ETHICAL IMPLICATIONS OF AI (ARTIFICIAL INTELLIGENCE) IN HEALTHCARE MAINLY FOCUS ON SURGICAL PROCEDURES

Identification Of Ethical Issues of AI In Surgical Procedures and Ranking of Ethical Issues Based on Criticality

Lappeenranta–Lahti University of Technology LUT

LUT School of Engineering Sciences

Software Engineering and Digital Transformation

2024

Muhammad Asif Khan

Examiners: Associate Professor Annika Wolff

Junior Researcher Arsalan Khan

ABSTRACT

Lappeenranta–Lahti University of Technology LUT

LUT School of Engineering Sciences

Software Engineering

Muhammad Asif Khan

ETHICAL IMPLICATIONS OF AI (ARTIFICIAL INTELLIGENCE) IN HEALTHCARE MAINLY FOCUS ON SURGICAL PROCEDURES

Identification Of Ethical Issues of AI In Surgical Procedures and Ranking of Ethical Issues Based on Criticality

Master's thesis

2024

80 pages, 7 figures, 5 tables

Examiners: Associate Professor Annika Wolff,

Junior Researcher Arsalan Khan

Keywords: AI Artificial Intelligence Healthcare Surgery Ethical Implications Ethical Issues Ethical Concerns Multi-Criteria Group Decision-Making (MCGDM) Surgical Procedures

Abstract: The integration of Artificial Intelligence (AI) in the healthcare sector, particularly within surgical procedures, presented advancements in accuracy and effectiveness while facing considerable ethical concerns. These concerns include transparency, medical data privacy, economic and accessibility challenges, algorithmic bias, human oversight, accountability, and the influence on professional surgeons.

This thesis identifies and prioritizes these ethical issues to ensure AI technologies' responsible and fair utilization in surgical procedures. The study aims to categorize the most

critical ethical concerns, assess them based on criticality, and propose recommendations to highlight the three most critical issues.

A comprehensive literature review and a survey involving experts from healthcare, AI, and ethics fields were conducted to rank the identified ethical issues based on their criticality. The Multi-Criteria Group Decision-Making (MCGDM) method was implemented to assess and prioritize these ethical issues methodically.

The study found the most critical ethical issues, where transparency and explainability ranked the foremost concern, followed by medical data privacy and economic and accessibility challenges. Drawing from these results, the study proposed recommendations for healthcare providers, researchers, and AI developers to ensure transparency, enhance medical data privacy, and overcome accessibility barriers. Furthermore, it recommends reducing algorithmic bias, ensuring continual human oversight, and furnishing recurrent training for surgeons. These recommendations are geared towards promoting ethical and secure integration of AI in surgical procedures, enhancing patient results, and upholding trust in AI-driven healthcare systems. This study contributes towards highlighting and mitigating the ethical implications caused by AI in surgical operations, providing a framework for forthcoming research and recommendations for the most critical ethical concerns.

ACKNOWLEDGMENTS

Completing this thesis has been a transformative journey marked by profound growth and deep gratitude for all who have supported me during this process.

Special thanks to my supervisor, Annika Wolff. Her resolute support and insightful guidance have been a beacon throughout this process. Her mentorship has been invaluable, and I am deeply thankful for that.

To my co-supervisor, Arsalan Khan, and my industry mentors, Shahid Bhat and Niaz Ali Khan, your critical contributions and steadfast support have been instrumental. Your wisdom and insights have enriched my work immeasurably.

To my friends, your unwavering support and the joy you brought to my life during this journey have been invaluable. A special thanks to all my colleagues and friends for being a steadfast presence during the toughest times.

Finally, I want to express my deep gratitude to my family, especially my father, mother, wife, brothers, and only sister, for their unwavering love, understanding, and support. Your encouragement has been my rock, keeping me grounded and motivated and giving me the strength to see this project through.

From the bottom of my heart, I am profoundly grateful to everyone involved in this project. Your collective efforts have been integral to the success of this thesis. Thank you for being part of this transformative journey with me.

Lappeenranta Finland
13th of June 2024

Muhammad Asif Khan

SYMBOLS AND ABBREVIATIONS

AI: Artificial Intelligence

GDPR: General Data Protection Regulation

HIPAA: Health Insurance Portability and Accountability Act

MCGDM: Multi-Criteria Group Decision-Making

TOPSIS: Technique for Order of Preference by Similarity to Ideal Solution

NLP: Natural Language Processing

LLM: Large Language Models

CNN: Convolutional Neural Networks

RAS: Robot-Assisted Surgery

Table of contents

Abstract

(Acknowledgements)

(Symbols and abbreviations)

Contents

1 INTRODUCTION

Integrating Artificial Intelligence (AI) in the healthcare domain showcased accomplishments in modern medical science, with the potential to transform various sides of patient care and operational efficiency. AI technologies, such as machine learning, natural language processing (NLP), and computer vision, have the potential to revolutionize healthcare by enhancing diagnostic accuracy, optimizing treatment plans, and improving patient monitoring capabilities (Liu et al., 2024). These advancements enable healthcare professionals to use extensive data for early disease detection, personalized treatment plans, and predictive analytics, resulting in improved patient outcomes and efficient clinical workflows (Pressman et al., 2024).

Among the diverse applications of AI in healthcare, the utilization of AI in surgical procedures is particularly notable for its ability to enhance surgical accuracy, reduce complications, and expedite patient recovery. Diverse methods have been employed to incorporate AI technologies into surgical practices, such as robotic-assisted surgery, real-time decision support systems, and predictive preoperative and postoperative care models. Platforms such as the da Vinci Surgical System and other robotic systems have demonstrated their ability to assist surgeons by providing improved visualization, enhanced dexterity, and the capacity to perform low-impact procedures with increased accuracy (Hussain et al., 2022).

The advantages of incorporating AI into surgical procedures are diverse. AI contributes to surgical precision and error reduction by providing real-time data and decision-making support, assisting surgeons in making well-informed choices during operations (Clark, 2024). AI algorithms can analyze vast amounts of patient data, encompassing medical records, imaging findings, and genetic details, to identify potential complications and suggest optimal surgical strategies. This not only enhances the accuracy of surgeries but also reduces the likelihood of postoperative complications and shortens recovery periods (Uddin et al., 2023).

Additionally, AI-driven surgical systems can execute complex tasks consistently and precisely, surpassing human capabilities. For example, AI can aid in the planning and executing of complex procedures like neurosurgery or cardiac surgery, where precision at

the millimeter level is crucial (Lam et al., 2022). AI systems also monitor patient vital signs in real-time, identifying deviations that may indicate complications and notifying surgical teams to take prompt action. This proactive monitoring enhances patient safety by minimizing risks during surgery (Hussain et al., 2022).

Integrating AI into surgical procedures presents various ethical and operational challenges despite the considerable advantages. The use of AI in surgery often requires the collection and analysis of sensitive patient data, raising issues concerning data storage, sharing, and protection against unauthorized access (Katwaroo et al., 2024). complying with regulations such as the General Data Protection Regulation (GDPR) and the Health Insurance Portability and Accountability Act (HIPAA) is crucial to upholding patient confidence and safeguarding personal information (Murphy & Saleh, 2020).

AI systems may treat patients unequally if the training data is insufficiently diverse, affecting different demographics adversely. Thorough testing is required to achieve fair healthcare solutions (Arigbede et al., 2023). Artificial intelligence in surgeries frequently lacks transparency, making decision-making difficult for healthcare providers to understand. This can breed mistrust and delay adoption. It is critical to make AI systems clear and understandable (Pressman et al., 2024).

This thesis aims to address these ethical issues and complications by methodically identifying, assessing, and prioritizing the ethical implications of AI in surgical procedures. Using a comprehensive literature review and expert survey, the study classified and ranked the most critical ethical concerns based on their criticality using the Multi-Criteria Group Decision-Making (MCGDM) method (Lai et al., 1994). The goal was to establish a formal framework for addressing these ethical issues, ensuring that AI technologies were introduced into surgical practice responsibly and fairly.

In addition to identifying and prioritizing ethical challenges, this thesis also includes recommendations. These recommendations focus on improving the transparency and explainability of AI systems, improving the privacy of medical data measures, overcoming economic and accessibility challenges, eliminating algorithmic biases, assuring constant human oversight, and offering ongoing training for surgeons to interact effectively with AI technology.

This study contributes to understanding and mitigating the ethical concerns of artificial intelligence in surgical procedures. By prioritizing and ranking ethical issues, the thesis aims to build a healthcare environment where AI improves human capacities, respects patient autonomy, and promotes equitable and safe medical procedures.

1.1 Problem Definition

Including Artificial Intelligence (AI) in the healthcare sector, particularly in surgical procedures, can enhance accuracy, reduce errors, and improve patient outcomes. Nevertheless, it also originates several ethical and practical concerns that need careful consideration and supervision (Arigbede et al., 2023; Katwaroo et al., 2024).

Despite the comprehensive analysis of AI's ethical implications in surgical procedures, most studies and discussions focused on identifying rather than systematically highlighting the most critical issues. Authors and scholars have identified various ethical issues, yet a lack of consent exists on the most critical issues and how they should be systematically addressed. This gap underscores the need for a targeted approach that prioritizes the most critical ethical concerns and provides recommendations.

This study aims to bridge this disparity by methodically identifying, inspecting, and prioritizing the ethical implications of AI in surgical procedures based on their criticality. Through a comprehensive literature review and expert survey, this research aims to classify the most critical ethical issues and rank them based on their importance using the Multi-Criteria Group Decision-Making (MCGDM) approach (Lai et al., 1994). By concentrating on the most crucial concerns and providing recommendations. this research attempts to ensure the integration of AI technologies into surgical practice in a responsible and equitable manner, contributing to enhancing patient care and the ethical framework of AI in healthcare.

1.2 Overview of AI in Surgical Procedure

The integration of AI into surgery marked a milestone with the advent of robotic surgical systems like the da Vinci Surgical System, enhancing precision and control in low-impact procedures. AI in healthcare, including surgical procedures, has shown the potential to

augment clinical capabilities, improve diagnostics, and enhance therapeutics, introducing a new era of precision and efficiency within the operating room. AI is stepping into real-time decision-making support during surgeries, providing immediate data-driven feedback to surgeons, thereby elevating the quality of care delivered within the operating room (Grezenko et al., 2023).

The introduction of AI in healthcare, particularly in surgeries, has accumulated attention in recent years, with the rise of Deep Learning (DL), which assists surgeons in several ways and has led to the development of Robot-Assisted Surgery (RAS) systems. AI advancements in healthcare, particularly in image-driven Robot-Assisted Surgery (RAS) systems, have revolutionized surgical processes, surgical tools, surveillance, and performance evaluation, focusing on image data and DL models like Convolutional Neural Networks (CNN). Developing fully autonomous image-guided surgical systems, reducing the need for direct surgeon involvement, is a predictable task for DL models, addressing complexities in surgical procedures and image interpretation challenges. Activity recognition in surgical interventions using CNN and LSTM networks has gained attention, with the integration of DL models for real-time procedure monitoring, despite challenges related to dataset availability and model training time (Hussain et al., 2022).

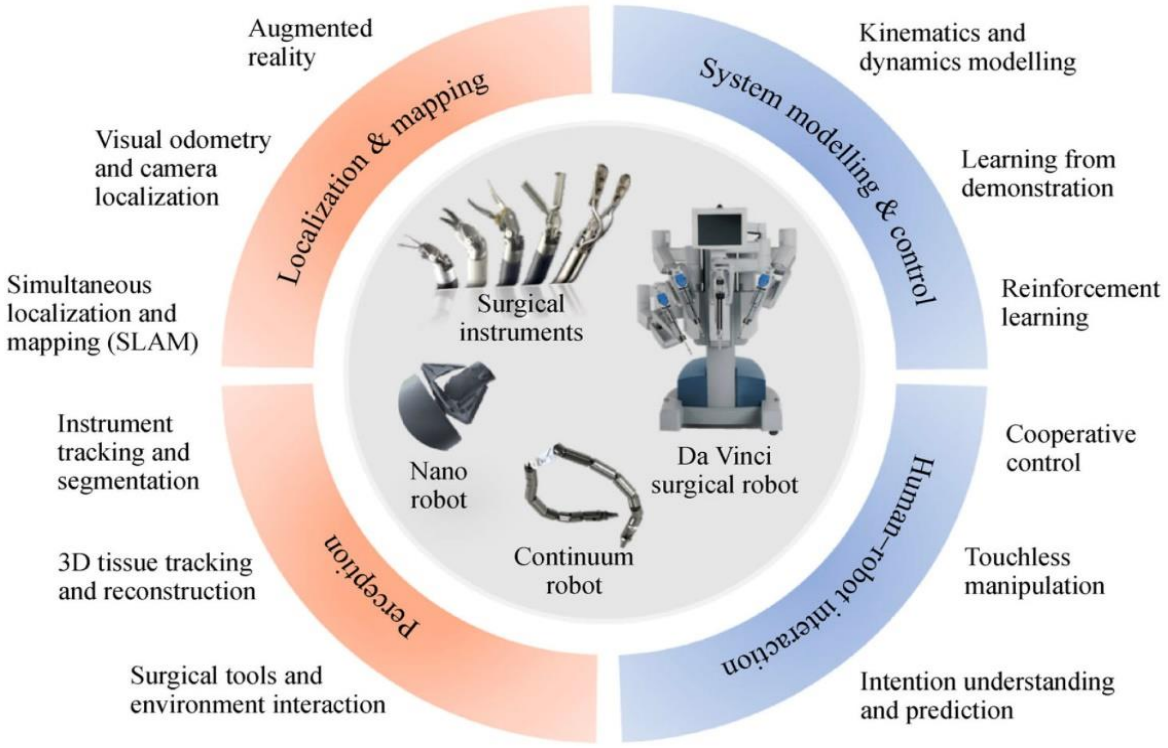
AI technologies in healthcare surgeries have demonstrated the potential to enhance clinical capabilities, diagnostics, and therapeutics, leading to improved precision and efficiency within the operating room (Oniani et al., 2023).

AI technologies have made contributions to various healthcare fields, including plastic surgery, by providing natural language processing (NLP) capabilities through AI chatbots (Liu et al., 2023). AI models have shown commitment to patient communication, postoperative recovery support, and generating healthcare communication documents such as discharge summaries and operation notes. AI-based technologies are seen as valuable tools that can revolutionize medical and surgical practice, although concerns have been raised regarding their implementation and ethical implications, emphasizing the need for evidence-based research to guide their use in practice (Chaand Sharma et al., 2023).

The application of AI in healthcare may impact the doctor-patient relationship, leading to potential dissatisfaction among patients and requiring healthcare professionals to adapt to

new skills and technologies, highlighting the importance of balancing technological innovation with traditional patient care (Li et al., 2024).

Fig 1 Robotic tools in AI Surgical Procedures.



While AI technologies have undoubtedly advanced diagnostic methods and surgical robots, addressing the challenges they present in surgical systems is crucial. These include technical risks, limited movement adaptability, and patient safety concerns. This underscores the need for in-depth studies and careful considerations to ensure AI's safe and effective integration into surgical procedures. (Hussain et al., 2022).

Surgeons encounter technical challenges during the learning curve of adopting robotic techniques, including instrument collisions and the need for precise hand movements, requiring continuous practice and troubleshooting skills; evaluating the cost-effectiveness of robotic breast surgery compared to traditional methods is crucial, considering the expenses of robotic systems, maintenance, and training programs, highlighting the challenge of managing healthcare costs while providing advanced technology (Jain et al., 2024).

1.3 Exploring Ethical Dimensions of AI-driven Surgical Care

This thesis investigates the ethical problems and potential solutions related to AI-assisted surgical care. This thesis aims to ensure the appropriate and equitable use of AI technologies in surgical practice by outlining and identifying the most critical ethical concerns that arise from AI integration in surgeries. This thesis aims to contribute to developing ethical guidelines and recommendations that can improve patient welfare and trust in AI-driven healthcare systems.

Artificial intelligence (AI) technology has transformed healthcare, giving rise to several medical specialties, including surgery. AI has also improved treatment planning and diagnostic accuracy, increasing surgical intervention accuracy. However, the quick uptake of AI in surgical settings raises several ethical implications that need to be properly identified, considered, and resolved.

1.4 Goals and Delimitation

This thesis aims to identify and discuss the ethical implications of artificial intelligence (AI) in healthcare, specifically in the context of surgical techniques. The study attempts to highlight the most critical ethical issues surrounding AI in surgery and provide recommendations.

Goals:

- To identify and classify the key ethical concerns associated with the application of AI-driven surgical procedures.
- To identify and categorize the key ethical issues surrounding the application of AI to healthcare, particularly surgeries.
- To evaluate each issue according to its criticality ratio, expert opinions obtained from a survey
- To prioritize and rank the most critical issues, use the Multi-Criteria Decision Making (MCGDM) approach to prioritize and rank the issues.

- To Provide direct recommendations for addressing the most critical ethical issues associated with AI-powered surgeries.

1.4.1 Delimitation

To ensure that the scope of the thesis is both realistic and focused, several delimitations were established:

- The study addresses only the ethical implications of AI in surgical techniques it does not cover any other aspect of healthcare. This aims to clarify and narrow the scope of the analysis.
- To provide a modern perspective of the ethical implications, the study draws on existing literature, expert opinions, and data from 2020 up to the current year without extending beyond what is practically feasible regarding research duration.
- To conduct an in-depth review of related ethical issues, the study focuses on AI technologies utilized in surgical settings, such as machine learning algorithms, robotic surgical systems, and AI-driven diagnostic tools.
- Healthcare practitioners, AI developers, and ethicists with significant expertise in AI-driven surgical techniques were requested to respond to an expert survey. This survey is only presented to respondents who meet the specific expertise standards.

