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Artificial Intelligence as a Decision-Making Tool for Bariatric Surgeries in the Preoperative Assessment: A Bibliometric Analysis

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ABSTRACT

Introduction: The use of artificial intelligence (AI) in medicine is becoming increasingly common, significantly altering medical practices. **Objective:** To analyze whether Artificial Intelligence can be an effective tool ou can support for the preoperative period of bariatric surgeries, helping both in decision-making to be carried out by the doctor and in predicting diseases that the patient is more likely to develop in the postoperative period. **Methods:** A systematic review was conducted, seeking studies published between 2011 and 2023, in English. The databases used were PubMed and Web of Science. **Results:** Most of the selected articles discussed the use of Machine Learning to assist in the preoperative period of bariatric surgeries, analyzing the general use of AI in this type of surgery and its contribution to the decision-making process, in addition to its use to predict the behavior of diseases that may arise in patients after bariatric surgery. **Conclusion:** Artificial Intelligence is being increasingly used in the medical field, including in bariatric surgery, where it helps in decision-making for faster and more accurate procedures, reducing errors, and promoting faster patient recovery, confirming the acceptance of the hypothesis of this study.

Keywords: Artificial Intelligence; decision making; Bariatric Surgery; preoperative period; Dimensional Measurement Accuracy.

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INTRODUCTION

Over time, artificial intelligence (AI) has been implemented in different sectors of society, such as medicine. However, how has AI been used and what are its impacts on the performance of the medical profession?

Although the incorporation of AI resources isn't unanimous among the medical profession, its presence is already widely felt, apparently causing changes in the interactions between healthcare professionals and their patients. The global market for AI in preventive and healthcare services is projected to grow at an average annual rate of 43.5% in 2023 (post-pandemic), reaching a US$27.6 billion/year valuation by 2025[1]. In the wake of investments, universities and research centers are responsible for discussing

two topics: 1) defining AI within the ethical scope for medical use, and 2) delimiting strategies to develop skills and leadership in AI in healthcare[2].

Deep learning and machine learning algorithms have the potential to be used widely in all fields of medicine, from drug discovery to clinical decision-making, significantly altering the way medicine is practiced. The success of AIs using algorithms in computer vision tasks in recent years appears at an opportune moment when medical records are gradually becoming more digitized[3,4].

At Duke University Medical Center (DUMC) in the United States, where the AI system in healthcare is being tested, the doctor observes the algorithmic indications from patient admission to bed allocation, diagnostic tests, and provider workflow[1,3,4]. This AI-based decision-making process has already proven efficient in predicting sepsis risk, selecting antibiotics, and automating administrative tasks. It has also allowed doctors to target critical areas (indication of vulnerability) for improvement that have already been sufficiently trained by the AI algorithm[5,6].

Health professionals don't need to become specialized programmers; they just need to have a basic understanding of the capabilities and limitations of algorithms to show programmers where the answers presented are on the right track and where the incorrect outputs are filtered out from the system[7]. Artificial Intelligence (AI) is increasingly transforming medical practice by enhancing decision-making, digitizing processes, and improving safety, as evidenced by its success in computer vision applications. With this, it is believed that an AI component should be included in the curriculum of health courses.

A systematic literature review (bibliometrics) was conducted as a starting point for this discussion, to substantiate the previously mentioned themes and examine emerging trends in the use of artificial intelligence in healthcare[5,6,8].

In this way, the research aimed to analyze whether Artificial Intelligence can be an effective tool ou can support for the preoperative period of bariatric surgeries, helping both in decision-making to be carried out by the doctor and in predicting diseases that the patient is more likely to suffer from developing postoperatively.

METHODS

The research was conducted using the systematic review method. The guidelines followed were those of Moher and Shekelle[9], which served as the basis for the development of the work. According to the authors, it is highly significant to have initial definitions for the continuation of the methodology, considering that this step facilitates the search for data.

Defining the hypothesis

For the systematic review carried out, the following hypothesis was the starting point: The increased use of "Artificial Intelligence" as a means of decision-making aims to accelerate clinical decision-making, reducing errors (accuracy) and promoting rapid patient recovery.

Search System

The PubMed and Web of Science platforms were chosen to respond to the above hypothesis, and thus, retrieve information from scientific databases. Next, the keywords that suited the hypothesis of the systematic review of this research were placed, therefore resulting in search strings (four different searches were entered) for the effectiveness of the results: 1) ("Artificial Intelligence") AND ("Bariatric Surgery") AND ("Operator") AND ("Decision"); 2) ("Sleeve Gastrectomy) AND ("Artificial Intelligence"); 3) ("Artificial Intelligence") AND (Decision-making) AND (Bariatric Surgery"); and 4) ("Artificial Intelligence") AND ("Bariatric Surgery"). Variations of this term have been applied when retrieving scientific information and in other languages. Articles were searched for the period 2011 – 2023 (until November).

