

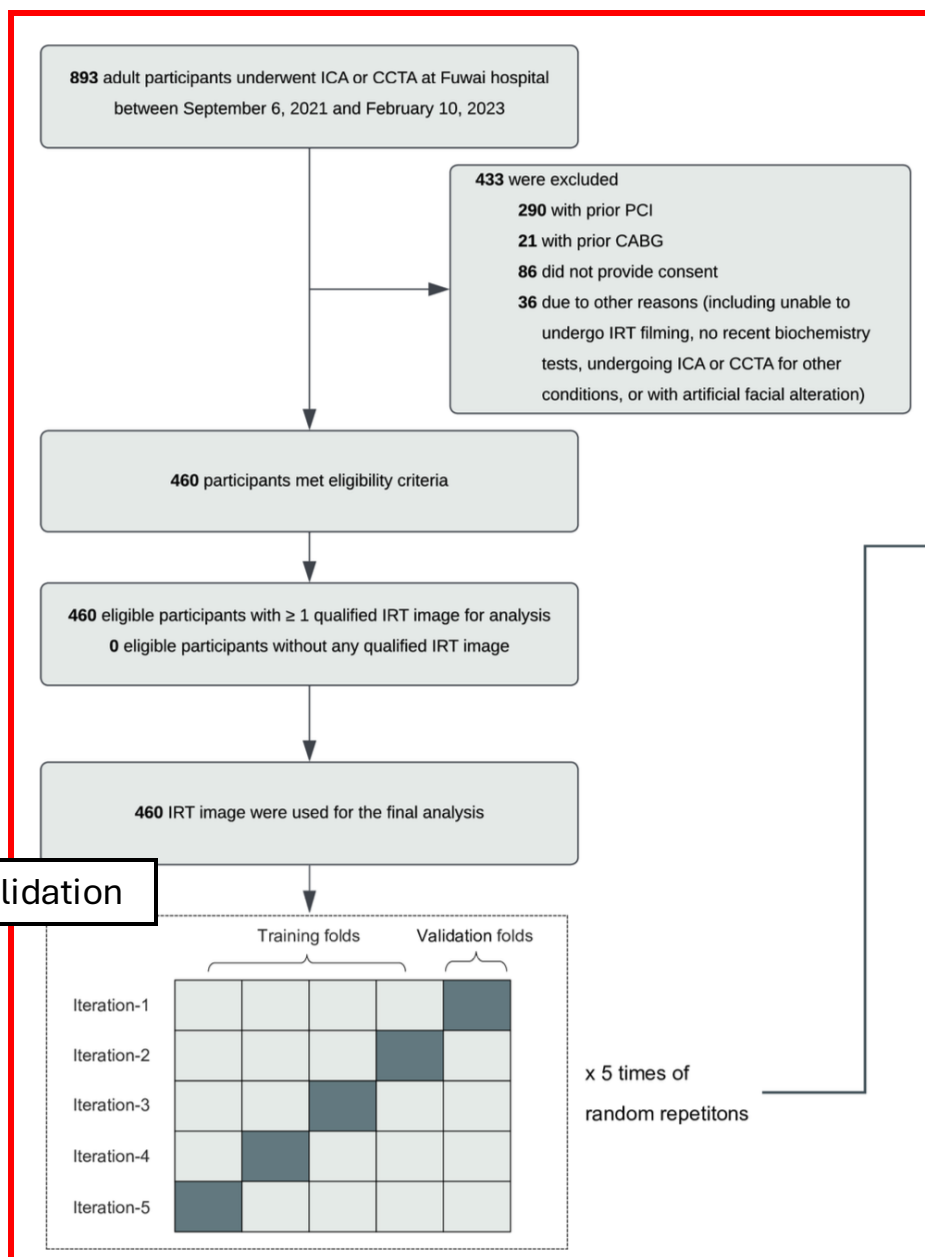


## Results

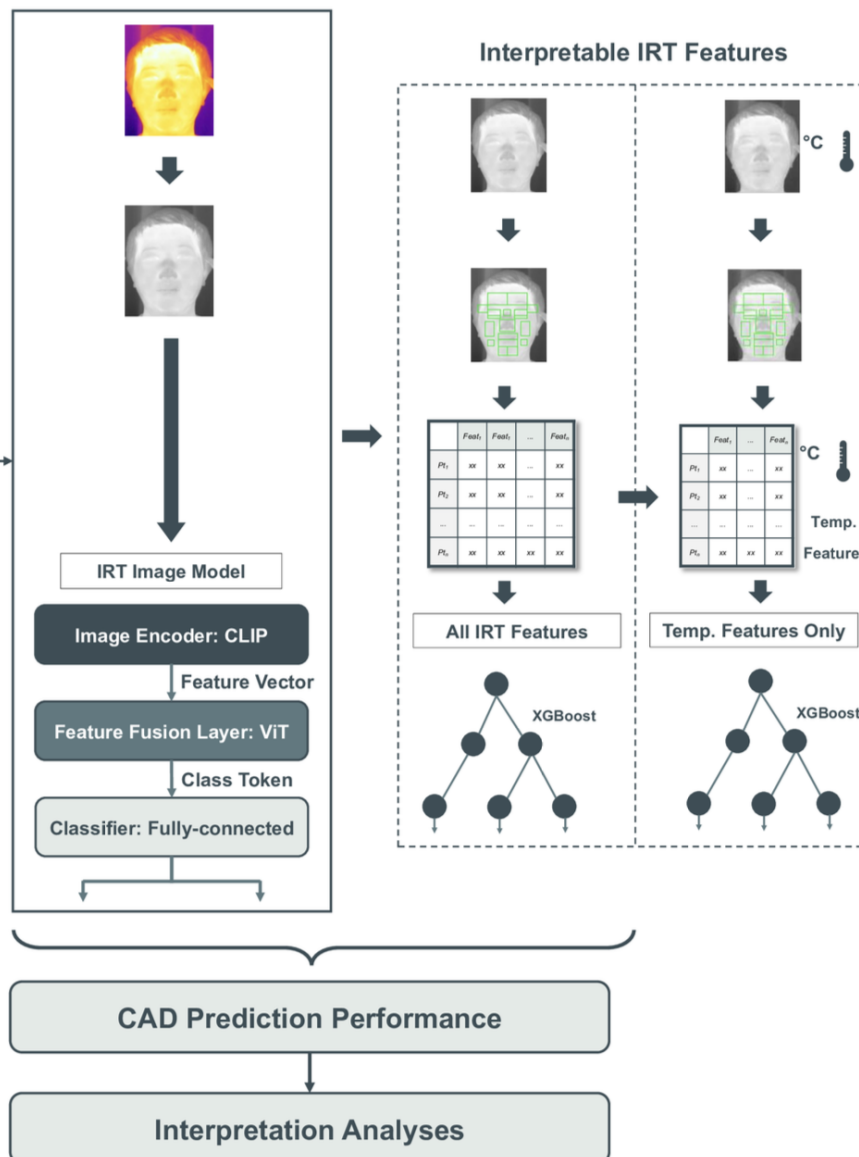
**Prediction of coronary artery disease  
based on facial temperature information captured  
by non-contact infrared thermography**

