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# Leveraging Artificial Intelligence (AI) Methods for Non-Small Cell Lung Cancer (NSCLC) Detection: A Review

**Faisal Asadi[1*], Ashraf Alif Adillah[2], Jonathan Lucas Fontana[3], Michael Dimas Chrispradipta[4], Mousa Khalil Mousa Ayesh[5], Wairanatha Halim[6]**

[1]Electrical Engineering Study Program, Faculty of Science and Technology,
Jambi University,
Jambi 36361, Indonesia
faisalasadi@unja.ac.id

[2-6] Computer Science Department, School of Computer Science,
Bina Nusantara University,
Jakarta 11480, Indonesia
ashraf.adillah@binus.ac.id; jonathan.fontana@binus.ac.id; michael.chrispradipta@binus.ac.id; mousa.ayesh@binus.ac.id; wairanatha.halim@binus.ac.id

*Correspondence: faisalasadi@unja.ac.id



***Abstracts -*** *One of the main causes of cancer-death that significant to global public health concern is lung cancer. NSCLC has been categorized as a burden disease, with an estimated reaching 85% of all lung cancer cases around the world. The problem was that NSCLC disease could only be detected when the disease has grown at a late stage. Therefore, AI technology is also being implemented to handle NSCLC disease. This review discusses how AI has played a role in treating NSCLC disease in the last five years of research journals that collected 5 years between 2019-2024. The database resources are from PubMed, Scopus, and Google Scholar. The process of selecting journal papers was analyzed based on an in-depth understanding of NSCLC disease journals as considered an inclusion criterion. This review used the PRISMA to analysis and review 17 journals. After carrying out the analysis process on the AI-NSCLC journals, we found that AI has been able to help humans respond to cases of NSCLC patients, starting from the detection stage, comprehensive diagnosis, and providing treatment recommendations. Treatments of NSCLC tend to be more personalized and could run more effectively and efficiently based on medical images input into the AI model. However, considering the urgency and vulnerability of the application of these AI models, which will be directly related to human health, the medical images dataset is also quite limited and the biggest challenge for AI-NSCLC.*

***Keywords:*** *artificial intelligence; cancer detection; non-small cell lung cancer; NSCLC*

## I. INTRODUCTION

Approximately 85% of all lung cancer diagnoses are Non-Small Cell Lung Cancer (NSCLC), which remains one of the leading causes of cancer-related mortality worldwide (Sung et al., 2021). Since the disease is frequently discovered at an advanced stage, systemic and targeted therapies are often less successful (Çalışkan & Tazaki, 2023; Fiste et al., 2024). Recent developments in Artificial Intelligence (AI) promise to enhance early diagnosis, treatment, and detection of NSCLC disease (Cellina et al., 2023; Chiu et al., 2022; Shao et al., 2022). Improved techniques for early detection are desperately needed, as treating NSCLC at later stages can be challenging. AI systems are capable of sifting through medical images, such as Computed Tomography (CT) scans, for indications of cancer and identifying high-risk individuals who might benefit from early intervention (Grossman et al., 2021; Kim et al., 2023; Ye et al., 2022). Furthermore, multimodal AI approaches that utilize imaging, genomic, and clinical data have demonstrated promising performance in oncology applications (Lipkova et al., 2022).

The interesting potential of AI in solving problems related to NSCLC has been reviewed by Charan and Parthiban (2023). Results showed that the use of AI-based approaches significantly improved the factors related to NSCLC care, especially for early detection using advanced image-analysis methods that can identify subtle signs of cancer in lung imaging (Cellina et al., 2023; Chiu et al., 2022). Furthermore, AI could enhance the accuracy of diagnosis by integrating imaging biomarkers with clinical and molecular data, thereby assisting doctors in making a more precise diagnosis (Çalışkan & Tazaki, 2023; Lipkova et al., 2022). Recent studies have also shown that deep learning algorithms can directly detect important genetic alterations such as ALK and ROS1 fusions from hematoxylin and eosin-stained slides in patients with NSCLC, thereby supporting precision oncology approaches (Mayer et al., 2022).