Inclusion and exclusion of articles

When using the defined search criteria and keywords, 15 articles were found in the databases used in the work. For the initial result, the inclusion and exclusion criteria were established[10]. If an article met any exclusion criteria, it was excluded, reducing the total number of studies to be analyzed in detail later, while articles that met all inclusion criteria were submitted to final analysis[11] (Table 1).

EC1 - To access the latest research findings with current data, it is advisable to review articles published in the last 12 years.

Table 1: Inclusion and Exclusion Criteria.

Exclusion Criteria	Inclusion Criteria
EC1 – Articles before 2011	IC1 – Primary Source Articles
EC2 – Articles that deal with postoperative bariatric surgeries	IC2 – Articles that deal Artificial Intelligence + Bariatric Surgery + Decision + Operator
EC3 – Duplicate studies in keywords	IC3 – Articles that deal with Sleeve Gastrectomy + Artificial Intelligence
----------	IC4 – Articles that deal Artificial Intelligence + Decision-making + Bariatric surgery
----------	IC5 – Articles that deal with Artificial Intelligence + Bariatric Surgery

Therefore, articles before 2011 were excluded, considering that the methodology is being carried out in 2023. EC2 - The objective of the work is to analyze the articles in the preoperative period; hence, the exclusion of articles that showed the advantages of the types of bariatric surgeries in the postoperative period. EC3 - Reducing the number of results provided to avoid analyzing identical articles. IC1 - It is important to analyze studies with primary sources because they provide direct information from the initial study to be carried out. IC2, IC3, IC4, and IC5 are the key elements of the hypothesis. Therefore, the analyzed studies must address these themes to ensure accurate and efficient results.

Following the IC1 and IC2 inclusion criteria, 25 articles (24 – PubMed and 1 – Web of Science) were found in the introductory search results. Moving on to the analysis of the titles of the articles, 13 were subjected to the best analysis (with the exclusion of 12 articles, as they were not in the preoperative context or the title referred to another medical area, not bariatric surgeries). Out of the texts that underwent full analysis, 12 were selected to form the final dataset for the systematic review. While one article was found on both platforms, it was excluded as it didn't meet the inclusion criteria (Figure 1A).

Following the IC1 and IC3 inclusion criteria, 46 articles (31 – PubMed and 15 – Web of Science) were found in the introductory search results. Moving on to the analysis of the titles of the articles, 9 were subjected to the best analysis (with the exclusion of 37 articles - many of them because they dealt with the postoperative period and others because they did not refer to bariatric surgery). Among these, 2 were present on both platforms, and 3 articles from PubMed and 3 from Web of Science are texts in common with the results of search string 1; therefore, excluded because they had already been analyzed previously. From these texts that underwent complete analysis, one article was selected to compose the final analysis of the systematic review (Figure 1B).

Following the IC1 and IC4 inclusion criteria, 10 articles (0 – PubMed and 10 – Web of Science) were found in the introductory search results. Among these, 4 were present on both platforms, and 4 texts were in common with the results of search strings 1 and 2; therefore, excluded because they had already been analyzed. Moving on to the analysis of the full text, 5 were excluded either by EC2 or because they did not portray the theme (not meeting the inclusion criteria). Thus, of the texts that underwent complete analysis, one article was selected (Figure 1C).

Following the IC1 and IC5 inclusion criteria, 240 articles (190 – PubMed and 50 –Web of Science) were found in the introductory search results. Moving on to the analysis of the titles of the articles analyzed by title, 32 were subjected to the best analysis (with the exclusion of 208 articles because they did not fit the inclusion criteria - they discussed other medical areas, or the topic was not contained in the keywords of the hypothesis). Among these, 9 were present on both platforms, and 14 articles from PubMed and 10 articles from Web of Science are in common with the results of search strings 1, 2, and 3; therefore, excluded because they had already been analyzed. Another 7 articles that weren't investigated in the previous strings were subjected to analysis of the full text, but all were discarded as they didn't meet the inclusion criteria, considering that they were not relevant to the hypothesis of the work. From the texts that underwent thorough analysis, one article was selected for inclusion in the final analysis of the systematic review (Figure 1D).

