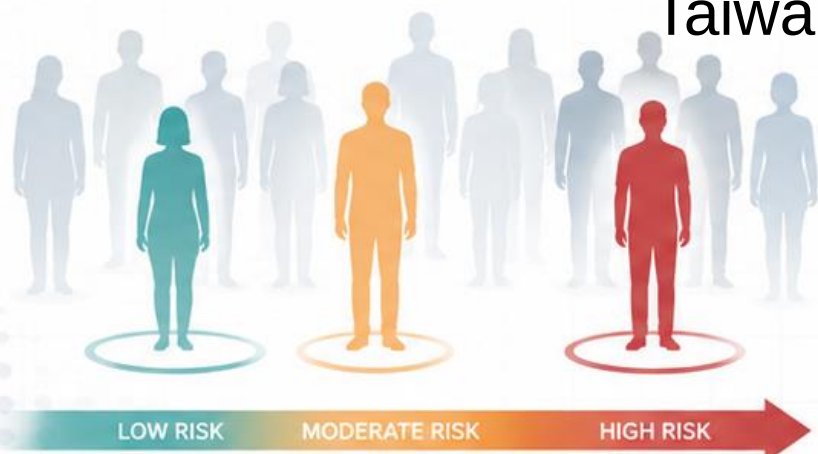


# Precision Lung Cancer Screening in Taiwan

**Dr Aiden Chen-Yang Hsu**

Taiwan Association of Medical Screening

2026-10-07



# Evidence-based Medicine of LDCT Screening for Heavy Smokers

## Benefit

Mortality Reduction  
21% (13-28%)

Small Size is Better

**NNS 222**

Number Needed to Screen to Prevent One Death

**Utility (QALY)**



Meta-  
analysis of  
LDCT RCTs



## Harm

Overdiagnosis  
18% (0-36%)

Large Size is Better

**NSO 270**

Number of Screen for One Over-diagnosis

**Cost**

EBM with Cost-effectiveness Analysis for LDCT Screening  
Ranging from \$ 1,464 – \$ 116,300

# Lung Cancer LDCT Screening Strategies

**NLST**

**Universal Screening +  
Lung RADS**

**NELSON/  
UKLS/  
K-LUCAS**

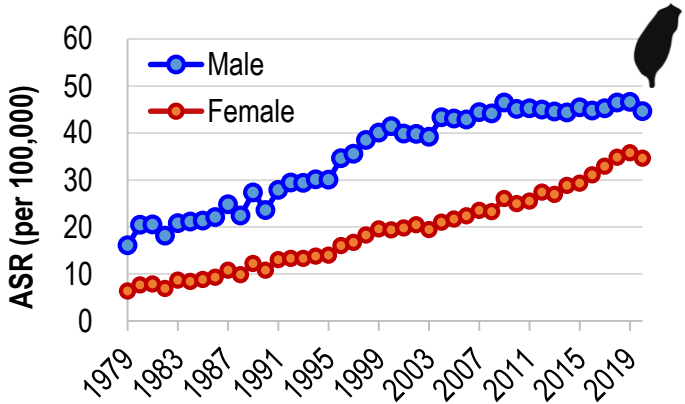
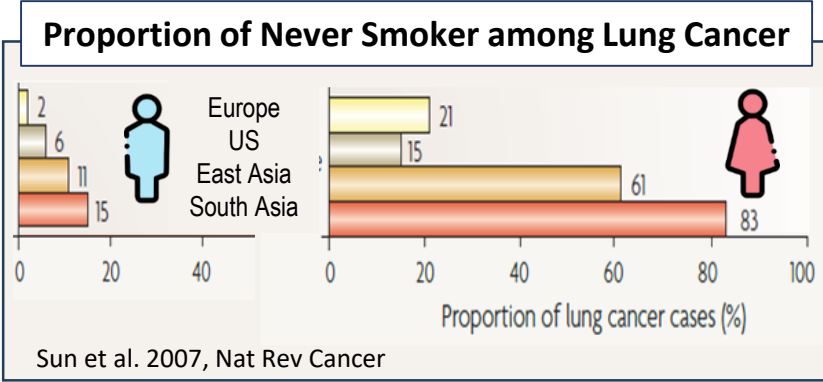
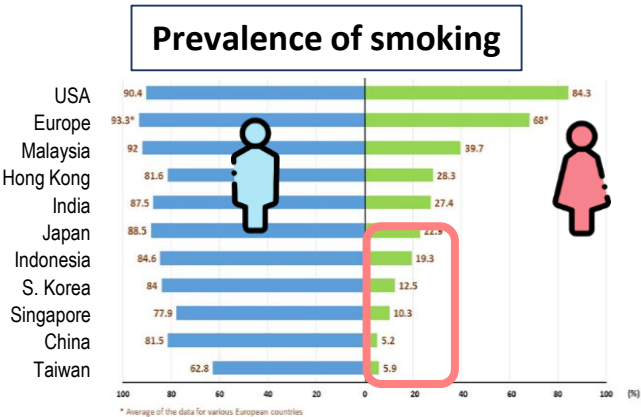
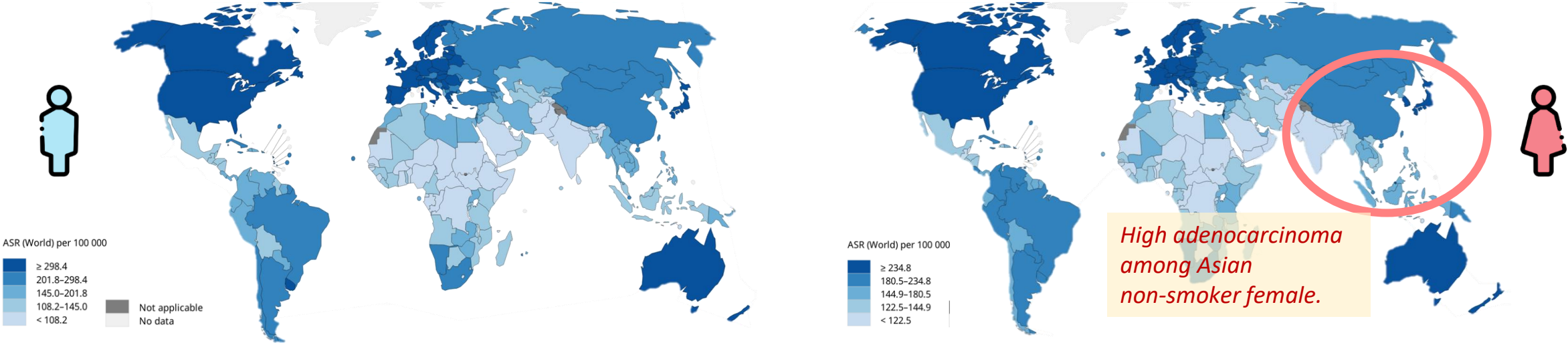
**Universal Screening /  
Triage of Nodular Management**

**Multi-model  
AI-Empowered  
Studies**

**Risk-based Screening/  
Triage of Nodule Management**

# Geographic and Gender Variations of Never-Smokers Among Lung Cancer

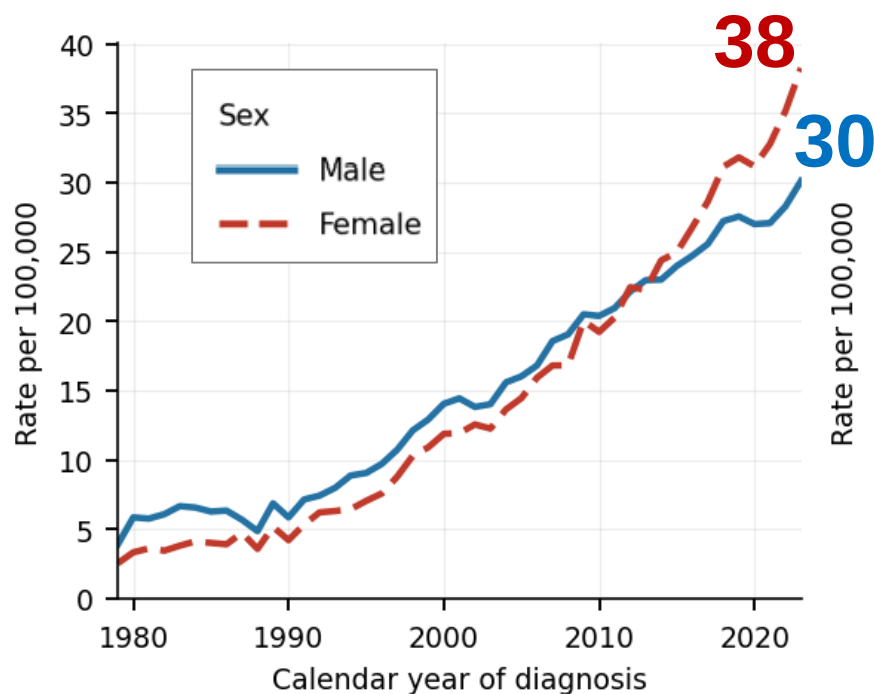
GLOBOCAN 2020



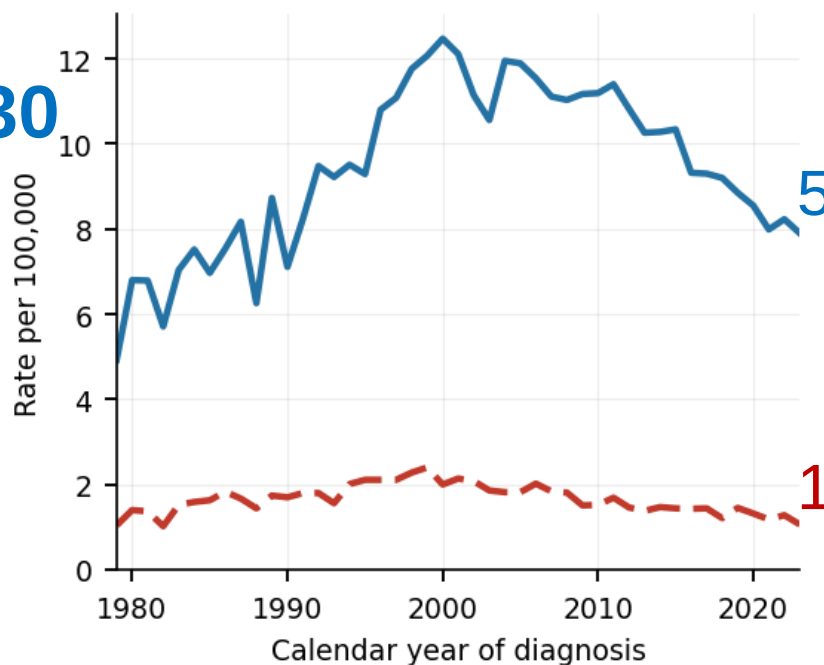
# Chronological trend of lung cancer by histological type, Taiwan 1979-2023

