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Current Trends and Hotspots of Machine Learning in Lung Cancer Research: A Bibliometric Analysis

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A B S T R A C T

To examine key areas and emerging trends in Machine learning (ML) research within the field of lung cancer. Methods Research literature on ML in the field of lung cancer was gathered from the Science Citation Index Expanded within the Scopus database. This data was then analyzed for insights on publication years, countries/regions, affiliation, funding sponsor, citations, and keywords. Co-occurrence network graphs were created using the VOSviewer library and CiteSpace tools on the online analysis platform. Result A total of 3,341 pertinent research articles from various nations were selected. From 2023 to 2024, there was a notable rise in the quantity of indexed documents, reaching a zenith of roughly 2000 in 2024. Nevertheless, this expansion was not maintained, and in 2025, the total declined precipitously to around 500. Geographically, India and China dominate research output, with India marginally in the lead. The United States occupies the third position but trails considerably behind the top two, with the United Kingdom in fourth place. Other nations, such as Italy, Canada, South Korea, Japan, Saudi Arabia, and Germany, provide relatively fewer documentation. The findings demonstrate significant research effort in Asia, especially in India and China, while North America and Europe also contribute considerably. Disparities in research output can be ascribed to elements such as funding, institutional backing, and national policies that affect publication trends, underscoring the necessity for additional exploration into the political and economic aspects of academic publishing. This research provides a comprehensive analysis of the challenges and prospective applications of machine learning in digital clinical diagnostic systems (DCDS) for the detection of LC. Conclusions The study identified key focus areas and emerging trends in ML for lung cancer diagnosis and indicating that this technology could greatly improve early detection.

1. Introduction

Oncological diseases include various forms of lung cancer and non-lung cancers, and among them lung cancer is the most pubescent type: it comprises approximately 2 million cases yearly with an average death rate of 1.8 million people. Lung cancer makes up 11.6% of cases diagnosed globally, as well as 18.4% of cancer related death [1]. Lung Cancer is devided into small-cell lung cancer (SCLC) and non small cell lung cancer (NSCLC), the latter is further classified into squamous cell lung cancer, and non squamous cell cancer, SCLC is a very rare type of lung cancer [2]. Squamous NSCLC has a strong association with high-tar tobacco smoking such as cigars; however, squamous carcinomas is dominant and unchallenged which poses qualitative dilemmas for targeted approaches in therapy [3].The other type is non squamous, which largely proliferates adenocarcinoma in the lung, large cell carcinoma is on the opposite side of the spectrum. This subtype is believed to be directly associated with the Western Hemisphere and their use of tobacco products , most importantly the moderately low-tar cigarettes. The fall in cigarette use in the recent times has resulted in growth of countries with lower cigarette smoking NSCLC patients. As a result, a considerable fraction of people with lung adenocarcinoma does not have any tobacco smoking background, in some populations these numbers reach 50%.Many researchers have pointed out the importance of genetic factors in association with the development of lung cancer [4],[5]. Defects of chromosome 3 along the p region (3p) stand out as the most prevalent genetic changes in small cell lung cancer (SCLC) and adnocarcninoma (ADC). Cytogenetic analysis has noted the 3p deletion as a common diagnostic marker of these cancers due to the presence of SCLC cases and ADC cases and in 68% SCLC and 8% of ADC cases 3p deletion or loss of heterozygosity in that region was noted [6] [7]. While such chromosomal abnormalities are associated with tumors, there have been a few atypical cases that have been documented in lymphocyte cultures from blood samples. [8],[9]. Like other epithelial tumors, lung cancer is multi-factorial in nature, arising from a combination of genetic and epigenetic deletions, mutations, and methylation changes including modifying tumor suppressor genes.Newer investigations have noted some potential tumor suppressor genes (TSGs) located on the third chromosome that may relate to the risk of lung cancer [8]. In this regard, Artificial Intelligence, especially Machine Learning (ML) and Natural Language Processing (NLP), has shown remarkable innovation in the treatment and care of patients suffering from NSCLC [10], [11]. ML algorithms increase the precision of classification of histological subtypes, molecular profiles, and treatment outcomes, while NLP aids in clinical and patient record data analytics. There have been increased efforts to incorporate the use of AI in thoracic pathology to assist MRI image reading to help in the detection and classification of lung cancer. There are still some outstanding issues, however, such as privacy of sensitive information, biases in AI algorithms, and the requirement of very well annotated information for AI algorithm training. It is important that even if AI-assisted decision- making offers major benefits for efficiency, the knowledge and skills of thoracic and molecular pathologists for diagnostic evaluation should not be overlooked [12]. This review aims to discuss specific examples of AI applied technology to lung cancer pathology, the pros and cons of AI in diagnostic Imotec, and the use of AI technology in formulation of treatment strategies and patient inclusion in the clinical trials.

