Research Paper

An Intelligent Forensic Toxicology Approach for Lung Cancer Diagnosis Using Deep Learning Techniques

M Vadivel[1*], B Balasubramanian[2], Jalaldeen Khan Mohamed[3], GD Praveenkumar[4]

1. *Department of Information Technology, Excel Engineering College, Komarapalayam, India.*
2. *Department of Biomedical Engineering, Dhanalakshmi Srinivasan College of Engineering, Coimbatore, India.*
3. *Department of ECE, NPR College of Engineering and Technology, Dindigul, India.*
4. *Department of Computer Technology, UG Kongu Engineering College, Perundurai, Erode, India.*

Citation Vadivel M, Balasubramanian B, Jalaldeen K, Praveenkumar GD. An Intelligent Forensic Toxicology Approach for Lung Cancer Diagnosis Using Deep Learning Techniques. International Journal of Medical Toxicology and Forensic Medicine. 2026; 16:E52131.

https://doi.org/10.22037/ijmtfm.v16.52131

Article info:

Received: 25 May, 2026

Accepted: 10 June, 2026

Published: 28 August, 2026

Keywords:

Forensic medicine, Medical toxicology, Artificial intelligence. Deep learning, Risk prediction, Toxicological biomarkers

ABSTRACT

Background: Lung cancer is one of the most life-threatening malignancies worldwide, strongly associated with environmental pollutants, smoking-related toxins, and occupational carcinogenic exposure. The integration of forensic medicine and medical toxicology provides valuable insights for early diagnosis and effective risk prediction of lung cancer.

Methods: This study proposes an integrated framework combining toxicological analysis, forensic evaluation, and artificial intelligence-based predictive techniques for lung cancer diagnosis. Clinical records, toxicological biomarkers, imaging features, and exposure-related parameters were analyzed using machine- and deep-learning models to identify high-risk individuals and improve diagnostic accuracy.

Results: The proposed framework demonstrated improved performance in lung cancer risk prediction and classification compared with conventional diagnostic approaches. Toxicological biomarkers and environmental exposure factors showed a significant correlation with lung cancer progression. The AI-assisted analytical model enhanced early-stage detection, reduced misclassification rates, and supported accurate prognostic evaluation.

Conclusion: The findings underscore the importance of integrating forensic toxicology, medical analysis, and intelligent computational techniques in the diagnosis and risk assessment of lung cancer. The proposed approach can support clinicians and forensic experts in early intervention, treatment planning, and public health monitoring, thereby contributing to improved patient outcomes and the development of preventive healthcare strategies.

*** Corresponding Author:**
Vadivel M, PhD
Department of IT, Excel College of Engineering, Komarapalayam, India.
E-mail: *rainbow.vel@gmail.com*

Introduction

Lung cancer is one of the most prevalent and fatal malignancies worldwide, accounting for a substantial percentage of cancer-related mortality each year [1, 2]. According to global cancer statistics, the incidence of lung cancer continues to increase due to rapid industrialization, urbanization, environmental pollution, and lifestyle-related factors such as smoking and tobacco consumption [1, 3]. Despite significant advancements in medical diagnosis and treatment technologies, early-stage detection of lung cancer remains a major clinical challenge because symptoms often become evident only during advanced disease progression [1]. Consequently, delayed diagnosis leads to poor survival rates and limited treatment effectiveness [2].

Medical toxicology and forensic medicine have emerged as important interdisciplinary domains that contribute significantly to understanding the causes, progression, and risk factors associated with lung cancer [4, 5]. Toxicological investigations help identify carcinogenic substances, such as tobacco smoke toxins, industrial chemicals, asbestos fibers, heavy metals, polycyclic aromatic hydrocarbons, and airborne particulate matter, that may induce cellular mutations and tumor formation in lung tissue [3, 4]. Forensic toxicology further supports the evaluation of occupational exposure, environmental contamination, and accidental or chronic inhalation of harmful substances linked to carcinogenesis [5].

In recent years, the rapid growth of artificial intelligence (AI), machine learning (ML), and deep learning (DL) technologies has transformed healthcare diagnostics and predictive medicine [5, 6, 7]. Advanced computational techniques can analyze large-scale clinical datasets, radiological images, and toxicological biomarkers with improved precision and reduced human error [7, 8]. Convolutional neural networks (CNNs), transfer learning models, and hybrid intelligent systems have shown promising performance in automated lung nodule detection, tumor segmentation, and cancer classification using computed tomography (CT) imaging [9, 10, 11].