1.5 Research Questions and Objectives

1. **Research Question R1**: In the context of the surgical healthcare system, what are the main ethical issues surrounding the application of AI in healthcare, particularly in surgical procedures?
2. **Research Question R2**: What are the most critical ethical issues in the application of AI-driven surgery, and how can these issues be prioritized and rated according to their criticality?

3. **Research Question R3**: What practical recommendations can be presented in surgical operations to improve and deal with the most critical ethical concerns in AI-driven surgical procedures?

Table 1 Summary of Research Objectives

Objective	***Description***
Identify Ethical Issues	To identify the primary ethical concerns associated with using AI in healthcare, in Surgeries.
Predict the Impact	Determine the most critical issues and the impact of these ethical issues on AI-driven Surgeries.
Rank Critical Issues	Rank the issues on a criticality level by expert opinions with expert survey data using Google Forms, and then prioritize these issues using Multi-Criteria Group Decision-Making (MCGDM).
Make Recommendations	Present recommendations to optimize the most critical ethical concerns for AI-driven surgical procedures.

1.6 Approach

This study adopted a comprehensive literature review method to comprehend the ethical issues of artificial intelligence in surgery. conducted a survey of experts to get their opinions on the ethical implications of AI-assisted surgery. Ranked and prioritized these concerns using the Multi-Criteria Group Decision-Making (MCGDM) method (Lai et al., 1994). Made recommendations to address the identified ethical issues based on the results of this study.

1.7 Structure of Thesis

The first chapter highlights the introduction, problem, a brief overview of AI in surgical procedures, and the study's methodology. The second chapter underscores the related work and background of the related to the topic. The third chapter highlights the methodology used for carrying out this thesis. The fourth chapter explains the identification and classification of ethical issues developed as part of this thesis. Chapter Five explains the proposed research methodology's implementation and the solution's findings or results demonstrated. Chapter Six contains the discussion and recommendation part of the thesis. The thesis concludes with a chapter called Conclusion. OBJ

2 LITERATURE REVIEW

The thesis follows a symmetric literature review process, as illustrated in Figure 2. The process consists of five main phases. In the first phase, a combination of keywords was used to gather suitable research articles for the symmetric literature review. It is important to note that the structured keyword combination search plays a crucial role in the article search. After several combinations, the main keywords for this literature process are "TS= ((AI OR Artificial Intelligence) AND (Healthcare) AND (Surgery) AND (Ethical implications OR Ethical Issues OR Ethical Concerns))." In phase two, these keywords were used, and the search was restricted to paper titles, abstracts, and keywords in Google Scholar and Web of Science (WoS). In phase third, the Boolean operators "AND" and "OR" imply that the search will cover both and at least one of the keywords, respectively, and the field tags are TS=Topic, TI=Title, and AB=Abstract. In the fourth phase, the results were collected and finally, sorting and screening were conducted.

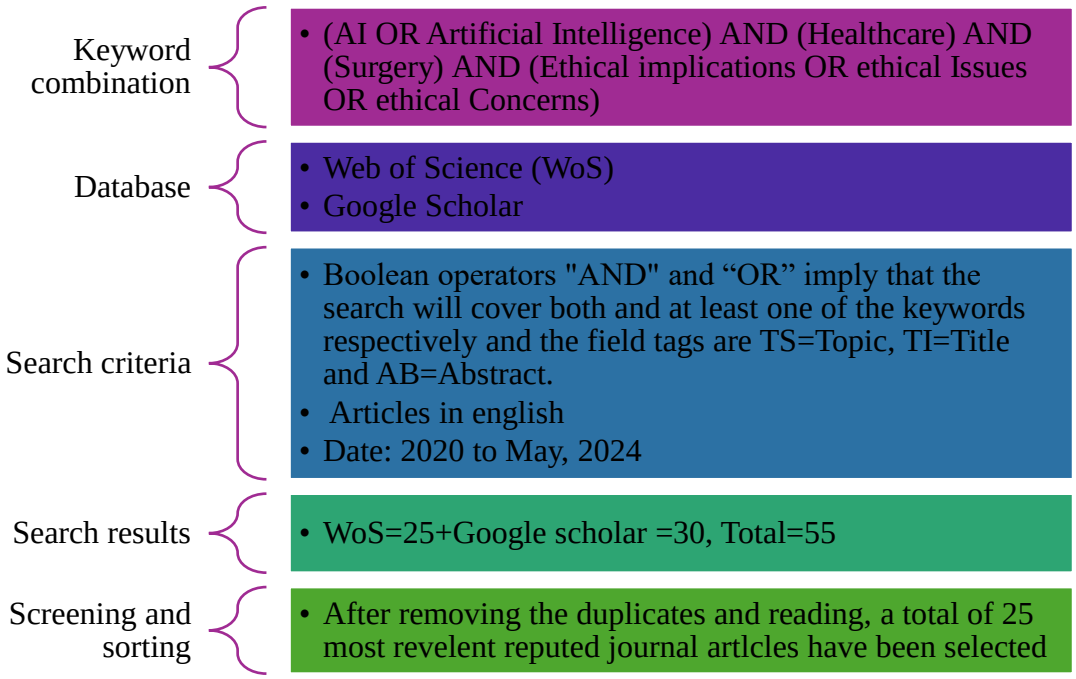


Figure 2 Overall Literature review process for the present work.

During the study, articles were screened and sorted based on their relevance to the topic, as shown in Figure 2. Initially, I searched both databases using the keyword combinations ((AI OR Artificial Intelligence) AND (Healthcare) AND (Surgery) AND (Ethical implications

OR Ethical Issues OR Ethical Concerns) from 2020 to May 2024 in English. This search yielded 26 results from WoS and 30 results from Google Scholar. After removing duplicates, this study obtained a total of 25 papers. This study analyzed titles, abstracts, results, discussions, and conclusions during the screening stage to remove inappropriate papers. This process resulted in the inclusion of 25 papers and the exclusion of 31. The inclusion criteria were: (a) research papers focusing on ethical issues of AI in surgeries and (b) papers published in peer-reviewed journals and proceedings. As discussed in the literature review above, 25 journals and articles were gathered and integrated into this thesis study. A summary and classification overview of the acquired articles is presented in the below sub-section.

2.1 Background and Related Work

In the reviewed articles and studies related to the ethical issues of AI in medical, especially in surgery, researchers highlighted various ethical issues and some specific concerns. In the past few years, the integration of artificial intelligence (AI) into plastic surgery has been discussed in (Murphy & Saleh, 2020.), and highlights several recent uses, such as surgical decision-making and medical imaging. Artificial intelligence (AI) technologies, like computer vision and machine learning, can potentially improve surgical outcomes and diagnostic accuracy. To ensure that AI is used responsibly in clinical practice, ethical factors, including bias and fairness, patient privacy, and the requirement of collaboration between surgeons and computer scientists, are highlighted (Murphy & Saleh, 2020). With an emphasis on its uses in big data analytics, machine learning, deep learning, and natural language processing, this article analyzed the importance of artificial intelligence in plastic surgery (Murphy & Saleh, 2020). AI technologies can improve patient outcomes, surgery planning, and diagnostic accuracy. The discussion of ethical issues, including patient autonomy, data privacy, and the possibility of biased algorithms, highlights how crucial it is to apply strict ethical guidelines when using AI in the healthcare industry (Murphy & Saleh, 2020).

Furthermore, other researchers (Jarvis et al., 2020; Murphy & Saleh, 2020; Rudzicz & Saqur, 2020) have explored how artificial intelligence (AI) is used in thoracic and plastic surgery, highlighting both present and potential uses. In many domains, artificial intelligence (AI)

technologies like computer vision and machine learning improve surgical results and diagnostic precision. Artificial intelligence (AI) is utilized in plastic surgery for big data analytics, surgical decision-making, and medical imaging in thoracic surgery; it enhances surgical robots, patient monitoring, and diagnostic imaging. Even with these encouraging developments, the responsible and successful application of AI in clinical practice requires careful consideration of ethical issues such as bias, patient privacy, data privacy, and the requirement of collaboration between computer scientists and healthcare practitioners. These ethical issues highlight the importance of upholding strict guidelines for AI research and implementation in the medical field (Jarvis et al., 2020; Murphy & Saleh, 2020; Rudzicz & Saqur, 2020).

Moreover, some other studies (Hussain et al., 2022; Kooli & Al Muftah, 2022a; Lam et al., 2022) Also, it draws attention to the ethical issues and advantages of utilizing digital and artificial intelligence (AI) in surgery and healthcare. These studies have highlighted how critical it is to face ethical issues, including patient safety, data security, privacy, and bias. Artificial intelligence (AI) technology, such as robots and machine learning, significantly increases surgical performance, diagnostic accuracy, and healthcare efficiency. However, ethical guidelines, ongoing observation, and cooperation between computer scientists and medical experts are essential to reduce hazards. Developing ethical norms and ensuring the proper application of AI in clinical practice requires the participation of all stakeholders, including patients. (Hussain et al., 2022; Kooli & Al Muftah, 2022; Lam et al., 2022).

Artificial intelligence (AI) and robots in medicine and surgery have the potential to revolutionize several industries, including face plastic surgery and the treatment of prostate cancer. Artificial intelligence (AI) technologies, such as machine learning and deep learning, improve surgical results, individualized treatment routines, and diagnostic accuracy by analyzing massive datasets and medical pictures. Recovery durations and surgical accuracy are further enhanced by robotics. But putting AI and robots into practice has many problems, such as algorithmic biases, data privacy, and other ethical issues (Grezenko et al., 2023). Strong ethical standards and ongoing oversight are necessary to ensure patient satisfaction and efficient AI integration. Advances in real-time surgical visualizations and more complex algorithms are anticipated in the future of artificial intelligence in healthcare, redefining medical procedures and enhancing patient outcomes (Arigbede et al., 2023; Choi et al., 2023).

To highlight the profound impact of artificial intelligence (AI) in modern medical practice, particularly on diagnostic, therapeutic, and ethical aspects. AI plays a crucial role in enhancing clinical diagnosis, pharmaceutical explorations, and patient care through the analysis of extensive medical datasets, thereby enhancing the precision and individualization of medical interventions (Uddin et al., 2023). Notably, AI's significance in medical imaging is evident in its ability to accurately detect cancerous cells and facilitate the creation of novel drug treatments. In plastic and reconstructive surgery, AI tools like ChatGPT produce academic publications, craft patient discharge summaries, assist patient interactions, and support medical training and education. Despite these notable advancements, substantial ethical issues persist, encompassing issues related to data privacy, biases within algorithms, and the imperative need for robust ethical frameworks. Tackling these challenges necessitates continual cooperation between technology experts and healthcare practitioners to ensure the ethical and effective use of AI in clinical settings (Katwaroo et al., 2023; Sharma et al., 2023).

Also, researchers have discussed how artificial intelligence (AI) and ChatGPT can revolutionize colorectal and bariatric surgery. They also show how these technologies can improve intraoperative decision-making, postoperative care, preoperative planning, and medical education. Artificial intelligence (AI) tools, like ChatGPT, improve patient outcomes, increase surgical precision, and offer individualized medical information. These developments do, however, also bring with them serious ethical, legal, and moral issues. Strong ethical frameworks and relevant rules are needed to address these issues and ensure AI's responsible and safe application in healthcare. Effective doctor-patient connections, algorithmic bias mitigation, and patient privacy preservation are all highlighted by the integration of AI into surgery (Law et al., 2024; Li et al., 2023; Oniani et al., 2023).

Recently, with the utilization of ChatGPT, researchers have highlighted the significant potential of ChatGPT and GPT-4 in reshaping various sectors of healthcare, including cardiac, plastic, colorectal, and bariatric surgery (Clark, 2024; Liu et al., 2023). ChatGPT notably improves preoperative planning, aids intraoperative decisions, and enhances postoperative care by providing timely information, analyzing patient data, and simulating surgical scenarios (Li et al., 2023; Liu et al., 2023). Its application extends to medical education, patient engagement, and research, delivering personalized and precise medical information that improves patient outcomes and reduces mistakes. However, integrating

ChatGPT into healthcare raises ethical and legal concerns, including data privacy, algorithmic biases, and clarity in AI-generated content (Li et al., 2023; Liu et al., 2023). To harness this technology safely and effectively, establishing strong ethical guidelines and fostering ongoing cooperation between technologists and medical professionals is essential (Clark, 2024). It is important to recognize that even with AI support from tools like ChatGPT, the aim is to augment, not replace, the expertise of healthcare professionals (Law et al., 2024; Li et al., 2023).

The potential impact of AI in healthcare focuses on how it can enhance patient outcomes and simplify procedures. However, it raises important ethical issues such as fairness, transparency, and privacy. The authors highlight the need to address biases in AI algorithms, maintain transparency in decision-making processes, and safeguard patient privacy through robust data security measures and informed consent mechanisms (Olaoye, 2024). Examine the ethical challenges of incorporating AI in healthcare. They focus on privacy, transparency, bias, patient autonomy, and the impact on healthcare professionals. The authors argue that while AI can improve healthcare delivery, addressing these ethical issues is important to ensure the responsible use of AI technologies. They advocate for strong data governance frameworks, transparent AI algorithms, and the involvement of patients in decision-making processes (Stephen et al., 2024).

Later (Liu et al., 2024) conducts a bibliometric analysis and scoping review to explore ChatGPT's role in plastic surgery. It highlights ChatGPT's applications in research, clinical practice, surgical training, and patient education while addressing ethical concerns such as patient privacy, plagiarism, and information accuracy. The authors call for cautious use and collaboration to maximize ChatGPT's advantages while mitigating risk.

Incorporating artificial intelligence (AI) in healthcare presents significant opportunities for improving patient outcomes and healthcare delivery. However, this development also brings about important ethical challenges. Key concerns include ensuring fairness and mitigating biases in AI algorithms, maintaining transparency and interpretability of AI systems, and safeguarding patient privacy through robust data security measures and informed consent (Katwaroo et al., 2024). Additionally, the impact of AI on healthcare professionals and the significance of interdisciplinary collaboration are highlighted to navigate these ethical challenges. It is crucial to address these issues through ethical frameworks, regulatory

guidelines, and continuous monitoring for the responsible and beneficial use of AI in healthcare (Liu et al., 2023; Olaoye, 2024; Stephen et al., 2024.; Tsai et al., 2024).

3 METHODOLOGY

This chapter covers the methodologies employed to discover AI's ethical concerns in surgical procedures. This includes a detailed explanation of the chosen methodology, its alignment with the research questions, and justification for selecting the particular methodology. To start this chapter, first revisit the research questions leading this research:

1. **Research Question R1**: In the context of the surgical healthcare system, what are the main ethical issues surrounding the application of AI in healthcare, particularly in surgical procedures?
2. **Research Question R2**: What are the most critical ethical issues in the application of AI-driven surgery, and how can these issues be prioritized and rated according to their criticality?
3. **Research Question R3**: What practical recommendations can be presented in surgical operations to improve and deal with the most critical ethical concerns in AI-driven surgical procedures?

3.1 Methodological Approach

This research employs a multi-method approach, including a literature review, the Multi-Criteria Group Decision Making (MCGDM) Method (Bhat, 2020; Lai et al., 1994), specifically the Technique for Order of Preferences by Similarity to Ideal Solution (TOPSIS), and an expert survey. This approach addresses the research questions by combining qualitative and quantitative data collection.

3.2 Justification of Chose Methodology

Given the research questions, a combination of literature review, MCGDM method using TOPSIS, and expert survey was selected as a suitable approach for this research. The justification for deciding the particular methodology is as follows:

The literature review and expert survey are important for collecting previous and current information and insights, which addresses Research Questions R1 and R2. The MCGDM method, specifically TOPSIS, is suitable for prioritization based on multiple criteria, which addresses the requirements of Research Question R2.

Combining a literature review and an expert survey allows a comprehensive understanding of theoretical and practical perspectives. This mixed-method approach enables a detailed analysis of the ethical challenges concerning AI-driven surgical procedures.

Other methods, such as exploring something over time or gathering a large amount of real-world data, could provide more precise information but cannot do so during this research. The mixed methodology adopted for this research adequately balances the research's goals and what this study could accomplish.

3.3 Consideration of Alternative Approaches

Throughout the planning stage of this research, a few different methodologies and approaches were considered to provide a detailed evaluation of the ethical implications of AI in surgical procedures.

One approach involved interviewing experts, including healthcare professionals, AI specialists, and ethicists. This technique had the potential to profound qualitative insights and comprehension of the ethical concerns highlighted in this research. It would have facilitated the exploration of individual perspectives and thoughts, thus generating detailed, context-specific information. Nonetheless, this strategy was considered unfeasible due to time constraints and the complexities of scheduling interviews with experts from distinct locations. Accessing such a highly specialized setting and ensuring interview engagement within the study's period presented hurdles.

Another method was to do a quantitative survey on various healthcare practitioners. This approach could have collected extensive data on the perceptions and encounters of a broader demographic concerning AI applications in surgical scenarios. Despite the chance to widen the range of data collection, it was seen as unreachable because of time constraints and the complexity of reaching suitably diverse participants within the study's restricted timeline.