## Adenocarcinoma Epidemic

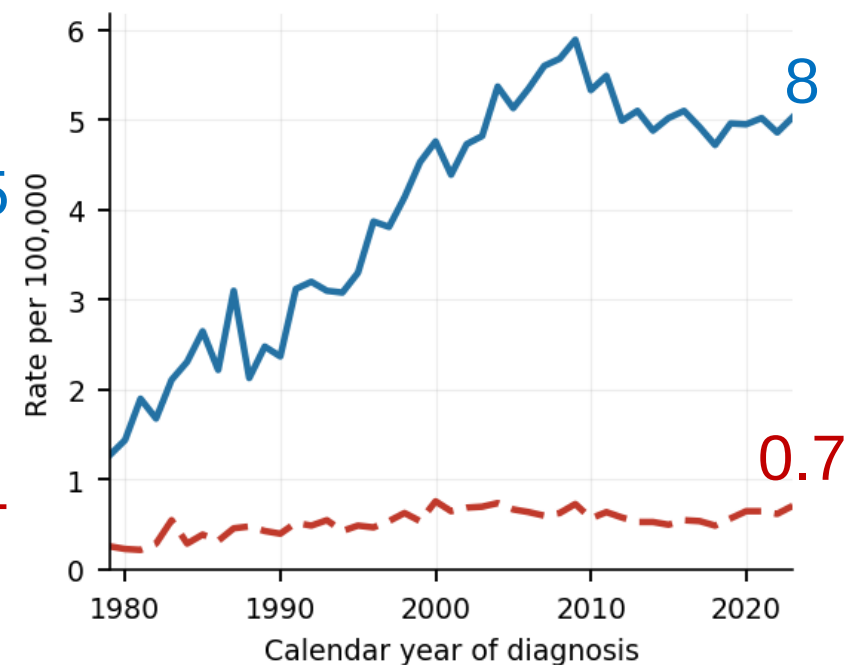
### Adenocarcinoma



### Squamous Cell Carcinoma



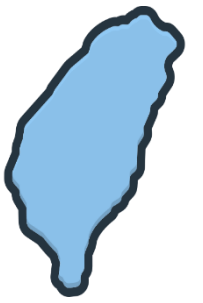
### Small Cell Carcinoma



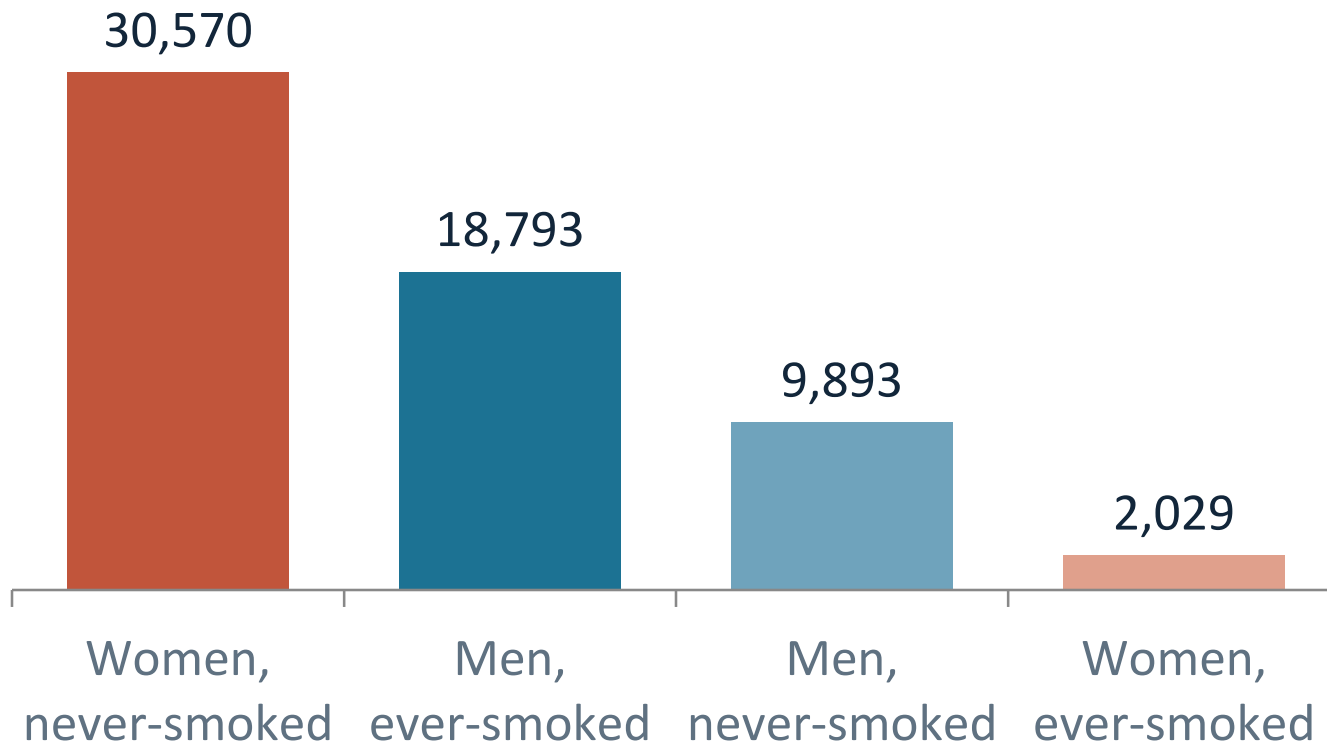
\*Age standardized incidence rate, per 100,000 (2000 world standard population)

## COMPOSITION

# Half of all adenocarcinomas: women who never smoked



Invasive lung adenocarcinoma,  
ages 40-84, 2011-2019 (n = 61,285)



**49.9%**

Of all lung adenocarcinoma

Women who had never smoked

**66.0%**

Occurred in never-smokers

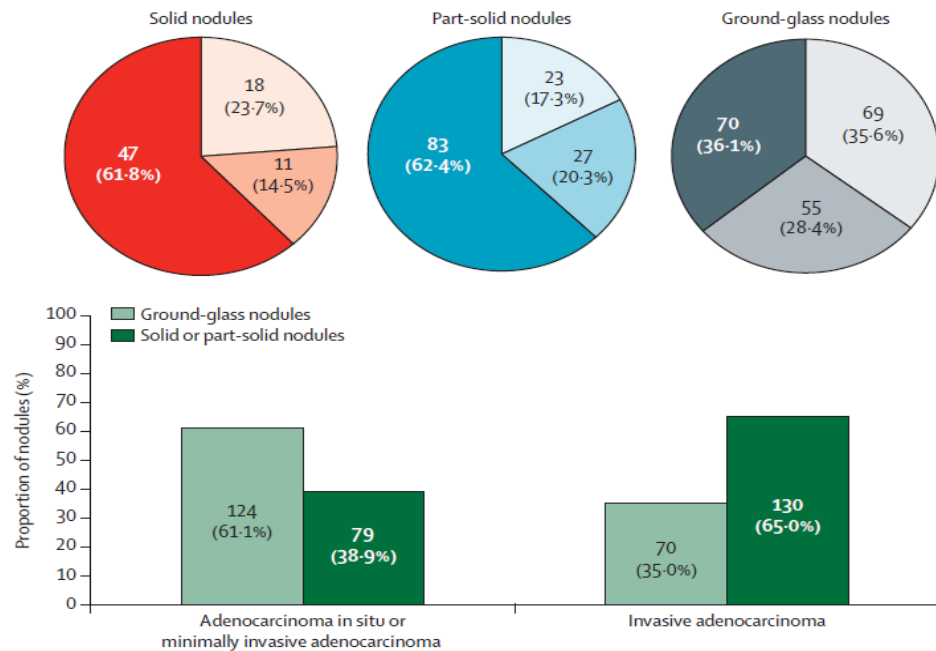
Combining both sexes

**Smoking-history-based eligibility would miss approximately two thirds of lung cancer cases.**

# Taiwan TALENT Study

Low-dose CT screening among never-smokers with or without a family history of lung cancer in Taiwan: a prospective cohort study

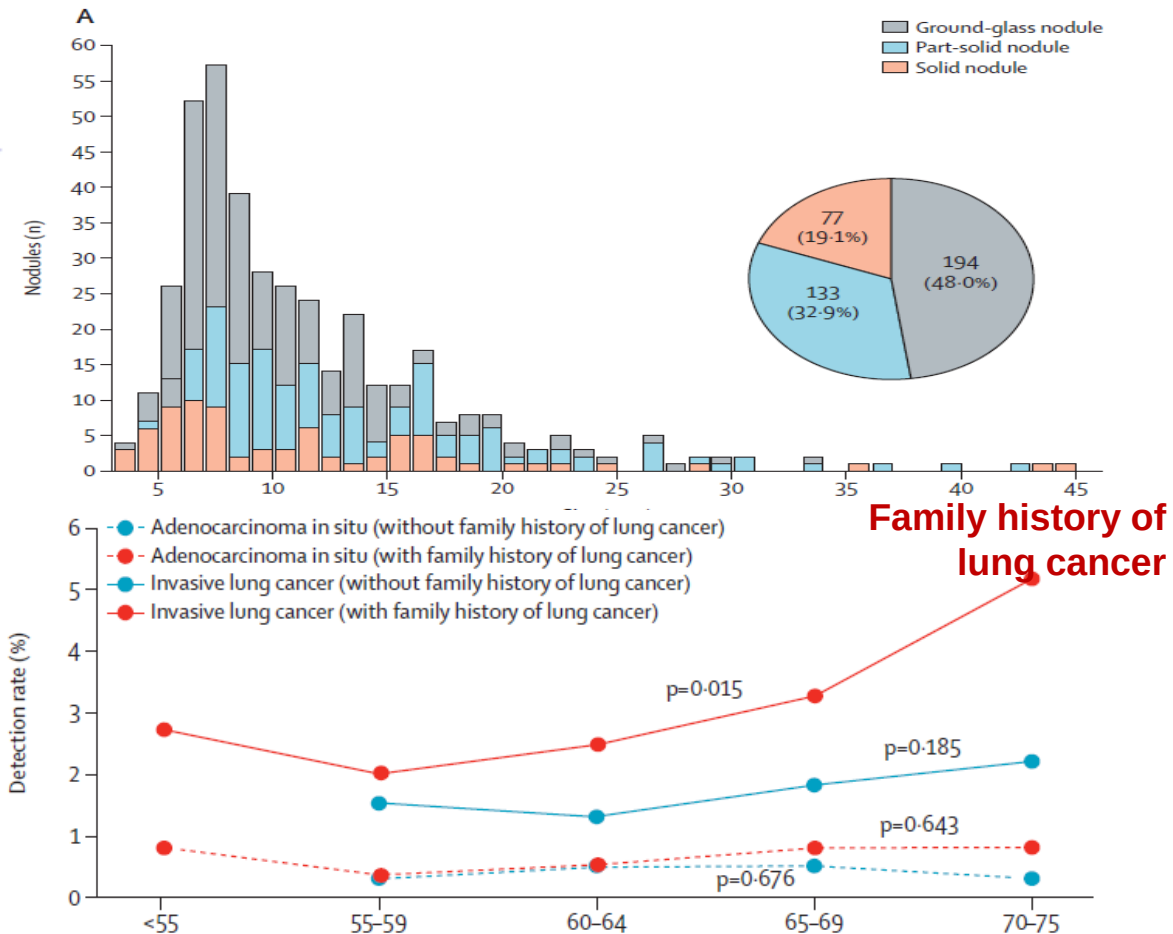
Gee-Chen Chang\*, Chao-Hua Chiu\*, Chong-Jen Yu\*, Yuen-Chung Chang, Ya-Hsuan Chang, Kuo-Hsuan Hsu, Yu-Chung Wu, Chih-Yi Chen, Hsian-He Hsu, Ming-Ting Wu, Cheng-Ta Yang, Inn-Wen Chong, Yu-Ching Lin, Te-Chun Hsia, Meng-Chih Lin, Wu-Chou Su, Chih-Bin Lin, Kang-Yun Lee, Yu-Feng Wei, Gong-Yau Lan, Wing P Chan, Kao-Lun Wang, Mei-Han Wu, Hao-Hung Tsai, Chih-Feng Chian, Ruay-Sheng Lai, Jin-Yuan Shih, Chi-Liang Wang, Jui-Sheng Hsu, Kun-Chieh Chen, Chun-Ku Chen, Jiun-Yi Hsia, Chung-Kan Peng, En-Kuei Tang, Chia-Lin Hsu, Teh-Ying Chou, Wei-Chih Shen, Ying-Huang Tsai, Chun-Ming Tsai, Yuh-Min Chen, Yu-Chin Lee, Hsuan-Yu Chen, Sung-Liang Yut, Chien-Jen Chen†, Yung-Liang Wang†, Chao Agnes Hsiung†, Pan-Chyr Yang, on behalf of the TALENT Investigators‡



In 2011–2015, **53%** of new cases occurred in non-smokers  
**93% of female patients** had never smoked

Family history of lung cancer, secondhand smoke, tuberculosis or chronic lung disease, higher cooking index, and unventilated cooking

**Female sex, family history of lung cancer, age >60 years**



Of 12,011 LDCT screenings, 2,094 (17.4%) were positive; of the 12,011 participants, 318 (2.6%) were diagnosed with lung cancer, including 257 (2.1%) with invasive lung cancer and 61 (0.5%) with adenocarcinoma in situ.

# Taiwan National Low-Dose Computed Tomography (LDCT) Lung Cancer Screening Program

Eligibility criteria for individuals at high risk of lung cancer



Health  
Promotion  
Administration  
Ministry of Health and Welfare,  
Taiwan



## First-degree family history of lung cancer

- Men: 50–74 years of age
- Women: 45–74 years of age



## Heavy smokers

- Age: 50–74 years
- Smoking exposure:  $\geq 20$  pack-years
- Current smokers or former smokers who quit within the past 15 years