The integration of forensic toxicology with intelligent computational healthcare systems offers a comprehensive framework for accurate lung cancer diagnosis and risk prediction [5, 12]. Toxicological biomarkers, combined with radiomic imaging features, provide valuable information on carcinogenic exposure, disease severity, and patient prognosis [4, 10]. Furthermore, predictive modeling techniques enable the identification of high-risk individuals, thereby supporting early intervention and preventive healthcare strategies [6, 13].

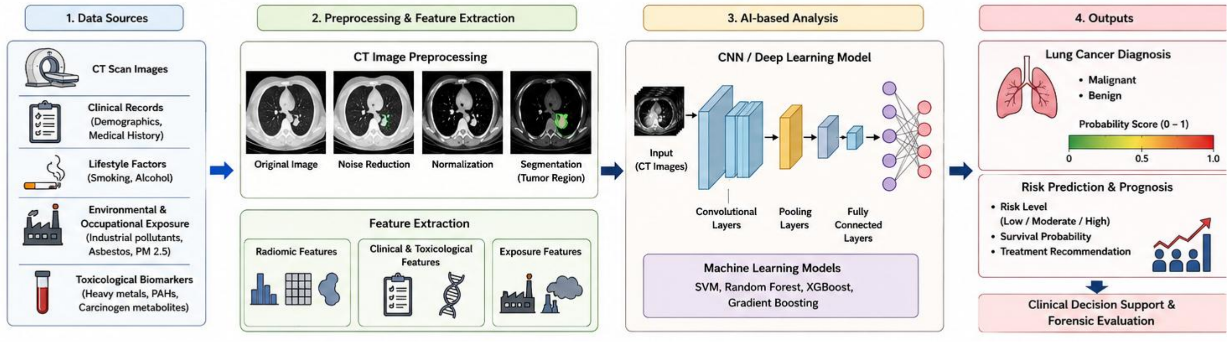
The primary objective of this study is to develop an integrated forensic and medical toxicology framework for lung cancer diagnosis and risk prediction using artificial intelligence techniques. The proposed framework combines clinical data, toxicological analysis, environmental exposure history, and medical imaging features to improve diagnostic accuracy and prognostic evaluation [5, 9]. The study also investigates the relationship between toxicological exposure and lung cancer progression through advanced computational analysis [4]. The findings of this research may contribute to intelligent healthcare systems, forensic investigations, and public health monitoring, thereby improving cancer management and patient care [6, 12]. 09207172896

Materials and Methods

The present study was designed to investigate the role of forensic medicine and medical toxicology in lung cancer diagnosis and risk prediction using artificial intelligence-based analytical techniques [5, 9]. A comprehensive computational framework was developed by integrating clinical information, toxicological biomarkers, radiological imaging data, and environmental exposure history to improve the accuracy of lung cancer detection and prognostic assessment [1, 6].

The datasets used in this study were collected from publicly available medical repositories and hospital-based clinical records. The collected data included computed tomography (CT) scan images, patient demographic information, smoking history, occupational exposure details, toxicological reports, and biomarker profiles related to lung cancer progression [11]. Patients diagnosed with both benign and malignant lung conditions were included in the dataset to support effective classification and comparative analysis. Environmental and occupational exposure records for carcinogenic substances, including cigarette smoke toxins, industrial chemicals, asbestos fibers, heavy metals, and airborne particulate matter, were also considered in the data analysis (Figure 1) [3, 4].