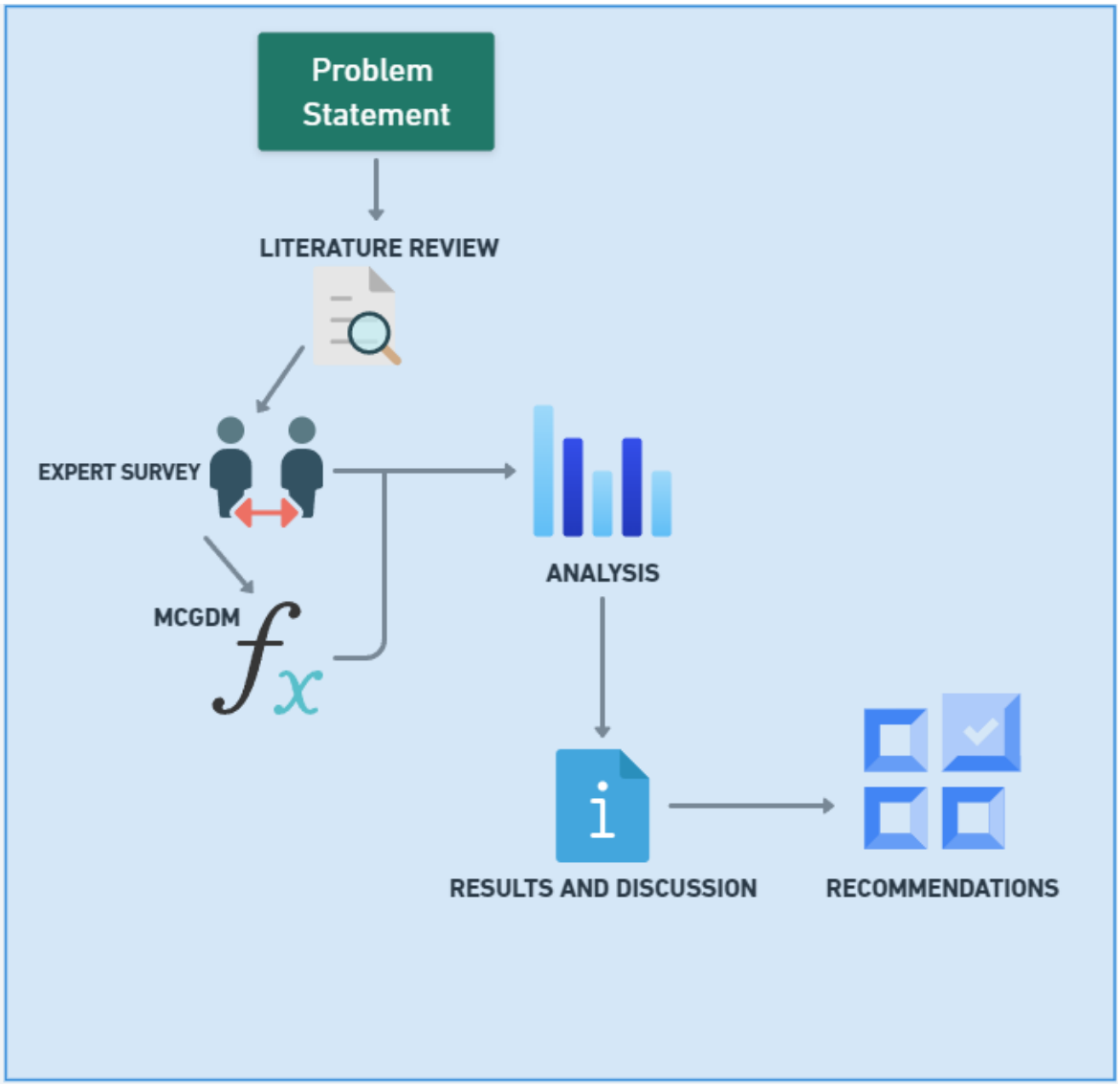
Moreover, ethnographic examination involving detailed observations within surgical settings was considered. Ethnography had the potential to provide valuable insights into the day-to-day ethical implications of AI integration in actual surgical contexts. Nonetheless, this technique presented substantial challenges, including the requirement for prolonged and consistent access to multiple surgical environments, which was not feasible within the study's period, as well as available resources and less access.

Considering the constraints stated above, the chosen approach of a literature review, targeted expert survey, and the Multi-Criteria Group Decision-Making (MCGDM) method (Bhat, 2020; Lai et al., 1994) The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) was considered the most feasible methodology for addressing the research questions. This methodology aligns with the study's objectives and establishes a balanced framework for finding and ranking the ethical concerns associated with AI implementation in surgical procedures.

3.4 Description Selective Methodology

Given the research questions, a combination of literature review, MCGDM method using TOPSIS, and expert survey was selected as the suitable approach for this research. The justification for selecting the particular methodology is as follows:

Figure 3 Overall workflow of Research Methodology.



3.5 Literature Review

The first step involved a comprehensive literature review to understand the ethical implications of AI in healthcare, particularly in AI-driven surgeries. Key focus areas include the use of AI in surgical procedures. By analyzing existing research, the literature review helps identify and finalize the major ethical issues, thereby directly contributing to answering **Research Question R1:** In the context of the surgical healthcare system, what are the main ethical issues surrounding the application of AI in healthcare, particularly in surgical procedures? It also provides a broad perspective on issues addressed in previous studies. Creating an environment for further exploration and validation through primary research.

3.6 Expert Survey

Building on information gathered via the literature review, an expert survey of ethicists, AI developers, and healthcare experts was carried out. This was set up to gather professional insights and opinions about ethical issues surrounding the application of AI to surgery. This approach is valuable for answering **Research Question 3:** What recommendations can be presented to address the most critical ethical concerns in AI-driven surgical procedures? The expert input helps to validate the literature findings while also providing insights into the practical implications and practical solutions to these ethical concerns. The research specifically searched for data on the following evaluation criteria:

- Ethical issues encountered or anticipated in AI-driven surgical procedures.
- Criticality (Impact on Patient Care)
- Trustworthiness (Data Security and Privacy)
- Implementability (Ease of Implementation)
- Success Rate (Effectiveness of Solutions)
- Usage Ratio (Prevalence of Issue)

To ensure participation from a broad and diverse range of expert perspectives, the survey was collected using Google Form.

3.7 Multi-Criteria Group Decision-Making (MCGDM) approach

The identified ethical concerns were prioritized based on their criticality using a well-known decision-making matrix MCGDM (Bhat, 2020; Lai et al., 1994). The approach involved several methodical stages to conduct a comprehensive assessment and prioritize and rank the issue based on expert opinion. The results from the expert survey were initially compiled into a decision matrix, with expert opinions as choices and ethical concerns as factors, and then evaluated based on their criticality ratio, which directly answers **Research Question R2:** What are the most critical ethical issues in the application of AI-driven surgery, and how can these issues be prioritized and rated according to their criticality? This stage

provided a framework for structured inputs, enabling the comparison and capture of various expert contributions.

This kind of problem, where there is a need to rank the alternatives $A_1, A_2, \ldots, A_m$ based on more than one conflicting criterion, is known as a multi-criteria decision-making method (MCGDM) (Bhat, 2020; Lai et al., 1994). An MCGDM problem in which there is a need to rank m alternatives $A_1, A_2, \ldots, A_m$ based on n conflicting attributes $C_1, C_2, \ldots, C_n$ can be represented by the matrix (Bhat, 2020).

$$M = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} C_1(w_1) \quad C_2(w_2) \ldots \quad C_n(w_n) \\ \begin{bmatrix} x_{11} & x_{12} & \ldots & x_{1n} \\ x_{21} & x_{22} & \ldots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \ldots & x_{mn} \end{bmatrix} \end{array}.$$

In the matrix M the element x_{ij} represents the assigned value of the expert or decision-maker to the alternative A_i with respect to the corresponding criteria C_j and w_j represents the weight of the j^{th} criteria, which satisfies the conditions $w_j \geq 0$ and $\sum_{j=1}^{n} w_j = 1$.

Several methods have been proposed in the literature for solving crisp MADM problems (Bhat, 2020). Out of these existing MCGDM methods, this study has used the widely known and widely used TOPSIS method due to its powerful mathematical logic and practicality.

3.7.1 A Brief Overview of the TOPSIS Method

Hwang and Yoon developed the concept of crisp TOPSIS (Hwang & Yoon, 1981; Lai et al., 1994), a process based on choosing alternatives simultaneously having the shortest distance from the positive ideal solution and the longest distance from the negative ideal solution. This method can solve MCGDM problems in which attribute preferences are based on cardinal values, requiring a set of weights for attributes. The solution depends on the weighting scheme provided by the decision maker. The steps of the TOPSIS process are as follows (Bhat, 2020; Hwang & Yoon, 1981):

Step 1: Transform the matrix $D = \left[x_{ij}\right]_{m\times n}$ into the matrix $R = \left[r_{ij}\right]_{m\times n}$, where

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}\ , i = 1, 2, \dots, m, \qquad j = 1, 2, \dots, n.$$

Step 2: Transform the matrix $R = [r_{ij}]_{m\times n}$ into the matrix $V = [v_{ij}]_{m\times n}$, $v_{ij} = w_j \times r_{ij}$, $i = 1, 2, \dots, m, j = 1, 2, \dots, n$ and w_j is the weight of the j^{th} attribute.

Step 3: Find the positive-ideal solution $v_j^+ = \begin{cases} \max\limits_{1\le i\le m}\{v_{ij}\}, j \in B \\ \min\limits_{1\le i\le m}\{v_{ij}\}, j \in C \end{cases}$ and the negative-ideal solution $v_j^- = \begin{cases} \min\limits_{1\le i\le m}\{v_{ij}\}, j \in B \\ \max\limits_{1\le i\le m}\{v_{ij}\}, j \in C \end{cases}$, where B is the benefit attribute (greater preference of v_{ij}) and C is the cost attribute (lesser preference of v_{ij}).

Step 4: Find

$$S_i^+ = \left[\sum_{j=1}^{n}(v_{ij} - v_j^+)^2\right]^{1/2},\ i = 1, 2, \dots, m,\ S_i^- = \left[\sum_{j=1}^{n}(v_{ij} - v_j^-)^2\right]^{1/2},\ i = 1, 2, \dots, m,$$

where, S_i^+ is the separation (Euclidean distance) of the i^{th} alternative from the positive-ideal solution $(v_1^+, v_2^+, \dots, v_n^+)$ and S_i^- is the separation (Euclidean distance) of the i^{th} alternative from the negative-ideal solution $(v_1^-, v_2^-, \dots, v_n^-)$.

Step 5: Find the relative closeness, $RC_i^+ = \frac{S_i^-}{S_i^+ + S_i^-}$, $i = 1, 2, \dots, m.$

Step 6: Check that $RC_i^+ > RC_j^+$ or $RC_i^+ < RC_j^+$ or $RC_i^+ = RC_j^+$

Case (i): If $RC_i^+ > RC_j^+$ then $A_i > A_j$,

Case (ii): If $RC_i^+ < RC_j^+$ then $A_i < A_j$,

Case (iii): If $RC_i^+ = RC_j^+$ then $A_i = A_j$.

The decision matrix's value normalization was the second phase. Normalization brought all values to a similar scale to ensure that all ethical problems were properly examined and that no value in the matrix would appear disadvantaged due to different measurement scales. Assigning weights to the various ethical problems was the third stage. The expert's opinion was considered when assigning weights to the various concerns, and the process of evaluation was conducted in a way that fully aligned with the expert's judgments through weighted normalization (Bhat, 2020; Lai et al., 1994).

Finding the optimal answers, identifying the ideal and worst circumstances for every ethical issue, and establishing a standard for contrast. After identifying the ideal solutions, the following stage involved calculating the separation between each option and the positive and negative ideal solutions. The separation metrics should quantify how much each ethical issue deviates from the ideal conditions. Calculating each ethical issue's relative proximity to the ideal solution assisted in determining how each issue stacks up against the best-case scenario and promoted unambiguous prioritizing. Ethical problems were graded according to how near the optimal answer they were. This assessment provides an explicit and methodical strategy for prioritizing ethical considerations.

3.8 Recommendations

This thesis provided suggestions to address the ethical issues of AI-driven surgical methods based on the comprehensive approach employed in this research. These recommendations are based on the systematic evaluation and prioritizing approach stated in the methodology, and they are based on the results of the literature review and expert surveys. The guidelines seek to improve patient care and confidence in AI-driven healthcare solutions by ensuring the ethical integration of AI in surgical operations.

4 ETHICAL ISSUES OF AI IN SURGICAL PROCEDURES

The complex ethical challenges of using artificial intelligence in surgical procedures are addressed in this chapter. This chapter explores the various aspects and details of these issues as it deeply explores the identification and classification of the main ethical challenges. The goal is to give a thorough understanding of these problems and an in-depth review of how integrating AI into surgery might be advantageous or ethically inappropriate.

4.1 Analysis of AI in Surgical Procedures

AI technology improved surgical accuracy, minimized risks, and enhanced patient results. Machine learning (ML) algorithms are essential in forecasting surgical results, enhancing decision-making processes, and boosting overall patient care through medical data analysis. Moreover, AI customizes treatment strategies to optimize results and decrease side effects, ensuring individualized care for each patient. The integration of AI into surgical procedures is transforming not only the execution of surgeries but also the pre-and post-operative care of patients (Tsai et al., 2024).

Large language models, a subset of AI, aid surgeons in consultations and patient interactions, streamlining engagements and enhancing patient comprehension of their conditions and treatments. Furthermore, advancements in augmented reality (AR) and virtual reality (VR) are revolutionizing surgical education and planning, offering immersive training settings and precise surgical simulations. These technologies are paving the way for more knowledgeable and well-prepared surgeons (Pressman et al., 2024).

AI continues to enhance surgical precision by decreasing errors and enhancing overall results. It plays a vital role in preoperative planning, image interpretation, and robotic surgeries, equipping surgeons with precise data and assistance throughout the surgical procedure. AI algorithms also evaluate patient data to forecast results and tailor treatments, making surgeries more efficient and successful (Stephen et al., 2024).

In thoracic surgery, AI applications encompass machine learning, independent surgical devices, and telecommunication, enhancing surgical outcomes, reducing surgery duration,

and improving patient recovery. Using big data platforms further expedites the comprehension of diseases and the advancement of precision medicine, establishing AI as an essential instrument in advanced surgical practices. AI technology has also significantly boosted surgical precision and accuracy in modern procedures. Machine learning algorithms aid surgeons in decision-making and crafting personalized treatment plans. Natural language processing (NLP) technology is employed to develop voice-activated surgical systems and automate surgical documentation, streamlining operations and reducing the administrative burden on surgical teams (Katwaroo et al., 2023b; Lam et al., 2022).

4.2 Importance of Ethical Considerations

Ethical consideration in surgeries is important for multiple reasons, including protecting patient autonomy, obtaining informed permission, and distributing resources fairly. Healthcare practitioners may ensure that all patients have equal access to important surgical operations by getting the patient's permission and allocating resources fairly. This will foster a sense of control and trust in the surgical team (Jain et al., 2024).

Additionally, incorporating AI into surgery necessitates an open and responsible decision-making process. Surgeons must completely comprehend and believe in AI solutions to retain control over patient care, highlighting the requirement for unambiguous and straightforward explanations. To appropriately integrate AI into surgical decision-making, ethical issues, including bias, fairness, and informed consent, must be addressed (Tsai et al., 2024).

Given the intrinsic hazards associated with surgical interventions, it is crucial to determine that the advantages surpass the potential risks for everyone. Ethical dialogues characterized by explainability and transparency are necessary to secure informed consent and ensure that patients understand the risks and benefits before consenting to a procedure. These discussions play a crucial role in striking a balance between promoting innovation and upholding patient safety, as well as in continuously evaluating ethical concerns related to the allocation of resources, patient selection, and conflicts of interest. Active participation in such dialogues promotes transparency and accountability and creates an environment of ethical behavior, thereby enhancing research methodologies and patient results (Pressman et al., 2024).

Ethical considerations encompass various issues, including privacy, consent procedures, data protection, and the implications of recordings on surgical teams and patients. These considerations are pivotal in upholding principles of respect, dignity, and equity throughout the surgical range, aligning with fundamental principles of medical ethics. They serve to safeguard patient autonomy, promising individuals the right to make well-informed choices regarding their treatment alternatives and complete care (Oniani et al., 2023; Quach et al., 2023).

Upholding strict ethical standards is essential for preserving patient autonomy, beneficence, non-maleficence, and fairness in surgical decision-making and therapeutic interventions. These standards are equally essential for the sensible and sustainable integration of artificial intelligence in the healthcare domain, ensuring the preservation of privacy and the ethical utilization of data (Etienne et al., 2020; Jarvis et al., 2020). By placing ethics at the forefront of surgical practices, the medical community cannot avoid legal and ethical concerns, reinforce patient autonomy, and encourage trust between patients and surgical teams, climaxing in enhanced healthcare outcomes (Jain et al., 2024).

4.3 Major Ethical Issues

This section addressed ethical issues regarding surgical procedures, paying particular attention to their impacts and consequences. The implications of these challenges on patients, the integrity of medical procedures, and compliance with laws like GDPR and HIPAA are reviewed.

4.3.1 Privacy of Medical Data

Ethical considerations regarding medical data privacy in surgical procedures encompass the requirement for clear consent and data usage agreements from data providers and third-party aggregators. Ensuring the quality of data utilized in AI algorithms is important, particularly in relation to the privacy of patient information during surgeries. Ethical issues concerning medical data privacy during surgical interventions involve inherent biases that may result in

conclusions that do not adequately represent certain patient demographics. Preserving patient privacy is a critical element of privacy in surgical settings, promising the protection of sensitive medical information (Jarvis et al., 2020; Murphy & Saleh, 2020).

