Ethical Discussions for Autonomous Robotic Surgeries

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ABSTRACT

Artificial Intelligence is extensively applied and evolving in every field with emerging new techniques and approaches. Similarly, in the health care sector, robotic surgeries are expanding too. The significant leap from the fourth generation to the fifth generation of robots in the medical sector involves crucial decision making, robust infrastructure, and addressing ethical and legal obligations. This research addresses the ethical concern that may arise if surgeons are replaced with autonomous Robots. In this research, we performed a mixed-method approach involving quantitative (various literature reviews) and a qualitative survey which involved 60 participants and was conducted online. 52% of the respondents were not ready for complete automation of surgeries, and 77% were opposed to the possibility of the robot replacing surgeons. 75% of respondents recommended that surgeons monitor the interaction and that robots are aided than being entirely autonomous. Although surgeon substitution is not an ethical choice, these skills should be included in anesthetic and surgical preparation curricula and improved in a simulation environment. The future of this area requires exposure to continuous technological advancement and costing models and healthcare benefit networks for the next wave of robotic systems to achieve a foothold in the new healthcare industry.

Keywords: Robotic surgeries (RSs), autonomous robots, surgeon replacement

1. INTRODUCTION

The most popular and exceptional technologies developed using Artificial Intelligence and Machine learning in the medical and healthcare sector are being adapted in skyrocket trends. These highly technical applications provide solutions to the most complex surgical practices, such as robot-assisted surgeries, and these solutions might often involve complexity and ambiguity in medical, legal, and ethical aspects. Robotic surgeries and AI-enabled services have already established stronger roots. Current trends suggest that these roots would grow deeper with high investments in expertise training and sophisticated technological developments. [1] Though these are not such early stages of AI invasion, people are comfortable welcoming with open doors while most research on adopting a new model is still in progress concerning data security, ethical issues, equipment safety and legal issues.

Robotic surgeries (RSs) had gained popularity and attention when there was a considerable demand for minimally invasive surgical processes for higher accuracy and safety. RSs were based on the master-slave system until the 4th generation. Robotic surgeries are common in the United States of America and parts of Europe to treat different ranges of conditions. Mainly it involves a robot with a surgical arm and camera. The arms have several surgical instruments attached to them for the surgery, but the surgery process is not autonomous. A surgeon controls the arm of the robot in the operating room and sits in front of a console to perform the surgery.

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The console has a magnified, high-definition 3-D image of the operative site. Surgeons can have a better view of the operated site than the traditional techniques of surgeries, leading to fewer complications. An example is the Da Vinci Robotic System (Da Vinci Si HD dual-console system), which has four robotic arms and a double operating console. This system allows two surgeons to operate simultaneously using the operating console to control the four robotic arms. Surgeons are seated when performing this operation, which makes it easier and comfortable. MRI and CT scans can also be seen by surgeons whiles operating. With the evolution of Artificial Intelligence and Machine learning in the 5th generation, it is evident that RS could be autonomous. [2]. An example is the Smart Tissue Autonomous Robot (STAR), which outperformed experienced surgeons in cutting soft tissue and stitching it up. The surgeons deviated more from the ideal cut line. One of the inventors, Axel Krieger stated that "the STAR is good at doing repetitive procedures that require much precision." This task could be performed precisely several times without errors like missing a suture that can cause a leak and lead to several problems. Furthermore, the calculated external force's mean absolute inaccuracy with robotic surgeries is less than the human detection limit in performing an operation.
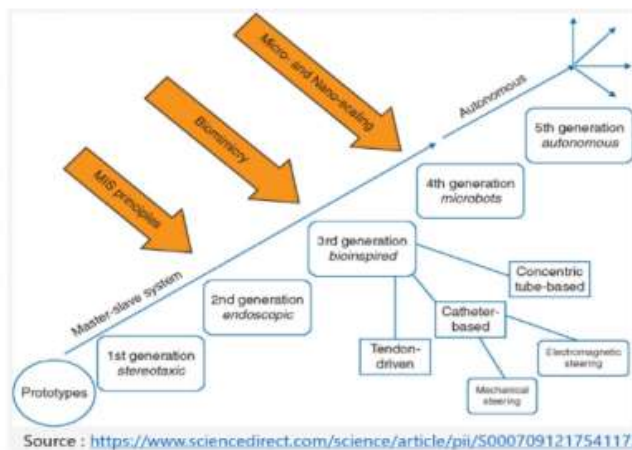

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Figure 1. Article: The evolution of robotic surgery: surgical and anesthetic aspects