AI algorithms have revolutionized the detection and treatment of NSCLC. The disease can now be identified earlier through highly accurate analyses of medical images and liquid biopsy data, making treatment more effective and personalized (Grossman et al., 2021; Ye et al., 2022). Furthermore, AI can assist medical professionals in developing tailored treatment strategies that maximize therapeutic efficiency while minimizing adverse effects (Fiste et al., 2024; Yang et al., 2023). The growing implementation of explainable machine learning and big-data analytics in oncology has further strengthened clinical decision-making processes and precision medicine initiatives (Walter et al., 2023; Zafar et al., 2023). Therefore, this review aimed to investigate the emerging field of AI-based methodologies in NSCLC disease and explore how AI could transform patient management through rapid and accurate cancer-cell recognition.

Furthermore, AI could assistance medical professionals to help and tailored treatments that maximize efficiency while minimizing adverse effects. To frame these problems, this review aimed to investigate the fascinating field of AI-based methodologies in NSCLC disease, and discover how AI could transform patient treatment by recognizing cells as quickly, and accurately as possible.

## II. METHODS

The aim of this review is to evaluate and assess the current research on AI in the discussing of NSCLC. Specifically, gained to identify and analyze researches that implement AI techniques for various goals, including diagnosis, prognosis prediction, selection for treatment, and outcome assessment for NSCLC patients. This review also focuses on researches that published between 2019-2024, and also encompassing both experimental and observational research that conducted across different healthcare settings. As shown in Figure 1, we proposed a PRISMA method for Systematic literature review (SLR), that was developing to identify the relevant researches for inclusion in this paper. The research database such as, PubMed, Scopus, and Google Scholar were impelemented using a combination of Medical subject headings (MeSH) terms, and keywords related. Those are *'artificial intelligence'*, *'non-small cell lung cancer'*, and relevant terms and synomys. The methodology have designed to be comprehensive yet focused by utilizing the Boolean operators (AND, OR) with the aiming is to refine the results. Also, the references lists of journal papers and relevant research were manually screened for identifying the essential of articles. The researches included for the review following criteria: (1) The journals only focused on the application of AI techniques, such as machine learning, deep learning algorithms in the discussing of NSCLC; (2) The journals that reported original data, and findings related to diagnosis, prognosis, and treatment for prediction, or other relevant clinical outcomes of the NSCLC; (3) The journals publiahes and written in english languange (4) The journals published between July 17, 2019, and June 18, 2024. Moreover, for exclusion criteria encompassed studies that were not primary journal papers, such as the paper still on the review process, in-press, pre-print, and on editorials process. Besides, the journals does not focused on NSCLC, and the studies lacking on sufficient detail of AI methodologies or outcomes.

