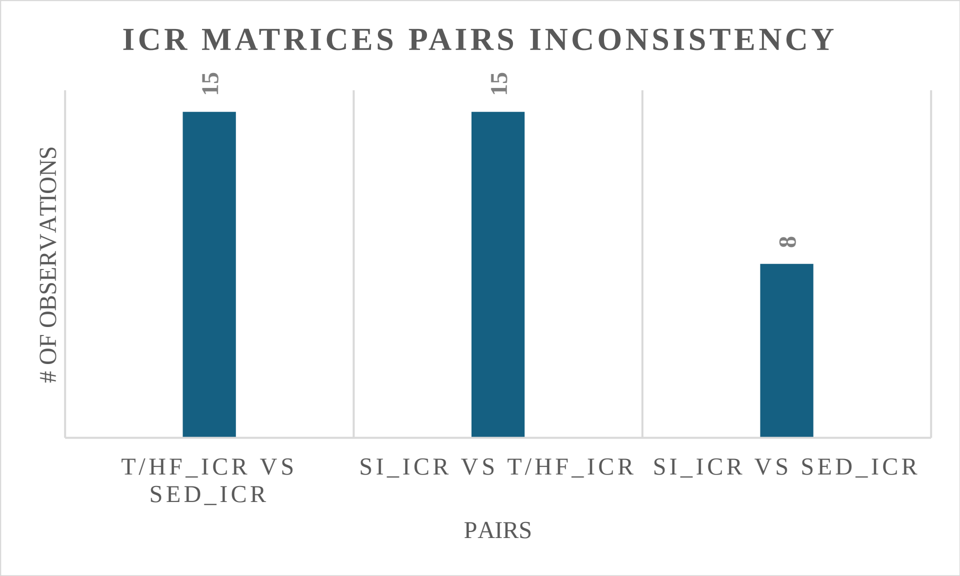


Figure 6: Intraoperative Complication Rates (ICR) Matrices Consistency Ratio Results for All Observations

Intraoperative Complication Rates (ICR) Matrices $(CR \leq 0.10)$ Figure 6 shows that 21% of all surgeons who completed the Intraoperative Complication Rates (ICR) matrices by pair of comparing Smaller Incisions (SI), Tactile / Haptic Feedback (T/HF), Surgeon Ergonomics and Dexterity (SED) are the factors each other, made consistent decisions. The remaining decision matrices were inconsistent according to $(CR \leq 0.10)$. In total, 38 surgeons have completed the ICR matrix. Thus, 21% equals 8 number of surgeons while 79% equals 30.



Abbreviations: ICR: Intraoperative Complication Rates, SI_ICR: Smaller Incisions for Intraoperative Complication Rates, T/HF_ICR: Tactile/Haptic Feedback for Intraoperative Complication Rates, SED_ICR: Surgeon Ergonomics and Dexterity for Intraoperative Complication Rates

Figure 7: Intraoperative Complication Rates (ICR) Matrices Pairs Inconsistency

Inferring from the figure above, comparing the Tactile/Haptic Feedback for Intraoperative Complication Rates (T/HF_ICR) versus Surgeon Ergonomics and Dexterity for Intraoperative Complication Rates (SED_ICR) pair and Smaller Incisions for Intraoperative Complication Rates (SI_ICR) versus Tactile/Haptic Feedback for Intraoperative Complication Rates (T/HF_ICR) pair are the most inconsistent when preferring by considering the Intraoperative Complication Rates (ICR) criterion, in the surgeons' perspective. Both share first place with 15 inconsistent observations for each out of 38. According to the result, the surgeons could not differentiate Tactile/Haptic Feedback for Intraoperative Complication Rates (T/HF_ICR) versus Surgeon Ergonomics and Dexterity for Intraoperative Complication Rates (SED_ICR) and Smaller Incisions for Intraoperative Complication Rates (SI_ICR) versus Tactile/Haptic Feedback for Intraoperative Complication Rates (T/HF_ICR) pairs sharply from each other. On the other hand, considering the Smaller Incisions for Intraoperative Complication Rates (SI_ICR) versus Surgeon Ergonomics and Dexterity for Intraoperative Complication Rates (SED_ICR) pair, this one seems relatively more consistent than the others. Removing Tactile/Haptic Feedback for Intraoperative

Complication Rates (T/HF_ICR) may provide a more convenient environment for pairwise comparisons regarding Intraoperative Complication Rates (ICR).

3.8.1.4. Postoperative Complication Rates (PCR) Matrices Consistency Ratio Results for All Observations

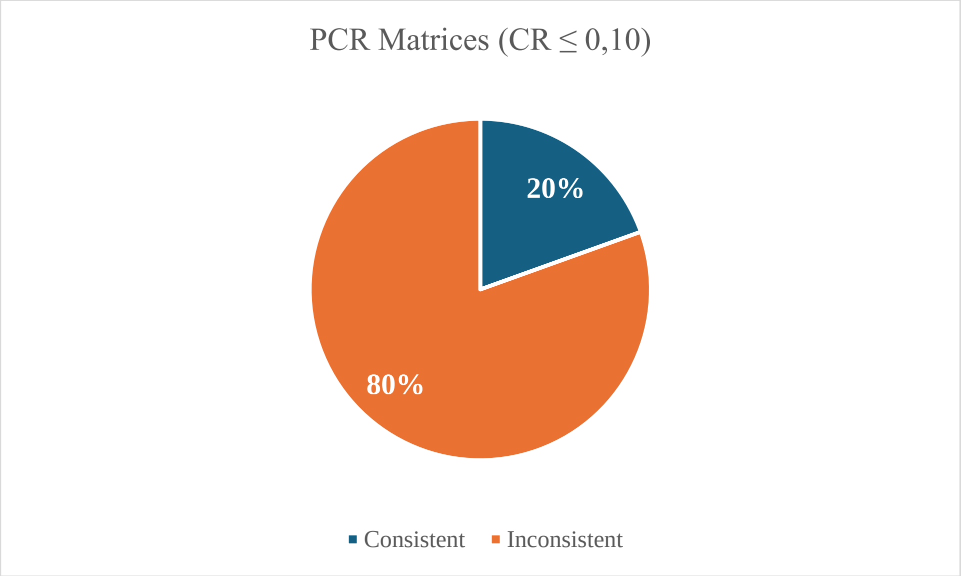
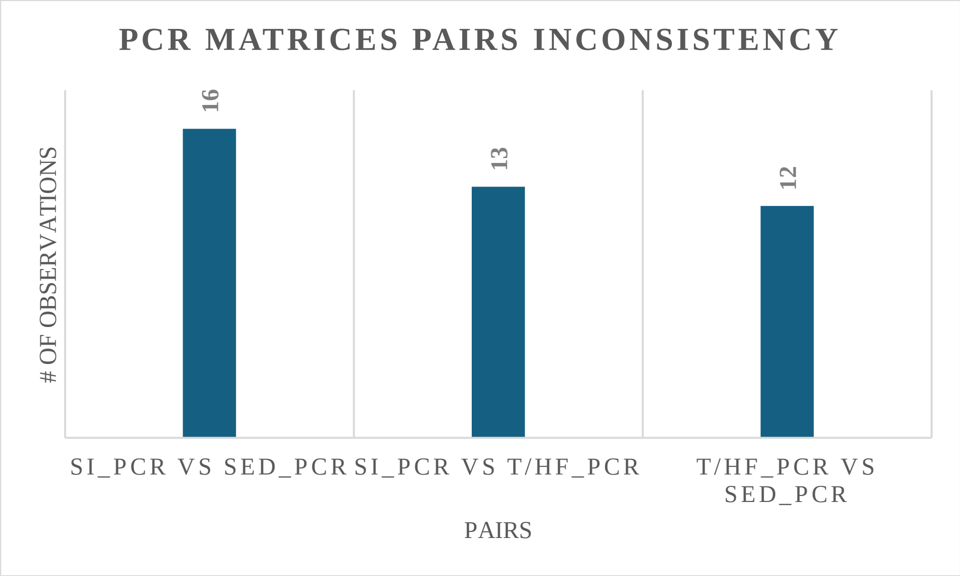


Figure 8: Postoperative Complication Rates (PCR) Matrices Consistency Ratio Results for All Observations

Postoperative Complication Rates (PCR) Matrices $(CR \leq 0.10)$ Figure 8 shows 20% of all surgeons who completed the Postoperative Complication Rates (PCR) matrices by comparing Smaller Incisions for Postoperative Complication Rates (SI_PCR), Tactile/Haptic Feedback for Postoperative Complication Rates (T/HF_PCR), and Surgeon Ergonomics and Dexterity for Postoperative Complication Rates (SED_PCR) the factors each other, made consistent decisions. The rest's decisions were inconsistent according to $(CR \leq 0.10)$ condition. In total, 41 surgeons have completed PCR matrices. Thus, 20% equals eight surgeons, while 80% equals 33.



Abbreviations: PCR: Postoperative Complication Rates, SI_PCR: Smaller Incisions for Postoperative Complication Rates, T/HF_PCR: Tactile/Haptic Feedback for Postoperative Complication Rates, SED_PCR: Surgeon Ergonomics and Dexterity for Postoperative Complication Rates

Figure 9: PCR Matrices Pairs Inconsistency

Figure 9 illustrates that surgeons' preferences relevant to the Postoperative Complication Rates (PCR) criterion, comparing Smaller Incisions for Postoperative Complication Rates (SI_PCR) versus Surgeon Ergonomics and Dexterity for Postoperative Complication Rates (SED_PCR) pair is the most inconsistent with 16 observations out of 41. According to this result, surgeons had difficulty deciding between smaller incisions and surgeon ergonomics and dexterity sub-criteria. The evaluation of the other two was also not easy for the surgeons, as the Figure shows. Another finding that was deduced is that the common factor of the top two pairs causes the most inconsistency. Thus, removing the Smaller Incisions for the Postoperative Complication Rates (SI_PCR) factor from that hierarchy level may be reasonable.

3.8.1.5. Patient Well-Being and Welfare (PW) Matrices Consistency Ratio Results for All Observations

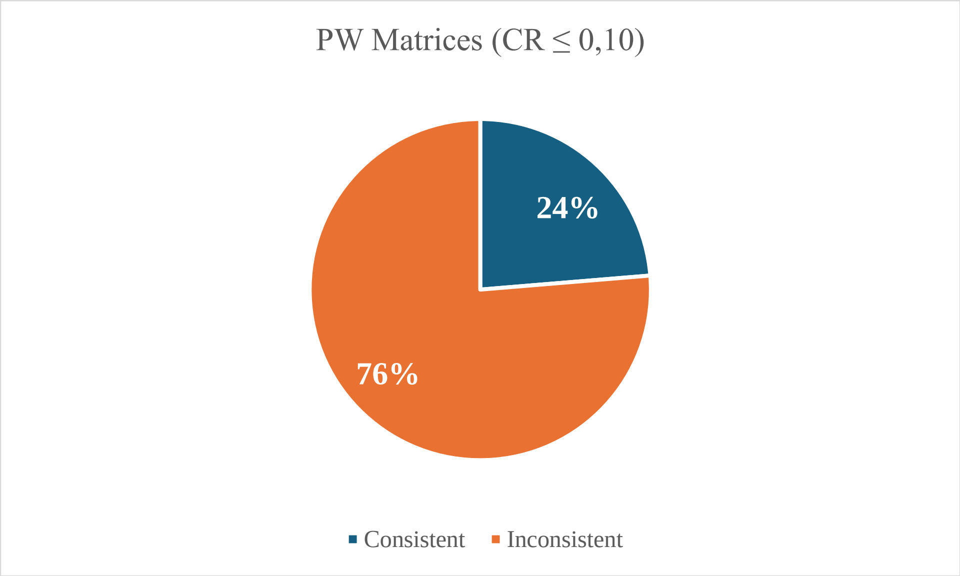
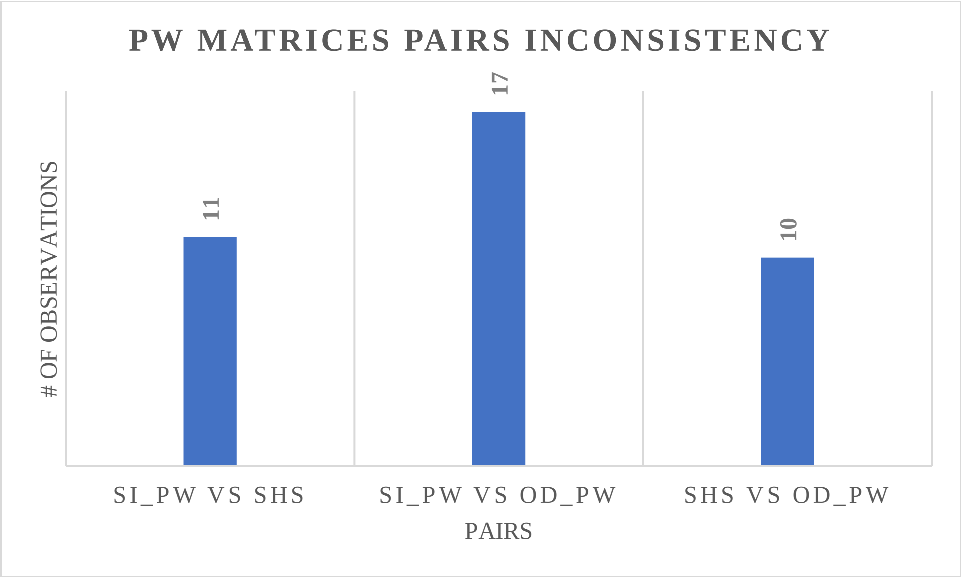


Figure 10: Patient Welfare (PW) Matrices Consistency Ratio Results for All Observations

The Patient Welfare (PW) $(CR \leq 0.10)$ Figure 10 shows that 24% of all surgeons who completed the Patient Welfare (PW) matrices by comparing Smaller Incisions for Patient Welfare (SI_PW), Shorter Hospital Stays (SHS), and Operation Duration for Patient Welfare (OD_PW) factors made consistent decisions. The rest's decisions were inconsistent according to $(CR \leq 0.10)$. In total, 38 surgeons have completed Patient Welfare (PW) matrices. Thus, 24% equals nine surgeons, while 76% equals 29.



Abbreviations: SI_PW: Smaller Incisions for Patient Welfare, SHS: Shorter Hospital Stays, OD_PW: Operation Duration for Patient Welfare

Figure 11: PW Matrices Pairs Inconsistency

Figure 11 shows that the Patient Welfare (PW) criterion, comparing Smaller Incisions for Patient Welfare (SI_PW) versus Operation Duration for Patient Welfare (OD_PW) pair, is the most inconsistent with 17 observations out of 38. As a result, surgeons had some difficulty deciding between Smaller Incisions for Patient Welfare (SI_PW) and Operation Duration for Patient Welfare (OD_PW) regarding Patient Well-Being and Welfare. When they compare the rest of the two pairs, it is obvious that the result of causing inconsistency level is almost the same. They differentiate from each other with only one observation. Hence, removing Smaller Incisions for Patient Welfare (SI_PW) or Operation Duration for Patient Welfare (OD_PW) alternatives from this hierarchy level may positively affect the study's consistent results.