[3]There is an increasing demand with exponential trends for artificial intelligence and machine learning-based solutions in recent years. [4] RSs have both benefits and risks, such as shorter hospitalization time, lower risk of adverse side effects, faster recovery times, and quicker return to normal activities. Risks and complications may occur because of surgeons' negligence or inability, device malfunction, improper maintenance, or wrong/biases technical implementation of the treatment[5]. These complications later arise from ethical and legal issues involved in RS. This study focuses on the ethical issues arising from the introduction of autonomous surgical robots.
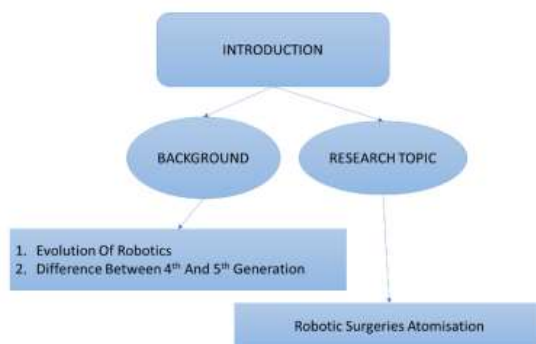

Figure 2. Background and Research Intent

1.1 Research question

When we talk about robotic surgery, we often assume that the robot is performing the surgery on its own, making decisions based on trained AI and ML algorithms. This is not the case in reality; a surgeon always controls the robot, and until our current fourth generation, it is only a robot-assisted surgery. The CARLO system is used for bone ablation and the Davinci surgical system can perform procedures on delicate and difficult-to-reach regions of the human body. It magnifies the image and greatly facilitates access using micro-incision scissors. According to the explained scenario, it is studied deeper how ethical it is to use this sophisticated Robotic equipment like CARLO, Davinci, ZEUS, etc., to replace medical surgeons if the RSs are entirely automated completely. And what factors to be reformed to overcome the ethical issues related to RS.

We have done a literature study to grasp the present aspects and perspectives of robotic surgery and found numerous review articles and analyses. This study comprised mapping research publications, qualitative and quantitative studies, it also featured semi-structured one-one interview analysis. As a result, we could construct the perspective of our current research, namely, whether the real world is ready to accept complete automation of complex robotic surgeries and whether the world is ready for a massive leap from robotics-assisted surgeries in the fourth generation to autonomous robotic surgeries in the fifth generation.
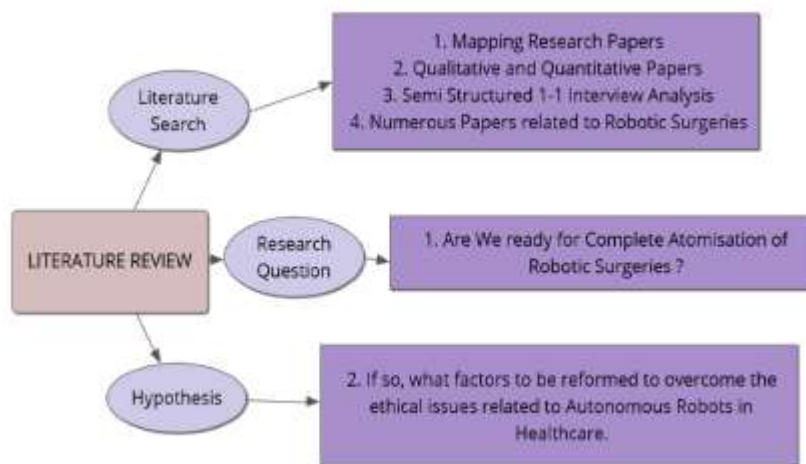
Figure 3. Literature Review, Research Intent, Hypothesis

2. LITERATURE REVIEW

A qualitative study published in the Journal of Medical Internet Research [4] identified significant opportunities to enhance RS's safety, quality, and efficiency. Identified barriers in improving RS were categorized into four groups, lack of wide acceptability, expectations and concerns related to the appearance of surgical robots, restructuring of workflow and control in performing surgeries and new ethical and legal challenges implying the necessity of new frameworks.

