

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

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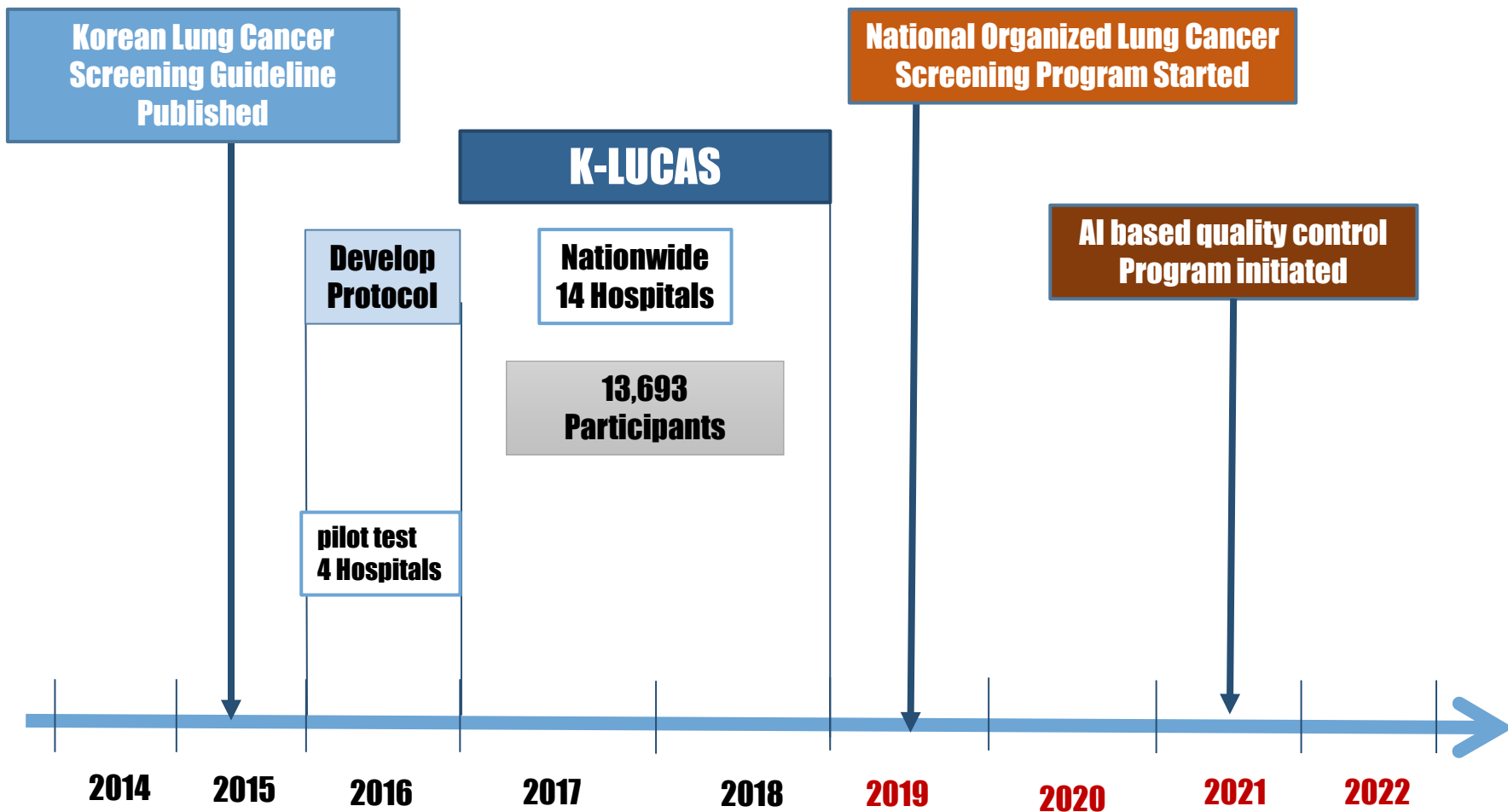
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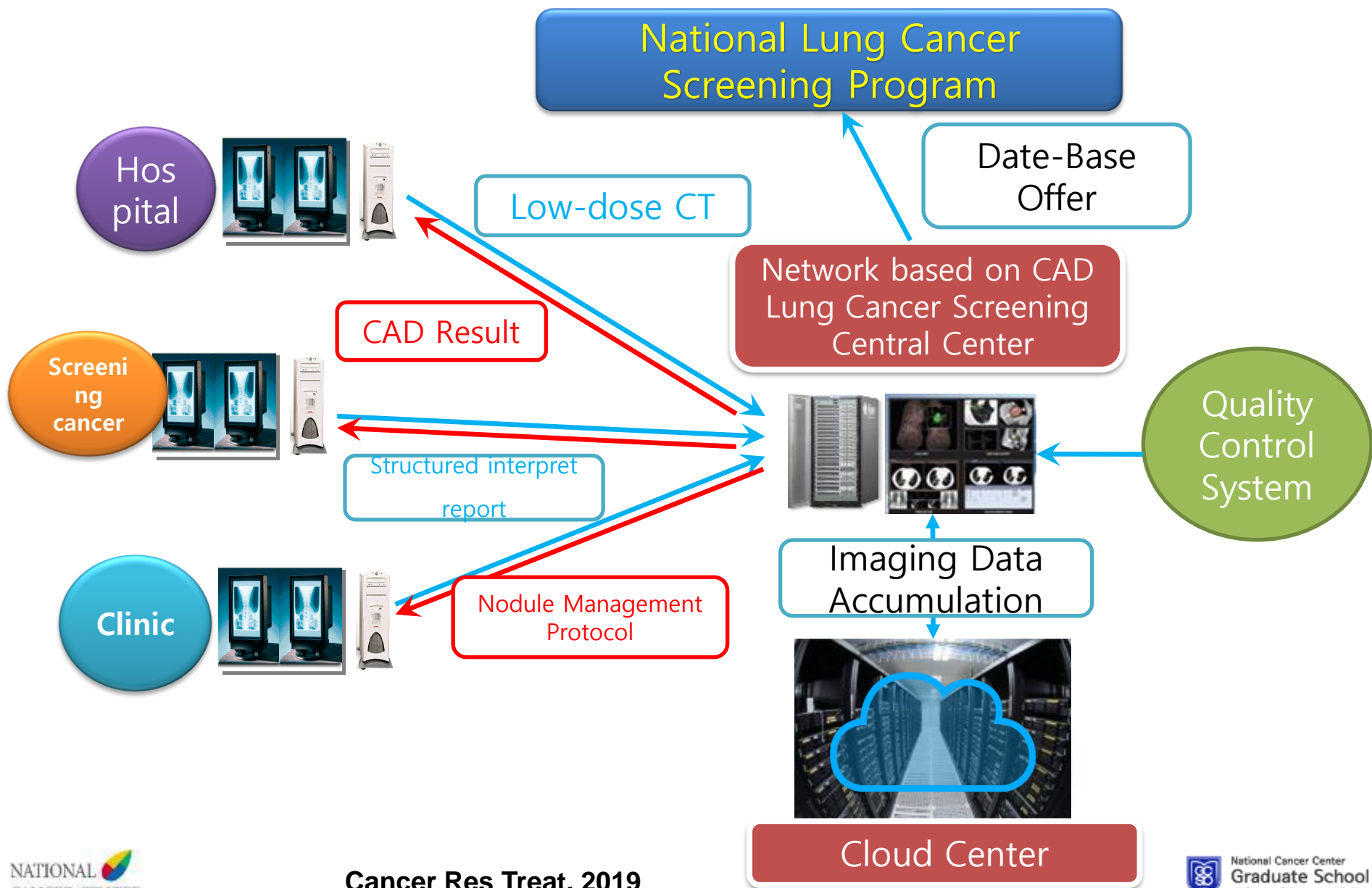
Korean Lung Cancer Screening History