**Figure 1: Flow chart of the study dataset and design**

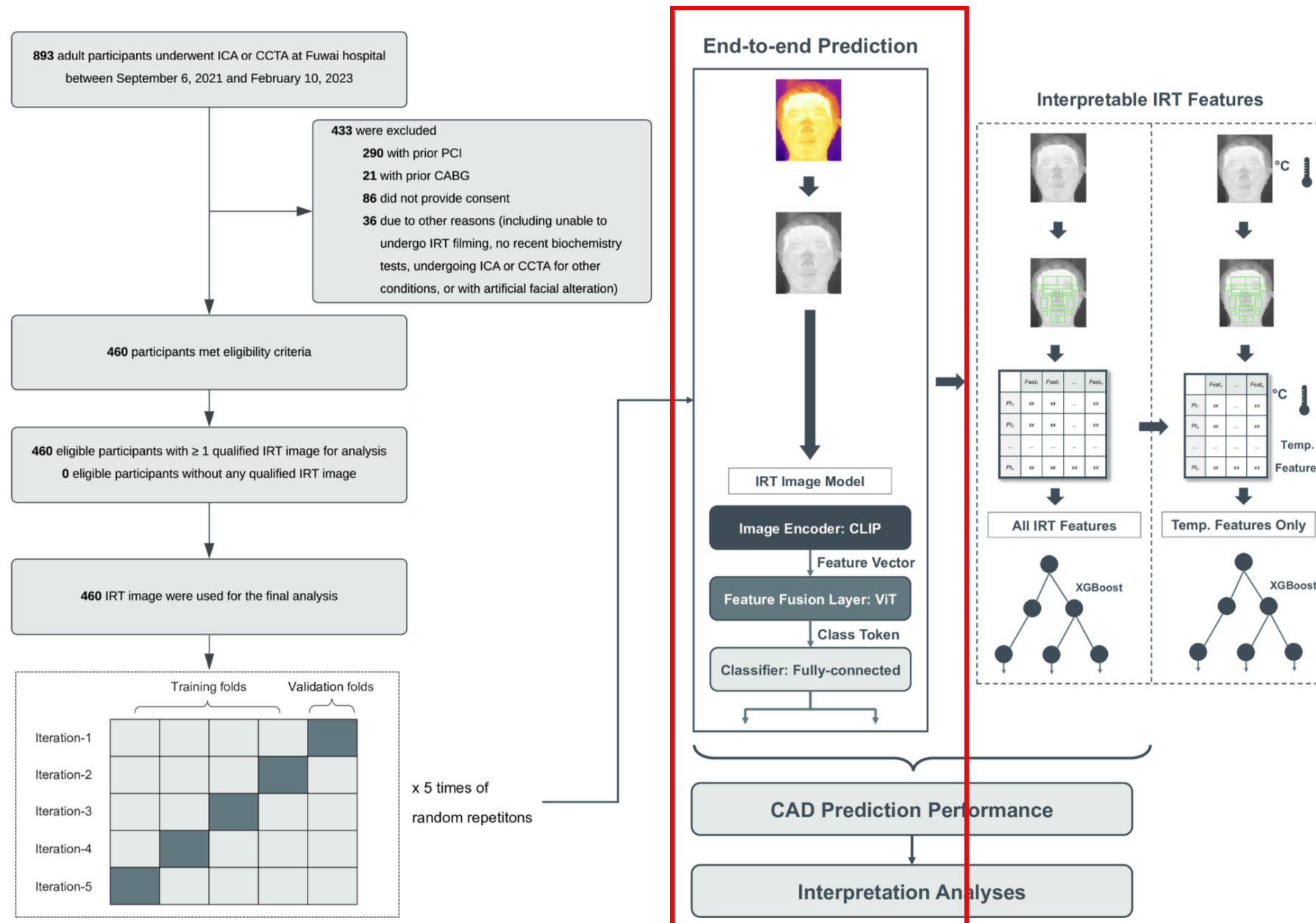
## Patient Selection Flowchart



## End-to-end Prediction



**Figure 1: Flow chart of the study dataset and design**



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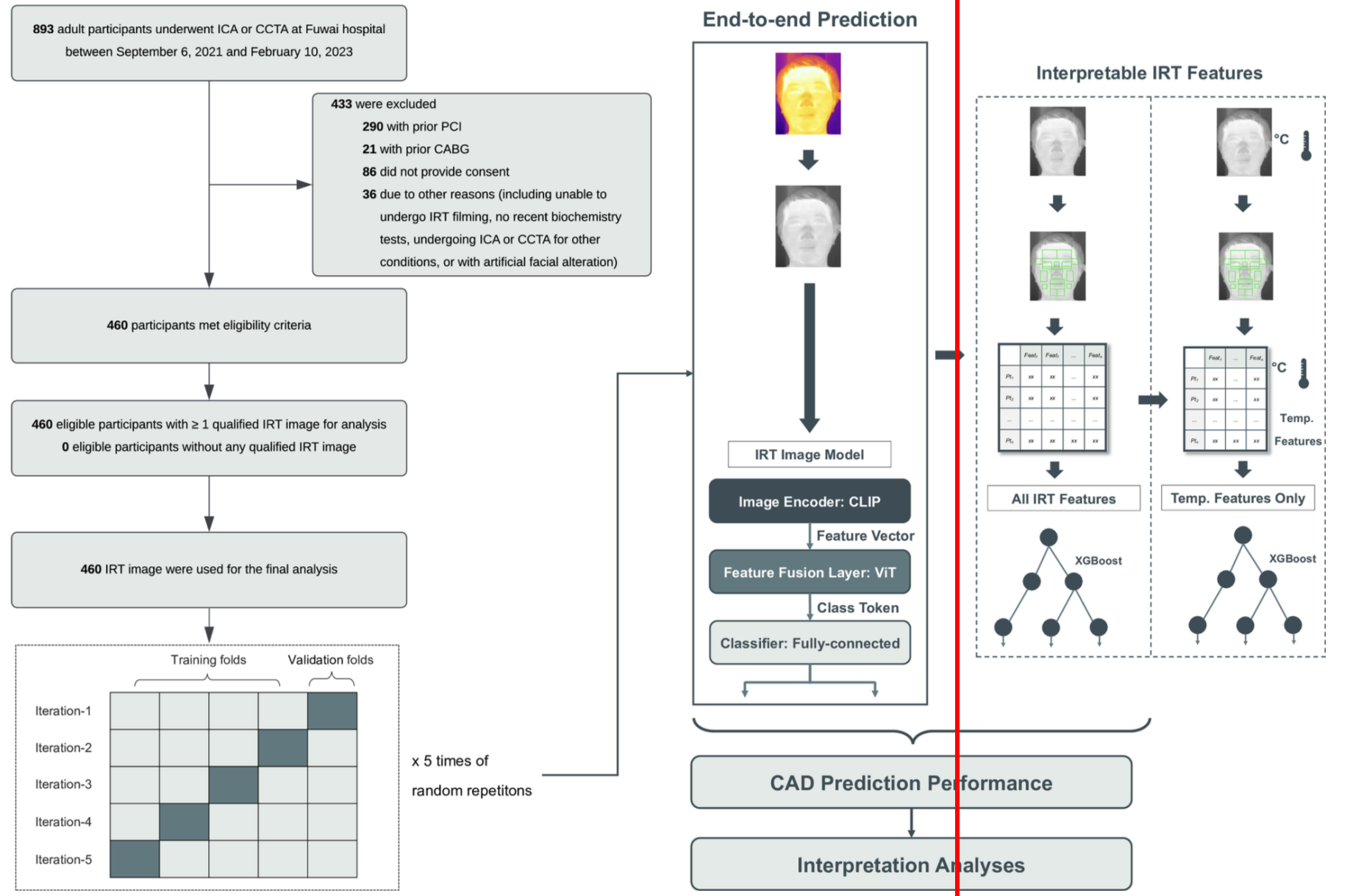