2. Materials and method

2.1. Data source and research process

The data were retrieved from the Science Citation Index Expanded (SCI-E) within the Scopus database on February 25, 2025, using the following search query: ALL=(machine learning) AND ALL=(lung cancer). The search was limited to publications in English and focused on research in the field of computer science published within the past three years. After applying these initial criteria, two researchers independently screened and evaluated all identified studies.Publications such as books, early access articles, data papers, and retracted works were excluded. The remaining articles underwent a detailed review, with titles and abstracts assessed to ensure relevance. Manual exclusion criteria included: (1) studies that did not establish a connection between machine learning (ML) and lung cancer, and (2) studies where ML and lung cancer were not the primary research focus. In cases of disagreement, decisions were resolved through discussion in a group meeting. The entire search and screening process is illustrated in Fig.1.

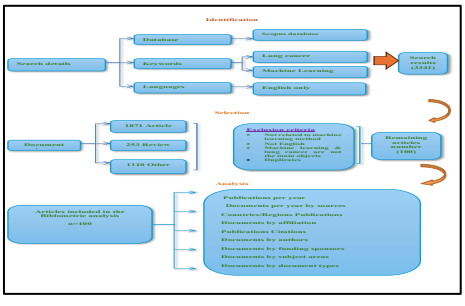

Fig. 1. Flowchart of Document Collection and Selection Process with Research Framework.

2.2. Bibliometric analysis

This study employs three analytical instruments to conduct a thorough bibliometric examination of the literature, addressing multiple facets of the topic area. Initially, the Library Online Analysis Platform (https://bibliometric.com/) was utilized to illustrate collaborative networks among various countries and areas. Secondly, VOSviewer 1.6.19.0 (Leiden University, Leiden, Netherlands) was employed for bibliometric mapping, primarily concentrating on co-occurrence clustering and the visualization of keyword networks. This research use diverse colors to signify various clusters, circles to represent keywords, and the size of the circles to indicate the frequency and intensity of their co-occurrence. The Publish or Perish tool was employed to analyze citation data and assess the influence of publications in the field. This study investigated the 20 most prominent terms, assessing their temporal occurrence trends and importance.

3. Results and Discussion

3.1. Publications per year

The Fig. 2 demonstrates a significant increase in the number of documents between 2023 and 2024, then a dramatic drop in 2025. As of 2023, the number of documents indexed exceeded 1000 by a small margin. In 2024, however, there was a massive increase where the maximum number of documents recorded was approximately 2000. This number, however, was not sustained and in 2025, there was an enormous drop in the figure, which fell below 500. It appears that 2024 was the year that maximum research was conducted followed by a drastic drop in 2025.

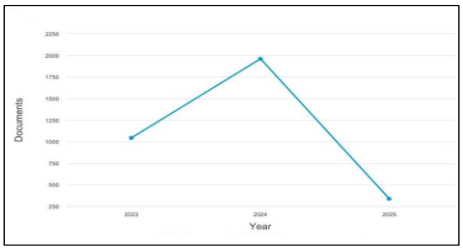

Fig. 2. Shows documents per year.