The twenty-year survey of RS in medicine [6] shows how frequently Robot-assisted surgeries are performed. This survey concludes a rapid increase in RS over 20 years, and significant contributions come from countries with high GDP. However, a retrospective study of FDA data for 14 years also identified that though there is a widespread acceptance for (MIS) robotics, there is an unacceptable number of technical complications and issues are being faced during the operation procedures. Despite the increasing use of robotic systems for minimally invasive surgery in the United States, there are still a significant number of technical issues and complications encountered during surgeries. Adopting new robotic surgical system design and operation approaches to improve procedures for adverse event reporting may help decrease these preventable occurrences in the future.[7-9]

Surgical robotics is a relatively young technology with much potential. Robotic surgery is often hailed as the next big thing, and it's one of the hottest topics in surgery right now. However, up until now, the market has primarily driven the desire to

create and acquire robotic gadgets. They would undoubtedly become a significant weapon in the surgical arsenal, but the amount they would be used is still being determined. [10]. On the horizon comes flexible robots. Greater scope-tip accuracy improved operational ergonomics, and lower occupational radiation exposure is all possibilities. Shortly, we believe it would be helpful for endoluminal therapeutic ureteror-enoscopy in urology. In the coming years, it may be possible to do transluminal surgery. [11]. As we approach a new industrial revolution defined by technologies that combine the physical and artificial worlds, it's essential to understand what measures we need to take to harness the potential of these technologies to simplify our lives without sacrificing our humanity [12].

2.1   Ethical

A Semi-structured one-to-one qualitative study indicates the most ethical issues are related to patients awareness and evolution in Health Information Technology [4]. In addition to this, other primary ethical concerns in BIG Data's era are information security and confidentiality. As the progression and development in AI and Data science are rapid, the concept of "personal data" is continuously changing. Training and building a machine learning model requires tons of data that cannot be anonymized completely. There is the possibility of bias introduced if the data sample does not replicate the real world.

In connection to robotic applied technology, it is critical to discuss the ethical domain and the necessity for informed permission or respect the individual's autonomy (patient or even the physician as operator). The growing attention and significance of ethical issues in AI in general and AI for robotics. [13]. Ethical concerns concerning surgical robotics differ depending on the robot's autonomy. As a result, there are fewer ethical issues if the robot is not autonomous, such as existing surgical support robots. Additionally, ethical issues are still present. For example, insisting on educating the surgeon on how to utilize robotic technology is critical, notably because each brand differs. Surgical robot manufacturers frequently give surgeons training. Simulators, dual console systems, and telementoring are also available (Canada). [13]

The ethical issues about the employment of care robots can be efficiently addressed when put in a utilitarian viewpoint. Regulation, particularly in the form of soft law, may prove to be a feasible option in terms of providing operators with direction and ensuring that users are not isolated. Similarly, privacy problems can be solved by deploying privacy-by-design approaches that are supervised by regulators [14].

2.2   Legal

Artificial intelligence is frequently used by tools that assess or analyze aspects of the surgery for performance improvement and reduction of errors. If the complete surgical process is recorded, this is likely to increase the concerns on legal risks. When it is known that they are being recorded, further issues may be raised around increased legal risk or behavior changes. Data is closely related to patient privacy and a crucial aspect of professional secrecy [12, 14]. Moreover, the major issues are with regards to robots that assist the surgeon during the surgical process. The responsibility and liability are not very clear as the robot is not considered a citizen, and hence not many legal obligations are applied to these machines [15].

The adoption of autonomous surgical robots is extremely unlikely to be any different. If surgical robots are used to help a humanitarian mission, they will very certainly need to be designed to comply with local laws and regulations. This important factor adds to the engineering challenges of building these systems: not only must these systems be designed to do complex jobs, but they must also be adaptable to diverse jurisdictions. [13, 14]. This conclusion does not rule out the necessity for a new framework to be adopted. Instead, it explains that a legal reform claim must be based on practical considerations. The incentives policymakers wish to give to consumers and researchers of care robots must prioritize product quality and safety while also guarantee a successful business. To begin with, the fact that robotic devices can function autonomously to a significant degree does not necessitate a shift in the present legal and philosophical paradigm, as there is no ontological basis for doing so. Robots are goods that can be dealt with within the legal and regulatory framework that already exists [14].

2.3   Economical

Adaption of assisted and automated RS enabled with highly advanced next-generation technologies is expensive. The development, installation, maintenance, and application of these advanced technologies are predicted because automated and robot-assisted surgeries outperformed compared surgeons leading operations with a prominent decrease in mortality rate. [16]. Success rates urge automation in the medical field with a wide range of commercial robots (direct control surgical – da Vinci system, shared control like Mako robotic arm, partial autonomous robots like cyberknife system).

