

INTRODUCTION

- Low-dose CT (LDCT) screening reduces lung cancer mortality.
- Current U.S. Preventive Services Task Force (USPSTF) guidelines recommend a uniform annual interval for high-risk adults, defined by age and smoking history.
- This one-size-fits-all approach overlooks substantial inter-individual risk heterogeneity, leading to over-screening of low-risk patients, higher healthcare costs, and cumulative radiation exposure that may itself raise cancer risk.

Goal: To develop a deep learning lung cancer risk model and evaluate its use for guiding a personalized, risk-stratified LDCT screening schedule.

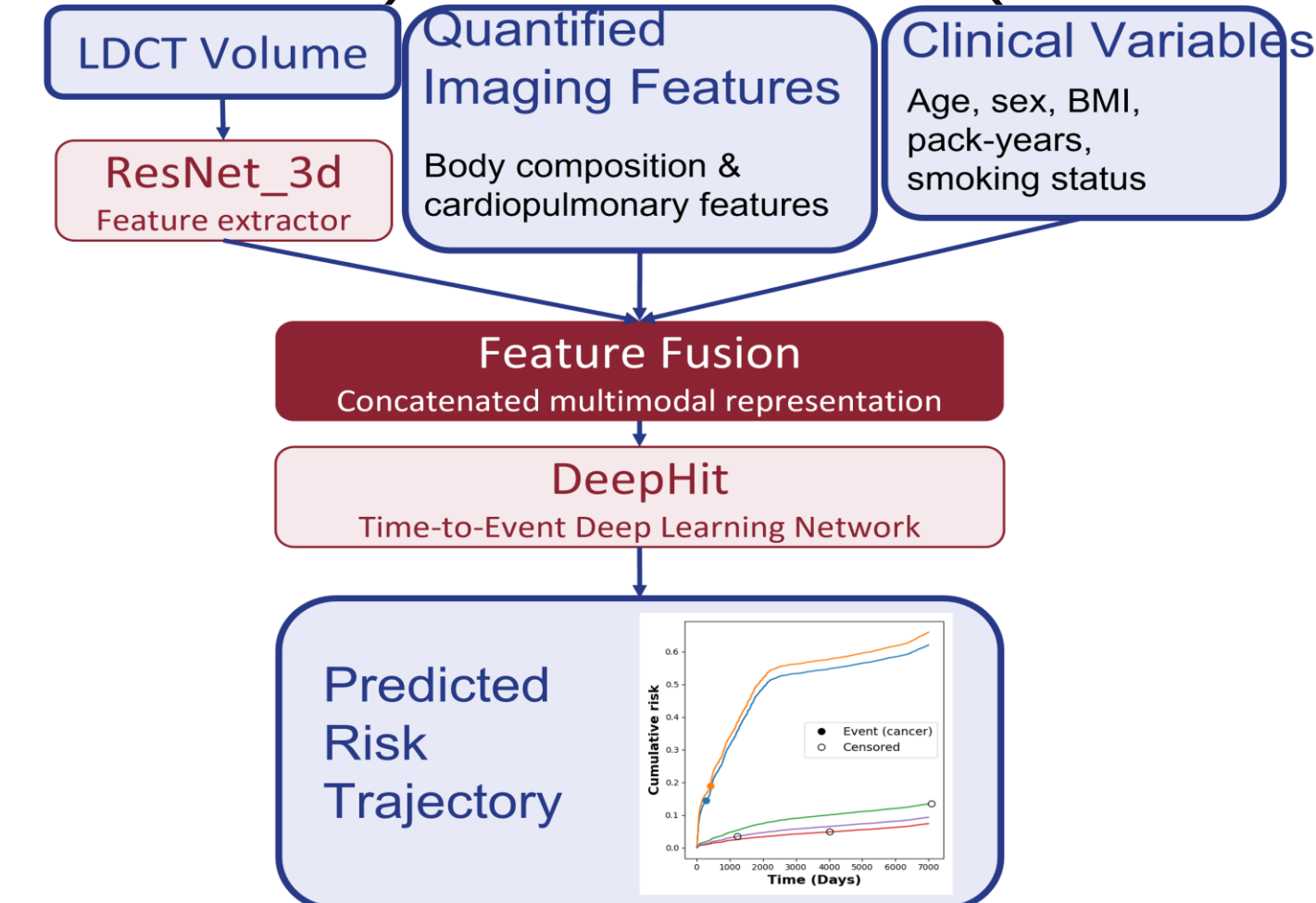
METHODS

Design:

Retrospective, pooled cohort:

- Pittsburgh Lung Screening Study (PLuSS):
 - 17,441 scans from 3,634 patients; 22 years of follow-up.
- National Lung Screening Trial (NLST):
 - 3,949 scans from 1,028 patients; 8 years of follow-up.
- Patients were randomly split (10:1, patient-level) into training (19,503 scans) and validation (1,887 scans) sets.

Model:



Strategy:

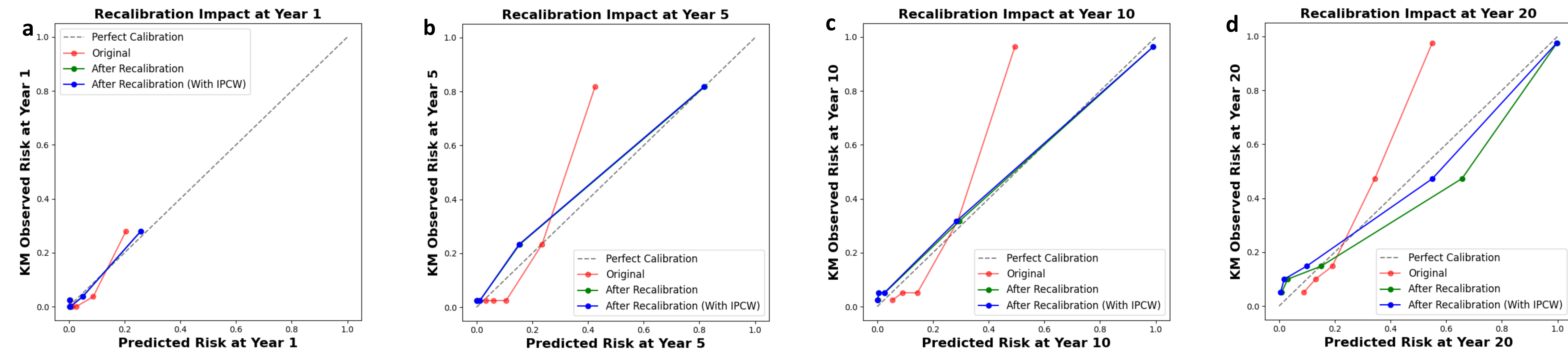
- Patients were split into high- and low-risk groups at the median of the predicted risk change between Year 1 and Year 2.
- Annual screening for high-risk patients, biennial for low-risk, benchmarked against standard annual screening.
- Performance was also evaluated across the full range of decile-based thresholds.

RESULTS

Model Discrimination and Calibration

The model showed strong discrimination and calibration on the held-out validation set (**C-index 0.83**; **IBS 0.13**) over 20 years.

