NEXT-GENERATION MEDICAL AI: BEYOND EXPERTS AND HYBRID ENHANCED

汇报人: 利友诚

Large-scale pancreatic cancer detection via non-contrast CT and deep learning

nature medicine

Article

https://doi.org/10.1038/s41591-023-02640-w

Large-scale pancreatic cancer detection via non-contrast CT and deep learning

Received: 9 February 2023

Accepted: 12 October 2023

Published online: 20 November 2023

Check for updates

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“医疗AI多癌早筛公益项目”落户浙江丽水

一次平扫CT 筛查多种癌症（大健康观察）

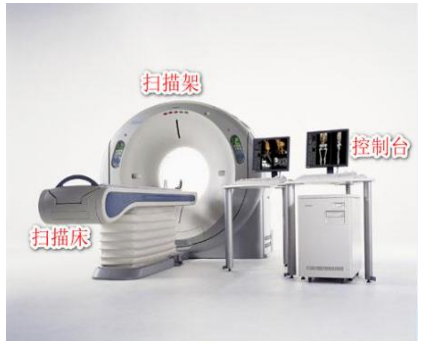
本报记者 熊 建

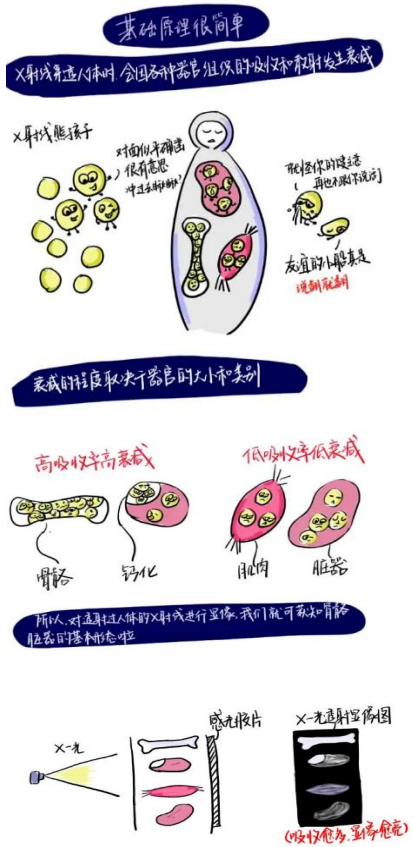
《 人民日报海外版 》（ 2024年02月27日 第 09 版）

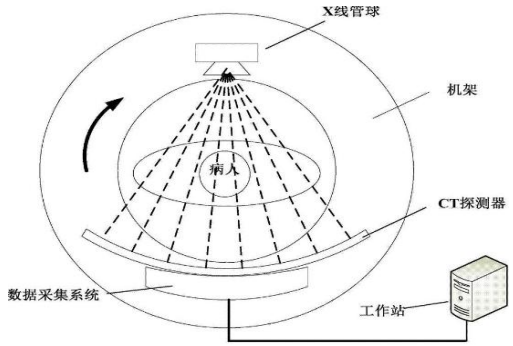
图为周永进正在检查患者的CT片。
阿里巴巴达摩院供图

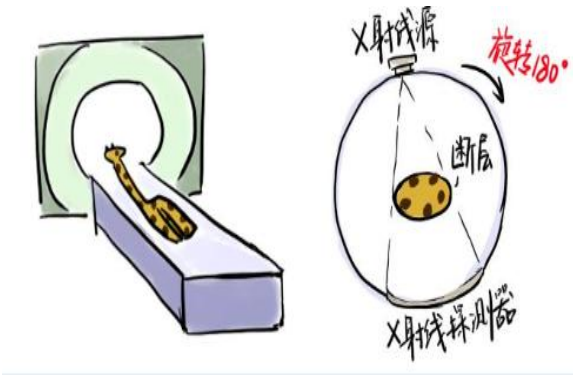
汇报人：利友诚

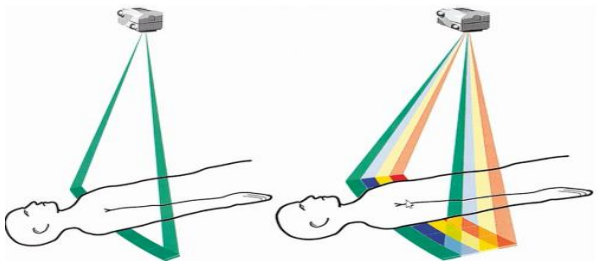
Introduction











不同排数CT检查比较

	平扫	强化	联合强化	常规血管	心脏(冠脉)	灌注	能谱
16排CT	√	√	-	√ 图像质量较差	-	-	-
64排CT	√	√	√ 小范围联合	√ 图像质量好	√ 心率70以下	√ 4cm灌注	-
超高端CT	√	√	√ 大范围联合	√ 多部位联合	√ 任意心率成像	√ 单器官灌注	√

Background and Contribution

北京大学 PEKING UNIVERSITY

Background

Pancreatic ductal adenocarcinoma (PDAC) is **the most lethal solid malignancy**, often diagnosed at an advanced stage and unsuitable for surgery.

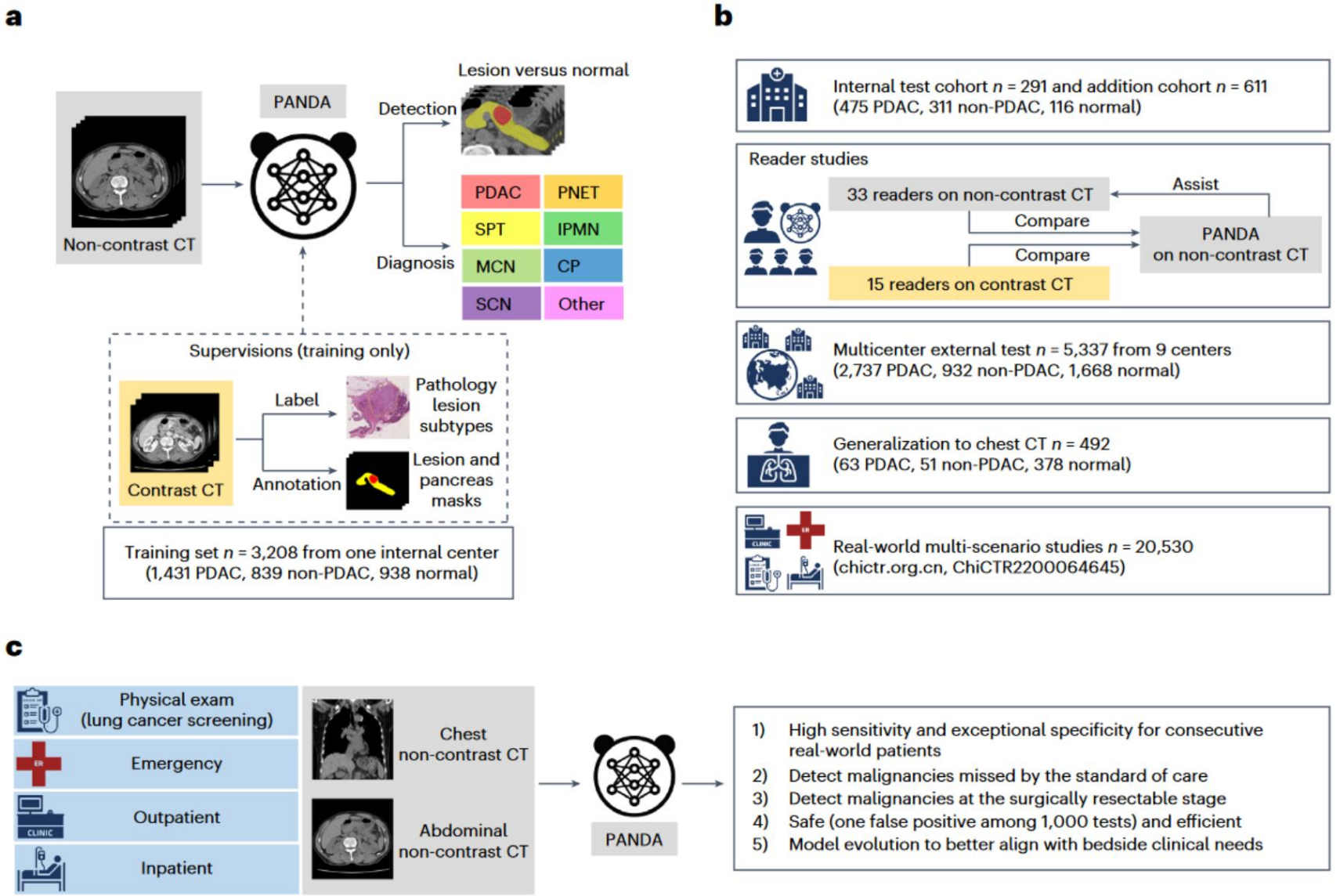
Early detection, early intervention.

However, due to the relatively low incidence of PDAC, effective screening in the general population requires **high sensitivity and specificity** to minimize the risk of overdiagnosis.

Challenge: **Non-contrast computed tomography (CT)** holds the potential for large-scale screening; however, the identification of PDAC using non-contrast CT has long been considered **impossible**, while **enhanced CT** is prohibitively expensive and has associated side effects on the body.

Contribution: An artificial intelligence-based system called Pancreatic Cancer Detection with Artificial Intelligence (**PANDA**) has been proposed for the detection and classification of pancreatic lesions **using non-contrast CT**. When combined with non-enhanced CT, PANDA is comparable to the use of enhanced CT in distinguishing common subtypes of pancreatic lesions.