System or software, and data presentation

Mendeley was used as it enabled citation management, facilitating the organization and cataloging of research data.

Data analysis

A bibliometric network is a research method used to analyze, quantify, and evaluate the scientific output on specific topics[12]. Therefore, for data analysis, a bibliometric network was built, which analyzed the MeSH (PubMed) words most present in the articles used in the work using the VOSviewer software[12]. For this, the MeSH keyword co-occurrence criteria were used (database of standardized words for research within Medline. They are the official keywords that represent concepts from the medical literature). While in Web of Science, it's the author's keywords.

RESULTS

Initially, to carry out the review, the following hypothesis was taken into consideration: "The increased use of 'Artificial Intelligence' as a means of decision-making aims to accelerate clinical decision-making, reducing errors (accuracy) and promoting rapid recovery of the patient."

Of the 321 articles initially identified, 15 were selected for in-depth analysis. A comprehensive evaluation of their full texts was conducted, addressing the outlined objectives, theoretical foundations, adopted methodological approaches, obtained results, discussions presented, and conclusions drawn[11]. This process aimed to enhance the depth and rigor of the systematic literature review[10].

Most of the selected articles discussed the use of Machine Learning to assist in the preoperative period of bariatric surgeries, analyzing the general use of AI in this type of surgery and its contribution to the decision-making process, in addition to its use to predict the behavior of diseases that may arise in patients after bariatric surgery[13-27](Table 2).

Data analysis relied on constructing a bibliometric network, which provided deeper insights into the MeSH keywords featured in the articles included in the study. This analysis was carried out using the VOSviewer software[12]. The MeSH keyword co-occurrence criteria were noted, which were based on a standardized database widely recognized in medical research. By analyzing

the MeSH keywords, it was possible to identify the most relevant themes, like "Bariatric Surgery", "Humans", "Machine Learning", and Artificial Intelligence" (Figure 2).

However, on the Web of Science, they only take the words that are repeated the most, and some of them are not connected because this platform isn't part of the medical field. By analyzing