3.8.1.6. Ease of Use (EOU) Matrices Consistency Ratio Results for All Observations

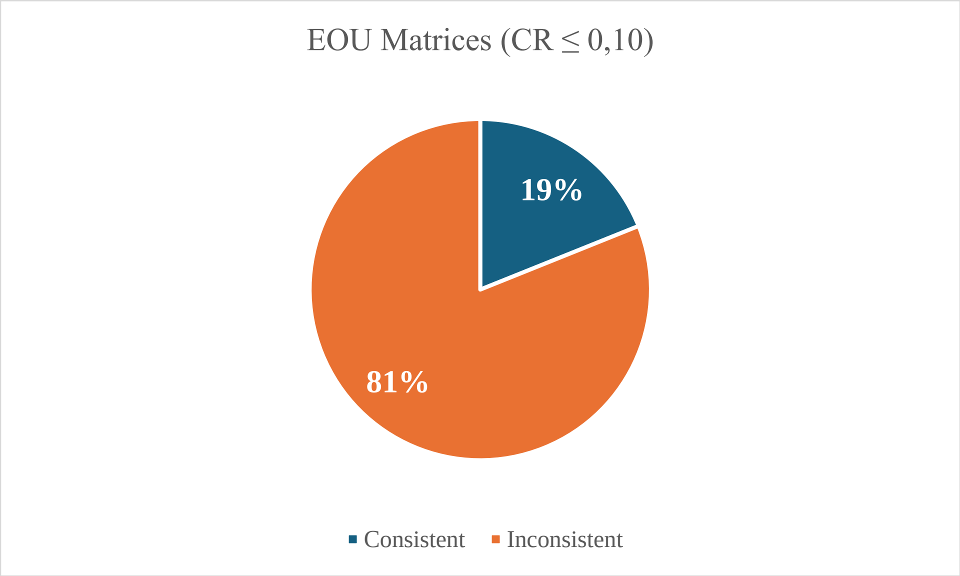
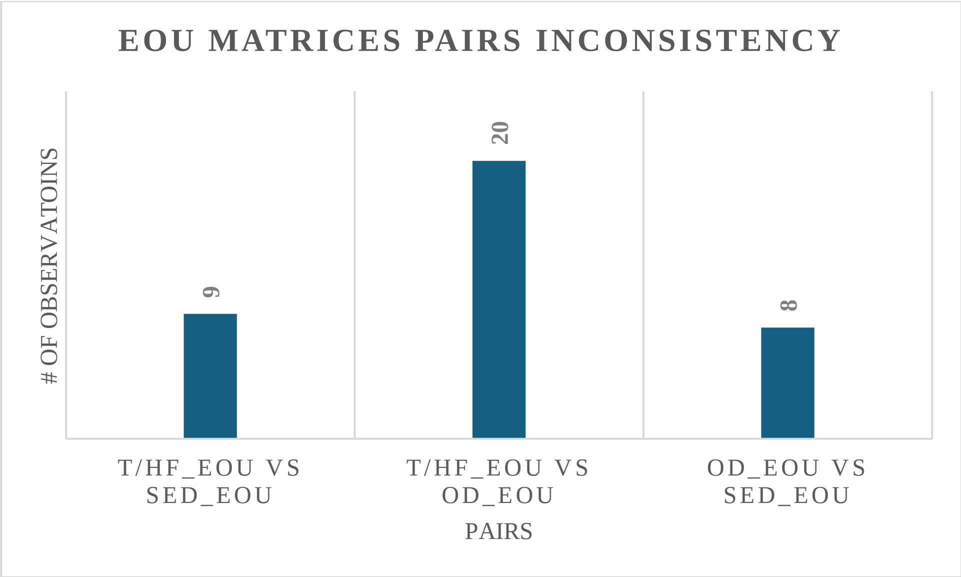


Figure 12: Ease of Use (EOU) Matrices Consistency Ratio Results for All Observations

Ease of Use (EOU) Matrices ($CR \leq 0.10$) Figure 12 shows that 19% of all surgeons who completed the Ease of Use (EOU) matrices by pair of comparing Surgeon Ergonomics and Dexterity for Ease of Use (SED_EOU), Operation Duration for Ease of Use (OD_EOU), Tactile/Haptic Feedback for Ease of Use (T/HF_EOU) factors each other, made consistent decisions. The rest's decisions were inconsistent according to ($CR \leq 0.10$). In total, 37 surgeons have completed Ease of Use (EOU) matrices. Thus, 19% equals seven surgeons, while 81% equals 30.



Abbreviations: T/HF_EOU: Tactile/Haptic Feedback for Ease of Use, OD_EOU: Operation Duration for Ease of Use, SED_EOU: Surgeon Ergonomics and Dexterity for Ease of Use

Figure 13: EOU Matrices Pairs Inconsistency

Figure 13 shows the inconsistent number of observations in pairs. Considering the Ease of Use (EOU) criterion, comparing the Tactile/Haptic Feedback for Ease of Use (T/HF_EOU) versus Operation Duration for Ease of Use (OD_EOU) pair is the most inconsistent with 20 observations out of 37. While evaluating Tactile/Haptic Feedback for Ease of Use (T/HF_EOU) over Operation Duration for Ease of Use (OD_EOU) regarding the Ease of Use (EOU) criterion, surgeons mostly found it hard to differentiate from each other. The data shows that they have quite a similar number of inconsistencies, with only one difference, which may be interpreted as these pairs not being found to have distinguishing characteristics. Since it is the common factor, it may have been a better way to initially remove the Tactile/Haptic Feedback for Ease of Use (T/HF_EOU) factor from the study.

3.8.1.7. MAIN Categories Matrices Consistency Ratio Results for All Observations

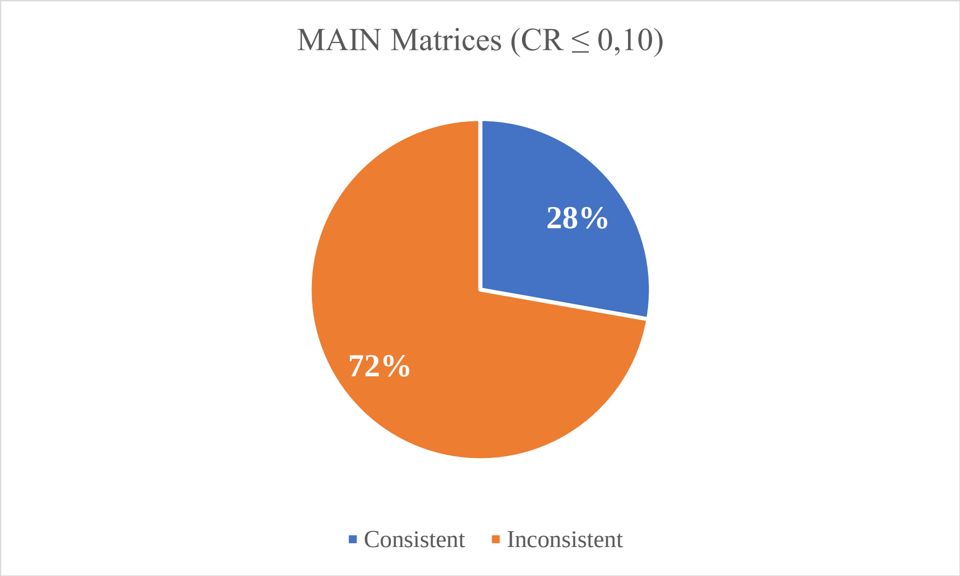
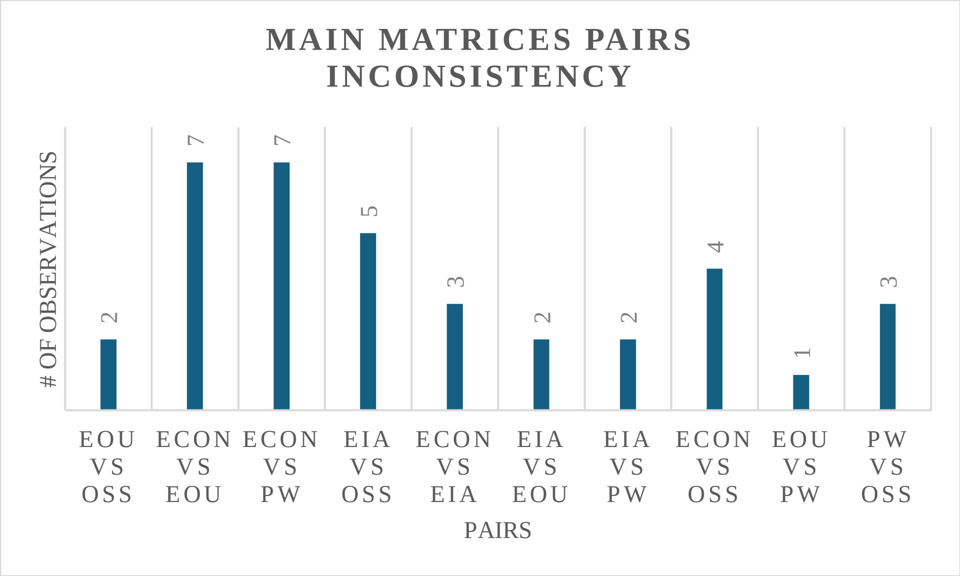


Figure 14: MAIN Matrices Consistency Ratio Results for All Observations

The MAIN Matrices ($CR \leq 0.10$) Figure 14 shows that 28% of all surgeons who completed the MAIN matrices by comparing Operation Safety and Success (OSS), Patient Well-Being and Welfare (PW), Ease of Use (EOU), Ease of Initial Adoption (EIA) and Economics (ECON) criteria each made consistent decisions The rest's decisions were inconsistent according to x condition. In total, 36 surgeons have completed MAIN matrices. Thus, 28% equals ten surgeons, while 72% equals 26.



Abbreviations: ECON: Economics, EIA: Ease of Initial Adaption, EOU: Ease of Use, PW: Patient Well-Being and Welfare, OSS: Operation Safety and Success

Figure 15: MAIN Matrices Pairs Inconsistency

As mentioned before, this study aims to evaluate the adoption factors for RAS to reach this goal. We determine five main criteria, and this graph shows these criteria's pairwise comparisons in the context of addressing the pair that causes the most inconsistency during decision-making preferences. Economics (ECON) versus Ease of Use (EOU) and Economics (ECON) versus Patient Well-Being and Welfare (PW) comparison pairs cause the same level of inconsistency, and they come front by sharing the being first at that with having seven observations for each. Thus, removing the Economics (ECON) criterion from this study's AHP tree may provide a higher consistency level by making the surgeons focus more deeply on the RAS platform's technical properties and the patient's side.

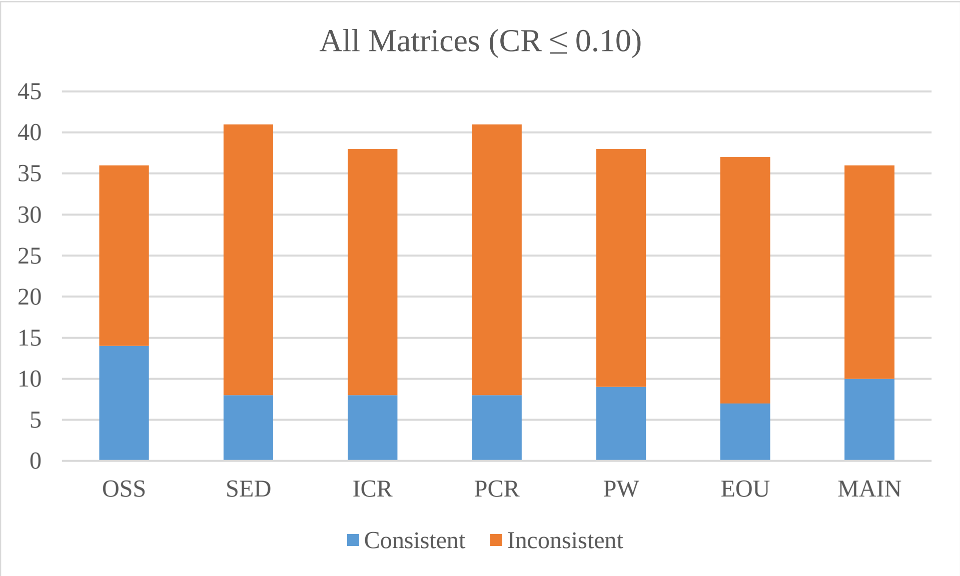
3.8.2. Consistent and Inconsistent Responses for all Decision Matrices

This section presents consistency ratio calculations for all pairwise matrices in terms of the number of observations and percentages. The findings of the data are shown as follows.

Table 7: Summary of Consistent and Inconsistent Decisions of All Surgeons

Matrice Name/CR Condition	OSS	SED	ICR	PCR	PW	EOU	MAIN
Consistent	14	8	8	8	9	7	10
Inconsistent	22	33	30	33	29	30	26
Percentage	0.39	0.20	0.21	0.20	0.24	0.19	0.28

Abbreviations: OSS: Operation Safety and Success, SED: Surgeon Ergonomics and Dexterity, ICR: Intraoperative Complication Rates, PCR: Postoperative Complication Rates, PW: Patient Well-Being and Welfare, EOU: Ease of Use, MAIN: MAIN Category



Abbreviations: OSS: Operation Safety and Success, SED: Surgeon Ergonomics and Dexterity, ICR: Intraoperative Complication Rates, PCR: Postoperative Complication Rates, PW: Patient Well-Being and Welfare, EOU: Ease of Use, MAIN: MAIN Category

Figure 16: All Matrices Consistency Ratio Results for All Observations

The most consistent decisions are made about the Operation Safety and Success (OSS) pairwise comparison matrices with 39% consistent preferences, and the second one is MAIN with a percentage of 28. Patient Well-Being and Welfare (PW) comes in third with 24%. Fourth is Intraoperative Complication Rates (ICR), with 21%. Surgeon

Ergonomics and Dexterity (SED) and Postoperative Complication Rates (PCR) share the fifth with 20% consistency of all pairwise decisions made for these matrices. Ease of Use (EOU) is the sixth with 19%.

3.9. Consistency Ratios and the Priority Vectors

3.9.1. Evaluation and Interpretation of Individual Priority Vectors

In this section of the study, their consistency ratio and priority vector calculations are presented with the surgeons' specialties for each pairwise comparison matrix. For all decision matrices on our AHP tree that are 3x3 or larger, we interpret consistent responses, while we interpret all responses for the 2x2 decision matrices that compare only two factors.

3.9.1.1. Consistent Operation Safety and Success (OSS) Matrices

Table 8: Summary of All Consistent OSS Pairwise Comparison Matrices

Surgeon ID	ICR	PCR	RDL	CR ≤ 0,10	Specialty
3	0.333	0.333	0.333	Consistent	Cardiac Surgery
4	0.455	0.455	0.091	Consistent	Cardiac Surgery
5	0.455	0.455	0.091	Consistent	Cardiac Surgery
18	0.333	0.333	0.333	Consistent	General Surgery
19	0.455	0.455	0.091	Consistent	General Surgery
20	0.258	0.637	0.105	Consistent	General Surgery
27	0.455	0.455	0.091	Consistent	Orthopedics and Traumatology
29	0.467	0.67	0.067	Consistent	Pediatric Surgery
30	0.474	0.474	0.053	Consistent	Thoracic Surgery
33	0.455	0.455	0.091	Consistent	Urology
35	0.333	0.333	0.333	Consistent	Urology
36	0.511	0.420	0.069	Consistent	Urology
37	0,637	0.258	0.105	Consistent	Urology
40	0.405	0.481	0.114	Consistent	Urology

Abbreviations: ICR: Intraoperative Complication Rates, PCR: Postoperative Complication Rates, RDL: Risks During Learning

Note: Surgeon ID is randomly given for easier reference to individual surgeons while presenting results.

Table 8 gives priority vectors calculated using the Eigenvector method for Operation Success and Safety factors for surgeons with consistent decision matrices. Fourteen surgeons’ preferences from six different specialties are calculated as consistent in their decision-making regarding the factors' effect on Operation Safety and Success (OSS). For this criterion, all consistent surgeons have more tolerance to safety risks during learning than the complication rates. Some surgeons share the same idea of their preferences even if they are from different disciplines. For instance, one cardiac surgeon and one general surgeon have the same priorities. The same vision is expected for surgeons whose specialties are the same. However, the data presented in Table 8 shows that seven surgeons out of 14 find the importance weights of having lower intraoperative and postoperative complication rates to be the same. There seems to be no distinguishable distinction between Intraoperative Complication Rates (ICR) and Postoperative Complication Rates (PCR) for surgeons. These results are also reflected in Figure 3: Operation Safety and Success (OSS) Matrices Pairs Inconsistency, Intraoperative Complication Rates (ICR) versus Postoperative Complication Rates (PCR) pairwise comparison shown as the most challenging pair to compare. Therefore, as the data shows, we emphasize that taking the whole complication as one may help to prevent the decision-makers' confusion. One urologist and one general surgeon seem neutral regarding the Intraoperative Complication Rates (ICR), Postoperative Complication Rates (PCR), and Risks During Learning (RDL) factors because they give each of their indifferent numerical ratings. This kind of answer cannot provide any invaluable information, even if it is within the limit of the consistency ratio.

3.9.1.2. Surgeon Ergonomics and Dexterity (SED) Matrices

Table 9: Summary of All Consistent SED Pairwise Comparison Matrices

Surgeon ID	MLT	TA	MS	EV	CR ≤ 0,10	Specialty
17	0.178	0.303	0.130	0.389	Consistent	General Surgery
26	0.251	0.083	0.392	0.274	Consistent	Maxillofacial Surgery
27	0.411	0.064	0.113	0.411	Consistent	Orthopedics and Traumatology
32	0.508	0.151	0.075	0.265	Consistent	Urology
34	0.227	0.047	0.204	0.521	Consistent	Urology
35	0.120	0.077	0.383	0.419	Consistent	Urology
36	0.368	0.096	0.169	0.368	Consistent	Urology
38	0.603	0.072	0.149	0.176	Consistent	Urology

Abbreviations: MLT: Multitasking, TA:Tremor Abolition, MS: Motion Scaling, EV: Enhanced Visualization

Note: Surgeon ID is randomly given for easier reference to individual surgeons while presenting results.