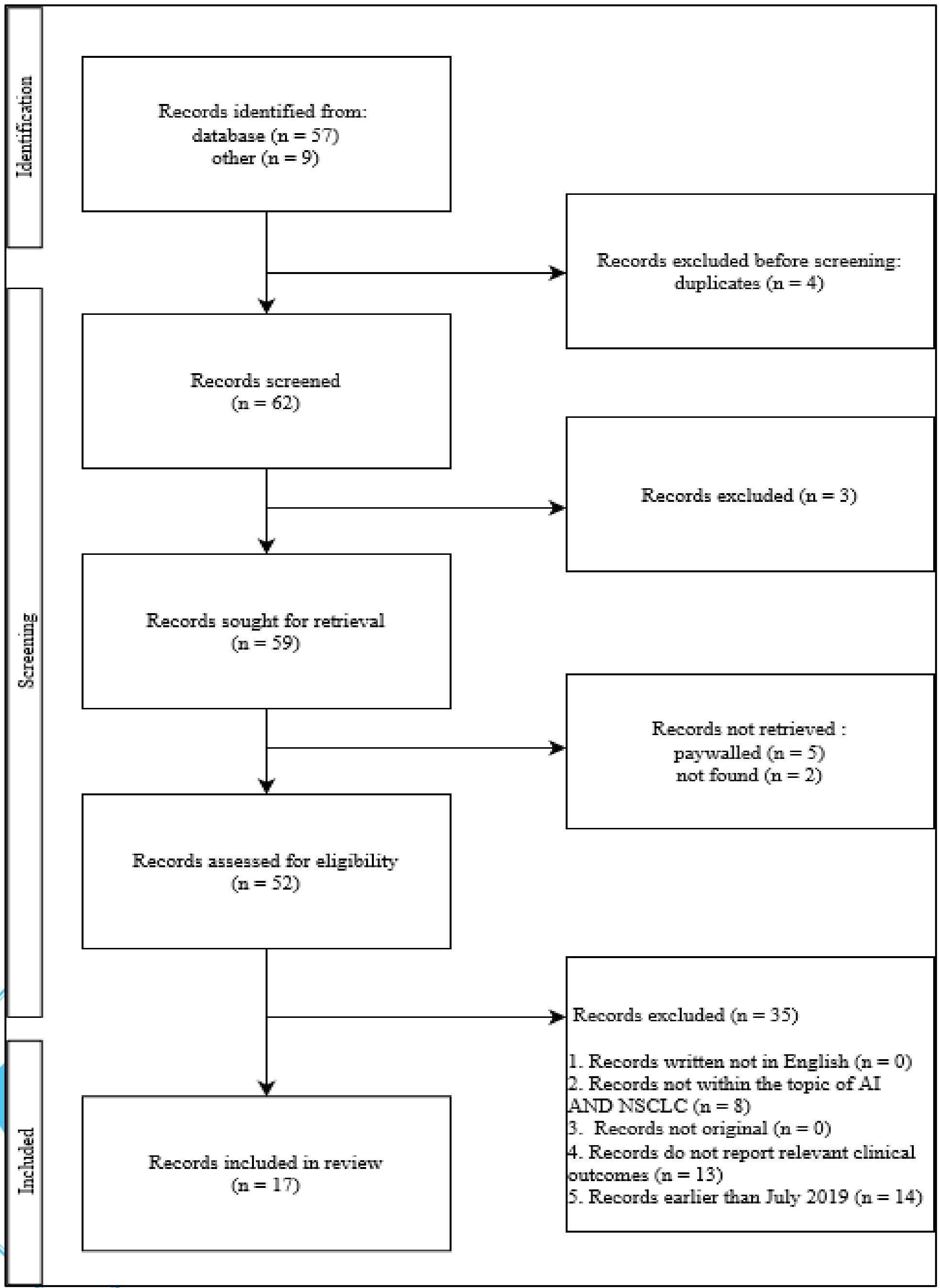


Figure 1. Methodology Flowchart

After these phases, data extraction was carried out by focusing on certain elements of the chosen publications. The research methodology, applicable algorithms, research datasets, primary results, limits, and conclusions are all important aspects of this review study. For every chosen paper, a synopsis of the general study framework was also given. In order to assist the production of this research on SLR, these elements are essential for a comprehensive assessment of the chosen studies. The extracted data were then arranged into a comparison table that will be covered in the next part.

## III. RESULTS AND DISCUSSION

AI's significance in medicine, especially with regard to non-small cell lung cancer (NSCLC), has greatly impacted the creation of numerous systems that help with diagnosis, detection, and therapy recommendations based on individual patient characteristics. From the 62 papers from recorded screening, 17 were selected for final review after completing the review methodology and procedure. The use of machine learning systems improves energy efficiency, accuracy, and consistency in the field of NSCLC as well as other research and practice domains. To ascertain the role of AI in lung cancer screening, for instance, Quanyang et al. (2024) carried out a thorough investigation. Their study shows how machine learning (ML) and deep learning (DL) could advance the identification of patterns in large datasets.

This study focuses on three key aspects. Lung segmentation was the subject of the initial emphasis, which included methods such as thresholding, region expanding, morphological filtering, boundary tracking, and connected component analysis for non-small cell lung cancer. The second was examining nodule detection, which involves identifying small lumps on CT scans crucial for lung cancer diagnosis. Models such as U-Net, RPNs, ResNets, and Retinal Nets are employed for this purpose. The third aspect was reducing false positives using advanced off-the-shelf CNNs and multi-stream heterogeneous CNNs, which is vital for minimizing misdiagnoses. Finally, this research emphasizes nodule classification using fine-tuned pre-trained ResNet50, 3D Faster RCNN, and Gradient Boosting Machine (GBM) techniques.

To be more specific, among the numerous research papers in this area, the most common focus was the application of AI in detecting cancer cells in a patient's CT scan image. For instance, Charan and Parthiban (2023) analyzed the performance of the DT and KNN algorithms as detectors for lung cancer. Using open-source SCLC and NSCLC datasets from IEEE Dataport and DataScience, the research successfully concluded that the DT outperformed KNN, achieving an accuracy of 98.06% compared to 90.73%.