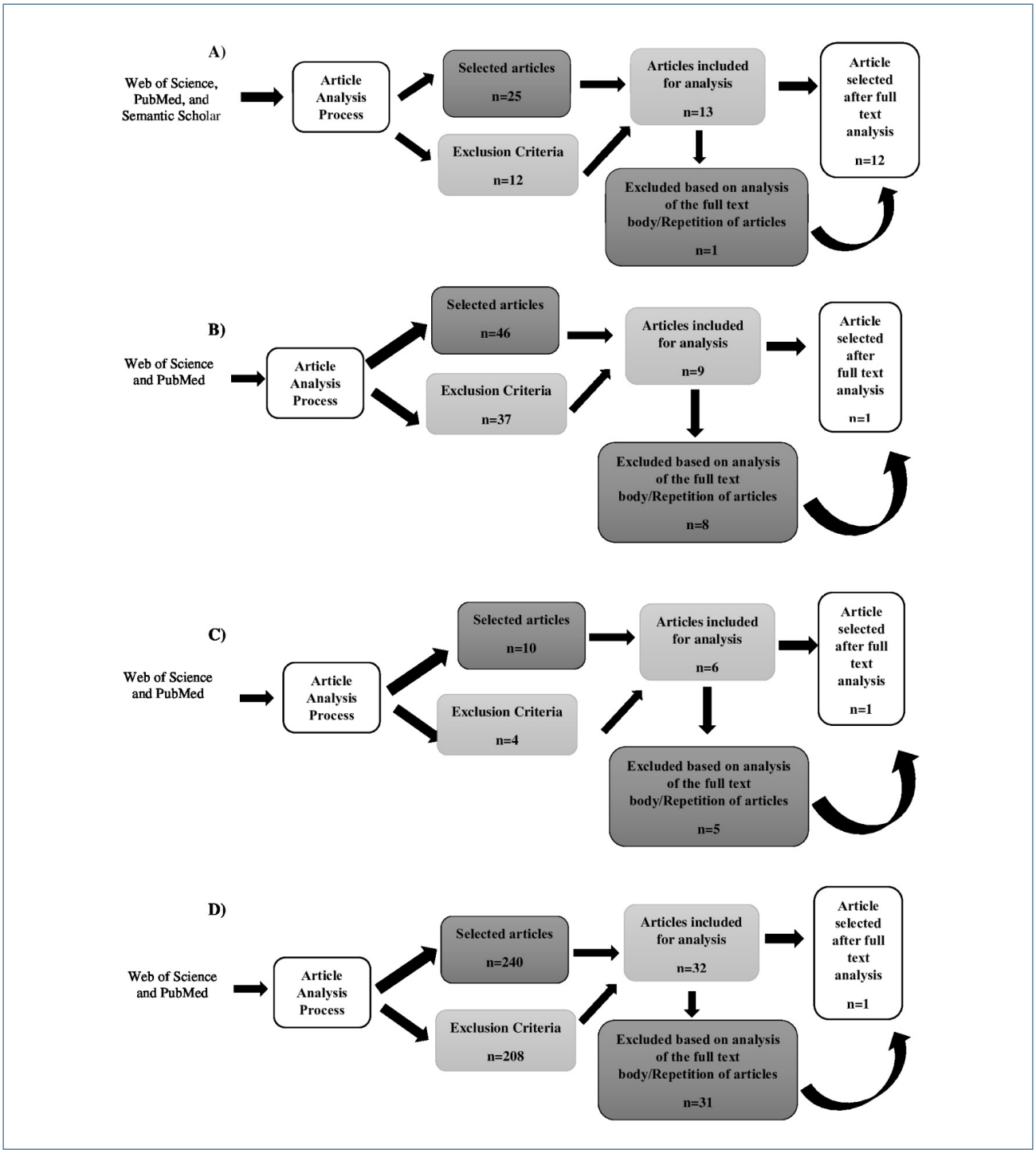

Figure 1: (A) Flowchart of the systematic review of the PubMed, Web of Science, and Semantic Scholar database with the keywords: ("Artificial Intelligence") AND ("Bariatric Surgery") AND ("Operator") AND ("Decision"). (B) Flowchart of the systematic review of the PubMed, Web of Science, and Semantic Scholar database with the keywords: ("Sleeve Gastrectomy) AND ("Artificial Intelligence"). (C) Flowchart of the systematic review of the PubMed, Web of Science, and Semantic Scholar database with the keywords: ("Artificial Intelligence") AND ("Decision-making") AND ("Bariatric Surgery"). (D) Flowchart of the systematic review of the PubMed, Web of Science, and Semantic Scholar database with the keywords: ("Artificial Intelligence") AND ("Bariatric Surgery")

Table 2: Articles found on the PubMed and Web of Science platforms (4 search strings).

Authors/year	Journal	Article	AI used
Miyahira et al. 2011[13]	J Translational Med	Fuzzy obesity index (MAFOI) for obesity evaluation and bariatric surgery indication	Fuzzy Method
Johnston et al. 2019[14]	Value in health	Using Machine Learning Applied to Real-World Healthcare Data for Predictive Analytics: An Applied Example in Bariatric Surgery	Machine Learning
Wise et al.2020[15]	Surgical endoscopy	Prediction of thirty-day morbidity and mortality after laparoscopic sleeve gastrectomy: data from an artificial neural network	Artificial Neural Networks
Cao et al. 2021[16]	JMIR Medical Informatics	Using a Convolutional Neural Network to Predict Remission of Diabetes After Gastric Bypass Surgery: Machine Learning Study from the Scandinavian Obesity Surgery Register	Machine Learning
Aminian et al. 2021[17]	Diabetes Care	Predicting 10-Year Risk of End-Organ Complications of Type 2 Diabetes with and Without Metabolic Surgery: A Machine Learning Approach	Machine Learning
Pantelis et al. 2021[18]	Obesity Surgery	A Scoping Review of Artificial Intelligence and Machine Learning in Bariatric and Metabolic Surgery: Current Status and Future Perspectives	Deep Learning
Emile et al. 2022[19]	Obesity Surgery	Development and Validation of an Artificial Intelligence-Based Model to Predict Gastroesophageal Reflux Disease After Sleeve Gastrectomy	Machine Learning
Bektaş et al. 2022[20]	Obesity Surgery	Artificial Intelligence in Bariatric Surgery: Current Status and Future Perspectives	Machine Learning
Pantelis 2022[21]	Metabolites	Metabolomics in Bariatric and Metabolic Surgery Research and the Potential of Deep Learning in Bridging the Gap	Deep Learning
Liu et al. 2022[22]	Frontiers in Endocrinology	A multi-center study on glucometabolic response to bariatric surgery for different subtypes of obesity	Machine Learning
Bellini et al. 2022[23]	Obesity Surgery	Current Applications of Artificial Intelligence in Bariatric Surgery	Machine Learning
Pereira et al. 2023[24]	Rev Endocr Metabol Disord	Towards precision medicine in bariatric surgery prescription	Machine Learning
Pan et al. 2023[25]	Nutrients	Machine Learning Prediction of Iron Deficiency Anemia in Chinese Premenopausal Women 12 Months after Sleeve Gastrectomy	Machine Learning
Hsu et al. 2023[26]	Surgical Endoscopy	Application of machine learning to predict postoperative gastrointestinal bleed in bariatric surgery	Machine Learning
Saux et al 2023[27]	The Lancet Digital Health	Development and validation of an interpretable machine learning-based calculator for predicting 5-year weight trajectories after bariatric surgery: a multinational retrospective cohort SOPHIA study	Machine Learning

