Effectiveness of Cloud-based Artificial Intelligence Aided Quality Control System in Korean National Lung Cancer Screening Program

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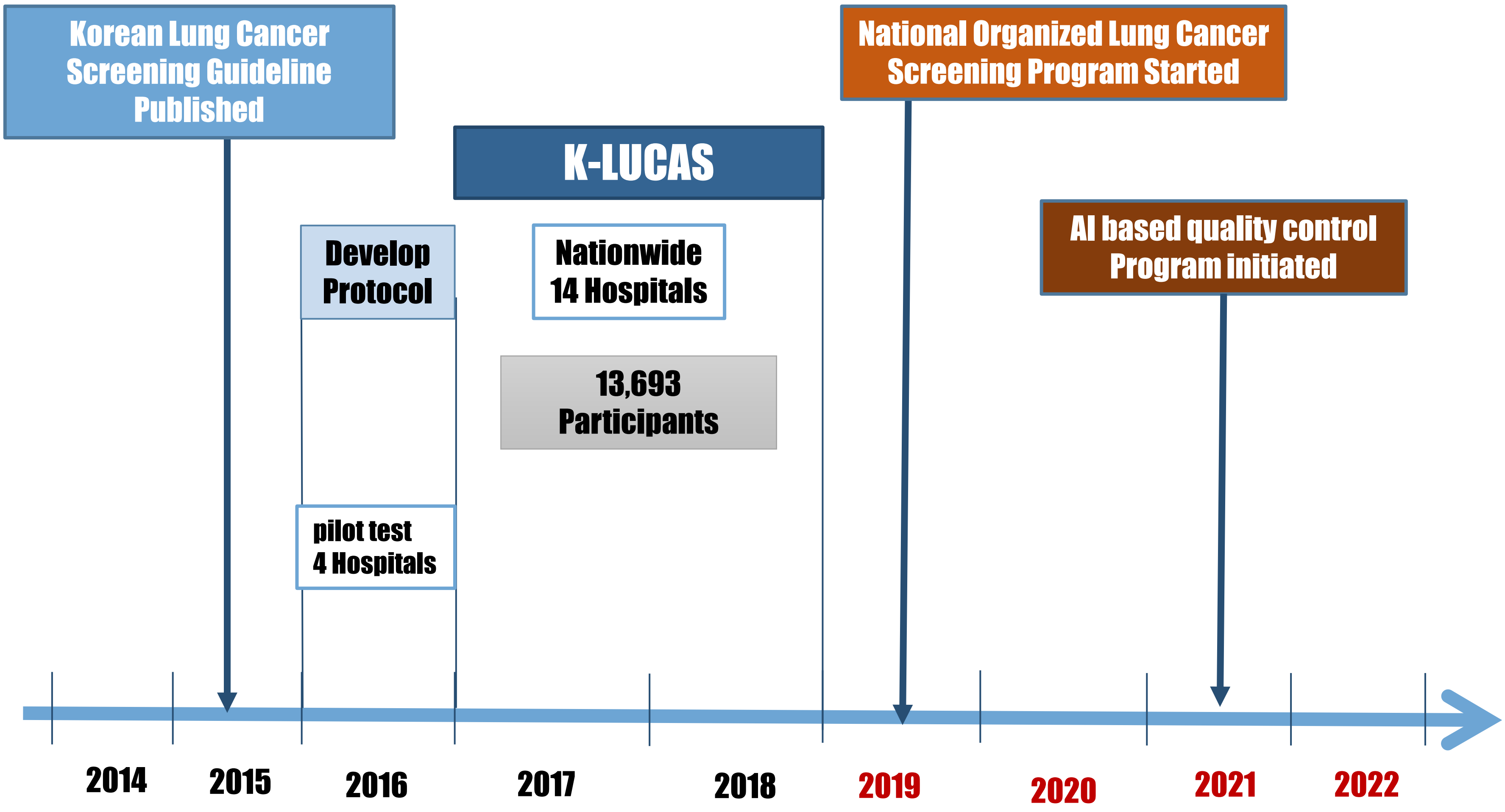
Korean Lung Cancer Screening History



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Korean Lung Cancer Screening project (K-LUCAS)

- Single arm, multicenter, prospective trial
- Targets 55-74 aged 30PY more smokers and quitters within 15Yrs
- Conducted from February 2017 to December 2018.
- K-LUCAS assessed the effectiveness, harm, and feasibility of population-based lung cancer screening in order to implement a national organized cancer screening program.
- K-LUCAS also evaluated the validation of the new standards of reporting form of LDCT using Lung-RADS and the quality of lung cancer screening by cloud-based network system.

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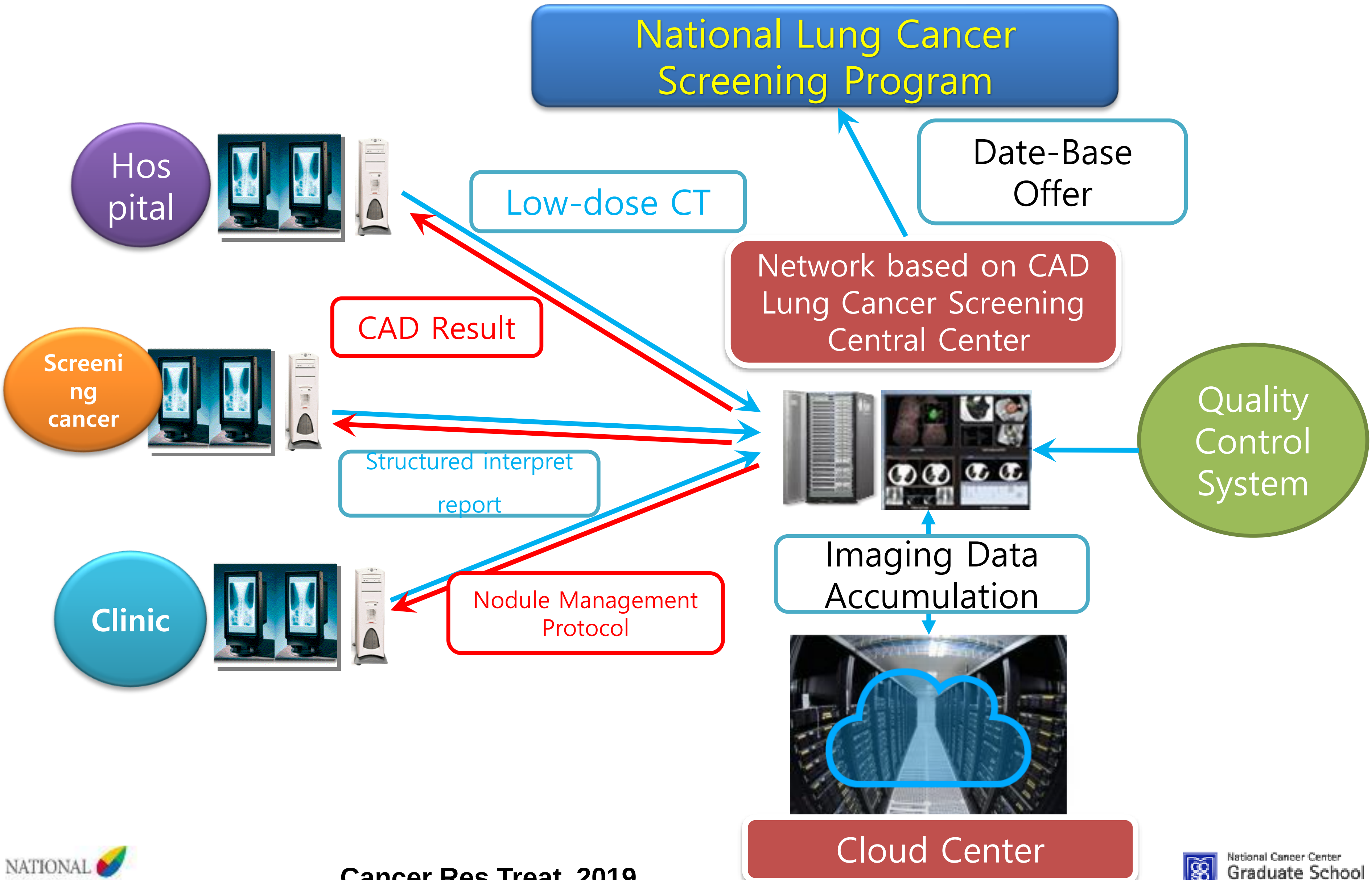
Korean Lung Cancer Screening demonstration project (K-LUCAS) with cloud-based quality control system