Introduction

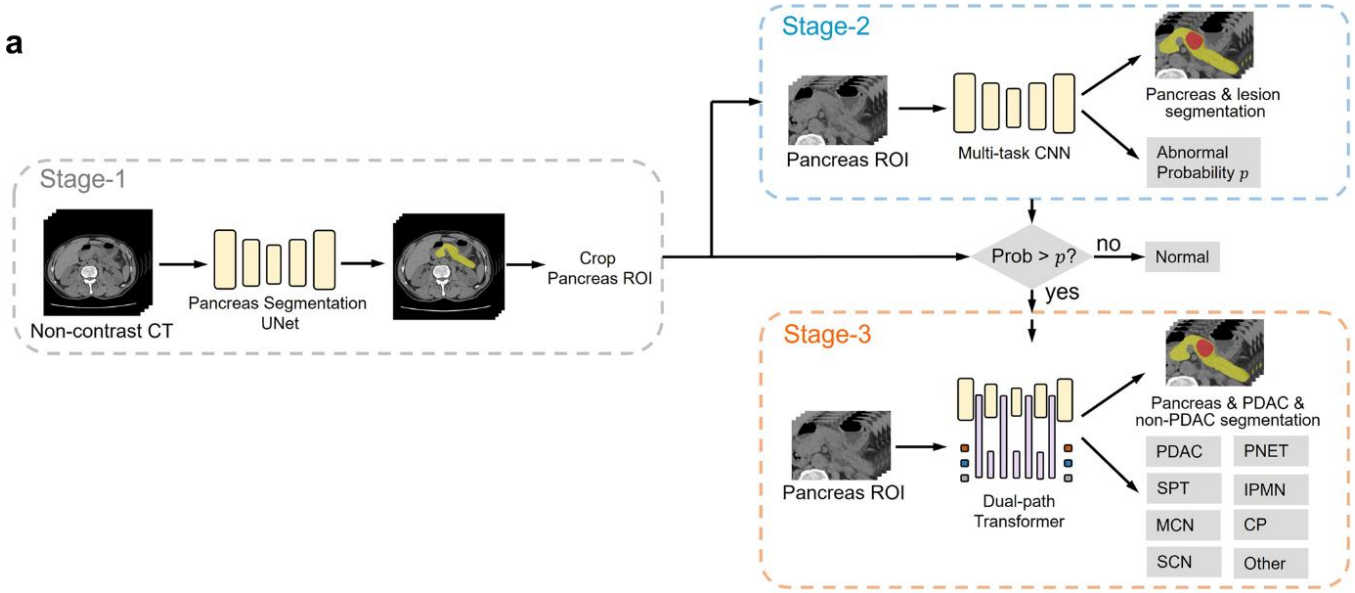


Stage 1 (Pancreas Localization):

Due to the typically small area of pancreatic lesions in CT scans, localizing the pancreas can expedite the process of lesion detection, eliminating irrelevant information and enabling focused training on the pancreatic region.

Method:

The input image size is (224, 192, 56). nnU-Net is employed for image segmentation, and the pancreatic region of the CT scan is extracted. It is then resized to a fixed size of (160, 256, 40) to enable more fine-grained classification and prediction of the CT scan.



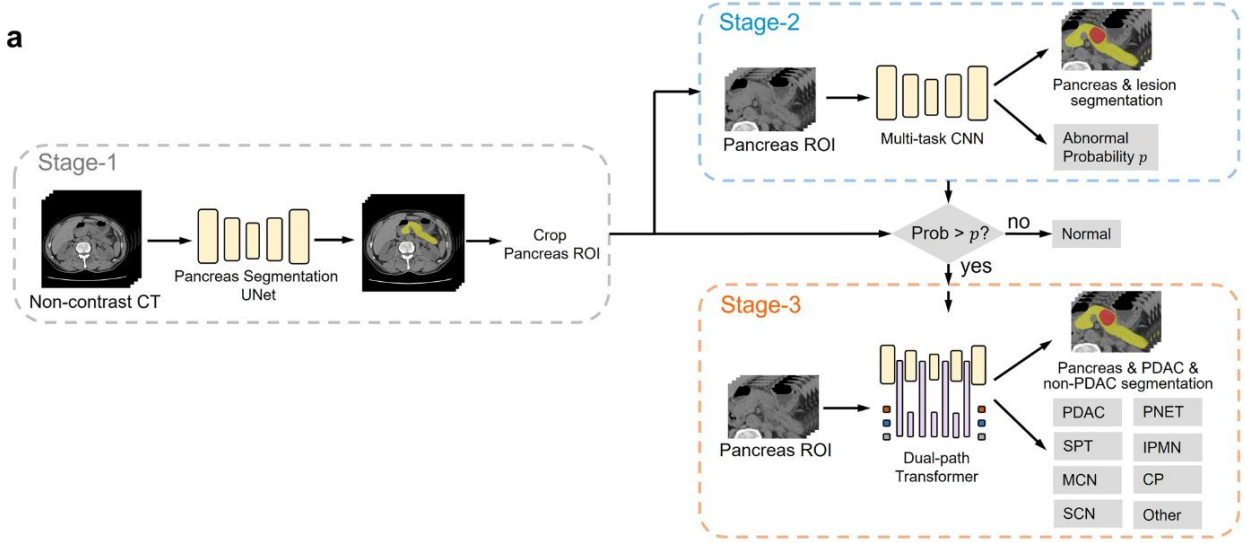
PANDA

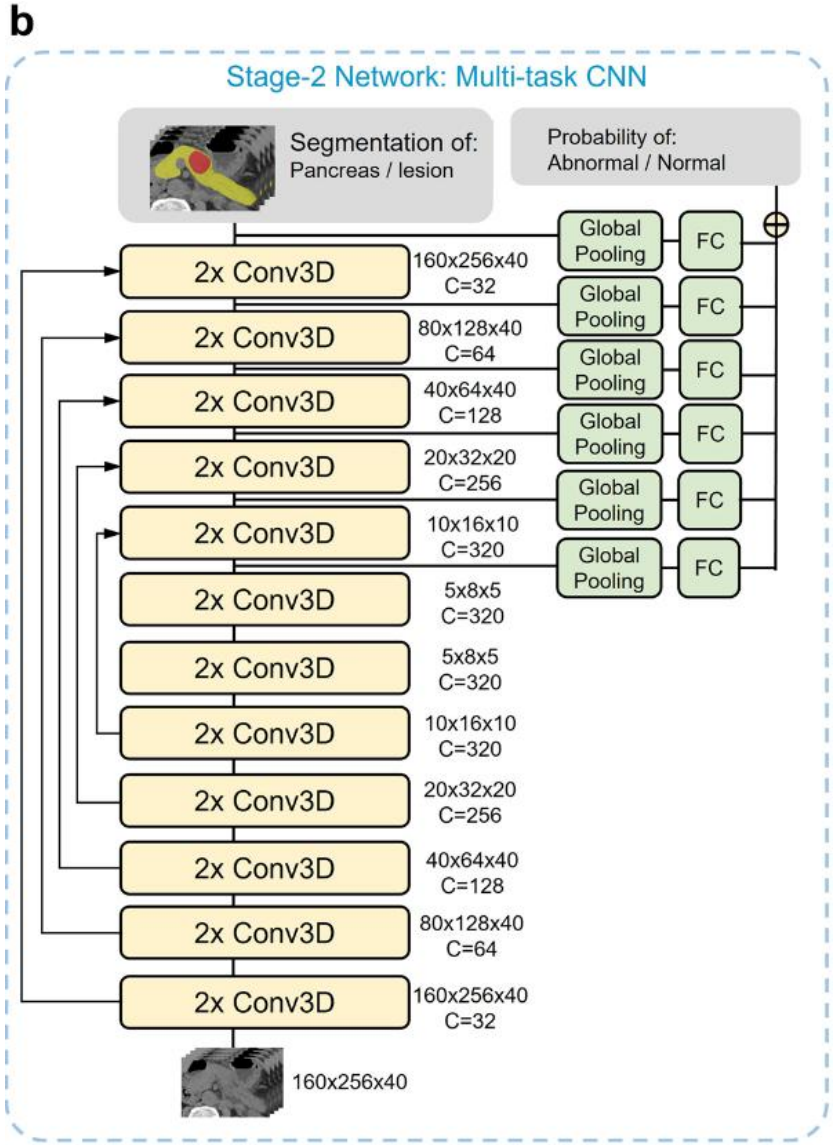
Stage 2 (Lesion Detection):

The purpose of this stage is to **detect lesions (PDAC/Non-PDAC) versus normal tissue.**

Method:

Using nnU-Net for further image segmentation, specifically segmenting the lesions. Additionally, multiple scale pooling layers are incorporated into the model to predict the probability of the presence of lesions.





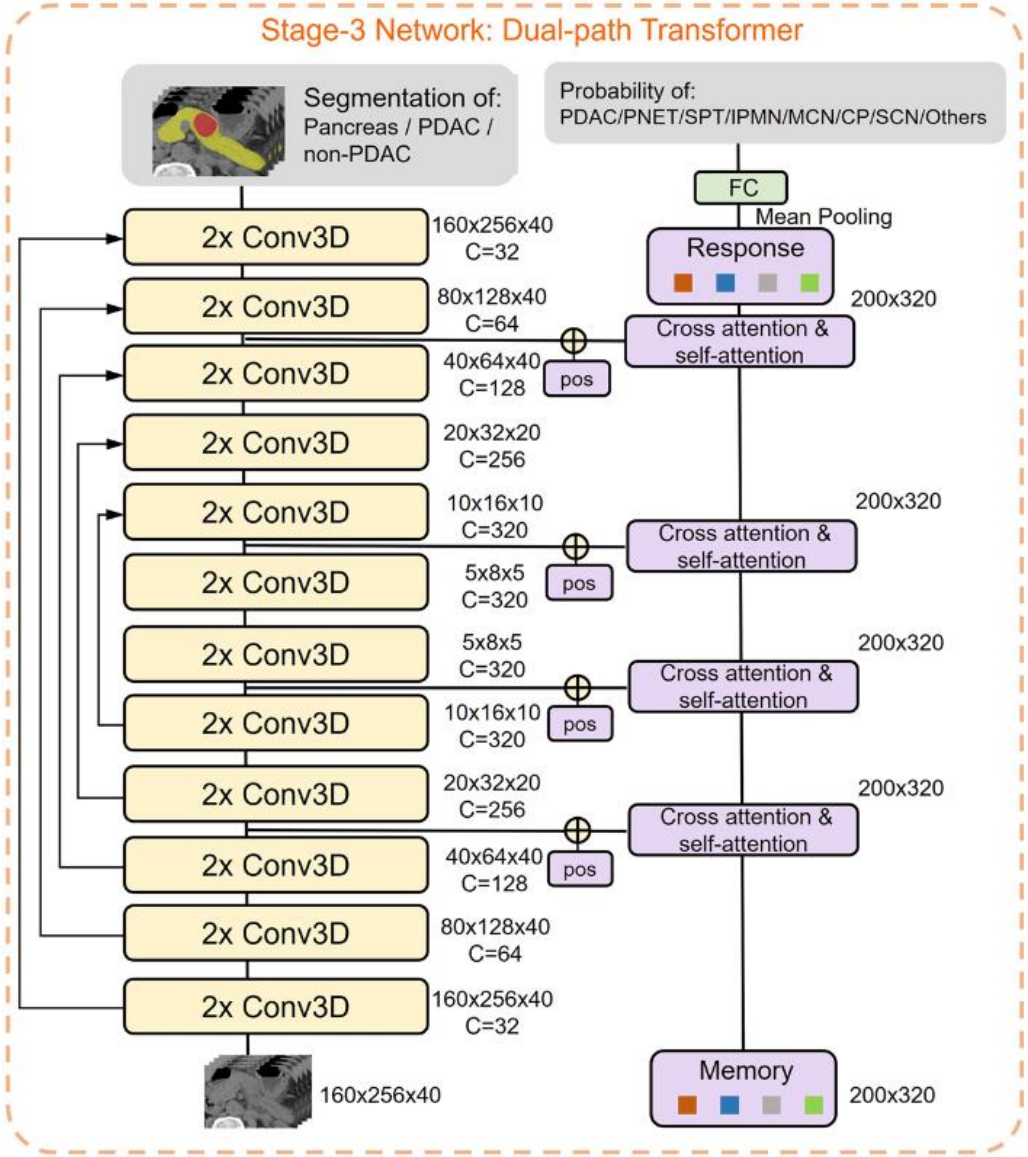
PANDA

Stage 3 (Differential Diagnosis):

The goal of the third stage is to **differentiate between different types of pancreatic lesions**, which are classified into eight subtypes: PDAC, PNET, SPT, IPMN, MCN, chronic pancreatitis, SCN, and others.