Table 1

Table 1 Baseline characteristics				
	Overall (n=460)	CAD (n=322)	No CAD (n=138)	P value
Age, mean (SD)	58.4 (10.4)	60.4 (9.7)	53.8 (10.6)	<0.001
Female sex, n (%)	126 (27.4)	74 (23.0)	52 (37.7)	0.002
Smoking, n (%)	219 (47.6)	177 (55.0)	42 (30.4)	<0.001
BMI, mean (SD)	25.5 (3.0)	25.6 (3.0)	25.2 (3.0)	0.155
Menopause, n (%)	107 (84.9)	71 (95.9)	36 (69.2)	<0.001
Early ASCVD family history, n (%)	18 (3.9)	15 (4.7)	3 (2.2)	0.128
Hypertension, n (%)	267 (58.0)	215 (66.8)	52 (37.7)	<0.001
Hyperlipidaemia, n (%)	348 (75.7)	295 (91.6)	53 (38.4)	<0.001
Diabetes mellitus, n (%)	112 (24.3)	96 (29.8)	16 (11.6)	<0.001
Cerebrovascular event, n (%)	67 (14.6)	59 (18.3)	8 (5.8)	0.001
Peripheral artery disease, n (%)	48 (10.4)	44 (13.7)	4 (2.9)	0.001
Congestive heart failure, n (%)	63 (13.7)	32 (9.9)	31 (22.5)	0.001
Chronic kidney disease, n (%)	5 (1.1)	4 (1.2)	1 (0.7)	1.00
COPD, n (%)	7 (1.5)	5 (1.6)	2 (1.4)	1.00
Atrial Fibrillation, n (%)	35 (7.6)	21 (6.5)	14 (10.1)	0.250
Chronic inflammatory disease, n (%)	18 (3.9)	14 (4.3)	4 (2.9)	0.637
CAD symptoms, n (%)				
No symptoms	77 (16.7)	42 (13.0)	35 (25.4)	0.002
Non-anginal	102 (22.2)	70 (21.7)	32 (23.2)	
Atypical	146 (31.7)	102 (31.7)	44 (31.9)	
Typical	135 (29.3)	108 (33.5)	27 (19.6)	

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ปัจจัยเสี่ยงพื้นฐาน

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อาการของโรค  
หลอดเลือดหัวใจ  
(CAD)



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การไขยา

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Statin, n (%)	210 (45.7)	173 (53.7)	37 (26.8)	<0.001
Nonstatin lipid-lowering drugs, n (%)	11 (2.4)	7 (2.2)	4 (2.9)	0.740
ACEI/ARB, n (%)	125 (27.2)	103 (32.0)	22 (15.9)	0.001
CCB, n (%)	121 (26.3)	94 (29.2)	27 (19.6)	0.042
Fast glucose, mean (SD)	6.3 (2.0)	6.5 (2.2)	5.7 (1.3)	<0.001
Total cholesterol, mean (SD)	4.3 (1.2)	4.2 (1.2)	4.7 (1.1)	<0.001
Triglyceride, mean (SD)	1.7 (1.7)	1.7 (1.9)	1.5 (0.9)	0.058
HDL, mean (SD)	1.2 (0.3)	1.2 (0.3)	1.3 (0.3)	<0.001
LDL, mean (SD)	2.5 (1.0)	2.4 (0.9)	2.9 (1.0)	<0.001
Haemoglobin A1c%, mean (SD)	6.3 (1.2)	6.4 (1.2)	5.9 (0.7)	<0.001
ESR, mean (SD)	8.0 (9.6)	8.3 (10.2)	6.7 (5.8)	0.069
CRP, mean (SD)	3.6 (5.2)	3.7 (5.5)	3.0 (3.4)	0.231
LVEF, mean (SD)	63.2 (6.2)	62.5 (6.6)	65.1 (4.5)	<0.001
Coronary confirmatory exam, n (%)				<0.001
ICA	379 (82.4)	310 (96.3)	69 (50.0)	
CCTA	81 (17.6)	12 (3.7)	69 (50.0)	
Coronary Lesion severity, n (%)				<0.001
No coronary stenosis >50%	138 (30.0)	/	138 (100.0)	
One vessel	89 (19.3)	89 (27.6)	/	
Two vessels	74 (16.1)	74 (23.0)	/	
Left main or three or more vessels	159 (34.6)	159 (49.4)	/	

ACEI/ARB, ACE inhibitor or angiotensin receptor blocker; ASCVD, atherosclerotic cardiovascular diseases; BMI, body mass index; CAD, coronary artery disease; CCB, calcium channel blocker; CCTA, coronary CT angiography; COPD, chronic obstructive pulmonary disease; CRP, C reactive protein; ESR, erythrocyte sedimentation rate; HDL, high-density lipoprotein; ICA, invasive coronary angiography; LDL, low-density lipoprotein; Lp(a), lipoprotein(a); LVEF, left ventricular ejection fraction.