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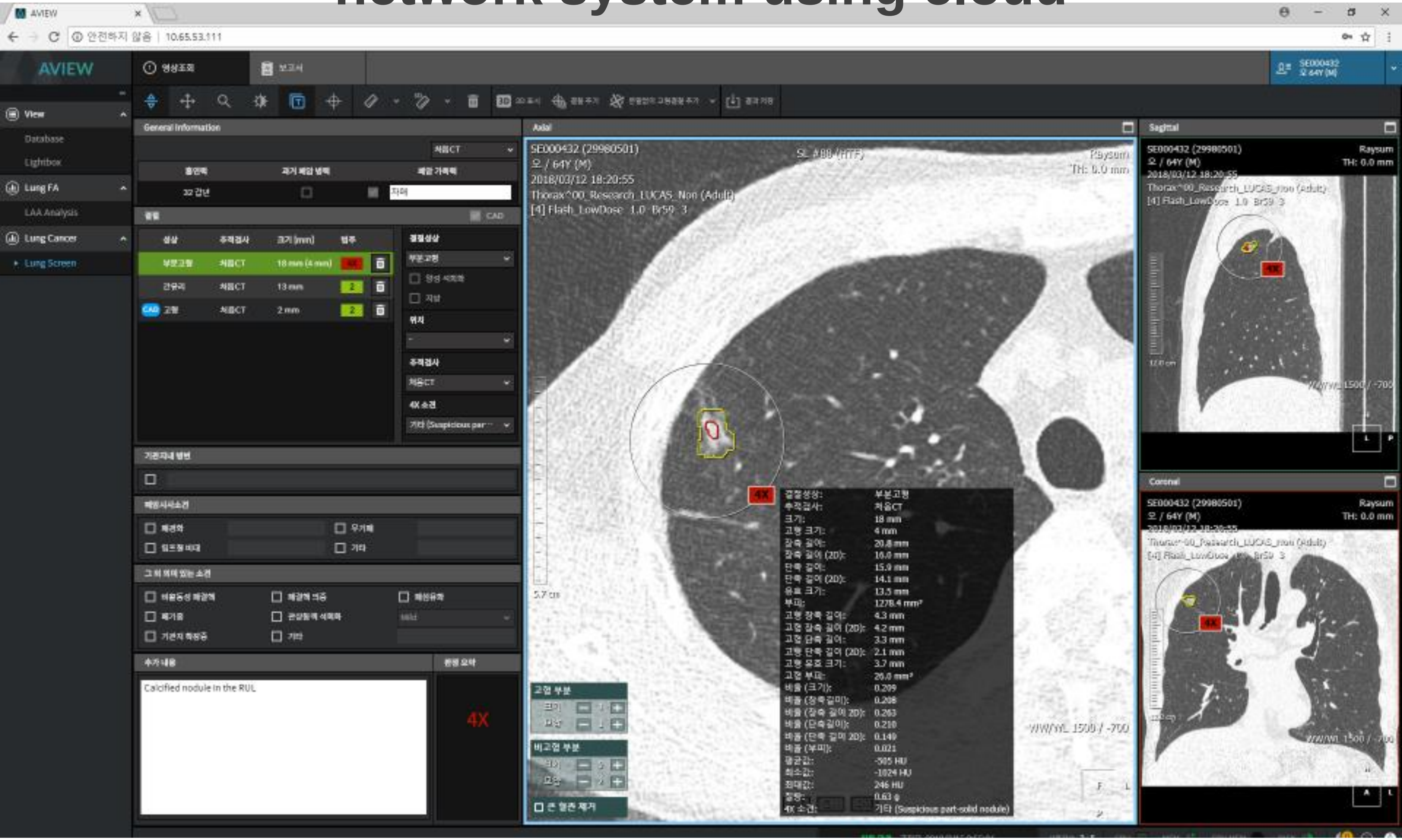
Cancer Res Treat. 2019

National Cancer Center Graduate School of Cancer Science and Policy

Computer Aid Diagnostic program based on network system using cloud



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Comparison of Performance & Outcome Indicators, K-LUCAS vs NLST

Indicators	Calculation Formula	K-LUCAS	NLST
Screening positive Rate	$\frac{positive\ screening}{Total\ screening} \times 100$	**15.3%** 2091 / 13692	**27.3%** 7191 / 26309
False Positive Rate	$\frac{False\ positive}{Non-cancer} \times 100$	**14.7%** (2091-88) / (13692-88)	**26.6%** (7191-270) / (26309-270)
Non-cancer case per positive	$\frac{Non-cancer\ case}{Positive\ screening} \times 100$	**95.8%** (2091-88) / 2091	**96.2%** (7191-270) / 7191
Cancer detection rate	$\frac{Total\ cancer\ diagnosed}{Total\ Screening} \times 100$	**0.66%** 90 / 13692	**1.0%** 270 / 26309
Early stage detection rate	$\frac{Stage\ 1\ or\ 2\ cancers}{Total\ cancer\ diagnosed} \times 100$	**70.0%** 63 / 90	**67.5%** 458 / 679 (Total rounds)
Cancer stage distribution	TNM stage 8th edition	**Ⅰ : 48 (53.9%)** **Ⅱ : 15 (16.9%)** **Ⅲ : 17 (19.1%)** **IV : 9 (10.1%)**	**Ⅰ : 407 (60.0%)** **Ⅱ : 51 (7.5%)** **Ⅲ : 126 (18.6%)** **IV : 95 (14.0%)** (Total rounds)

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Cost-Effectiveness Analysis

- LDCT screening vs no screening for high risk group

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Original Article

Cost Utility Analysis of a Pilot Study for the Korean Lung Cancer Screening Project

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Purpose The aim of this study was to evaluate the cost utility of a pilot study of Korean Lung Cancer Screening Project.

Materials and Methods We constructed a Markov model consisting of 26 states based on the natural history of lung cancer according to the Surveillance, Epidemiology, and End Results summary stage (localized, regional, distant). In the base case, people aged 55-74 years were under consideration for annual screening. Costs and quality-adjusted life years were simulated to calculate the incremental cost utility ratio. Sensitivity analyses were performed on the uncertainty associated with screening target ages, stage distribution, cost, utility, mortality, screening duration, and discount rate.