Also, the statistics show massive investments production of robotic surgery in medicine [6, 17]. The possibility of these robotic surgery costs might be minimized in the future as the correlation between industry competition and technology might minimize the equipment cost and effective, affordable techniques [18].

2.4   Learning curve

The learning curves for surgical competence using robotic platforms vary greatly depending on the operation, pathology, and anatomical location (just as in open and MIS procedures). As a result, comparing learning curves and competence rates between procedures and methods can be difficult because achieving the same result using open, MIS and robotic treatments may not follow the same stages. The technological benefits of robotic surgery, which lessen the cognitive and physical demands of minimally invasive surgery, have been recommended to ease the surgical learning curve. This would allow doctors, even those with no prior laparoscopic expertise, to provide their patients with the benefits of minimally invasive surgery. However, evidence is unavailable to back up these claims, as well as comparison statistics. Based on the definition of "learning curve" used, sources indicate a learning curve that spans between 12 and 250 cases for robot-assisted laparoscopic radical prostatectomy (RALP). The learning curve for operating time generally takes 150–250 instances, whereas the learning curve for oncological and biochemical results, in this case, is over 750 cases [19].

2.5   Limitations in terms of operations and the environment

For day-to-day use, most existing robotic systems face a variety of operational challenges like the adequate theatrical area to support the present gadgets' enormous size, theatre personnel who are knowledgeable with the robotic platform setup, using an in-situ robotic device to manage the complicated ergonomics of a busy theatrical area and the capacity to reduce the time spent in a robotic operating room [19].

3.   METHODOLOGY

3.1   Data collection

Numerous ethical, legal, and economic concerns have been in the limelight as the gradual shift from the 4th generation to the 5th generation of RS is developing. In our report, we concentrated on the following classes of issues, which by no means eliminate the potential set of relevant ethical questions addressed in the preceding section and elsewhere, but which supported us, in the beginning, to include participant opinions in research in this area.
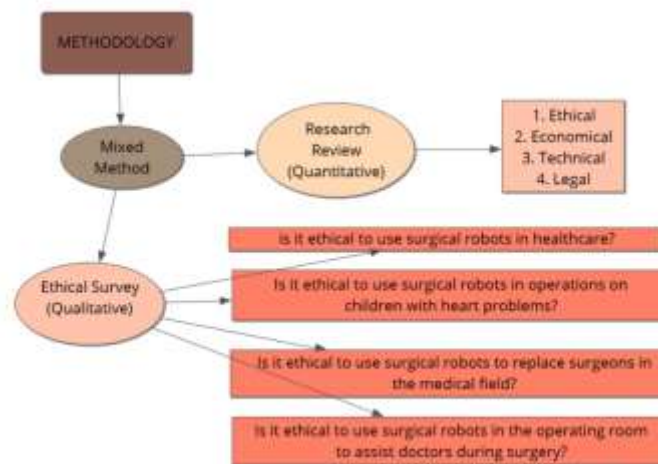

Figure 4 In this Section - Methodology (Qualitative and Quantitative)

3.2 Acceptability replacement and autonomy

Given the previously stated general attitude toward robotics in health care, we want to know if this is true for surgeons and patients requiring critical surgical care. More precisely, do patients and surgeons believe that using robotics in healthcare is **ethically acceptable**? Do they have issues believing that robots can replace surgeons or that it is more appropriate for robots to assist without replacing the human therapist(s)? **Replacement** is a problem not only in surgeries but also in the ethics of healthcare robotics in general. These issues are also related to **autonomy**: does the use of automated robotics necessitate the substitution of human surgeons? How precisely do auto robots alter the practice of care? In the survey we conducted, we have gathered opinions related to acceptability replacement and autonomy.

Is it ethical to use surgical robots in healthcare?

Is it legal to use surgical robots in procedures on children with heart problems?

Is it ethical to use surgical robots to replace surgeons in the medical field?

Is it ethical to use surgical robots in the operating room to assist doctors?

4. ANALYSIS

The statistical analysis and the researchers' conclusion of the literature review related to ethical, legal, economic, and technical play a significant role in RS. A quantitative online survey was conducted where information from 60 respondents was gathered. The responses were analyzed using PowerBI to gain more information. We conducted patients' perspectives and to identify what additional challenges might occur in the future with AI automation and how these concerns can be addressed.