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ผลตรวจทาง  
ห้องปฏิบัติการ

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ผลการวินิจฉัย

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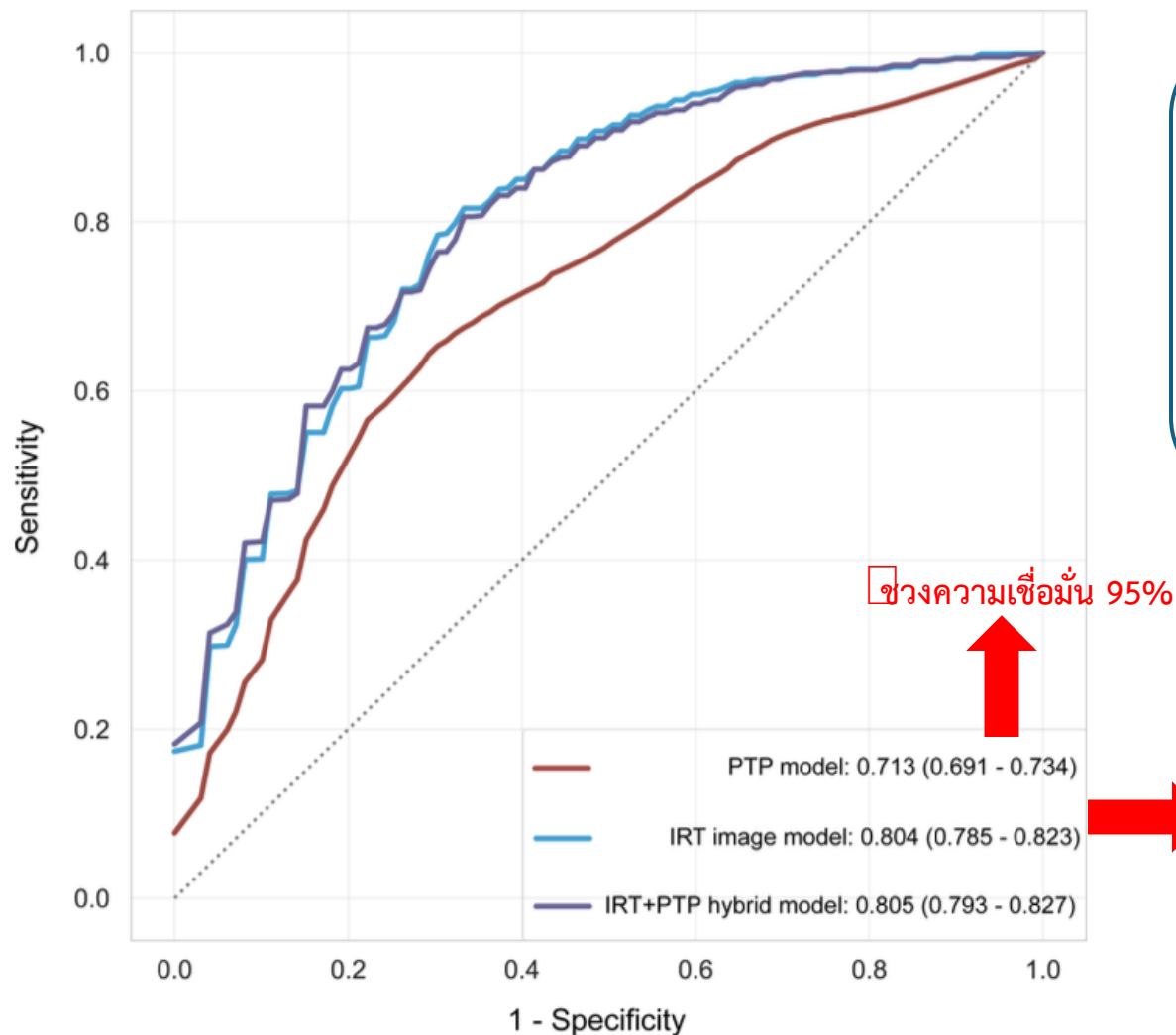
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ความรุนแรง  
ของโรค

**Figure 2: Receiver operating characteristic curves of models performance for CAD prediction.**

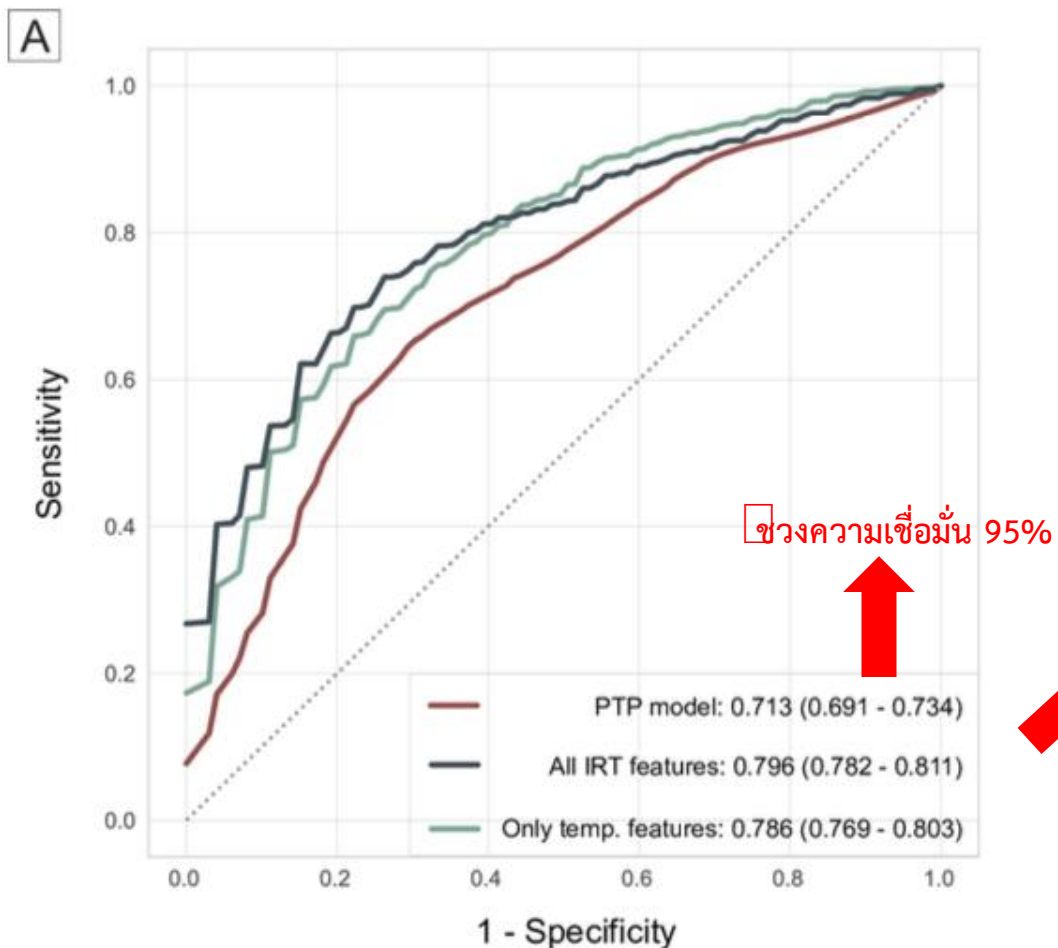


แบบจำลอง AI ที่วิเคราะห์จากภาพถ่ายอุณหภูมิต้องเท้า (IRT image model) มีประสิทธิภาพในการทำนายโรคหลอดเลือดหัวใจได้ดีกว่าวิธีการประเมินความเสี่ยงทางคลินิกแบบดั้งเดิม (PTP model) อย่างมีนัยสำคัญ

#### จากกราฟ ROC Curve

- PTP model: AUC = 0.713
- IRT image model: AUC = 0.804
- IRT+PTP hybrid model: AUC = 0.805

**Figure 3A: Predictive performance for using all or traditional temperature- only IRT features for CAD prediction, as compared with the PTP model**

