

Artificial Intelligence: Advances in the Fight Against Lung Cancer

Inteligência Artificial: Avanços no Combate Ao Câncer de Pulmão

Inteligencia Artificial: Avances en la Lucha Contra el Cáncer de Pulmón

RESUMO

Este trabalho teve como objetivo identificar os avanços da inteligência artificial (IA) no combate ao câncer de pulmão, por meio de uma revisão terciária da literatura. Utilizou-se a metodologia de Felizardo et al.(14), composta pelas fases de planejamento, condução e publicação dos resultados. Entre setembro e novembro de 2024, foram analisados 22 estudos extraídos das bases PubMed e Web of Science. Os resultados indicam que a IA tem potencial para melhorar o diagnóstico, otimizar recursos e acelerar o início dos tratamentos. No entanto, ainda enfrenta desafios como a limitação na diversidade e qualidade dos dados utilizados para treinamento, além de questões éticas envolvendo privacidade e transparência. Conclui-se que, apesar das limitações, a IA representa um avanço significativo no enfrentamento do câncer de pulmão, sendo recomendada a realização de novas revisões sobre sua aplicação em outros tipos de câncer.

DESCRIPTORIOS: Inteligência Artificial; Câncer de Pulmão; Revisão Terciária; Diagnóstico Médico; Tecnologias em Saúde.

ABSTRACT

This study aimed to identify advances in artificial intelligence (AI) in the fight against lung cancer through a tertiary literature review. The methodology followed the approach proposed by Felizardo et al.(14), consisting of the stages of planning, execution, and publication of results. Between September and November 2024, 22 studies were analyzed from the PubMed and Web of Science databases. The results indicate that AI has the potential to improve diagnosis, optimize resources, and accelerate the start of treatments. However, it still faces challenges such as limited diversity and quality of training data, as well as ethical issues involving privacy and transparency. It is concluded that, despite these limitations, AI represents significant progress in addressing lung cancer, and further reviews on its application in other types of cancer are recommended.

DESCRIPTORS: Artificial Intelligence; Lung Cancer; Tertiary Review; Medical Diagnosis; Health Technologies.

RESUMEN

Este estudio tuvo como objetivo identificar los avances de la inteligencia artificial (IA) en la lucha contra el cáncer de pulmón, mediante una revisión terciaria de la literatura. Se utilizó la metodología propuesta por Felizardo et al.(14), compuesta por las etapas de planificación, ejecución y publicación de resultados. Entre septiembre y noviembre de 2024 se analizaron 22 estudios extraídos de las bases de datos PubMed y Web of Science. Los resultados indican que la IA tiene potencial para mejorar el diagnóstico, optimizar recursos y agilizar el inicio de los tratamientos. Sin embargo, aún enfrenta desafíos como la limitada diversidad y calidad de los datos utilizados para el entrenamiento, además de cuestiones éticas relacionadas con la privacidad y la transparencia. Se concluye que, a pesar de estas limitaciones, la IA representa un avance significativo en el abordaje del cáncer de pulmón, recomendándose nuevas revisiones sobre su aplicación en otros tipos de cáncer.

DESCRIPTORIOS: Inteligencia Artificial; Câncer de Pulmón; Revisión Terciaria; Diagnóstico Médico; Tecnologías en Salud.

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Literature Review

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INTRODUCTION

Artificial intelligence (AI) is a field of computer science that develops systems capable of simulating and expanding human intelligence⁽¹⁾. One of its subareas is machine learning, which uses statistical methods to analyze data and predict patterns. Among the types of learning, deep learning stands out, based on neural networks that simulate the functioning of the brain, allowing complex predictions. These techniques enable the analysis of large volumes of data and are applicable in areas such as health, education, and transportation.

