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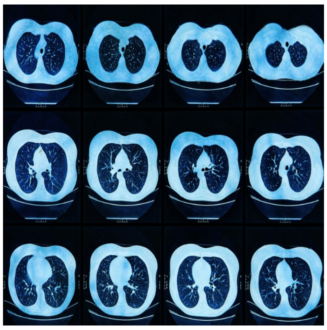
Lung Cancer Risk Prediction: AI vs. Traditional Regression Models



Lung cancer remains a leading cause of cancer-related mortality worldwide, with early detection being critical for improving survival rates. Screening programmes employing low-dose computed tomography (LDCT) have demonstrated significant mortality reductions in high-risk individuals. However, optimising screening strategies requires precise risk stratification to ensure that individuals at the highest risk receive timely screening while minimising unnecessary scans for low-risk individuals.

Traditional regression models have long been used to predict lung cancer risk, relying on demographic and clinical variables. More recently, artificial intelligence models have emerged as a promising alternative, leveraging complex data patterns to improve predictive performance. A systematic review and meta-analysis compared the effectiveness of these two modelling approaches in lung cancer risk prediction, assessing their strengths, limitations and potential integration into screening programmes.

Performance Comparison: AI vs Traditional Regression Models

The study reviewed 140 studies, evaluating 185 traditional regression models and 64 AI-based models for lung cancer risk prediction. AI models demonstrated superior predictive performance, with a pooled area under the receiver operating characteristic curve (AUC) of 0.82, compared to 0.73 for traditional regression models. Among AI-based models, those incorporating LDCT imaging data achieved the highest predictive accuracy, with a pooled AUC of 0.85. These results suggest that AI models may enhance risk prediction, particularly when integrating imaging data with clinical and epidemiological variables.

Traditional regression models primarily relied on well-established risk factors such as age, smoking history, family history of lung cancer and body mass index. Some models also incorporated clinical biomarkers and genetic information to refine risk estimates. AI models, in contrast, used a combination of structured and unstructured data, including demographic, clinical and imaging features, to identify complex patterns predictive of lung cancer risk. The findings indicate that AI-based models generally outperform traditional models, although their implementation in clinical practice is hindered by several limitations, including a high risk of bias in many studies.

Must Read:* *Non-Invasive Imaging for Lung Cancer Prediction

Despite the apparent advantages of AI models, both modelling approaches exhibited a high risk of bias. AI-based models had an overall bias rate of 83%, with the most significant concerns arising in participant selection and analytical methodology. Similarly, 66% of traditional regression models were deemed to have a high risk of bias, highlighting the need for more rigorous validation and standardisation in lung cancer risk prediction research.

The Role of Imaging in AI-based Predictions

LDCT imaging has played a pivotal role in lung cancer screening, and AI models incorporating imaging data have shown marked improvements in predictive accuracy. AI models that utilised imaging achieved higher discrimination performance than those relying solely on demographic and clinical data. These models offer the potential to refine lung cancer screening protocols by identifying high-risk individuals who would benefit most from regular screening while reducing unnecessary exposure for those at lower risk.

AI models integrating imaging data demonstrated promising discrimination performance across various study populations. Among the validated AI models, those incorporating LDCT imaging achieved a pooled AUC of 0.85, suggesting they could be used to further optimise lung cancer screening strategies. However, a major limitation is that most AI models have been validated in a limited number of external datasets, raising concerns about their generalisability to broader populations. While traditional regression models have undergone extensive validation in multiple cohorts, AI models remain relatively under-examined in diverse populations, limiting their immediate applicability in routine clinical practice.

Further research is needed to assess the real-world performance of AI-based risk prediction models, particularly in prospective studies that evaluate their impact on clinical decision-making and screening outcomes. The integration of AI into lung cancer screening programmes will require robust validation and regulatory approval to ensure its effectiveness across different populations and healthcare settings.

Challenges and Future Directions

Although AI models present a compelling case for improved lung cancer risk prediction, several challenges remain. One of the primary concerns is the high risk of bias associated with AI studies, particularly in participant selection and data analysis. Many AI models rely on electronic health records (EHRs) for validation, which introduces inconsistencies in variable reporting and data completeness. Additionally, AI models often lack transparency in their analysis methodologies, making it difficult to assess their reliability and reproducibility.

The absence of standardised validation frameworks further complicates the adoption of AI-based models in clinical practice. While traditional regression models benefit from well-established validation protocols, AI models require new evaluation criteria that account for their unique methodological characteristics. The development of AI-specific quality assessment tools, such as the forthcoming PROBAST-AI framework, may help address these issues and improve the reliability of AI-based lung cancer risk prediction models.

Future research should focus on validating AI models in large, diverse cohorts to ensure their generalisability across different demographic and geographic populations. Additionally, prospective studies comparing AI and traditional regression models within the same patient populations are needed to minimise variability and assess real-world applicability. Direct comparisons between AI-based models and traditional risk assessment methods will be essential for determining the clinical utility of AI in lung cancer screening.

Another critical consideration is the integration of AI models into existing screening guidelines. Current lung cancer screening criteria are based on smoking history and age, informed by data from large randomised controlled trials. Shifting towards AI-driven screening selection would require extensive prospective research demonstrating its superiority over existing screening models. Furthermore, the high risk of bias identified in AI studies must be addressed before these models can be widely adopted in screening programmes.

AI-based models offer enhanced predictive accuracy for lung cancer risk, particularly when incorporating imaging data. However, their widespread clinical implementation is contingent upon further validation and standardisation. Traditional regression models remain widely used due to their established frameworks, but their predictive performance is comparatively lower. Future efforts should focus on refining AI models, improving external validation and integrating them into screening programmes to optimise early lung cancer detection. A standardised approach to model development and validation will be essential to ensure that AI-based lung cancer risk prediction models can be effectively and equitably deployed in clinical settings.

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