Results The base case (US$25,383 per quality-adjusted life year gained) was cost-effective compared to the scenario of no screening and acceptable considering a willingness-to-pay threshold of US$27,000 per quality-adjusted life years gained. In terms of the target age of screening, the age between 60 and 74 years was the most cost-effective. Lung cancer screening was still cost-effective in the sensitivity analyses on the cost for treatment, utility, mortality, screening duration, and less than 5% discount rates, although the result was sensitive to a rise in positive rates or variation of stage distribution.

Conclusion Our results showed the cost-effectiveness of annual low-dose computed tomography screening for lung cancer in high-risk populations.

Key words Cost-benefit analysis, Lung neoplasms, Mass screening, Markov chains

Table 4. Results of cost utility analysis in the base case

	No screening	Screening[a)]
Costs (USD)	26,961,422	45,132,450
Incremental costs (USD)	-	18,171,028[b)]
QALYs	117,223	117,939
Incremental QALYs	-	716[b)]
ICUR	-	25,383[b)]

ICUR, incremental cost-utility ratio; QALY, quality-adjusted life year; USD, United States dollars. [a)]Base case, [b)]The difference is due to rounding errors.

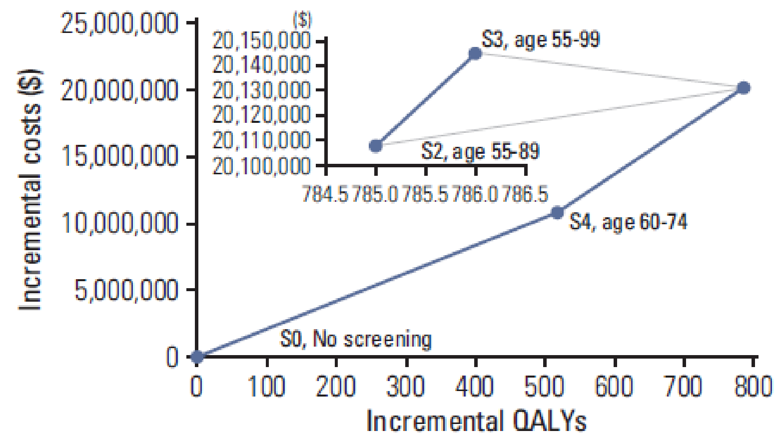

Fig. 2. Cost utility efficiency frontier. S, Scenario; S0, No screening; S1, age 55-79, S2, age 55-89; S3, age 55-99; S4, age 60-74; S5, age 65-74. Base case, S1, and S5 were excluded due to extended dominance.

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Selection & Invitation for National Lung Cancer Screening Program in Korea

- **Korea National Lung Caner Screening Program (KNLCS) launched from Aug. 2019 for the first time in the world.**
- **Korea national health insurance (NHI) has centralized database regarding people's smoking history** on the basis of **questionnaires** submitted in **national health screening program** or **public smoking cessation program**
- NHI sent **invitation letters** to **high-risk population** aged 54–74 years **current smokers** with 30 Pack-Year smoking history

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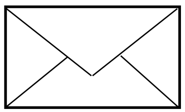
Process of National Lung Cancer Screening Program in Korea

Selection&Invitation

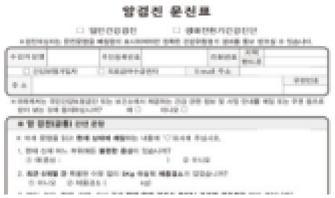


Send Invitation Letter to high-risk population

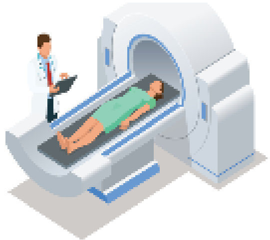
Booking Screening

Checking Targeted Participants in Screening Units

Screening Day



Fill-up Questionnaire and prescreening counselling



Lung Cancer Screening by Low-dose CT

Screening Result Reporting and Counselling

Reporting Screening Results by mail or email

Counselling Screening Results by doctors in screening units

Counselling Smoking Cessation

Post-Screening Care

- **Diagnosis process when abnormal findings are detected**
- **Continuous smoking cessation Treatment**

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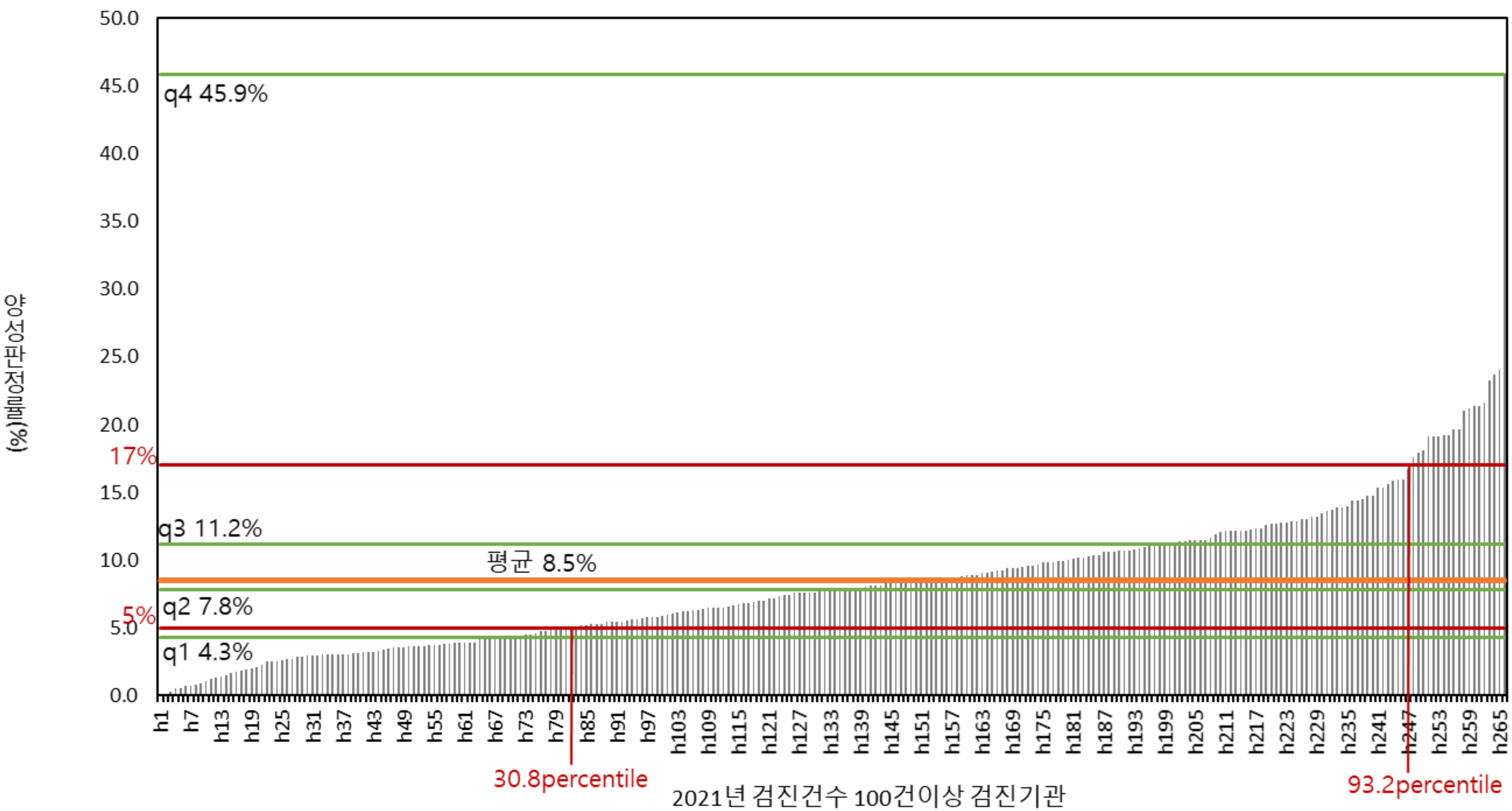
Status of Korean National Lung Cancer Screening Program