Table 9 gives priority vectors calculated using the Eigenvector method for Surgeon Ergonomics and Dexterity factors for surgeons with consistent decision matrices. It can be deduced from Table 9 that the surgeons have some difficulties in deciding the RAS platforms' Motion Scaling (MS) and Enhanced Visualization (EV) properties regarding improving their ergonomics and dexterity during the operation. As inferred from synthesizing all responses to determine the top inconsistent pairs of the data shown in Figure 5, the most common pair is comparing Enhanced Visualization (EV) and Motion Scaling (MS). A pairwise comparison of Tremor Abolition (TA) and Motion Scaling (MS) follows them. In total, both pairs cause 29 inconsistencies out of 41. Since the common factor for both is Motion Scaling (MS), removing it from the SED matrix may be better. The first preference of 4 out of 8 surgeons is Multitasking (MLT), while 5 of them find Enhanced Visualization (EV) more significant. One critical thing to emphasize is that the weights of the two surgeons' first decision priorities are not different; in their opinion, Multitasking (MLT) and Enhanced Visualization (EV) have the same importance. In light of this information, we observed that when the surgeons found Motion Scaling (MS) as the second significant factor, their first two were Multitasking (MLT) and Enhanced Visualization (EV) with the same importance. However, when Enhanced Visualization (EV) comes first, the second one is Motion Scaling (MS), with a relatively higher importance of 3 surgeons than only one surgeon's second preference is Multitasking (MLT). Multitasking (MLT) and Enhanced Visualization (EV) are the first for two surgeons whose specialties are Orthopedics and Traumatology, and Urology. Maxillofacial surgeon priorities differentiate from the others as finding motion scaling is the most important. The second is Enhanced Visualization (EV), Multitasking (MLT) is the third, and the last is Tremor Abolition (TA). Tremor Abolition (TA) is relatively significant for general surgery as it is the second highest priority for the single general surgeon in our sample. At the same time, it is the lowest priority of the other disciplines.

3.9.1.3. Intraoperation and Complication Rates (ICR) Matrices

Table 10: Summary of All Consistent ICR Pairwise Comparison Matrices

Surgeon ID	SI_ICR	T/HF_ICR	SED_ICR	CR ≤ 0,10	Specialty
7	0.143	0.429	0.429	Consistent	Colorectal Surgery
12	0.053	0.474	0.474	Consistent	General Surgery
19	0.429	0.143	0.429	Consistent	General Surgery
20	0.104	0.127	0.769	Consistent	General Surgery
28	0.200	0.200	0.600	Consistent	Orthopedics and Traumatology
34	0.066	0.149	0.785	Consistent	Urology
37	0.388	0.097	0.515	Consistent	Urology
40	0.063	0.265	0.672	Consistent	Urology

Abbreviations: SI_ICR: Smaller Incisions for Intraoperative Complication Rates, T/HF_ICR: Tactile/Haptic Feedback for Intraoperative Complication Rates, SED_ICR: Surgeon Ergonomics and Dexterity for Intraoperative Complication Rates

Note: Surgeon ID is randomly given for easier reference to individual surgeons while presenting results.

Table 10 gives priority vectors calculated using the Eigenvector method for Intraoperative Complication Rates (ICR) factors for surgeons with consistent decision matrices. Even if half of the respondents struggle with distinguishing some factors' impact on Intraoperative Complication Rates (ICR), they are confident that improved Surgeon Ergonomics and Dexterity (SED) are always the first for reducing Intraoperative Complication Rates (ICR). The second is Tactile/Haptic Feedback (T/HF_ICR), while the third is Smaller Incisions (SI_ICR). The two, whose specialties are in Colorectal and General Surgery, state that the information received by touching is of the same importance as Surgeon Ergonomics and Dexterity (SED). In contrast, the other single general surgeon determines that it is the capability of making more minor cuts in the patients' body. A surgeon from Orthopedics and Traumatology found that improved surgeon ergonomics and dexterity conditions were three times more important than smaller incisions and had a touch of sense to lower intraoperative complications. Reckoning the decisions that the rest have the same priority weights for any pair comparison relevant to the Intraoperative Complication Rates (ICR) matrix, data shows that the three surgeons' second preference is tactile/haptic feedback. At the same time, one single urologist gives more importance to the ability to make more minor cuts in the patients' body. With the help of all this observation, it is understood that comparing the factor pair of smaller incisions with surgeon ergonomics and dexterity is much easier for the surgeons than comparing the pairs, including tactile/haptic feedback factor. Thus, removing the tactile/haptic feedback factor from this decision-making hierarchy level may provide a clearer picture for the decision-makers.

3.9.1.4. Postoperative and Complication Rates (PCR) Matrices

Table 11: Summary of All Consistent PCR Pairwise Comparison Matrices

Surgeon ID	SI_PCR	T/HF_PCR	SED_PCR	CR≤0,10	Specialty
7	0.143	0.429	0.429	Consistent	Colorectal Surgery
15	0.107	0.149	0.745	Consistent	General Surgery
18	0.200	0.200	0.600	Consistent	General Surgery
28	0.131	0.217	0.652	Consistent	Orthopedics and Traumatology
30	0.217	0.131	0.652	Consistent	Thoracic Surgery
35	0.091	0.453	0.455	Consistent	Urology
36	0.143	0.143	0.714	Consistent	Urology
40	0.063	0.265	0.672	Consistent	Urology

Abbreviations: SI_PCR: Smaller Incisions for Postoperative Complication Rates, T/HF_PCR: Tactile/Haptic Feedback for Postoperative Complication Rates, SED_PCR: Surgeon Ergonomics and Dexterity for Postoperative Complication Rates

Note: Surgeon ID is randomly given for easier reference to individual surgeons while presenting results.

Table 11 presents the priority vectors, a crucial component of our study, calculated using the scientifically rigorous Eigenvector method. These vectors are based on the Postoperative Complication Rates (PCR) factors identified by surgeons with consistent decision matrices. It is a consensus among surgeons that the most significant factor in preventing postoperative complications is the provision of a high-standard operation environment. Figure 8 further supports this, showing that 25 out of 41 inconsistent responses share a common factor, Tactile/Haptic Feedback (T/HF_PCR), and the pairs with this factor show a high level of convergence in the number of inconsistencies. Therefore, the same interpretation of the Inconsistency Comparison Ratio (ICR) matrix is also applicable to the Postoperative Complication Rates (PCR) matrix, suggesting that Tactile/Haptic Feedback should be excluded from these comparison matrices.

Our data reveals exciting insights into the perspectives of different surgical disciplines on postoperative complication prevention. Both Orthopedics and Traumatology and Thoracic Surgery agree on the importance of enhancing surgeon ergonomics and dexterity. However, they diverge on the issue of Smaller Incisions and Tactile/Haptic Feedback. This divergence is exemplified in our sample, where we obtained contrasting responses from two surgeons, each representing one of these disciplines. The most common second preference among surgeons is tactile/haptic feedback, with 6 surgeons' responses. However, two of them share the second priority with the smaller incisions factor. Smaller incisions rank third, with the lowest priority weights.

Given the lack of observed differences among surgeons’ decisions on reducing operation phase complications, it is logical to consolidate these decisions under one comprehensive term, 'complications'. This approach not only simplifies the understanding of the study's findings but also facilitates their practical application in surgical settings.

3.9.1.5. Patient Well-Being and Welfare (PW) Matrices

Table 12: Summary of All Consistent PW Pairwise Comparison Matrices

Surgeon ID	SI_PW	SHS	OD_PW	CR≤0,10	Specialty
6	0.091	0.818	0.091	Consistent	Colorectal Surgery
20	0.429	0.429	0.143	Consistent	General Surgery
21	0.188	0.081	0.731	Consistent	General Surgery / Gynecology
22	0.490	0.451	0.059	Consistent	Gynecologic Laparoscopic Surgery
27	0.091	0.455	0.455	Consistent	Orthopedics and Traumatology
31	0.731	0.188	0.081	Consistent	Urology
32	0.429	0.429	0.143	Consistent	Urology
33	0.091	0.455	0.455	Consistent	Urology
38	0.091	0.455	0.455	Consistent	Urology

Abbreviations: SI_PW: Smaller Incisions for Patient Welfare, SHS: Shorter Hospital Stays, OD_PW: Operation Duration for Patient Welfare

Note: Surgeon ID is randomly given for easier reference to individual surgeons while presenting results.

Table 12 gives priority vectors calculated using the Eigenvector method for Patient Well-Being and Welfare factors for surgeons with consistent decision matrices. The surgeons mostly agree that creating convenient conditions to make it possible to stay shorter in the hospital may contribute to the patient's well-being and welfare. Even though they are entirely different surgeons, four surgeons prefer Smaller Incisions as the most critical factor, while the other four's first is Operation Duration. Figure 11 also illustrates that pairwise comparison of Smaller Incisions and Operation Duration causes the most inconsistency. Thus, comparing the pair of Smaller Incisions and Operation Duration is hard for surgeons to distinguish in terms of Patient Well-Being and Welfare. Since the Smaller Incisions factor is the common factor in top inconsistent pairs, removing it from this comparison matrix may help to make more proper decisions by the respondents. To look at specialty-based decisions, urologists' highest priority is discharging the patients from the hospital to make them return to their daily routine as soon as possible, like a colorectal surgeon in our sample. One general surgeon finds Smaller Incisions and Shorter Hospital Stays as the most and equally important; on the other hand, a surgeon has two specialties, one of which is general surgery, and thinks that operation duration is the most important. On the gynecology side, this surgeon's sight is also different from the other consistent gynecologists for patient well-being and welfare matrix in our sample. The respondent with the 21st surgeon ID is confident that Operation Duration is the most important. However, the one with the 22nd surgeon ID's first and second decisions are very convergent, and Operation Duration has the lowest priority for that surgeon. The Orthopedics and Traumatology representative thinks Smaller Incisions have the lowest significance.

3.9.1.6. Ease of Use (EOU) Matrices

Table 13: Summary of All Consistent EOU Pairwise Comparison Matrices

Surgeon ID	T/HF_EOU	OD_EOU	SED_EOU	CR ≤ 0,10	Specialty
3	0.053	0.474	0.474	Consistent	Cardiac Surgery
17	0.333	0.333	0.333	Consistent	General Surgery
28	0.091	0.455	0.455	Consistent	Orthopedics and Traumatology
30	0.669	0.088	0.243	Consistent	Thoracic Surgery
35	0.429	0.143	0.429	Consistent	Urology
38	0.200	0.600	0.200	Consistent	Urology
41	0.156	0.185	0.659	Consistent	Urology

Abbreviations: T/HF_EOU: Tactile/Haptic Feedback for Ease of Use, OD_EOU: Operation Duration for Ease of Use, SED_EOU: Surgeon Ergonomics and Dexterity for Ease of Use

Note: Surgeon ID is randomly given for easier reference to individual surgeons while presenting results.

Table 13 gives priority vectors calculated using the Eigenvector method for Ease of Use factors for surgeons with consistent decision matrices. Most surgeons’ priorities state that they find improved ergonomic conditions and dexterity the most significant. At the same time, the two of them also give the same weights for Operation Duration, considering the effect on easy use of RAS platforms. Similarly, Surgeon Ergonomics and Dexterity share the top place for one urologist with Tactile/Haptic Feedback. For another urologist, Operation Duration is the most important. However, taking the all-urologist decisions, which are consistent, into consideration that their opinion is parallel to the standard view of the surgeons. A representative respondent from Thoracic Surgery reckons that the Tactile/Haptic Feedback factor is the most significant. At the same time, the one from the Cardiac Surgery discipline thinks that the sense of touch has the lowest priority, considering the effect of easier usage on the RAS platform. In general, in contrast to the literature, surgeons do not care very much about the lack of Tactile/Haptic Feedback effect on RAS platform usage (BenMessaoud et al. 2011; Ghezzi and Corleta 2016; Lendvay et al. 2013; Mohammadzadeh and Safdari 2014 and Williams et al. 2014). They are more interested in the benefits of enhanced Surgeon Ergonomics and Dexterity and the shorter Operation Duration acquired after the RAS platforms' learning curve has passed. By the result of all this interpretation and knowing that the pairwise comparison of Tactile/Haptic Feedback and Operation Duration causes the most inconsistent decision results, as shown in Figure 13, removing Tactile/Haptic Feedback may help to obtain more confident opinions from the survey participants.

3.9.1.7. Ease of Initial Adoption (EIA) Matrices

Table 14: Summary of All EIA Pairwise Comparison Matrices

Surgeon ID	EOI	TR	Specialty
2	0.83	0.17	Brain and Nerve Surgery
3	0.10	0.90	Cardiac Surgery
4	0.50	0.50	Cardiac Surgery
6	0.10	0.90	Colorectal Surgery
8	0.50	0.50	Colorectal Surgery
9	0.83	0.17	Endourology
10	0.83	0.17	Gastrointestinal Surgery
11	0.88	0.13	General Surgery
12	0.88	0.13	General Surgery
13	0.75	0.25	General Surgery
14	0.88	0.13	General Surgery
15	0.83	0.17	General Surgery
16	0.83	0.17	General Surgery
17	0.75	0.25	General Surgery
18	0.17	0.83	General Surgery
19	0.75	0.25	General Surgery
20	0.10	0.90	General Surgery
21	0.90	0.10	General Surgery Gynecology
22	0.13	0.88	Gynecologic Laparoscopic Surgery

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Table 14 (cont)

Surgeon ID	EOI	TR	Specialty
23	0.13	0.88	Gynecological Oncology
24	0.10	0.90	Gynecological Oncology
25	0.13	0.88	Gynecology
26	0.90	0.10	Maxillofacial Surgery
27	0.10	0.90	Orthopedics and Traumatology
28	0.50	0.50	Orthopedics and Traumatology
29	0.13	0.88	Pediatric Surgery
30	0.50	0.50	Thoracic Surgery
31	0.10	0.90	Urology
32	0.17	0.83	Urology
33	0.10	0.90	Urology
35	0.25	0.75	Urology
36	0.50	0.50	Urology
37	0.17	0.83	Urology
38	0.17	0.83	Urology
39	0.13	0.88	Urology
40	0.17	0.83	Urology
41	0.13	0.88	Urology

Abbreviations: EOI: Ease of Installation, TR: Training Requirements

Note: Surgeon ID is randomly given for easier reference to individual surgeons while presenting results.

Considering the Ease of Initial Adoption, surgeons have a shared sense of the relatively negative effect of training requirements. Discipline-based interpretation inferred from the data in Table 14 states that the most significant factor for general surgeons is the Ease of Installation. At the same time, it is a Training Requirement for Gynecologists and Urologists. A respondent, whose field is Brain and Nerve Surgery, thinks like the General Surgeons on the adoption process of RAS regarding the Ease of Initial Adoption matrix. From the sample, while one cardiac surgeon stays indifferent, the other is quite confident that the Training Requirements have the most significance in the adoption process. Colorectal surgery and Orthopedics and Traumatology representatives draw the same picture as the ones in cardiac surgery. Gastrointestinal and Endourology Surgeons agree that the most critical factor is Ease of Installation, and a representative of Maxillofacial Surgery quite agrees with their idea. A surgeon with a Pediatric Surgery Specialty state that the Training Requirements factor is the most significant. The Thoracic Surgery representative in our sample is neutral about these two factors.