## National LDCT Screening Program

LDCT screening with smoking-cessation counseling when indicated

Program start  
July 1,  
2022

Program end  
December 31,  
2025



Number of participants **277,599**



Lung cancers detected **3,247**

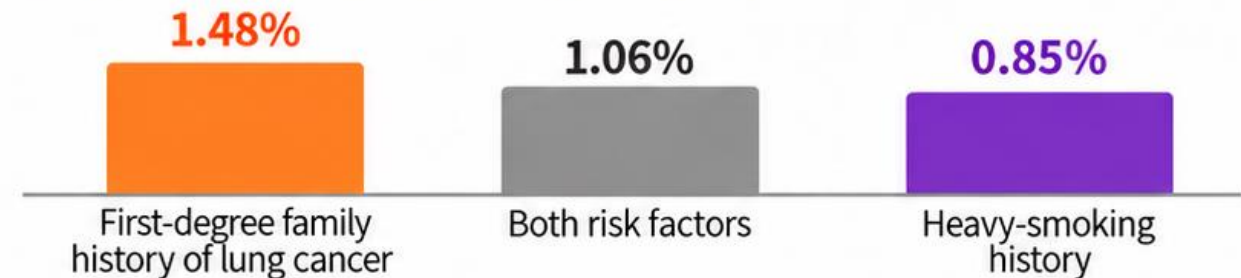


Detection rate **1.17%**

### Distribution of screened participants



### Lung cancer detection rates by risk group

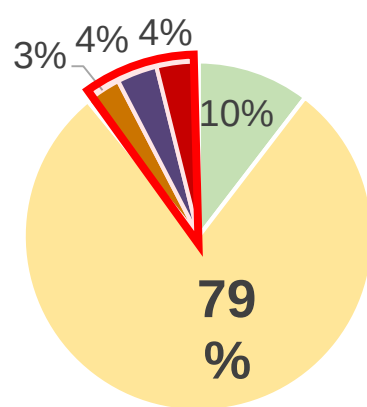


# Proportional stage shift

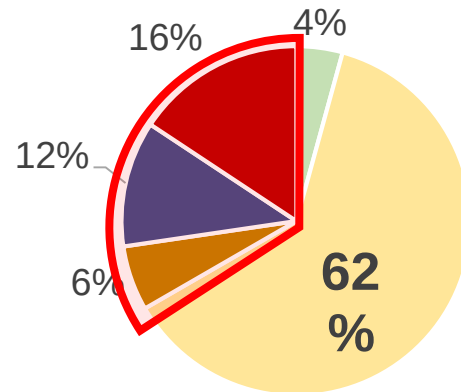
## Taiwan LDCT screening

**Stage Distribution of Taiwan Nationwide LDCT Screening**  
(2022/7/1-2025/12/31)

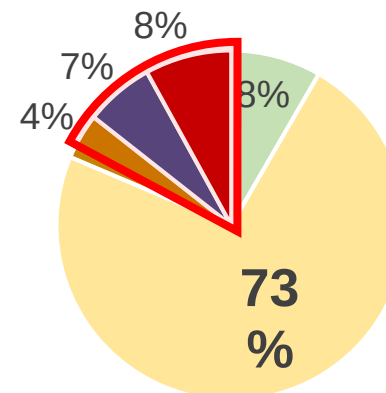
Family History



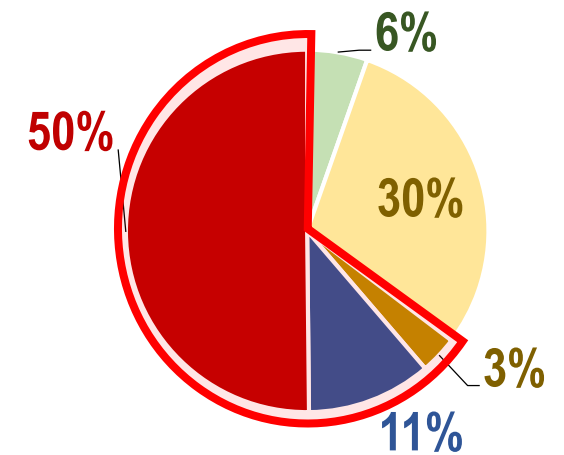
Heavy Smokers



Overall



**Stage Distribution Before Nationwide Program, 2021**



**Stage II+**

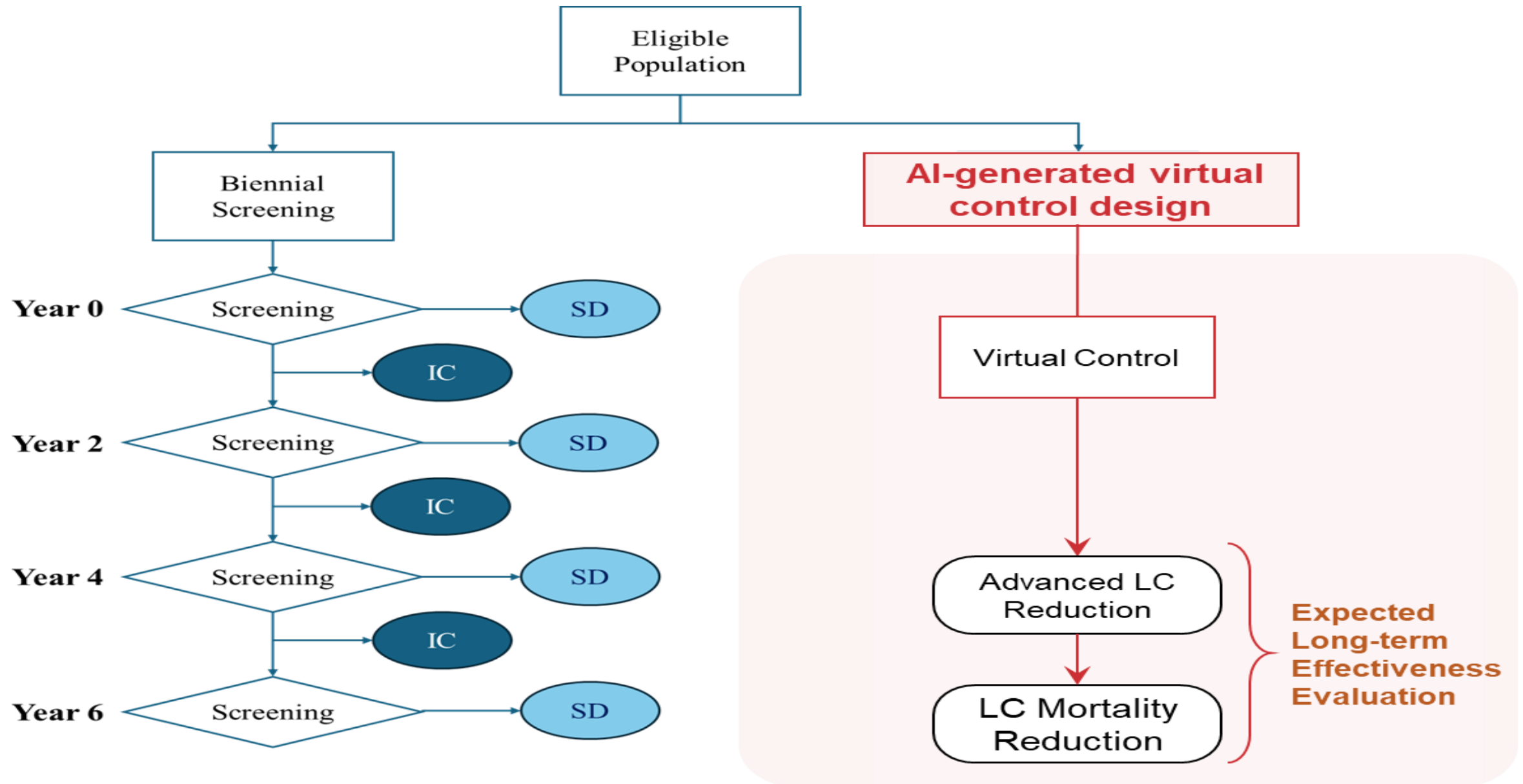
**11%**

**32%**

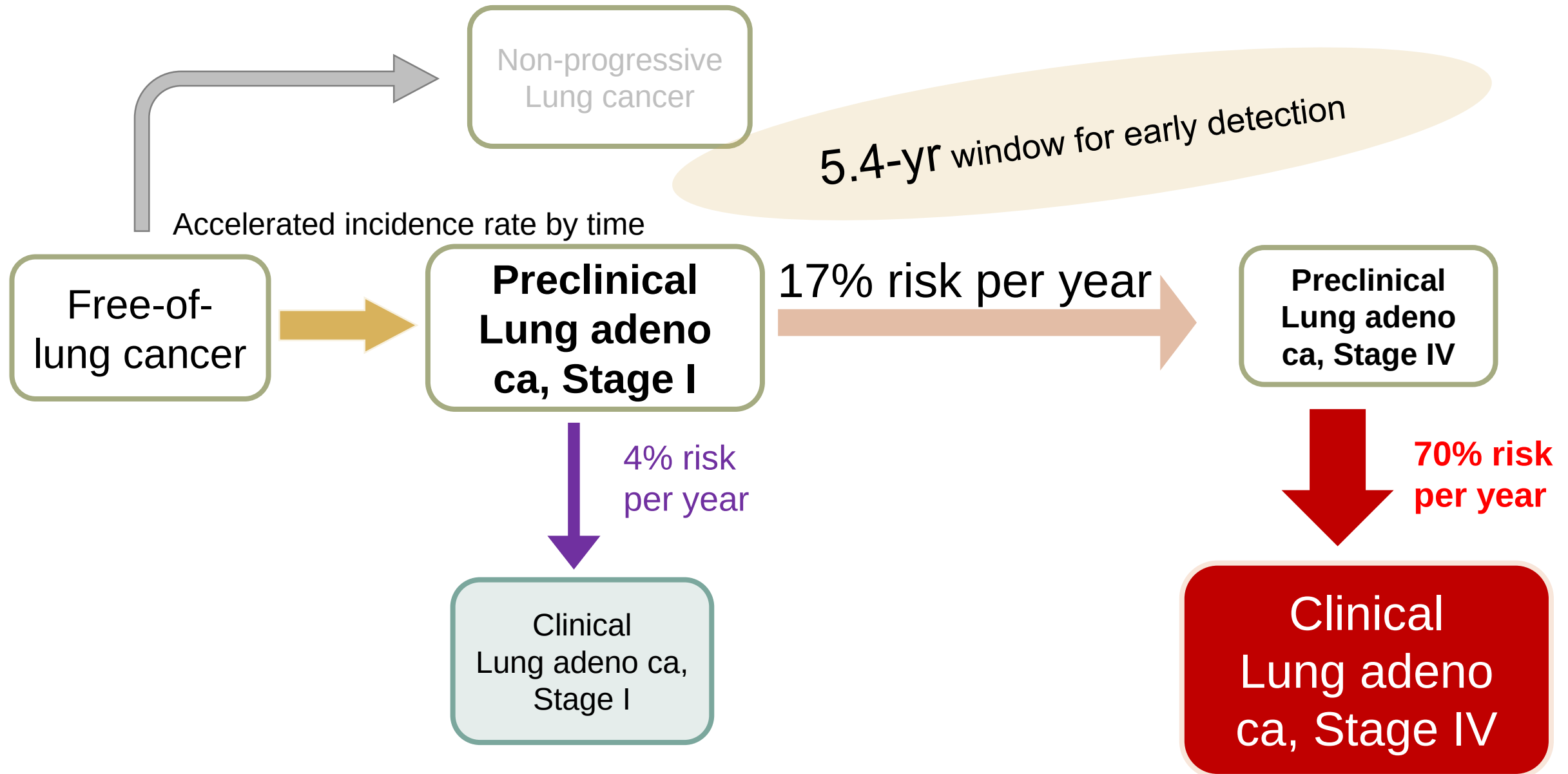
**19%**

**64%**

# Digital twin design for the evaluation of LDCT screening

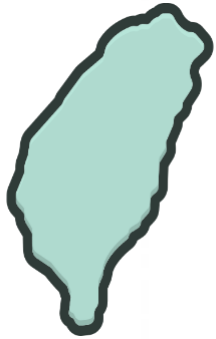


# Natural history of lung adenocarcinoma

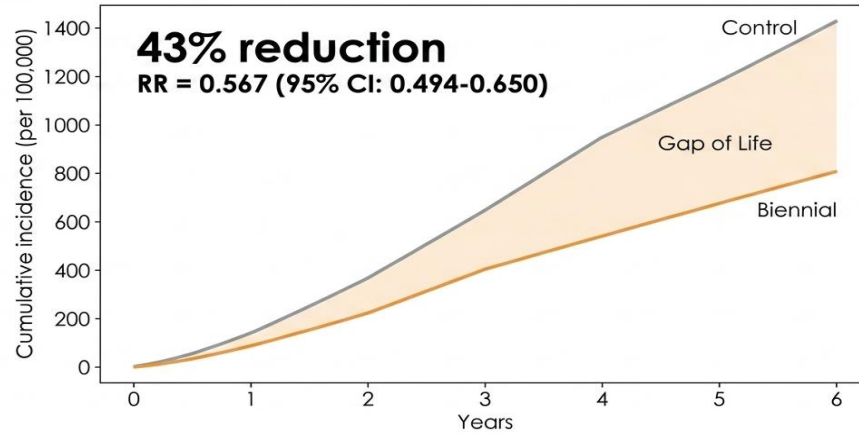


# Projected Long-Term Benefit: Heavy Smokers

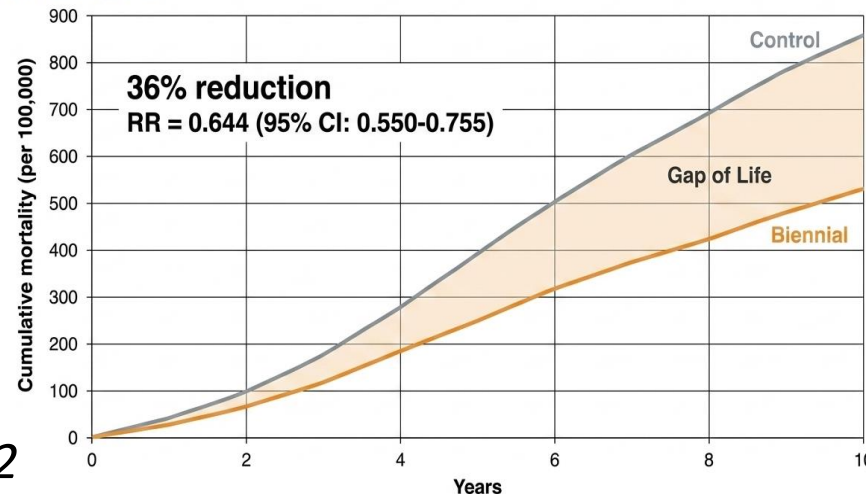
Advanced lung cancer (Stage 2+) among participants with heavy smokers