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.

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



Computer Aid Diagnostic program based on network system using cloud

AVIEW | 10.65.53.111

영상조작 | 보고서

SE000432 (29980501)
오 / 64Y (M)
2018/03/12 18:20:55
Thorax^00_Research_LUCAS_Non (Adult)
[4] Flash_LowDose 1.0 Br59 3

세검CT

총검액 | 과거 세검 날짜 | 과거 기록액

322 건 | | |

발행 | CAD

상상	추적검사	크기 (mm)	범주	결정상상
부분고형	세검CT	18 mm (4 mm)	4	부분고형
간유리	세검CT	13 mm	2	<input type="checkbox"/> 양성 세검액
CAD 고형	세검CT	2 mm	2	<input type="checkbox"/> 지남

위치

추적검사

세검CT

4X 소진

기타 (Suspicious part-)

기본내역

확인

해당시작조건

확인자 | 무거해

검토중 비대 | 기타

그림 영태 있는 조건

비윤동성 해갈액 | 해갈액 비동 | 해성유액

복거음 | 균상하게 석회화

거르지 핵부동 | 기타

추거내용 | 병명 요약

Calified nodule in the RUL

4X

결절상상:	부분고형
추적검사:	세검CT
크기:	18 mm
고형 크기:	4 mm
장축 길이:	20.8 mm
장축 길이 (2D):	16.0 mm
단축 길이:	15.0 mm
단축 길이 (2D):	14.1 mm
윤부 크기:	13.5 mm
부피:	1278.4 mm ³
고형 장축 길이:	4.3 mm
고형 장축 길이 (2D):	4.2 mm
고형 단축 길이:	3.3 mm
고형 단축 길이 (2D):	2.1 mm
고형 윤부 크기:	3.7 mm
고형 부피:	26.8 mm ³
비율 (크기):	0.299
비율 (장축길이):	0.288
비율 (장축 길이 2D):	0.263
비율 (단축 길이):	0.218
비율 (단축 길이 2D):	0.149
비율 (부피):	0.021
평균값:	-905 HU
최소값:	-1024 HU
최대값:	246 HU
질량:	0.63 g
4X 소진:	기타 (Suspicious part-solid nodule)

고형 부분

크기: - 1 +

자란: - 1 +

비고형 부분

크기: - 5 +

모양: - 5 +

소진 제거

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

Indicators	Calculation Formula	K-LUCAS	NLST
Screening positive Rate	$\frac{\text{positive screening}}{\text{Total screening}} \times 100$	15.3% 2091 / 13692	27.3% 7191 / 26309
False Positive Rate	$\frac{\text{False positive}}{\text{Non - cancer}} \times 100$	14.7% (2091-88) / (13692-88)	26.6% (7191-270) / (26309-270)
Non-cancer case per positive	$\frac{\text{Non - cancer case}}{\text{Positive screening}} \times 100$	95.8% (2091-88) / 2091	96.2% (7191-270) / 7191
Cancer detection rate	$\frac{\text{Total cancer diagnosed}}{\text{Total Screening}} \times 100$	0.66% 90 / 13692	1.0% 270 / 26309
Early stage detection rate	$\frac{\text{Stage 1 or 2 cancers}}{\text{Total cancer diagnosed}} \times 100$	70.0% 63 / 90	67.5% 458 / 679 (Total rounds)
Cancer stage distribution	TNM stage 8 th 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)

Cost-Effectiveness Analysis

- LDCT screening vs no screening for high risk group

<https://doi.org/10.4143/crt.2021.480>

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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.