In the context of healthcare, AI has been applied especially in the fight against cancer, with a focus on diagnostic imaging, analysis of medical records, and genetic information. Its use allows for the detection of patterns and anomalies that may not be noticed by human professionals⁽²⁾. Cancer is one of the leading causes of death worldwide and represents a major challenge to public health⁽³⁾. The National Cancer Institute (INCA) defines cancer as a group of more than 100 diseases characterized by disordered cell growth, whose treatment may include surgery, chemotherapy, radiotherapy, and bone marrow transplantation, often in combination⁽⁴⁾. Technological advances have allowed cancer surgeries to become less invasive, especially in cases with early diagnosis⁽⁵⁾.

Several factors contribute to the development of cancer, such as poor diet,

physical inactivity, smoking, alcohol consumption, genetic predisposition, and exposure to carcinogens⁽⁶⁾. Data from the Global Cancer Observatory (GCO) indicate that, in 2022, there were 19.9 million new cases and approximately 10 million deaths from cancer worldwide⁽⁷⁾. In Brazil, approximately 627,100 new cases and 278,800 deaths were recorded. Lung cancer is the most common and lethal type of cancer globally, with around 2.5 million new cases and 1.8 million deaths, being the most common among men and the second most common among women⁽⁷⁾. In Brazil, it is among the five most frequent types of cancer, with approximately 44,200 new cases and 38,200 deaths⁽⁷⁾.

Lung cancer is difficult to detect early, as it is usually asymptomatic in its early stages, which reduces the chances of treatment and worsens the prognosis⁽²⁾. It is classified into two subtypes: non-small cell lung cancer (NSCLC) and small cell lung cancer (SCLC). NSCLC is the most common and is subdivided into squamous cell carcinoma, adenocarcinoma, and large cell carcinoma, with the first two being the most frequent.

The main risk factor for lung cancer is smoking, but exposure to pollution, recurrent lung infections, vitamin A deficiency, COPD, heredity, and advanced age are also relevant. Tobacco control is identified as an effective prevention strategy. The World Health Organization (WHO) proposes the MPOWER package, which brings together six policy measures: monitor to-

bacco use, protect the population from smoke, offer help to quit smoking, warn about the risks, ban advertising, and increase taxes⁽¹¹⁾.

Low-dose computed tomography (LDCT) is used for lung cancer screening, allowing lung nodules to be identified and their morphology assessed. This technique is promising for early detection and can significantly reduce mortality⁽¹²⁻¹³⁾. However, it still has limitations, reinforcing the importance of technological innovations.

During an exploratory study conducted between September and November 2024, several systematic reviews on AI and lung cancer were found, but no tertiary review that synthesized this knowledge in a comprehensive and structured manner. Thus, there was a need to organize this evidence to identify advances, gaps, and challenges, culminating in the following central question: how have artificial intelligence applications been used in the fight against lung cancer?