Firstly, we identify the elements related to a patient undergoing the assisted robotic surgery. These elements can be classified into five groups, patients' concern about his/her personal information and identity, the whole process of the surgery, issues arising because of the medical condition and available treatment paths, patients' psychological fears and beliefs, and most importantly, the patient - surgeon relationship.
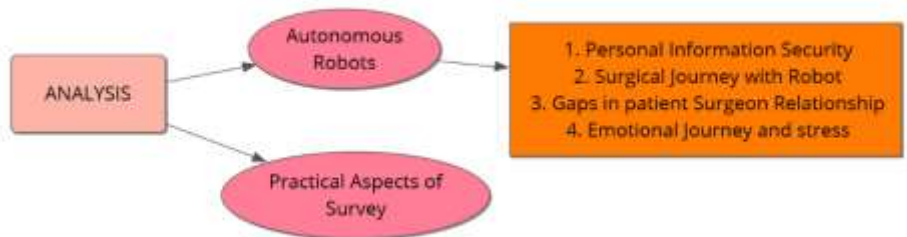

Figure 5 Analysis - Issues related to Autonomous Robots and Practical aspects of analysis

4.1 Personal information security

The current era of artificial intelligence and Big Data is overwhelming to preserve personal identity and secure personal information. Data availability and exchange in real-time are often alarming because of hidden clauses, and often people tend to give consent to use their data without recognition. Therefore, it is essential to break down ambiguous clauses and information stored and to which extent the data is anonymized and who controls provided data. Also, let patients know how the data is for research purposes or marketing purposes while not occupying or violating their personal space.

4.2 Surgical journey

4.2.1 Consent process

Undergoing surgery could be stressful and quite emotional for a person. Independent of patients' awareness, curiosity and behavior process of surgery must be explained to the patient. This might add additional emphasis on the consent process but educating the patient about the surgeons and people involved, post-surgery care and complications and a tour of the operation and pot-operating environment adds value and ease the patient from stress.
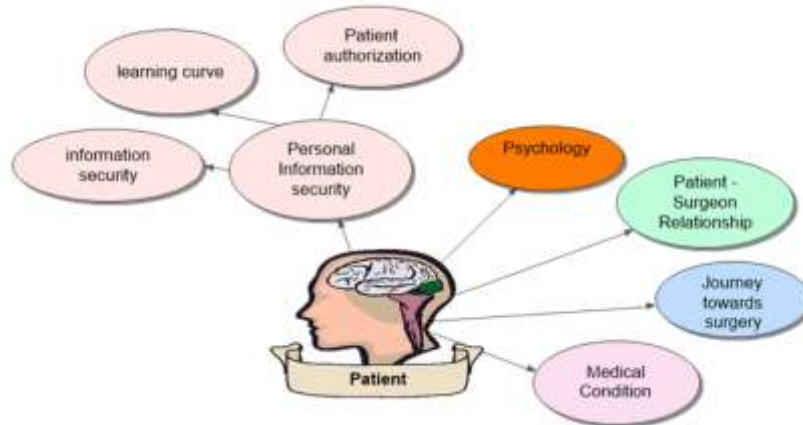

Figure 6 Concerns of Surgical processing focusing the patient

(Epistemic and normative ethical issues - [20]), Also as the literature explains, the surgeon's explanation and responsibility of consent method depend firstly on the patient's focus on procedure and post-operative risk and complications and then on the patient's concern regarding the surgery's details [21]. This will avoid misunderstanding negative publicity and misconceptions of RS.

4.2.2 Dynamic ethical challenges of AI

The constant evolution of AI and exponentially increasing robotics autonomy are other main factors for the dynamic ethical challenges[22]. Ethical concerns of implementing AI in healthcare frequently involve data security and privacy elements, ethics across data sourcing, growth and deployment, and the maintenance of transparency standards [23].

4.2.3 Patient – surgeon relationship

The patient-surgeon partnership is the bedrock upon which health treatment is built. Patient-surgeon partnerships may have a significant impact on health treatment. Improved health conditions are associated with stronger patient-surgeon relationships. It comprises four components: trust, experience, regard, and commitment, and the essence of this relationship influences patient outcomes[24].

4.2.4 Emotional journey

Emotions are widespread in social interaction, and experiments have shown that patients' motivation is critical. This raises the prospect of using robotics as a "social crutch." [25]. The attachment appears to be both beneficial and harmful. It should be regarded as beneficial insofar as attachment facilitates the mechanism and aims of therapy: without attachment, it would be impossible to offer such treatment. Researchers from robotics and human-robot interaction (HRI) are consciously attempting to stimulate connection by, for example, modeling the robot in particular ways [26].