3.9.1.8. Benefits and Hospital Quality (ECON_B) Matrices

Table 15: Summary of All ECON_B Pairwise Comparison Matrices

Surgeon ID	ANP	ABS	Specialty
2	0.83	0.17	Brain and Nerve Surgery
4	0.25	0.75	Cardiac Surgery
6	0.90	0.10	Colorectal Surgery
8	0.10	0.90	Colorectal Surgery
9	0.83	0.17	Endourology
10	0.10	0.90	Gastrointestinal Surgery
11	0.90	0.10	General Surgery
12	0.10	0.90	General Surgery
13	0.88	0.13	General Surgery
14	0.13	0.88	General Surgery
15	0.83	0.17	General Surgery
16	0.83	0.17	General Surgery
17	0.50	0.50	General Surgery
18	0.83	0.17	General Surgery
19	0.25	0.75	General Surgery
20	0.83	0.17	General Surgery
21	0.75	0.25	General Surgery Gynecology
22	0.50	0.50	Gynecologic Laparoscopic Surgery
23	0.83	0.17	Gynecological Oncology
24	0.90	0.10	Gynecological Oncology
25	0.17	0.83	Gynecology
26	0.75	0.25	Maxillofacial Surgery
27	0.75	0.25	Orthopedics and Traumatology
28	0.50	0.50	Orthopedics and Traumatology
29	0.50	0.50	Pediatric Surgery
30	0.75	0.25	Thoracic Surgery
31	0.75	0.25	Urology
32	0.75	0.25	Urology
33	0.50	0.50	Urology
35	0.50	0.50	Urology
36	0.75	0.25	Urology
37	0.50	0.50	Urology
38	0.75	0.25	Urology

(cont. on the next page)

Table 15 (cont)

Surgeon ID	ANP	ABS	Specialty
39	0.17	0.83	Urology
40	0.75	0.25	Urology
41	0.50	0.50	Urology

Abbreviations: ANP: Attract New Patients, ABS: Attract Better Surgeons

Note: Surgeon ID is randomly given for easier reference to individual surgeons while presenting results.

The majority of General Surgeons' first preference is for the Attracting New Patients factor. Half of the Urologist in our sample and an Endourologist think the Attracting New Patients factor is the most essential. At the same time, almost the rest of them have no opinion on how to differentiate these comparison pairs' factors from each other, and only one of them states that Attracting Better Surgeons is the first preference. The participants with a specialty in Gynecology seem to have no common sense regarding the effects of economic benefits on adopting RAS technology. The physicians of Gynecological Oncology prefer the Attracting New Patients factor as the highest importance weight, similar to the decision of General Surgeons. A participant of our survey from Brain and Nerve Surgery, another one from Maxillofacial Surgery, the other one from Thoracic Surgery, and one from Orthopedics and Traumatology fields think also that the Attracting New Patients factor is the most significant. The factor of Attracting Better Surgeons has the highest charm for one Cardiac, a Colorectal Surgeon, and a Gastrointestinal Surgeon. The other Colorectal Surgeon and one Pediatric Surgeon are neutral between the comparison pairs.

3.9.1.9. Costs (ECON_C) Matrices

Table 16: Summary of All ECON_C Pairwise Comparison Matrices

Surgeon ID	PC	OMC	Specialty
2	0.88	0.13	Brain and Nerve Surgery
4	0.50	0.50	Cardiac Surgery
6	0.50	0.50	Colorectal Surgery
8	0.50	0.50	Colorectal Surgery

(cont. on the next page)

Table 16 (cont)

Surgeon ID	PC	OMC	Specialty
9	0.83	0.17	Endourology
10	0.17	0.83	Gastrointestinal Surgery
11	0.90	0.10	General Surgery
12	0.90	0.10	General Surgery
13	0.10	0.90	General Surgery
14	0.88	0.13	General Surgery
15	0.17	0.83	General Surgery
16	0.83	0.17	General Surgery
17	0.50	0.50	General Surgery
18	0.50	0.50	General Surgery
19	0.25	0.75	General Surgery
20	0.75	0.25	General Surgery
21	0.90	0.10	General Surgery Gynecology
22	0.13	0.88	Gynecologic Laparoscopic Surgery
23	0.50	0.50	Gynecological Oncology
24	0.90	0.10	Gynecological Oncology
25	0.25	0.75	Gynecology
26	0.90	0.10	Maxillofacial Surgery
27	0.17	0.83	Orthopedics and Traumatology
28	0.25	0.75	Orthopedics and Traumatology
29	0.17	0.83	Pediatric Surgery
30	0.75	0.25	Thoracic Surgery
31	0.50	0.50	Urology
32	0.50	0.50	Urology
33	0.25	0.75	Urology
35	0.75	0.25	Urology
36	0.25	0.75	Urology
37	0.17	0.83	Urology
38	0.17	0.83	Urology
39	0.88	0.13	Urology
40	0.50	0.50	Urology
41	0.83	0.17	Urology

Abbreviations: PC: Purchase Cost, OMC: Operational and Maintanance Cost

Note: Surgeon ID is randomly given for easier reference to individual surgeons while presenting results.

Thirty-six respondents answered the pairwise comparison matrices regarding the monetary costs of RAS technology. The general picture of their decisions presents no difference between the Initial Purchase Costs and the Operational and Maintenance Costs because fourteen surgeons prefer Initial Purchase Costs as the first. In comparison, the rest of the thirteen surgeons prefer Operational and Maintenance Costs, and the last nine surgeons are indifferent. General Surgeons' preference is relatively higher for Initial Purchase Costs than the Operational and Maintenance Costs, while the two general surgeons stay neutral. Among ten urology surgeons, four of them think the Operational and Maintenance Costs are the most significant, while three of the rest find the purchase costs are the most important; the final three Urologists have no distinguishing opinion for these two factors. Two surgeons’ decisions from Gynecological Oncology do not share a common opinion because one of them thinks that the Initial Purchase Cost has the highest importance. At the same time, the other one stays indifferent to both factors. Operational and Maintenance Costs are of relatively significant importance for Gynecologists. For the Brain and Nerve Surgery surgeon in our sample, the Initial Purchase Cost is the highest priority. The Cardiac and Colorectal surgeons' preferences are neutral for these factors. A participant in the Endourology discipline chose the Initial Purchase Cost as the most significant, while a surgeon in Gastrointestinal Surgery made the opposite decision. Maxillofacial Surgery and Thoracic Surgery find the Initial Purchase Costs, the most important. Operational and Maintenance Costs factor is the first for Orthopedics and Traumatology, and Pediatric Surgery.

3.9.1.10. Economics (ECON) Matrices

Table 17: Summary of All ECON Pairwise Comparison Matrices

Surgeon ID	Cost	Benefit	Specialty
2	0.13	0.88	Brain and Nerve Surgery
4	0.50	0.50	Cardiac Surgery
6	0.90	0.10	Colorectal Surgery
8	0.50	0.50	Colorectal Surgery
9	0.83	0.17	Endourology
10	0.83	0.17	Gastrointestinal Surgery
11	0.90	0.10	General Surgery
12	0.13	0.88	General Surgery
13	0.75	0.25	General Surgery
14	0.88	0.13	General Surgery

(cont. on the next page)

Table 17 (cont)

Surgeon ID	Cost	Benefit	Specialty
15	0.13	0.88	General Surgery
16	0.83	0.17	General Surgery
17	0.50	0.50	General Surgery
19	0.75	0.25	General Surgery
20	0.17	0.83	General Surgery
21	0.90	0.10	General Surgery Gynecology
22	0.50	0.50	Gynecologic Laparoscopic Surgery
23	0.75	0.25	Gynecological Oncology
24	0.90	0.10	Gynecological Oncology
25	0.88	0.13	Gynecology
26	0.10	0.90	Maxillofacial Surgery
27	0.25	0.75	Orthopedics and Traumatology
28	0.50	0.50	Orthopedics and Traumatology
29	0.17	0.83	Pediatric Surgery
30	0.75	0.25	Thoracic Surgery
31	0.75	0.25	Urology
32	0.75	0.25	Urology
33	0.17	0.83	Urology
35	0.25	0.75	Urology
36	0.17	0.83	Urology
37	0.13	0.88	Urology
38	0.75	0.25	Urology
39	0.83	0.17	Urology
40	0.50	0.50	Urology
41	0.17	0.83	Urology

Abbreviations: Costs: Costs, Benefit: Benefits, Hospital Quality

Note: Surgeon ID is randomly given for easier reference to individual surgeons while presenting results.

Thirty-five decision matrices were obtained from the respondents. Of the 17 out of 35 respondents, the Cost factor is the most important, while 12 prefer Benefit as their priority. Six surgeons have yet to determine which has the highest importance. Half of the Urologist in our sample decide that the Benefit is the most significant for them, while 4 of the rest think that the Cost factor has the highest priority, and the last one stays indifferent. The Cost factor is of relatively higher importance among the General Surgeons' highest priorities; 6 out of 10 prefer Cost as the first, while 3 out of 10 prioritize Benefit, and the last one is neutral. One respondent from each discipline, Cardiac Surgery, Colorectal Surgery, Gynecologic Laparoscopic Surgery, and Orthopedics and Traumatology, has no distinguishing preference to make a prioritization decision between these factors. Cost is the most important for two surgeons from Gynecological Oncology and two from Gynecology. One surgeon from each discipline of Colorectal Surgery, Endourology, Gastrointestinal Surgery, and Thoracic Surgery thinks Cost is the most important. The ones from Brain and Nerve Surgery, Maxillofacial Surgery, Orthopedics and Traumatology, and Pediatric Surgery prefer the Benefit with the highest significance.

3.9.1.11. Comparison of MAIN Categories

Table 18: Summary of All Consistent MAIN Pairwise Comparison Matrices

Surgeon ID	ECON	EIA	EOU	PW	OSS	CR ≤ 0,10	Specialty
4	0.127	0.264	0.160	0.075	0.373	Consistent	Cardiac Surgery
9	0.070	0.025	0.197	0.171	0.536	Consistent	Endourology
15	0.057	0.026	0.174	0.188	0.554	Consistent	General Surgery
19	0.139	0.041	0.074	0.219	0.526	Consistent	General Surgery
23	0.039	0.058	0.128	0.388	0.388	Consistent	Gynecological Oncology
25	0.494	0.046	0.171	0.225	0.064	Consistent	Gynecology
28	0.096	0.051	0.096	0.379	0.379	Consistent	Orthopedics and Traumatology
35	0.061	0.237	0.267	0.211	0.225	Consistent	Urology
36	0.048	0.071	0.272	0.286	0.324	Consistent	Urology
40	0.035	0.024	0.162	0.227	0.552	Consistent	Urology

Abbreviations: ECON: Economics, EIA: Ease of Initial Adaption, EOU: Ease of Use, PW: Patient Welfare, OSS: Operation Safety and Success

Note: Surgeon ID is randomly given for easier reference to individual surgeons while presenting results.

Table 18 gives priority vectors calculated using the Eigenvector method for surgeons with consistent decision matrices for the Main Criteria. It is obvious to deduce from the data in Table 18 that the surgeons' first priority is Operation Safety and Success. Hence, it seems that the impact of that factor on an adoption decision for RAS technologies is excellent. It may be noted that any positive iteration that contributes to making the operations safer and more successful is well received by the physicians. According to a consistent decision matrix of one Cardiac Surgeon, the Operation Safety and Success (OSS) factor is most important. Then, Ease of Initial Adoption (EIA) comes at the second one. Ease of Use (EOU) is the third, while Economics (ECON) is fourth, and Patient Well-Being and Welfare (PW) is the lowest importance for that surgeon. Among the preferences of an Endourology surgeon, the Operation Safety and Success (OSS) factor is the most essential criterion to effect the adoption decision of RAS. EOU is the second with the relatively highest significance to Patient Well-Being and Welfare (PW) and then, Economics (ECON) comes as the fourth. Ease of Initial Adoption (EIA) has the lowest priority weight for this representative respondent. The two General Surgeons' pairwise comparison matrices for MAIN categories are evaluated as consistent. They have a common sense for their highest essential criteria, which is Operation Safety and Success (OSS), the second one is Patient Well-Being and Welfare (PW), and the lowest significance is Ease of Initial Adoption (EIA) for them. Their preferences for Economics (ECON) and Ease of Use (EOU) are the opposite of one another. A representative surgeon in the field of Gynecological Oncology has equal priority preferences for Operation Safety and Success (OSS) and Patient Well-Being and Welfare (PW). Both have the highest importance, while the third is Ease of Use (EOU), the fourth is Ease of Initial Adaption (EIA), and the fifth is Economics (ECON). As a result of this decision, Ease of Initial Adoption (EIA) and Economics (ECON) criteria are of very convergent importance from this surgeon's perspective. A Gynecology surgeon prefers Economics (ECON) as the most significant criterion of MAIN categories. Then, Patient Well-Being and Welfare (PW) comes as second and third, Ease of Use (EOU), while fourth and fifth, Operation Safety and Success (OSS) and Ease of Initial Adoption (EIA), respectively. Except for the Economics (ECON), the other priority weights are very convergent, such as the pair-based approach, Patient Well-Being and Welfare (PW) versus Ease of Use (EOU), and Operation Safety and Success (OSS) versus Ease of Initial Adoption (EIA). Orthopedics and Traumatology representative participant in our sample has the same first preferences as the one from Gynecological Oncology. Then, Economics (ECON) and Ease of Use (EOU) are placed in the second preference by having equal priority weights, and the last one is Ease of Initial Adoption (EIA). Operation Safety and Success (OSS) has the highest importance of the majority of Urologist. At the same time, Patient Well-Being and Welfare (PW) comes second, Ease of Use (EOU) is the third, and the fifth one is Economics (ECON) for them. However, they do not share any common ideas regarding the fourth one.

3.10. Priorities Based on Aggregated Decision Matrices for Individual Disciplines

In this section, we aggregate consistent decision matrices within individual surgical disciplines using the geometric method for all aggregation calculations.

Table 19: Specialty-Based Aggregated Priority Vectors for Operation Safety and Success (OSS) Matrices

Specialty	Number of Observation	Priority Vector Elements			Consistency Ratio (CR≤0.10)
		ICR	**PCR**	**RDL**	
Cardiac Surgery	3	0.427	0.427	0.146	0.000
General Surgery	3	0.359	0.485	0.155	0.004
Urology	5	0.478	0.397	0.125	0.001

Abbreviations: ICR: Intraoperative Complication Rates, PCR: Postoperative Complication Rates, RDL: Risks During Learning

According to Table 19, data shows that surgeons from three different specialties have a common sense that higher safety risks during inexperienced use and learning do not cause alarm regarding operation safety and success. Cardiac Surgeons do not see any differences between Intraoperative and Postoperative Complication Rates. While General Surgeons prioritize Postoperative Complications Rates (PCR), Urology Surgeons' preferences are for Intraoperative Complications Rates (ICR), but there are no vast differences between the operational phases' complication rates for both disciplines' preferences. We treat them separately in this study since they are examined in that way in the literature. (Abdollah et al. 2017; Aggarwal et al. 2018; Diana and Marescaux 2015; Fletcher et al. 2018; Kim et al. 2013; Lim et al. 2011; Mohammadzadeh and Safdari 2014; Sheetz et al. 2020; Sheth et al. 2018; Siaulys et al. 2021; Sivarajan et al. 2015; Thompson et al. 2014; Williams et al. 2014). Shortly, combining the complication rates in one name and treating it as one factor seems more logical, even if they are handled separately in the literature.

Table 20: Specialty-Based Aggregated Priority Vectors and Consistency Ratios of Surgeon Ergonomics and Dexterity (SED) Matrices

Specialty	Number of Observation	Priority Vector Elements				Consistency Ratio (CR≤0.10)
		MLT	TA	MS	EV	
Urology	5	0.348	0.091	0.191	0.370	0.000369

Abbreviations: MLT: Multitasking, TA:Tremor Abolition, MS: Motion Scaling, EV: Enhanced Visualization

We can only aggregate within Urology for the Surgeon Ergonomics and Dexterity (SED) matrix since all consistent responses come from this discipline. For urology surgeons, Enhanced Visualization (EV) is the most important property of RAS platforms to adopt in their operation practice, considering enhanced Surgeon Ergonomics and Dexterity (SED). The second one is Multitasking (MLT) for that discipline. Motion Scaling (MS) comes as the third even it is quite a substantial property and a kind of facilitator for adopting RAS in the literature (BenMessaoud et al. 2011; Ghezzi and Corleta 2016; Mohammadzadeh and Safdari 2014 and Nasser et al. 2020). Tremor abolition has the lowest priority from the Urologist perspective, which is also stated as one of the most critical functions of the RAS platforms in the literature (BenMessaoud et al. 2011; Ghezzi and Corleta 2016; Mohammadzadeh and Safdari 2014 and Nasser et al. 2020). Thus, improving the Enhance Visualization (EV) properties and its Multitasking (MLT) functions may facilitate the adoption of RAS by contributing to its capability to provide enhanced surgeon ergonomics and dexterity.