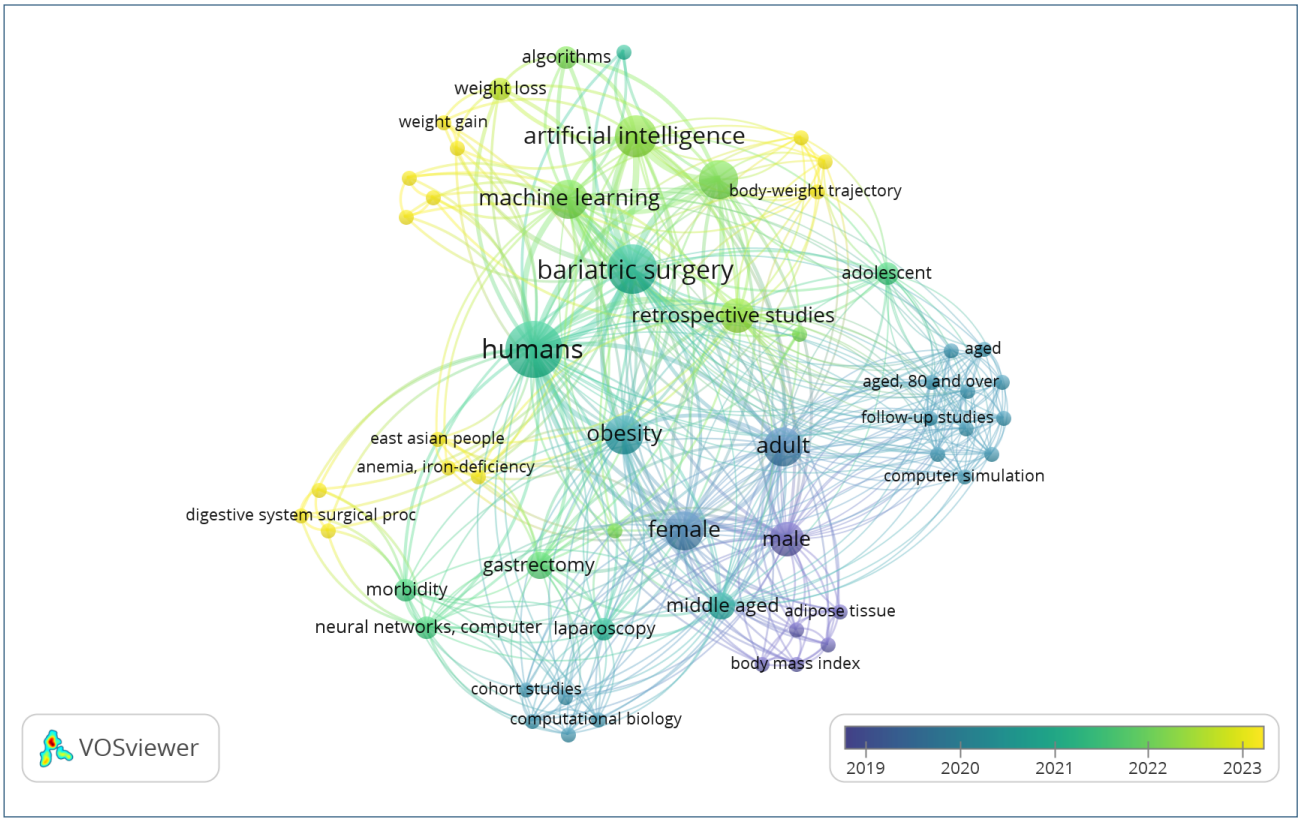

Figure 2: Presentation of the most cited terms with the date on which these terms appeared (PubMed).

keywords, it was possible to identify the most relevant themes, like "Bariatric Surgery" and Artificial Intelligence" (Figure 3).