Similarly, Choi et al. (2023) conducted research based on DL to predict NSCLC recurrence. The research utilized a multi-scale 2D CNN, which processes input images at various scales (50 × 50 and 150 × 150, resized to 100 × 100), and a multi-kernel 2D CNN, which uses different kernel sizes (2 × 2, 4 × 4, 5 × 5, and 6 × 6). Moreover, the study used an ensemble of DL models that combines prediction results of different 2D CNN models via a feature fusion approach. One of the main findings of the study was that this method was able to successfully capture information from multiple models and inputs, making it a suggested decision aid for patients with NSCLC.

Another application of AI concerning NSCLC is the development of systems and models that are able to classify image patterns in CT scans as SCLC or NSCLC. This is important to choose the correct treatment and to recognize it early. Ahmed et al. (2023) developed a classification system based on the CNN model with the ResNet101 architecture and improved it with XGBoost. In addition to 3,863 pneumonia and 1,525 normal chest X-rays (CXR) from Kaggle and the NIH, the study trained the model using 945 CT scans from the Lung Cancer Alliance (LCA). The model also included two manually created features, the Gray Level Co-occurrence Matrix (GLCM) and Haralick. The application of XGBoost with ResNet101 and optimized hyperparameters proved through the study that it can be used to identify and classify lung cancer with an almost perfect accuracy and F1-score which outperforms the existing models.

In addition, Kriegsmann et al. (2020) performed research to classify the lung cancer in subtype level. The model produced three types of output: SCLC, ADC and SqCC. The data used for the research were obtained from the Institute of Pathology at University Clinic Heidelberg and extracted as image patches of 100 x 100 micrometers for 80 samples per class. For the research, three models were tested: CNN with VGG16 architecture, InceptionV3 and InceptionResNetV2. The optimization of hyperparameters was performed, such as input image size, batch size and dropout rate. The study achieved high accuracy but 31% of ADC and SqCC cases needed further immunohistochemical (IHC) assessment.

Furthermore, Tashtoush et al. (2023) enhanced CNN models for NSCLC subtype classification. The research investigated a series of model updates and modifications, including developing an attention-augmented CNN with modified VGG16 and VGG19 models combined with SVM. The CNN model used five convolutional layers with three max-pooling layers. The modified model achieved 7.3% higher accuracy than basic CNN models when tested on 1,000 annotated CT scans from Kaggle, covering normal lung, ADC, SqCC, and large cell carcinoma (LCC).

The categorization of malignant (cancerous) and benign (non-cancerous) tumor cells is another use of AI in the setting of non-small cell lung cancer (NSCLC). Chen et al. (2020) conducted research to create a classifier model by merging five different types of ML models: SVM, LR, DT, MLP, and KNN. For categorization, the study employed a Max Voting method. The dataset consisted of 561 CT-scan pictures of malignant tumors and 416 pictures of benign tumors. The first step of the process was to segment the picture using Otsu Thresholding and extract region based characteristics. The combined model was able to correctly classify 85% of the cases. The study also illustrates how DL can help future development.

There are more applications of AI in NSCLC than benign vs malignant tumor cell classification. Classifier research has advanced to models that can categorize cancer stages I–IV. In addition to the study by Chen et al. (2020), SVM was utilized to categorize benign or malignant tumor cells on CT scans, and SVM was coupled with ANN (both MLP and RBF) to categorize cancer stages using several kernel functions (linear, polynomial, and Gaussian). The dataset contained data of 12,186 patients in Xiangya Hospital, Xiangya Second Hospital and Xiangya Third Hospital in China. The study incorporated a feature for therapy recommendations based on the classification results and achieved 88% accuracy.

In NSCLC, AI applications enabled more accurate assessment, for example, of the pathogenic index of lung cancer cells. For instance, Wu et al. (2022) developed an AI-based approach to automatically calculate the Tumor Proportion Score (TPS) of PD-L1 expression in NSCLC. PD-L1 TPS is a protein that can suppress the immune system's response to cancer and it is therefore important to measure it to select the appropriate treatment. A 256 × 256 pixel dataset of tumor cells segmented using a modified watershed method in QuPath Software, comprising 22c3 and SP263 PD-L1 tests, was used to train the system's U-Net architecture. This model showed good agreement with trained pathologists in assessing TPS and improved the repeatability and efficiency of TPS assessment for untrained pathologists.