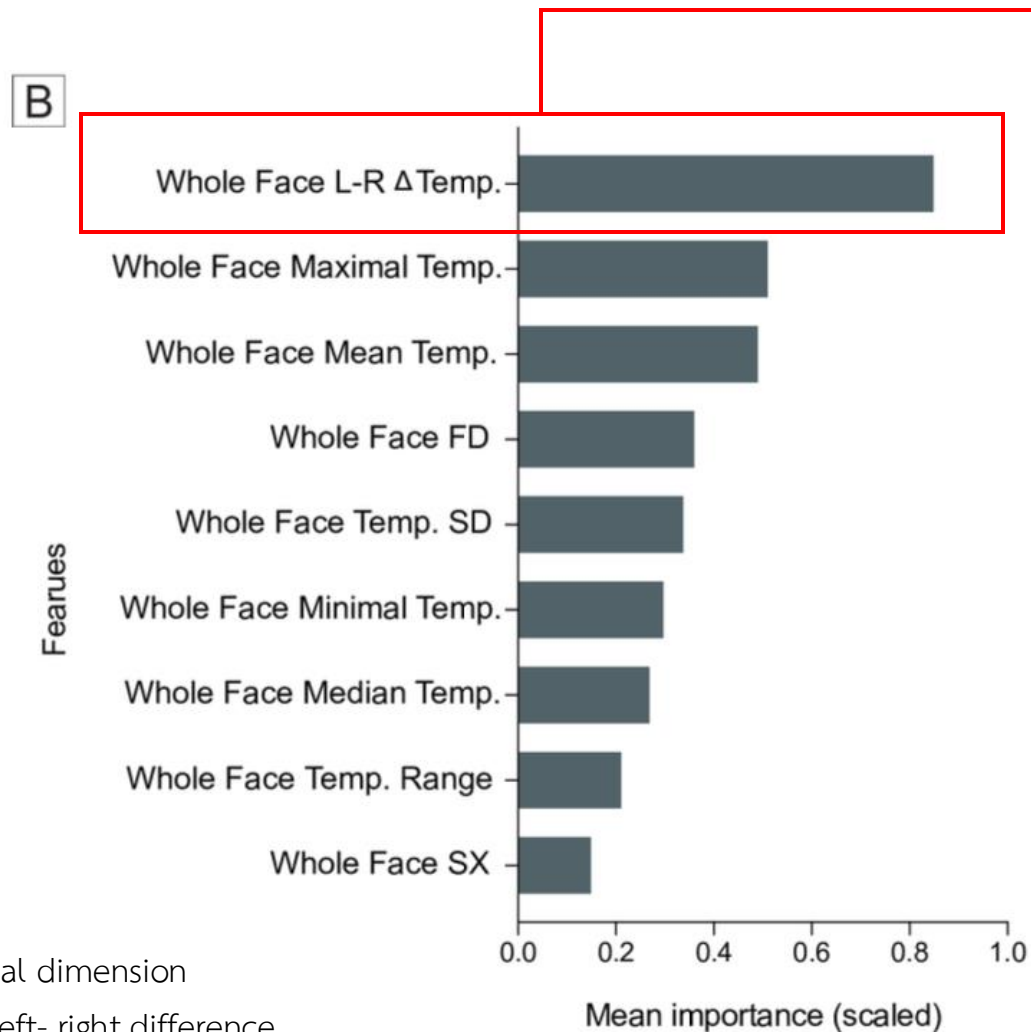


### จากกราฟ ROC Curve

- PTP model: AUC = 0.713
- All IRT features: AUC = 0.796  
(แบบจำลองที่ใช้ค่า features ที่สกัดจากภาพ IRT)
- Traditional temperature features: AUC = 0.786  
(แบบจำลองที่ใช้เฉพาะข้อมูลอุณหภูมิพื้นฐานที่วัดได้จากภาพ)

งานวิจัยนี้สามารถสร้าง Model ที่สามารถทำนายโรคได้ดีกว่าวิธีดั้งเดิม และสามารถบอกได้ว่าใช้ข้อมูลส่วนไหนในการตัดสินใจ (Interpretable Model)

**Figure 3B: The ranking of the scaled importance value of the whole - face level features.**



ความแตกต่างของอุณหภูมิระหว่างใบหน้าซ้ายและขวาโดยรวม แสดงว่าความไม่สมมาตรของอุณหภูมิ เป็นสัญญาณเตือนที่สำคัญของ โรคหลอดเลือดหัวใจ (CAD)

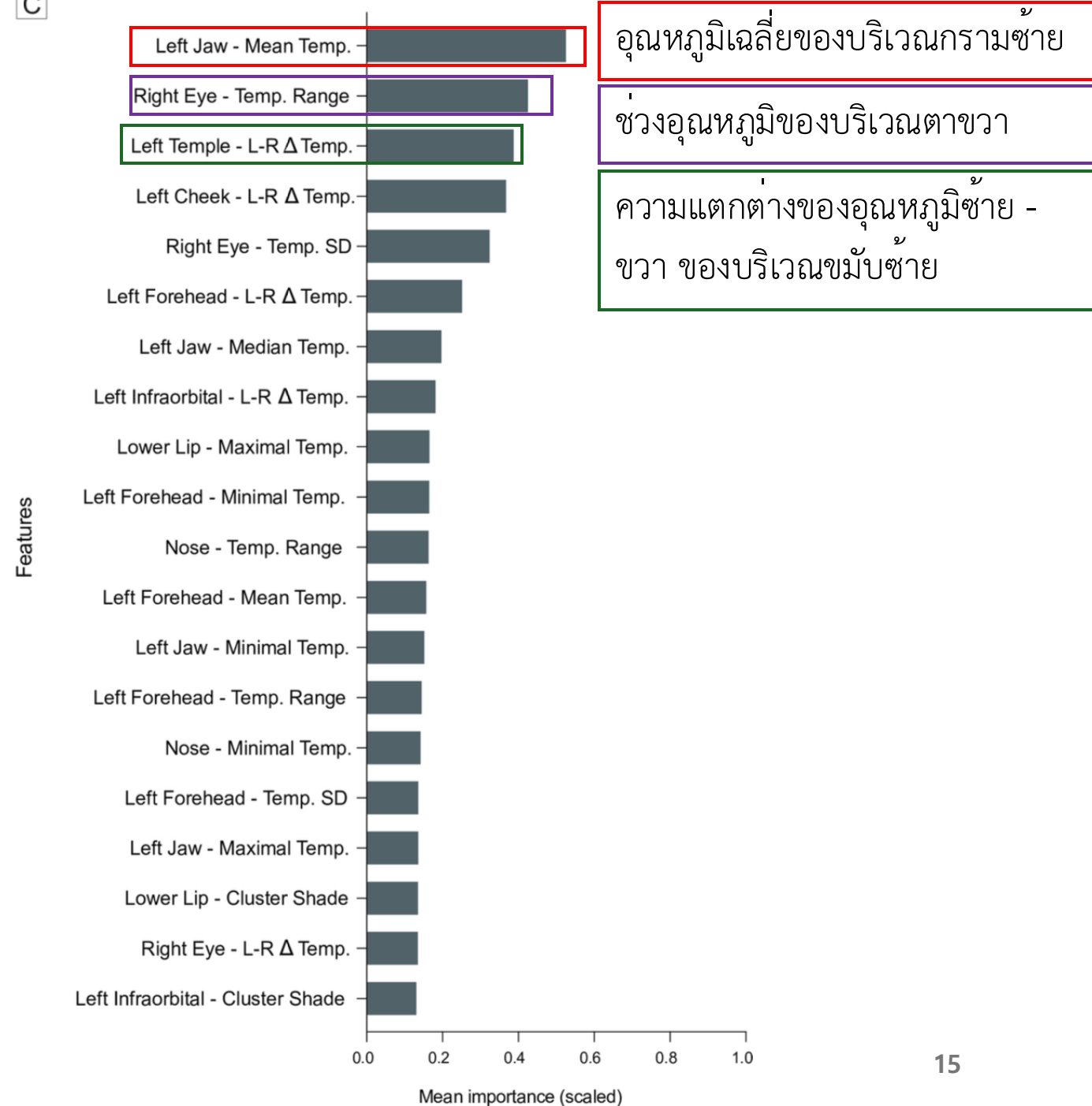
เป็นการมองภาพรวมของทั้งใบหน้า เพื่อสรุป ว่า features ใดมีอิทธิพลสูงสุดในการทำนายโรค