TAIWAN



Mortality of lung cancer among heavy smokers



Reduced Lung-Cancer Mortality with Volume CT Screening  
in a Randomized Trial

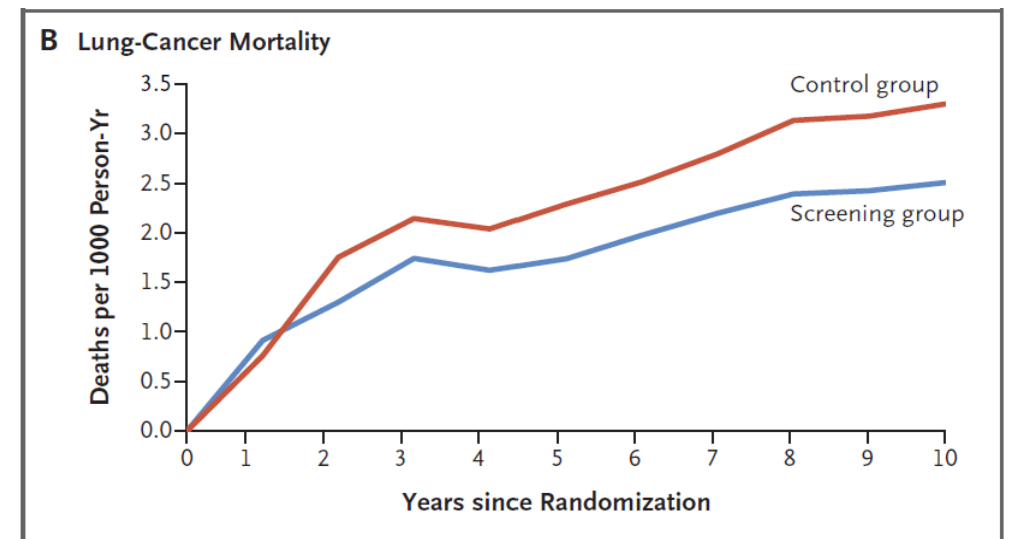
H.J. de Koning, C.M. van der Aalst, P.A. de Jong, E.T. Scholten, K. Nackaerts, M.A. Heuvelmans, J.-W.J. Lammers,

**NELSON**

2003.12 ~ 2006.07

**Lung-cancer mortality**

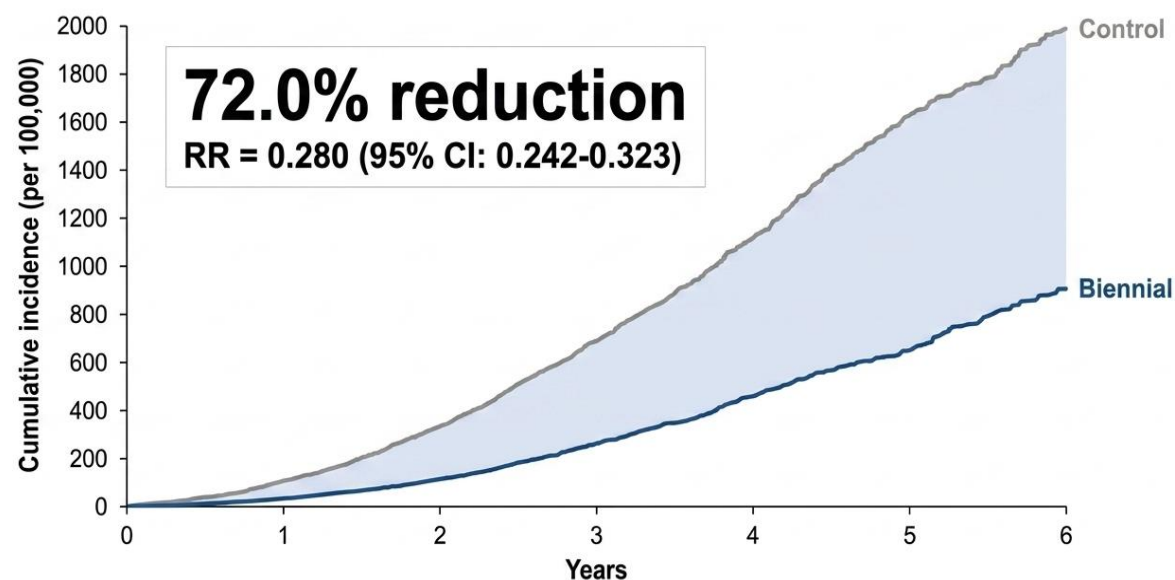
**RR=0.76** (0.61-0.94) at 10-year follow-up among  
male participants



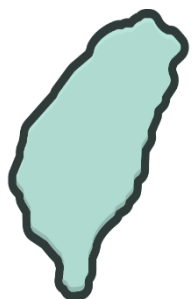
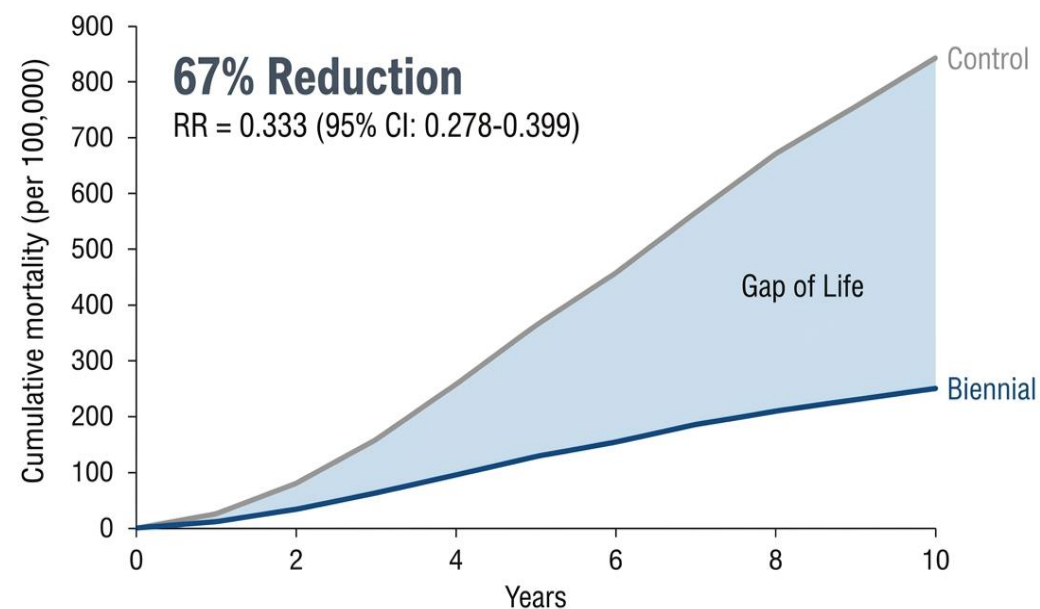
2022.07 ~ 2025.12