Within the European Union, AI technologies classified as medical devices are subject to regulation under the General Data Protection Regulation (GDPR), which upholds patients' rights to clear consent and informed decision-making regarding algorithmic processes and data collection. Patients are also entitled to monitoring collected data and requesting its removal, with data processing permissible only under specific circumstances. The General Data Protection Regulation (GDPR) established by the European Union underscores the provision of concise and transparent information as well as the protection of user privacy, aiming to afford individuals maximum control over their data privacy (Hussain et al., 2022; Murphy & Saleh, 2020).

Safeguarding patient autonomy and building patient trust is pivotal in upholding privacy and privacy in surgical settings, which is critical for advancing digital surgical technologies. The author mentions the importance of appropriately anonymizing data to maintain privacy and security. Moreover, they highlight the requirement of patient agreements for data sharing, emphasizing the need for data to be utilized exclusively for its intended purposes, alongside advocating for enhanced education on data governance and security among surgical teams. Concerns have been raised regarding the potential misuse of personal data, particularly in collaborations with commercial entities, resulting in reduced public trust in data sharing. Issues such as limited public engagement, insufficient education on AI, and challenges like the opacity of surgical AI systems and biases in datasets have further degraded public trust in data sharing. Privacy and security concerns extend beyond patients to encompass the broader surgical team. Protecting patient data privacy in surgical contexts represents a significant ethical concern, particularly with integrating AI technologies in healthcare. The threat of breaching patient privacy is a major concern, especially with deploying technologies like facial recognition that could undermine informed consent and data security. Healthcare institutions face the risk of data breaches, potentially leading to patients withholding crucial health information from medical practitioners, therefore compromising the privacy of medical data (Kooli & Al Muftah et al., 2022; Lam et al., 2022).

Integrating third-party AI software into patient care requires strict protocols on the use and storage of patient information, in line with the Health Insurance Portability and

Accountability Act (HIPAA) guidelines, to ensure data privacy and security. The application of video-based AI models in surgical contexts raised ethical issues, including obtaining informed consent, offering the option to opt out of data retention, and upholding strict security standards to safeguard patient privacy in video recordings. The adoption of distributed storage and collaborative machine learning (ML) presents an opportunity to train AI models while maintaining patient data on individual devices, thereby reducing the risk of data compromise or loss, and ensuring data security during the AI training phase. The security of medical data in surgical procedures emerges as a crucial focal point when integrating AI and robotics in the management of prostate cancer. Data privacy concerns are a major challenge in the collaborative integration of AI and robotics, underscoring the requirement for careful attention to preserve patient privacy and data protection. The ethical and regulatory dimensions of collaborative AI and robotics demand comprehensive analysis to effectively address concerns regarding data privacy (Arigbede et al., 2023; Choi et al., 2023).

Safeguarding medical data and privacy in surgical settings represents a significant issue within the healthcare sector due to the substantial volume of data essential for operating AI systems, prompting privacy and data protection inquiries. AI systems must be constructed and deployed with robust data security protocols to address these concerns effectively. It is essential to secure informed consent from patients and empower them with control over their data. The deployment of extensive language models (LLM (Large Language Models)) in healthcare, such as OpenAI, introduces ethical and legal challenges concerning the processing and preserving patients' medical data or personal information, underscoring the criticality of ensuring data protection and privacy. Developers and users of OpenAI should comply with relevant privacy regulations and implement strategies such as data encryption, anonymization, and secure storage to protect the integrity of users' personal information. Concerns arise due to the substantial data volume necessary for LLMs' training and learning processes, encompassing user details such as medical background, behavioral attributes, and sensitive information, requiring precise consideration on data collection, storage, and security. enhancing identification and filtration mechanisms for misinformation is essential to boost the accuracy and trustworthiness of AI, entailing the incorporation of moderation mechanisms and the tagging of generated content (Katwaroo et al., 2023; Law et al., 2024).

Patient security is a paramount consideration in recordings of surgical procedures, centering on upholding dignity and respect throughout the recording session. Patients undergoing surgery have voiced concerns regarding the potential identification of their name, visage, or any distinctive characteristics in video recordings (Quach et al., 2023).

The ethical practice of AI in healthcare necessitates a steadfast commitment to data security and patient security, particularly in surgical settings. boosting cybersecurity measures, acquiring informed patient consent, and following relevant regulations are imperative steps for ensuring patient safety, trust, and the integrity of the healthcare system during surgical procedures. Patients must be fully informed about the utilization of their data in surgeries, and securing precise and informed consent from patients is important for upholding privacy and trust. Regulations like GDPR in Europe and HIPAA in the United States protect patient interests and privacy during surgical interventions. Compliance with these regulations ensures legal agreement and highlights the dedication to safeguarding patient data and upholding privacy during surgeries. AI systems access patient data and pose security and privacy risks. Inaccurate medical advice and lack of accountability can result, calling for strict validation and advanced security protocols (Grezenko et al., 2023; Liu et al., 2023). Surgeons must prioritize the privacy of medical data during surgical procedures, using AI technologies to ensure secure handling and security (Clark, 2024).

AI systems in surgical settings raise privacy concerns due to sensitive patient data access. Unauthorized access or data breaches could lead to inaccurate medical proposals, highlighting the need for thorough oversight and verification (Liu et al., 2023). Privacy in surgical procedures involves safeguarding personal health information and preventing unauthorized access, breaches, and secondary use without consent. Legal frameworks like HIPAA set standards, and data encryption and anonymization techniques are employed to protect health information. Ethical considerations in AI applications in healthcare, including surgeries, include patient privacy and security. Secure data storage, access controls, anonymization, and data minimization strategies are crucial for protecting patient data (Olaoye, 2024; Stephen et al., 2024).

4.3.2 Algorithmic Bias and Fairness

AI surgery algorithms can be biased due to data limitations and under-representing certain populations. Surgeons need to understand AI decision processes and collaborate with technicians and engineers. Deep Learning in image-guided Robot-Assisted Surgery systems highlights the need to address bias and fairness in surgical AI applications. AI algorithms can produce biased results if trained on specific data, impacting treatment fairness. The trust in AI in surgical settings may intensify societal biases, affecting diagnoses and treatment recommendations and raising fairness concerns in healthcare delivery (Etienne et al., 2020.; Kooli & Al Muftah, 2022).

AI systems in plastic surgery raise ethical concerns about bias and fairness, particularly in cosmetic surgery interventions and attractiveness classification. Discrimination based on ethnicity and gender can lead to racial divides and consolidation of human image. AI's influence on beauty standards may also affect mental health and body dysmorphic disorder. Limitations include potential biases in data input, leading to unreliable patterns and predictions, especially for underrepresented groups (Murphy & Saleh, 2020).

AI bias in surgeries can be influenced by training data, leading to inherent biases from documentation providers. Patients from lower socioeconomic backgrounds may face care disparities due to fragmented electronic health records. Ethical concerns arise from algorithmic biases in prostate cancer management, historical biases, and disparities in treatment recommendations due to socioeconomic differences in access to advanced surgical therapies (Arigbede et al., 2023; Choi et al., 2023).

If trained on non-diverse datasets, AI surgery systems may demonstrate bias, potentially leading to inaccurate diagnoses and treatment recommendations, affecting patient outcomes and surgical effectiveness. Addressing bias and discrimination requires training on diverse datasets representing different demographics (Katwaroo et al., 2023).

AI models in bariatric healthcare raise concerns about bias and fairness, particularly in medical errors and decision-making. AI systems should be trained on diverse datasets to mitigate bias risks, and ethical frameworks should be developed for responsible use in surgeries. AI systems should assist healthcare professionals, not replace human expertise,

and require professional supervision for the appropriate use and review of AI outputs (Law et al., 2024; Li et al., 2023).

Using generative AI in surgeries can lead to mistreating patients due to algorithmic bias. To ensure fairness and equity, models should account for health disparities and set standards for algorithmic fairness evaluation. Ethical concerns, such as patient privacy and information accuracy, arise from OpenAI in plastic surgery literature. Oversight, fact-checking, and disclosure are necessary to address biases and ensure fairness (Liu et al., 2023; Oniani et al., 2023).

Patient confidence may be degraded, and treatment discrepancies may result from AI bias in surgical procedures. Diverse datasets documenting patient demographics and health variables are required to ensure fairness. Using techniques like data augmentation and oversampling underrepresented groups, artificial intelligence systems can make better decisions. AI systems must be consistent, reviewed, and monitored to reduce bias and discrimination. Preventing biased outcomes and promoting fair access to care are the goals of addressing algorithmic bias. To provide fair medical advice and build trust in AI conclusions, techniques for identifying and measuring bias in AI outputs, particularly regarding patient demographics and socioeconomic status, must be developed (Olaoye, 2024; Pressman et al., 2024; Stephen et al., 2024).

4.3.3 Transparency and Explainability

Transparency and explainability in surgeries involving large language models are crucial ethical concerns. Transparency is essential for upholding autonomy and ensuring that patients and healthcare professionals understand how Large Language Models (LLMs) derive conclusions, including limitations, training data, and algorithms. In plastic surgery research, transparency considerations are notably higher compared to other surgical specialties, demanding the need for comprehensive disclosure to patients. Transparency and explainability in surgeries are crucial for building trust and enabling critical evaluation of AI-generated recommendations in the healthcare sector. This ensures that healthcare professionals can make informed decisions based on a clear understanding of AI outputs (Pressman et al., 2024; Stephen et al.,2024).

Transparency and public trust are crucial in digital surgery, involving the public at all development and deployment stages to form trust and ensure patient acceptance of digital surgery applications. Privacy, security, and public trust are essential in digital surgery to safeguard patient autonomy and ensure patient trust, which is vital for the future development of digital surgical applications. The author mentioned the importance of precise anonymization of data, patient agreements for data sharing, and the need for greater education around data governance and security among surgical teams (Lam et al., 2022).

Transparency and explainability are crucial in surgeries, especially when integrating generative AI systems into healthcare practices. In surgeries, transparency involves tracking and documenting data, processes, and artifacts related to AI systems for transparent development, ensuring that healthcare professionals understand the capabilities, methodologies, and data sources of the AI they interact with. Integrating ChatGPT into clinical cardiac surgery and heart transplantation can facilitate extensive data collection and analysis, leading to valuable insights and advancements in the field. ChatGPT can assist researchers in identifying trends, patterns, and potential risk factors associated with cardiac conditions, contributing to developing new surgical techniques and better postoperative care strategies. In surgeries, transparency and explainability are crucial when utilizing AI technology for tasks like image classification and surgical outcome prediction. AI techniques should clearly understand the decision-making process, particularly in healthcare contexts. Explainable AI might be particularly advantageous in cosmetic surgery scenarios, where it can assist in forecasting and recognizing specific regions of the face that could potentially be negatively impacted by procedures, enabling surgeons to prioritize these regions accordingly. The use of predictive software during patient consultations for aesthetic procedures should consider the potential impact of AI on perceptions of beauty and minimize the risk of compulsion in pursuing outcomes misaligned with patient goals, highlighting AI as a tool that aids patient decision-making in surgeries (Choi et al., 2023; Clark, 2024; Oniani et al., 2023).

4.3.4 Human Oversight in AI Surgical Procedures

Human oversight in surgical procedures is important for supervising and assessing a surgeon's progression during the learning phase, aiming to safeguard patient well-being and

care quality. Regular evaluation and feedback are valuable for underscoring areas requiring improvement and enabling prompt intervention in the context of robotic breast surgery. Human supervision in surgeries involving Large Language Models (LLMs) is critical to ensuring the precision and dependability of information generated by these models in alignment with patient welfare and ethical standards. The involvement of medical professionals is essential for verifying the output of LLMs, thus promoting responsible and ethical utilization to uphold accuracy and dependability in surgical contexts (Jain et al., 2024; Pressman et al., 2024).

Using OpenAI in surgical procedures raises ethical issues related to patient privacy, originality, and the accuracy of data sourced from ChatGPT-generated platforms, underscoring the requirement of human oversight in surgical environments. AI's ethical and responsible deployment in academic activities, particularly in surgical training and implementation, mandates careful supervision, fact validation, and content authentication by human experts to ensure patient safety and systematic integrity. Although AI chatbots can support research and surgical undertakings, they should be employed alongside human expertise to preserve the validity and integrity of surgical findings, underscoring the pivotal role of human discernment and analytical thinking in surgical contexts (Liu et al., 2023).

In the specified scenario, the ethical consequences of AI in the healthcare sector, particularly in surgical procedures, highlight the significance of human oversight in safeguarding the appropriate and ethical application of AI technologies in medical practices. Human oversight in surgical procedures is essential to uphold patient safety and procedural effectiveness. Surgeons are crucial in supervising and executing surgical interventions to ensure optimal patient outcomes. Establishing transparency in surgical processes is vital for cultivating trust between patients and healthcare providers, enabling patients to comprehend the rationale behind treatment suggestions and empowering them to make well-informed decisions regarding their healthcare. Strategies to enhance transparency in surgeries encompass the adoption of explainable AI techniques that clarify the decision-making mechanisms of AI algorithms, offering insights into the factors directing algorithmic forecasts and ensuring the dependability and equity of AI-driven healthcare solutions (Olaoye, 2024; Stephen et al.,2024).

Human oversight in surgical procedures is important to ensure patient safety and navigate complex decisions requiring a sophisticated understanding of individual patient contexts.

Surgeons must acknowledge that while AI technologies can complement and elevate their competencies, they should not replace their expertise and judgment in critical decision-making and procedures. Real-time monitoring and analysis during cardiac surgery and heart transplants benefit from human oversight to interpret complex data, make immediate decisions, and ensure timely interventions. Surgeons and anesthetists can leverage OpenAI to analyze real-time patient data, offer immediate assessments, and tailor treatment strategies, yet human involvement remains indispensable for secure and efficacious patient care (Clark, 2024).

The importance of ethical considerations in human supervision during surgical procedures lies in verifying and validating the data produced by AI conversational agents. The appropriate and ethical utilization of AI in surgical contexts requires a delicate equilibrium between utilizing the advantages offered by AI chatbots and mitigating the potential hazards they could introduce. The involvement of human expertise alongside AI chatbots in surgical scenarios is essential to uphold human judgment and critical thinking processes, thereby ensuring the accuracy and authenticity of surgical interventions. In surgical practices, human supervision is important in ensuring that AI tools are employed as enhancements rather than substitutes for healthcare practitioners. The collaboration between healthcare professionals and AI in surgical environments should be perceived as a mutually beneficial association where AI enhances the capabilities of healthcare providers, underscoring the significance of human interaction, clinical insight, and patient harmony (Grezenko et al., 2023; Liu et al., 2023).

Human oversight of surgical procedures is vital to verify the appropriate and secure utilization of AI tools in colorectal surgery. Supervisory roles are crucial to analyze the outcomes generated by OpenAI before applying them to influence patient care, underscoring the significance of human proficiency in conjunction with AI tools. The oversight of humans in surgical contexts is critical to highlight constraints and ethical issues linked to the deployment of AI and robotic technologies in the management of prostate cancer (Arigbede et al., 2023; Li et al., 2023).

The oversight of humans in surgical settings is important to ensure that AI-driven medical suggestions align with physicians' decisions and provide the needs of patient care. Surgeons are pivotal in supervising AI-driven forecasts and recommendations during surgical procedures to promise that the choices are in the patient's best interest. Human oversight is

crucial in surgical practices, particularly in robot-assisted surgeries. It involves evaluating manual skillfulness and monitoring the skill development of physicians, surgeons, and medical trainees. This ensures competency in surgical abilities and prevents mistakes. Human oversight is essential to address concerns about patient safety, as even a minor mistake can endanger the patient's life. Even a minor error can endanger the patient's life in semi-autonomous surgical systems. It is essential to provide clear accountability for any harm caused to patients or their data during surgical procedures, emphasizing the importance of human oversight in ensuring accountability and liability in surgical procedures (Choi et al., 2023; Hussain et al., 2022).

4.3.5 Responsibility, Liability, and Accountability

Patient selection during the learning phase is crucial to reduce risks and achieve optimal results. The liability in these surgical procedures is related to technical challenges surgeons face, such as instrument collisions and the requirement for precise hand movements, which demand continuous practice and problem-solving skills. Accountability encompasses informed consent, resource allocation, and fair access, ensuring that patients are well informed and can take advantage of robotic advancements in breast surgery. Incorporating AI in pediatric surgery presented complex issues concerning liability and legal obligations, particularly when an AI algorithm provided an inaccurate diagnosis or treatment suggestion. Determining accountability in such scenarios requires well-defined guidelines and frameworks to determine whether the surgeon, the hospital, or the AI developer should be held responsible. Upholding regulatory compliance for AI applications in pediatric surgery is essential yet challenging, necessitating thorough testing and validation to meet regulatory criteria and obtain approval. (Jain et al., 2024; Law et al., 2024). Integrating large language models (LLMs) in surgery necessitates precise legal structures and guidelines to clarify responsibility and liability for mistakes or adverse incidents, ensuring fairness and accountability in surgical contexts. The utilization of LLMs raises complex ethical dilemmas, especially when their use contributes to medical errors, underscoring the importance of clear guidelines and legal frameworks to address these concerns (Clark, 2024).

Clear guidance and frameworks are indispensable to address responsibility, liability, and accountability in AI-related surgeries. Healthcare professionals need to be educated on AI

systems to make decisions that prioritize patient welfare. Liability entails establishing legal and ethical accountabilities for errors, adverse events, or damages caused by AI systems involving developers, healthcare professionals, and healthcare institutions. Accountability involves establishing mechanisms to hold relevant parties accountable for AI-related errors, underscoring the requirement of regulatory frameworks to elucidate these responsibilities (Liu et al., 2023).