4.2.5 Practical aspects of survey

This survey concentrated on the ethical aspects of robotic-assisted therapies and surgeries. The survey was conducted online by the free, open-source web application called SoGoSurvey. This application allows researchers to create and post surveys and gather responses without having to do any programming. The raw data is collected and analyzed using power BI. Visualizations are created and presented below for the ethical questioned answered in the survey.
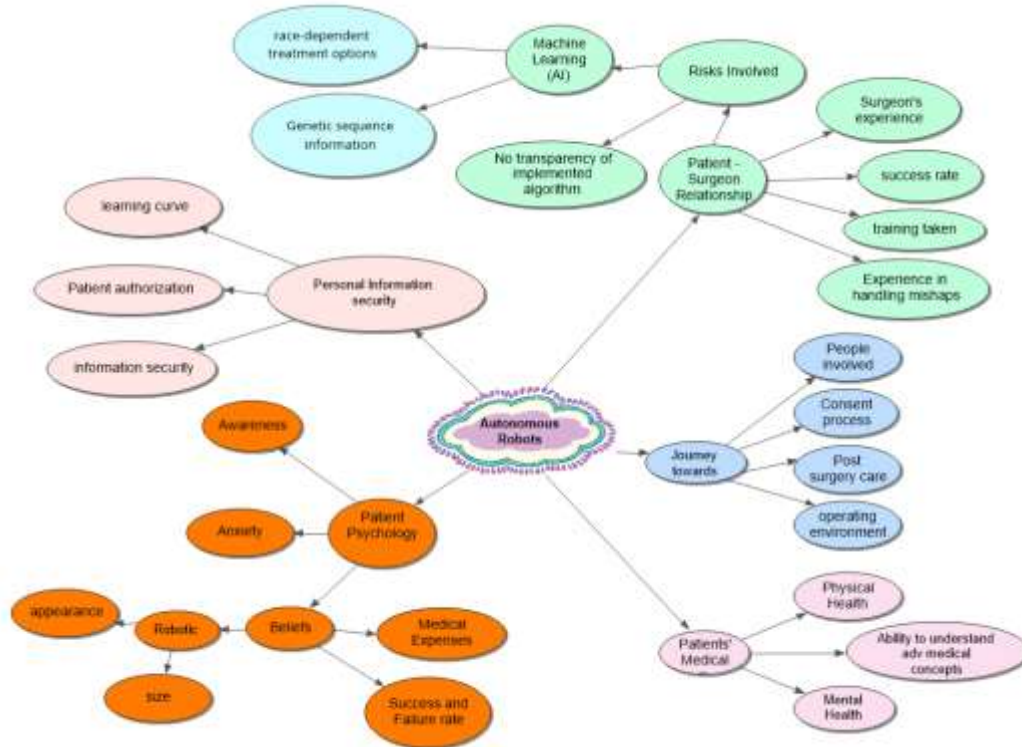

Figure 7 Major concerns and issues related to Autonomous Robotic Surgeries

5. DATA ANALYSIS

5.1 Data collection

In this research, we only discuss a subset of the findings obtained from questionnaire responses: those that we believe are most important to some of the core ethical and clinical problems identified in the preceding sections. As described in the review, this research aims to explore how ethical it is to replace surgeons completely with autonomous robots in surgeries. Even if the world is ready for the expected digital transformations, ethical challenges such as data protection and user privacy cannot be avoided in the coming future. We conducted a poll and received 66 answers. The study includes four questions on the world's readiness for autonomous robotic technology, particularly focused on surgeries and impacts on fragile patients.

Is using surgical robots in healthcare ethical? Is it permissible to employ surgical robots on children with cardiac issues during procedures? In the medical profession, is it ethical to deploy surgical robots to replace surgeons? And is it ethical to utilize surgical robots to help doctors during surgery in the operating room?

5.2 Data analysis and findings

The allocation of answers to the first two questions, "Is it ethically correct to use robotics in healthcare?' (33.33+16.67 = 50% agree, (18.18+12.12) = 30.3 % disagree, and about 20% are neutral- Fig. 8,9)
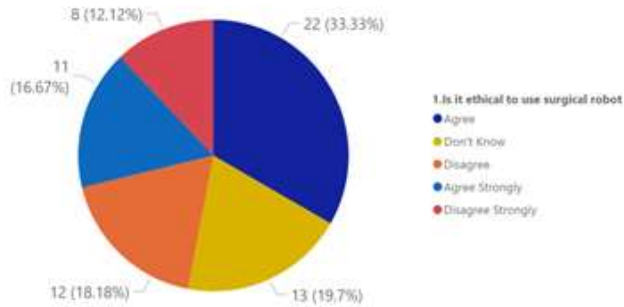