# Projected Long-Term Benefit: Non-Smokers with LCFH

## Advanced lung cancer (Stage 2+) among nonsmokers with LCFH

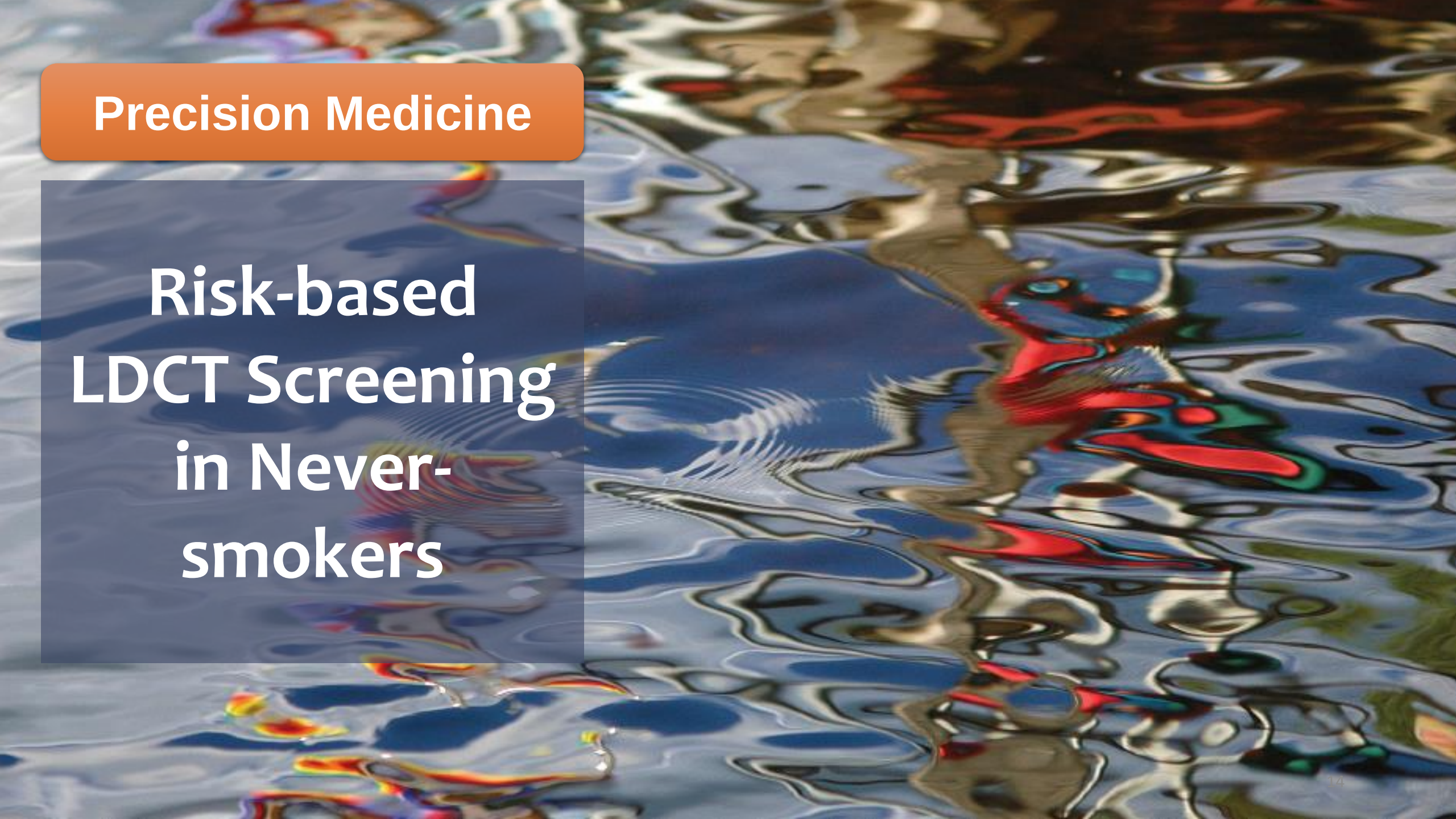


## Mortality of lung cancer among nonsmokers with LCFH



TAIWAN

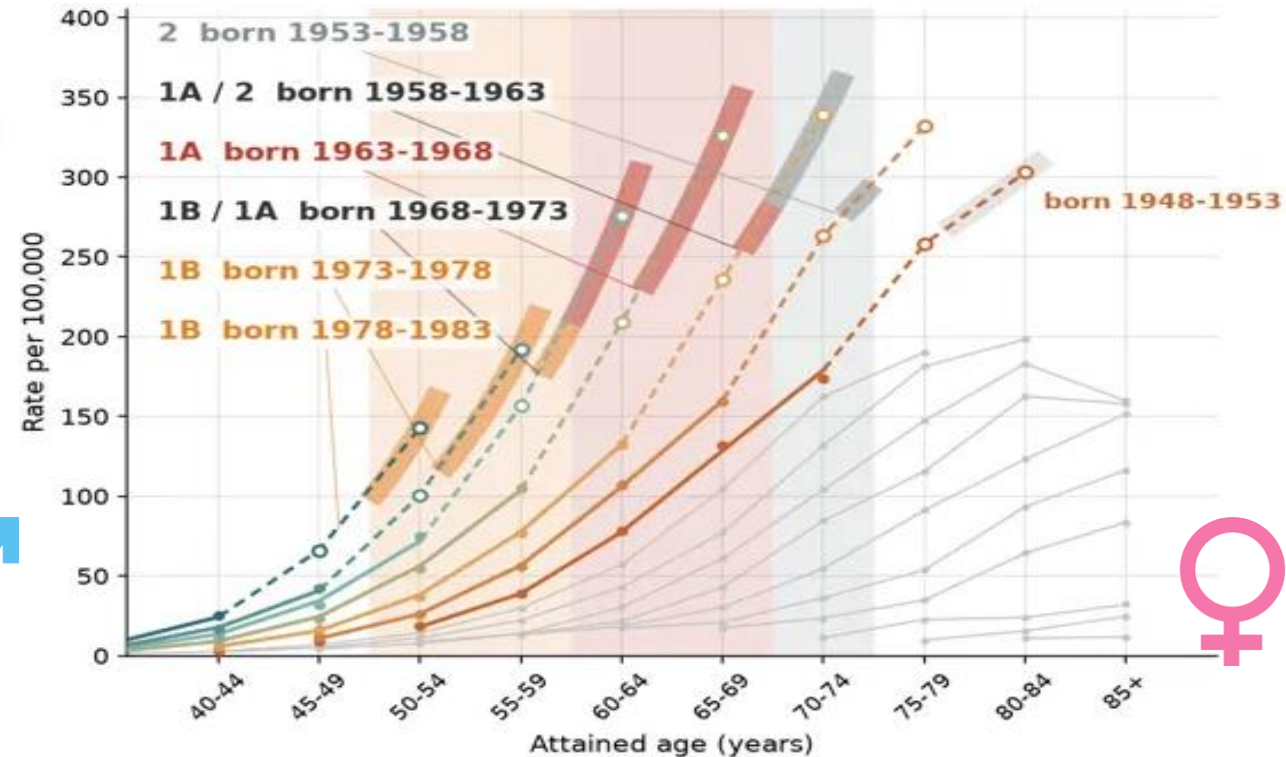
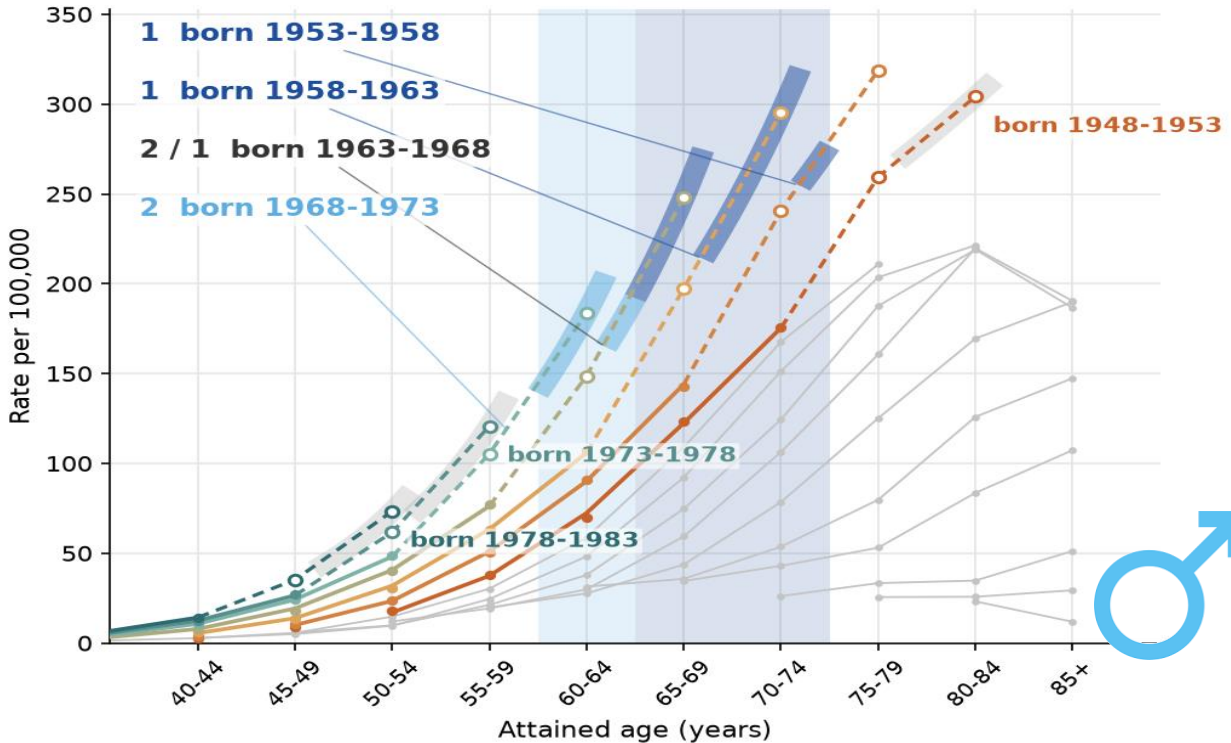
2022.07 ~ 2025.12



## Precision Medicine

# Risk-based LDCT Screening in Never- smokers

# Identification of high-risk birth cohorts for Female and Male in Taiwan



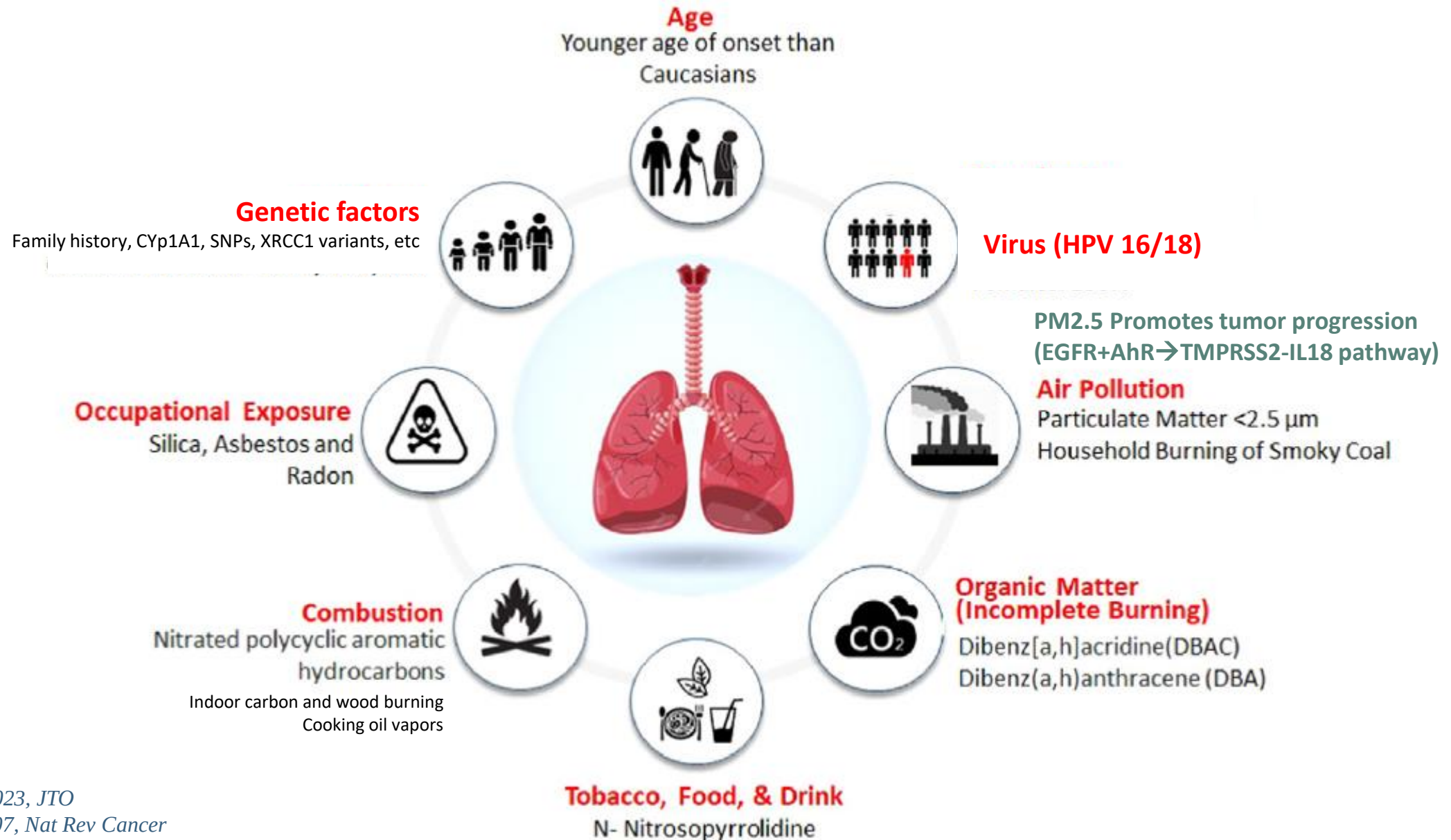
## Conventional eligibility

- Constructed around smoking exposure
- Individual-level risk assessment
- Static, age-threshold entry criteria
- Poor fit for never-smoker adenocarcinoma

## Cohort-informed complement

- Attained age — biological accumulation of risk
- Birth cohort — generational exposure profile
- Calendar period — ascertainment and access
- Built for a rising adenocarcinoma burden

# Biological and environmental factors for lung cancer among never smokers



# Data Collection Framework for Community-based Lung Cancer Screening

## 1. Demographic and Baseline Information



### A. Participant characteristics

- Sex
- Age at screening
- Educational attainment



### B. Anthropometric and geographic information

- Height and weight
- Body mass index
- Residential address and geographic area



### C. Screening context

- Screening hospital
- Examination date and screening year
- Repeat screening status

## 2. Risk Factors Collected



### A. Smoking and second-hand smoke

- Smoking status
- Smoking intensity, duration, and pack-years
- Years since cessation
- Household second hand smoke exposure



### B. Family and medical history

- Family history of lung cancer
- History of pulmonary disease
- History of tuberculosis
- History of breast cancer
- Family history of breast cancer



### C. Household and environmental exposures

- Cooking oil fume exposure
- Indoor passive-related exposure
- Industrial area related exposure
- Power plant or incinerator related exposure

## 3. Occupational and Exposure-Related Recruitment Groups



### A. Occupational groups collected in the program

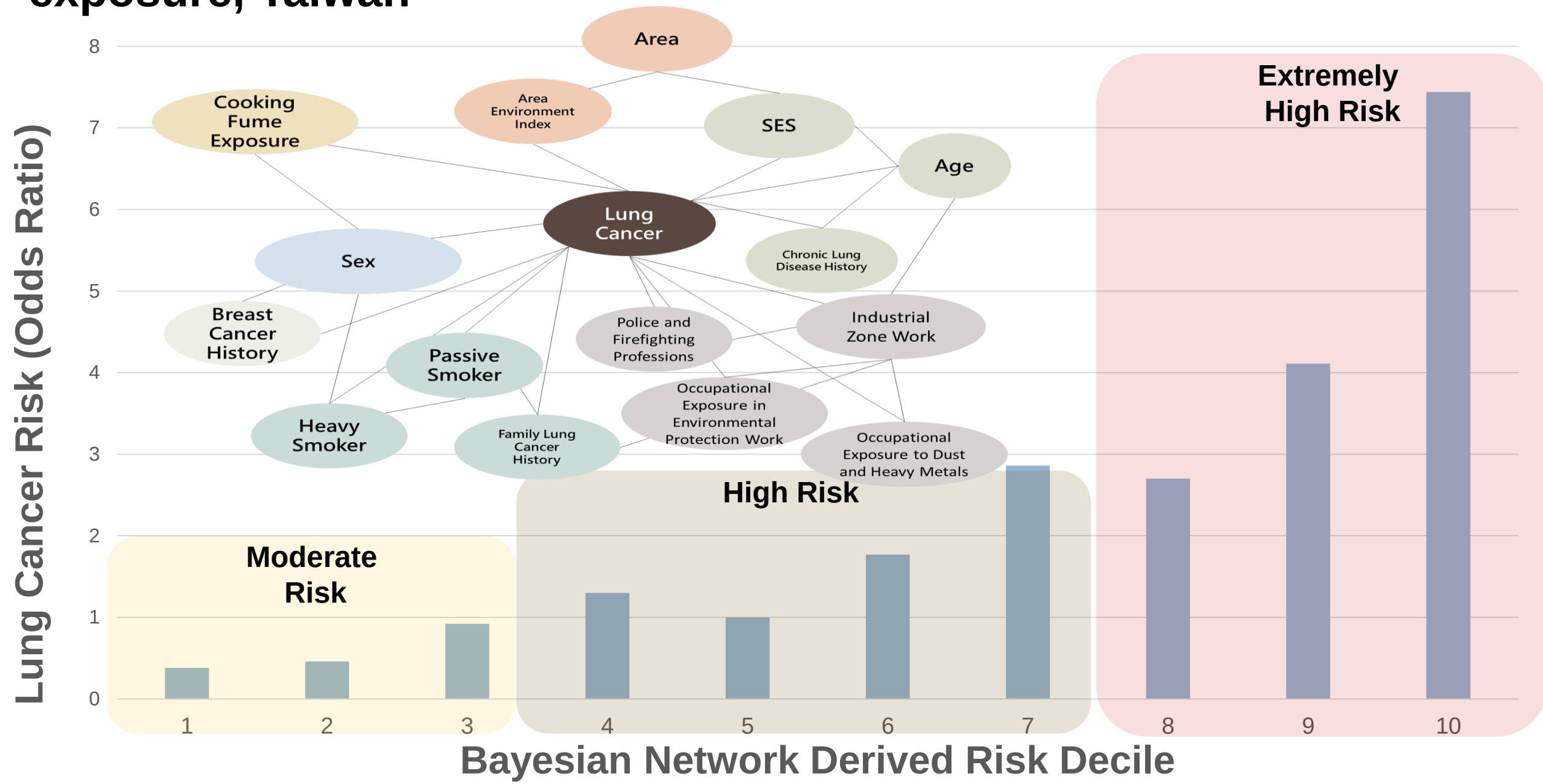
- Environmental sanitation and cleaning workers
- Police, firefighters, and traffic-related personnel
- Workers with asbestos exposure
- Workers exposed to arsenic, cadmium, nickel, or other dusts
- Workers with prolonged cooking oil fume exposure