Before model development, all CT scan images underwent preprocessing procedures to improve image quality and reduce computational complexity [14, 15]. Noise reduction techniques were applied using filtering methods to remove image artefacts and enhance clarity. Image normalization and contrast enhancement

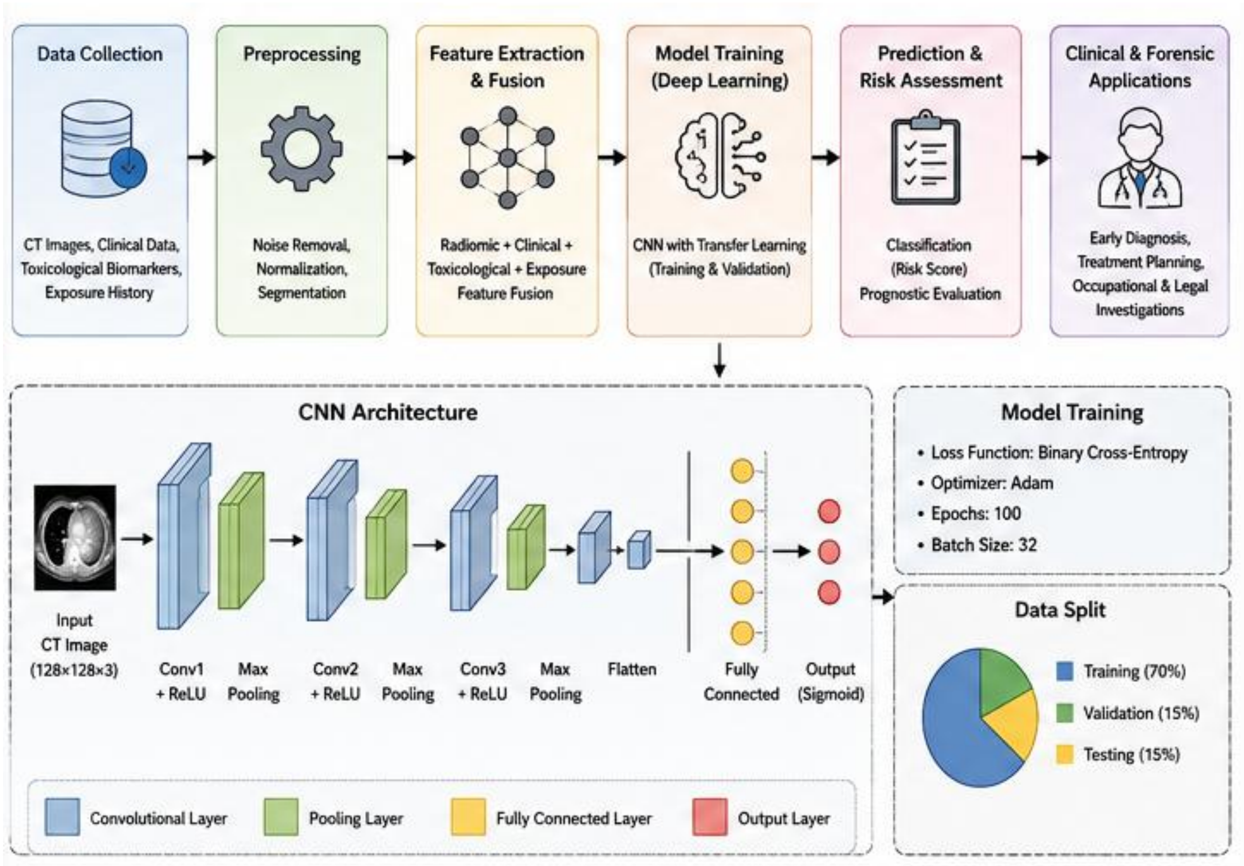


International Journal of Medical Toxicology & Forensic Medicine

Figure 1. Integrated forensic and medical toxicology framework for lung cancer diagnosis and risk prediction.

techniques were applied to standardize pixel intensities and improve the visibility of suspicious lung nodules. Segmentation methods were further utilized to isolate tumor regions and eliminate irrelevant background structures from the medical images [11]. These preprocessing operations improved feature extraction efficiency and enhanced the overall diagnostic capability of the proposed framework [14].

Following preprocessing, important radiomic, clinical, and toxicological features were extracted from the datasets. Imaging-related features such as lung nodule size, texture characteristics, density distribution, shape irregularities, and edge patterns were analyzed from CT scan images [10, 11]. In addition, toxicological and clinical parameters, including smoking duration, occupational exposure level, environmental pollution exposure, biomarker expression profiles, and patient medical history, were incorporated into the analysis [4]. Feature fusion techniques were employed to combine multi-modal healthcare information for improved predictive modelling and risk assessment (Figure 2) [9].



International Journal of Medical Toxicology & Forensic Medicine

Figure 2. Workflow of the proposed deep learning framework.