PARTICIPATION RATE AND POSITIVE RATE

	Invited	Screened	Participation Rate	Positive Rate (Cat 3 + 4)	Category 4 (Suspicious)	Smoking Cessation Counselling Rate
2019	332,244	82,438	24.8%	9.1%	4.6%	44.8%
2020	359,212	92,903	25.9%	8.9%	4.1%	40.2%
2021	310,260	120,138	38.7%	8.7%	4.1%	35.0%

Distribution of positive rates among screening units participated in National lung cancer screening program

2021 Year



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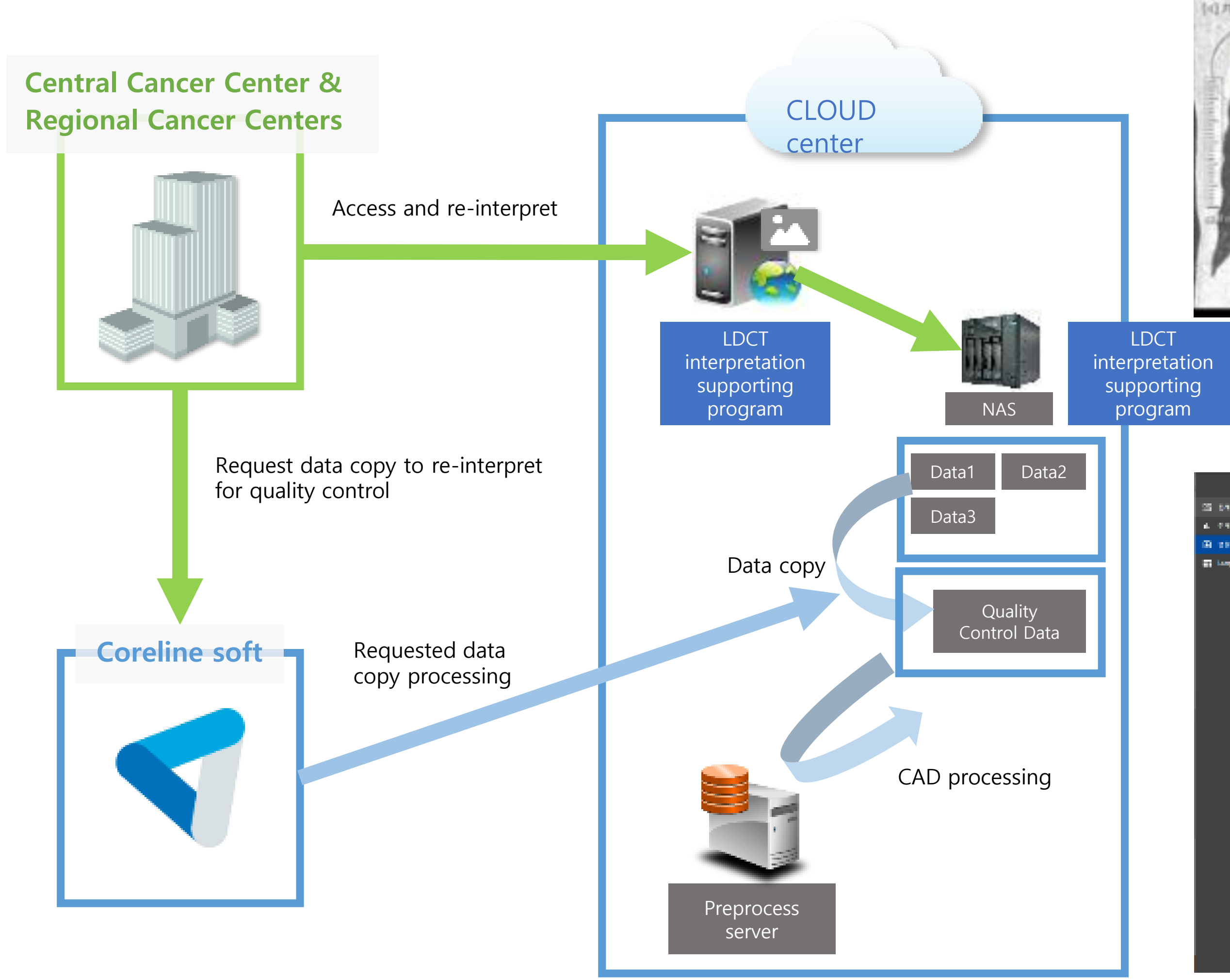
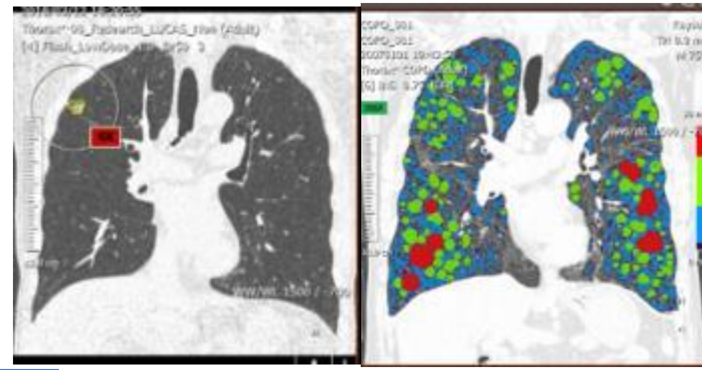
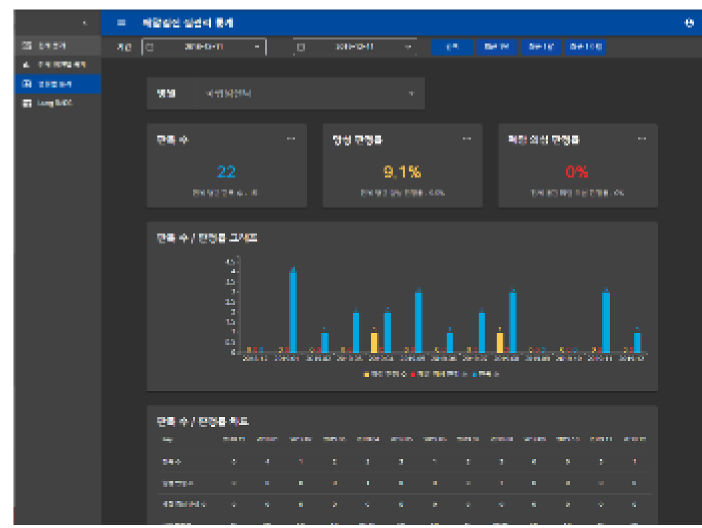
Overview of Cloud-based Computer Aided Quality Control System (CQCS) using A.I. based Nodule Detection Program