Regarding the most cited terms in the figures, it is observed that the pattern repeats itself. Each year, new words emerge in the constructed articles; in 2019, the keywords were more general, focusing on the human body and obesity. Over time, especially in 2022, there was an increase in "artificial intelligence," "machine learning," and "body-weight trajectory," which highlighted the rise in research on the use of Artificial Intelligence, a fact attributed to technological advancements during this period. In 2023, it was observed that the language used in studies has become increasingly tailored to specific populations. This trend reflects the growing focus on conducting targeted research with well-defined analysis groups, aiming to minimize AI-related errors. Such an approach enhances the effectiveness and precision of AI applications by improving risk assessment and predicting patient recovery outcomes.

Furthermore, the visualization of these networks could help to elucidate interdisciplinary connections and evaluate the impact of different approaches and techniques within the academic artificial intelligence community. In this way, bibliometric networks offered a solid basis for informed discussions and targeted research strategies in the field of AI, represented fundamental concepts in the medical literature, and their analysis provided valuable insights into trends and interconnections within the field studied (Figure 2 and Figure 3).

DISCUSSION

The use of artificial intelligence (AI) in medical decision-making is increasingly relevant for evaluating its impact on accuracy and patient recovery speed. The initial hypothesis suggests that AI can accelerate decision-making by providing data and comparisons, reducing errors, and potentially leading to more effective recovery with treatment tailored to the patient's condition. However, the nuances of this claim require further examination[28-32].

The analysis of the presented studies clearly shows that AI has played a crucial role in enhancing the accuracy of medical decisions, particularly in bariatric surgery. It offers a complete analysis of patient data, considering a wide range of variables, from physical characteristics to circulating biomarkers and socioeconomic factors, which allows the doctor to analyze and indicate, even though auxiliary AI in possible future complications, what the best surgical method to be performed for the patient to have the best possible recovery[18,24,32,33].

Artificial Intelligence in decision-making

Pereira et al.[24] present a critical assessment of factors that can be considered when recommending and deciding which bariatric procedure will be used. Considering that only the factors BMI, age, and type II diabetes are not enough to determine which technique will be successful, it is also necessary to observe sex, anthropometry, obesity comorbidities, eating behavior, genetic background, circulating biomarkers (microRNAs, metabolites and hormones),