METHOD

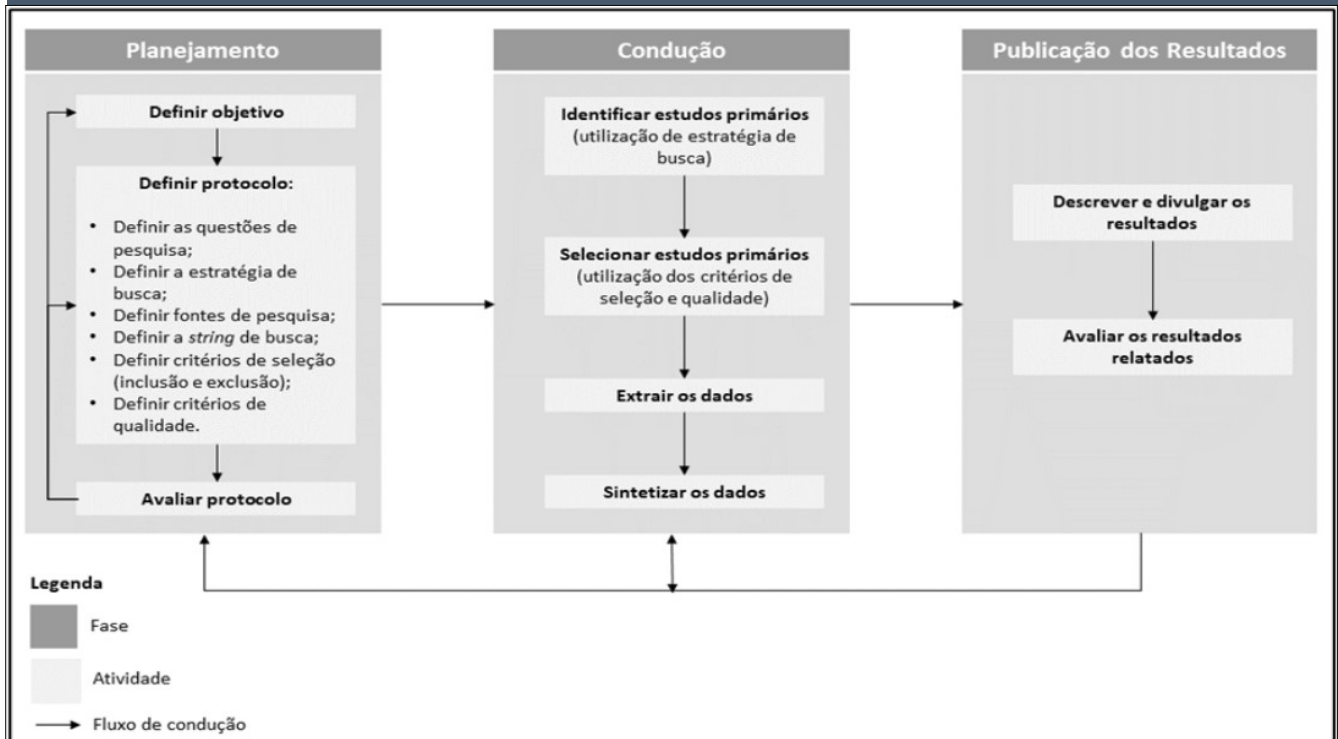
A systematic review is a secondary study conducted in defined stages. This investigation adopts the recommendations of Felizardo et al.⁽¹⁴⁾, based on consolidated studies on literature reviews. The model follows the Evidence-Based Software Engineering (EBSE) framework, derived from guidelines widely used in the medical field. Before the planning phase, it is essential to verify the existence of secondary studies on

the topic. To this end, techniques inspired by Kitchenham et al.⁽¹⁵⁾, Imtiaz et al.⁽¹⁶⁾, and Verner et al.⁽¹⁷⁾, cited as

good examples of tertiary reviews, were applied. Thus, this tertiary review follows a systematic process divided into

three phases, as shown in Figure 1, and has as its corpus a set of systematic reviews.

Figure 1 - Phases and activities of the Systematic Review process



Source: Felizardo, Nakagawa, Fabbri, and Ferrari (2017).

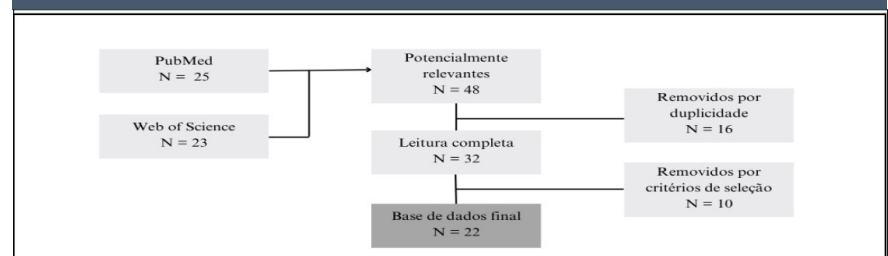
The planning phase of this tertiary review focused on developing a structured protocol to systematically guide the stages of data search, selection, extraction, and analysis, ensuring consistency and criticality in the study. The objective is to synthesize and evaluate evidence available in systematic reviews on the use of artificial intelligence (AI) in the fight against lung cancer, based on five research questions that address applications, limitations, ethical challenges, and future recommendations. The PubMed and Web of Science databases were selected, accessed via the CAPES Portal, as they performed best in search tests with the string ("artificial intelligence" AND "lung cancer" AND "systematic review"). The selection of studies involved reading titles, abstracts,