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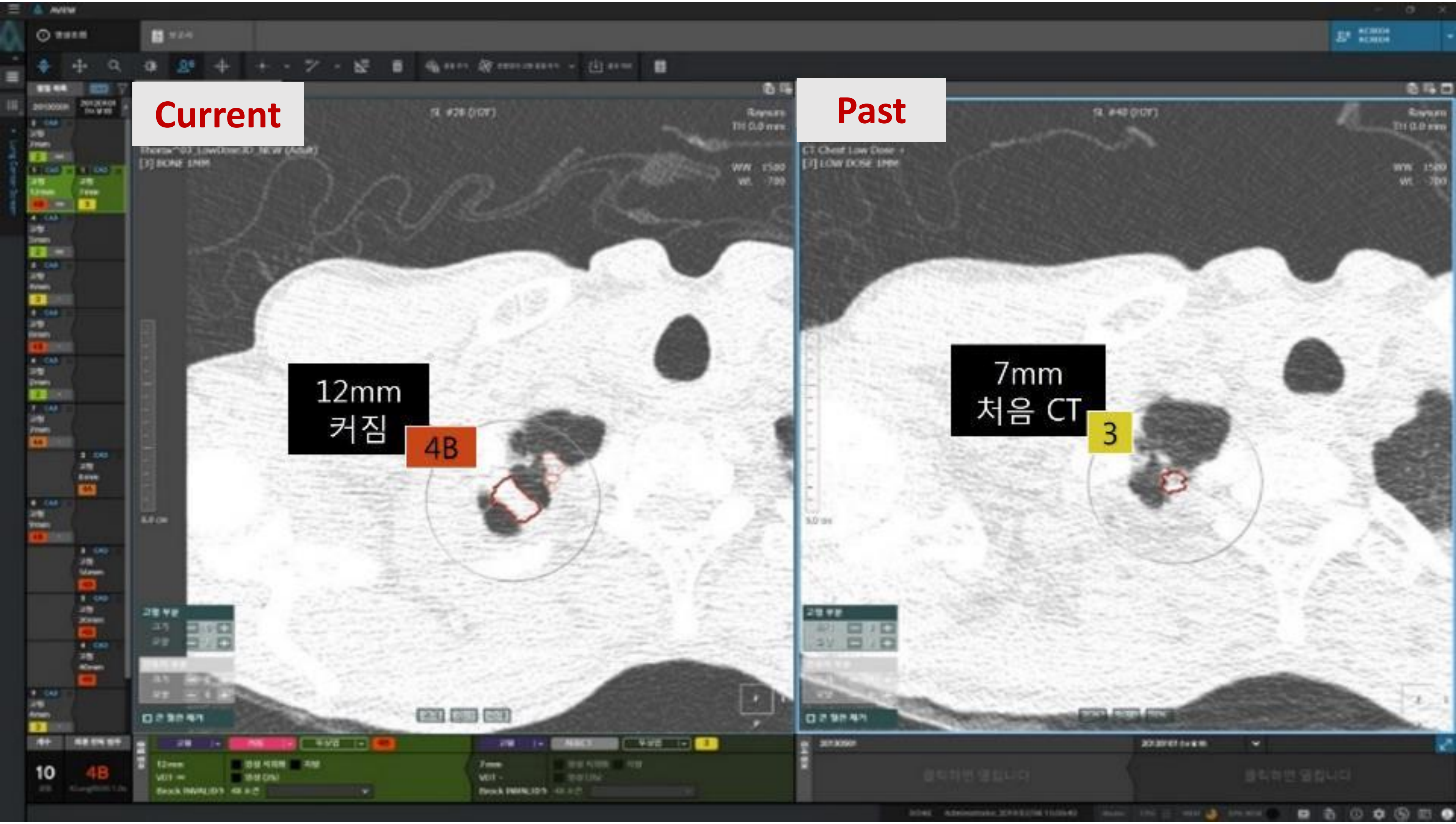
A.I. based Computer-aided diagnosis Program for detection of pulmonary nodule

A.I. based Computer Program assist to diagnosis compare with past-examination



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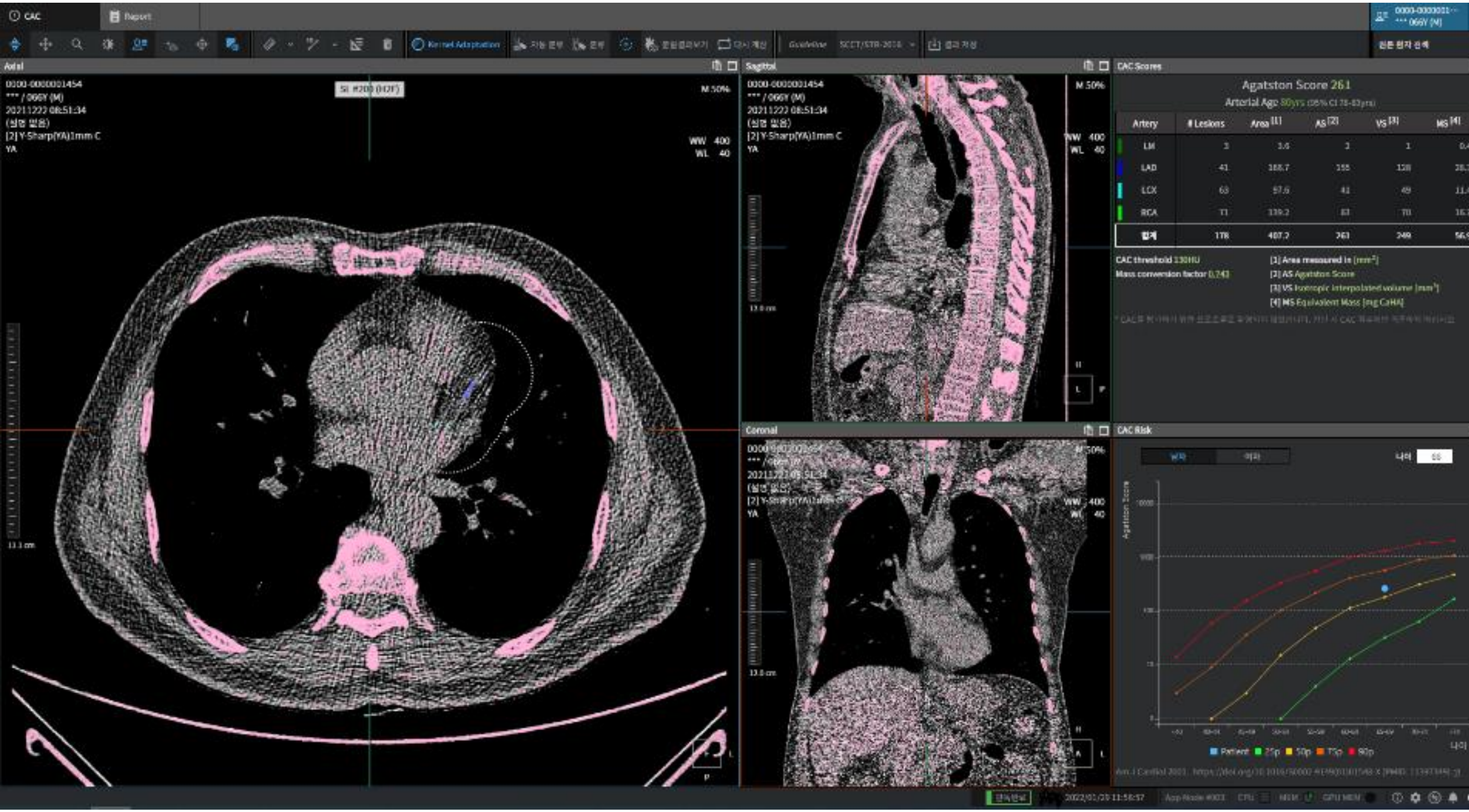
Auto calculation of coronary artery calcification (CAC)