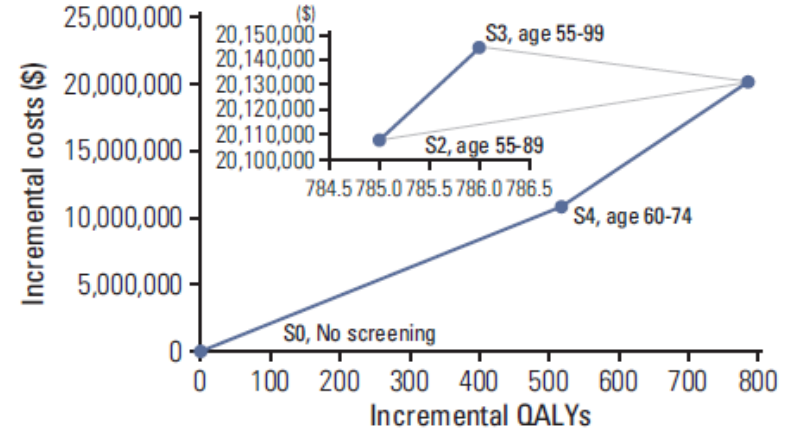
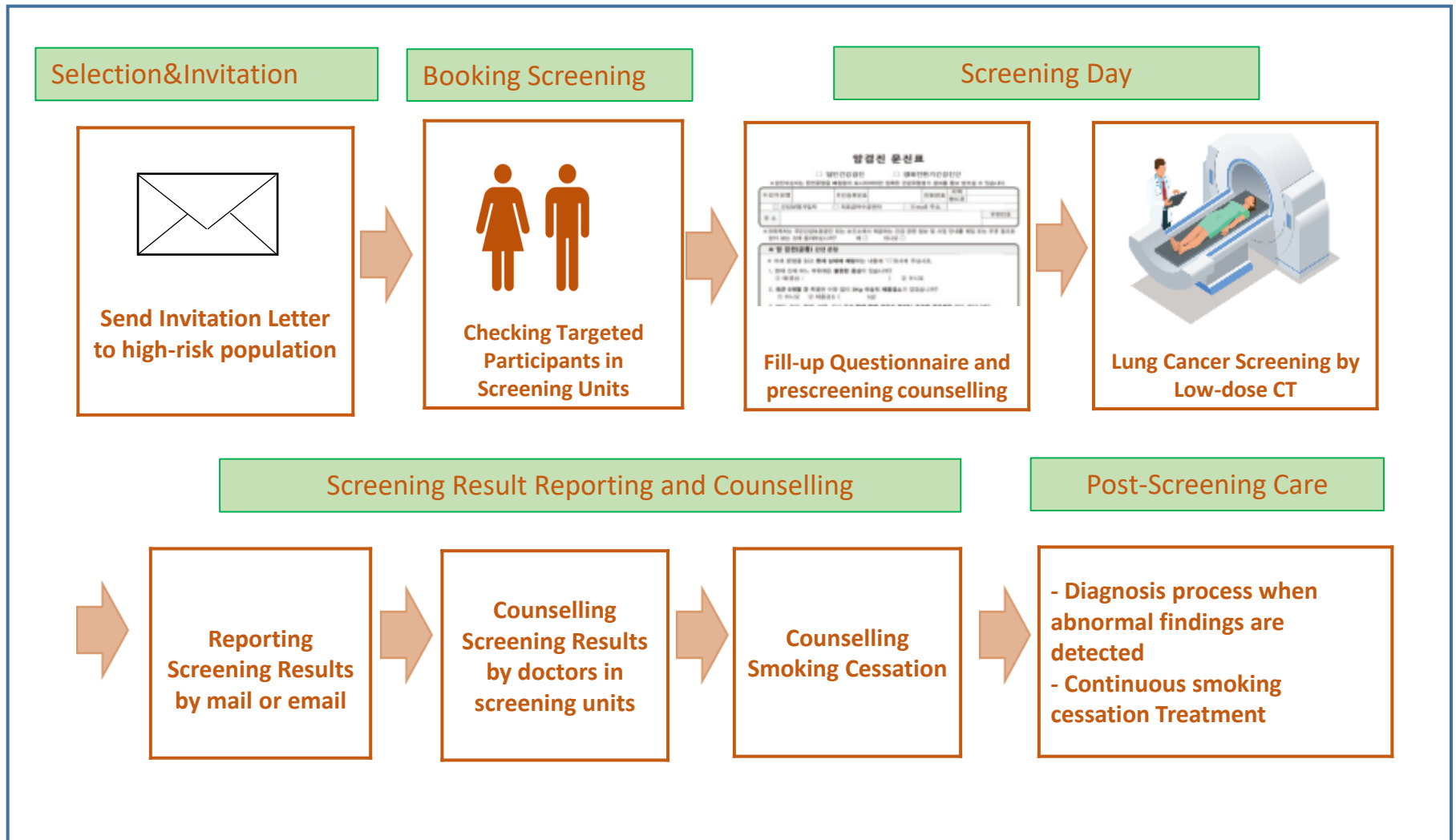


Fig. 2. Cost utility efficiency frontier. S, Scenario; S0, No screening; S1, age 55-79; S2, age 55-89; S3, age 55-99; S4, age 60-74; S5, age 65-74. Base case, S1, and S5 were excluded due to extended dominance.