Table 21: Speciality-Based Aggregated Priority Vectors and Consistency Ratios of Intraoperative Complication Rates (ICR) Matrices

Specialty	Number of Observation	Priority Vector Elements			Consistency Ratio (CR≤0.10)
		SI_ICR	T/HF_ICR	SED_ICR	
General Surgery	3	0.152	0.234	0.615	0.004
Urology	3	0.127	0.170	0.703	0.057

Abbreviations: SI_ICR: Smaller Incisions for Intraoperative Complication Rates, T/HF_ICR: Tactile/Haptic Feedback for Intraoperative Complication Rates, SED_ICR: Surgeon Ergonomics and Dexterity for Intraoperative Complication Rates

General Surgeons' and Urology surgeons' decisions are parallel for all elements of Intraoperative Complication Rates (ICR) matrices. Physicians of both disciplines in Table 21 think that providing enhanced Surgeon Ergonomics and Dexterity (SED) during the operation significantly reduces Intraoperative Complication Rates (ICR). The most significant part of all Intraoperative Complication Rates (ICR) group shares was captured by this factor, as observed. It can be inferred from their second preference that the information transferred by the Tactile/Haptic Feedback (T/HF_ICR) during the operation is essential. However, a considerable portion does not differentiate it from the Smaller Incisions (SI_ICR).

Table 22: Specialty-Based Aggregated Priority Vectors and Consistency Ratios of Postoperative Complication Rates (PCR) Matrices

Specialty	Number of Observation	Priority Vector Elements			Consistency Ratio (CR≤0.10)
		SI_PCR	T/HF_PCR	SED_PCR	
General Surgery	2	0.156	0.166	0.678	0.003
Urology	3	0.120	0.232	0.647	0.014

Abbreviations: SI_PCR: Smaller Incisions for Postoperative Complication Rates, T/HF_PCR: Tactile/Haptic Feedback for Postoperative Complication Rates, SED_PCR: Surgeon Ergonomics and Dexterity for Postoperative Complication Rates

The exact interpretation of data in Table 21 is also valid for the data shown in Table 22 (PCR). Keeping these in mind, it must be emphasized that taking the complications regardless of the operation phase would be more logical and helpful to simplify the problem as the observation of the surgeons' decisions addresses that.

Table 23: Patient Welfare (PW) Matrices, Aggregated Priority Vectors

		Priority Vector Elements			
Specialty	**Number of Observation**	**SI_PW**	**SHS**	**OD_PW**	**Consistency Ratio (CR≤0.10)**
General Surgery	2	0.358	0.235	0.407	0.015
Urology	4	0.280	0.446	0.274	0.004
Gynecology	2	0.432	0.272	0.296	0.007

Abbreviations: SI_PW: Smaller Incisions for Patient Welfare, SHS: Shorter Hospital Stays, OD_PW: Operation Duration for Patient Welfare

It is hard to say any standard view from the data in Table 23. The highest importance of each of the three disciplines is different. The reason for this may be a specialty-based perspective developed over the years. While Urology Surgeons give their most attention to making inpatient hospital stays shorter as much as possible, it is the lowest priority of General Surgeons and Gynecologists. Their highest priorities also differ from each other. For General Surgeons, Operation Duration (OD_PW) is the most important, while it is Smaller Incisions (SI_PW) for Gynecology. The most challenging decision preference pair is Smaller Incisions (SI_PW) versus Operation Duration (OD_PW) for Urologists, which are very convergent.

Table 24: Specialty-Based Aggregated Priority Vectors and Consistency Ratios of Ease of Use (EOU) Matrices

		Priority Vector Elements			
Specialty	**Number of Observation**	**T/HF_EOU**	**OD_EOU**	**SED_EOU**	**Consistency Ratio (CR≤0.10)**
Urology	3	0.272	0.288	0.440	0.003

Abbreviations: T/HF_EOU: Tactile/Haptic Feedback for Ease of Use, OD_EOU: Operation Duration for Ease of Use, SED_EOU: Surgeon Ergonomics and Dexterity for Ease of Use

Urology physicians agreed that enhancing Surgeon Ergonomics and Dexterity (SED_EOU) is the most significant impact on facilitating the usage of RAS platforms. However, their preferences for Tactile/Haptic Feedback (T/HF_EOU) and Operation Duration (OD_EOU) are convergent. Thus, it seemed like they had difficulty during the process of making decisions between this pair.

Table 25: Specialty-Based Aggregated Priority Vectors and Consistency Ratios of MAIN Categories

		Priority Vector Elements					
Specialty	**Number of Observation**	**ECON**	**EIA**	**EOU**	**PW**	**OSS**	**Consistency Ratio (CR≤0.10)**
General Surgery	2	0.117	0.096	0.216	0.238	0.333	0.243
Urology	3	0.051	0.129	0.286	0.279	0.255	0.051
Gynecology	2	0.174	0.070	0.184	0.358	0.214	0.083

Abbreviations: ECON: Economics, EIA: Ease of Initial Adaption, EOU: Ease of Use, PW: Patient Welfare, OSS: Operation Safety and Success

General surgeons' decisions are inconsistent according to the result of the aggregated geometric mean. Their aggregated priority vector has very convergent weights for the two different pairs. One is Economics (ECON) and Ease of Initial Adoption (EIA). Second is Ease of Use (EOU) and Patient Well-Being and Welfare (PW). At the beginning of this section, the pairs that cause the most inconsistent results are examined. They address the most inconsistent pairs with a common criterion, Economics (ECON). It is understood that removing the economics cluster from the decision-making hierarchy of this study may provide more consistent preferences. The Urologists and Gynecologists have consistently aggregated priority vectors. The most important criterion differs between them: Ease of Use (EOU) for Urology and Patient Well-Being and Welfare (PW) for Gynecology. Patient Well-Being and Welfare (PW) is the second preference of Urology, but it is pretty convergent with the Ease of Use (EOU) criterion. Gynecologists' second most important criterion is Operational Safety and Success (OSS), but there is no considerable difference between these criteria. The third is Operational Safety and Success (OSS) for Urology, which is quite convergent with the results of Patient Well-Being and Welfare (PW). They could not differentiate these criteria from each other. The third of Gynecologists is the Ease of Use (EOU), which is hardly differentiated from the Economics (ECON) criterion. Economic considerations (ECON) are the lowest priority for Urologists, while Ease of Initial Adoption (EIA) is for Gynecologists.

Table 26: All Aggregated Priority Vectors for Consistent Responses

	Priority Vector Elements					
Matrix	**ICR**	**PCR**	**RDL**			**Consistency Ratio (CR≤0.10)**
OSS ALL	0.558	0.309	0.133			0.013
	MLT	**TA**	**MS**	**EV**		
SED ALL	0.292	0.108	0.172	0.428		0.015
	SI_ICR	**T/HF_ICR**	**SED_ICR**			
ICR ALL	0.155	0.248	0.597			0.0005
	SI_PCR	**T/HF_PCR**	**SED_PCR**			
PCR ALL	0.157	0.271	0.572			0.008
	SI_PW	**SHS**	**OD_PW**			
PW ALL	0.176	0.553	0.272			0.010
	T/HF_EOU	**OD_EOU**	**SED_EOU**			
EOU ALL	0.282	0.172	0.545			0.004
	EOI	**TR**				
EIA ALL	0.402	0.598				
	ANP	**ABS**				
ECON_B ALL	0.608	0.392				
	PC	**OMC**				
ECON_C ALL	0.539	0.461				
	Cost	**Benefit**				
ECON ALL	0.547	0.453				
	ECON	**EIA**	**EOU**	**PW**	**OSS**	
MAIN ALL	0.112	0.113	0.198	0.205	0.373	0.027

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Table 26 (cont)

Abbreviations: ICR: Intraoperative Complication Rates, PCR: Postoperative Complication Rates, RDL: Risks During Learning, MLT: Multitasking, TA:Tremor Abolition, MS: Motion Scaling, EV: Enhanced Visualization, SI_ICR: Smaller Incisions for Intraoperative Complication Rates, T/HF_ICR: Tactile/Haptic Feedback for Intraoperative Complication Rates, SED_ICR: Surgeon Ergonomics and Dexterity for Intraoperative Complication Rates, SI_PCR: Smaller Incisions for Postoperative Complication Rates, T/HF_PCR: Tactile/Haptic Feedback for Postoperative Complication Rates, SED_PCR: Surgeon Ergonomics and Dexterity for Postoperative Complication Rates, SI_PW: Smaller Incisions for Patient Welfare, SHS: Shorter Hospital Stays, OD_PW: Operation Duration for Patient Welfare, T/HF_EOU: Tactile/Haptic Feedback for Ease of Use, OD_EOU: Operation Duration for Ease of Use, SED_EOU: Surgeon Ergonomics and Dexterity for Ease of Use, EOI: Ease of Installation, TR: Training Requirements, ANP: Attract New Patients, ABS: Attract Better Surgeons, PC: Purchase Costs, OMC: Operational and Maintenance Costs, ECON: Economics, EIA: Ease of Initial Adaption, EOU: Ease of Use, PW: Patient Welfare, OSS: Operation Safety and Success

The AHP Tree with these results is in Figure 17 as follows.

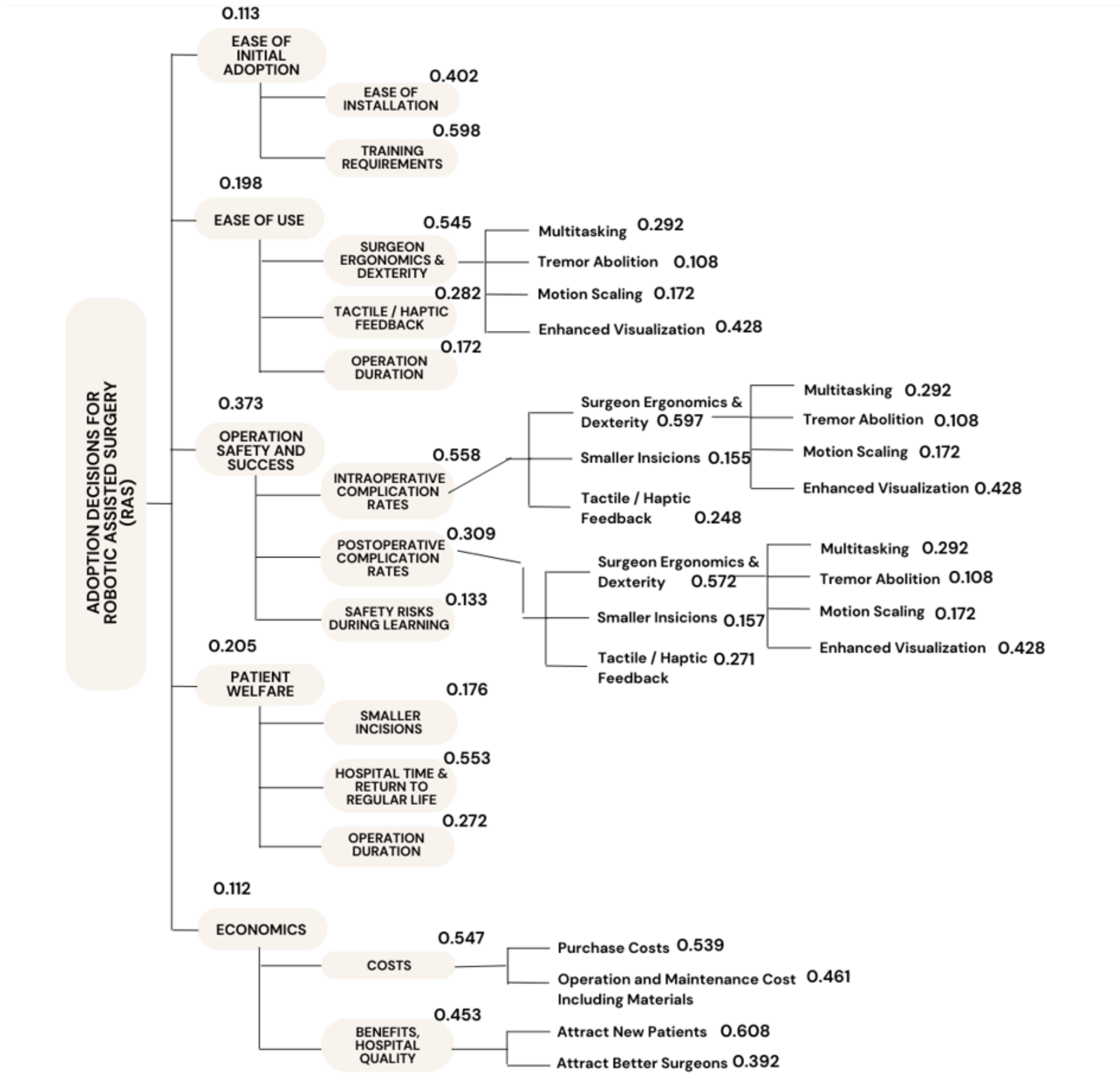

Figure 17: AHP Tree with all Aggregated Priority Vectors

Extrapolating the final results from evaluating all pairwise comparison matrices aggregated priority vectors shown in Table 26 contributes to developing a general perspective relevant to all factors of our research on affecting the adoption of RAS platforms by surgeons. Surgeons' general opinion about the factors that affect the adoption of RAS into their practice is that, based on Operation Safety and Success (OSS), the factor of Intraoperative Complication Rates (ICR) has the highest priority.

Risk During Learning (RDL) is deemed the lowest significance, indicating their confidence in managing the incomplete training/learning process within the Operational Safety and Success (OSS) context. Applying the same perspective on enhancing Surgeon Ergonomics and Dexterity (SED) during the operation, they agree that the Enhanced Visualization (EV) of the RAS technology is the most significant contribution. To avoid Intraoperative Complication Rates (ICR), surgeons think that enhancing the factor of Surgeon Ergonomics and Dexterity is of the highest importance. When it comes to reducing Postoperative Complication Rates (PCR), Surgeon Ergonomics and Dexterity (SED) have also become prominent among physicians. Hence, the surgeons' priority for both phases of the operation process complications is the same. Surgeons' second and third priorities regarding the complications that may arise during or after the operation also do not differentiate.

One of the key findings of our study is the consensus among surgeons on certain factors. For instance, surgeons unanimously agree that preparing patients as early as possible for their daily routine is the most significant element for Patient Welfare (PW).

Surgeons’ Ergonomics and Dexterity (SED) were found the most important factors to make the much easier of use - Ease of Use (EOU) - the RAS platform. Having the required training - Training Requirements (TR) - relevant to RAS technology, has been placed on the top by surgeons, considering its impact on the Ease of Initial Adoption (EIA) process. Regarding economic considerations - Economics (ECON), Attracting New Patients (ANP) is a top priority for surgeons on the benefits side. At the same time, the initial Purchase Cost (PC) is a significant concern on the Costs side. To decide between the pair of Costs and Benefits, considering the Economics (ECON), Cost comes as the first among the surgeons. The aggregated priority vector of the main criteria pairwise comparison of our research states that the effect of Operation Safety and Success (OSS) is the highest priority of the surgeons to adopt the RAS platform into their operations practice. Patient Welfare (PW), defined as the group of factors that have no direct impact on operation safety, is their second priority. The usage easiness - Ease of Use (EOU) - of the RAS technology comes as the third one, from surgeons’ perspectives. The priority weights of Ease of Initial Adoption (EIA) and Economics (ECON) criteria are very convergent with each other. As a result, both of these are almost equally important for surgeons.