3.2. Documents per year by sources

Figure 3 illustrates the annual distribution of publications from diverse sources from 2023 to 2025, providing insights into trends in specific journals and conference proceedings. "Lecture Notes in Networks and Systems" has a significant increase in 2024, reaching a peak of about 70 documents, followed by a dramatic decline in 2025. This pattern signifies a temporary rise in publications, probably due to special issues or conferences."Frontiers in Oncology" and "Cancers," both oncology journals, have largely stable trends, with a little decline in publishing output. This stability indicates the continuous research efforts in oncology and the steady contributions of these journals to the field.

Conversely, "Biomedical Signal Processing and Control" exhibits a consistent upward trend over the years, indicating a growing scholarly interest in biomedical signal processing applications."Computers in Biology and Medicine" maintains a consistent publishing frequency with few fluctuations, underscoring its role as a dependable platform for interdisciplinary computational research in biology and healthcare. The graphic illustrates discrepancies in publication trends among sources, shaped by research funding, changing scientific agendas, and regular conference timelines.

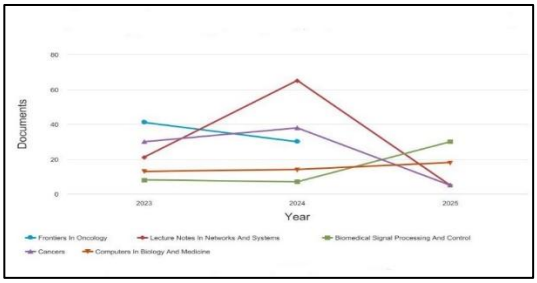

Fig. 3. Documents by document types.

3.3. Countries/regions publications and collaborations

Figure 4 illustrates the distribution of publications by country, offering an overview of the research production across different regions. The document counts for India and China are the highest, with India marginally surpassing China. The United States ranks as the third contributor, however there is a notable disparity compared to the top two contributors. The United Kingdom ranks fourth, much below the United States but above the other countries. The nations ranked lower include Italy, Canada, South Korea, Japan, Saudi Arabia, and Germany, each possessing significantly less papers than those ranked above. The distribution indicates robust research activity in Asia, particularly in India and China, while North America and Europe also demonstrate significant effort. The disparity in document numbers can be elucidated by factors such as research funding, institutional support, and national policies that preferentially promote publishing. The evidence shows that there is great diversity in research efforts of different countries and this difference is a published document's politics which needs deeper scrutiny.

ranking indicates a strong focus on research in these regions. The difference in document counts

Table 1. Top 10 most cited articles in the field of machine learning and lung cancer.

Authors	Year	Source	Publisher	Citation with WOS only			Author Count in the paper	Age
				Per papers	Per years	Per authors		
[13]	2023	The Lancet	thelancet.com	255	127.5	43	6	2
[14]	2023	Cell	cell.com	241	120.5	48	5	2
[15]	2023	Seminars in cancer biology	Elsevier	154	77	31	5	2
[16]	2023	Journal of multidisciplinary healthcare	Taylor &Francis	139	69.5	46	3	2
[17]	2023	Nature	nature.com	123	61.5	25	5	2
[18]	2023	Applications of Artificial	Elsevier	93	46.5	16	6	2
[19]	2023	Scientific reports	nature.com	93	46.5	19	5	2
[20]	2023	Diagnostic and interventional	Elsevier	89	44.5	45	2	2
[21]	2023	Japanese journal	Springer	83	41.5	28	3	2
[22]	2023	Seminars in cancer biology	Elsevier	81	40.5	16	5	2

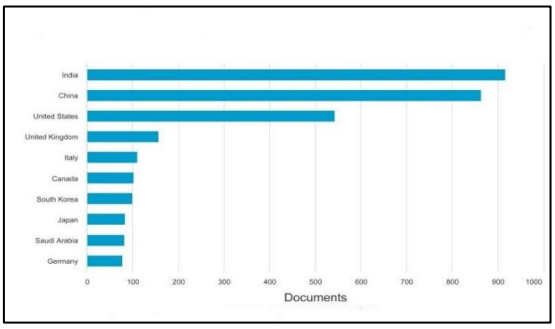

Fig. 4. Documents by country.