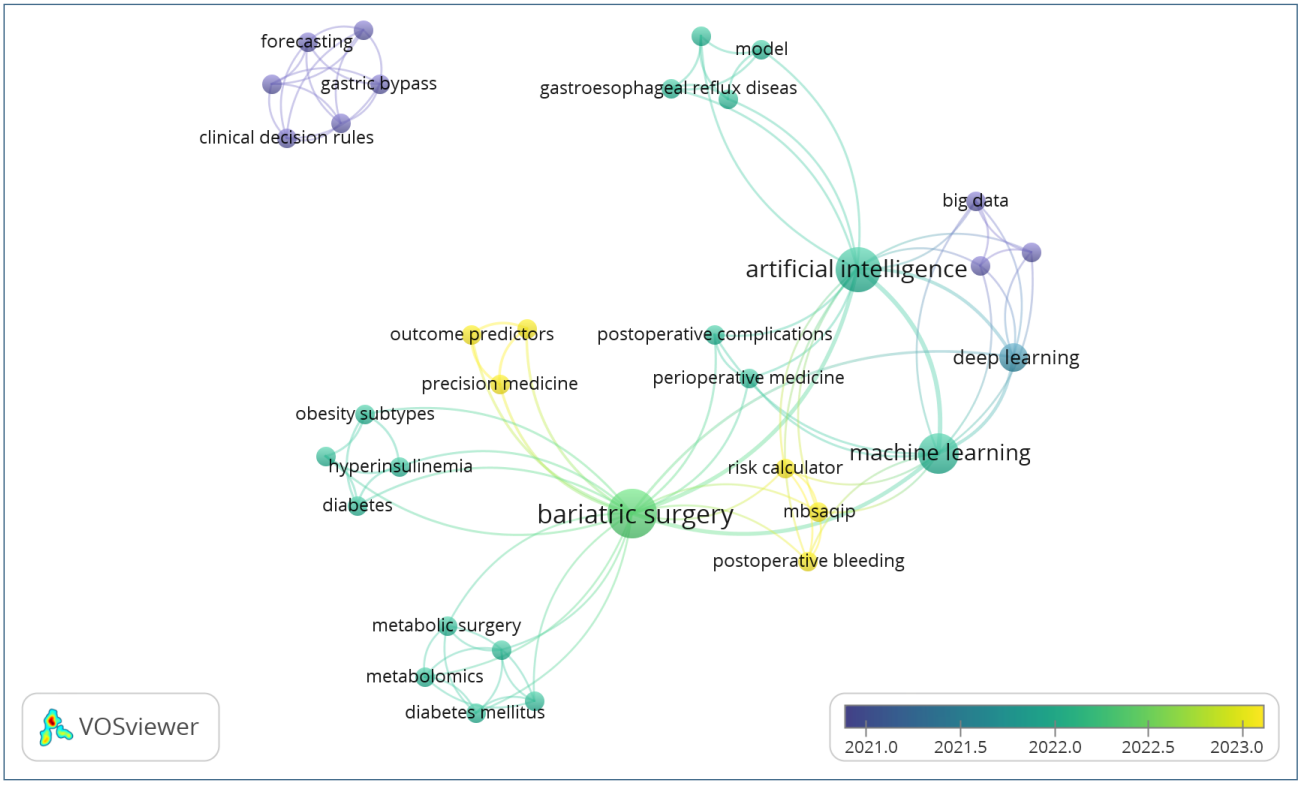

Figure 3: Presentation with the author's keywords (since there is no mesh option – Web of Science).

psychological and socioeconomic factors to obtain a better result and this can be accomplished by AI, which can group information, make comparisons and send data analysis to the doctor, which allows for better identification needs links to the causes of weight gain and loss, making a complete analysis of the patient.

The literature review conducted by Bellini et al.[23] addresses the current applications of AI in bariatric surgery. These claim that the success of AI in preoperative procedures is machine learning in the categories of supervised, unsupervised, and reinforcement learning. There must be a careful pre-surgical analysis to assess the risks and individual prognosis, and, in this context, artificial intelligence can be applied, especially to patients who suffer comorbidities related to obesity.

In the article proposed by Pantelis Stravodimos and Lapatsanis[18], there is a finding that the most widespread use of AI in decision-making in metabolic bariatric surgery is Deep Learning, which facilitates data sharing among clinicians. The algorithms typically used must comprise three data sets (training, validation, and testing) and at least one benchmarking method.

The study by Bektas et al.[20] addressed the application of Machine Learning in bariatric surgery, finding that most algorithms predicted postoperative complications and weight loss with an accuracy of up to 98%. The AI was able to anticipate the percentage of excess BMI loss within 180 and 360 days after surgery.

In research carried out by Saux et al.[27], a model was developed using machine learning to predict weight loss trajectories after 5 years of bariatric surgery, considering that this result is quite variable between patients, and its prediction helps in the treatment that must be carried out. The outcome of the primary study was successful, where to develop the model, patients' basic information was pre-processed, using machine learning algorithms called decision trees to create subgroups that shared similar information and could be analyzed with greater precision.

The metabolic effects of each individual are essential in determining how the body functions when losing or gaining weight. With this aspect in mind, Pantelis[21] carried out research to demonstrate the role that artificial intelligence can play in revealing the influence of metabolic effects on the body and, in this way, helping doctors in the decision-making process for patients on an individual basis. Metabolomics datasets are quite broad and different from person to person.

A study was carried out by Liu et al.[22] on the neurometabolic response to bariatric surgery for different subtypes of obesity. It evaluates the benefits of bariatric surgery in improving glycometabolism and achieving remission of diabetes and hyperinsulinemia, based on the analysis of four types of obesity provided by artificial intelligence. AI-based subtypes are effective and can help doctors make better decisions and advise patients more safely.

In a study carried out by Miyahira et al.[13], a description of the Miyahira-Araújo Fuzzy Obesity Index (MAFOI) is presented, which uses artificial intelligence to more accurately assess obesity, considering that the Body Mass Index (BMI) is not sufficient to identify the best bariatric surgery procedure that should be performed. The input variables of this algorithm are BMI and body fat percentage, and for the output variable, an obesity classification with new types is used within the Fuzzy context (an area of artificial intelligence that uses qualitative concepts to classify data for decision-making). In the end, MAFOI proved to be effective in evaluating obesity and assisting surgeons in selecting appropriate bariatric procedures, providing results that are more aligned with each patient's individual BMI analysis.

A significant study carried out by Wise et al.[15] in the field of bariatric surgery stands out for the use of artificial neural networks in optimizing the prediction of readmissions, reoperation, re-intervention, or mortality within 30 days after laparoscopic sleeve gastrectomy. In the end, the risk factors considered for increased morbidity were advanced age, non-white race, higher Body Mass Index (BMI), severe hypertension, diabetes mellitus, non-independent functional status, and previous bariatric surgery. The model was effective, indicating which patients are most likely to have postoperative complications, representing an advance for the surgical area.