and full texts, with inclusion criteria such as English language, open access, recent publications, and a focus on AI applied to lung cancer; and exclusion criteria such as duplication, superficial focus, or application to other diseases. The extracted data were organized in a spreadsheet containing bibliographic information (title, authors, year, country, DOI, etc.) and study data (abstract,

objective, methodology, results, type of AI, cancer subtype, metrics, limitations, suggestions, and relevant references).

The conduct phase resulted from the application of the protocol defined in the planning, and from this, it was possible to obtain 22 studies for the research corpus, as shown in Figure 2.

Figure 2 - Identification of studies included in the research corpus



Source: Research data; 2024

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Potentially relevant articles were selected using free access filters and a time frame of up to two years of publication, considering the availability of full text in the databases consulted - "free full text" in PubMed and "fully open access" in Web of Science. The definition of the time frame follows the recommendation of Felizardo et

al.⁽¹⁴⁾, according to which, although there is no definitive scientific evidence on the ideal frequency for updating systematic reviews, in the field of medicine it is considered appropriate to revisit this type of study every two years.

RESULTS

The results were obtained from data extracted from the spreadsheet, separating these data by columns to help answer each of the research questions. The studies included in the research corpus are presented in Table 1.

Table 1 – List of studies included in the research corpus

ID	Author & year	Title
E1	KANAN, Mohammed <i>et al.</i> , 2024	AI-Driven Models for Diagnosing and Predicting Outcomes in Lung Cancer: A Systematic Review and Meta-Analysis
E2	POKHRIYAL, Sindhu C. <i>et al.</i> , 2024	Application of Artificial Intelligence in Neuroendocrine Lung Cancer Diagnosis and Treatment: A Systematic Review
E3	DIDIER, Alexander J. <i>et al.</i> , 2024	Application of Machine Learning for Lung Cancer Survival Prognostication: A Systematic Review and Meta-Analysis
E4	SINHA, Tanya <i>et al.</i> , 2024	Artificial Intelligence and Machine Learning in Predicting the Response to Immunotherapy in Non-small Cell Lung Carcinoma: A Systematic Review
E5	COLQUITT, Jill <i>et al.</i> , 2024	Artificial intelligence software for analysing chest X-ray images to identify suspected lung cancer: an evidence synthesis early value assessment
E6	JOO, Min Soo <i>et al.</i> , 2023	Artificial Intelligence-Based Non-Small Cell Lung Cancer Transcriptome RNA-Sequence Analysis Technology Selection Guide
E7	LUO, Xinmin <i>et al.</i> , 2024	CT-based radiomics for predicting Ki-67 expression in lung cancer: a systematic review and meta-analysis
E8	DAVRI, Athena <i>et al.</i> , 2023	Deep Learning for Lung Cancer Diagnosis, Prognosis and Prediction Using Histological and Cytological Images: A Systematic Review
E9	GAO, Chuan <i>et al.</i> , 2024	Deep learning in pulmonary nodule detection and segmentation: a systematic review
E10	WULANINGSIH, Wahyu <i>et al.</i> , 2024	Deep Learning Models for Predicting Malignancy Risk in CT-Detected Pulmonary Nodules: A Systematic Review and Meta-analysis
E11	PACURARI, Alina Cornelia <i>et al.</i> , 2023	Diagnostic Accuracy of Machine Learning AI Architectures in Detection and Classification of Lung Cancer: A Systematic Review
E12	SHAHIDI, Ramin <i>et al.</i> , 2024	Diagnostic Performance of Radiomics in Prediction of Ki-67 Index Status in Non-small Cell Lung Cancer: A Systematic Review and Meta-Analysis
E13	THONG, Lay Teng <i>et al.</i> , 2023	Diagnostic test accuracy of artificial intelligence-based imaging for lung cancer screening: A systematic review and meta-analysis
E14	GEBREMESKEL, Teferi Gebru <i>et al.</i> , 2024	Facilitators and Barriers to Lung Cancer Screening during Long COVID: A Global Systematic Review and Meta-Study Synthesis of Qualitative Research
E15	QUIRK, Joseph <i>et al.</i> , 2024	Future Implications of Artificial Intelligence in Lung Cancer Screening: A Systematic Review
E16	EVANGELISTA, Laura <i>et al.</i> , 2023	PET Radiomics and Response to Immunotherapy in Lung Cancer: A Systematic Review of the Literature
E17	ALTUHAIFA, Fatimah Abdulazim <i>et al.</i> , 2023	Predicting lung cancer survival based on clinical data using machine learning: A review
E18	CHEN, Zhi <i>et al.</i> , 2024	Predicting Radiation Pneumonitis in Lung Cancer Using Machine Learning and Multimodal Features: A Systematic Review and Meta-Analysis of Diagnostic Accuracy
E19	GEPPERT, Julia <i>et al.</i> , 2024	Software Using Artificial Intelligence for Nodule and Cancer Detection in CT Lung Cancer Screening: Systematic Review of Test Accuracy Studies
E20	LIU, Mingsi <i>et al.</i> , 2023	The Value of Artificial Intelligence in the Diagnosis of Lung Cancer: A Systematic Review and Meta-Analysis
E21	YUAN, Lei <i>et al.</i> , 2024	Unveiling the Landscape of Pathomics in Personalized Immunotherapy for Lung Cancer: A Bibliometric Analysis
E22	CHEN, Lujiao <i>et al.</i> , 2024	Using Artificial Intelligence Based Imaging to Predict Lymph Node Metastasis in Non-Small Cell Lung Cancer: A Systematic Review and Meta-Analysis