Method:

The image is further segmented using nnU-Net to separate the lesions into **pancreatic tissue, PDAC, and Non-PDAC regions**. Additionally, the model incorporates learnable memory tokens and learnable positional encodings for cross-layer sharing.



Task

1. **Lesion detection:** This task involves distinguishing lesions from normal tissue, including detection rates based on lesion type and cancer stage.

2. **Primary diagnosis:** This task focuses on differentiating PDAC from non-PDAC lesions and normal tissue. It also includes evaluating PDAC identification compared to non-PDAC + normal cases.

3. **Differential diagnosis:** This task involves classifying PDAC and seven subtypes of non-PDAC lesions.

Evaluation

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Sensitivity（敏感性）, Specificity（特异性）, AUC

Pred/GT		Ground Truth		Total		
		True	False			
Diagnosis	Pos.	TP	FP	prediction positive=TP+FP	PPV=TP/prediction positive, Precision	FDR=FP/prediction positive
	Neg.	FN	TN	prediction negative=FN+TN	FOR=FN/prediction positive	NPV=TN/prediction positive
合计		condition positive=TP+FN	condition negative=FP+TN	N=TP+FN+FP+TN		
		TPR=TP/condition positive, Sensitivity, Recall	FPR=FP/condition negative, 1-Specificity			
		FNR=FN/condition positive, 1-Sensitivity	TNR=TN/condition negative, Specificity			

Internal Evaluation & External Evaluation

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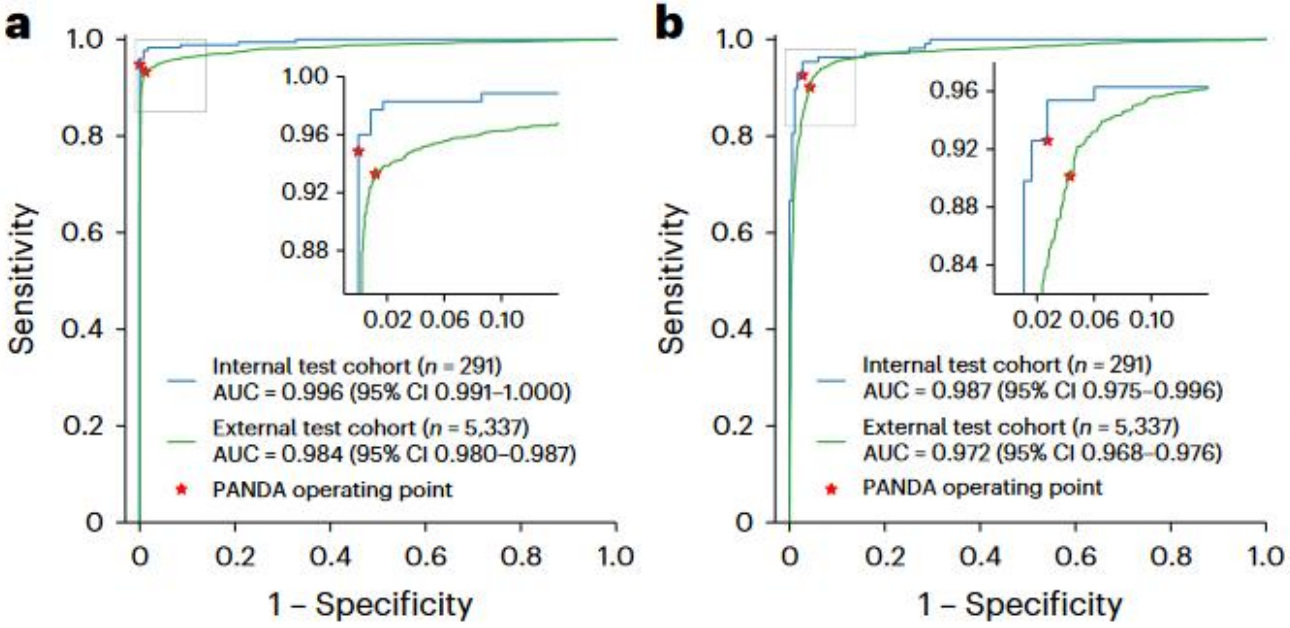
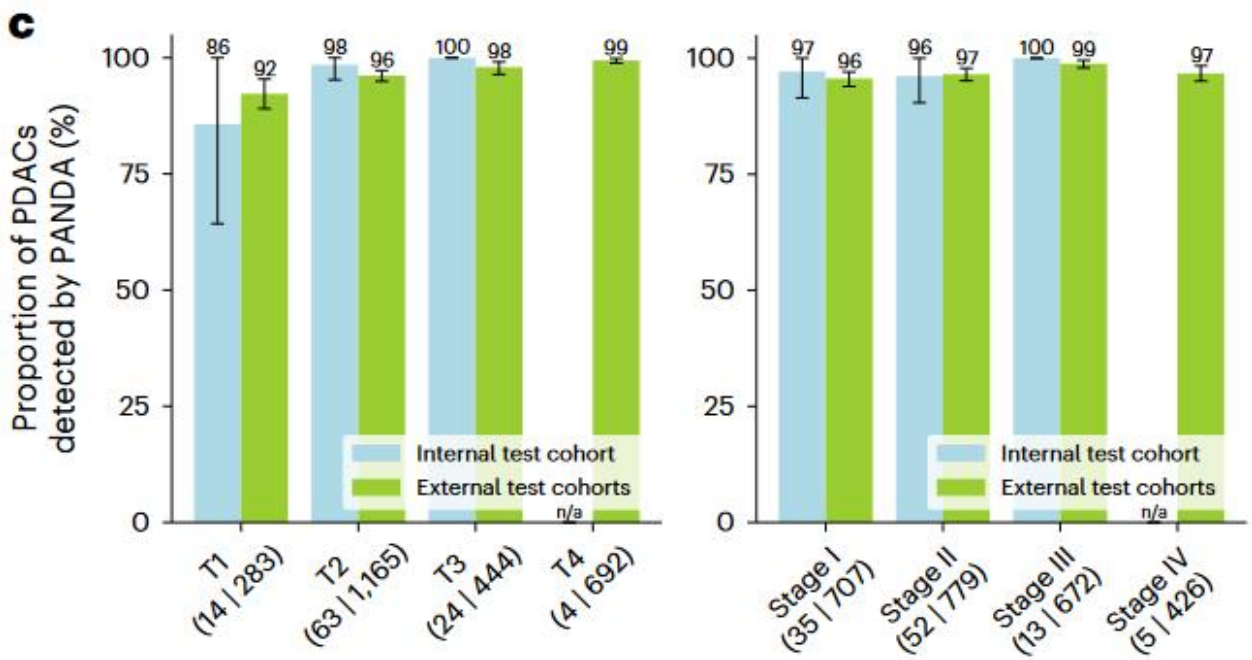
Lesion Detection