Table 27: A Field-Based Aggregated Priority Vectors for Consistent Responses: An Evaluation for Urology

	Priority Vector Elements					Consistency Ratio
Matrix	**ICR**	**PCR**	**RDL**			**(CR≤0.10)**
OSS Urology	0.478	0.397	0.125			0.001
	MLT	**TA**	**MS**	**EV**		
SED Urology	0.348	0.091	0.191	0.370		0.000369
	SI_ICR	**T/HF_ICR**	**SED_ICR**			
ICR Urology	0.127	0.170	0.703			0.057
	SI_PCR	**T/HF_PCR**	**SED_PCR**			
PCR Urology	0.120	0.232	0.647			0.014
	SI_PW	**SHS**	**OD_PW**			
PW Urology	0.280	0.446	0.274			0.004
	T/HF_EOU	**OD_EOU**	**SED_EOU**			
EOU Urology	0.272	0.288	0.440			0.003
	EOI	**TR**				
EIA Urology	0.327	0.673				
	ANP	**ABS**				
ECON_B Urology	0.647	0.353				
	PC	**OMC**				
ECON_C Urology	0.318	0.682				
	Cost	**Benefit**				
ECON Urology	0.510	0.490				
	ECON	**EIA**	**EOU**	**PW**	**OSS**	
MAIN Urology	0.051	0.129	0.286	0.279	0.255	0.051

Abbreviations: ICR: Intraoperative Complication Rates, PCR: Postoperative Complication Rates, RDL: Risks During Learning, MLT: Multitasking, TA:Tremor Abolition, MS: Motion Scaling, EV: Enhanced Visualization, SI_ICR: Smaller Incisions for Intraoperative Complication Rates, T/HF_ICR: Tactile/Haptic Feedback for Intraoperative Complication Rates, SED_ICR: Surgeon Ergonomics and Dexterity for Intraoperative Complication Rates, SI_PCR: Smaller Incisions for Postoperative Complication Rates, T/HF_PCR: Tactile/Haptic Feedback for Postoperative Complication Rates, SED_PCR: Surgeon Ergonomics and Dexterity for Postoperative Complication Rates, SI_PW: Smaller Incisions for Patient Welfare, SHS: Shorter Hospital Stays, OD_PW: Operation Duration for Patient Welfare, T/HF_EOU: Tactile/Haptic Feedback for Ease of Use, OD_EOU: Operation Duration for Ease of Use, SED_EOU: Surgeon Ergonomics and Dexterity for Ease of Use, EOI: Ease of Installation, TR: Training Requirements, ANP: Attract New Patients, ABS: Attract Better Surgeons, PC: Purchase Costs, OMC: Operational and Maintenance Costs, ECON: Economics, EIA: Ease of Initial Adaption, EOU: Ease of Use, PW: Patient Welfare, OSS: Operation Safety and Success

The AHP Tree with these results is in Figure 18 as follows.

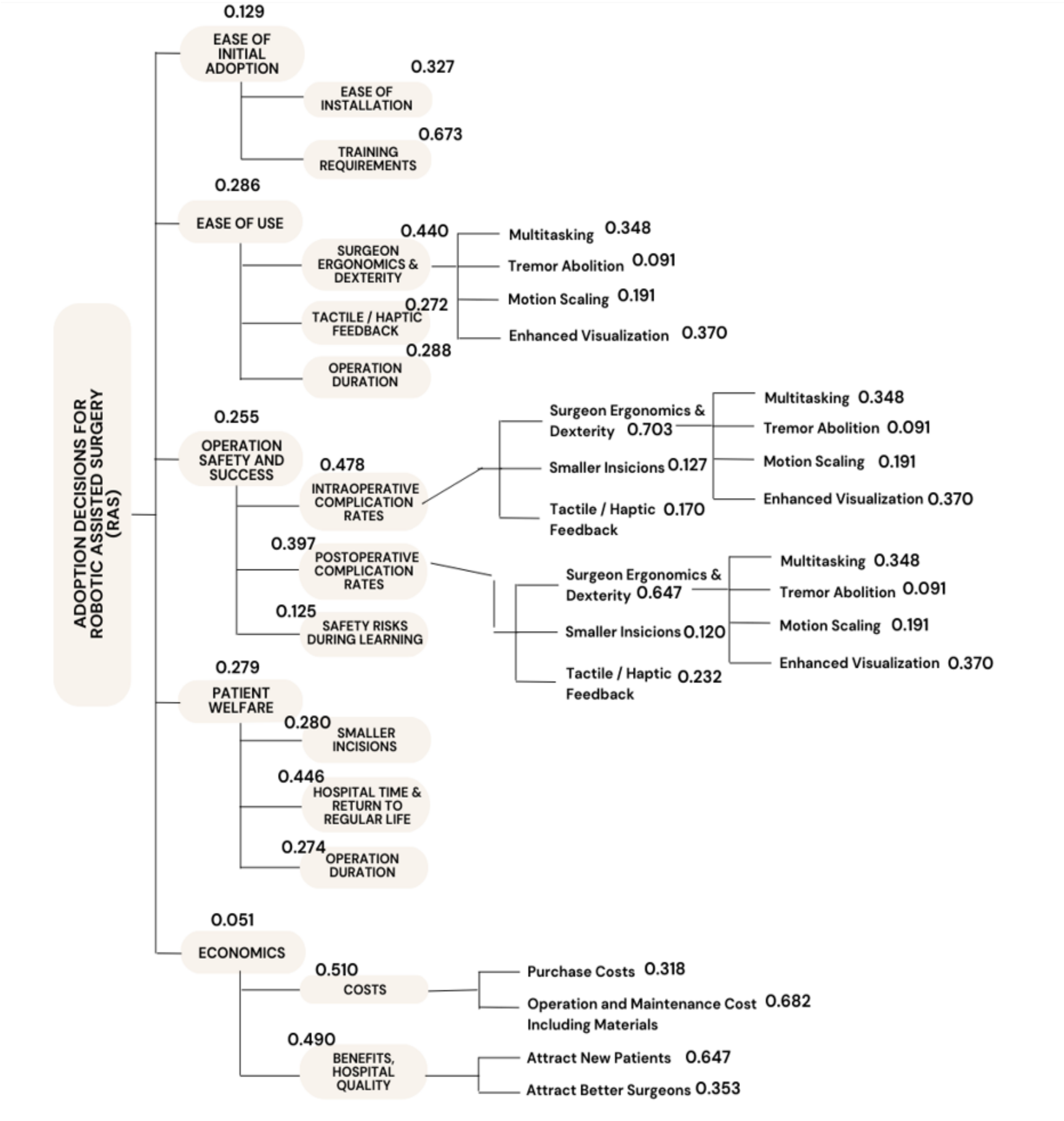

Figure 18: AHP Tree of Urology Aggregated Priority Vectors

Urology surgeons reckon having a minimum complication rate regarding Operation Safety and Success (OSS) is significant. Considering the operation stages, their first preference is to lower Intraoperative Complication Rates (ICR). Even with the reduction of Postoperative Complication Rates (PCR), evaluated as the second one, these two factors do not have a considerable weight difference in the urologists' perspectives. Urology surgeons are confident in coping with the possible training/learning incompetence during the operation - Risks During Learning (RDL) - as it is the lowest significant factor for them regarding Operational Safety and Success (OSS). The factors influencing lowering Intraoperative and Postoperative Complication Rates (ICR and PCR) and priorities calculation give the same sequence of significance even if their priorities are slightly different.

For urologists, the Enhanced Visualization (EV) feature of RAS platforms contributes the most to the adoption by improving Surgeon Ergonomics and Dexterity (SED). To establish a more patient-friendly environment, discharging the inpatients as soon as possible after the operation - Shorter Hospital Stays (SHS) - is their first priority. The perspective of urologists reflects that improving Surgeon Ergonomics and Dexterity (SED) has the most significant impact on making the RAS platform usage easier - Ease of Use (EOU). Training Requirements (TR) have the most negative effect on urology surgeons adopting RAS technology into their daily operation practice in the Ease of Initial Adoption (EIA) context. On the Costs side, Operation and Maintenance Costs (OMC) have the most enormous negative effect on the adoption process of RAS, according to the Urologist. Considering the Benefits relevant to Economic concerns - Economics (ECON) - of adopting the technology, Urology Surgeons find that Attracting New Patients (ANP) is more important than Attracting Better Surgeons (ABS) with this technology. Among the five main criteria, Ease of Use (EOU) is the first priority of Urology Surgeons. Patient Well-Being and Welfare (PW) follows as the second one, and the third is Operational Safety and Success (OSS). Ease of Initial Adoption (EIA) is their fourth priority in adopting RAS, while Economics (ECON) is the last.

3.11. An Evaluation of All Aggregated Priorities Versus Urology Aggregated Priorities

In this section, we compare the results of all aggregated priorities with field-based aggregated priorities to investigate if there is any difference.

Considering the Operational Safety and Success (OSS) decision-making matrix, the highest importance for the result of all aggregation and Urology disciplines is the same: Intraoperative Complication Rates (ICR). The sequence of the other factors is also parallel to each other. Both groups’ preferences for Intraoperative and Postoperative Complications Rates (ICR and PCR) are very convergent. Intraoperative

Complication Rates (ICR) are the first in both, but they are relevantly higher than Postoperative Complication Rates (PCR). Since there are no considerable differences, these matrices may combine into one.

The evaluation results of the factors of Surgeon Ergonomics and Dexterity (SED) matrices address the same interpretation of Operation Safety and Success (OSS), with the priority order for each factor to stay the same. Enhancing Visualization (EV) has the highest significance for both groups in improving Surgeon Ergonomics and Dexterity (SED). The second one is the same for both: Multitasking (MLT). Also, Motion Scaling (MS) is relatively higher than Tremor Abolition (TA) for both.

The order of Intraoperative Complication Rates (ICR) and Postoperative Complication Rates (PCR) matrices decision priorities are also the same for this aggregation evaluation. Surgeon Ergonomics and Dexterity (SED) is the most significant for both assessments. Tactile/Haptic Feedback (T/HF_ICR and T/HF_PCR) is not a big drawback for both groups.

Reckoning the priority weights of the Patient Well-Being and Welfare (PW) matrices, the Shorter Hospital Stays (SHS) factor is the most important factor for both aggregation evaluations. Urologists see the pair of Smaller Incisions (SI_PW) and Operation Duration (OD_PW) as almost equally important. The result of this pair for all aggregation priorities is also convergent. The second and third priority orders are the opposite for all surgeons and the Urologists.

It is inferred from both aggregated Ease of Use (EOU) matrices priorities; the most significant factor is Surgeon Ergonomics and Dexterity (SED_EOU). It is also observed that the second and third-factor sequence opposition is valid for this matrices' priority vectors. Additionally, the factors the surgeons find challenging to distinguish become more distant in all aggregation calculations.

The degrees of Ease of Installation (EOI) and Training Requirements (TR) become more convergent in all surgeons' aggregation priority vector evaluations than the aggregation of Urology priority vectors. The order of priorities stays the same in all aggregation evaluation results: the first is Training Requirements (TR), and the second is Ease of Installation (EOI).

Training Requirements are found to have a relatively higher effect on preventing Ease of Initial Adoption (EIA) by the Urologists. Its impact proportion is lower for all surgeons.

Even though some different preferences were observed in Training Requirements, both groups did not hesitate about Operation Safety and Success (OSS) during their learning process.

For the Benefits matrices, all aggregation and Urologists' aggregation results' first priority preferences are Attract New Patients (ANP), while the second is Attract Better Surgeons(ABS). The decision directions are opposite for Costs matrices results. The Costs matrix factors' priority order is different for both aggregated matrices. The result of all aggregated priority vectors in the Purchase Cost (PC) is the most significant, while it is the lowest for Urologists. Costs and Benefits factors' priorities of Economics (ECON) decision matrices are convergent, while both aggregation results, show that Costs are the most significant for the respondents. However, these are almost equal from the Urologists' point of view.

For the main categories all surgeons' highest priority is Operation Safety and Success (OSS), while the Urologists' first is Ease of Use (EOU). Patient Well-Being and Welfare (PW) is the second for the Urologist, which is also the case for all surgeons in our sample. All surgeon's preferences for Patient Welfare (PW) are relatively higher than Ease of Use (EOU). For Urologists, Patient Welfare (PW) is relatively higher than Operation Safety and Success (OSS). Operational Safety and Success (OSS) comes at the third place for Urologists. Ease of Use (EOU) is the third priority for all surgeons' perspectives. The priority order of Economics (ECON) and Ease of Initial Adoption (EIA) criteria are the same for each. All aggregated priorities' results state that Economics (ECON) and Ease of Initial Adaption (EIA) are almost equally important. For Urologists, the Ease of Initial Adoption (EIA) is relatively higher than Economics (ECON). Economics (ECON) matrix factors' priority weights are almost equal for all aggregation results. This observation states that surgeons think the impact of Costs and Benefits on adopting the RAS platform is almost equally important considering Economic concerns (ECON). This interpretation is also valid for the Urologists.

CHAPTER 4

CONCLUSION

The research question of this study addresses a very complex problem. The literature related to the adoption factors of the RAS technology was reviewed comprehensively to determine and address all relevant factors in this study. Then, we carefully examined all factors, took the influencing relationship between them, and combined them into categories. Thus, an infrastructural study took place before the final structure of the RAS AHP decision tree was developed.

Data was collected via an online survey from different surgical fields' surgeons and analyzed AHP Theory developed by Saaty (Saaty 1980). Priority vectors were calculated using the Eigenvector method for all surgeons with consistent decision matrices. The geometric mean method was executed to obtain the aggregated results of the decision matrices.

The evaluation of individual consistent decision matrices presents the following results. We observed that respondents do not see any value in evaluating separately the factors, Intraoperative Complication Rates (ICR) and Postoperative Complication Rates (PCR), that affect the Operational Safety and Success (OSS) criterion. Reckoning all the operation stages from the beginning and after the duration of the operation and combining them regarding complications under one name may create a suitable environment to compare the pairs of Operation Safety and Success (OSS) criterion. As a result, combining Intraoperative and Postoperative Complications Rates (ICR and PCR) factors as complications simplifies the decision-making problem. The other important point is inferred from this analysis that individuals from different disciplines have a common opinion that the Risks During Learning (RDL) of using the RAS platform are not a drawback for surgeons in the Operational Safety and Success (OSS) context.

For Surgeon Ergonomics and Dexterity (SED) matrices, the individuals who are consistent with their preferences state that the most important factor is Enhance Visualization (EV) to facilitate the surgeons' adoption of the RAS technology. Enhancing Visualization (EV) and Multitasking (MLT) are accepted as advantages by surgeons. Their technical improvements may facilitate the adoption process of the RAS.

In contrast to the literature, Tremor Abolition (TA) is not an obstacle for surgeons. It hardly affects the adoption since Tremor Abolition (TA) is the least charming factor influencing RAS technology adoption.

The surgeons highly appreciate any improvements in the RAS technology that enhance Surgeon Ergonomics and Dexterity (SED) to lower Intraoperative and Postoperative Complication Rates (ICR and PCR). The Tactile/Haptic Feedback (T/HF_ICR and T/HF_PCR) is not a critical drawback to the adoption process of the RAS platform, as mentioned in the literature.

Discharging patients from the hospital as early as possible is paramount to Patient Well-Being and Welfare (PW). Smaller Incisions (SI_PW) and Operation Duration (OD_PW) significance levels are very convergent.

Therefore, surgeons have some difficulty in distinguishing the effect of Operation Duration (OD_PW) and Smaller Incisions (SI_PW) on improved Patient Well-Being and Welfare (PW). Thus, it may be better to remove one of them to avoid confusion. Smaller Incisions (SI_PW) are observed as the most problematic mutual factor in Figure 11. Hence, removing it from this hierarchy of the AHP tree may provide more consistent decisions from the respondents.

In the context of Ease of Use (EOU), lacking Tactile/Haptic Feedback (T/HF_EOU) has a very low effect on adopting the RAS, according to surgeons' perspectives. This factor is put on the radar due to the effort of creating an atmosphere where the physicians can use the RAS platform most easily in the context of Ease of Use matrices. Additionally, the Tactile/Haptic Feedback (T/HF_EOU) factor is found to be the root cause of creating the top inconsistency regarding this pairwise comparison matrix pairs. Based on all these results, removing Tactile/Haptic Feedback from the Ease of Use (EOU) branch of our AHP tree allows us to make the surgeons think more structured.

The findings show that the Training Requirements (TR) factor is a drawback for surgeons, as in the literature (BenMessaoud et al. 2011; Krishnan et al. 2018; Vichitkraivin et al. 2020). Since it is surgeons' first priority, having a structured training program is more significant than the platforms’ Ease of Installation (EOI). Even if the impact of the Training Requirements (TR) on Ease of Initial Adoption (EIA) is the highest, surgeons are not afraid of the safety Risks During Learning (RDL) to ensure Operational Safety and Success (OSS).

The surgeons' preference in our sample regarding Economic Benefits (ECON_B) is primarily for Attracting New Patients (ANP). Since the physicians think that making more charming of the operation processes by raising the demand from the patients, may create additional benefits on adopting that technology for the surgeons. Results show that surgeons have some challenges in differentiating the Purchase Costs (PC) and Operation and Maintenance Costs (OMC) in the concept of Economic Costs (ECON_C). They evaluate the Economics (ECON) matrix factors almost equally.

Considering our study's MAIN criteria pairwise matrices, the results are examined in three steps: individual-based, disciplined-based, and aggregation of all respondents.