3.4. Documents by affiliation

Figure 5 illustrates the distribution of publications by affiliation, highlighting the leading research institutions. The Ministry of Education of the People's Republic of China holds the most number of documents, significantly surpassing all other organizations. This dominance indicates the institution's significant role in coordinating and promoting academic research on a national scale.Chitkara University, Punjab, ranks second, followed by Fudan University and the Chinese Academy of Sciences, both renowned for their significant scientific contributions. Institutions like Vellore Institute of Technology, Saveetha Institute of Medical and Technical Sciences, and the Chinese Academy of Medical Sciences demonstrate substantial document production, indicating their research engagement in specific fields. The presence of multiple Chinese and Indian institutions in the reflects changes in institutional priorities, funding structures, and publication practices. Further investigation may provide insights into the research impact and cooperation networks across these institutions.

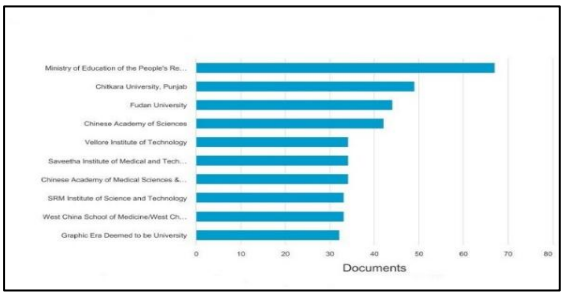

Fig. 5. Documents by affiliation.

3.5. Publications citations

The table1 provides a systematic analysis of scientific publications from 2023, highlighting their influence and authorship distribution among high-impact journals. The data encompasses critical indicators such citation counts from Web of Science (WOS), citation rates per paper and annually, and author counts per publication, offering insights into the scholarly impact of these works.Among the enumerated journals, The Lancet and Cell demonstrate the highest citation impact, with 255 and 241 citations, respectively, indicating their significant scientific importance. Their annual citation rates, at 127.5 and 120.5, further emphasize their relevance in swiftly evolving research

domains. Seminars in Cancer Biology has a citation count of 154, whilst publications like Nature and Scientific Reports exhibit intermediate influence with citations between 93 and 123.

The citation efficiency per author indicates a disparity in collaborative involvement, with Applications of Artificial Intelligence exhibiting the lowest citations per author (16) despite a considerable author count (6), whereas the Journal of Multidisciplinary Healthcare shows greater individual author contributions with 46 citations per author. This variety indicates disparities in research scope, collaborative dynamics, and citation patterns particular to topics.The chart provides a thorough overview of the contributions of several scientific publications to the academic landscape, emphasizing citation impact, author contributions, and multidisciplinary scope. This comparative analysis facilitates comprehension of academic output and the impact of collaborative research across different fields.

2.6 Documents by authors

The bar chart illustrates a comparative examination of document counts associated with various authors in the Scopus database. It emphasizes the major contributors, with a limit of 15 writers shown Fig. 6. M. Provencio has the greatest document count, followed closely by A. Santone and M. Torrente. The distribution reveals a minor fluctuation in publication output, with most authors producing a similar quantity of publications, between five and eight.The dataset indicates a fairly uniform distribution among the specified authors, with slight variations in publishing frequency. The existence of numerous authors with comparable publication counts indicates a competitive research landscape characterized by approximately equal contributions. This may suggest ongoing cooperation or independent research endeavors yielding comparable results. From an academic standpoint, this distribution offers information into research productivity within a certain field. Assessing document counts by author facilitates an evaluation of research impact and involvement within the scientific community. This analysis can further inform funding bodies, institutions, and peer researchers about key contributors and emerging trends within the field.