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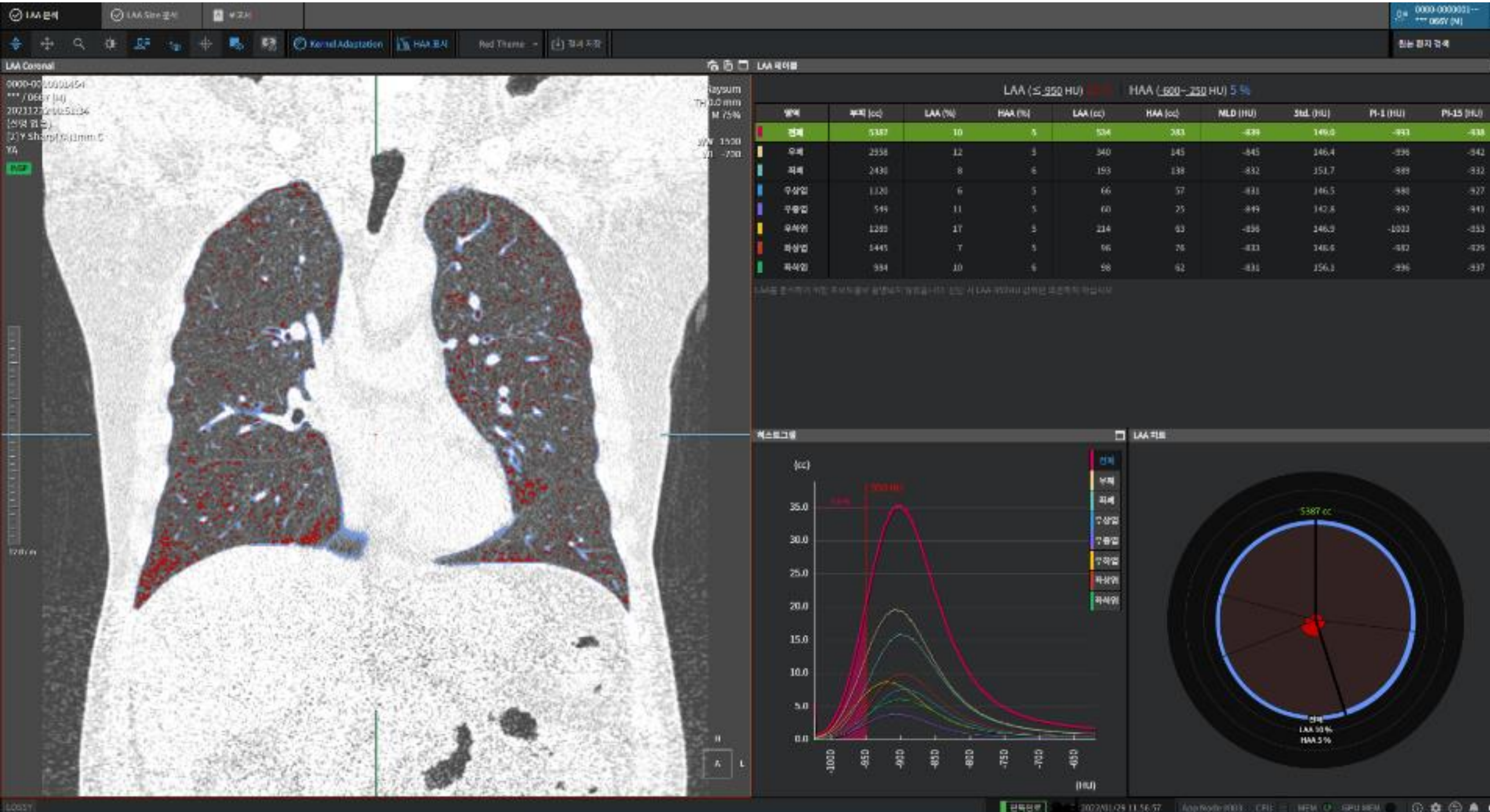
Auto calculation of degree of emphysema by calculating low attenuated area (LAA)



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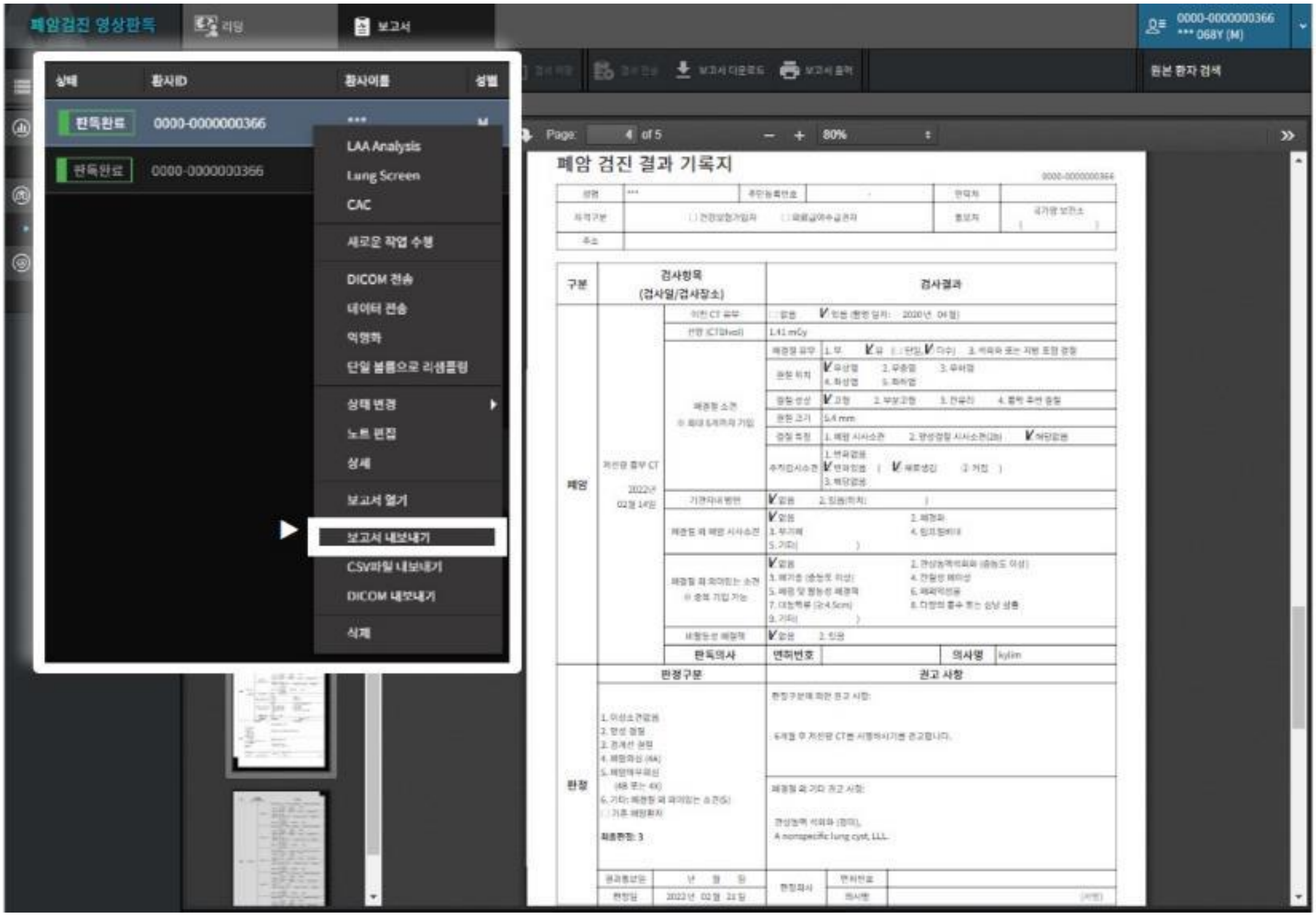
Auto-generating reports based on national lung cancer screening program