FD: fractal dimension  
L- R  $\Delta$ : left- right difference  
SX: sum of extrema  
 $\Delta$ : value difference.

**Figure 3C: The ranking of the scaled importance value of the top 20 region of interest (ROI) - level features.**

จากข้อมูลทั้งหมดที่วัดได้จากภาพถ่ายอุณหภูมิใบหน้า จะ ดูในบริเวณเล็กๆ ที่น่าสนใจ 20 บริเวณ เพื่อดูว่า บริเวณใดที่ AI คิดว่าสำคัญที่สุดในการทำนายโรค

C

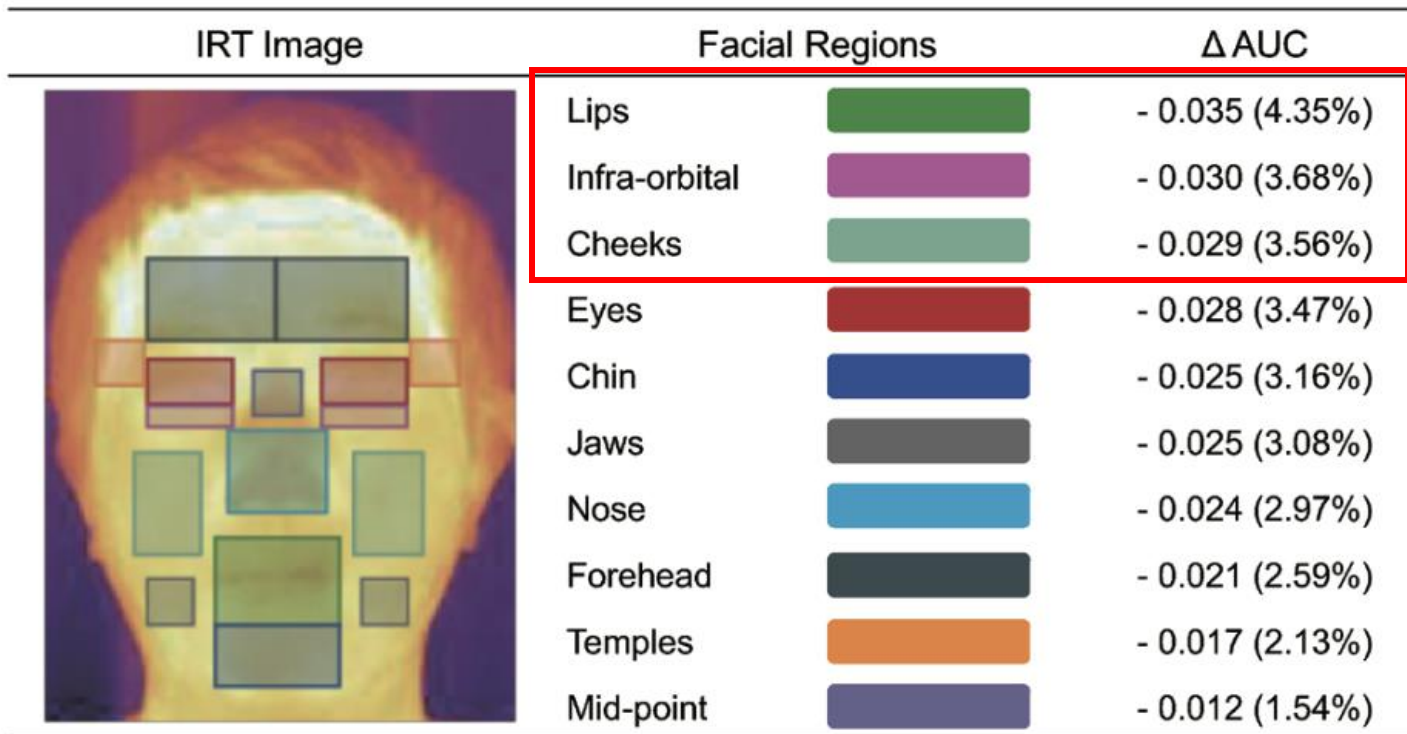




## Interpretation and visualisation of the IRT image model

Figure 4A: Results of the occlusion tests in assessing the effect of individual facial regions after occlusion on the IRT image model's predictive performance, measured by the degree of AUC reduction ( $\Delta$ AUC)

A



นักวิจัยได้ทำการปิดส่วนต่างๆ ของใบหน้าทีละส่วน แล้ววัดว่าประสิทธิภาพของ AI ในการทำนายโรค ลดลงไปเท่าไร ( $\Delta$ AUC)

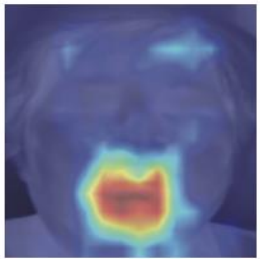
ค่า  $\Delta$ AUC ตีลบเยอะ

ส่วนที่ถูกปิดนั้นสำคัญต่อการตัดสินใจของ AI มากที่สุด

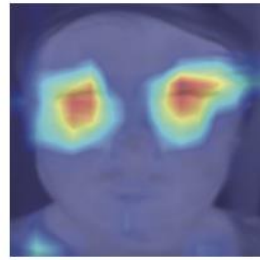
AI ให้ความสำคัญกับ **บริเวณกลางใบหน้า (Central Face)** โดยเฉพาะ **รอบปาก, ตา, และแก้ม** เป็นพิเศษในการค้นหาสัญญาณของโรค

**Figure 4B:** Visualisation of examples with specific facial regions deemed important for IRT image model prediction highlighted by the Gradient - weighted Class Activation Map methods