Responsibility, liability, and accountability in surgeries are fundamental elements that ensure ethical and safe practices in healthcare systems. Healthcare providers are obligated to provide safe and efficient care during surgical procedures. Liability pertains to the legal responsibility of healthcare professionals to compensate patients for any harm or injury incurred during surgeries. Accountability involves transparency and answerability for their actions and decisions during surgical interventions. Responsibility in surgeries entails the duty of healthcare providers to ensure the competent and ethical execution of their responsibilities. Liability concerns the legal obligation of healthcare professionals for any harm inflicted on patients during surgical procedures. Accountability involves being accountable for their decisions and actions, promoting transparency and compliance with ethical standards (Grezenko et al., 2023; Olaoye, 2024).

In surgeries, responsibility necessitates ensuring that all actions by the surgical team prioritize patient welfare and comply with ethical and legal norms. Liability involves the legal responsibility for any harm during surgery from privacy breaches, lack of consent, or data security risks. Accountability requires the surgical team to justify their actions and decisions, particularly regarding recording and data security, ensuring transparency and ethical conduct (Choi et al., 2023).

Responsibility, liability, and accountability are crucial in maintaining patient safety and care quality in colorectal surgery. Healthcare professionals must adhere to care protocols and standards to mitigate risks and achieve favorable outcomes. Surgeons and healthcare facilities can be held accountable for malpractice, negligence, or mistakes leading to adverse patient events. Accountability necessitates healthcare professionals taking responsibility for their actions and decisions during surgeries, upholding ethical standards, and openly addressing errors or complications. Colorectal surgery faces challenges in regulating litigation and liability in digital surgical systems, encompassing issues like system failures and the use of AI decision-support tools. Responsibility for data oversight in digital surgery

presents obstacles such as defining responsibilities, resource limitations, costs, standardization, and challenges in measuring progress. Legal considerations in digital surgery involve matters such as data governance, ownership, standardizing terminology, intellectual property, data integrity, and complying with international data transfer regulations (Arigbede et al., 2023; Kooli & Al Muftah, 2022).

Responsibility during surgical procedures encompasses the care and supervision medical professionals owe their patients. Liability pertains to the legal liability for any harm or neglect that may arise during surgeries. Accountability involves healthcare providers being accountable for their decisions and actions in surgical settings. Responsibility, liability, and accountability are essential considerations in surgeries. Responsibility entails ensuring that appropriate actions are taken by the surgical team to deliver safe and efficient patient care. Liability involves the legal responsibility assigned to the manufacturer, operator, or maintenance personnel in case of damages during surgery. Accountability requires justifying actions taken during surgical procedures, ensuring decisions are made in the patient's best interest (Etienne et al., 2020.-; Hussain et al., 2022).

4.3.6 Impact on Professional Surgeon

The technology brings up issues regarding the impact of AI integration on healthcare personnel and the workforce, with a particular emphasis on job displacement and de-skilling. Human-AI cooperation should be given priority in the ethical use of AI, providing healthcare practitioners with the knowledge, tools, and resources they need to successfully incorporate AI technology into their work. It is critical to ensure AI complements healthcare professionals rather than replacing them, highlighting the requirement of striking a balance between human knowledge and AI capabilities. Informed consent and patient autonomy are affected by using AI in healthcare. Thus, it is important to ensure patients are fully informed about how AI will be used in their treatment (Stephen et al.,2024). To truly grasp the benefits of artificial intelligence (AI) for clinical care, decision-making, training, research, and teaching, surgeons must be aware of the technology and how it is used using generative pre-trained transformers. Clinicians must understand that the dangers associated with validation, ethical concerns, and medicolegal considerations outweigh the benefits and the possibility of a revolutionary shift in practice. Human supervision and involvement will always be

required to ensure patient safety and make complex judgments that call for a thorough comprehension of each patient's unique situation. Rather than replacing a surgeon's expertise and judgment, ChatGPT should be viewed as a tool to supplement and improve their abilities. By supporting pre-operative planning, surgical decision-making, real-time monitoring, and other aspects of cardiac surgery and heart transplantation, ChatGPT has the potential to significantly change these procedures (Clark, 2024).

Medical practitioners must adjust to the AI-driven environment and help shape its moral and practical advancement for the good of patients and the healthcare sector so that AI can be successfully integrated into healthcare. Medical practitioners require lifetime learning and continual education programs to keep up to speed with the newest breakthroughs and properly utilize AI tools. The growing use of AI in healthcare presents ethical questions for medical practitioners, such as algorithmic transparency, data privacy, and biases in AI models that require careful evaluation. The use of AI-driven technologies in surgery and medicine holds the potential to be cost-effective, but healthcare practitioners must carefully weigh the short- and long-term advantages to allocate resources in a way that will ensure sustainability (Grezenko et al., 2023).

The Hawthorne effect, which causes behavior changes because of being aware that one is being filmed, impacts medical personnel during procedures. This leads to more meticulous adherence to protocols. Proceduralists aware that they were being recorded beforehand experienced this impact, which resulted in extended examination periods during colonoscopy procedures. Even though compliance rates improved because of remote auditing during preoperative time-outs, staff members resisted this practice because of privacy concerns, negatively impacting morale. Slight behavioral adjustments, like cutting down on pointless chats, can result from recording surgeries. These adjustments can affect team chemistry and the overall flow of the operating room (Quach et al., 2023). Healthcare workers' roles in patient care may change because of ChatGPT use; they may need to learn new skills to use the technology successfully, which may mean obtaining more education and training. It may be necessary for healthcare practitioners to keep current with AI techniques and technology to preserve patients' faith in their expertise and understanding (Li et al., 2023).

Healthcare workers who perform operations may be impacted by the dangers associated with using digital technology in surgery that are not disclosed to patients as part of the existing

consent procedures. Apart from the known hazards associated with implementing innovative technology in healthcare settings, digital technologies frequently need extensive processing of individualized data, which presents unique ethical and data governance issues that may impact healthcare practitioners. The absence of clarity in digital surgery hinders advancement and may have consequences for medical professionals. This is because quickly developing topics such as digital surgery requires defining research goals and areas of collaboration, which are critical for healthcare practitioners (Lam et al., 2022). Healthcare workers, especially thoracic surgeons, should be aware of the new potential that the direct or indirect use of AI technology in allied medical domains like radiology, pathology, and respiratory medicine may bring about that might impact their day-to-day work. Understanding how AI affects healthcare and how professionals might use this technology requires awareness of these issues. Artificial intelligence's potential to enhance surgical treatment is expected to increase due to the constructive collaboration between various medical disciplines and the partnerships between surgeons and machines. Surgeons should play a key role when evaluating AI's applicability and confirming its use in routine practice to improve patient care in a specific clinical route (Etienne et al., 2020).

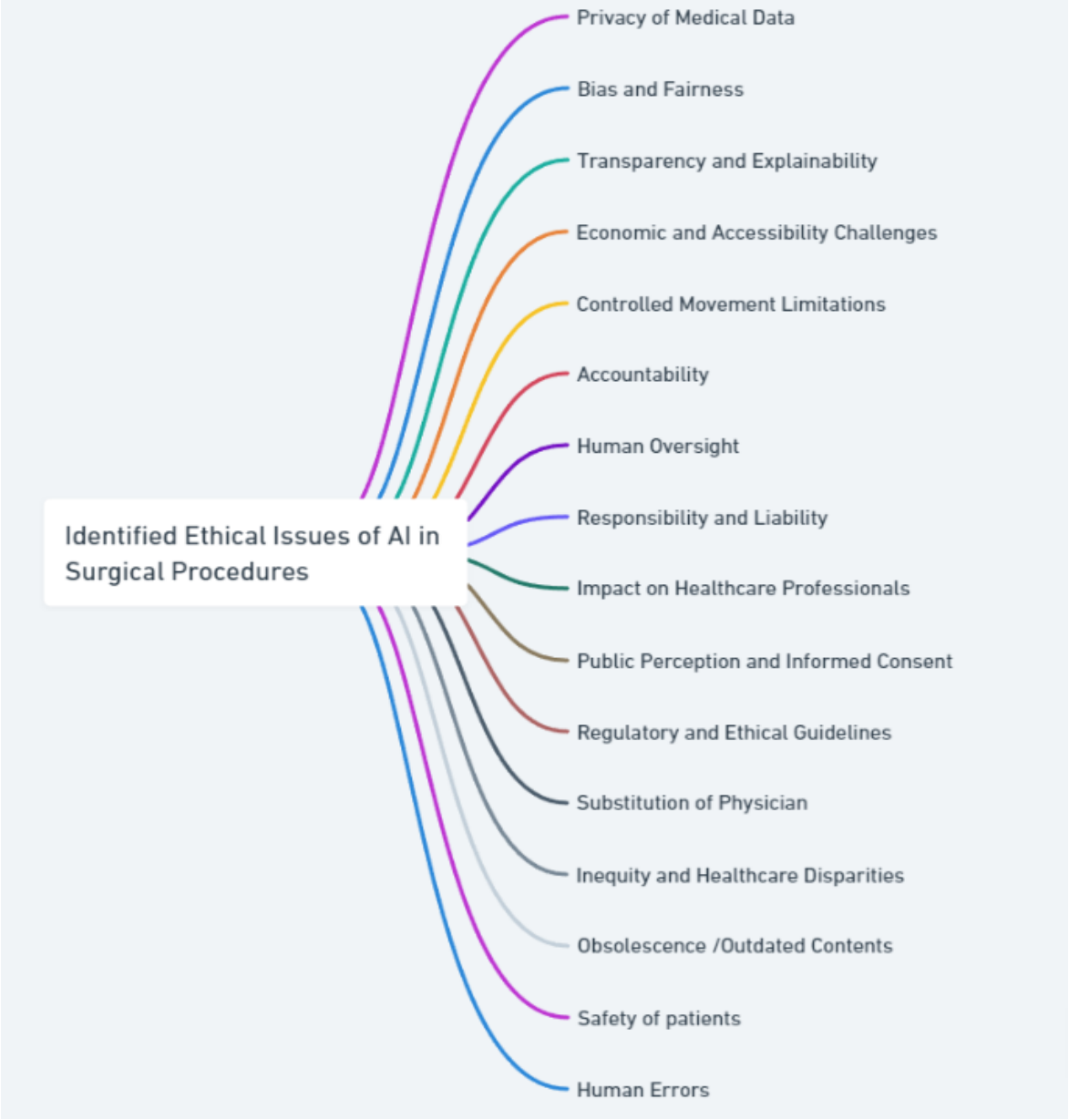
4.3.7 Human Error and Safety of Patients

To fully understand the uses of artificial intelligence (AI) for clinical care, decision-making, training, research, and teaching, surgeons must be aware of the technology and how it is used using generative pre-trained transformers. Human supervision and involvement will always be required to ensure patient safety and make complex judgments that require thoroughly comprehending each patient's unique situation. Rather than replacing a surgeon's expertise and judgment, ChatGPT should be viewed as a tool to supplement and improve their abilities. Human supervision and involvement will always be required to ensure patient safety and to make complex judgments that can call for a more nuanced comprehension of each patient's unique situation. In every clinical situation, the surgeon must always and without a doubt retain the final say in decision-making. They must also avoid becoming overly dependent on technology or accepting recommendations from AI and GPT without giving context or unique patient circumstances any thought (Clark, 2024).

Concerns regarding patient privacy, plagiarism, and the accuracy of data obtained from OpenAI sources have been brought up in the literature on plastic surgery. These issues might result in human mistakes and put patients' safety at risk. The study highlights the requirement of cautious use and teamwork to maximize OpenAI advantages while lowering dangers, particularly when it comes to patient safety (Liu et al., 2023).

Rules and regulations are urgently needed to ensure the safe and responsible use of the AI model in healthcare. The study article analyses the possible limits of ChatGPT/GPT-4 regarding medical mistakes. To ensure patient safety, it is critical to address the issues raised, which include medical, legal, ethical, data security, privacy, and liability concerns resulting from medical mistakes brought on by ChatGPT/GPT-4 (Law et al., 2024).

Figure 4 Visual Diagram of Identified Ethical Issues in Surgical Procedures


Identified Ethical Issues of AI in Surgical Procedures
Privacy of Medical Data
Bias and Fairness
Transparency and Explainability
Economic and Accessibility Challenges
Controlled Movement Limitations
Accountability
Human Oversight
Responsibility and Liability
Impact on Healthcare Professionals
Public Perception and Informed Consent
Regulatory and Ethical Guidelines
Substitution of Physician
Inequity and Healthcare Disparities
Obsolescence /Outdated Contents
Safety of patients
Human Errors

5 IMPLEMENTATION OF PROPOSED RESEARCH METHODOLOGY AND ANALYSIS

This chapter describes how to prioritize and analyze the ethical concerns of artificial intelligence in surgical procedures using the Multi-Criteria Group Decision-Making (MCGDM) technique. In addition to presenting the analysis of these ethical issues, it explains the procedure for collecting data, which includes the literature review and expert survey. The results are utilized to create useful recommendations in the next chapter for dealing with the major ethical issues raised by AI-driven surgery.

5.1 Problem Description and Data Collection

There have been major improvements in the accuracy and effectiveness of medical interventions since AI has been included in surgical operations. However, to ensure the ethical and responsible application of AI in surgical procedures, several ethical issues are brought up by the rapid pace of technology. The main ethical concerns identified were medical data privacy, algorithmic bias and fairness, human oversight, responsibility and accountability, transparency and explainability of AI systems, and the effect on patient safety and professional surgeons. Careful analysis and a methodical approach are required to address these ethical issues since they can build patient confidence, enhance data security, and induce biases in surgical outcomes.

A multi-phase research methodology was employed to recognize and evaluate the crucial ethical issues linked with AI-facilitated surgeries. Initially, an extensive literature review was carried out to compile existing knowledge and perspectives on the ethical concerns of AI in surgical procedures. This analysis established a groundwork for comprehending the current ethical scenario and pinpointed areas necessitating further investigation.

Following this, an expert survey was formulated and circulated to accumulate expert opinions and insights from medical professionals, AI specialists, and ethicists possessing substantial proficiency and knowledge in AI-driven surgical practices. The survey aimed to collect information on the primary ethical challenges faced or envisioned in AI-driven

surgery; the impact of these issues on patient care and the healthcare sector, as well as recommendations for addressing specific ethical concerns, were thoroughly studied.

Table 2 consists of definitions of ethical issues and IDs.

Issue ID	*Issue*	*Definition*
CI1	Accountability	Establishing clear guidelines to determine who is responsible for AI-assisted surgical outcomes.
CI2	Bias and Fairness	Addressing and mitigating biases in AI algorithms to ensure equitable treatment and outcomes for all patient groups.
CI3	Human Errors	Recognizing and addressing potential human errors in deploying and overseeing AI systems in surgeries.
CI4	Privacy of Medical Data	Ensuring the privacy and security of patient data used and generated by AI systems in surgical procedures.
CI5	Controlled Movement Limitations	Addressing the limitations of AI in performing precise surgical movements and ensuring patient safety.
CI6	Human Oversight	Ensuring human supervisors oversee AI decisions to ensure patient safety and accuracy.
CI7	Economic and Accessibility Challenges	Ensuring AI technologies are affordable and accessible to all healthcare providers and patients
CI8	Responsibility and Liability	Clarifying legal responsibilities and liabilities associated with AI-assisted surgery errors or adverse events.
CI9	Transparency and Explainability	Understanding how AI integration affects healthcare professionals' roles, skills, and job security. Maintaining clarity in AI decision-making processes so healthcare professionals and patients can trust AI outputs.
CI10	Public Perception and Informed Consent	Ensure patients are fully informed about AI use in their care and maintain public trust in AI technologies.

CI11	Regulatory and Ethical Guidelines	Adhering to ethical standards and regulatory requirements for AI use in surgical procedures.
CI12	Accuracy	Ensuring AI systems provide accurate and reliable information and recommendations during surgeries.
CI13	Substitution of Physician	Addressing potential and implications of AI systems replacing human physicians in surgical tasks.
CI14	Inequity and Healthcare Disparities	Preventing and addressing disparities in healthcare access and outcomes from AI implementation.
CI15	Obsolescence /Outdated Contents	Managing and updating AI systems to avoid reliance on outdated or obsolete information.
CI16	Cyber Security Threats on Medical Data	Protecting patient data from cyber threats and ensuring robust cybersecurity for AI systems.
CI17	Safety of Patients	Ensuring AI use in surgeries does not compromise patient safety and improves outcomes.
CI18	Impact on Healthcare Professionals	

The data obtained from the expert's survey was subsequently analysed through the application of the Multi-Criteria Group Decision-Making (MCGDM) method (Lai et al., 1994). This technique entailed the utilization of a decision-making matrix for the purpose of prioritizing and ranking the ethical issues based on their level of criticality. The systematic analysis offered a coherent framework for evaluating expert inputs and identifying the ethical challenges that require immediate attention.

5.2 Identification Of Critical Issues Using Multi-Criteria Group Decision-Making (MCGDM) Method

In this phase, a Google Form was used to rate the set of ethical concerns about AI-driven surgical procedures. Experts in the domains of AI and healthcare provided their input on the questionnaire. Ten specialists were given access to the form to rate the list of ethical

concerns. 18 ethical issues were listed in the form and their five-criticality evaluation and forwarded to ten experts who were requested to grade the issues based on criticality using a grid choice form including 18 ethical issues and 5 evaluation criteria, with 1 indicating the lowest rate and 5 the highest.