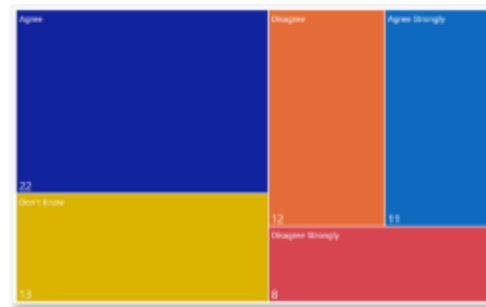Figure 8. Is it ethical to use surgical robots in healthcare?

Figure 9. Tree map

and "Is it legal to use surgical robots in procedures on children with heart problems?' (15.15+10.61) = 25.76% agree, (18.18+33.33) = 51.5% disagree, and 22.73% neutral - Fig. 10).
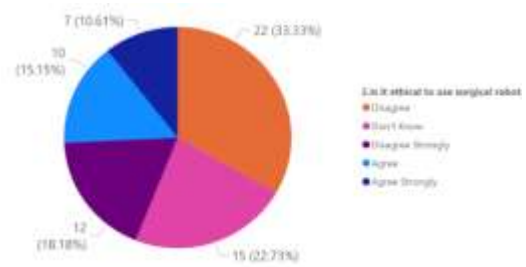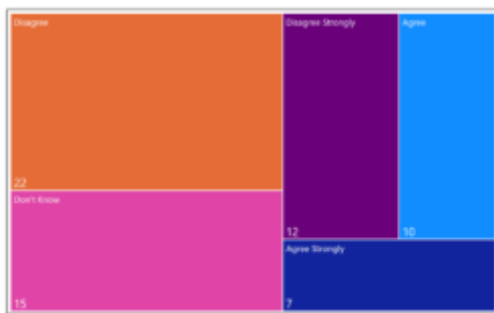

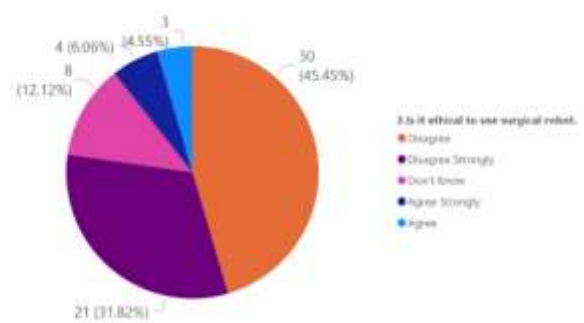Figure 9. Is it legal to use surgical robots in procedures on children with heart problems?

Figure 11. Is it ethical to use surgical robots to replace surgeons in the medical field?

Nevertheless, along with our discussion of ethical concerns, a large majority of participants (45.45+31.82) = 77.27% were opposed to the possibility of the robot replacing surgeons (Fig. 11 - Is it ethical to use surgical robots to replace surgeons in the medical field?)
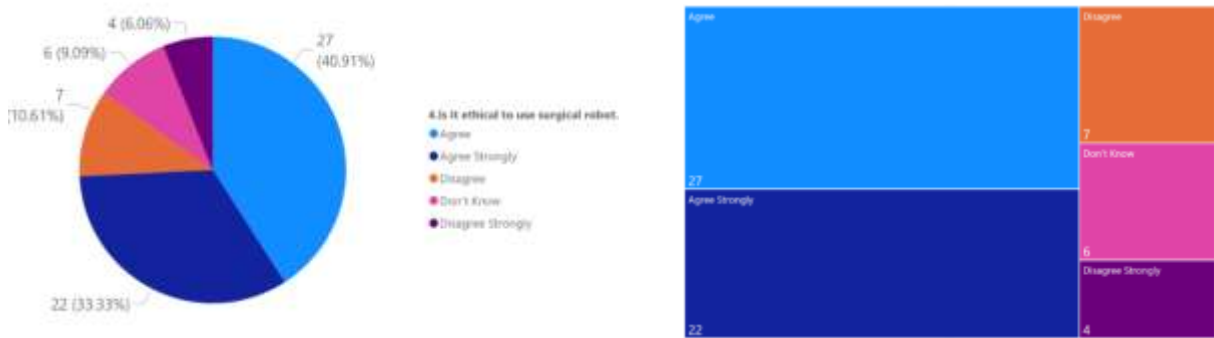

Figure 10 Is it ethical to use surgical robots in the operating room to assist doctors?