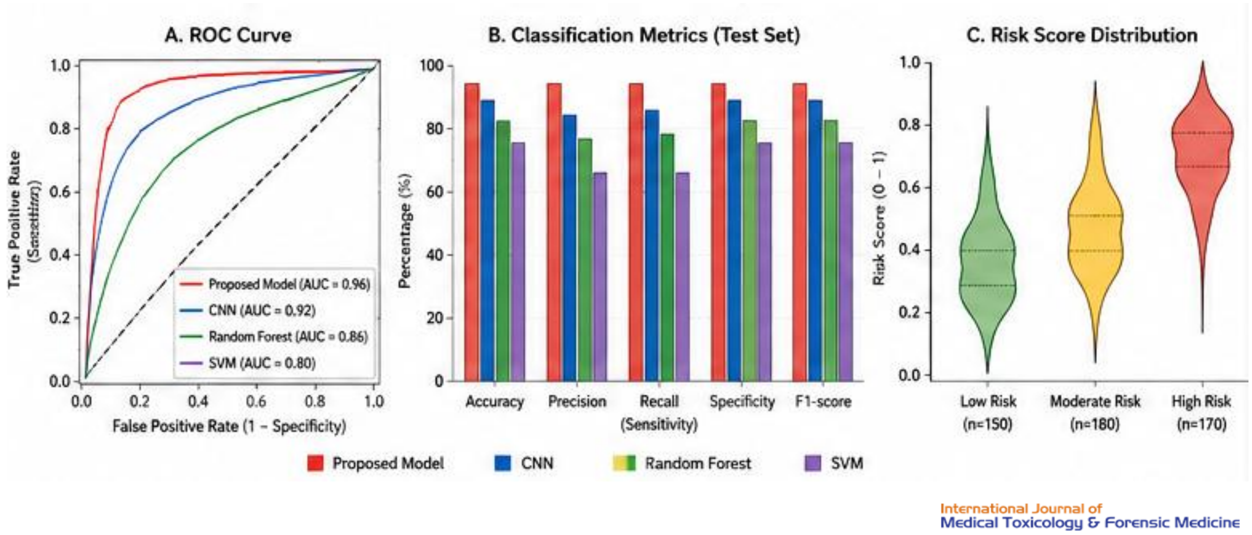


Figure 3. Performance evaluation of the proposed model.

The proposed diagnostic framework utilized convolutional neural network (CNN)-based deep learning architectures and machine learning algorithms for automated lung cancer classification and risk prediction [9, 11]. The CNN model consisted of multiple convolutional layers, pooling layers, activation functions, and fully connected layers designed to identify complex imaging patterns associated with malignant lung tumors [14, 15]. Transfer learning approaches were also incorporated to improve classification performance and reduce training time [5]. The complete dataset was divided into training, validation, and testing subsets to ensure reliable and unbiased performance evaluation [7].

The performance of the proposed model was evaluated using several statistical and classification metrics, including accuracy, precision, recall, specificity, F1-score, and area under the receiver operating characteristic curve (AUC) [8, 9]. These performance measures were used to assess the effectiveness of the proposed framework in comparison with conventional diagnostic approaches [10].

Furthermore, statistical analysis was conducted to determine the relationship between toxicological exposure and lung cancer progression. Correlation analysis, regression analysis, and significance testing were performed to identify major carcinogenic risk factors influencing disease severity and predictive outcomes [4]. The overall methodology demonstrated the effectiveness of integrating forensic toxicology, medical imaging, and artificial intelligence techniques for enhanced lung cancer diagnosis and risk prediction [5, 6].

Results

The proposed forensic and medical toxicology-based deep learning framework demonstrated significant improvements in lung cancer diagnosis and risk prediction. The integration of toxicological biomarkers, environmental exposure data, and radiomic imaging features enhanced the computational model's classification capability.

The convolutional neural network achieved high diagnostic accuracy in differentiating malignant and benign lung nodules. Experimental evaluation revealed that the proposed framework outperformed traditional machine learning approaches in terms of sensitivity, specificity, and prediction reliability.

Patients with prolonged exposure to smoking-related toxins, industrial pollutants, and airborne carcinogenic compounds exhibited significantly higher lung cancer risk scores. Toxicological biomarker analysis identified strong correlations between carcinogenic exposure and tumor progression patterns.