Selection & Invitation for National Lung Cancer Screening Program in Korea

- Korea National Lung Cancer 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

Process of National Lung Cancer Screening Program in Korea



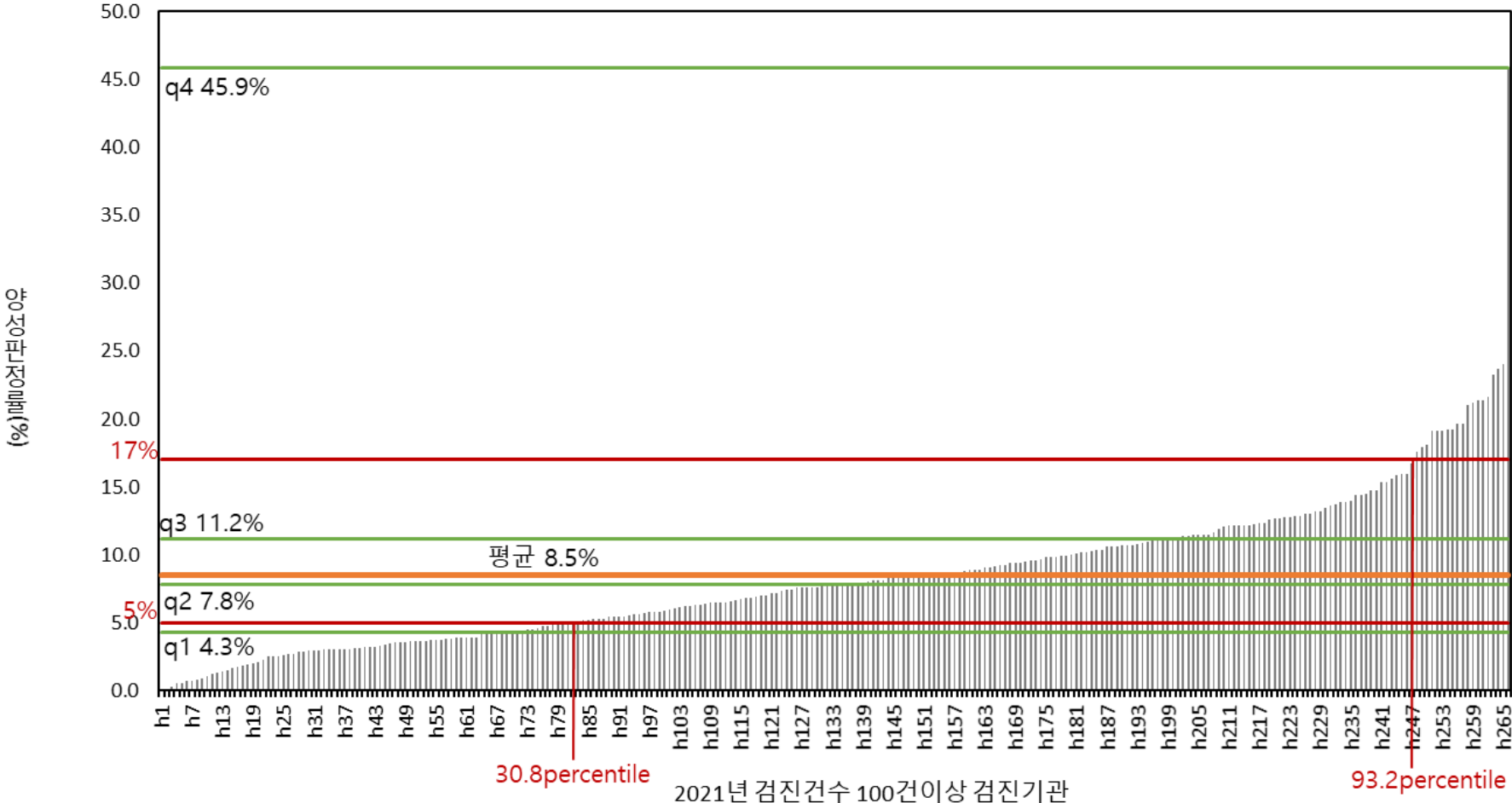
Status of Korean National Lung Cancer Screening Program

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



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

Central Cancer Center & Regional Cancer Centers



Access and re-interpret

Request data copy to re-interpret for quality control

Coreline soft



Requested data copy processing

CLOUD center



LDCT interpretation supporting program



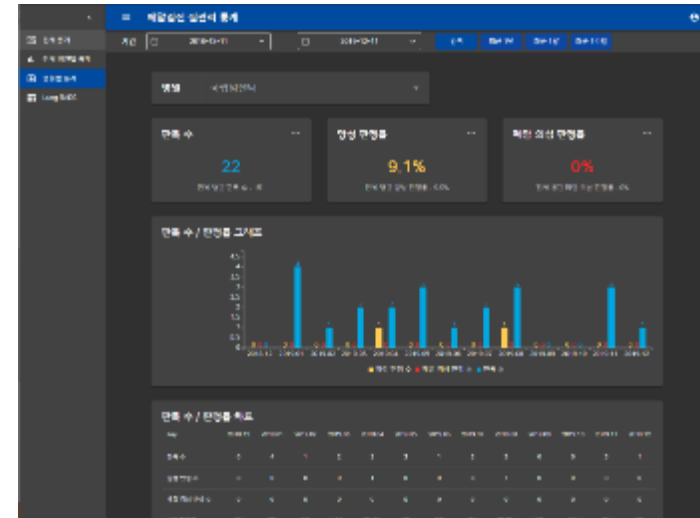
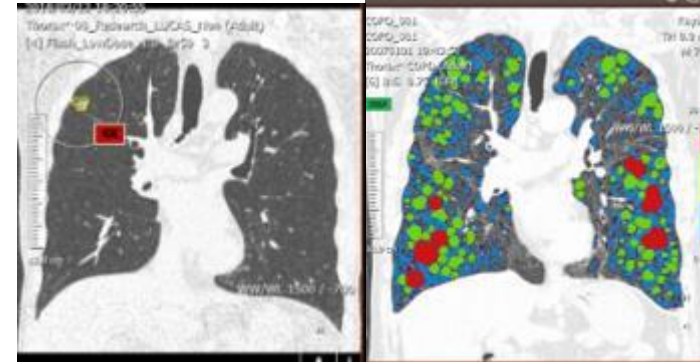
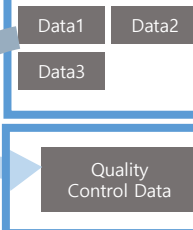
NAS