Furthermore, AI can help doctors personalize treatment for each patient, taking into account their characteristics and potential risks. For example, predictive models developed with AI can estimate the risk of specific postoperative complications for each patient, allowing more informed decision-making about the most appropriate procedure to be performed, which brings benefits in post-surgical recovery[18,24,33-36].

Artificial Intelligence to predict diseases after bariatric surgery

One application of Artificial Intelligence (AI) in medicine is the prediction and assessment of potential pre- and postoperative complications, as certain profiles are more susceptible to developing diseases. These models are created to perform data combinations and are essential in helping medical professionals make decisions, providing a better understanding of risks, and allowing proactive interventions to ensure a quick patient recovery, which may reduce the risk of complications and ensure greater medical precision[37,38].

One way to assist in the way in which the surgical procedure should be performed is by predicting possible diseases that may occur preoperatively through combinations of data, in which certain profiles are more likely to develop diseases, and to use methods that promote rapid recovery of the patient[39].

In this context, the article published by Bellini et al.[23] shows that AI can evaluate several comorbidities related to obesity. One such application is airway analysis, aimed at identifying potential challenges in managing difficult airways in obese individuals. AI models are used to predict difficult intubation through algorithms.

The possibility of developing Obstructive Sleep Apnea, whose main risk factor is obesity, can also be assessed by algorithms, where different Machine Learning methods can be useful to identify a priority level to assign patients to the test polysomnography.

The study by Cao et al.[16] focused on predicting the remission of type II diabetes after bariatric surgery. This condition is marked by high blood glucose levels, often due to insulin resistance or reduced insulin production, impairing glucose absorption by cells. Johnston et al.[14] also explored type II diabetes remission by developing an algorithm that utilized demographic data, patient conditions, medications, measurements, and procedures for those undergoing laparoscopic metabolic bariatric surgery.

An AI-based model was developed to predict the onset of gastroesophageal reflux disease after sleeve gastrectomy, which helps in the decision and selection of the bariatric procedure[19]. Age, weight, gastroesophageal reflux disease after sleeve gastrectomy, size of the orogastric tube used, and distance of the first shot of the stapler from the pylorus (where food passes from the stomach to the duodenum) were the main predictors[18].

Machine learning to create a model that predicts postoperative gastrointestinal bleeding, a rare but serious complication, to assist the surgeon in decision-making and improve patient counseling about postoperative bleeding was used by Hsu et al.[26]. The main predictors were the type of bariatric surgery, preoperative hematocrit, age, duration of the procedure, and preoperative creatinine[26].

A study published by Pan et al.[25] aimed to establish a machine-learning model to assess the risk of new-onset iron deficiency anemia in premenopausal women 12 months after sleeve gastrectomy. The model developed was effective in accurately predicting the disease in women, which confirms that AI can be a great medical ally in carrying out bariatric surgeries, as it predicts future complications.

The authors[18,40] developed a prediction model to assess the risk of complications in target organs among patients with type II diabetes mellitus and obesity, particularly those considering metabolic surgery. The algorithm can provide data on possible organs that may be affected after bariatric surgery.

The systematic review revealed a growing integration of artificial intelligence (AI) in bariatric surgeries, particularly during the preoperative phase. This advancement underscores the need for further investigation, especially regarding the incorporation of AI techniques into medical education. Integrating AI into medical curricula enhances academic training, facilitates personalized learning experiences for students, and supports educators in adapting to emerging technologies. Nevertheless, the potential applications and implications of AI in healthcare training warrant deeper analysis to comprehensively assess its impact on the development of future medical professionals[33,40].

Researchers Winkler-Schwartz et al. [40] analyzed the application of AI in medical training, particularly in surgical areas, which aligns with the focus of this systematic review. They emphasize the importance of incorporating AI into the curriculum and identifying professionals needed to develop and implement these technologies. This highlights the broad perspective on AI's integration into medicine and the need for healthcare professionals to be trained to navigate these changes.

Conclusion

The analysis showed that Artificial Intelligence (AI) is an effective tool for decision-making in the preoperative period of bariatric surgeries and in predicting postoperative complications like obstructive sleep apnea and gastroesophageal reflux. The integration of artificial intelligence (AI) significantly improved surgical precision and patient recovery outcomes, providing robust validation for the initial hypothesis. Additionally, AI demonstrated its utility in predicting weight loss and type II diabetes remission, providing valuable support in selecting the most appropriate surgical techniques. The bibliometric analysis highlighted interdisciplinary connections and trends in AI's medical applications, laying a strong foundation for future research and discussions.

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