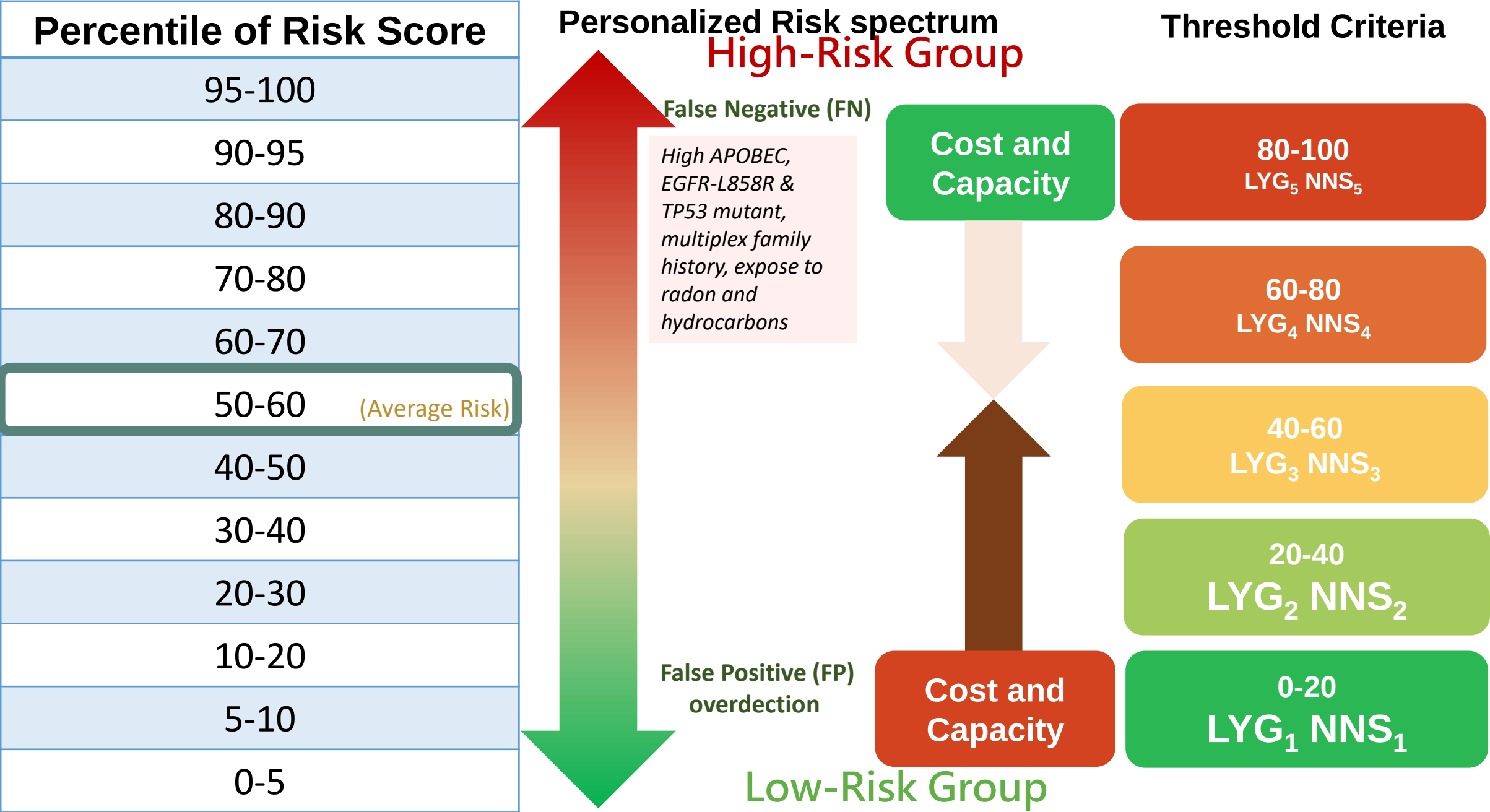
### B. Other exposure-related program groups

- Temple related exposure group
- Industrial area related exposure group
- Power plant or incinerator related exposure group

# Bayesian prediction model for occupational and environmental exposure, Taiwan

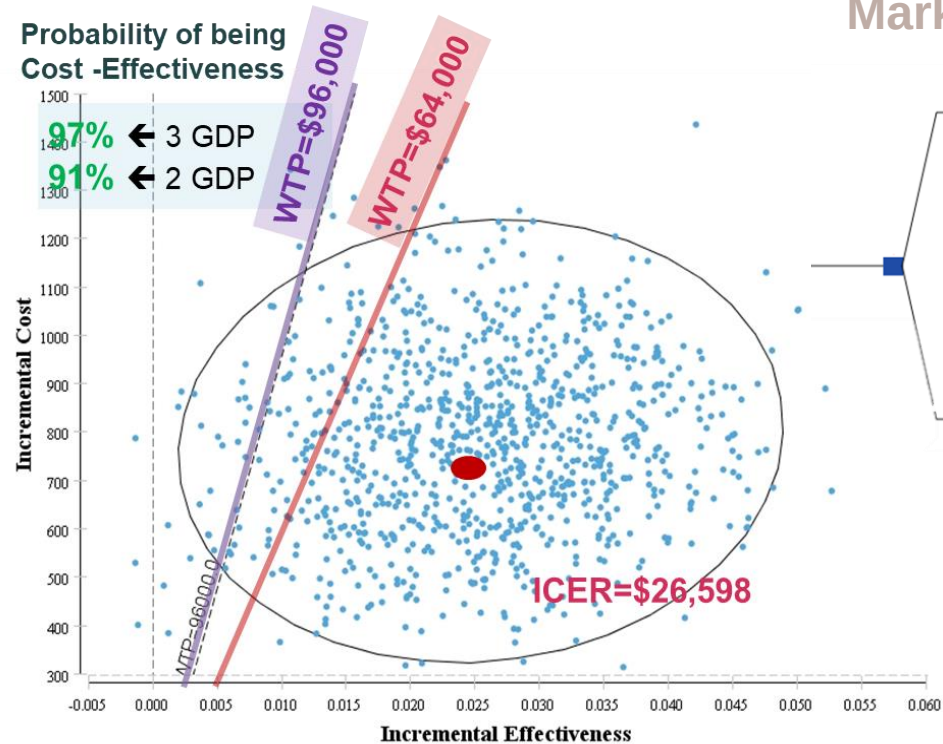


# Personalized risk score and threshold criteria

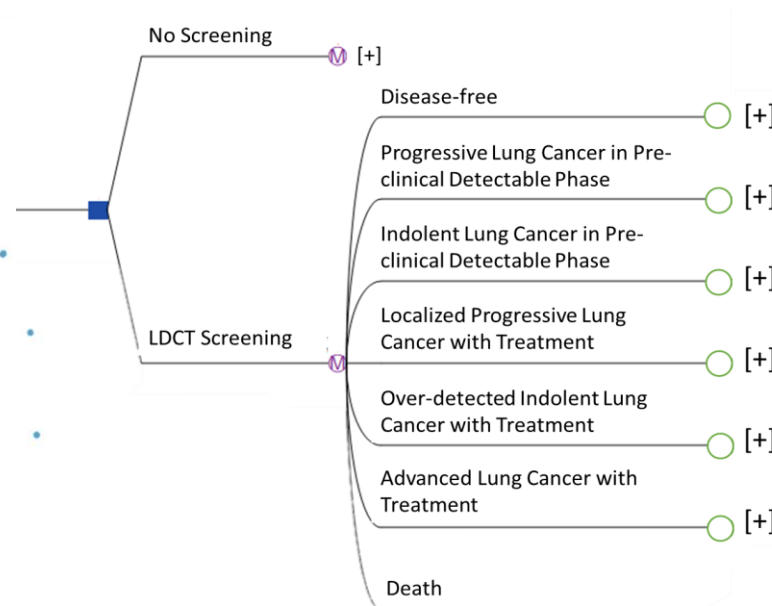


# Cost-Effectiveness Analysis of Biennial LDCT Lung Cancer Screening for Heavy Smokers

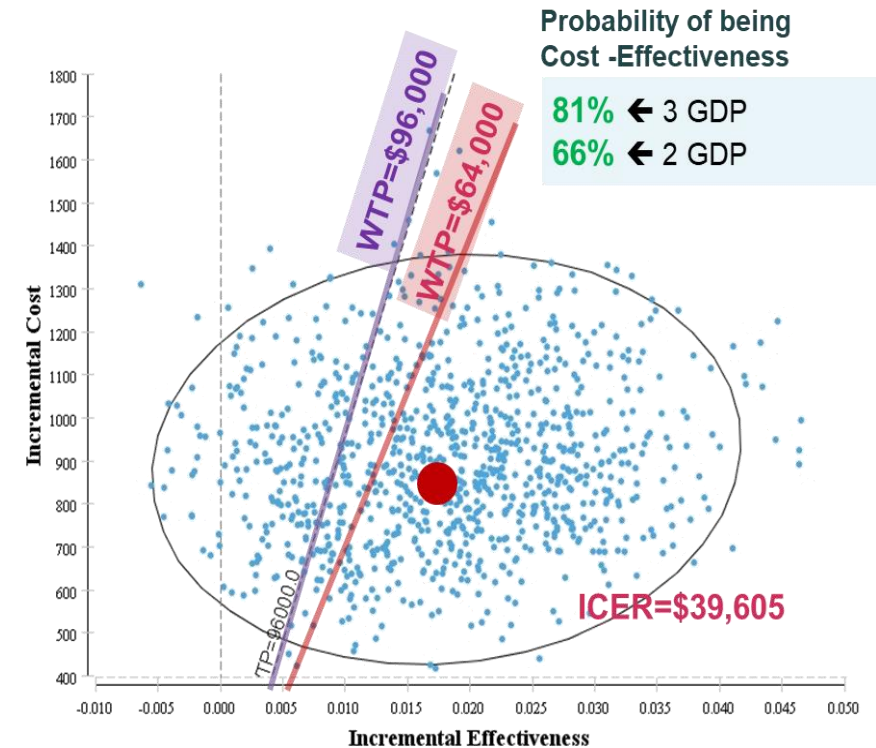
## Scenario 1: No over-detection



## Bayesian Cost-effectiveness Markov Decision Tree Analysis



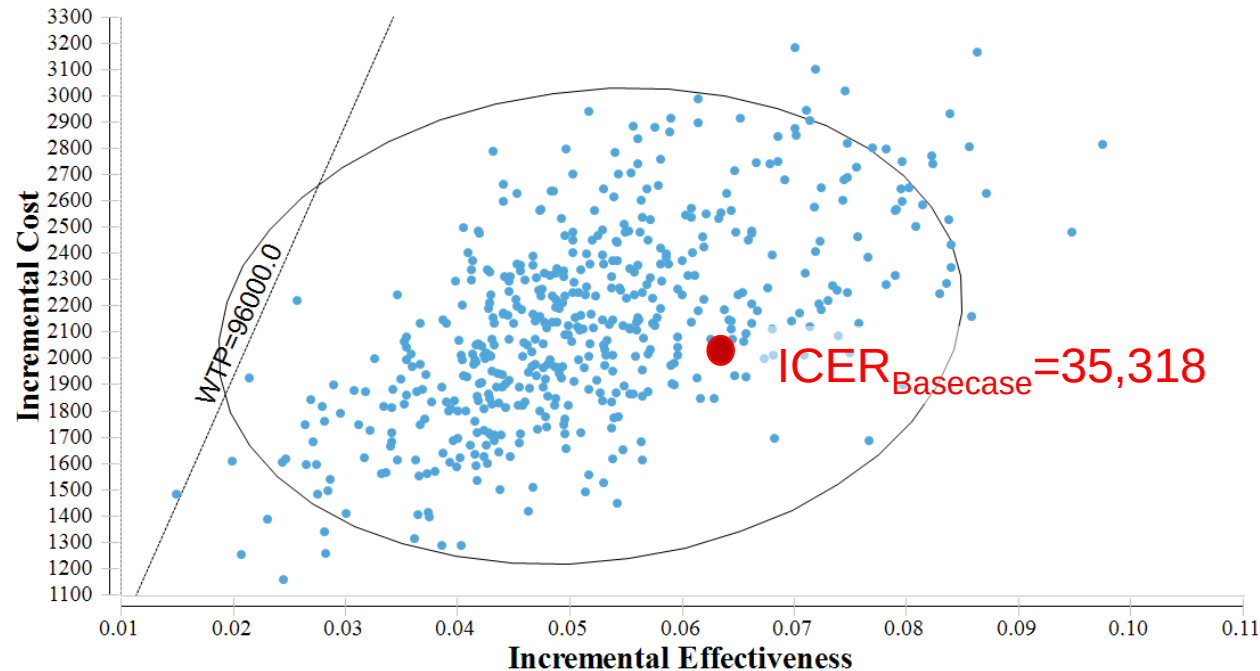
## Scenario 2: 20% over-detection



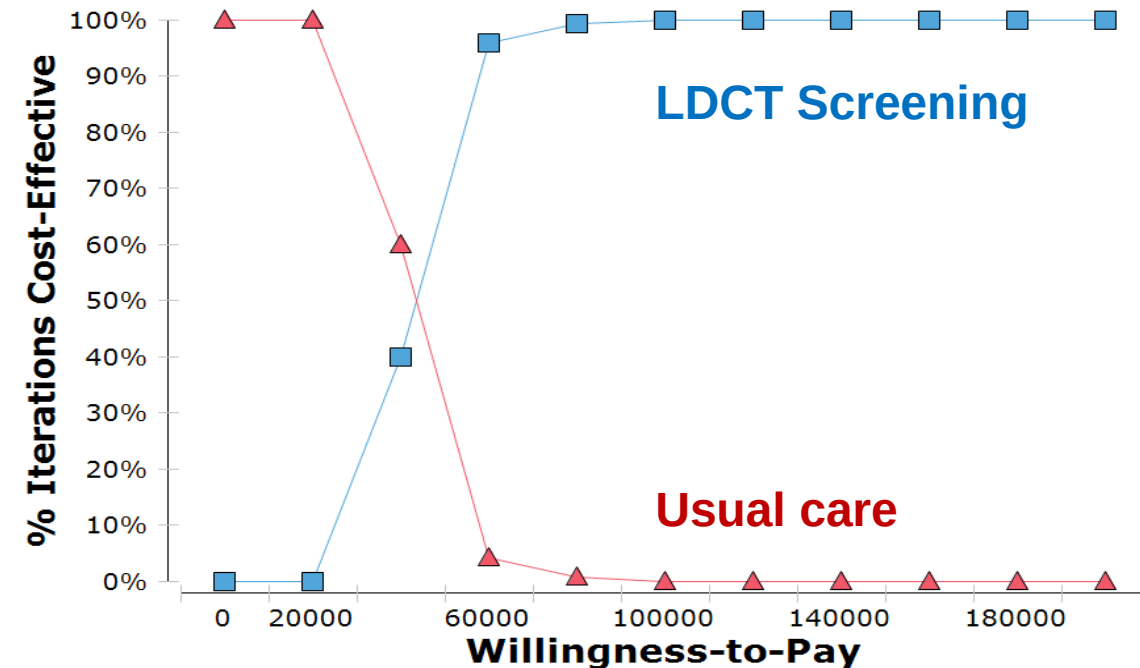
ICER: Incremental Cost Effectiveness Ratio