LDCT interpretation supporting program

Data copy

CAD processing

Preprocess server



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

The screenshot displays a medical software interface for CT scan analysis. The main window shows three views: Axial, Sagittal, and Coronal. A red circle highlights a pulmonary nodule in the Axial view, labeled '4A'. A pop-up window provides detailed information about the nodule:

질량 중심:	고형
주격 간격:	자음나
크기:	14 mm
상하 길이 (SD):	16.1 mm
단축 길이 (SD):	14.3 mm
상하 길이 (SD):	15.6 mm
단축 길이 (SD):	13.2 mm
형태학적:	Coronal
상부 크기:	13.8 mm
부피:	1374 mm³
복합성:	155 HU
평균값:	-943 HU
최대값:	211 HU
브록 모델:	2%
브록 스크린:	N/A

The bottom right panel shows a list of detected nodules:

- 4A: 14 mm, 고형, 자음나, 14 mm, 16.1 mm, 14.3 mm, 15.6 mm, 13.2 mm, Coronal, 13.8 mm, 1374 mm³, 155 HU, -943 HU, 211 HU, 2%, N/A

The interface also includes a toolbar with various tools and a status bar at the bottom showing the date and time: APR 2019 15:13 17:29:21.

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

Current

12mm
커짐

4B

Past

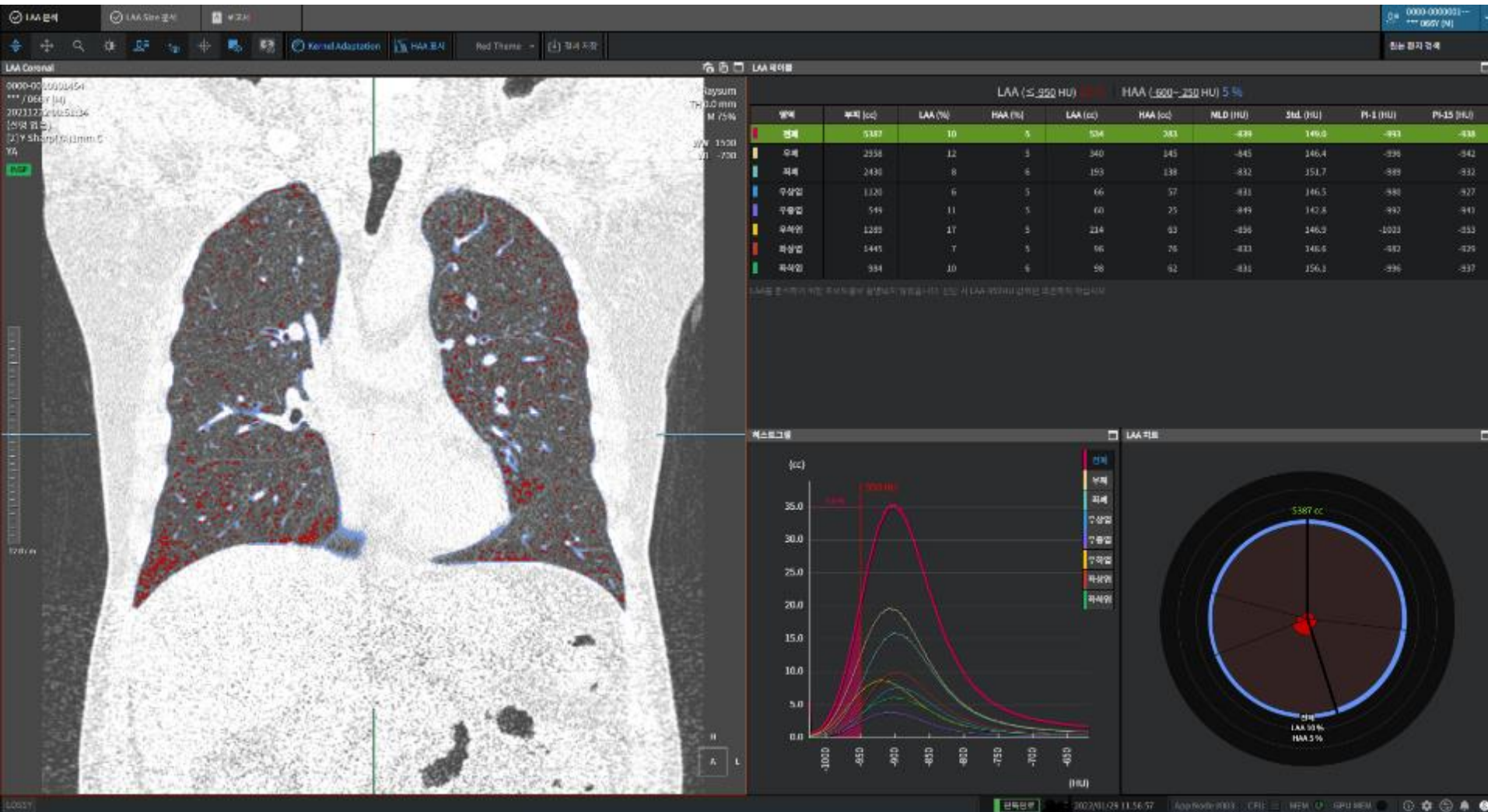
7mm
처음 CT

3

Auto calculation of coronary artery calcification (CAC)