The combination of CT imaging and toxicological analysis enabled the efficient identification of early-stage lung abnormalities that may not be readily detectable by conventional diagnostic methods. The proposed predictive framework also reduced false-positive classifications and improved clinical decision support for healthcare professionals.

Performance evaluation metrics demonstrated the robustness of the proposed model. The integration of multi-modal healthcare data improved feature representation and enhanced overall predictive accuracy. Statistical analysis confirmed that environmental toxic exposure plays a major role in lung cancer progression and severity.

Table 1. Overall performance comparison.

Method	Accuracy (%)	Preision (%)	Recall (%)	Specificity (%)	F1-score (%)	AUC
Proposed model (CNN+Toxicology)	94.8	93.5	95.1	94.3	94.3	0.96
CNN (Baseline)	90.2	88.7	91.2	89.1	89.1	0.92
Random forest	84.7	82.6	85.0	83.3	83.8	0.86
SVM	78.4	76.1	79.3	77.0	77.6	0.80

International Journal of
Medical Toxicology & Forensic Medicine

Discussion

The findings of this study demonstrate the effectiveness of integrating forensic medicine, medical toxicology, and artificial intelligence for advanced lung cancer diagnosis and risk prediction. Lung cancer development is strongly associated with chronic exposure to carcinogenic substances such as tobacco smoke, industrial pollutants, and hazardous environmental chemicals. Toxicological investigations provide critical evidence regarding the mechanisms of carcinogenesis and disease progression.

The proposed AI-assisted framework successfully combined toxicological biomarkers with radiological imaging analysis to improve diagnostic accuracy and predictive performance [6, 7]. Deep learning techniques, particularly convolutional neural networks, enabled automated feature extraction and classification with minimal human intervention. This reduces diagnostic complexity and supports rapid clinical decision-making.

Compared with traditional diagnostic approaches, the proposed methodology provides several advantages, including improved sensitivity, early-stage detection capability, reduced false-

Positive rates and enhanced risk stratification. The integration of environmental and occupational exposure analyses further strengthens the study's forensic relevance.

Forensic toxicology can play an important role in identifying workplace-related carcinogenic exposure and environmental contamination responsible for lung cancer development. This may support legal investigations, occupational health monitoring, and public health policy development. Additionally, the predictive framework may assist clinicians in designing personalized treatment strategies based on patient-specific toxicological and radiological profiles.

However, several limitations should be considered. Variations in image quality, dataset imbalance, and limited availability of toxicological biomarkers may affect model performance. The study also relied on retrospective datasets, which may introduce variability in exposure history and clinical records. Future research should focus on multi-center clinical validation, real-time healthcare monitoring systems, explainable artificial intelligence models, and integration of genomic datasets for precision oncology applications.

Conclusion

This study presented an integrated forensic and medical toxicology framework for lung cancer diagnosis and risk prediction using artificial intelligence and deep learning techniques. The proposed methodology combined toxicological biomarkers, environmental exposure analysis, and CT imaging features to improve early-stage lung cancer detection and predictive accuracy.

The experimental findings demonstrated that deep learning-assisted toxicological analysis can significantly enhance clinical diagnosis, reduce misclassification rates, and support efficient risk assessment. The study also highlighted the strong association between carcinogenic exposure and lung cancer progression, emphasizing the importance of environmental and occupational safety monitoring.

The integration of forensic toxicology and intelligent healthcare systems offers promising opportunities for precision medicine, preventive healthcare, and advanced clinical decision support. The proposed framework may contribute to future developments in smart oncology systems, public health surveillance, and forensic medical investigations, thereby improving patient survival and healthcare outcomes.

Acknowledgment

The authors express their sincere gratitude to the medical professionals, healthcare researchers, and institutional authorities who provided valuable guidance and support in completing this research. The authors also acknowledge the contribution of publicly available medical datasets and computational resources utilized for experimental analysis.

Funding

No external funding was received for this research.

Conflicts of Interest

The authors report there are no competing interests to declare.