PDAC Identification

American Joint Committee on Cancer (AJCC) T staging

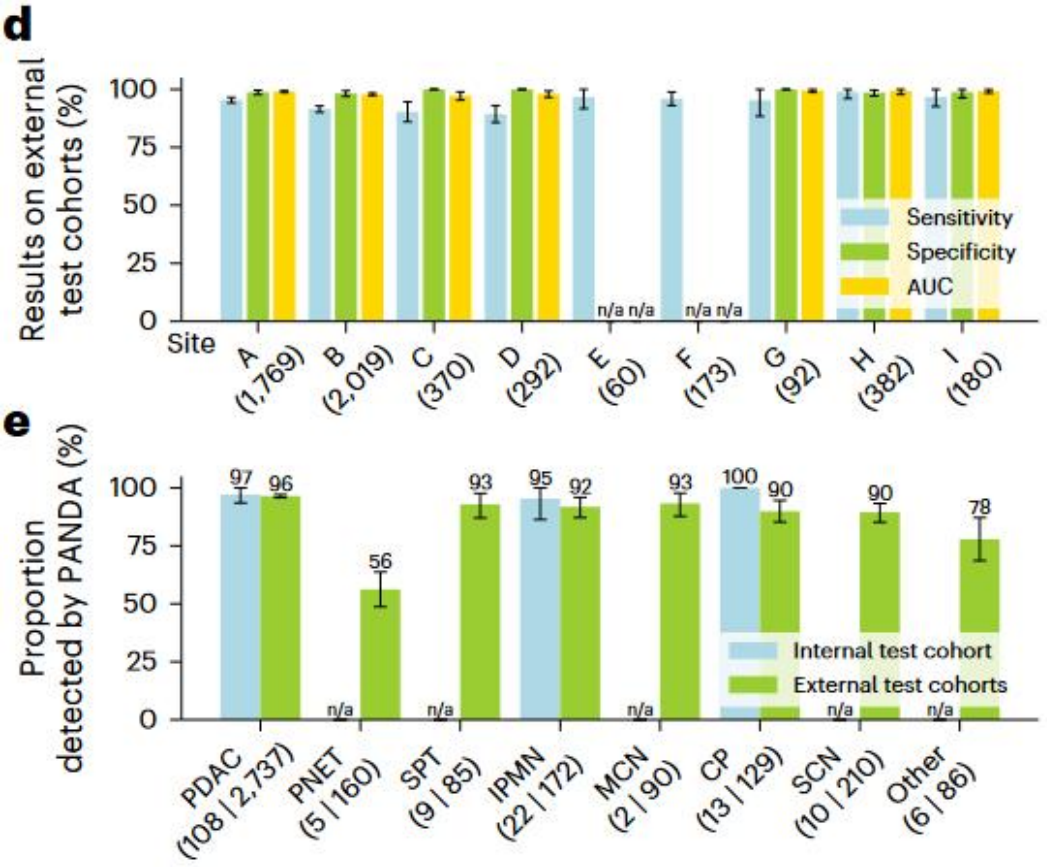
TNM(tumor, nodes, metastasis) staging





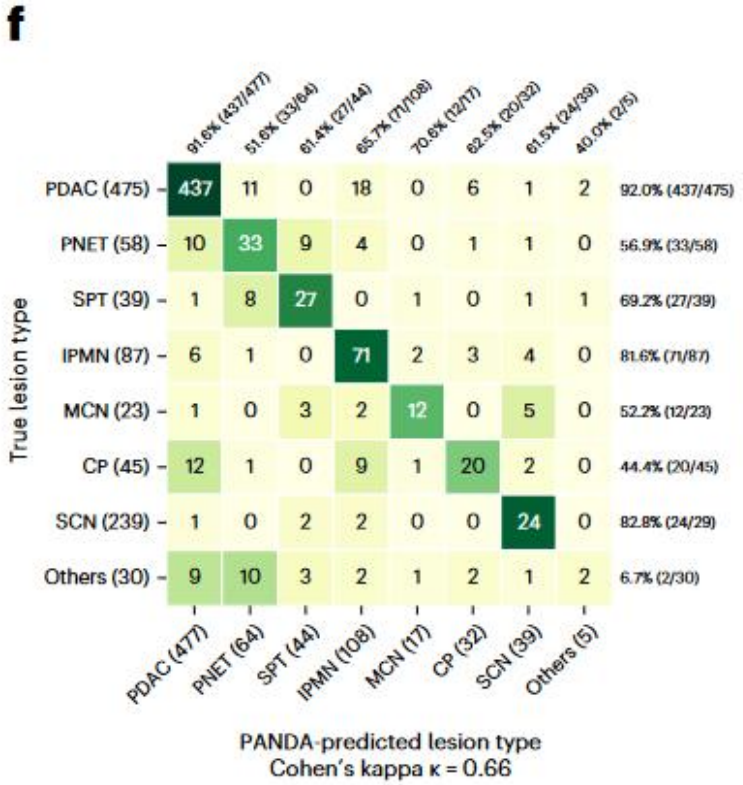
Internal Evaluation & External Evaluation

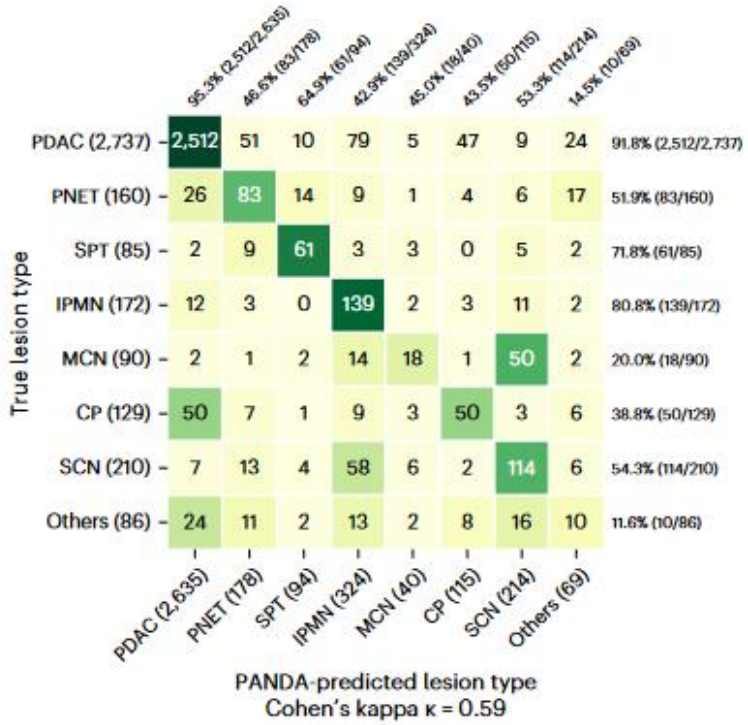
External evaluation centers



Identification of lesions in different lesion sbutype.

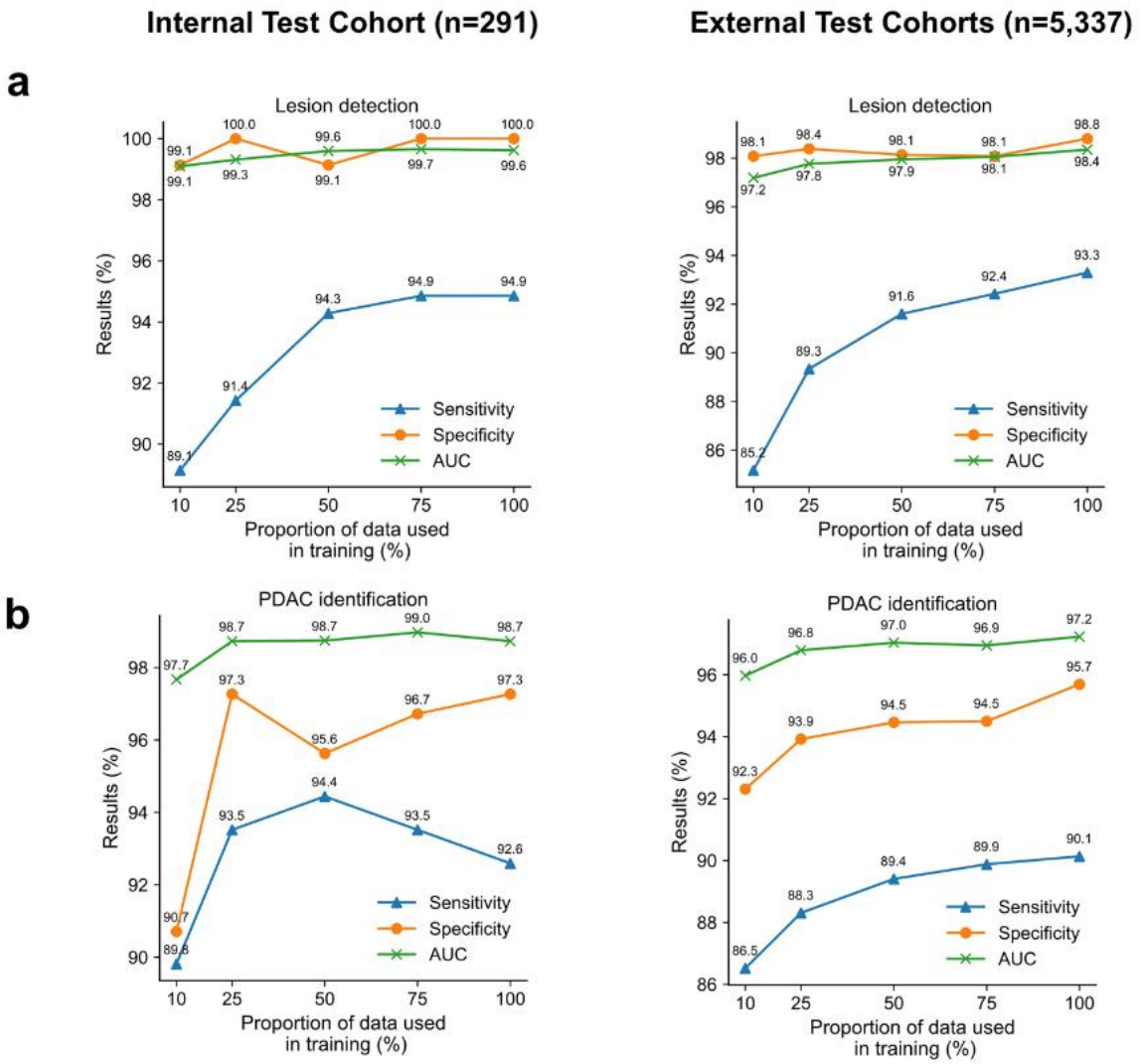
Confusion matrix for the external validation cohort.