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



Auto-generating reports based on national lung cancer screening program

폐암검진 영상판독 | **리딩** | **보고서**

0000-0000000366 *** 068Y (M)

Page: 4 of 5 | 80%

폐암 검진 결과 기록지

0000-0000000366

성명	***	주민등록번호	-	인적처	안양지
차적구분	() 건강보험가입자	() 의료급여수급권자	홍보처	()	국가암보건소
주소					

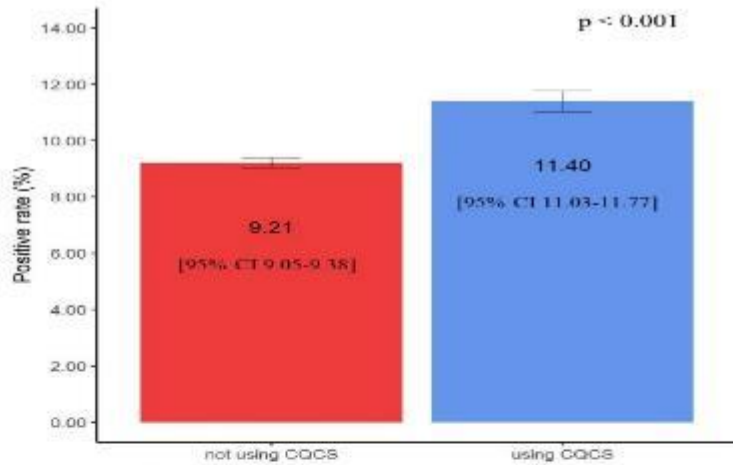
구분	검사항목 (검사일/검사장소)	검사결과			
폐암	이전 CT 유무	<input type="checkbox"/> 없음 <input checked="" type="checkbox"/> 있음 (행명 일자: 2020년 04월)			
	선량 (CTDIvol)	1.41 mGy			
	폐검출 필무	1. 부 <input checked="" type="checkbox"/> 무 <input checked="" type="checkbox"/> () 안양 <input checked="" type="checkbox"/> 다수 <input type="checkbox"/> 3. 비육아 또는 지방 포함 양형			
	유형 위치	<input checked="" type="checkbox"/> 위상형 <input type="checkbox"/> 무종양 <input type="checkbox"/> 3. 무서형 4. 좌상형 <input type="checkbox"/> 5. 좌하형			
	영양양성	<input checked="" type="checkbox"/> 고형 <input type="checkbox"/> 2. 무양고형 <input type="checkbox"/> 3. 전유자 <input type="checkbox"/> 4. 불확 추연 양형			
	유형 크기	5.4 mm			
폐암	유형 특징	1. 폐암 시사소견 <input type="checkbox"/> 2. 양성양형 시사소견() <input checked="" type="checkbox"/> 애단양형			
	유형 시사소견	1. 변과양형 <input type="checkbox"/> 2. 유방양형 <input checked="" type="checkbox"/> () <input checked="" type="checkbox"/> 폐쇄양형 <input type="checkbox"/> () <input type="checkbox"/> 거점 () 3. 폐단양형			
	기관차내 병변	<input checked="" type="checkbox"/> 없음 <input type="checkbox"/> 있음(위치:)			
	폐검출 외 폐암 시사소견	<input checked="" type="checkbox"/> 없음 <input type="checkbox"/> 있음 1. 부기배 <input type="checkbox"/> 2. 폐경화 3. 기종 () 4. 임피딩네			
폐암	폐검출 외 확인되는 소견 () 중독 기입 가능	<input checked="" type="checkbox"/> 없음 1. 폐기종 (중독도 미상) 2. 관상동맥비확 (중독도 미상) 3. 폐문 및 정상형 폐경화 4. 간질성 폐이상 5. 폐쇄양형 6. 폐쇄양형 7. 대동맥류 (< 4.5cm) 8. 다량의 흉수 또는 상당 흉종 9. 기타 ()			
	비정양성 폐양형	<input checked="" type="checkbox"/> 없음 <input type="checkbox"/> 있음			
판독의사		면허번호	의사명	kylin	
판정구분		권고 사항			
1. 위상소견없음 2. 양성 결절 3. 경계선 결절 4. 폐암양성 (NA) 5. 폐암양성 의심 (< 8 또는 < 4) 6. 기타: 폐양형 외 확인되는 소견 () () 기종 폐양화자		판정구분에 따른 권고 사항: 4개월 후 재진행 CT를 시행하시기 바랍니다. 폐양형 외 기타 권고 사항: 관상동맥 비확 () () A nonspecific lung cyst, LLL.			
최종판정: 3					
등록번호	년 월 일	면허번호			
현안일	2022년 02월 22일	판정일자	의사명		

상세 변경 > | 노트 편집 | 상세 | 보고서 열기 | **보고서 내보내기** | CSV파일 내보내기 | DICOM 내보내기 | 삭제

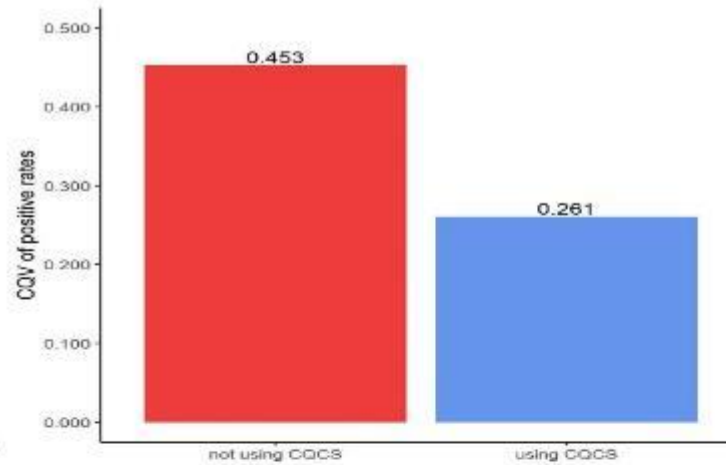
Methods of analyzing the effectiveness of CQCS using in Korean national lung cancer screening program