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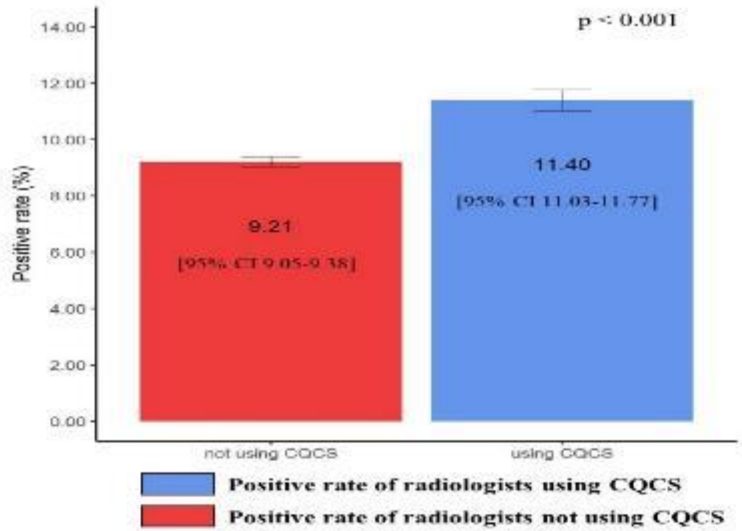
Methods of analyzing the effectiveness of CQCS using in Korean national lung cancer screening program

- The study compared the quality index measured between groups of radiologists using and not using CQCS and before and after using CQCS.
- The quality index was evaluated by positive rates (the proportion of nodules classified as Lung-RADS category 3 and 4) and their variabilities across radiologists in screening units. Coefficient of quartile variation (CQV) of positive rates was used to calculate variabilities

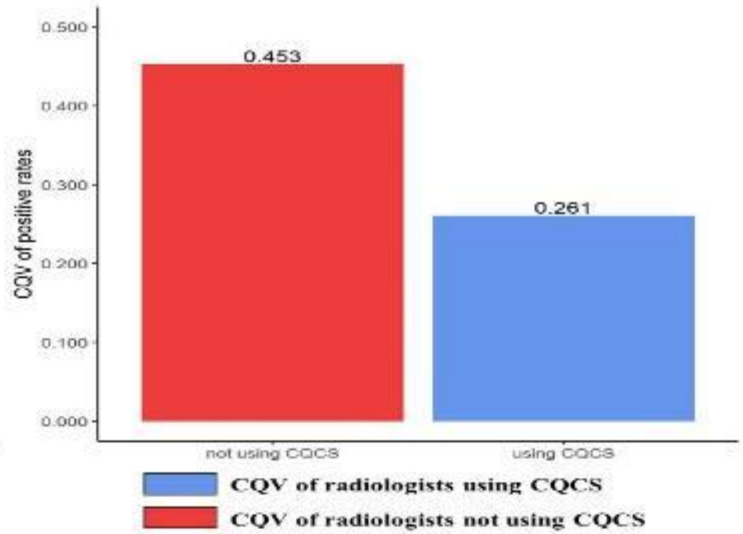
  $(\hat{\theta}_{CQV}=(\hat{\theta}_3-\hat{\theta}_1)/(\hat{\theta}_1+\hat{\theta}_3))$.

- Also, we measured reading time for evaluation a LDCT based on questionnaire to radiologists using CQCS.

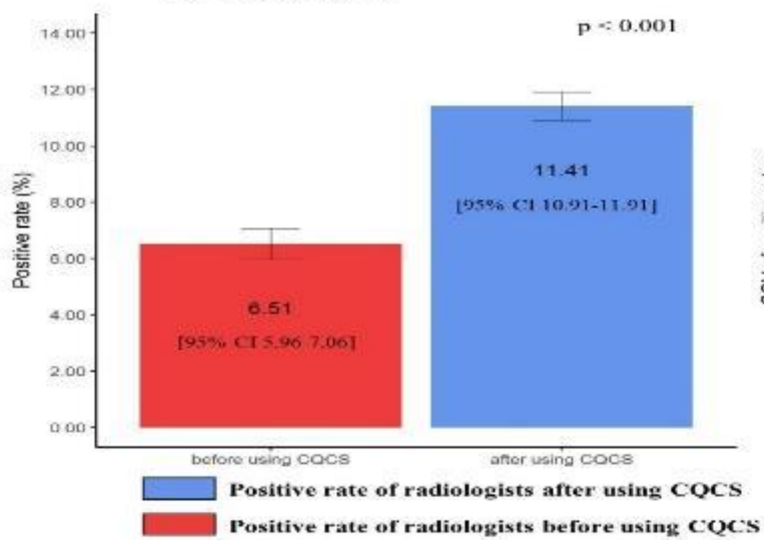
Effectiveness of Cloud-based Computer Aided Quality Control System (CQCS) in Korean National Lung Cancer Screening



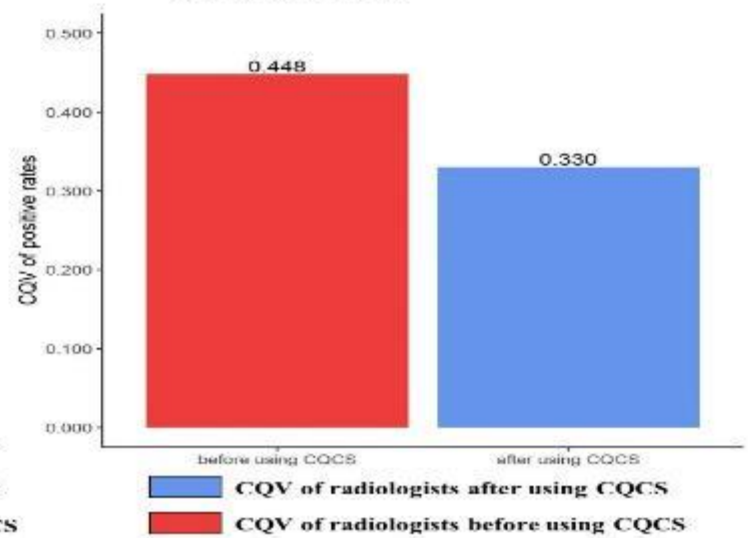
(A) Positive rates of radiologists using and not using CQCS