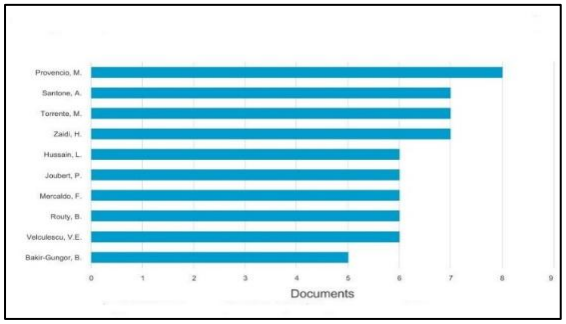

Fig. 1. Documents by authors

2.7 Documents by funding sponsors

The bar chart presents a comparative study of document counts linked to different financial sponsors, emphasizing the research contributions facilitated by these organizations Fig.7. The National Natural Science Foundation has the biggest number of financed documents, followed by the Ministry of Science and Technology. This signifies a substantial expenditure in research by these institutions, highlighting their contribution to the advancement of scientific knowledge.Other significant funding entities, such as the National Institutes of Health, the U.S. Department of Health and Human Services, and the National Key Research and Development Program, exhibit considerable contributions, underscoring their dedication to financing high-impact research. The involvement of the European Commission and the National Cancer Institute highlights worldwide and specialized funding initiatives, especially in health and medical sciences. The distribution indicates a concentration of funding from governmental and intergovernmental entities, underscoring the global commitment to scientific advancement. These data elucidate financing trends and research agendas, furnishing essential information for researchers pursuing financial assistance and institutions striving to augment research productivity.

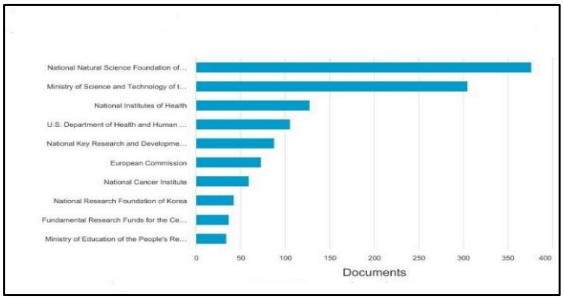

Fig. 2. Documents by funding sponsors

2.8 Documents by subject areas

The pie chart illustrates the distribution of documents among distinct subject areas, providing insights into research activities across different disciplines (Fig 8). The predominant proportion of papers is attributed to Computer Science (21.3%), closely succeeded by Medicine (20.7%). This signifies a robust research emphasis on technical progress and medical sciences, mirroring global priorities in digital transformation and healthcare innovation.Engineering constitutes 13.8% of the publications, underscoring its significance in applied sciences and technological advancement. Biochemistry, Genetics, and Molecular Biology account for 10.6%, indicating a substantial focus on life sciences and biomedical research. Mathematics (7.3%) and Decision Sciences (4.5%) provide

significant contributions, underscoring their relevance in analytical and computational approaches.

Minor yet pertinent proportions are noted in Physics and Astronomy (3.9%), Materials Science (2.2%), Energy (2.1%), and Chemistry (1.8%), indicating their roles in fundamental and applied research. The "Other" category (11.7%) denotes multidisciplinary studies and nascent disciplines. This distribution highlights the diversity of scientific inquiry and the dynamic character of study across several fields**.**

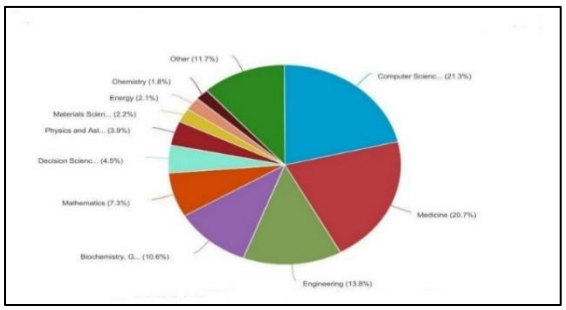

Fig. 8. Documents by subject areas.