- 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
$$(\theta_{CQV} = (\theta_3 - \theta_1) / (\theta_1 + \theta_3)).$$
- Also, we measured reading time for evaluation a LDCT based on questionnaire to radiologists using CQCS.

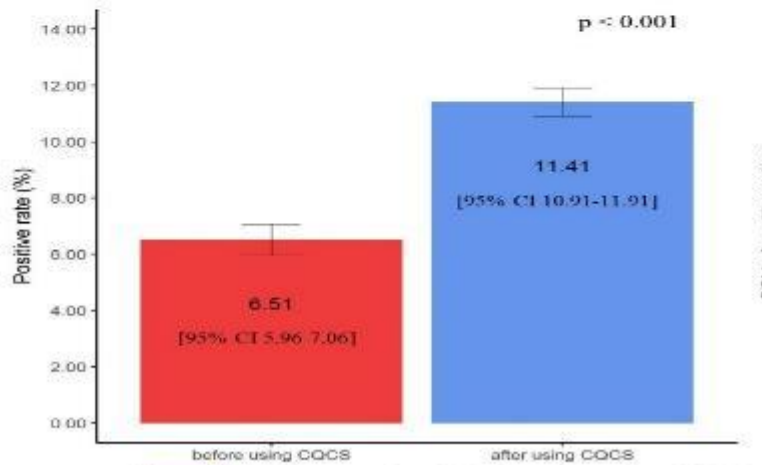
Effectiveness of Cloud-based Computer Aided Quality Control System (CQCS) in Korean National Lung Cancer Screening



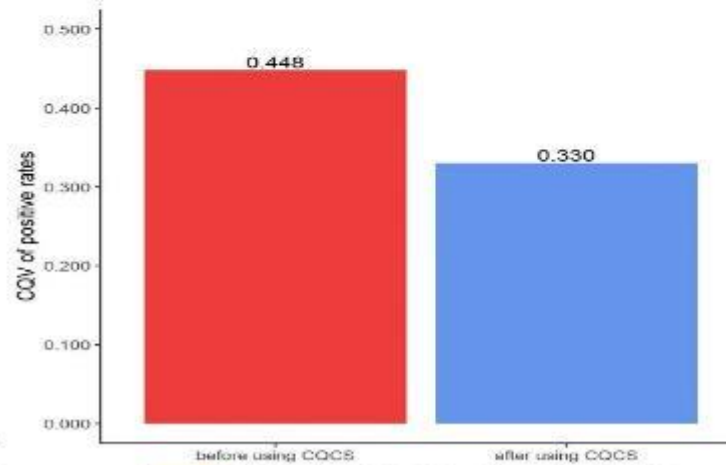
(A) Positive rates of radiologists using and not using CQCS