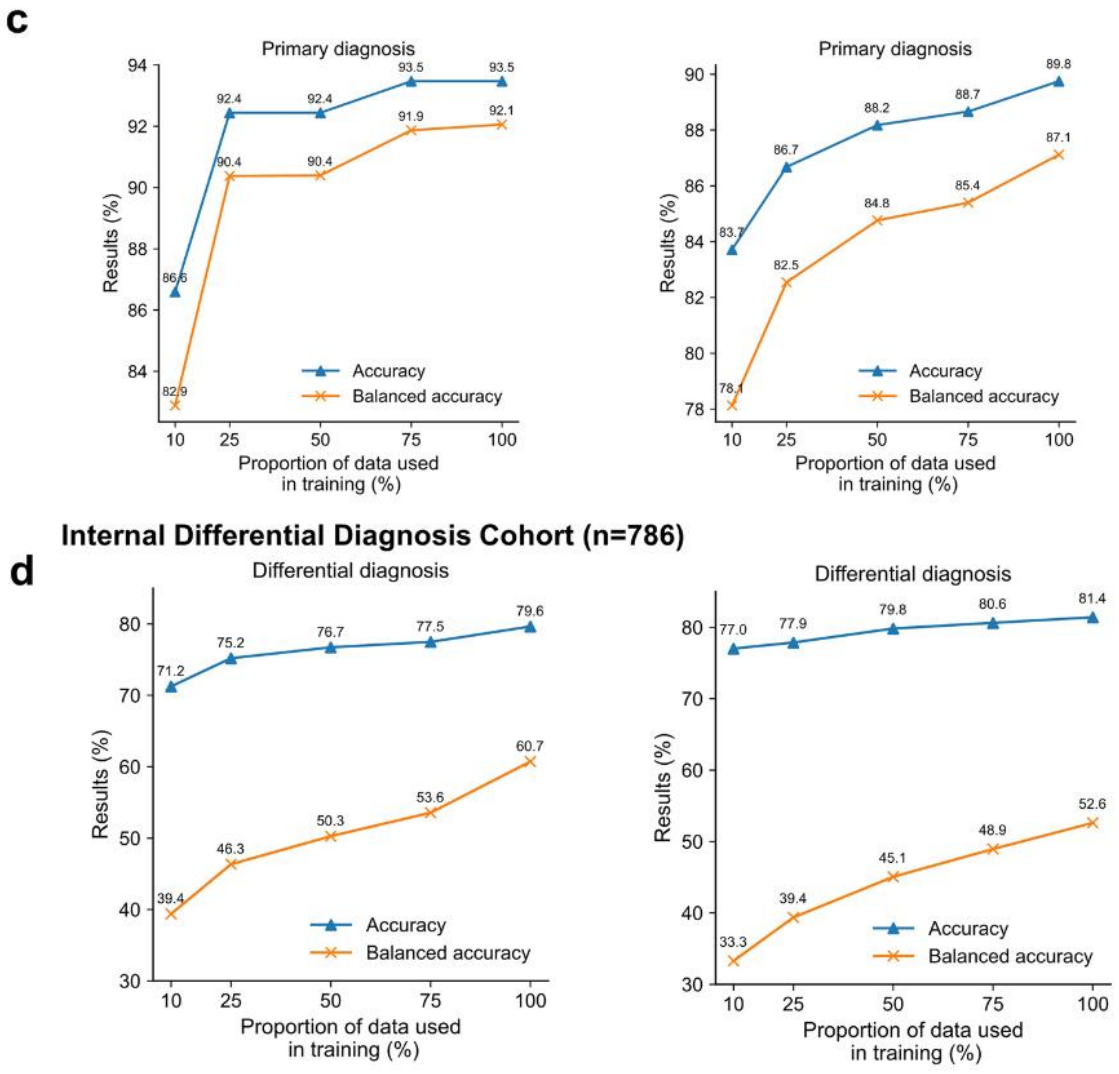




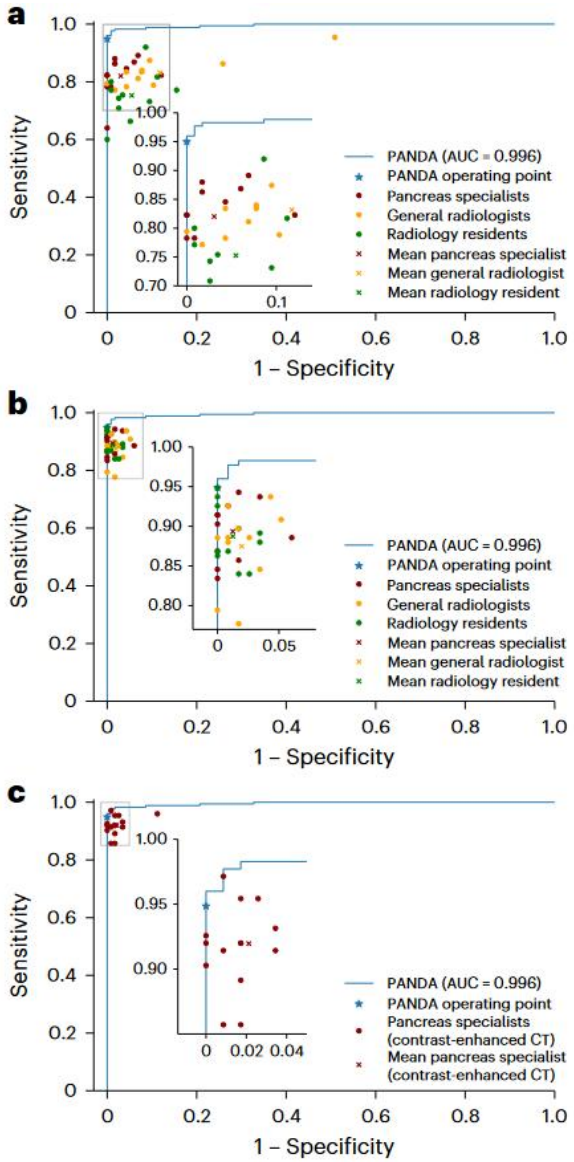
Confusion matrix for the internal validation cohort.

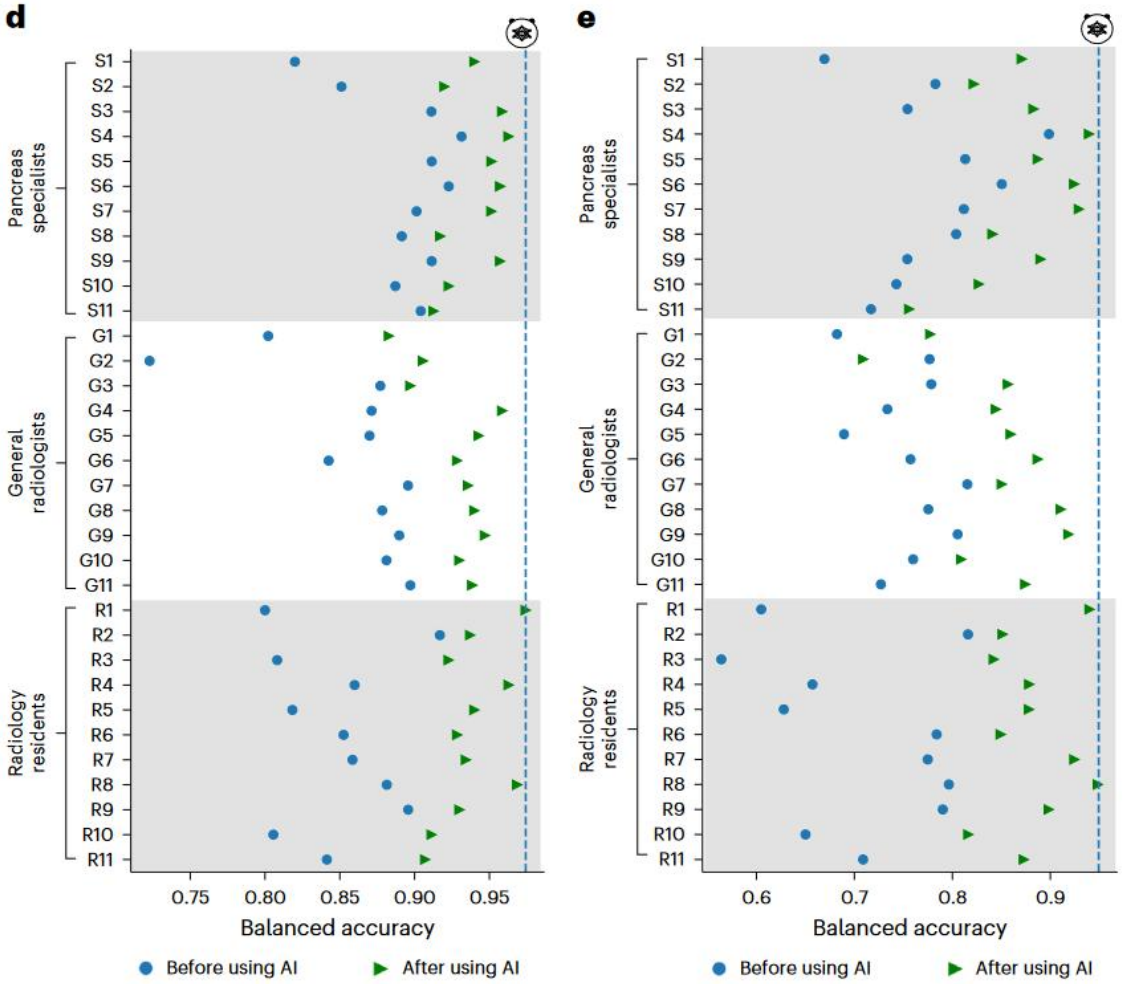
Internal Evaluation & External Evaluation