2.9 Documents by document types

The pie chart illustrates the distribution of document types in the Scopus data-base, offering insights into the prevalent formats of scholarly communication (Fig 9). Articles constitute 56.0%, indicating their status as the principal medium for the dissemination of original research. Conference papers represent 29.1%, underscoring the importance of conferences in swiftly evolving domains, especially in technology and engineering sectors.Review articles constitute 7.6%, highlighting their function in synthesizing current research and directing future inquiries. Conference reviews (2.5%) and book chapters (1.6%) provide further viewpoints, frequently including wider academic discourses.

Editorials (1.5%), notes (0.9%), errata (0.3%), and letters (0.3%) constitute ancillary formats that provide clarifications, comments, and modest additions.Books and other document formats constitute a minimal proportion, signifying a preference for concise, peer-reviewed articles rather than lengthy monographs. This distribution illustrates the academic community's focus on high-impact, peer-reviewed outputs while ensuring a balanced representation among all publication formats.

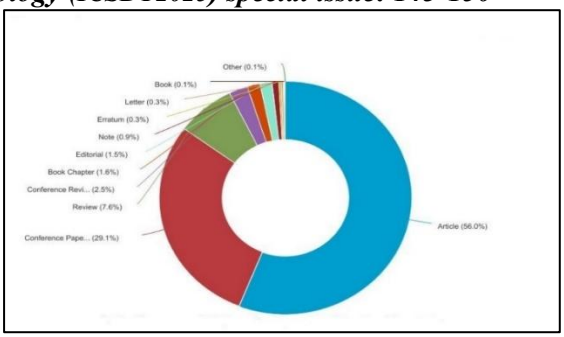

Fig. 9. Documents by document types.

2.9 Co-occurrence of keywords

The co-occurrence analysis of keywords derived from Scopus-indexed papers about lung cancer and machine learning offers essential insights into the scientific landscape (Table 2) . The predominant term, "Lung cancer" (2341 occurrences, 7942 total link strength), highlights the significance of this condition in the examined studies. The elevated total link strength (TLS) signifies substantial interconnections with other terms, underscoring its crucial position in the research domain (Fig10) "Machine learning" (2232 instances, 10,789 TLS) indicates a significant prevalence, underscoring the growing use of artificial intelligence methodologies in lung cancer research. The elevated TLS indicates significant interconnection with other terms, underscoring its interdisciplinary character. Likewise, "Human" (1682 times, 10,885 TLS) and "Humans" (997 occurrences, 7466 TLS) underscore a significant focus on research involving human subjects, affirming the clinical pertinence of machine learning applications in lung cancer detection and treatment. Keywords linked to certain pathological classifications, including "Lung tumor" (640 occurrences, 5327 TLS), "Lung neoplasms" (617 occurrences, 5273 TLS), and "Non-small cell lung cancer" (663 occurrences, 4544 TLS), indicate an emphasis on various manifestations of lung cancer. The phrase "Controlled study" (753 instances, 6099 TLS) indicates a dominance of stringent experimental and clinical trial techniques, hence enhancing the credibility of the results.The co-occurrence structure demonstrates a complex research network in which machine learning is significantly integrated into lung cancer studies, especially in human-centric research and controlled environments. The robust linkages among keywords signify a well-established research foundation, bolstering the ongoing advancement of AI-driven techniques in oncology.