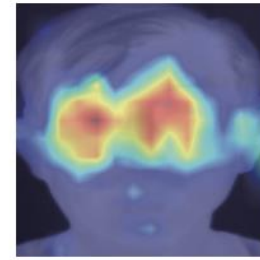
B



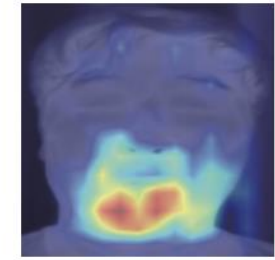
Lips



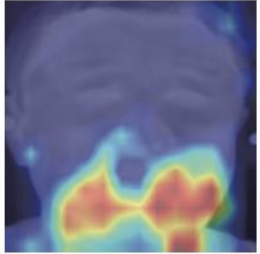
Eyes & Infra-orbital



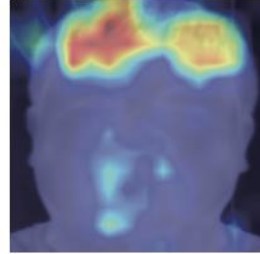
Cheeks & Nose



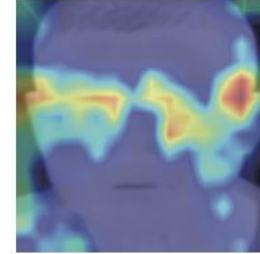
Chin



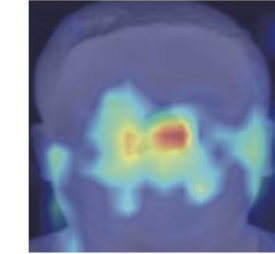
Jaws



Forehead



Temples



Mid-point

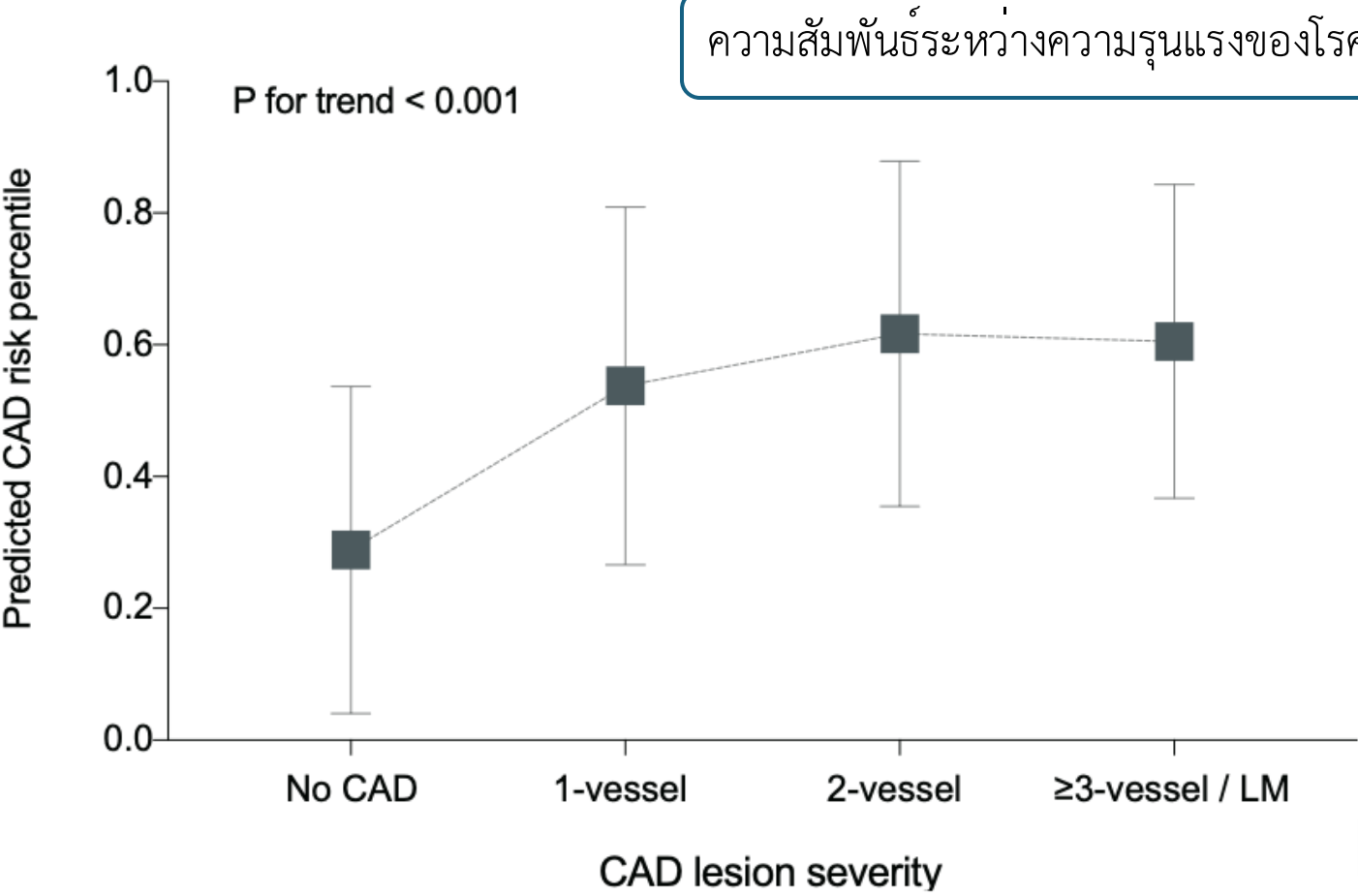
แผนที่ความร้อน (Heatmap)  
แสดงจุดที่ AI สนใจ

เทคนิค Grad-CAM จะสร้าง  
ภาพซ้อนทับบนใบหน้า

บริเวณที่เป็นสีแดง/เหลือง  
(พื้นที่ร้อน)

Figure 4C: Dose – response relationship between the CAD lesion severity and the IRT image model predicted CAD risk percentiles.

C



ผู้ป่วยที่อาการรุนแรงขึ้น

ค่าความเสี่ยงที่ AI ทำนายสูงขึ้น

AI สามารถแยกแยะระดับความรุนแรงของโรคได้จริง

Table 2

<b>Table 2</b> IRT model prediction for surrogate labels contributing or related to CAD		(Mean Absolute Error)
<b>Surrogate labels</b>	<b>AUC (95% CI)</b>	<b>MAE (95% CI)</b>
ASCVD traditional risk factors		
Hyperlipidaemia	0.831 (0.811 to 0.850)	/
Hypertension	0.640 (0.607 to 0.673)	/
Diabetes mellitus	0.659 (0.573 to 0.745)	/
Male	0.988 (0.985 to 0.991)	/
Age	/	8.23 (7.543 to 8.914)
Body mass index	/	2.593 (2.147 to 3.038)
Smoking	0.749 (0.694 to 0.804)	/
Early ASCVD family history	0.691 (0.587 to 0.795)	/
HbA1C%	/	0.772 (0.686 to 0.859)
Inflammation and other cardiovascular markers		
Chronic inflammatory diseases	0.631 (0.536 to 0.726)	/
Elevated ESR level*	0.645 (0.524 to 0.766)	/
Elevated Inflammatory Markers <sup>†</sup>	0.601 (0.539 to 0.663)	/
NT-proBNP>300pg/mL	0.636 (0.593 to 0.678)	/
<p>*The elevated level refers to the laboratory value higher than the upper bound of reporting normal range.</p> <p>†Inflammatory markers include ESR, C reactive protein and Interleukin-6.</p> <p>ASCVD, atherosclerotic cardiovascular diseases; AUC, area under the curve; CAD, coronary artery disease; CRP, C reactive protein; ESR, erythrocyte sedimentation rate; HbA1C%, Hemoglobin A1C%; IRT, infrared thermography; MAE, mean absolute error; NT-proBNP, N-terminal pro-B-type natriuretic peptide.</p>		