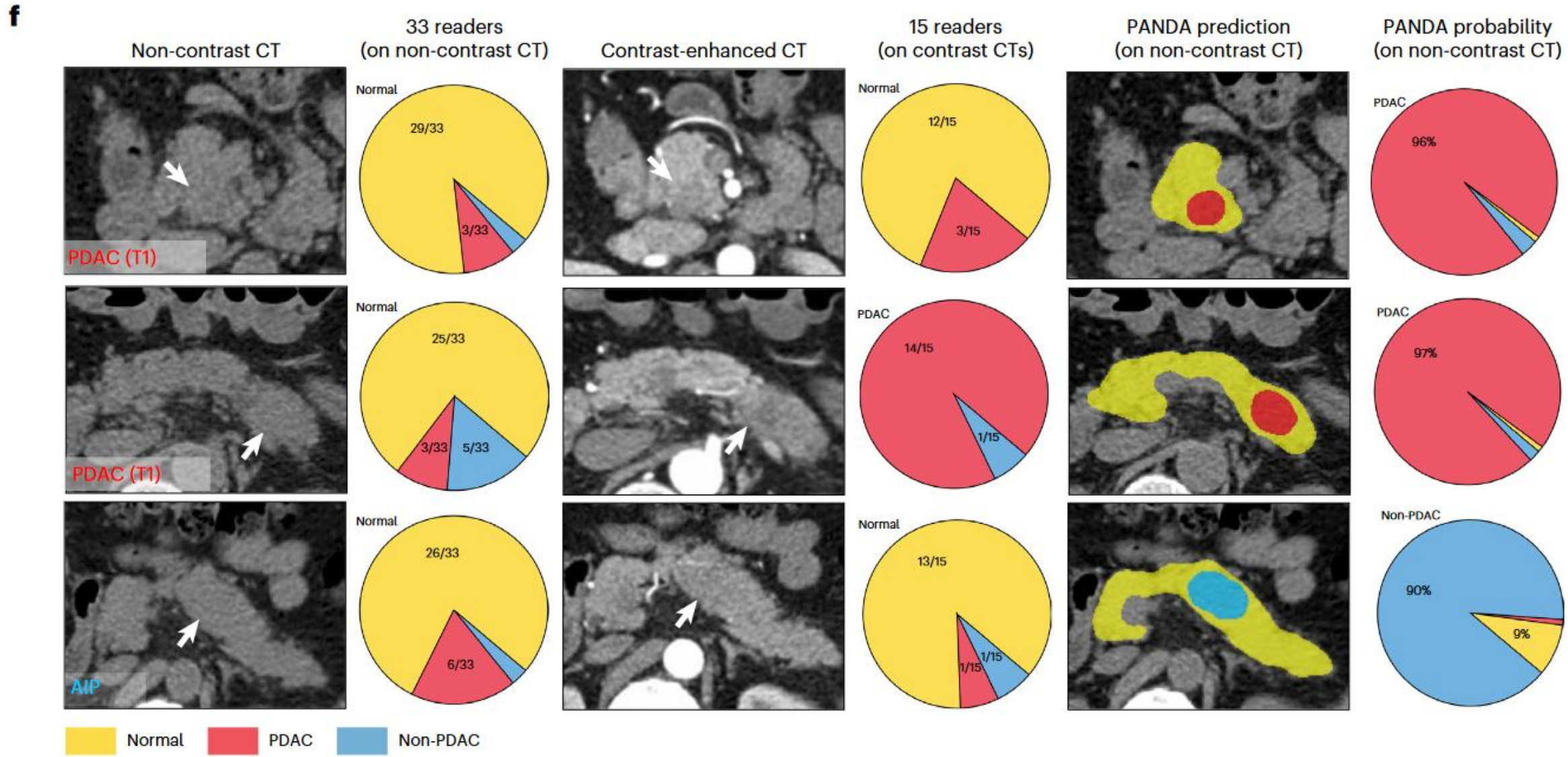


Reader Studies

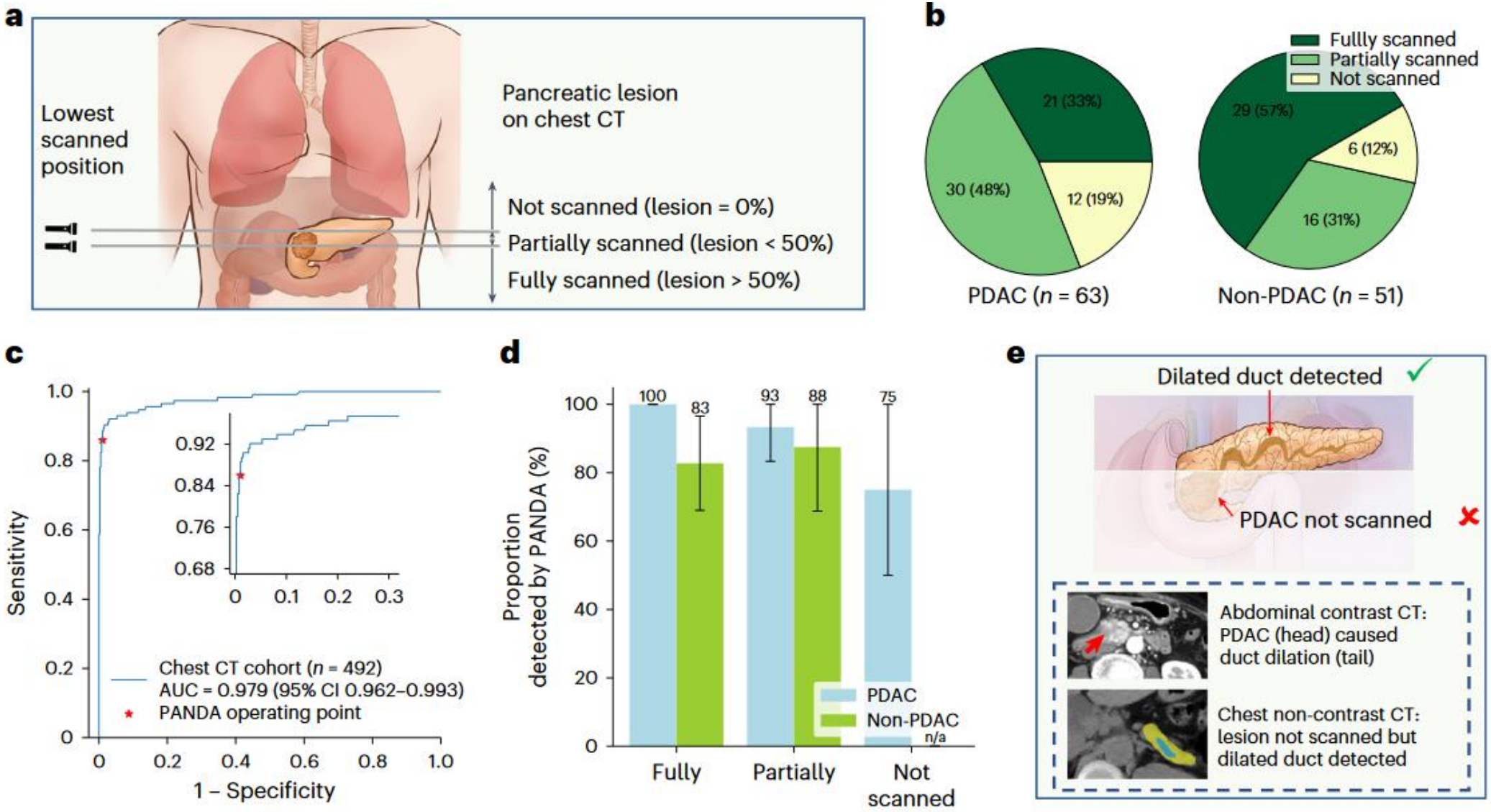




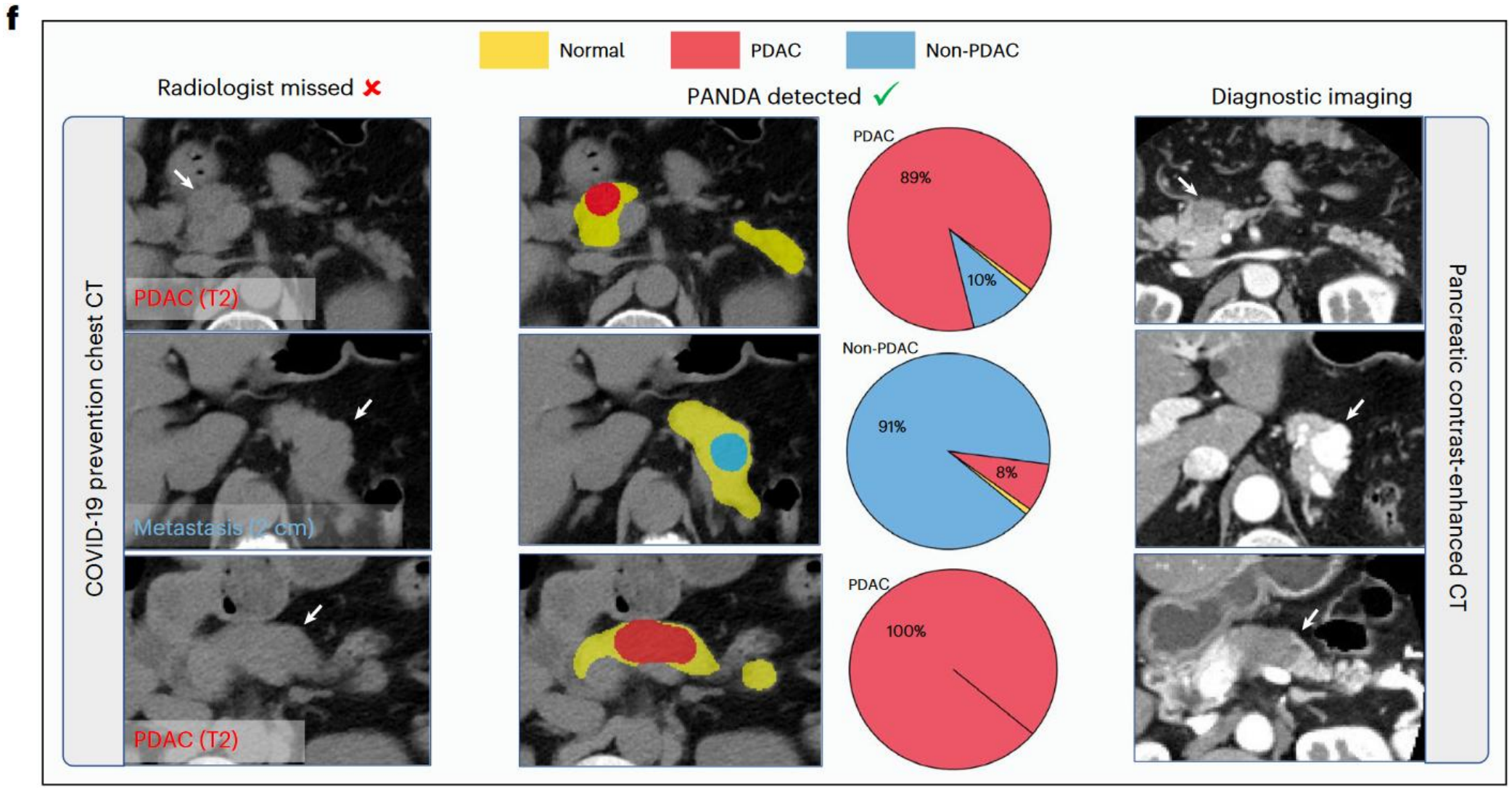
Reader Studies



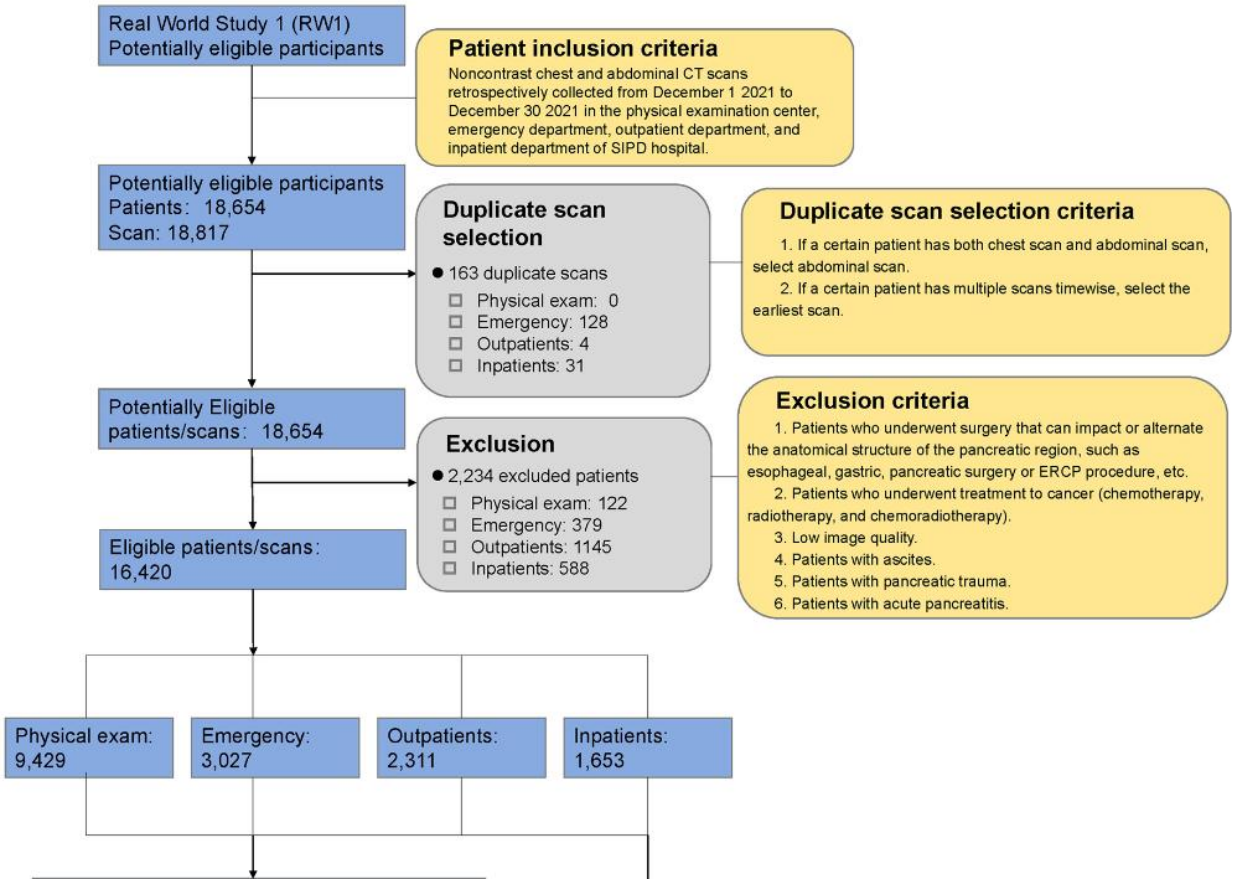
Lesion Detection on Chest CT

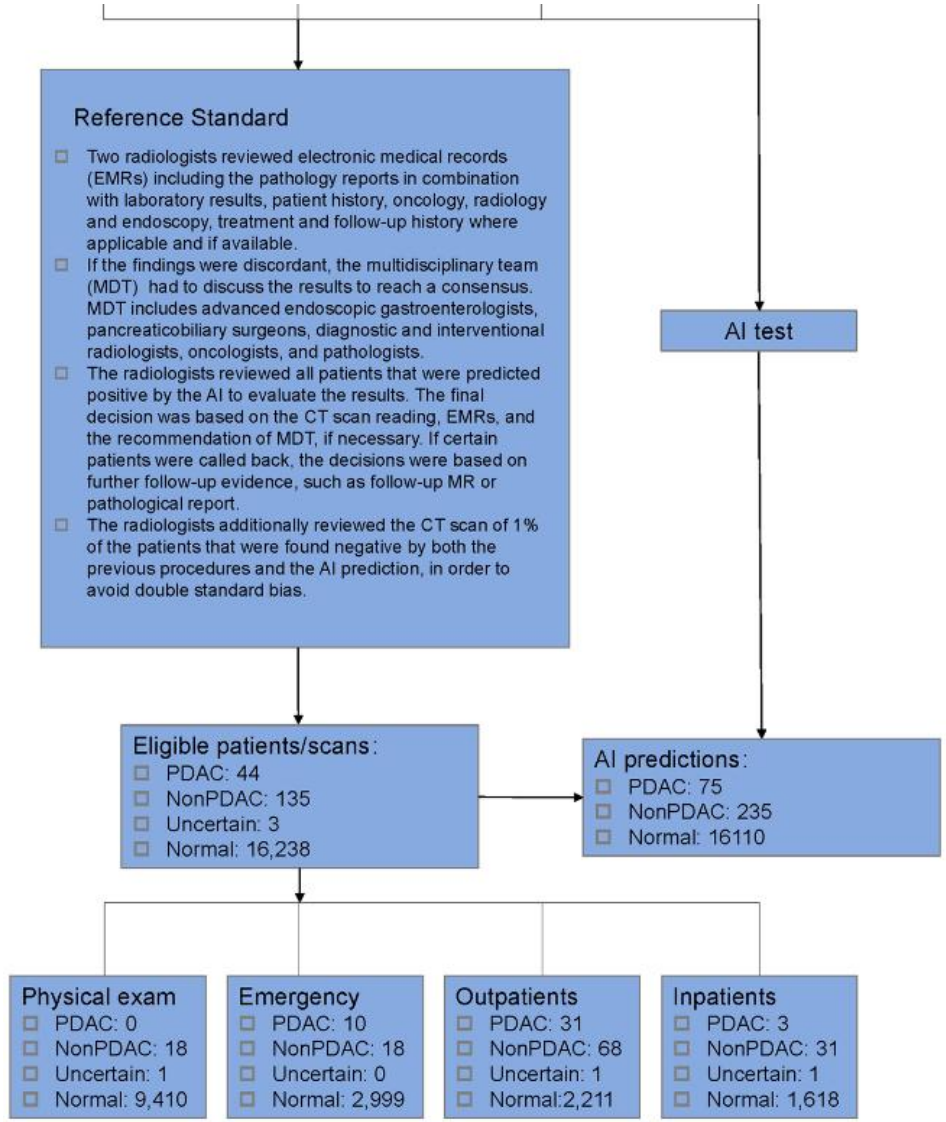


Lesion Detection on Chest CT

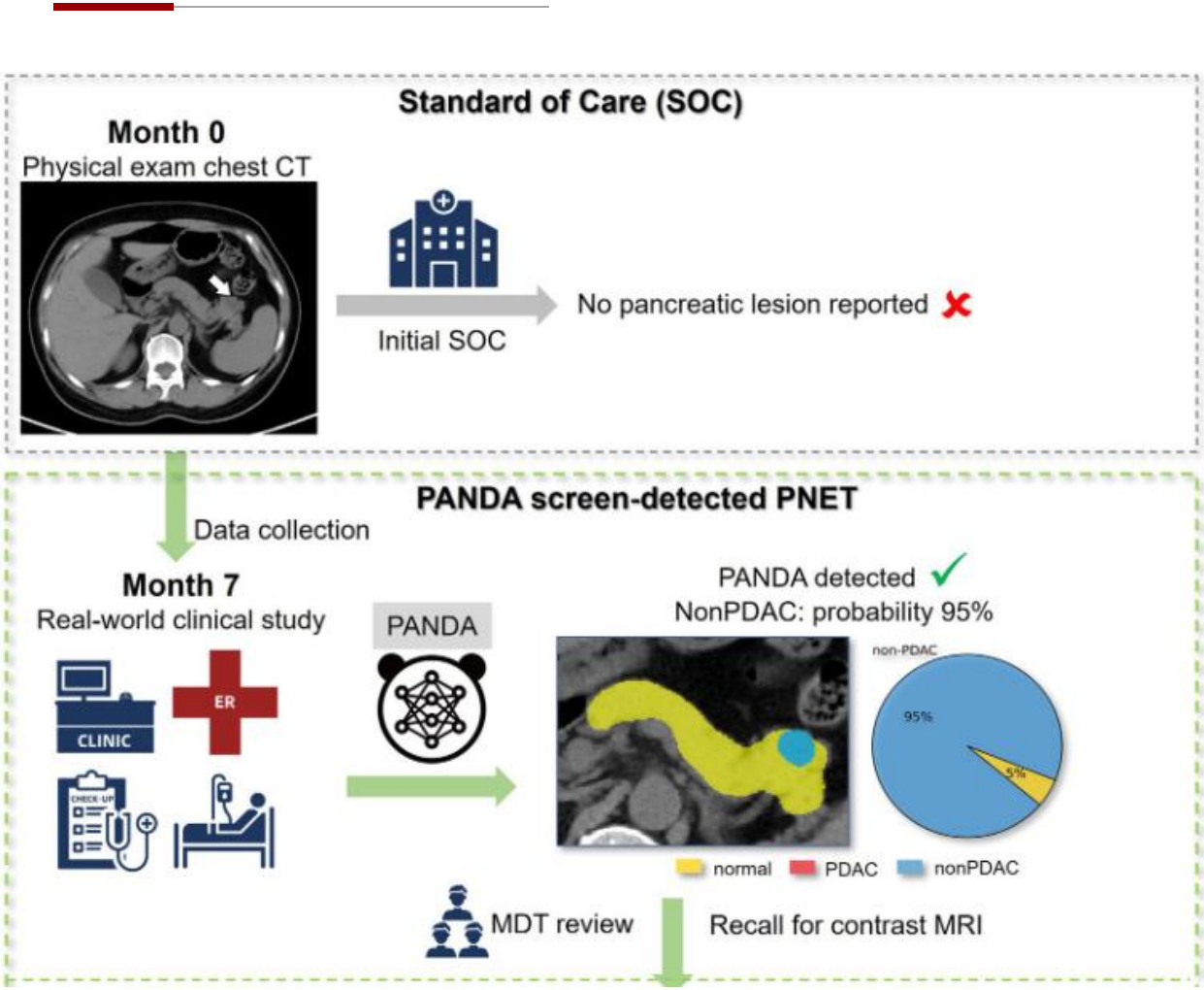


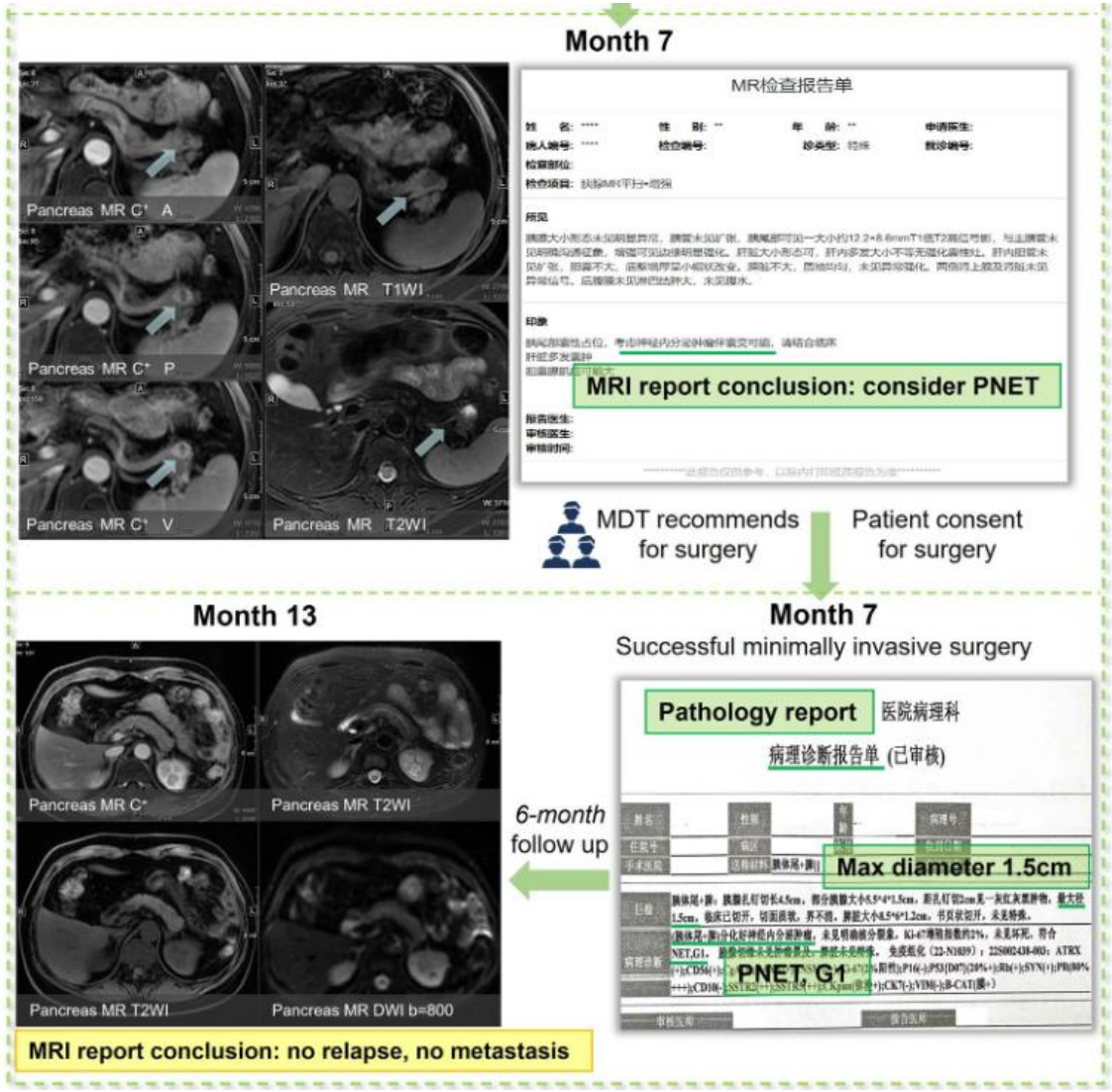
Real-World Study





Case Study


Standard of Care (SOC)
Month 0
Physical exam chest CT
Initial SOC
No pancreatic lesion reported
Data collection
PANDA screen-detected PNET
Month 7
Real-world clinical study
CLINIC
ER
PANDA
PANDA detected
NonPDAC: probability 95%
non-PDAC
95%
5%
normal
PDAC
nonPDAC
MDT review
Recall for contrast MRI


Month 7
Pancreas MR C+ A
Pancreas MR T1WI
Pancreas MR C+ P
Pancreas MR C+ V
Pancreas MR T2WI
MR检查报告单
MRI report conclusion: consider PNET
MDT recommends for surgery
Patient consent for surgery
Month 13
Pancreas MR C+
Pancreas MR T2WI
Pancreas MR T2WI
Pancreas MR DWI b=800
MRI report conclusion: no relapse, no metastasis
6-month follow up
Month 7
Successful minimally invasive surgery
Pathology report
医院病理科
病理诊断报告单 (已审核)
Max diameter 1.5cm
PNET G1

Reader Experience

Reader ID	Experience (yr)	CT read per year	Pancreatic CT read per year	Traning/Expertise
Specialist 1 (S1)	17	7,500	950	Pancreatic radiology
Specialist 2 (S2)	14	3,000	550	Pancreatic radiology
Specialist 3 (S3)	14	15,000	1,500	Pancreatic radiology
Specialist 4 (S4)	7	20,000	2,000	Pancreatic radiology
Specialist 5 (S5)	7	12,000	460	Pancreatic radiology
Specialist 6 (S6)	7	12,000	1000	Pancreatic radiology
Specialist 7 (S7)	9	7500	340	Pancreatic radiology
Specialist 8 (S8)	12	11,000	450	Pancreatic radiology
Specialist 9 (S9)	13	16,565	2600	Pancreatic radiology