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

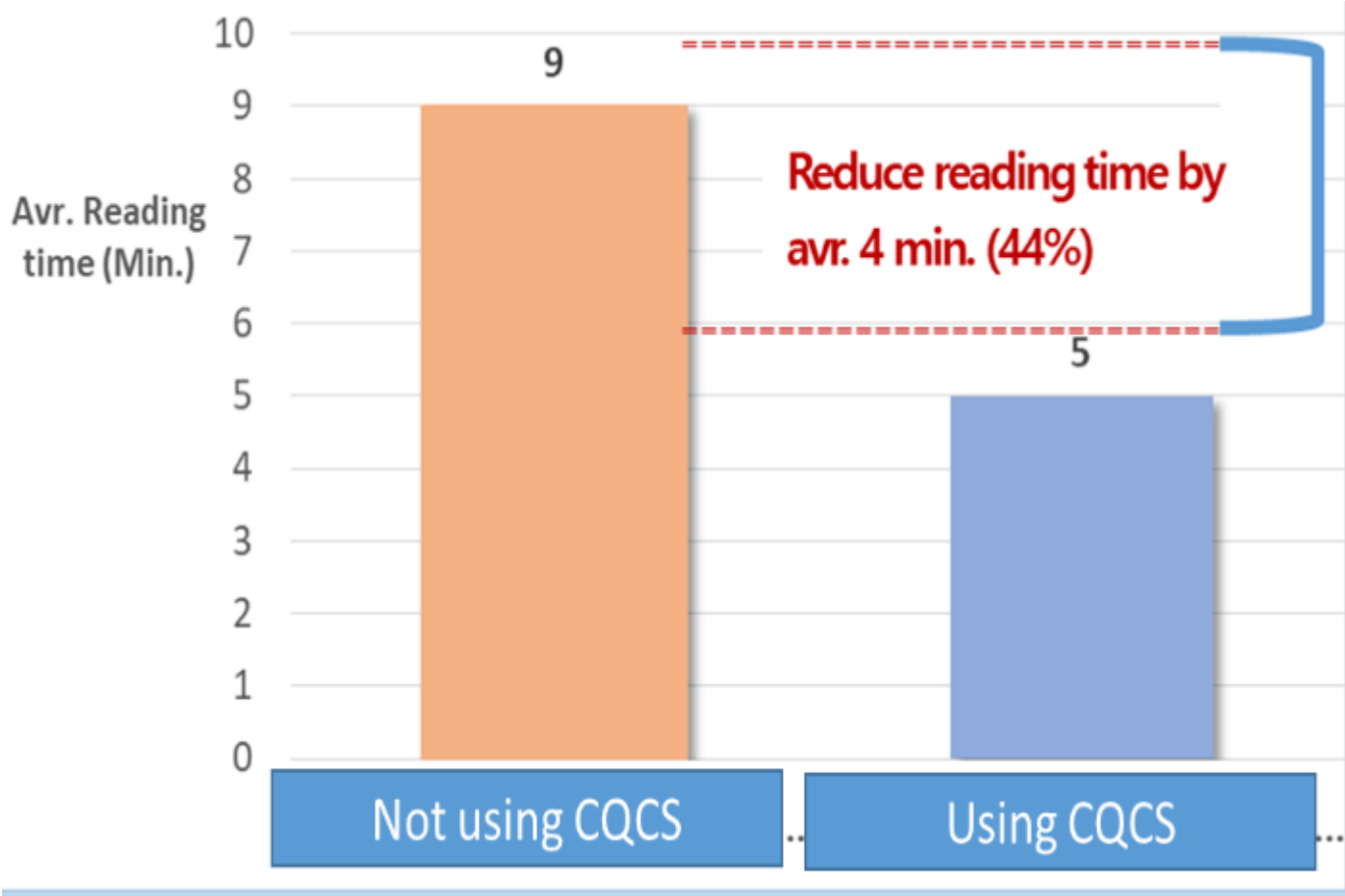


(C) Positive rates of radiologists before and after using CQCS



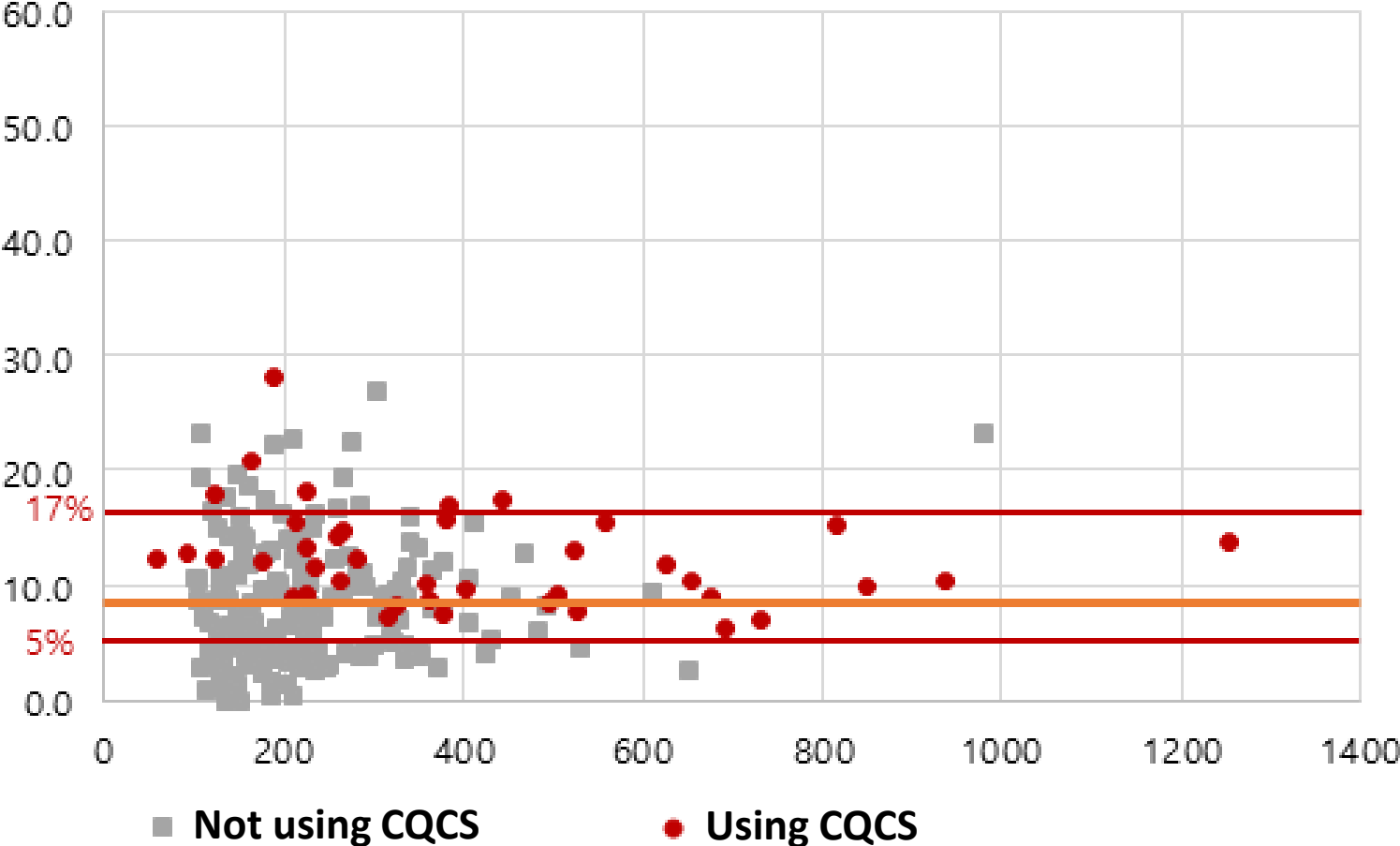
(D) Inter-radiologist variabilities before and after using CQCS

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



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

Positive rate (%)



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.

Thank you !

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