(B) Inter-radiologist variabilities using and not using CQCS



(C) Positive rates of radiologists before and after using CQCS



(D) Inter-radiologist variabilities before and after using CQCS

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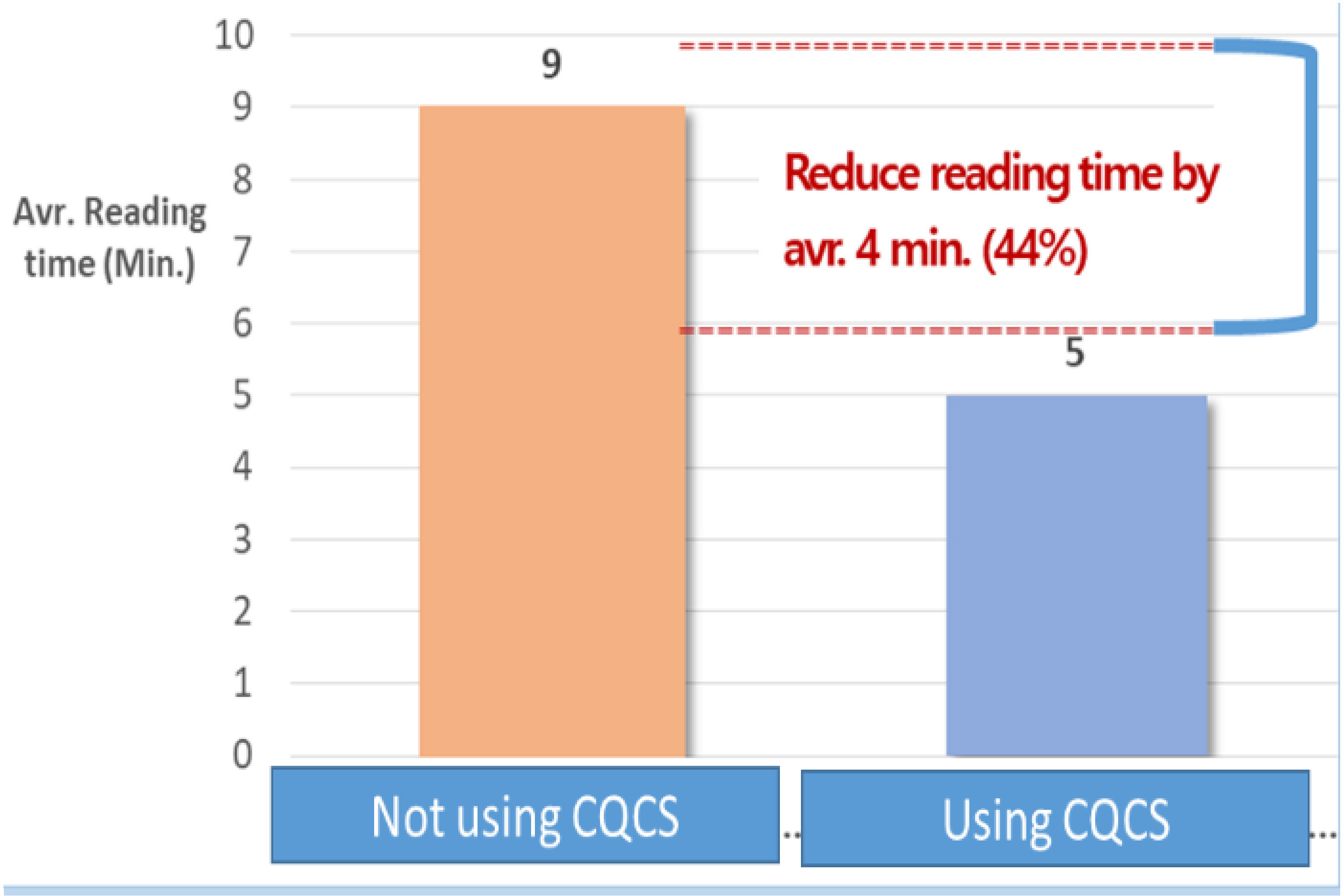
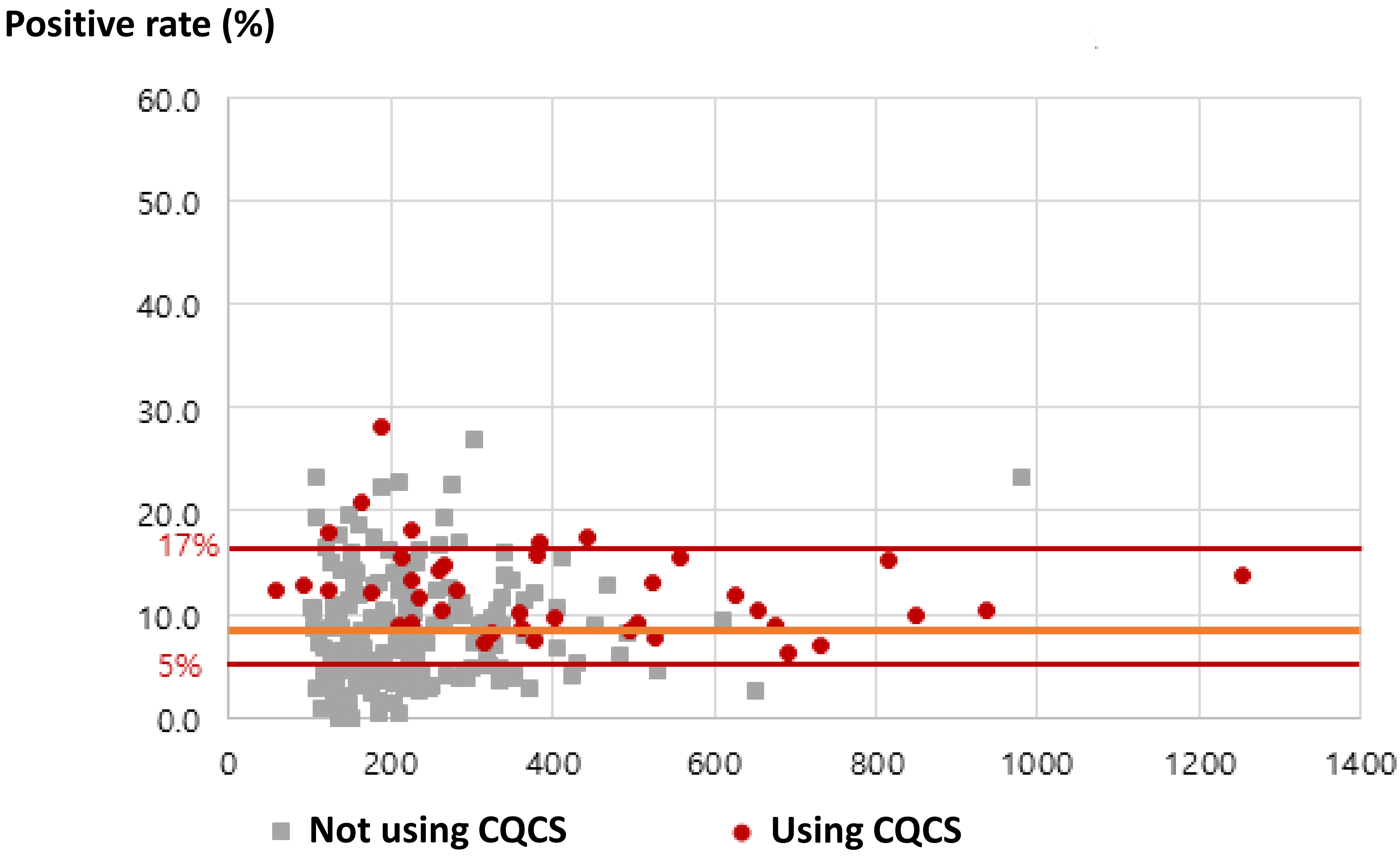


Distribution of positive rates among screening hospitals participated in national lung cancer screening program



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Conclusion

- **A cloud-based quality control system (CQCS) using artificial intelligence (AI)** aided reading program
- showed effectiveness in assisting small lung nodule detection and measuring the nodule size,
- lowering variabilities of screening results across radiologists,
- and reducing burden of radiologists participated in mass lung cancer screening.

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Thank you !

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