# Cost-effectiveness Analysis for LDCT screening for non-smokers in the Talent program

Incremental Cost-effectiveness, LDCT Screening vs Usual care



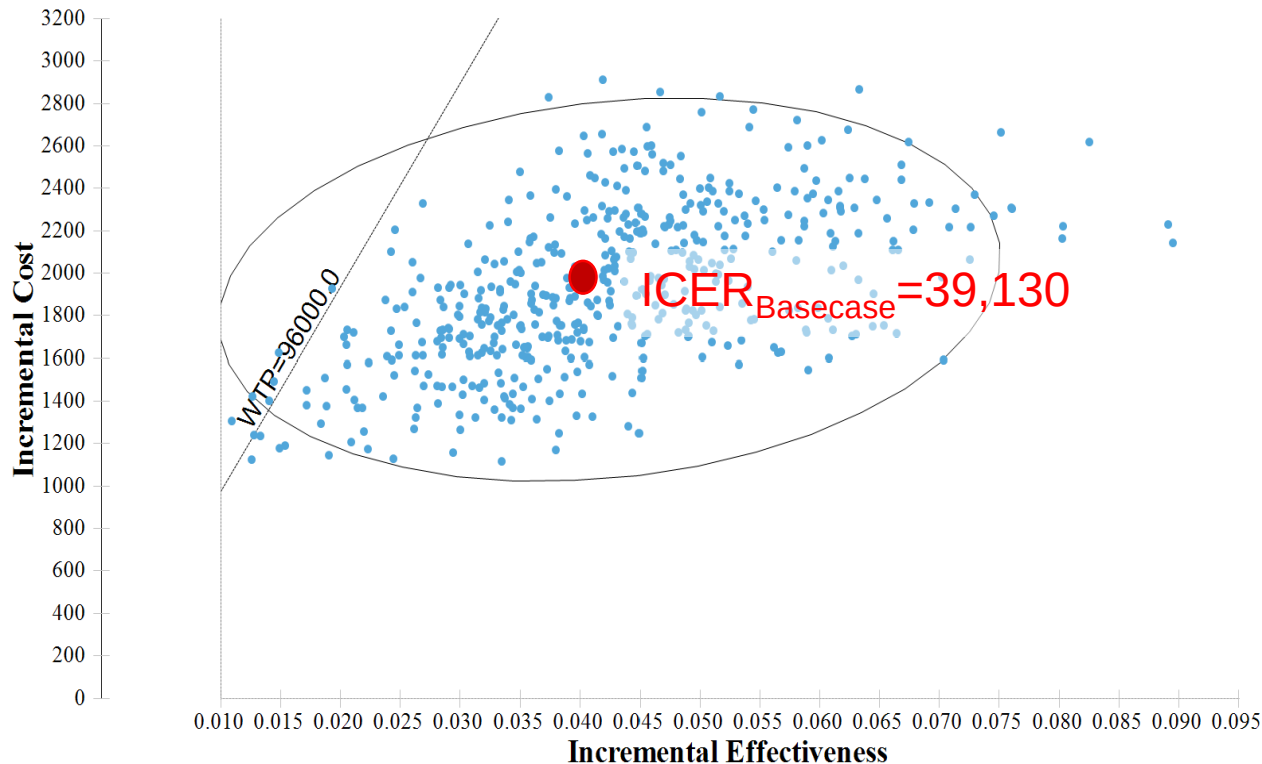
Acceptability Curve



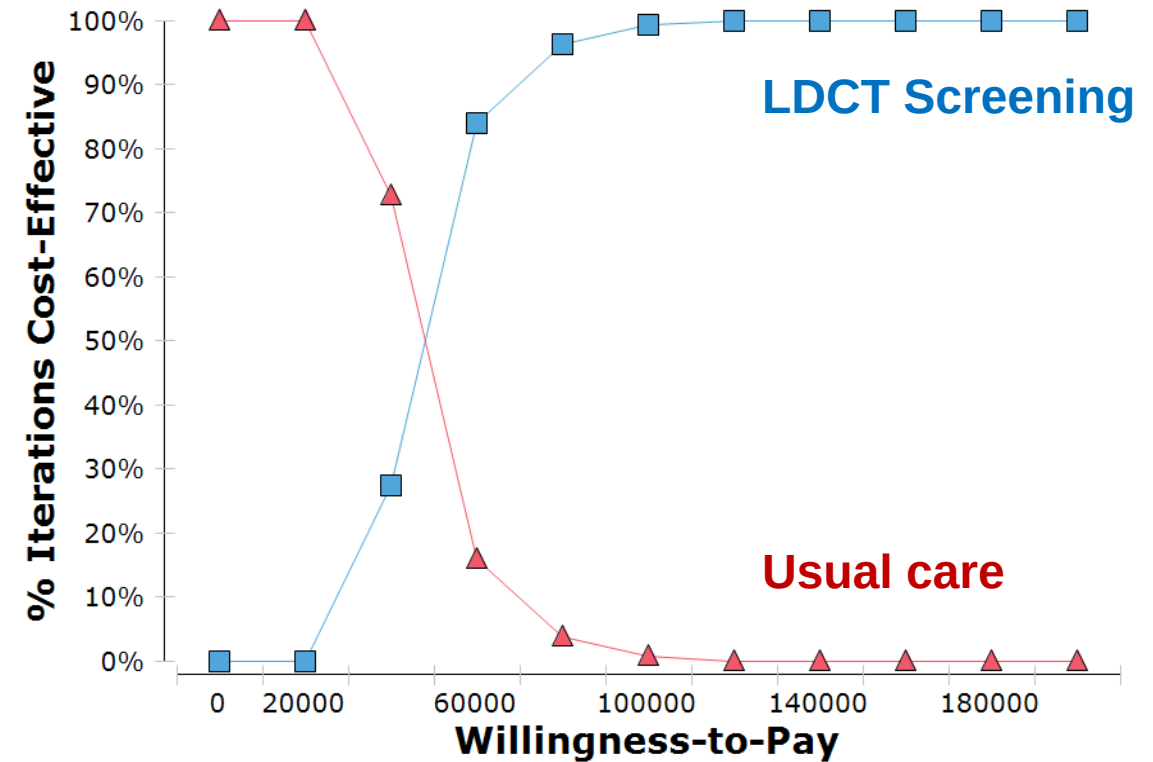
% of being cost-eff at 3GDP: 99.8%  
% of being cost-eff at 2GDP: 97.6%