Source: Own elaboration.

Based on the data collected, it is possible to answer the research questions defined above, starting with the first research question.

QP1: How has artificial intelligence been used to combat lung cancer? Artificial intelligence (AI) has been applied mainly on three fronts: diagnosis, prognosis, and treatment personalization. Thirteen studies (E1, E2, E5, E8, E9, E10, E11, E13, E14, E15, E19, E20, E22) focus on the use of AI in diagnosis, especially for early detection and classification of lung nodules. Deep learning models have demonstrated high accuracy, comparable to specialists (E1, E2, E5). AI has also been used to support clinical decisions and integrate multiple data sources, optimizing the screening and analysis of medical images (E11, E14, E20, E22). Five studies (E3, E7, E12, E17, E18) explore the use of AI in prognosis, focusing on the prediction of survival, biomarkers, and complications, such as radiation pneumonitis. Techniques such as radiomics and machine learning models have proven effective in anticipating the clinical evolution of patients. Four studies (E4, E6, E16, E21) address treatment personalization, with an emphasis on predicting response to immunotherapy in cases of non-small cell lung cancer (NSCLC). AI has contributed to identifying biomarkers, analyzing transcriptomic data and digital images, promoting more effective and individualized therapies.

QP2: What are the main applications of artificial intelligence described in the research?