The individual-based consistent decisions' matrices data shows that the highest importance for the respondents at individual level is Operational Safety and Success (OSS) criterion to decide an adoption decision for the RAS. Ease of Use (EOU) is the most important criterion in the aggregated decision matrix of the urologists while it is, also, Operational Safety and Success (OSS) in the whole aggregated decision matrix. The second highest priority for these three concepts is Patient Well-Being and Welfare (PW). The third one is the same for individual-based, and all aggregated decisions are Ease of Use (EOU). For Urologists, it is Operation Safety and Success (OSS). Economic concerns (ECON) come at the fourth one regarding individual-based decision matrices. Ease of Initial Adoption (EIA) is the fourth priority level for Urologists and all surgeons in our sample. While Ease of Initial Adoption (EIA) is the fifth for individual consistent respondents, Economics (ECON) is for Urologists and all surgeons in our sample.

It is inferred from these results that the individual-based decisions and the group of surgeons with different specialties aggregated decisions are in more harmony. In contrast, a particular discipline's aggregated decisions are more differentiated than theirs.

4.1. Limitations

In this study, we developed a comprehensive AHP tree that consists of each category of the adoption process of the RAS. Since the results show slight differences between the Economics (ECON) branch's factors, Economics (ECON) criteria and its whole hierarchical branch may be removed from the study context. Removing this may also be beneficial in simplifying the problem. Another thing considering this perspective is that combining the Intraoperative Complications Rates (ICR) and Postoperative Complications Rates (PCR) as one Complications Rates helps to simplify this problem. We understand that being as specific as possible may contribute to obtaining better-understood responses. From the surgeons' side, the limitation is that since the adoption levels and perspectives of the RAS may be differentiated by the surgeons' disciplines, applying the survey to an equal number and adoption level of surgeons from each discipline may allow for more sharply differentiated results.

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APPENDICES

APPENDIX A

SURVEY DESIGN

A.1. English Version of the Survey

Robotic-Assisted Surgery Adoption Decision with the Analytical Hierarchy Process

⊕ PAGE TITLE

This questionnaire was created with the purpose of studying the relative importance of factors for the adoption of Robotic Assisted Surgery (RAS) among practicing surgeons in various disciplines. It's a part of MA study at Izmir Institute Of Technology, Technology, Design and Innovation Management Program. Your preferences will be quantified and prioritized using the Analytical Hierarchy Process (Saaty, 1980, 2013), an Expert Judment Quantification tool. The method uses pairwise comparisons of factors, along a decision tree.

The study is designed to provide useful quantitative information for the improvement and customization decisions for next generation of Robotic Assistants. We value your contribution highly, and we hope to incorporate your expert opinion and preferences. The survey will take about 20 minutesto complete. If you provide us with your e-mail address, we will be happy to share with you the final results of the study, as well as a quantitative summary of your personal preferences for RAS adoption, which we hope will be of interest to you. No information will be shared with third parties of any kind.

Thank you again for your valuable expert opinion and contribution to the study.
Işın Sözen Sarıgöl, Izmir Institute Of Technology
Asst. Prof. Burak Dindaroğlu, Izmir Institute Of Technology
Prof. Dr. Erman Aytaç, Acıbadem University

Robotic-Assisted Surgery Adoption Decision with the Analytical Hierarchy Process

Background Information and Decision-Making Context

* 1. Please select your age interval 0

- ◯ 25-34
- ◯ 35-44
- ◯ 45-54
- ◯ 55-64
- ◯ 65 or above

* 2. What is your surgical specialization? 0

[ ]

* 3. In your current surgical practice, you use (please all that apply) 0

- ☐ Open surgery
- ☐ Laparoscopy
- ☐ Robotic Assisted Surgery

4. If you are not currently using Robotic Assisted surgery, do you intend to use it in the future? 0

- ◯ I have no intention to adapt robotic assistance in the future.
- ◯ I am open to learn more about robotic assistants before making my mind.
- ◯ I have an intention to use a robotic assistant in the future.
- ◯ I am willing but cannot adapt, due to (please add reason briefly)

[ ]

* 5. Please select your current title 🗨 0

◯ Attending Physician

◯ Assistant Professor

◯ Associate Professor

◯ Professor

* 6. Please provide any administrative duties or roles, i.e., the context of decision making. 🗨 0

☐ Chief executive officer / chief physician for hospital

☐ Director of surgical department

☐ None

☐ Other (please specify)

* 7. Which one is true for you? 🗨 0

☐ I work for a hospital.

☐ I work for someone else's private practice.

☐ I work at a university.

☐ I run my of surgical practice.

☐ Other (please specify)

* 8. Please select your country of residence (street address not required). 🗨 0

City

Country

Select country

9. Provide your e-mail address if you wish to receive research outputs and a quantitative summary of your decision priorities. 🗨 0

Email address

10. If you have provided an e-mail address, is it OK if we contact you in the future for additional (short and concise) inquiries? 🗨 0

◯ Yes

◯ No

Robotic-Assisted Surgery Adoption Decision with the Analytical Hierarchy Process

AHP Questionnaire Format

In what follows, **you will be asked to compare two Factors at a time in terms of their importance for a Criterion** to be examined, and give your preference on a scale of 1 to 9, as described in the table below. Each question will be of the form:

Please compare Factor A and Factor B, in terms of their importance for Criterion C.

To answer, you will need to pick the more important factor for you, A or B, using the drop-down menu on the left, and also give the strength of your preference on a scale of 1 to 9, using the menu on the right. If the two factors are equally important for you for the Criterion, you can pick any one of them on the left menu, and select the number 1 using the menu on the right.

Relative Comparison of Factors	Numerical Ratings
Equally Important	1
Moderately More Important	3
Strongly More Important	5
Very Strongly More Important	7
Extremely More Important	9

Robotic-Assisted Surgery Adoption Decision with the Analytical Hierarchy Process

Criterion 1: Operation Safety and Success

The first criterion deals with factors that lead to higher success rates and reduced operation risk, leading to successful completion of the surgery. RAS is found to **reduce Intraoperative and Postoperative Complications, though may present additional risks during Inexperienced Use and Learning.**

Which of the following, in your opinion, is more important for Operation Safety and Success? 0

* 11. Obtaining **Lower Intraoperative Complication Rates**, or **Lower Postoperative Complication Rates**? 0

Preference Direction	Level of Preference

* 12. **Lower Intraoperative Complication Rates**, or **Safety Risks During Inexperienced Use and Learning**? 0

Preference Direction	Level of Preference

* 13. **Lower Postoperative Complication Rates**, or **Safety Risks During Inexperienced Use and Learning?** 🗨 0

	Preference Direction	Level of Preference
-		

RAS platforms offer Enhanced Surgeon Ergonomics and Dexterity. Which features below, in your opinion, are more important for Surgeon Ergonomics and Dexterity? Please make pairwise comparisons by answering the questions below.

Factors contributing to Enhanced Surgeon Ergonomics are explained below:
Multitasking refers to the ability to perform multiple processes at once.
Tremor Abolition refers to the elimination of involuntary hand movements.
Motion Scaling refers to the conversion of large hand movements into smaller movements in the operative field.
Enhanced Visualization refers to stable and magnified image, often in 3D. 🗨 0

* 14. **Multitasking**, or **Tremor Abolition?** 🗨 0

	Preference Direction	Level of Preference
-		

* 15. **Multitasking**, or **Motion Scaling?** 🗨 0

	Preference Direction	Level of Preference
-		

* 16. **Multitasking**, or **Enhanced Visualization?** 🗨 0

	Preference Direction	Level of Preference
-		

17. **Tremor Abolition**, or **Motion Scaling?** 🗨 0

	Preference Direction	Level of Preference
-		

* 18. **Tremor Abolition,** or **Enhanced Visualization?** 🗨 0

	Preference Direction	Level of Preference
-		

* 19. **Motion Scaling,** or **Enhanced Visualization?** 🗨 0

	Preference Direction	Level of Preference
-		

RAS is claimed to reduce Intraoperative Complications: Please choose which factor among each pair is more important for reducing Intraoperative Complications? Factors related to fewer complications can be listed as

-**Smaller Incisions** with RAS,
-**Tactile/Haptic Feedback** (which current RAS platforms lack), and
-**Surgeon Ergonomics and Dexterity** with RAS. 0

* 20. The ability to make **Smaller Incisions**, or the presence of **Tactile/Haptic Feedback?** 0

	Preference Direction	Level of Preference

* 21. The ability to make **Smaller Incisions**, or **Surgeon Ergonomics and Dexterity?** 0

	Preference Direction	Level of Preference

* 22. **Surgeon Ergonomics and Dexterity**, or **Tactile/Haptic Feedback?** 0

	Preference Direction	Level of Preference

Postoperative Complications: Please choose which factor is more important for reducing Postoperative Complications? Factors are the same as for Interoperative Complications. 0

* 23. The ability to make **Smaller Incisions**, or the presence of **Tactile/Haptic Feedback?** 0

	Preference Direction	Level of Preference

* 24. The ability to make **Smaller Incisions**, or **Surgeon Ergonomics and Dexterity?** 0

	Preference Direction	Level of Preference

* 25. **Surgeon Ergonomics and Dexterity**, or **Tactile/Haptic Feedback?** 0

	Preference Direction	Level of Preference

Robotic-Assisted Surgery Adoption Decision with the Analytical Hierarchy Process

Criterion 2: Patient Well-Being and Welfare

Defined as all factors that improve the well-being of the patient, other than factors that directly relate to Operation Success. Main factors that contribute are listed as,

Smaller Incisions,
Shorter Hospital Stays and Earlier Return to Human Activity,
Operation Duration.

Which of the following, in your opinion, is more important for improving Patient Well-Being? 0

26. The ability to make **Smaller Incisions**, or **Shorter Hospital Stays?** 0

Preference Direction	Level of Preference

27. The ability to make **Smaller Incisions**, or **Operation Duration?** 0

Preference Direction	Level of Preference

28. **Shorter Hospital Stays**, or **Operation Duration?** 0

Preference Direction	Level of Preference

Robotic-Assisted Surgery Adoption Decision with the Analytical Hierarchy Process

Criterion 3: Ease of Use

This criterion refers to factors that make the platform easier to use. Current Robotic Surgery platforms are known to enhance **Surgeon Ergonomics and Dexterity**, and reduce **Operation Duration**. However, the absence of **Tactile (Haptic) Feedback** is noted as a significant drawback. Please compare these three factors, in pairs, in terms of their importance for Ease of Use, via the questions below.

Which of the following, in your opinion, is more important for Ease of Use? 0

29. **Tactile/Haptic Feedback**, or **Operation Duration?** 0

	Preference Direction	Level of Preference
-		

30. **Tactile/Haptic Feedback**, or **Surgeon Ergonomics and Dexterity?** 0

	Preference Direction	Level of Preference
-		

31. **Surgeon Ergonomics and Dexterity,** or **Operation Duration?** 0

	Preference Direction	Level of Preference
-		

Robotic-Assisted Surgery Adoption Decision with the Analytical Hierarchy Process

Criterion 4: Ease of Initial Adoption

Factors facilitating or inhibiting the accesibility of the robotic platform for the hospital. Two factors are considered:
-Ease of Installation,
-Training Requirements (initial training needs for surgeons and staff).

Which of the following, in your opinion, is more important for the Ease of Initial Adoption? 0

32. **Ease of Installation** vs. **Training Requirements** 0

	Preference Direction	Level of Preference
-		

Robotic-Assisted Surgery Adoption Decision with the Analytical Hierarchy Process

Criterion 5: Economics

All factors related to monetary costs and benefits for the surgeon or the hospital. We consider **Initial Costs and** and **Operation Costs** separately, as well as **Benefits (Including Quality Procedures)**. Potential benefits of RAS platforms include **Attracting New Patients**, and **Attracting Better Surgeons**, for the hospital or practice.

Please make the three pairwise comparisons on this Section from the perspective of your hospital or practice, i.e., the unit making the purchase decision. If you are not familiar with Economic considerations, you may choose to skip this Section.

Which of the following, in your opinion, is more important for Economic concerns regarding Robotic Surgery Platform adoption? 0

33. For benefits, **Attracting New Patients,** or **Attracting Better Surgeons** for the hospital or practice? 0

	Preference Direction	Level of Preference
.		

34. For costs, **Initial Purchase Costs**, or **Operation and Maintenance Costs?** 0

	Preference Direction	Level of Preference
.		

35. For economic concerns, **Costs**, or **Benefits for the Hospital/Practice?** 0

	Preference Direction	Level of Preference
.		

Robotic-Assisted Surgery Adoption Decision with the Analytical Hierarchy Process

Comparisons of Main Criteria for the Adoption Decision

In this final section, you are asked to compare the relative importance of each of the five main criteria for your decision to adopt a Robotic Assistant.

Which of the following, in your opinion, is more important for your decision to adopt a Robotic Surgery Platform or not? 0

36. **Economic Considerations,** or **Ease of Initial Adoption?** 0

	Preference Direction	Level of Preference
.		

37. **Economics**, or **Ease of Use?** 0

	Preference Direction	Level of Preference
.		

38. **Economics**, or **Patient Well-Being?** 0

	Preference Direction	Level of Preference
-		

39. **Economics**, or **Operational Safety and Success?** 0

	Preference Direction	Level of Preference
-		

40. **Ease of Initial Adaption**, or **Ease of Use?** 0

	Preference Direction	Level of Preference
-		

41. **Ease of Initial Adaption**, or **Patient Well-Being?** 0

	Preference Direction	Level of Preference
-		

42. **Ease of Initial Adaption**, or **Operational Safety and Success?** 0

	Preference Direction	Level of Preference
-		

43. **Ease of Use**, or **Patient Well-Being?** 0

	Preference Direction	Level of Preference
-		

44. **Ease of Use**, or **Operational Safety and Success?** 0

	Preference Direction	Level of Preference
-		

45. **Patient Well-Being**, or **Operational Safety and Success?** 0

	Preference Direction	Level of Preference
-		

Robotic-Assisted Surgery Adoption Decision with the Analytical Hierarchy Process

Thank you for your Expert Opinion!

We are grateful for your expert opinion and time, and we are certain that your information will contribute greatly to the study. If you would like to obtain further information about the study, ask questions, or offer other comments, please contact, burakdindaroglu@iyte.edu.tr

A.2. Turkish Version of the Survey

Analitik Hiyerarşi Süreç ile Robotik Cerrahi Adaptasyon Kararı

⊕ PAGE TITLE

Bu anket, çeşitli disiplinlerde çalışan cerrahlar arasında Robotik Yardımlı Cerrahinin (RAS) benimsenmesine ilişkin faktörlerin göreceli önemini incelemek amacıyla oluşturulmuştur. İzmir Yüksek Teknoloji Enstitüsü, Teknoloji Tasarım ve İnovasyon Yönetimi Programında yürütülmekte olan bir yüksek lisans tez çalışması kapsamında alınmaktadır. Tercihleriniz, bir Uzman Kararı Ölçüm aracı olan Analitik Hiyerarşi Süreci (Saaty, 1980, 2013) kullanılarak ölçülecek ve önceliklendirilecektir. Yöntem, bir karar ağacı boyunca faktörlerin ikili karşılaştırılmalarına dayanır.

Çalışma, yeni nesil Robotik Asistanlar için iyileştirme ve özelleştirme kararlarına yönelik yararlı niceliksel bilgiler sağlamak üzere tasarlandı. Katkınıza çok değer veriyoruz ve uzman görüşünüzü ve tercihlerinizi dahil etmeyi umuyoruz. Anketin tamamlanması yaklaşık 20 dakika sürecektir. Bize e-posta adresinizi verirseniz, çalışmanın nihai sonuçlarını ve ilginizi çekeceğini umduğumuz RAS'ın benimsenmesine yönelik kişisel tercihlerinizin niceliksel bir özetini sizinle paylaşmaktan mutluluk duyarız. Hiçbir şekilde üçüncü şahıslarla bilgi paylaşılmayacaktır.