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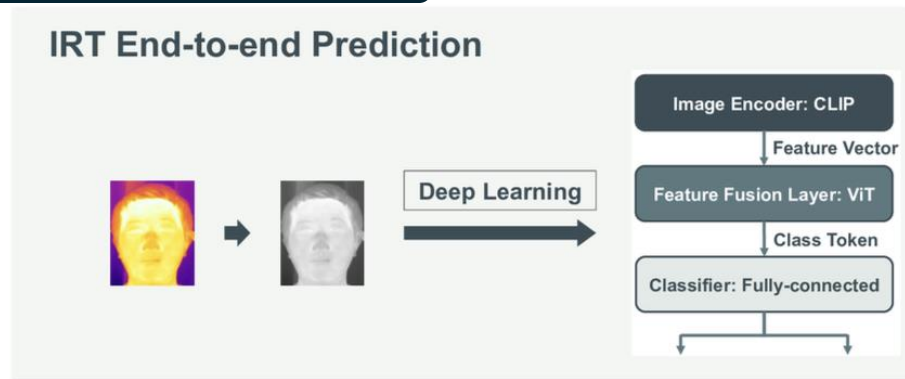
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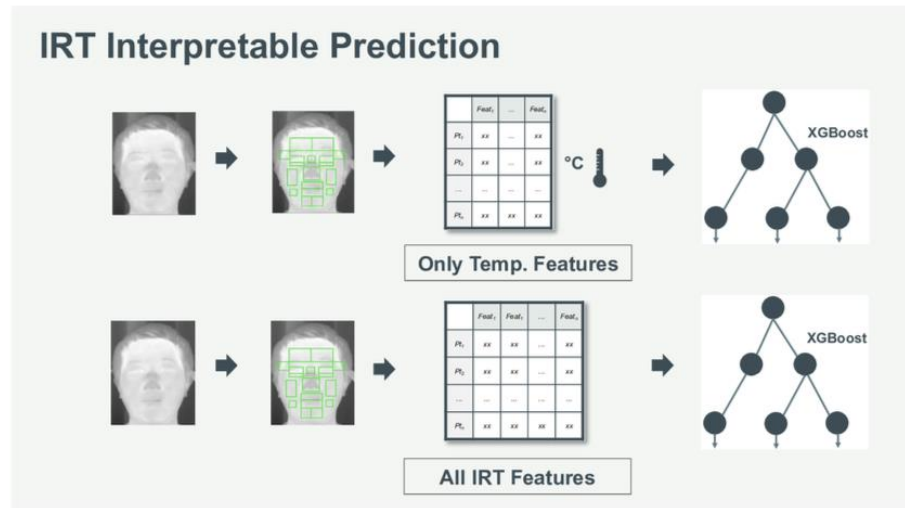


**Figure 5:Central illustration**

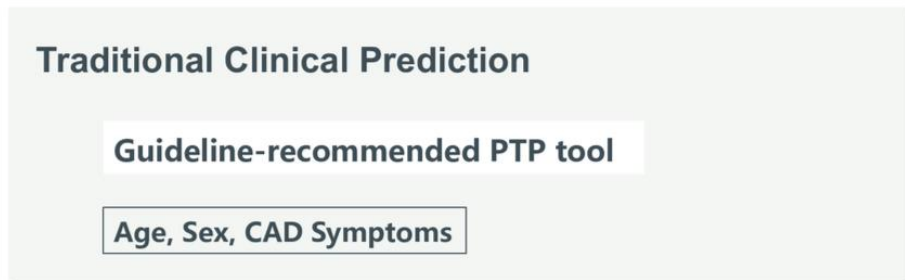
1



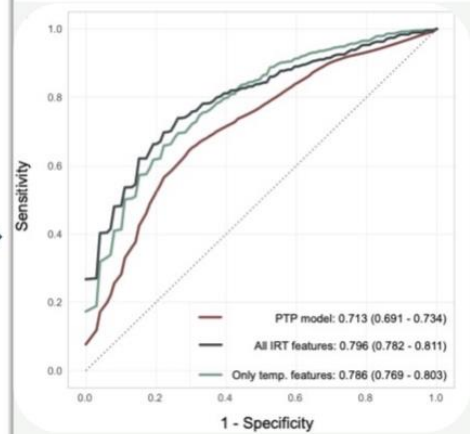
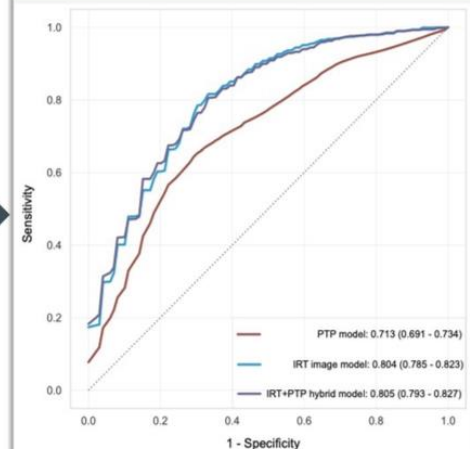
2



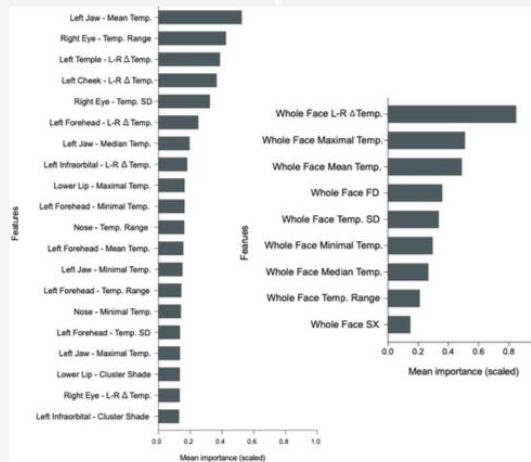
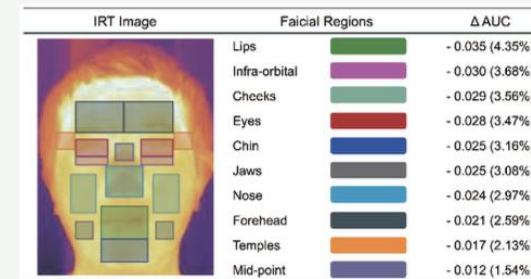
3



### CAD Prediction Performance



### CAD Prediction Interpretation



**Conclusions:**

Facial IRT information is feasible for non-contact, real-time prediction of obstructive CAD, with potentially superior predictive values than traditional clinical risk factors