The application of artificial intelligence in the reviewed studies highlights the use of convolutional neural networks (CNNs), support vector machines (SVMs), Random Forest (RF), XGBoost, and LASSO Regression. In diagnosis, E1 addresses CNNs for the detection and segmentation of lung nodules with high accuracy

(sensitivity/specificity > 0.85), while E2 applies CNNs to the classification of neuroendocrine neoplasms. E4 explores SVMs and RF in chest radiographs, increasing diagnostic sensitivity. E8 and E9 review models such as U-Net, which achieve Dice coefficients greater than 0.90. In multiomic analysis, E6 highlights deep neural networks for RNA-seq, accelerating the identification of biomarkers, and E7 uses radiomic techniques combined with LASSO Regression to predict the Ki-67 index. E21 deals with pathomics with CNNs in digital images to predict immunotherapeutic response. In therapeutic prediction, E3 and E16 highlight models such as XGBoost and RF to predict response to immunotherapy in NSCLC, and E18 integrates CNNs, SVMs, and Gradient Boosted Trees in predicting complications such as radiation pneumonitis. These studies show the relevance of AI in precision oncology, especially in lung cancer.

QP3: What were the main limitations and gaps identified in these studies? Studies applying AI to combat lung cancer face limitations such as heterogeneity between studies (patients, data, and methods), hindering comparisons and clinical application, as pointed out by E3 and E11. The low diversity of public databases and the geographic concentration of samples (such as in China) were criticized in E2, E7, E13, and E22, compromising the generalization of results. Most studies are retrospective, with limited validation (E12, E15, E22), which may inflate the performance of the models. There is a lack of methodological standardization and comparisons between traditional and modern approaches, as noted in E6, E9, and E16. The opacity of deep learning models (“black box”) reduces the confidence of physicians and patients, as discussed in E8 and E20. There are also technical, economic, and organizational barriers

(E8, E14, E15), as well as specific challenges such as the detection of complex lesions (E10, E11), a shortage of longitudinal data for prognosis (E3, E18), and the need for data integration in personalized treatment (E4, E16). These obstacles compromise the clinical applicability of AI and require coordinated actions to overcome them.

QP4: What are the main challenges related to ethical issues identified in these studies? One of the main ethical challenges in the use of AI for lung cancer involves the protection of sensitive data, highlighted by E5, E13, and E19, which warn of the risks of leaks and unauthorized use in public databases, compromising trust. Bias in data sets and the geographic concentration of studies, especially in China, were pointed out by E7, E19, and E22 as limiting generalizability and causing inequalities in diagnosis and treatment. The absence of clear processes for informed consent was highlighted in E13 and E22, affecting transparency and ethics. Questions about legal liability for model errors, addressed by E1 and E13, raise uncertainties about who is responsible for harm to patients. Technological and economic barriers to training and implementing complex models, highlighted in E8 and E15, hinder access in low-income regions. Thus, overcoming challenges such as privacy, bias, explainability, consent, responsibility, and accessibility requires clear regulations, ethical practices, and more inclusive technologies to ensure fair distribution of the benefits of AI.

QP5: What are the recommendations for future research? The studies analyzed recommend improving the reliability of AI models and standardizing standards, as suggested in E1, E3, and E22, through collaboration between researchers, clinicians, and policymakers. The integration of clinical, genetic, transcriptomic, and

lated to privacy, transparency, and algorithmic bias. These aspects limit the generalization of models and may impact their large-scale adoption.

CONCLUSION

This study analyzed 22 systematic reviews selected from the PubMed and Web of Science databases on the use of artificial intelligence (AI) in lung cancer. Based on the results obtained in each of the research questions, its role

in diagnosis, prognosis, and personalized treatment can be highlighted. Results indicate that algorithms such as convolutional neural networks, deep learning, and machine learning have contributed to early detection, survival prediction, and response to immunotherapies. However, challenges such as lack of standardization, limited validations, data bias, and ethical issues such as privacy and transparency limit their practical application.

The main limitation of this research

was the fact that the researcher is undergoing cancer treatment, which made it impossible for him to participate at certain times during the development of this work. In addition, another limiting factor was the database search, as the initial idea was to address all types of cancer, but due to the large number of studies, it was decided to analyze only studies related to lung cancer. As a suggestion for future studies, more tertiary literature reviews on other types of cancer should be conducted.

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