# Cost-effectiveness Analysis for LDCT screening for non-smokers (with family hx) in the HPA program

Incremental Cost-effectiveness, LDCT Screening vs Usual care

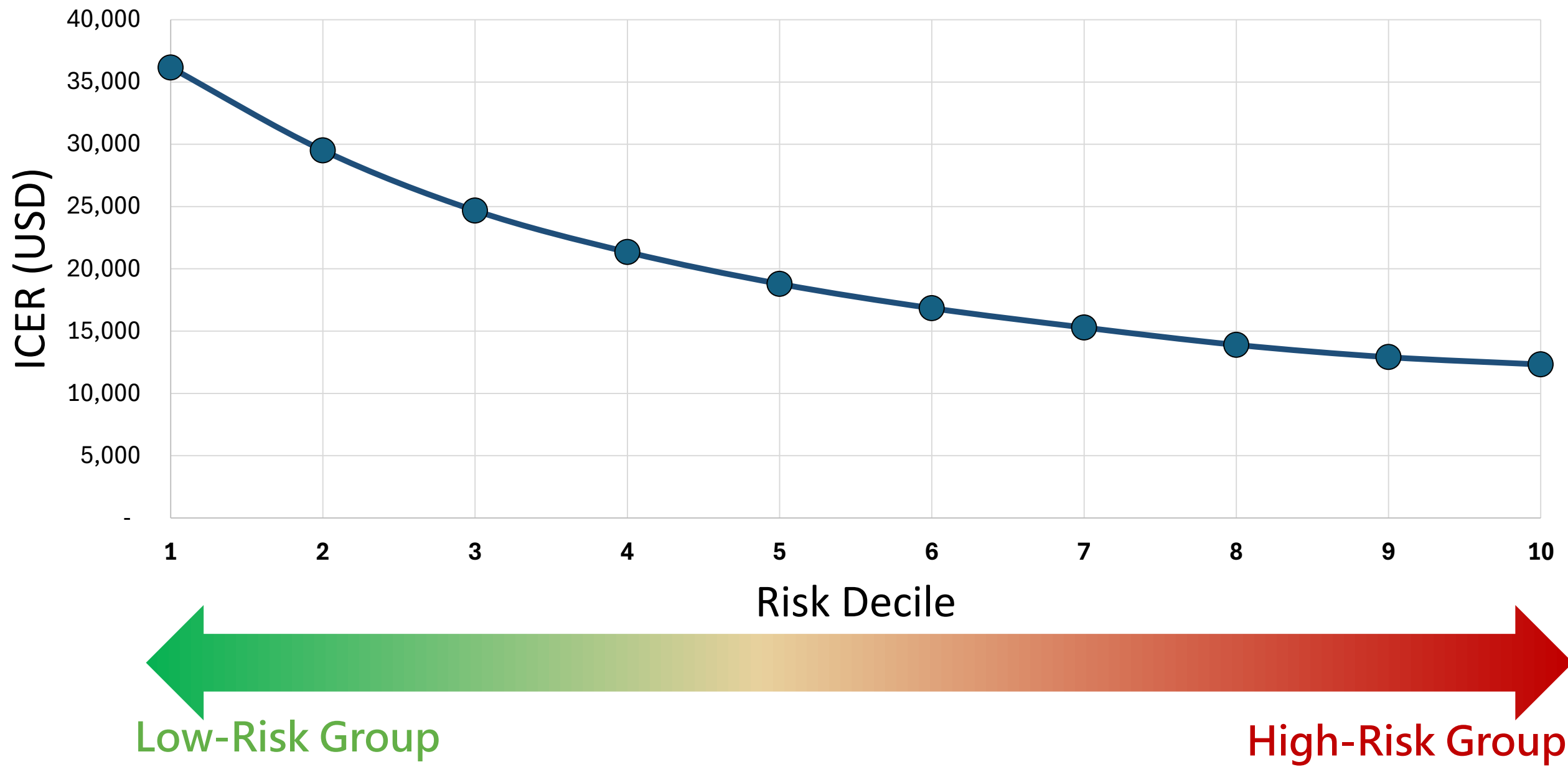


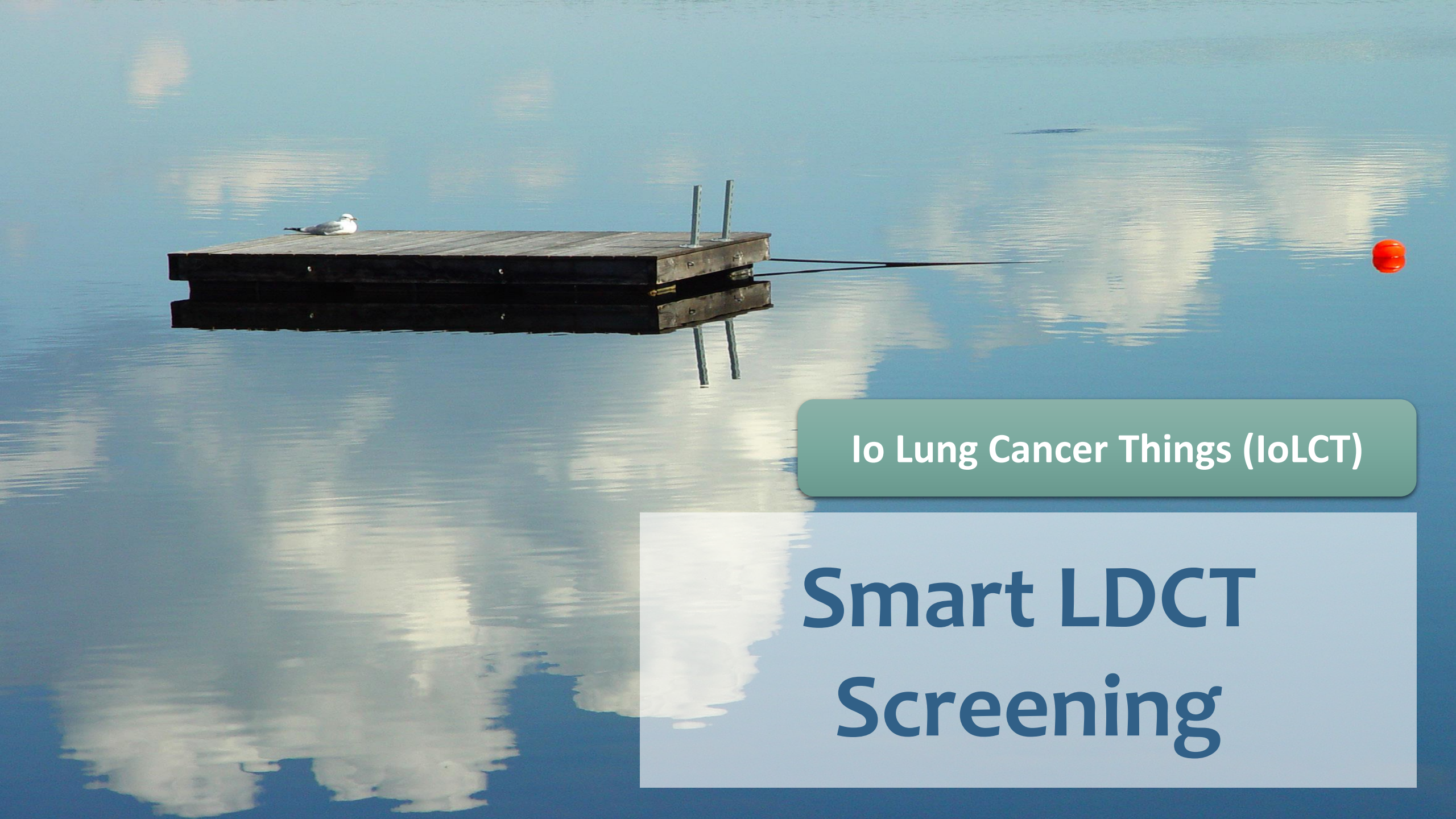
Acceptability Curve



% of being cost-eff at 3GDP: 98.6%  
% of being cost-eff at 2GDP: 88.8%

# Risk threshold for cost-effectiveness criteria



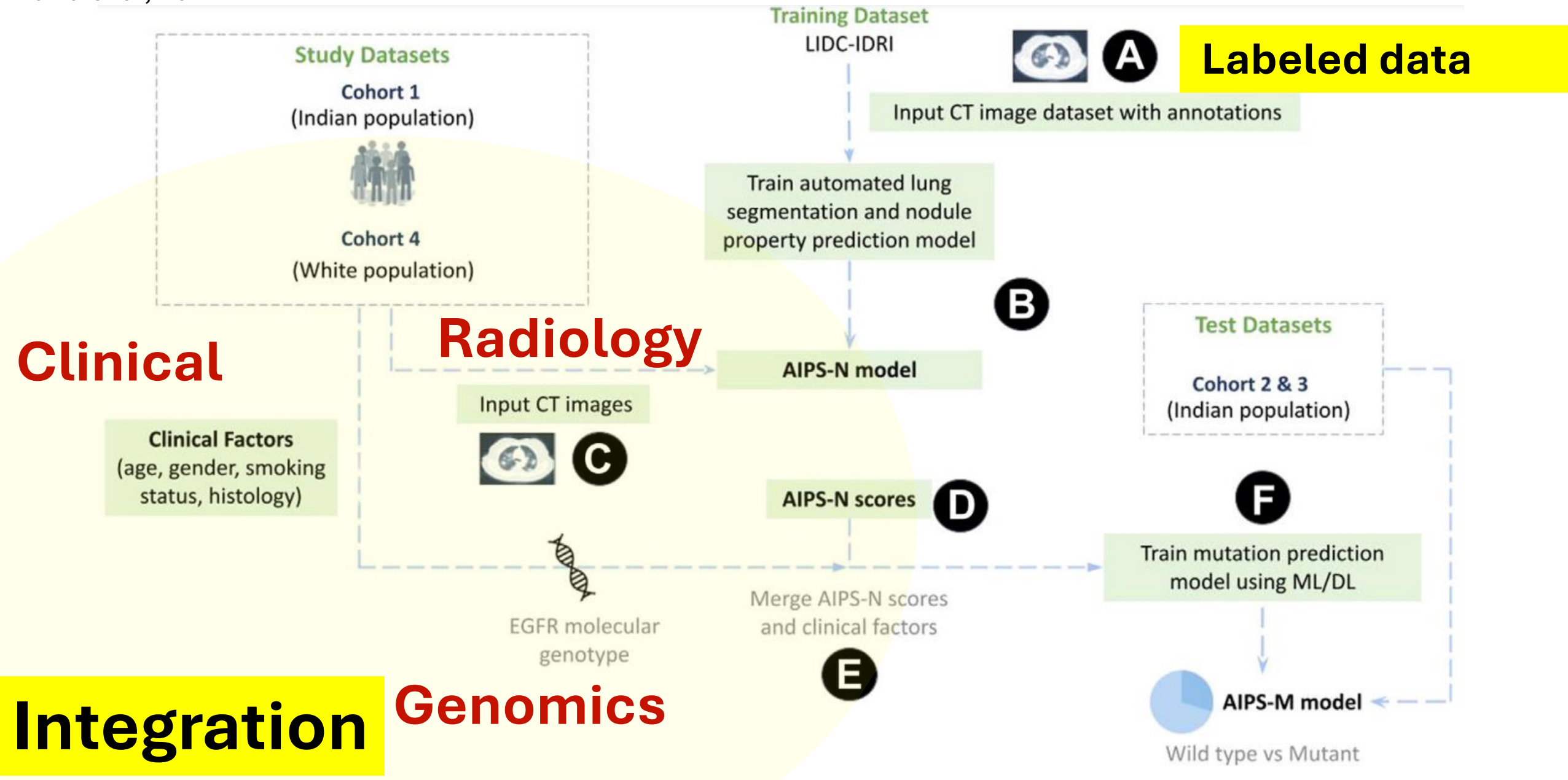


Io Lung Cancer Things (IoLCT)

# Smart LDCT Screening

# AI-based Pipeline for Early Screening of Lung Cancer

Barta et al, 2024



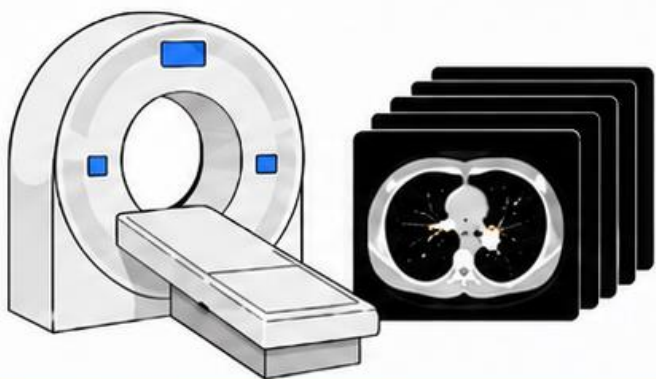
# AI-Assisted LDCT Nodule Assessment: LiberLung

Workflow and clinical value of the LibraLung computer-aided reading system

Chang et al., 2022

## 1. Screening context

- LDCT finds early lung cancer.
- Each scan has many slices and tiny nodules.



## 2. AI-assisted review

- Radiologist + AI read CT together.
- AI detects, segments, and classifies nodules.



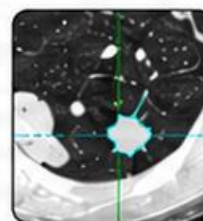
### AI examples

Solid



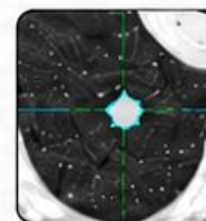
8.0 mm  
(LUL)

Part-solid



13.0 mm  
(LLL)

Non-solid



5.9 mm  
(RLL)

## 3. Structured output

- Reports type, lobe, size, volume, and location.



- Nodule type: Solid
- Location: RUL
- Diameter: 6.2 mm
- Volume: 124 mm<sup>3</sup>
- Coordinates: (x, y, z)

## Clinical validation

- Built with 16 radiologists.
- 2,000 cases; 6,30 nodules.
- Each nodule reviewed by  $\geq 3$  physicians.

## Algorithm performance

- Detection recall: 92%.
- Type classification: P 0.91, R 0.88.
- Lobe localization: P/R 0.99.

**COHESION DATA**  
Cohesion Data, AI ahead professional aid



Accuracy  
**+25%**



Type consistency  
**+31%**

## Observed clinical utility



Lobe consistency  
**+33%**



Reading time  
**-29%**



**12%** follow-up  
nodule found  
(Lung-RADS 1 --> Lung-RADS  $\geq 2$ )

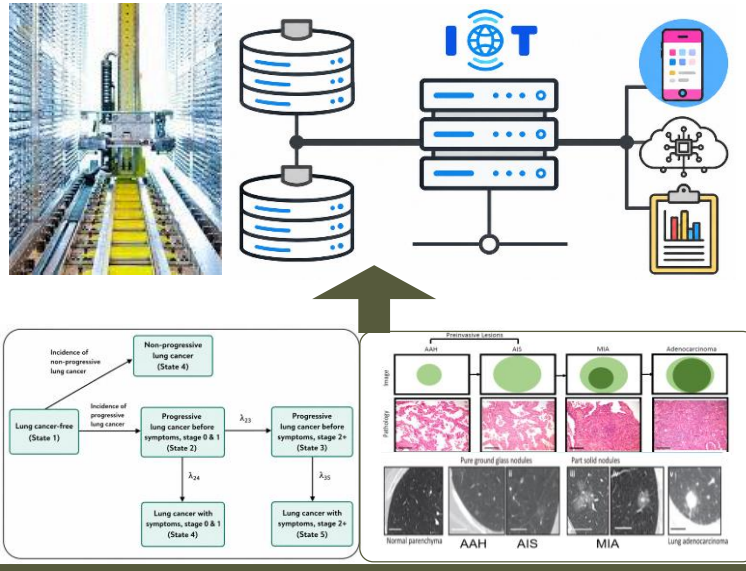
# Digital Twin for Personalized Lung Cancer Prevention

## Physical World

Real Patient  
with delayed  
cancer care



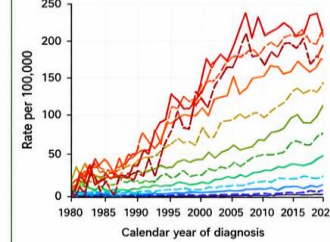
## Computational World



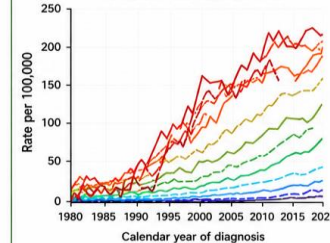
## Virtual World

### 1 APC

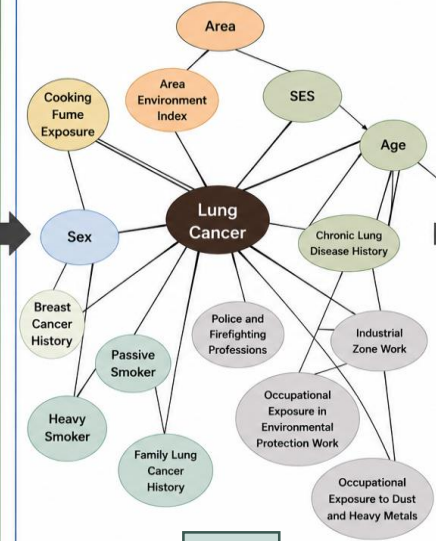
Male - Adenocarcinoma



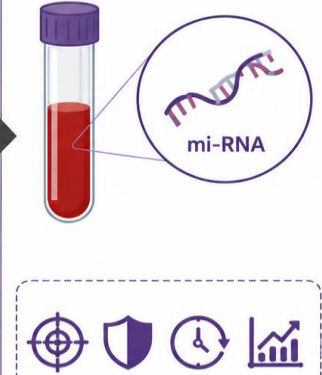
Female - Adenocarcinoma



### 2 Risk prediction

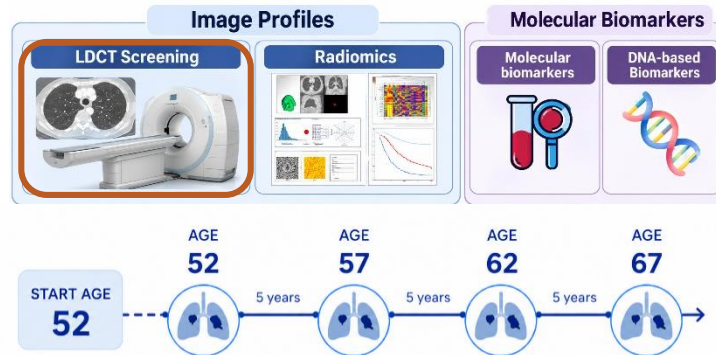


### 3 mi-RNA



## Decision World

### Secondary Prevention



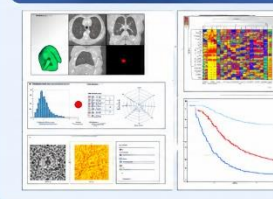
## Secondary Prevention

### Image Profiles

#### LDCT Screening



#### Radiomics



### Molecular Biomarkers

#### Molecular biomarkers



#### DNA-based Biomarkers



Healthy