5.2.1 Steps Of Method

Phase 2: Application of MCGDM Approach to Assess Interrelationships

During this phase, the identified ethical difficulties in AI-driven surgical procedures were evaluated relative to one another using the Multi-Criteria Group Decision-Making (MCGDM) technique. Below is a summary of the approach's steps and results.

Step 1:

The literature review and expert survey highlighted ethical issues prioritized and evaluated using the MCGDM approach. This approach is crucial for methodically assessing and prioritizing ethical issues according to how important they are, as mentioned in Table 4.

Step 2:

A decision matrix was created based on the experts' evaluations of the 18 ethical issues that were found. The experts graded each issue using a five-point Likert scale, where 1 represents the least criticality, and 5 is the highest.

Step 3:

The average of the corresponding entries was used to aggregate the matrices. The experts' collective opinion on ethical issues is shown in this aggregated matrix.

aggregatedMatrix = mean (matrices, 3).

Table 3 Aggregated matrix

Issues	*Criticality Evaluation C1*	*C2*	*C3*	*C4*	*C5*
CI1	1.9000	1.4000	1.4000	1.2000	1.6000
CI2	2.6000	1.2000	1.8000	1.7000	2.0000
CI3	2.5000	1.4000	1.7000	2.0000	1.7000
CI4	2.9000	1.6000	1.7000	1.9000	1.9000
CI5	2.5000	1.7000	1.3000	1.9000	1.9000
CI6	2.6000	1.6000	1.6000	1.5000	1.7000
CI7	2.6000	1.7000	1.4000	1.8000	2.1000
CI8	2.3000	1.0000	1.6000	1.0000	1.8000
CI9	2.5000	1.5000	1.8000	1.9000	2.3000
CI10	2.6000	1.5000	1.5000	1.3000	2.0000
CI11	2.6000	1.4000	1.4000	1.6000	1.8000
CI12	2.0000	1.3000	1.9000	1.5000	1.7000
CI13	2.3000	1.5000	1.8000	1.4000	1.8000
CI14	2.9000	1.7000	1.6000	1.6000	1.4000
CI15	2.0000	1.7000	1.5000	1.5000	1.9000
CI16	1.9000	1.2000	1.3000	1.9000	1.5000
CI17	2.2000	1.1000	1.2000	1.7000	1.4000
CI18	2.3000	1.4000	1.4000	1.6000	1.4000

Normalization:

The values in the aggregate decision matrix were normalized to ensure that every ethical issue was assessed. All values were brought to a comparable scale in this phase to prevent biases resulting from disparate measurement scales.

[n, m] = size(aggregatedMatrix).

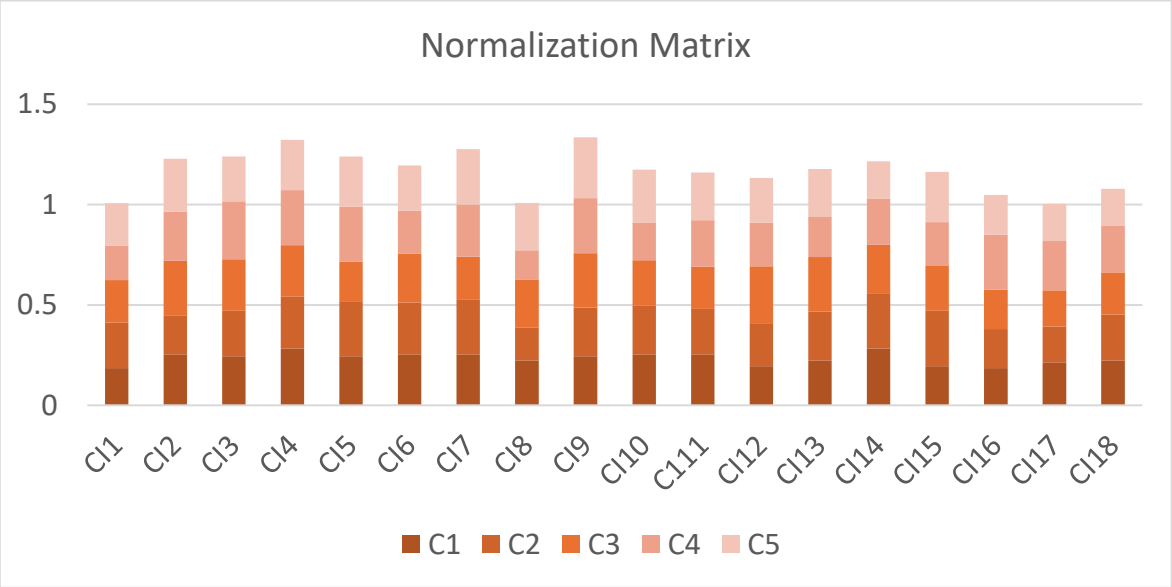
normMatrix = aggregatedMatrix. / Sqrt (sum (aggregatedMatrix. ^2, 1)).

Table 4 Normalization Matrix

Issues	***Criticality Evaluation***	***C2***	***C3***	***C4***	***C5***
CI1	0.1852	0.2270	0.2112	0.1732	0.2108
CI2	0.2534	0.1945	0.2715	0.2454	0.2635
CI3	0.2436	0.2270	0.2564	0.2887	0.2240
CI4	0.2826	0.2594	0.2564	0.2743	0.2503
CI5	0.2436	0.2756	0.1961	0.2743	0.2503
CI6	0.2534	0.2594	0.2413	0.2166	0.2240
CI7	0.2534	0.2756	0.2112	0.2599	0.2767
CI8	0.2241	0.1621	0.2413	0.1444	0.2372
CI9	0.2436	0.2432	0.2715	0.2743	0.3030
CI10	0.2534	0.2432	0.2263	0.1877	0.2635
C111	0.2534	0.2270	0.2112	0.2310	0.2372
CI12	0.1949	0.2107	0.2866	0.2166	0.2240
CI13	0.2241	0.2432	0.2715	0.2021	0.2372
CI14	0.2826	0.2756	0.2413	0.2310	0.1845
CI15	0.1949	0.2756	0.2263	0.2166	0.2503

CI16	0.1852	0.1945	0.1961	0.2743	0.1976
CI17	0.2144	0.1783	0.1810	0.2454	0.1845
CI18	0.2241	0.2270	0.2112	0.2310	0.1845

Fig 5 Visual Presentation of Normalization Matrix



Weighted Normalization:

Based on the expert opinion, weights were allocated to the different ethical issues. Using a weighted normalization procedure, the evaluation was made sure to match the expert survey completely.

weights = [1, 1, 1, 1, 1].

weighted matrix =normMatrix...* weights;

Table 5 Weighted Matrix

Issues	*Criticality Evaluation*	*C2*	*C3*	*C4*	*C5*
CI1	0.1852	0.2270	0.2112	0.1732	0.2108
CI2	0.2534	0.1945	0.2715	0.2454	0.2635
CI3	0.2436	0.2270	0.2564	0.2887	0.2240
CI4	0.2826	0.2594	0.2564	0.2743	0.2503
CI5	0.2436	0.2756	0.1961	0.2743	0.2503
CI6	0.2534	0.2594	0.2413	0.2166	0.2240
CI7	0.2534	0.2756	0.2112	0.2599	0.2767
CI8	0.2241	0.1621	0.2413	0.1444	0.2372
CI9	0.2436	0.2432	0.2715	0.2743	0.3030
CI10	0.2534	0.2432	0.2263	0.1877	0.2635
CI11	0.2534	0.2270	0.2112	0.2310	0.2372
CI12	0.1949	0.2107	0.2866	0.2166	0.2240
CI13	0.2241	0.2432	0.2715	0.2021	0.2372
CI14	0.2826	0.2756	0.2413	0.2310	0.1845
CI15	0.1949	0.2756	0.2263	0.2166	0.2503
CI16	0.1852	0.1945	0.1961	0.2743	0.1976
CI17	0.2144	0.1783	0.1810	0.2454	0.1845
CI18	0.2241	0.2270	0.2112	0.2310	0.1845

TOPSIS Score and Ranking:

The best (positive-ideal) and worst (negative-ideal) conditions for each ethical issue were determined to create a baseline for comparison. This was a major step in determining how every issue differed from the perfect scenario.

Each ethical issue was ranked in relation to the best possible answer. This stage made it easier to prioritize issues by demonstrating how each compare to the best-case scenario.

Finally, the ethical issues were prioritized based on their proximity to the optimal solution. This systematic and explicit approach established a solid framework for prioritizing ethical considerations in AI-driven surgical processes.

The outcomes, which encompass the prioritized ethical issues and their connections, present a thorough comprehension of the ethical terrain in AI-assisted surgical operations. This methodical method supports well-informed decision-making and strategic planning in addressing the significant ethical hurdles that have been identified.

The detailed procedures and findings are crucial in ensuring that the integration of AI in surgical processes is conducted ethically and accountable, improving patient care and results. The detailed procedures and findings are crucial in ensuring that the integration of AI in surgical processes is conducted ethically and accountable, improving patient care and results.

Table 6 Comprehensive TOPSIS Analysis Summary

Critical Issues	***Positive Ideal Solution***	***Negative Ideal Solution***	***TOPSIS Score***	***Ranking***
CI1	0.0815	0.0815	0.2911	18
CI2	0.1742	0.1742	0.6233	6
CI3	0.1890	0.1890	0.6426	4
CI4	0.2142	0.2142	0.7686	2
CI5	0.1943	0.1943	0.6329	5
CI6	0.1566	0.1566	0.5643	8
CI7	0.2007	0.2007	0.6908	3
CI8	0.0891	0.0891	0.2992	17
CI9	0.2216	0.2216	0.8017	1
CI10	0.1463	0.1463	0.5264	11
CI11	0.1416	0.1416	0.5237	12
CI12	0.1428	0.1428	0.4830	13
CI13	0.1496	0.1496	0.5378	9
CI14	0.1831	0.1831	0.5677	7
CI15	0.1568	0.1568	0.5300	10
CI16	0.1354	0.1354	0.4179	14

CI17	0.1064	0.1064	0.3440	16
CI18	0.1189	0.1189	0.4117	15

6 RESULTS AND RECOMMENDATIONS

The study's findings are presented in this chapter, along with an analysis of the outcomes of the Multi-Criteria Group Decision-Making (MCGDM) method and Literature review, which was employed to rank and evaluate ethical concerns related to AI-driven surgical operations. The analysis provides a thorough grasp of the ethical landscape, which sheds light on the significance of each ethical issue and how they relate. The chapter ends with recommendations based on the findings to address the most important ethical issues and ensure the ethical integration of AI in surgical operations.

6.1 Results

The results and some findings from the Multi-Criteria Group Decision-Making (MCGDM) approach are presented in this section. Their important value determines the ethical concerns' relative order (Pi = [ri + cj]). Based on the results, the ethical issues are ranked in the following order:

Based on the graph in the image, here is the corrected order from highest to lowest values:

CI9 > CI4 > CI7 > CI14 > CI15 > CI13 > CI12 > CI10 > CI11 > CI5 > CI3 > CI6 > CI2 > CI16 > CI18 > CI17 > CI8 > CI1

According to the rating, the most critical issue among subject matter experts in this domain is **"transparency and explainability (CI9)".** This indicates that building confidence between medical personnel and patients requires assuring Transparency and Explainability in AI-driven surgical procedures. Explainability and Transparency in surgery are essential in making sure patients are fully aware of their data, particularly when that data is being used to build artificial intelligence (AI) models. By giving people authority over their health information, this transparency improves the interaction between patients and surgeons (Grezenko et al., 2023a). Furthermore, as mentioned by (Law et al., 2024c) It is important to consider transparency and explainability when performing surgeries, particularly when incorporating ChatGPT/GPT-4 AI models into clinical settings. In

healthcare settings, particularly operations, the lack of clarity and openness of the data from data sources used to train AI models like ChatGPT/GPT-4 might be a genuine problem.

Furthermore, Transparency and explainability are important considerations when applying AI to medical activities such as image classification and surgical outcome prediction. Explainable AI enables surgeons to prioritize areas by predicting and identifying areas that an operation may negatively affect. This transparency explains the AI's decision-making process regarding surgical results (Choi et al., 2023). Furthermore, mentioned by (Kooli & Al Muftah, 2022) that transparency in the context of surgery refers to the requirement of honest and open discussion with patients and their families on the steps, dangers, and results of surgical treatments to foster trust and ensure informed decision-making. For this reason, to ensure that patients entirely understand the surgical procedure, healthcare providers must be able to communicate all surgical procedures, potential dangers, and expected outcomes to patients in a clear and understandable manner. This is known as explainability.

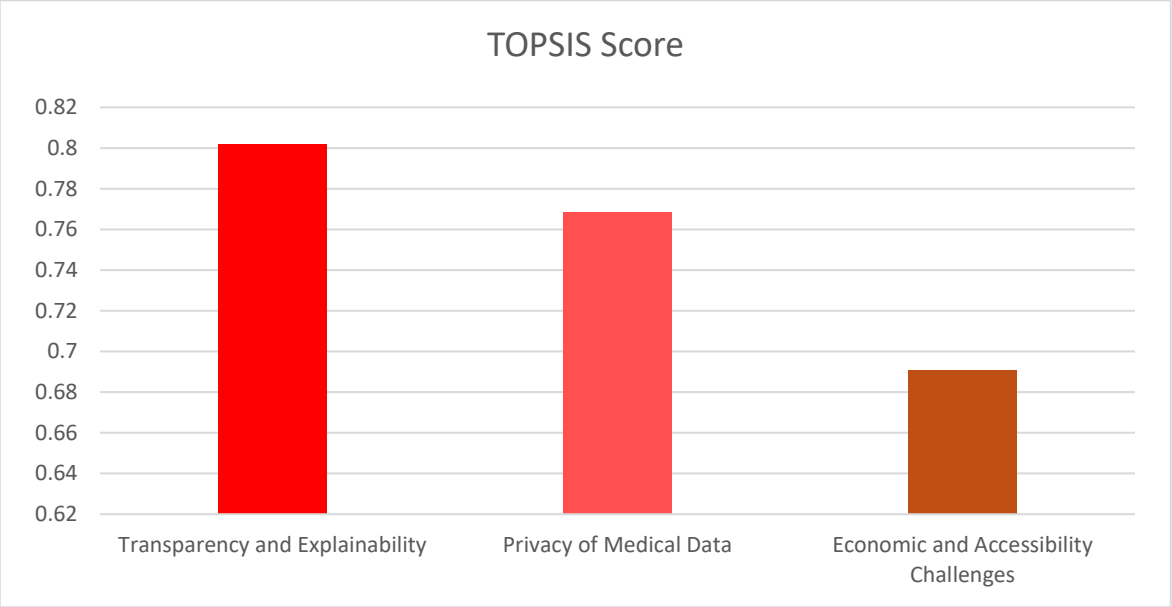
Apart from transparency and explainability (CI9), the second critical issue is the **privacy of medical data (CI4),** according to the MCGDM method as the privacy of medical data highlights how crucial it is to protect patient data collected and used by AI systems during surgical procedures, assuring privacy and security. The importance of informed consent and data use agreements on the side of data providers and third-party data aggregators is an ethical concern regarding medical data privacy during procedures. It is vital to ensure the authenticity of data used in AI algorithms, particularly regarding patient data privacy in surgical settings (Hussain et al., 2022). also mentioned by (Kooli & Al Muftah, 2022) A significant ethical challenge in surgery is the privacy of patient data, particularly considering the growing use of AI in healthcare. Concerns regarding the use of facial recognition technology and associated risks to data security make the possibility of patient privacy and privacy breaches a fundamental problem. Data breaches can quickly risk patient trust and cause people to conceal important health information from doctors, putting healthcare institutions at risk. Human error and improper use of data are two major contributing factors to data breaches in the healthcare sector. Concerns regarding patient privacy rights, data protection regulations, and the requirement for privacy protection by design and default are brought up by the introduction of AI in the healthcare sector. Because AI systems require huge quantities of data for operation, medical data privacy during surgeries is a major concern in the healthcare sector. Data security and privacy are called into doubt by this. AI

systems must be developed and used with strong data security procedures to ease these concerns. Furthermore, it is essential to get patients' informed consent and provide them ownership over their data (Katwaroo et al., 2024). Regarding this vital ethical issue (Uddin et al., 2023) mentioned that Patients undergoing surgery may have privacy concerns due to data leaks during information transmission. If the end devices are infiltrated or hacked, wearable sensors to record hand movements and eye contact during procedures could put patient privacy at risk. Also (Tsai et al., 2024) said that Patient data privacy in surgeries is a genuine issue, especially when it comes to gathering, storing, and analyzing sensitive medical data that needs to comply with strict privacy laws like the General Data Protection Regulation (GDPR) and the Health Insurance Portability and Accountability Act (HIPAA).

The regulatory authorities in this matter mentioned that in the context of surgical data, the European Union's General Data Protection Regulation (GDPR) strongly emphasizes providing users with clear, transparent information and protecting their privacy. Although the GDPR gives the highest control over data privacy, concerns over data protection in surgical settings remain as the law has not yet been fully enforced. To solve issues with patient data privacy and potential injury during surgeries, extensive security checks are necessary before developing completely autonomous robotic surgical systems. Concerns about accountability if patients or their data are harmed in autonomous surgical systems bring attention to how crucial data security and privacy are in the field of medical robotics (Hussain et al., 2022).