Additionally, Wang et al. (2022) built a prediction model to investigate not only PD-L1 but also EGFR (Epidermal Growth Factor Receptor), a protein that can lead to uncontrolled cell growth when mutated. The aim of this study was to combine clinical-radiological features with LDCT images and liquid biopsy to identify high-risk lung cancer. The study employed a novel dual-pathway DL network architecture for local and global feature extraction from CT-scan images (DL module), radiomics features from tumor images (Radiomics module) and structured clinical information and symptoms (Clinical module) integrated via feature fusion. The resulting classifier achieved superior performance than existing models, with an AUC of 0.895 in an independent validation cohort.

The tables below show several conclusions for NSCLC evaluation models using AI, summarized from the journal publications reviewed in this research paper.

Table 1. NSCLC Detection Models Evaluation

| Model | Accuracy (%) |
|---|---|
| K-Nearest Neighbor (KNN) (Ahmed et al., 2023) | 90.73 |
| Decision Tree (DT) (Ahmed et al., 2023) | 98.06 |
| Multi-model Ensemble Network (Kriegsmann et al., 2020) | 69.62 |

Table 2. Benign (Malignant) Classification Evaluation

| Model | Specificity (%) | Accuracy (%) |
|---|---|---|
| End-to-end (Chen et al., 2020) | 80.95 | N/A |
| Ensemble-based Decision Making (Kim et al., 2023) | N/A | 88 |
| Ensemble Classifiers (Tashtoush et al., 2023) | N/A | 85 |
| Random Forest (Tashtoush et al., 2023) | N/A | 88 |

N/A: Not available*

Table 3. NSCLC Advanced Model Classification Evaluation

| Model | Precision (%) | Recall (%) | F1-Score (%) | Accuracy (%) |
|---|---|---|---|---|
| U-Net + ResBlocks (Quanyang et al., 2024) | 96.24 | 92.65 | 88.48 | 97.93 |

Table 4. NSCLC Sub-Type Classification Model Evaluation

| Model | Precision (%) | Recall (%) | F1-Score (%) | Accuracy (%) |
|---|---|---|---|---|
| KNN (Charan & Parthiban, 2023) | 97 | 98 | 97 | 97 |
| SVM (Charan & Parthiban, 2023) | 83 | 69 | 75 | 83 |
| XGBoost (Charan & Parthiban, 2023) | 100 | 99 | 99 | 99.45 |

Table 5. NSCLC Classification Model Evaluation

| Model | Overall accuracy (%) |
|---|---|
| CNN-Inception V3 (Kriegsmann et al., 2020) | 100 |
| CNN (Ye et al., 2022) | 65.08 |
| CNN + Attention (Özbay & Özbay, 2023) | 72.38 |
| VGG16 (Ye et al., 2022) | 78.08 |
| VGG16+SVM (Ye et al., 2022) | 83.49 |
| VGG19 (Ye et al., 2022) | 74.60 |
| VGG19+SVM (Ye et al., 2022) | 79.05 |

## IV. CONCLUSION

AI has greatly affected many areas such as medicine, in terms of optimizing system usage and minimizing errors. This paper talks of NSCLC and its applications. Over the last five years, AI model designs have appeared to detect the presence of cancer cells, identify tumor cell types, and predict cancer subtypes. These advances increase the speed of diagnosis, accuracy of disease identification and treatment efficacy. In the end of the review, we conclude that based on review AI models mainly deep learning and machine learning algorithms could assist to recommend treatment based on CT-Scan data, making NSCLC treatment more efficient and quality-oriented. However, limitations must be addressed, as well as suggestions for future research to improve AI in diagnosing and treating NSCLC.

### 5.1. Limitations

NSCLC research journals frequently face data limitations when conducting studies, such as obtaining specific data types and specialized datasets. A large amount of data is required to train models for high-risk tasks in medical settings. Collaboration with institutions or hospitals is necessary to access high-quality medical datasets, but licensing, agreement, and data quantity constraints can make this difficult. External validation is also required to ensure the dataset is representative. Advanced models or algorithms are required for maximum performance in the medical field.

### 5.2. Future Works

This paper discusses future work potentials for an AI model for NSCLC in the medical field. It suggests using a larger clinical dataset to increase robustness and reduce inter-scanner variability. The paper also suggests incorporating medical datasets from all vendors and using AI and ML tools to more efficiently analyze large and complex biomarker data. The paper also emphasizes the need for optimal models, such as deep learning models, new models that outperform current ones, and attention methods that can be adapted to improve results. It also suggests further validation of algorithms and integrating estimation models in applications to predict algorithm accuracy. The paper also suggests developing guidelines and regulations, such as those from the Food and Drug Administration (FDA) and Consort-AI.

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