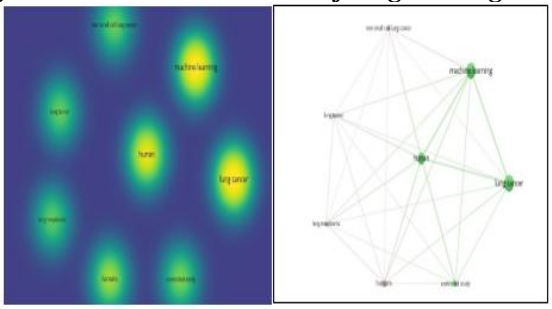

Fig. 10. Keyword Co-occurrence Network in Research Related to lung cancer and Machine Learning.

improve the interdisciplinary competence of our research team to deepen and extend our studies.

4. Conclusion

This study identifies the research focal points and prospective trends of machine learning in relation to lung cancer. Machine learning models possess significant potential in all facets of lung cancer detection and therapy; however, their efficacy and safety must be validated by extensive data collection over an extended duration. This study will assist pertinent researchers, doctors, and government agencies in comprehending the advanced trends of machine learning in lung cancer and in effectively incorporating machine learning into clinical practice for the benefit of humanity.

Table 2. Keyword Occurrences and Total Link Strength in Research Topics.

Keyword	Occurrences	Total link strength
Machine Learning	2232	10789
Human	1682	10885
Lung cancer	2341	7942
Humans	997	7466
Controlled study	753	6099
Lung tumor	640	5327
Lung neoplasms	617	5273
Non small cell lung caner	663	4544

3. Limitations

The study is carried out by extensive A bibliometric analysis rigorously and systematically analyzes all pertinent findings in the selected literature; yet, we must acknowledge our limits. In summary, three principal constraints exist. The research first analyzes the SCI-E database within the Scopus citation index, a significant international resource. Our bibliometric research is limited by inadequate relevant data, which constrains the comprehensiveness of our conclusions. Secondly, by confining our search parameters to English language publications and manually excluding irrelevant information, we risk omitting important research in other languages or formats. This careful human-mediated curation may have been affected by researchers' expertise constraints, leading to the omission of relevant studies. Our definitive research focused on the extraction and analysis of keywords pertaining to "ML" and "lung cancer." Our study parameters may have impeded the thorough collection of relevant information on the topic. Moreover, keyword analysis revealed that general terms such as lung cancer, AI, deep learning, and machine learning predominated the high-frequency results, which, while informative, did not significantly enhance our analytical findings with nuanced information. Future efforts aim to expand data sources, enhance keyword accuracy, and

References

[1] F. Bray, J. Ferlay, I. Soerjomataram, R. L. Siegel, L. A. Torre, and A. Jemal, "Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries," CA: Cancer J. Clin., vol. 68, no. 6, pp. 394–424, 2018.

[2] N. Duma, R. Santana-Davila, and J. R. Molina, "Non–small cell lung cancer: Epidemiology, screening, diagnosis, and treatment," in Mayo Clinic Proceedings, Elsevier, 2019, pp. 1623–1640.

[3] A. Friedlaender, G. Banna, U. Malapelle, P. Pisapia, and A. Addeo, "Next generation sequencing and genetic alterations in squamous cell lung carcinoma: Where are we today?," Front. Oncol., vol. 9, p. 166, 2019.

[4] H. Nakamura and H. Saji, "A worldwide trend of increasing primary adenocarcinoma of the lung," Surg. Today, vol. 44, pp. 1004–1012, 2014.

[5] V. Gristina et al., "The significance of epidermal growth factor receptor uncommon mutations in non-small cell lung cancer: A systematic review and critical appraisal," Cancer Treat. Rev., vol. 85, p. 101994, 2020.

[6] A. Alhamadany, "The fluorescence in situ hybridization (FISH): Types and application: A review," NTU J. Pure Sci., vol. 2, no. 2, 2023, doi: 10.56286/ntujps.v2i2.416.