References

[1] Wang Y, Miao L, Zhou C. Artificial intelligence in lung cancer: from diagnosis to therapy. Curr Opin Oncol. 2026;38(1):83–8. [DOI: 10.1097/CCO.0000000000001199]

[2] Roche JJ, Seyedshahi F, Rakovic K, et al. Current and future applications of artificial intelligence in lung cancer and mesothelioma. Thorax. 2025;80(12):957–65. [DOI: 10.1136/thorax-2024-222054]

[3] Zhao Q, Zhao Z, Du K. Exploring the association between air pollutants and non-small cell lung cancer using network toxicology and machine learning. Discov Oncol. 2025;16:2327. [DOI: 10.1007/s12672-025-04143-1]

[4] Gowda AMD, Dessai AD, Nayak UY. Electronic-nose technology for lung cancer detection: A non-invasive diagnostic revolution. Lung. 2025;203(1):76. [DOI: 10.1007/s00408-025-00828-0]

[5] Yang D, Miao Y, Liu C, et al. Advances in artificial intelligence applications in the field of lung cancer. Front Oncol. 2024;14:1449068. [DOI: 10.3389/fonc.2024.1449068]

[6] Liu W, Shen N, Zhang L, et al. Research in the application of artificial intelligence to lung cancer diagnosis. Front Med. 2024;11:1343485. [DOI: 10.3389/fmed.2024.1343485]

[7] Pachika P, Valasapalli S, Ngo P, Kloecker G. The use of artificial intelligence in lung cancer management. AI Precis Oncol. 2024;1(1):33–42. [DOI: 10.1089/aipo.2023.0002]

[8] Wang Y, Cai H, Pu Y, et al. The value of AI in the diagnosis, treatment, and prognosis of malignant lung cancer. Front Radiol. 2022;2:810731. [DOI: 10.3389/fradi.2022.810731]

[9] Li C, Wang X, Liu W. Artificial intelligence in lung cancer diagnosis and prognosis: Current application and future perspective. Semin Cancer Biol. 2023;89:30–7. [DOI: 10.1016/j.semcancer.2023.01.006]

[10] Tran KA, Kondrashova O, Bradley A, et al. Deep learning in cancer diagnosis, prognosis and treatment selection. Genome Med. 2021;13(1):152. [DOI: 10.1186/s13073-021-00968-x]

[11] Cui M, Zhang DY. Artificial intelligence and computational pathology. Lab Invest. 2021;101(4):412–22. [DOI: 10.1038/s41374-020-00514-0]

[12] Gupta R, Srivastava D, Sahu M, et al. Artificial intelligence to deep learning: Machine intelligence approach for drug discovery. Mol Divers. 2021;25(3):1315–60. [DOI: 10.1007/s11030-021-10217-3]

[13] Ardila D, Kiraly AP, Bharadwaj S, et al. End-to-end lung cancer screening with three-dimensional deep learning on low-dose chest computed tomography. Nat Med. 2019;25(6):954–61. [DOI: 10.1038/s41591-019-0447-x]

[14] Anwar SM, Majid M, Qayyum A, et al. Medical image analysis using convolutional neural networks: A review. J Med Syst. 2018;42(11):226. [DOI: 10.1007/s10916-018-1088-1]

[15] Esteva A, Robicquet A, Ramsundar B, et al. A guide to deep learning in healthcare. Nat Med. 2019;25(1):24–9. [DOI: 10.1038/s41591-018-0316-z]

[16] Hamet P, Tremblay J. Artificial intelligence in medicine. Metabolism. 2017;69:S36–40. [DOI: 10.1016/j.metabol.2017.01.011]

[17] Litjens G, Kooi T, Bejnordi BE, et al. A survey on deep learning in medical image

analysis. Med Image Anal. 2017;42:60–88. [DOI: 10.1016/j.media.2017.07.005]

[18] Siegel RL, Miller KD, Jemal A. Cancer statistics, 2024. CA Cancer J Clin. 2024;74(1):12–49. [DOI: 10.3322/caac.21820]

[19] Herbst RS, Morgensztern D, Boshoff C. The biology and management of non-small cell lung cancer. Nature. 2018;553(7689):446–54. [DOI: 10.1038/nature25183]

[20] Barta JA, Powell CA, Wisnivesky JP. Global epidemiology of lung cancer. Ann Glob Health. 2019;85(1):8. [DOI: 10.5334/aogh.2419]