The Third critical issue regarding AI in surgeries is **economic and accessibility challenges (CI7); challenges** related to affordability and accessibility are important, highlighting the requirement for AI technology to be accessible and inexpensive for all patients and healthcare practitioners. Economic disparities in healthcare access raise ethical concerns, underscoring the requirements of removing financial obstacles that may hinder fair access to medical developments like advanced surgeries. This includes the worry about unequal access to healthcare resulting from things like low internet availability and the high expense of putting innovative AI technologies into practice. Initiatives aimed at impoverished populations are necessary to mitigate these healthcare inequities. Initiatives that ensure fair access to healthcare advances are also being developed in response to the rising affordability and accessibility of sophisticated AI technologies. These initiatives seek to improve equitable treatment for all patients and lessen healthcare disparities (Pressman et al., 2024).

Figure 6 Showcasing the TOPSIS Score of 3 most Critical Issues



The fifth challenge is Fairness and Bias (CI2); it indicates how important it is to address and mitigate biases in AI algorithms to ensure fair treatment and outcomes for all patient groups; ethical issues of bias and fairness in surgeries performed by AI need to be addressed, especially considering the use of large language models (LLMs) in surgical research. For surgical guidance and decision-making to be fair and non-discriminatory, bias in LLM outputs pertaining to patient demographics, socioeconomic status, and medical problems must be identified and quantified (Pressman et al., 2024). Controlled Movement constraints (CI5), To preserve patient safety, controlled movement constraints of AI in carrying out exact surgical actions need to be addressed. Accountability and Duty (CI1), Accountability requires defining legal obligations and liabilities related to mistakes or unfavorable outcomes in AI-assisted surgery. Accountability in surgeries involves healthcare professionals being answerable for their actions and decisions made during surgical procedures, ensuring transparency and adherence to ethical standards (Grezenko et al., 2023a). Human Errors (CI3), Ensuring safety and efficacy in surgical procedures requires acknowledging and mitigating human error when implementing and supervising AI technologies; human error as an ethical concern is brought up by the ethical consequences of utilizing chatbots in scientific writing, including the possibility of producing erroneous or wrong text (Sharma et al., 2023).

The further five ethical concerns are "regulatory and ethical guidelines (CI11)," "Accuracy (CI12)," "Substitution of Physician (CI13)," "Inequity and Healthcare Disparities (CI14)," as well as "Cyber Security Threats on Medical Data (CI16)." These issues are also important to ensure the ethical integration of AI in surgical procedures. Standards compliance and ethical integrity need adherence to ethical and legal standards. Accuracy is essential for assurance that AI systems deliver trustworthy data and recommendations. Physician substitution deals with the possible consequences of artificial intelligence (AI) taking over human jobs, whereas healthcare disparities and inequality aim to stop unequal access to AI technologies. The need to protect patient data from breaches and illegal access is highlighted by cyber security risks (Oniani et al., 2023).

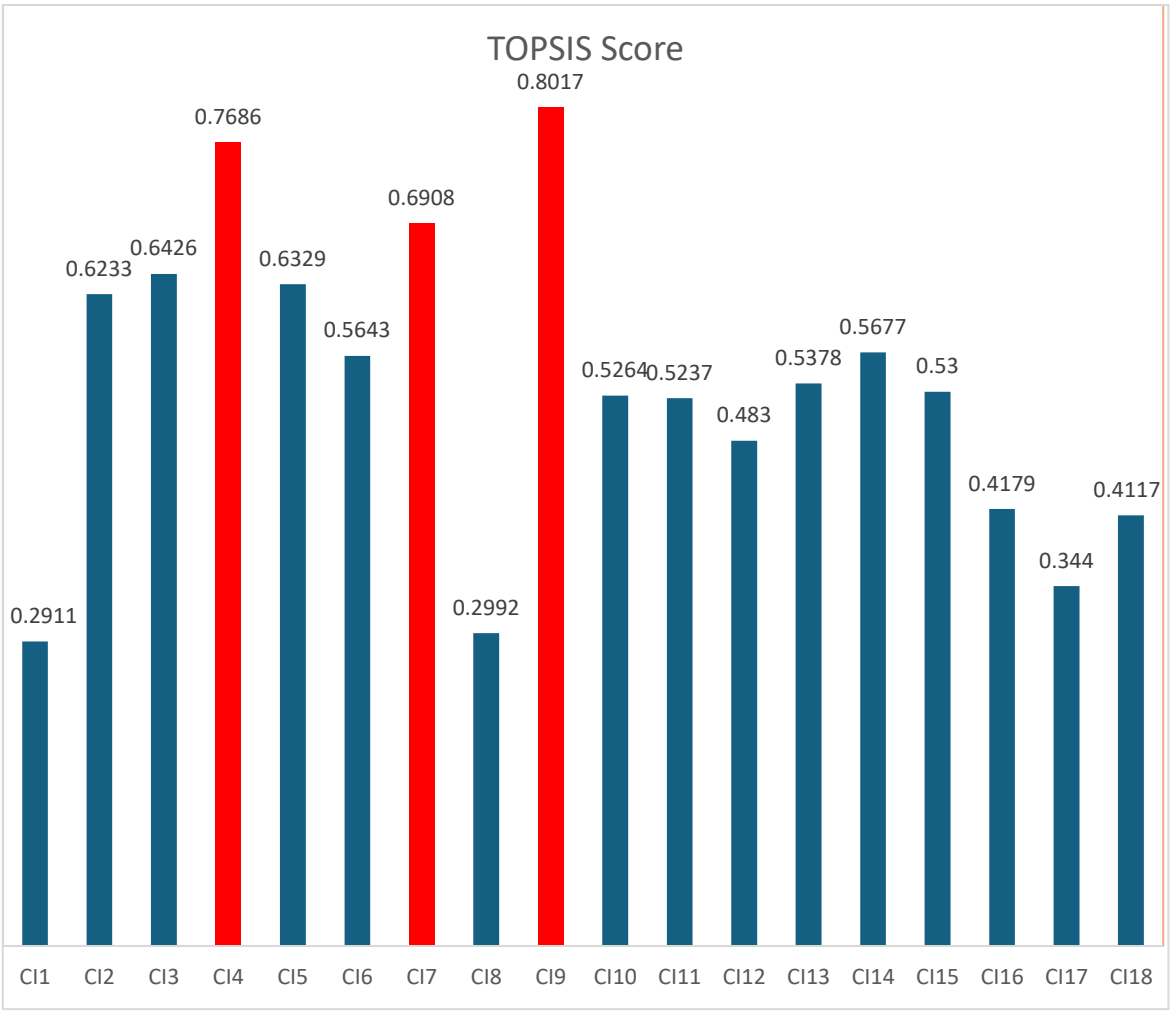
The remaining ethical issues are “Obsolescence /Outdated Contents (CI15)," "Controlled Movement Limitations (CI5)," and “Safety of Patients (CI17)”. Despite being of lesser importance as per this study, these issues have a notable influence on the moral framework of artificial intelligence in the context of surgical interventions. Obsolescence deals with the obstacles posed by outdated artificial intelligence systems, economic and accessibility challenges underscore the financial hindrances, controlled movement limitations focus on the accuracy of artificial intelligence in surgical procedures, and the safety of patients ensures that artificial intelligence does not compromise patient well-being. Surgeons must ensure patient safety by maintaining human oversight and intervention to make complex decisions that require a refined understanding of individual patient circumstances (Clark, 2024).

Although each problem has the potential to impact AI-powered surgical techniques, comprehending cause-and-effect relationships can aid professionals in formulating efficient protocols and procedures to alleviate the most influential risks. The subsequent segments offer a more refined assessment of certain cause-and-effect relationships.

Cause group ethical issues are those that impact other problems. The degree of "causality" depends on the extent of the positive value of Ei = [ri - cj]. The outcomes reveal the following sequence for the 12 issues oriented towards causality:

CI9 > CI4 > CI7 > CI14 > CI15 > CI13 > CI12 > CI10 > CI11 > CI5 > CI3 > CI6 > CI2 > CI16 > CI18 > CI17 > CI8 > CI1

Figure 7 TOPSIS score of the ranked ethical issues



The research results demonstrate that the ethical matter "Transparency and Explainability (CI9)" holds the highest value in the causal group. This suggests that transparency and explainability are essential for ensuring the ethical integration of AI in surgical procedures, as they affect numerous other concerns. Professionals stress that transparent AI decision-making processes foster trust and enable informed consent, vital for ethical medical conduct.

Subsequently, the following highest causal ethical issues are "Privacy of Medical Data (CI4)" and "Economic and Accessibility Challenges (CI7)." Safeguarding the privacy of medical data is crucial for preserving patient privacy, while economic and accessibility challenges underscore the financial obstacles to fair access to AI technologies. Both issues are pivotal in ensuring that AI integration does not worsen healthcare inequalities.

The findings also indicate that "Bias and Fairness (CI2)," "Controlled Movement Limitations (CI5)," and "Responsibility and Liability (CI8)" are ranked as the fourth, fifth, and sixth, respectively. These issues can be causal while also significantly influencing other ethical

considerations. Addressing bias and fairness ensures fair treatment, controlled movement limitations concentrate on AI accuracy in surgeries, and responsibility and liability establish clear lines of accountability in AI-supported procedures.

The emphasis should be on endeavors to diminish these primary causal ethical issues because of their substantial impact on effect group matters. Prioritizing these issues enables the efficient and ethical integration of AI in surgical settings, ensuring that the most crucial ethical issues are dealt with initially with the available resources.

6.3 Recommendations

After a comprehensive examination of ethical considerations within AI-facilitated surgical procedures through the utilization of the Multi-Criteria Group Decision-Making (MCGDM) methodology and Literature review, recommendations are put forth to highlight these most critical issues. The recommendations are designed to improve patient well-being, ensure the ethical incorporation of AI technology, and foster confidence in AI-supported surgical interventions. Every issue in AI surgical procedures has an impact on healthcare professionals and patients, but as per my research questions, this study found the following recommendations:

6.3.1 Improve Transparency and Explainability

Clear and understandable AI decision-making procedures must be ensured to increase trust among medical personnel and patients. Transparency and explainability in surgeries involving large language models are crucial ethical concerns. Transparency is essential for upholding autonomy and ensuring patients and healthcare professionals understand how LLMs derive conclusions, including limitations, training data, and algorithms. In plastic surgery research, transparency considerations are notably higher than in other surgical specialties, emphasizing the need for comprehensive disclosure to patients. Transparency and explainability in surgeries are crucial for fostering trust and enabling critical evaluation of AI-generated recommendations in the healthcare setting. This ensures that healthcare professionals can make informed decisions based on a clear understanding of AI outputs (Pressman et al., 2024; Stephen et al., 2024.).

Transparency and public trust are crucial in digital surgery, involving the public at all development and deployment stages to increase trust and ensure patient acceptance of digital surgery applications. Privacy, privacy, and public trust are essential in digital surgery to safeguard patient autonomy and ensure patient trust, which is vital for the future development of digital surgical applications. The author also mentioned the importance of appropriate anonymization of data, patient agreements for data sharing, and the need for greater data governance and security education among surgical teams. Adopt frameworks for explainable AI, clearly record AI decision-making procedures, and incorporate understandable explanations into clinician-facing AI interfaces. (Lam et al., 2022).

6.3.2 Enhance Privacy of Medical Data

Ethical considerations pertaining to the privacy of medical data in surgical procedures encompass the requirements for explicit consent and data usage agreements from data providers and third-party aggregators. Ensuring the quality of data utilized in AI algorithms is paramount, particularly in relation to the privacy of patient information during surgeries. Ethical issues concerning medical data privacy during surgical interventions involve inherent biases that may result in conclusions that do not adequately represent certain patient demographics. Preserving patient privacy is critical in surgical settings, ensuring the protection of sensitive medical information (Jarvis et al., 2020; Murphy & Saleh, 2020).

Integrating third-party AI software into patient care requires strict protocols on using and storing patient information, in line with the Health Insurance Portability and Accountability Act (HIPAA) guidelines, to ensure data privacy and security. The application of video-based AI models in surgical contexts raises ethical issues, including obtaining informed consent, offering the option to opt out of data retention, and upholding stringent security standards to safeguard patient privacy in video recordings. The adoption of distributed storage and federated machine learning (ML) presents an opportunity to train AI models while maintaining patient data on individual devices, thereby reducing the risk of data compromise or loss, and ensuring data privacy during the AI training phase. The privacy of medical data in surgical procedures emerges as a crucial focal point when integrating AI and robotics in the management of prostate cancer. Data privacy concerns are identified as a major obstacle in the synergistic amalgamation of AI and robotics, underscoring the requirement for

meticulous attention to preserve patient privacy and data protection. The ethical and regulatory dimensions of amalgamating AI and robotics demand comprehensive examination to effectively address concerns regarding data privacy (Arigbede et al., 2023; Choi et al., 2023).

Strict privacy laws like the General Data Protection Regulation (GDPR) in Europe and the Health Insurance Portability and Accountability Act (HIPAA) in the United States must be followed to protect the privacy of patient data, especially sensitive information (Tsai et al., 2024).

6.3.3 Economic And Accessibility Challenges

The third recommendation is Economic and Accessibility Challenges, which are important challenges related to affordability and accessibility, highlighting the requirement for AI technology to be accessible and inexpensive for all patients and healthcare practitioners. Economic disparities in healthcare access raise ethical concerns, underscoring the requirement to remove financial obstacles hindering fair access to medical developments like advanced surgeries. This includes the worry about unequal access to healthcare resulting from things like low internet availability and the high expense of putting innovative AI technologies into practice. Initiatives aimed at impoverished populations are necessary to mitigate these healthcare inequities. Initiatives that ensure fair access to healthcare advances are also being developed in response to the rising affordability and accessibility of sophisticated AI technologies. These initiatives seek to improve equitable patient treatment and lessen healthcare disparities (Pressman et al., 2024).

7 DISCUSSION

The focus of this chapter is to go over the detailed parts of the thesis that were studied. It provides comprehensive responses to the research questions, considering the goals that have been accomplished. The chapter summarizes the most significant findings made throughout the analysis and evaluates the consequences of the results. It also concludes with an overview of the lessons learned during the thesis work, providing reflections on the approaches and results to improve further study and field implementation.

7.1 Overview of the Result

This thesis started to identify and analyze the main ethical concerns surrounding AI-driven surgical procedures. The thesis was first conferred with experts in AI and healthcare. This intensive consultation engaged key parties such as medical specialists and AI technologists to ensure a thorough understanding of the issue. As part of the primary study methodology, the Multi-Criteria Group Decision-Making (MCGDM) approach, which was chosen for the thesis, the study undertook a thorough literature review.

7.2 Answers to Research Questions

There are 4 main research questions established as part of this thesis project. The first **question was RQ1**:" In the context of the surgical procedures through AI, what are the main ethical issues surrounding the application of AI in healthcare, particularly in surgical procedures?"

This question aimed to identify the primary ethical concerns associated with using AI in healthcare, in Surgeries. After comprehensive research, the aim of this question was to find the primary ethical issues of AI in surgical procedures.

These issues include Transparency and Explainability (CI9), which underscore the significance of elucidating AI decision-making processes to healthcare professionals and

patients to establish trust and enable informed consent (Pressman et al., 2024a). Safeguarding patient information utilized by AI systems, known as Privacy of Medical Data (CI4), is paramount to uphold privacy and security (Jarvis et al., 2020b). The Economic and Accessibility Challenges (CI7) strive to address financial obstacles and promote fair access to AI technologies to mitigate healthcare inequalities. Bias and Fairness (CI2) are crucial categories that address mitigating biases in AI algorithms to ensure equitable treatment of all patient cohorts (Arigbede et al., 2023a). The issue of Controlled Movement Limitations (CI5) pertains to addressing AI's limitations in executing precise surgical maneuvers to uphold patient safety. Responsibility and Liability (CI8) stress the importance of defining legal responsibilities and accountabilities related to AI-assisted surgical outcomes to ensure transparency. Accountability (CI1) underscores the need for establishing clear directives to determine the parties accountable for AI-assisted surgical results (Jain et al., 2024).

Human Oversight (CI7) highlights the essential role of continuous human supervision to ensure precise and safe AI decisions in surgical interventions (Liu et al., 2024). Public Perception and Informed Consent (CI10) focus on ensuring comprehensive awareness among patients regarding the use of AI in their treatment to maintain trust in AI technologies (Olaoye, 2024b). Impact on Healthcare Professionals (CI18) refers to the repercussions of AI integration on healthcare practitioners' roles, competencies, and job stability. Regulatory and Ethical Guidelines (CI11) ensure compliance with established norms for the ethical application of AI in surgical procedures (Oniani et al., 2023c; Quach et al., 2023b). Accuracy (CI12) is paramount in furnishing dependable information and recommendations throughout surgical interventions. Substitution of Physician (CI13) investigates the potential implications of AI systems supplanting human physicians (Grezenko et al., 2023a). Inequity and Healthcare Disparities (CI14) aim to forestall variations in healthcare access and outcomes stemming from the integration of AI. Obsolescence/Outdated Contents (CI15) manage challenges posed by obsolete AI systems, while Cyber Security Threats on Medical Data (CI16) stress the importance of shielding patient data from cyber risks. Safety of Patients (CI17) ensures that the utilization of AI in surgeries upholds patient safety, while Human Errors (CI3) acknowledge the prospect of errors in the deployment and supervision of AI systems in surgical settings (Clark, 2024; Law et al., 2024).

Research Question R2: What are the most critical ethical issues in the application of AI-driven surgery, and how can these identified issues be prioritized and rated according to their criticality using expert opinions obtained through surveys and the MCGDM method?