Specialist 10 (S10)	8	15,000	560	Pancreatic radiology
Specialist 11 (S11)	8	8000	1000	Pancreatic radiology
General 1 (G1)	13	3,000	150	General radiology
General 2 (G2)	31	5,000	300	General radiology
General 3 (G3)	9	13,000	200	General radiology
General 4 (G4)	9	3800	170	General radiology
General 5 (G5)	8	1,800	100	General radiology
General 6 (G6)	8	20,000	500	General radiology
General 7 (G7)	8	1500	100	General radiology
General 8 (G8)	10	15,000	300	General radiology
General 9 (G9)	9	3200	150	General radiology
General 10 (G10)	10	18,000	200	General radiology
General 11 (G11)	9	3000	150	General radiology
Resident 1 (R1)	2	4,500	300	General radiology
Resident 2 (R2)	3	5,000	350	General radiology
Resident 3 (R3)	2	1,000	200	General radiology
Resident 4 (R4)	2	12,000	1,000	General radiology
Resident 5 (R5)	2	500	100	General radiology
Resident 6 (R6)	4	6500	200	General radiology
Resident 7 (R7)	2	300	100	General radiology
Resident 8 (R8)	8	12,000	350	General radiology
Resident 9 (R9)	4	6000	200	General radiology
Resident 10 (R10)	2	1200	100	General radiology
Resident 11 (R11)	4	6000	200	General radiology
Specialist 12 (S12)	6	16,000	400	Pancreatic radiology
Specialist 13 (S13)	7	17,000	400	Pancreatic radiology
Specialist 14 (S14)	7	15,000	500	Pancreatic radiology
Specialist 15 (S15)	12	17,000	2,000	Pancreatic radiology
Specialist 16 (S16)	8	25,000	500	Pancreatic radiology
Specialist 17 (S17)	10	17,000	1,000	Pancreatic radiology
Specialist 18 (S18)	6	23,000	500	Pancreatic radiology
Specialist 19 (S19)	12	20,000	2,000	Pancreatic radiology
Specialist 20 (S20)	12	30,000	3,000	Pancreatic radiology
Specialist 21 (S21)	6	17,000	400	Pancreatic radiology
Specialist 22 (S22)	7	15,000	1,000	Pancreatic radiology