Additionally, (40.91+33.33) = 74.24% percent of respondents recommended that the surgeon monitor the interaction and that the robot is aided rather than entirely autonomous (Fig. 12 - Is it ethical to use surgical robots in the operating room to assist doctors during surgery?).

6. DISCUSSION AND LIMITATIONS

The survey result analysis on surgeon replacement can provide crucial messages for the philosophical debate around robot-assisted therapy and specialists and academics who use and build robots. These findings imply that practitioners should perform their treatment and study to prevent (perceived) therapist substitution or relocation. In addition, we expect those ethicists working in other areas of human-robot interaction can find these findings useful. When it comes to ethical questions, it is evident that there are many parallels and convergences; the question now is to properly grasp them conceptually (the deceit problem, for example, is quite complex) and to conclude design and real-time use.

Ultimately, there are some limitations of this study. For example, as this paper suggests, there are several ethical issues. However, we had to narrow our scope: we only included a short and tentative outline of these questions. We restricted our survey to a range of questions and very general questions about robot assisted. More research is needed to broaden the ethical analysis. Future work can focus more on new robotic systems that are being developed and gather more responses from a more devised public. Experts' opinions can also contribute to more knowledge in terms of the ethical concerns raised.
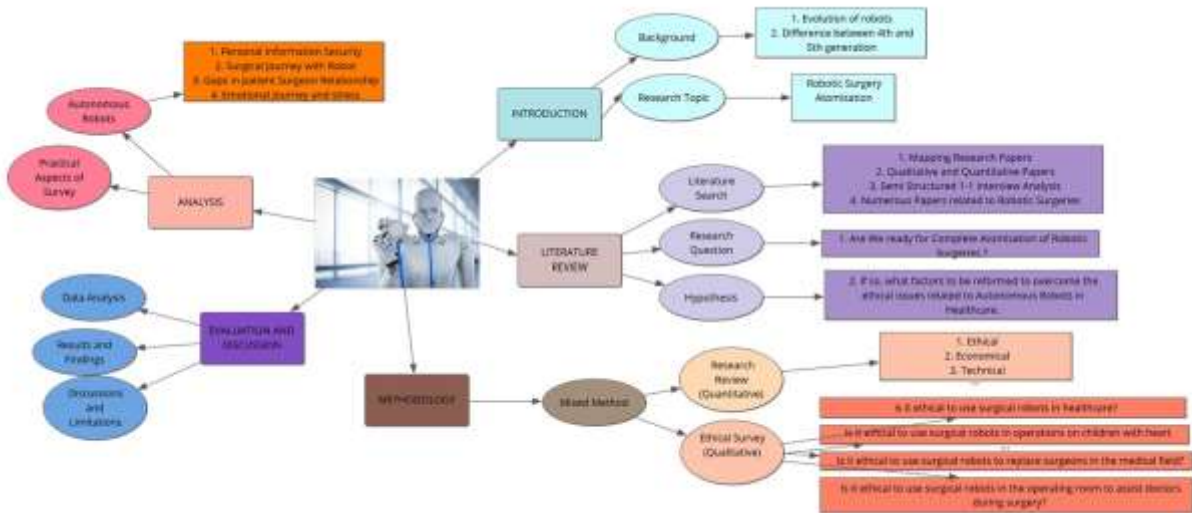
Figure 13. Layout of the research paper

7. CONCLUSION

Scientific developments and advancements in robotics are significant and positively impact patient treatments, but these always come with complex challenges in the ethical, legal, medical, and healthcare sectors. Artificial Intelligence and Data science are certainly quite crucial in today's advancing real world, but at the same time, they can become chaotic with fading away in terms of ethical aspects. Robotic surgery can be radically revolutionary in global healthcare, but it has not yet reached this status. This also involves preparing and implementing evidence-based robotic techniques and gaining expertise and faith in the skills required to manage the challenges and risks of patients undertaking robotic surgery. Seeking consent from patients and letting them know the risk and benefits of robotic surgeries, whether assisted or autonomous, should also be of high priority.

Although surgeon substitution is not an ethical choice, these skills should be included in anesthetic and surgical preparation curricula and improved in a simulation environment. Having AI systems or machines that work hand in hand with surgeons will help improve outcomes and safety and offer tremendous benefits for societies.

The future of this area requires exposure to continuous technological advancement and costing models and healthcare benefit networks for the next wave of robotic systems to achieve a foothold in the new healthcare industry.

8. ACKNOWLEDGMENT

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