The Aim of this question was to prioritize the identified ethical issues and rank them based on their criticality using an expert survey and MCGDM method. The study evaluated and ranked the most important ethical issues related to AI-driven surgery, using expert opinions and the Multi-Criteria Group Decision-Making (MCGDM) technique. A precise structure for resolving these challenges was established by evaluating and ranking the identified issues according to their criticality.

7.2.1 Expert Opinion Obtained through Survey

- A list of all the identified issues was shared with the experts, including health practitioners, AI specialists, and stakeholders through Google form.
- All the issues were listed using a five-point Likert scale; experts assessed the ethical issues according to their criticality ratio, where 1 was the lowest and 5 was the highest criticality ratio.

7.2.2 MCGDM Method

- The Multi-Criteria Group Decision-Making (MCGDM) approach was used to assess the data gathered, methodically evaluating, and ranking the criticality of ethical issues.
- To determine the relative relevance of each issue, the MCGDM approach involves creating a decision matrix, normalizing the data, allocating weights, TOPSIS score, and ranking order.

7.2.3 Most Critical Ethical Issues Identified

By using the above methodology and approach, this study has identified the most critical ethical issues of AI in surgical procedures these are:

1. **Transparency and Explainability**

Transparency and public trust are crucial in digital surgery, involving the public at all development and deployment stages to form trust and ensure patient acceptance of digital surgery applications. Privacy, privacy, and public trust are essential in digital surgery to safeguard patient autonomy and ensure patient trust, which is vital for the future development of digital surgical applications. The author mentioned the importance of appropriate anonymization of data, patient agreements for data sharing, and the need for greater education around data governance and security among surgical teams (Lam et al., 2022). Particularly when integrating inductive AI technology into the healthcare sector, transparency and Explainability in actions are essential. To enable clear development and understanding by medical experts, transparency in operations involves collecting and documenting data, processes, and artifacts connected to the AI system utilized during surgical procedures. The relationship between healthcare practitioners and their AI is made more trustworthy because of this transparency. To enable a smooth deployment and reproducibility across healthcare systems, surgeons and medical staff must comprehend the capabilities, development process, methodology, data sources, and documentation of the AI system utilized in surgeries (Oniani et al., 2023).

2. **Privacy of Medical Data**

Ethical considerations pertaining to the privacy of medical data in surgical procedures encompass the requirement for explicit consent and data usage agreements from data providers and third-party aggregators. Ensuring the quality of data utilized in AI algorithms is paramount, particularly in relation to the privacy of patient information during surgeries. Ethical issues concerning medical data privacy during surgical interventions involve inherent biases that may result in conclusions that do not adequately represent certain patient demographics. Preserving patient privacy is a critical element of privacy in surgical settings, ensuring the protection of sensitive medical information (Jarvis et al., 2020; Murphy & Saleh, 2020).

3. **Economic and Accessibility Challenge**

Economic and accessibility challenges pertaining to the affordability and accessibility of AI technology are significant, underscoring the imperative for ensuring that such technology is within reach and cost-effective for all individuals needing medical care and healthcare

professionals. Ethical concerns are heightened by economic inequalities in healthcare access, emphasizing the importance of eliminating financial barriers that could impede fair access to medical advancements such as innovative surgeries. Concerns also arise regarding unequal healthcare access due to limited internet availability and the costs associated with implementing advanced AI technologies. Interventions targeting underserved populations play a crucial role in addressing these disparities in healthcare. Efforts are being made to promote fair access to healthcare innovations considering the increasing affordability and accessibility of sophisticated AI technologies. These endeavors are focused on enhancing equitable healthcare provision for all patients and reducing disparities in healthcare (Pressman et al., 2024).

Research Question R3: In surgical operations, what recommendations can be presented to optimize and handle the most critical ethical issues in AI-driven surgical procedures?

To achieve this objective, this study Followed a thorough analysis of ethical issues related to AI-assisted surgical operations using the Multi-Criteria Group Decision-Making (MCGDM) approach and a review of the literature; a few suggestions are made to address these most important problems are discussed below:

Transparency and explainability are crucial ethical concerns in AI decision-making procedures, especially in large language models (LLMs) surgeries. These considerations ensure patients and healthcare professionals understand how LLMs derive conclusions, including limitations, training data, and algorithms. Transparency and public trust are essential in digital surgery, involving the public at all development and deployment stages to increase trust and patient acceptance. Privacy, privacy, and public trust are essential in digital surgery to safeguard patient autonomy and ensure patient trust (Pressman et al., 2024; Stephen et al., 2024).

Ensuring the privacy of medical data is essential in surgical procedures, with explicit consent and data usage agreements from data providers and third-party aggregators. Strict protocols on the use and storage of patient information, in line with the guidelines of the Health Insurance Portability and Accountability Act (HIPAA), are necessary to protect data privacy and security (Arigbede et al., 2023; Choi et al., 2023).

Economical and accessibility challenges are also important, with concerns about unequal access to medical advancements like advanced surgeries. Initiatives aimed at impoverished

populations are necessary to mitigate these healthcare inequities. As sophisticated AI technologies become more affordable and accessible, initiatives to ensure fair access to healthcare advancements are being developed to improve equitable treatment for all patients and reduce healthcare disparities (Pressman et al., 2024).

7.3 Study Contribution

This thesis employed the Multi-Criteria Group Decision-Making (MCGDM) methodology and addressed crucial ethical concerns in AI-facilitated surgical procedures. This study has played a crucial role in shifting from a subjective manual assessment process to a methodical, organized approach utilizing MCGDM. The study has made a notable contribution to the field by prioritizing and alleviating ethical concerns through expert surveys and a robust decision-making framework.

Moreover, the literature review performed within the scope of this study offers valuable perspectives that can be utilized in diverse scenarios where ethical considerations in AI and healthcare converge. This encompasses safeguarding data security, bias, and fairness, amplifying openness and comprehensibility in AI systems, as elaborated in Chapter 4.

The study illustrated that incorporating the MCGDM approach into the assessment of AI-driven surgical processes improves the ethical considerations of these technologies and boosts overall reliance and reception among medical practitioners and patients. The structure formulated through this study can function as a yardstick for forthcoming research endeavors striving to integrate ethical considerations into AI applications within healthcare and other domains.

Lastly. this research indicates that automating the assessment of ethical issues in AI-driven surgeries advances the sustainability and dependability of the system. The favorable effects extend to enhancing patient results, ensuring ethical adherence, and nurturing greater reliance on AI technologies among all parties involved.

8 CONCLUSION

This chapter brings this thesis dissertation to an end. The chapter highlights the research objective, key findings, and the dependability and limitations of the suggested solution. In addition to the conclusion, the chapter provides information on potential future initiatives that could be undertaken to improve the use of AI in surgeries.

8.1 Achieving Research Objectives

The objectives of this research were effectively met by carefully studying the ethical implications of artificial intelligence in AI-driven surgeries. Transparency and explainability, medical data privacy, economic and accessibility challenges, algorithmic bias and fairness, human oversight, responsibility and liability, the effect on professional surgeons, patient safety, and more are among the main ethical concerns raised. The study prioritized these concerns using the MCGDM method based on their criticality and offered a thorough understanding through a comprehensive literature review and expert survey.

8.2 Key Findings and their Implications

The study highlights the importance of transparency and explainability in AI-driven surgical procedures, highlighting the need for clear and understandable decision-making processes. It also highlights the importance of protecting patient data and adhering to HIPAA and GDPR regulations. Mitigating biases in AI algorithms is crucial for equitable treatment across diverse patient populations. Human oversight is essential for patient safety and the accuracy of AI-driven decisions. Legal responsibilities and accountability for AI-assisted surgical outcomes are also crucial. The study also highlights the impact on professional surgeons and the safety of patients, suggesting ongoing training and adaptation programs. The study also offers practical recommendations to address the most critical ethical issues, such as improving transparency and explainability, enhancing medical data privacy, and addressing economic and accessibility challenges to ensure equitable healthcare.

8.3 Limitations and Future Research

Despite its contributions, this study is subject to certain limitations. Applying expert insights in the realm of Multi-Criteria Group Decision Making (MCGDM) could result in biases originating from the perspectives and backgrounds of the experts. Furthermore, considering the constantly evolving landscape of Artificial Intelligence (AI) technology, fresh ethical concerns over time highlight the requirement for continuous monitoring and adaptation of ethical frameworks.

Subsequent research endeavors should prioritize the development of flexible and adaptive ethical principles that can progress in tandem with the advancements in AI technology. Conducting longitudinal studies to evaluate the prolonged effects of AI on surgical outcomes and professional behaviors would offer deeper insights into the changing ethical ground. In addition, expanding the range of expert surveys or interviewing experts to include a wider variety of stakeholders, like patients and policymakers, could improve the understanding of ethical issues and strengthen the validity of the findings.

8.4 Conclusion

In conclusion, this thesis offers a comprehensive and well-organized approach to examining the ethical consequences of artificial intelligence in surgical procedures. Through identifying, prioritizing, and recommending the most critical ethical concerns, this study contributes to the ethical integration of AI technologies in the healthcare sector, particularly in surgeries. The sustainability of transparency, privacy, economic and accessibility challenges, bias and fairness, and human supervision in AI applications is crucial for establishing trust, improving patient outcomes, and upholding the ethical standards of AI-driven healthcare systems.

As artificial intelligence continues to advance and become more widespread in various healthcare fields, it is essential to keep ethical considerations at the forefront of technological progress. This study represents an important first step in working towards this goal by

establishing a foundation for ongoing discussion, deliberation, and implementation of ethically applicable AI in surgical procedures. The findings and recommendations presented in this thesis aim to foster a healthcare environment where AI enhances human capabilities, respects patient autonomy, and promotes fair and secure medical practices.

References

1. Arigbede, O., Amusa, T., & Buxbaum, S. G. (2023). Exploring the Use of Artificial Intelligence and Robotics in Prostate Cancer Management. *Cureus*. https://doi.org/10.7759/cureus.46021
2. Bhat, S. A. (2020). *SOME METHODS FOR PRIORITIZATION OF ALTERNATIVES OF MADM PROBLEMS IN FUZZY ENVIRONMENT AND ITS EXTENSIONS DOCTOR OF PHILOSOPHY IN SCHOOL OF MATHEMATICS*.
3. Chaand Sharma, S., Parkash Ramchandani, J., Thakker, A., & Lahiri, A. (2023). *ChatGPT in Plastic and Reconstructive Surgery*. https://doi.org/10.1055/s-0043-1771514
4. Choi, E., Leonard, K. W., Jassal, J. S., Levin, A. M., Ramachandra, V., & Jones, L. R. (2023). Artificial Intelligence in Facial Plastic Surgery: A Review of Current Applications, Future Applications, and Ethical Considerations. *Facial Plastic Surgery*, *39*(5), 454–459. https://doi.org/10.1055/s-0043-1770160
5. Clark, S. C. (2024). Can ChatGPT transform cardiac surgery and heart transplantation? In *Journal of Cardiothoracic Surgery* (Vol. 19, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s13019-024-02541-0
6. Etienne, H., Hamdi, S., Le Roux, M., Camuset, J., Khalife-Hocquemiller, T., Giol, M., Debrosse, D., & Assouad, J. (n.d.-b). *Artificial intelligence in thoracic surgery: past, present, perspective and limits*. https://doi.org/10.1183/16000617.0010
7. Grezenko, H., Alsadoun, L., Farrukh, A., Rehman, A., Shehryar, A., Nathaniel, E., Affaf, M., I KH Almadhoun, M. K., & Quinn, M. (2023). From Nanobots to Neural Networks: Multifaceted Revolution of Artificial Intelligence in Surgical Medicine and Therapeutics. *Cureus*. https://doi.org/10.7759/cureus.49082
8. Hussain, S. M., Brunetti, A., Lucarelli, G., Memeo, R., Bevilacqua, V., & Buongiorno, D. (2022). Deep Learning Based Image Processing for Robot Assisted Surgery: A Systematic Literature Survey. *IEEE Access*, *10*, 122627–122657. https://doi.org/10.1109/ACCESS.2022.3223704
9. Hwang, C.-L., & Yoon, K. (1981). Multiple Attributes Decision Making Methods and Applications. *Multiple Attribute Decision Making*.
10. Jain, Y., Lanjewar, R., & Shinde, R. K. (2024). Revolutionising Breast Surgery: A Comprehensive Review of Robotic Innovations in Breast Surgery and Reconstruction. *Cureus*. https://doi.org/10.7759/cureus.52695
11. Jarvis, T., Thornburg, D., Rebecca, A. M., & Teven, C. M. (2020). Artificial Intelligence in Plastic Surgery: Current Applications, Future Directions, and Ethical Implications. *Plastic and Reconstructive Surgery - Global Open*, *8*(10), E3200. https://doi.org/10.1097/GOX.0000000000003200
12. Katwaroo, A. R., Adesh, V. S., Lowtan, A., & Umakanthan, S. (2023). The diagnostic, therapeutic, and ethical impact of artificial intelligence in modern medicine. *Postgraduate Medical Journal*. https://doi.org/10.1093/postmj/qgad135

13. Kooli, C., & Al Muftah, H. (2022). Artificial intelligence in healthcare: a comprehensive review of its ethical concerns. *Technological Sustainability*, *1*(2), 121–131. https://doi.org/10.1108/TECHS-12-2021-0029
14. Lai, Y. J., Liu, T. Y., & Hwang, C. L. (1994). TOPSIS for MODM. *European Journal of Operational Research*, *76*(3), 486–500. https://doi.org/10.1016/0377-2217(94)90282-8
15. Lam, K., Abràmoff, M. D., Balibrea, J. M., Bishop, S. M., Brady, R. R., Callcut, R. A., Chand, M., Collins, J. W., Diener, M. K., Eisenmann, M., Fermont, K., Neto, M. G., Hager, G. D., Hinchliffe, R. J., Horgan, A., Jannin, P., Langerman, A., Logishetty, K., Mahadik, A., … Purkayastha, S. (2022). A Delphi consensus statement for digital surgery. *Npj Digital Medicine*, *5*(1). https://doi.org/10.1038/s41746-022-00641-6
16. Law, S., Oldfield, B., & Yang, W. (2024). ChatGPT/GPT-4 (large language models): Opportunities and challenges of perspective in bariatric healthcare professionals. *Obesity Reviews*. https://doi.org/10.1111/obr.13746
17. Li, W., Zhang, Y., & Chen, F. (2023). ChatGPT in Colorectal Surgery: A Promising Tool or a Passing Fad? In *Annals of Biomedical Engineering* (Vol. 51, Issue 9, pp. 1892–1897). Springer. https://doi.org/10.1007/s10439-023-03232-y
18. Liu, H. Y., Alessandri-Bonetti, M., Arellano, J. A., & Egro, F. M. (2023). Can ChatGPT be the Plastic Surgeon's New Digital Assistant? A Bibliometric Analysis and Scoping Review of ChatGPT in Plastic Surgery Literature. In *Aesthetic Plastic Surgery*. Springer. https://doi.org/10.1007/s00266-023-03709-0
19. Murphy, D. C., & Saleh, D. B. (2020). Artificial Intelligence in plastic surgery: What is it? Where are we now? What is on the horizon? *Annals of the Royal College of Surgeons of England*, *102*(8), 577–580. https://doi.org/10.1308/RCSANN.2020.0158
20. Olaoye, G. O. (2024). *The Ethical Implications of AI in Healthcare: Ensuring Fairness, Transparency, and Privacy*.
21. Oniani, D., Hilsman, J., Peng, Y., Poropatich, R. K., Pamplin, J. C., Legault, G. L., & Wang, Y. (2023). Adopting and expanding ethical principles for generative artificial intelligence from military to healthcare. *Npj Digital Medicine*, *6*(1). https://doi.org/10.1038/s41746-023-00965-x
22. Pressman, S. M., Borna, S., Gomez-Cabello, C. A., Haider, S. A., Haider, C., & Forte, A. J. (2024). AI and Ethics: A Systematic Review of the Ethical Considerations of Large Language Model Use in Surgery Research. In *Healthcare (Switzerland)* (Vol. 12, Issue 8). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/healthcare12080825
23. Quach, W. T., Vittetoe, K. L., & Langerman, A. (2023). Ethical and Legal Considerations for Recording in the Operating Room: A Systematic Review. In *Journal of Surgical Research* (Vol. 288, pp. 118–133). Academic Press Inc. https://doi.org/10.1016/j.jss.2023.02.017
24. Sharma, S. C., Ramchandani, J. P., Thakker, A., & Lahiri, A. (2023). ChatGPT in Plastic and Reconstructive Surgery. In *Indian Journal of Plastic Surgery* (Vol. 56, Issue 4, pp. 320–325). Georg Thieme Verlag. https://doi.org/10.1055/s-0043-1771514
25. Stephen, M., Mohamed, S., & Potter, K. (2024). *The Ethical Implications of Artificial Intelligence in Healthcare*. https://www.researchgate.net/publication/377661463
26. Tsai, A. Y., Carter, S. R., & Greene, A. C. (2024). Artificial intelligence in pediatric surgery. *Seminars in Pediatric Surgery*, *33*(1). https://doi.org/10.1016/j.sempedsurg.2024.151390
27. Uddin, M., Manickam, S., Ullah, H., Obaidat, M., & Dandoush, A. (2023). Unveiling the Metaverse: Exploring Emerging Trends, Multifaceted Perspectives, and Future Challenges.

In *IEEE Access* (Vol. 11, pp. 87087–87103). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ACCESS.2023.3281303