[7] A. Y. M. Alhamadany and W. S. Sadek, "Analysis of the chromosomal aberrations in hepatitis B virus (HBV), hepatitis C virus (HCV), and hepatocellular carcinoma patients (HCC) in Mosul City, Iraq," NTU J. Pure Sci., vol. 1, no. 2, pp. 48–53, 2022.

[8] J. N. E. Ashman et al., "Chromosomal alterations in small cell lung cancer revealed by multicolour fluorescence in situ hybridization," Int. J. Cancer, vol. 102, no. 3, pp. 230–236, 2002.

[9] Y. Tarkan-Argüden, S. Hacihanefioglu, G. Öngen, M. Erk, and A. Cenani, "3p abnormalities in peripheral lymphocytes in small cell lung cancer," Tumori J., vol. 95, no. 4, pp. 535–537, 2009.

[10] B. J. Dave, V. L. Hopwood, M. R. Spitz, and S. Pathak, "Shared cytogenetic abnormalities in lung tumors and corresponding peripheral blood lymphocytes," Int. J. Oncol., vol. 7, no. 6, pp. 1297–1305, 1995.

[11] S. Khan, J. M. Coulson, and P. J. Woll, "Genetic abnormalities in plasma DNA of patients with lung cancer and other respiratory diseases," Int. J. Cancer, vol. 110, no. 6, pp. 891–895, 2004.

[12] S. Wang et al., "ConvPath: A software tool for lung adenocarcinoma digital pathological image analysis aided by a convolutional neural network," EBioMedicine, vol. 50, pp. 103–110, 2019.

[13] S. J. Adams, E. Stone, D. R. Baldwin, R. Vliegenthart, P. Lee, and F. J. Fintelmann, "Lung cancer screening," Lancet, vol. 401, no. 10374, pp. 390–408, 2023.

[14] K. Swanson, E. Wu, A. Zhang, A. A. Alizadeh, and J. Zou, "From patterns to patients: Advances in clinical machine learning for cancer diagnosis, prognosis, and treatment," Cell, vol. 186, no. 8, pp. 1772–1791, 2023.

[15] S. Huang, J. Yang, N. Shen, Q. Xu, and Q. Zhao, "Artificial intelligence in lung cancer diagnosis and prognosis: Current application and future perspective," in Seminars in Cancer Biology, Elsevier, 2023, pp. 30–37.

[16] B. Zhang, H. Shi, and H. Wang, "Machine learning and AI in cancer prognosis, prediction, and treatment selection: A critical approach," J. Multidiscip. Healthc., pp. 1779–1791, 2023.

[17] C. Martínez-Ruiz et al., "Genomic–transcriptomic evolution in lung cancer and metastasis," Nature, vol. 616, no. 7957, pp. 543–552, 2023.

[18] R. Raza et al., "Lung-EffNet: Lung cancer classification using EfficientNet from CT-scan images," Eng. Appl. Artif. Intell., vol. 126, p. 106902, 2023.

[19] A. A. Shah, H. A. M. Malik, A. H. Muhammad, A. Alourani, and Z. A. Butt, "Deep learning ensemble 2D CNN approach towards the detection of lung cancer," Sci. Rep., 2023.

[20] C. de Margerie-Mellon and G. Chassagnon, "Artificial intelligence: A critical review of applications for lung nodule and lung cancer," Diagn. Interv. Imaging, vol. 104, no. 1, pp. 11–17, 2023.

[21] G. Chassagnon et al., "Artificial intelligence in lung cancer: Current applications and perspectives," Jpn. J. Radiol., vol. 41, no. 3, pp. 235–244, 2023.

[22] M. Chen, S. J. Copley, P. Viola, H. Lu, and E. O. Aboagye, "Radiomics and artificial intelligence for precision medicine in lung cancer treatment," in Seminars in Cancer Biology, Elsevier, 2023, pp. 97–113.