Değerli uzman görüşünüz ve çalışmaya katkınız için tekrar teşekkür ederiz.
Işın Sözen Sarıgöl, İzmir Yüksek Teknoloji Enstitüsü.
Dr. Öğretim Üyesi Burak Dindaroğlu, İzmir Yüksek Teknoloji Enstitüsü.
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Arka Plan Bilgisi ve Karar Verme Bağlamı

* 1. Lütfen yaş aralığınızı seçininiz. 0

- ◯ 25-34
- ◯ 35-44
- ◯ 45-54
- ◯ 55-64
- ◯ 65 ya da üstü

* 2. Cerrahi uzmanlığınız hangi alandadır? 0

[ ]

* 3. Mevcut cerrahi uygulamalarınızda kullandığınız yöntemler nelerdir? (Lütfen geçerli olanların tümünü seçiniz) 0

- ☐ Açık Ameliyat
- ☐ Laparoskopi
- ☐ Robotik Yardımlı Cerrahi

4. Şu anda Robotik Yardımlı Cerrahiyi kullanmıyorsanız, gelecekte kullanmayı düşünüyor musunuz? 0

- ◯ Gelecekte robotik yardımlı cerrahiyi, cerrahi pratiğime uyarlamaya niyetim yok.
- ◯ Kararımı vermeden önce robotik yardımlı cerrahi hakkında daha fazla bilgi edinmeye açığım.
- ◯ Gelecekte robotik yardımlı cerrahi kullanmayı planlıyorum.
- ◯ İstiyorum ama pratiğime adapte edemiyorum, çünkü (lütfen kısaca nedenini belirtiniz)

* 5. Lütfen mevcut unvanınızı seçiniz. 0

- ◯ Uzman Doktor
- ◯ Dr. Öğretim Üyesi
- ◯ Doçent Dr.
- ◯ Profesör

* 6. Lütfen idari görevinizi ya da rolünüzü, yani karar alma bağlamınızı belirtin. 0

- ☐ Hastanenin İcra Kurulu Başkanı / Başhekimi
- ☐ Cerrahi Bölüm Direktörü
- ☐ Hiçbiri
- ☐ Diğer (Lütfen belirtin)

* 7. Sizin için aşağıdakilerden hangisi doğru? 0

- ☐ Bir hastanede çalışıyorum.
- ☐ Bir başkasına ait özel bir pratikte çalışıyorum.
- ☐ Bir üniversitede çalışıyorum.
- ☐ Kendi cerrahi pratiğimi yürütüyorum.
- ☐ Diğer (Lütfen belirtin).

* 8. Lütfen ikamet ettiğiniz şehri ve ülkeyi seçiniz (açık adres gerekli değildir). 0

Şehir

Ülke

Select country

9. Araştırma çıktılarını ve karar önceliklerinizin niceliksel bir özetini almak istiyorsanız e-posta adresinizi belirtiniz. 0

E-posta

10. Bizimle bir e-posta adresi paylaştıysanız, gelecekte ek (kısa ve öz) sorular için sizinle iletişime geçmemiz uygun olur mu? 0

◯ Evet

◯ Hayır

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AHP Anket Formatı

Aşağıda sizden, incelenecek bir Kriter için önemleri açısından iki Faktörü aynı anda karşılaştırmanız ve aşağıdaki tabloda açıklandığı gibi tercihinizi 1'den 9'a kadar bir ölçekte belirtmeniz istenecektir. Her soru şu biçimde olacaktır:

Lütfen A Faktörü ile B Faktörünü C Kriteri açısından önemlerine göre karşılaştırın.

Yanıtlamak için, soldaki açılır menüyü kullanarak sizin için en önemli faktörü (A veya B) seçmeniz ve ayrıca sağdaki menüyü kullanarak tercihinizin gücünü 1'den 9'a kadar bir ölçekte belirtmeniz gerekecektir. Kriter açısından iki faktör sizin için eşit derecede önemliyse soldaki menüden herhangi birini seçip, sağdaki menüyü kullanarak 1 sayısını seçebilirsiniz.

Faktörlerin Göreceli Karşılaştırması	Sayısal Derecelendirmeler
Eşit Derecede Önemli	1
Orta Derecede Daha Önemli	3
Çok Daha Önemli	5
Çok Güçlü Daha Önemli	7
Son Derece Daha Önemli	9

Analitik Hiyerarşi Süreç ile Robotik Cerrahi Adaptasyon Kararı

Kriter 1: Operasyon Güvenliği ve Başarısı

İlk kriter, daha yüksek başarı oranlarına ve daha az ameliyat riskine yol açan ve ameliyatın başarıyla tamamlanmasını sağlayan faktörlerle ilgilidir. Robotik yardımlı cerrahinin **Ameliyat Sırasındaki ve Sonrasındaki Komplikasyonları azalttığı bulunmuştur ancak Deneyimsiz Kullanım ve Öğrenme sırasında ek riskler ortaya çıkarabilir.**

Sizce Operasyon Güvenliği ve Başarısı için aşağıdakilerden hangisi daha önemlidir? 0

* 11. **Ameliyat Sırasında Daha Düşük Komplikasyon Oranları** elde etmek mi, yoksa **Ameliyat Sonrasında Daha Düşük Komplikasyon Oranları** elde etmek mi? 0

	Tercih Yönü	Tercih Düzeyi
-		

* 12. **Ameliyat Sırasındaki Daha Düşük Komplikasyon Oranları** mı yoksa **Deneyimsiz Kullanım ve Öğrenme Sırasındaki Daha Yüksek Güvenlik Riskleri** mi? 0

	Tercih Yönü	Tercih Düzeyi
-		

* 13. **Ameliyat Sonrasındaki Daha Düşük Komplikasyon Oranları** mı yoksa **Deneyimsiz Kullanım ve Öğrenme Sırasındaki Daha Yüksek Güvenlik Riskleri** mi? 0

	Tercih Yönü	Tercih Düzeyi
-		

Robotik yardımlı cerrahi platformları Gelişmiş Cerrah Ergonomisi ve El Becerisi sunar. Size göre aşağıdaki hangi özellikler Cerrah Ergonomisi ve El Becerisi açısından daha önemlidir? Lütfen aşağıdaki soruları yanıtlayarak ikili karşılaştırmalar yapınız.

Gelişmiş Cerrah Ergonomisine katkıda bulunan faktörler aşağıda açıklanmaktadır:
Çoklu Görev, aynı anda birden fazla işlemi gerçekleştirebilme yeteneğini ifade eder.
Titreme Önleme, istemsiz el hareketlerinin ortadan kaldırılması anlamına gelir.
Hareket Ölçeklendirme, büyük el hareketlerinin ameliyat sahasında daha küçük hareketlere dönüştürülmesini ifade eder.
Gelişmiş Görselleştirme, genellikle üç boyutlu (3D) olarak sabit ve büyütülmüş görüntüyü ifade eder.
0

* 14. **Çoklu Görev**, ya da **Titreme Önleme?** 0

	Tercih Yönü	Tercih Düzeyi
-		

* 15. **Çoklu Görev**, ya da **Hareket Ölçeklendirme?** 0

	Tercih Yönü	Tercih Düzeyi
-		

* 16. **Çoklu Görev**, ya da **Gelişmiş Görselleştirme?** 0

	Tercih Yönü	Tercih Düzeyi
-		

* 17. **Titreme Önleme**, ya da **Hareket Ölçeklendirme?** 0

	Tercih Yönü	Tercih Düzeyi
-		

* 18. **Titreme Önleme,** ya da **Gelişmiş Görselleştirme?** 0

	Tercih Yönü	Tercih Düzeyi
-		

* 19. **Hareket Ölçeklendirme,** ya da **Gelişmiş Görselleştirme?** 0

	Tercih Yönü	Tercih Düzeyi
-		

Robotik yardımlı cerrahinin Ameliyat Sırasındaki Komplikasyonları azalttığı iddia ediliyor: Lütfen her bir çift arasından hangi faktörün Ameliyat Sırasındaki Komplikasyonları azaltmak için daha önemli olduğunu seçin. Daha az komplikasyonla ilgili faktörler şu şekilde sıralanabilir:

-Robotik Yardımlı Cerrahi ile **Daha Küçük Kesiler**,
-**Dokunsal Geribildirim** (mevcut Robotik Yardımlı Cerrahi platformlarında bulunmamakta) ve
-Robotik Yardımlı Cerrahi ile **Cerrah Ergonomisi ve El Becerisi**.
0

* 20. **Daha Küçük Kesiler** yapma yeteneği mi, yoksa **Dokunsal Geri Bildirimin** varlığı mı? 0

	Tercih Yönü	Tercih Düzeyi
-		

* 21. **Daha Küçük Kesiler** yapma yeteneği mi, yoksa **Cerrahın Ergonomisi ve El Becerisi** mi? 0

	Tercih Yönü	Tercih Düzeyi
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* 22. **Cerrahın Ergonomisi ve El Becerisi mi**, yoksa **Dokunsal Geribildirim** mi? 0

	Tercih Yönü	Tercih Düzeyi

Ameliyat Sonrası Komplikasyonlar: Lütfen Ameliyat Sonrası Komplikasyonları azaltmak için hangi faktörün daha önemli olduğunu seçin. Faktörler Ameliyat Sırasındaki Komplikasyonlarla aynıdır.
0

* 23. **Daha Küçük Kesiler** yapma yeteneği mi, yoksa **Dokunsal Geribildirimin** varlığı mı? 0

	Tercih Yönü	Tercih Düzeyi

* 24. **Daha Küçük Kesi** yapma yeteneği mi, yoksa **Cerrahın Ergonomisi ve El Becerisi** mi? 0

	Tercih Yönü	Tercih Düzeyi

* 25. **Cerrahın Ergonomisi ve El Becerisi** mi, yoksa **Dokunsal Geribildirim** mi? 0

	Tercih Yönü	Tercih Düzeyi

Analitik Hiyerarşi Süreç ile Robotik Cerrahi Adaptasyon Kararı

Kriter 2: Hastanın Sağlığı ve Refahı

Operasyon Başarısı ile doğrudan ilgili faktörler dışında, hastanın refahını artıran tüm faktörler olarak tanımlanır. Katkıda bulunan ana faktörler şöyle sıralanmıştır:

Daha Küçük Kesiler,
Daha Kısa Hastanede Kalış Süresi ve Günlük Hayata Daha Erken Dönüş,
Operasyon Süresi.

Size göre aşağıdakilerden hangisi Hastanın Sağlığını/İyi Olma Halini iyileştirmek için daha önemlidir? 0

26. **Daha Küçük Kesiler** yapmak mı, yoksa **Hastanede Kalış Süresini Kısaltmak mı?** 0

	Tercih Yönü	Tercih Düzeyi

27. **Daha Küçük Kesiler** yapabilme yeteneği mi**, Operasyon Süresi** mi? 0

	Tercih Yönü	Tercih Düzeyi

28. **Daha Kısa Hastanede Kalış Süresi** mi, **Operasyon Süresi** mi? 0

	Tercih Yönü	Tercih Düzeyi

Analitik Hiyerarşi Süreç ile Robotik Cerrahi Adaptasyon Kararı

Kriter 3: Kullanım Kolaylığı

Bu kriter platformun kullanımını kolaylaştıran faktörleri ifade etmektedir. Mevcut Robotik Cerrahi platformlarının **Cerrahın Ergonomisini ve El Becerisini** arttırdığı ve **Operasyon Süresi**ni kısalttığı bilinmektedir. Ancak **Dokunsal Geribildirim**in olmayışı önemli bir dezavantaj olarak belirtilmektedir. Lütfen aşağıdaki soruları kullanarak bu üç faktörü Kullanım Kolaylığı açısından önemlerine göre ikili olarak karşılaştırın.

Sizce Kullanım Kolaylığı açısından aşağıdakilerden hangisi daha önemlidir? 0

29. **Dokunsal Geribildirim** mi, **Operasyon Süresi** mi? 0

	Tercih Yönü	Tercih Düzeyi
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30. **Dokunsal Geribildirim** mi yoksa **Cerrahın Ergonomisi ve El Becerisi** mi? 0

	Tercih Yönü	Tercih Düzeyi
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31. **Cerrahın Ergonomisi ve El Becerisi** mi, **Operasyon Süresi** mi? 0

	Tercih Yönü	Tercih Düzeyi
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Analitik Hiyerarşi Süreç ile Robotik Cerrahi Adaptasyon Kararı

Kriter 4: İlk Adaptasyon Kolaylığı

Robotik platformun hastane için erişilebilirliğini kolaylaştıran veya engelleyen faktörler. İki faktör dikkate alınır:
-**Kurulum kolaylığı,**
-**Eğitim Gereksinimleri** (cerrahlar ve personel için başlangıç eğitim ihtiyaçları).

İlk Adaptasyon Kolaylığı açısından aşağıdakilerden hangisi sizce daha önemlidir? 0

32. **Kurulum Kolaylığı, veya Eğitim Gereksinimleri** 0

	Tercih Yönü	Tercih Düzeyi
.		

Analitik Hiyerarşi Süreç ile Robotik Cerrahi Adaptasyon Kararı

Kriter 5: Ekonomi

Cerrah veya hastane için parasal maliyet ve faydalarla ilgili tüm faktörler. **İlk Maliyetleri** ve **Operasyon Maliyetleri**ni ve ayrıca **Faydaları (Kalite Prosedürleri dahil)** ayrı ayrı ele alıyoruz. Robotik Yardımlı Cerrahi platformlarının potansiyel faydaları arasında hastane veya muayenehane için **Yeni Hastaların Etkilenmesi** ve **Daha İyi Cerrahların Etkilenmesi** yer almaktadır.

Lütfen bu Bölümdeki üç ikili karşılaştırmayı hastanenizin veya muayenehanenizin, yani satın alma kararını veren birimin bakış açısından yapın. Ekonomik hususlara aşina değilseniz, bu Bölümü atlamayı seçebilirsiniz.

Robotik Cerrahi Platformunun benimsenmesine ilişkin Ekonomik kaygılar açısından aşağıdakilerden hangisi sizce daha önemlidir? 0

33. Faydaları düşündüğünüzde, **Yeni Hastaların Etkilenmesi** mi, yoksa hastane veya muayenehane için **Daha İyi Cerrahların Etkilenmesi** mi? 0

	Tercih Yönü	Tercih Düzeyi
.		

34. Maliyetleri düşündüğünüzde, **İlk Satın Alma Maliyetleri** mi yoksa **Operasyon ve Bakım Maliyetleri** mi? 0

	Tercih Yönü	Tercih Düzeyi
.		

35. Ekonomik konuları düşündüğünüzde, **Maliyetler** mi yoksa, **Hastanelere/Muayenehanelere Sağladığı Faydalar** mı? 0

	Tercih Yönü	Tercih Düzeyi
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Analitik Hiyerarşi Süreç ile Robotik Cerrahi Adaptasyon Kararı

Adaptasyon Kararlarına İlişkin Ana Kriterlerin Karşılaştırılması

Bu son bölümde, Robotik Yardımlı Cerrahiyi benimseme kararınız için beş ana kriterin her birinin göreceli önemini karşılaştırmanız istenmektedir.

Robotik Cerrahi Platformunu benimseme kararınızda sizce aşağıdakilerden hangisi daha önemli? 0

36. **Ekonomik Hususlar** mı, yoksa **İlk Adaptasyon Kolaylığı** mı? 0

	Tercih Yönü	Tercih Düzeyi
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37. **Ekonomi** mi, **Kullanım Kolaylığı** mı? 0

	Tercih Yönü	Tercih Düzeyi
.		

38. **Ekonomi** mi, **Hasta Refahı** mi? 🗨 0

	Tercih Yönü	Tercih Düzeyi
-		

39. **Ekonomi** mi, **Operasyonel Güvenlik ve Başarı** mı? 🗨 0

	Preference Direction	Level of Preference
-		

40. **İlk Adaptasyon Kolaylığı**, mı **Kullanım Kolaylığı** mı? 🗨 0

	Tercih Yönü	Level of Preference
-		

41. **İlk Adaptasyon Kolaylığı** mı, yoksa **Hasta Refahı** mı? 🗨 0

	Tercih Yönü	Tercih Düzeyi
-		

42. **İlk Adaptasyon Kolaylığı** mı yoksa, **Operasyonel Güvenlik ve Başarı** mı? 🗨 0

	Tercih Yönü	Tercih Düzeyi
-		

43. **Kullanım Kolaylığı** mı yoksa, **Hasta Refahı** mı? 🗨 0

	Tercih Yönü	Tercih Düzeyi
-		

44. **Kullanım Kolaylığı** mı yoksa, **Operasyonel Güvenlik ve Başarı** mı? 🗨 0

	Tercih Yönü	Tercih Düzeyi
-		

45. **Hasta Refahı** mı yoksa, **Operasyonel Güvenlik ve Başarı** mı? 🗨 0

	Tercih Yönü	Tercih Düzeyi
-		

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Uzman Görüşünüz için teşekkür ederiz!

Uzman görüşünüz ve zamanınız için minnettarız, bilgilerinizin çalışmaya büyük katkı sağlayacağından eminiz. Çalışma hakkında daha fazla bilgi edinmek, soru sormak veya başka görüşlerinizi iletmek isterseniz lütfen burakdindaroğlu@iyte.edu.tr adresiyle iletişime geçin.