Model Recalibration

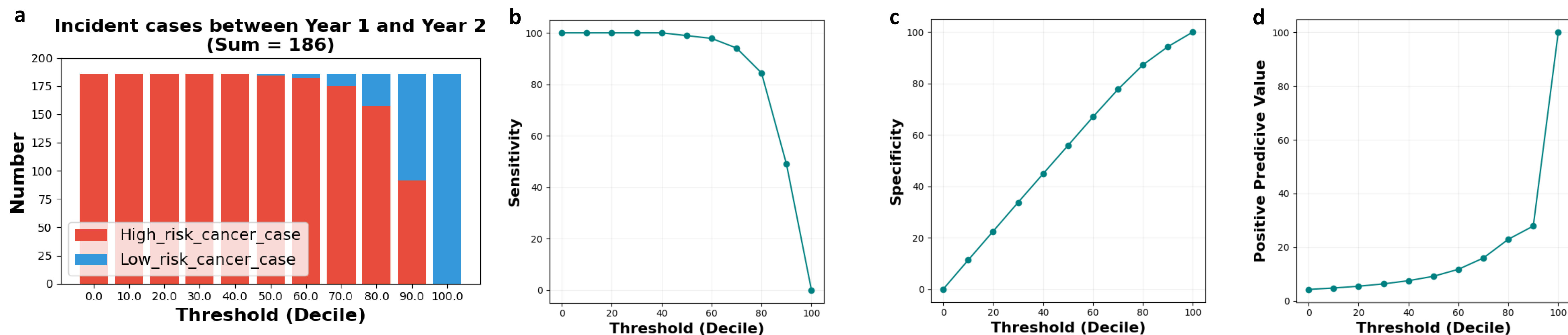


Recalibration curve fit on training data and evaluated on the held-out validation set at (a) Year 1, (b) Year 5, (c) Year 10, and (d) Year 20.

Risk Stratification

Using the recalibrated model, patients were stratified into high- and low-risk groups based on the risk difference between Year 1 and Year 2.

- The risk-based strategy detected 184 of 186 incident cancers between Year 1 and Year 2 (**sensitivity 98.9%**) vs. 100% under annual screening.
- It also substantially improved **specificity (55.9%** vs. 0%) and positive predictive value (**PPV (9.2%** vs. 4.3%).
- NNS improved from 26 (annual) to 13 in the high-risk group, while **low-risk patients** were safely deferred (**NNS 1,166**), **reducing** total 2-year screening volume by **~25%** with minimal loss in sensitivity.



Risk-stratified screening performance. (a) Incident lung cancer cases (n=186) between Year 1 and Year 2 across risk-stratification thresholds (deciles). (b) Sensitivity, (c) specificity, and (d) PPV of the risk-stratified strategy across decile thresholds.

Summary of lung cancer cases in the high- and low-risk groups, stratified using the median predicted risk change as the cutoff.

	High-Risk Group (n=2,331)	Low-Risk Group (n=2,331)
Prevalent Cases (< Year 1)	310 (13.3%)	9 (0.39%)
Incident Cases (Year 1 - Year 2)	184 (7.89%)	2 (0.09%)
Total Cases	494 (21.19%)	11 (0.47%)
Negative Scans (Non-events)	1,815 (77.86%)	2,299 (98.63%)
Censored	22 (0.94%)	21 (0.90%)

Note: Risk-stratification performance was assessed on the full cohort (n=4,662) due to limited incident cases in the validation set alone (n=14); discrimination and calibration metrics above were assessed on the held-out validation set only.

DISCUSSION AND CONCLUSION

Actionable Take Away Message

- Deep learning-based time-to-event risk modeling enables a shift from uniform to risk-based lung cancer screening, supporting clinically actionable interval personalization.
- Personalized intervals cut 2-year screening volume by ~25% while preserving 98.9% sensitivity.
- Number needed to screen (NNS) nearly halved for high-risk patients (26 → 13), while low-risk patients were safely deferred (NNS 1,166).

Future Direction for Research

- External validation in diverse, multi-center cohorts and prospective testing of the risk-adaptive interval strategy are needed before clinical implementation.
- Incorporating nodule features and additional biomarkers may further refine individualized screening schedules.

REFERENCES & ACKNOWLEDGEMENTS

- Wilson, David O., et al. "The Pittsburgh Lung Screening Study (PLuSS): outcomes within 3 years of a first computed tomography scan." American journal of respiratory and critical care medicine 178.9 (2008): 956-961.
- Pu, Jiantao, et al. "Pulmonary circulatory system characteristics are associated with future lung cancer risk." Medical physics 51.4 (2024): 2589-2597.
- Wang, Jing, et al. "Beyond nodules: body composition as a biomarker for future lung cancer." European radiology 35.12 (2025): 7834-7844.
- Lee, Changhee, et al. "Deephit: A deep learning approach to survival analysis with competing risks." Proceedings of the AAAI conference on artificial intelligence. Vol. 32. No. 1. 2018.

Artificial Intelligence (AI) Use Disclaimer

Claude (Anthropic) was used to assist with wording and phrasing of text content. All scientific content, data, and conclusions were reviewed and verified by the authors.