Specialist 23 (S23)	19	20,000	450	Pancreatic radiology
Specialist 24 (S24)	10	20,000	450	Pancreatic radiology
Specialist 25 (S25)	10	20,000	500	Pancreatic radiology
Specialist 26 (S26)	10	21,000	500	Pancreatic radiology

Conclusion

The good generalizability of PANDA can be attributed to the following factors:

1. Training data from large tertiary hospitals, covering **diverse representations** of the Chinese population.
2. Non-contrast CT scans may be more universal for AI models compared to contrast-enhanced CT scans.
3. Integration of segmentation (capturing local pathological basis) and classification reduces the risk of overfitting in pure classification-based AI models.
4. The model was fine-tuned to achieve reliable control of false positives, with a specificity of 99% in the cross-validation process on a large training set (n=3,208).
5. Specificity was further improved to 99.9% by fine-tuning on false positives from external centers and the real world (tune on RW1 and val on RW2).
6. Regarding training data, **similar CT imaging protocols (e.g., slice thickness, CT dose index, oral contrast)** were used for cases and controls, forcing the model to focus on the primary learning objectives rather than fitting shortcuts or confounding factors.

AI-based pathology predicts origins for cancers of unknown primary

nature

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Article | Published: 05 May 2021

AI-based pathology predicts origins for cancers of unknown primary

Ming Y. Lu, Tiffany Y. Chen, Drew F. K. Williamson, Melissa Zhao, Maha Shady, Jana Lipkova & Faisal Mahmood ✉

Nature **594**, 106–110 (2021) | Cite this article

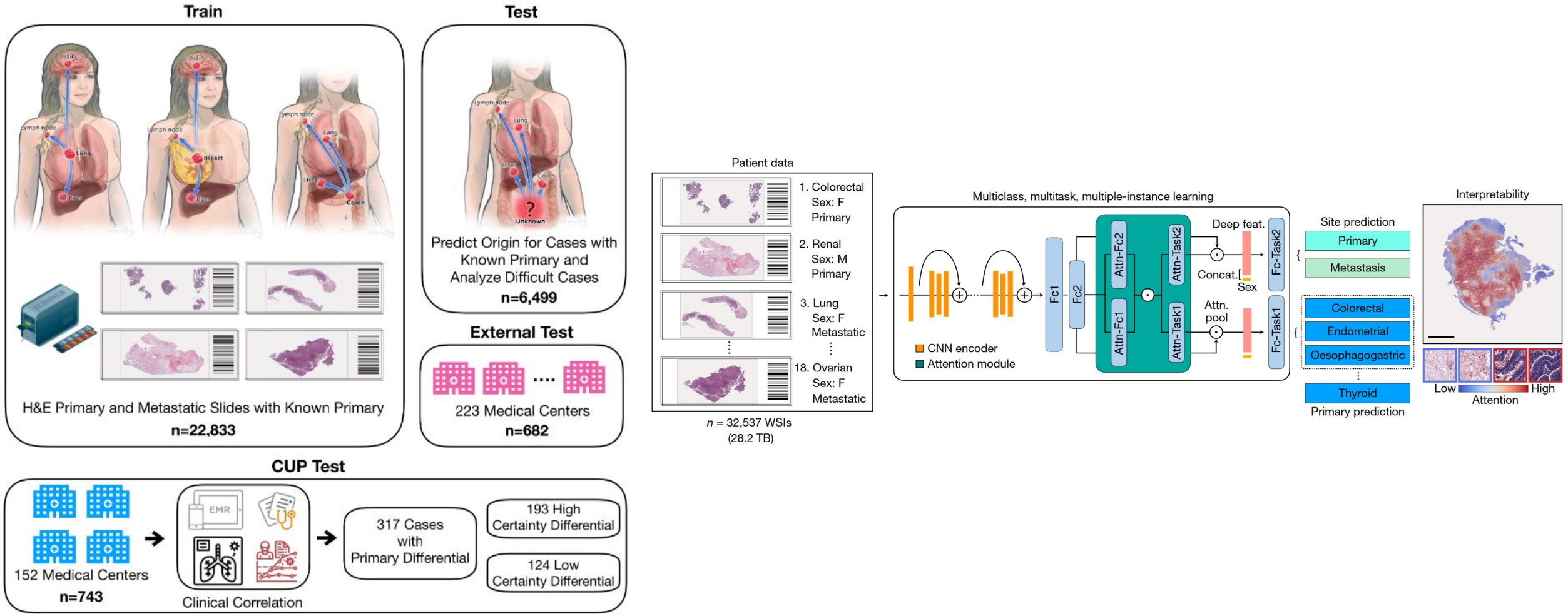
38k Accesses | **246** Citations | **416** Altmetric | Metrics

汇报人：利友诚

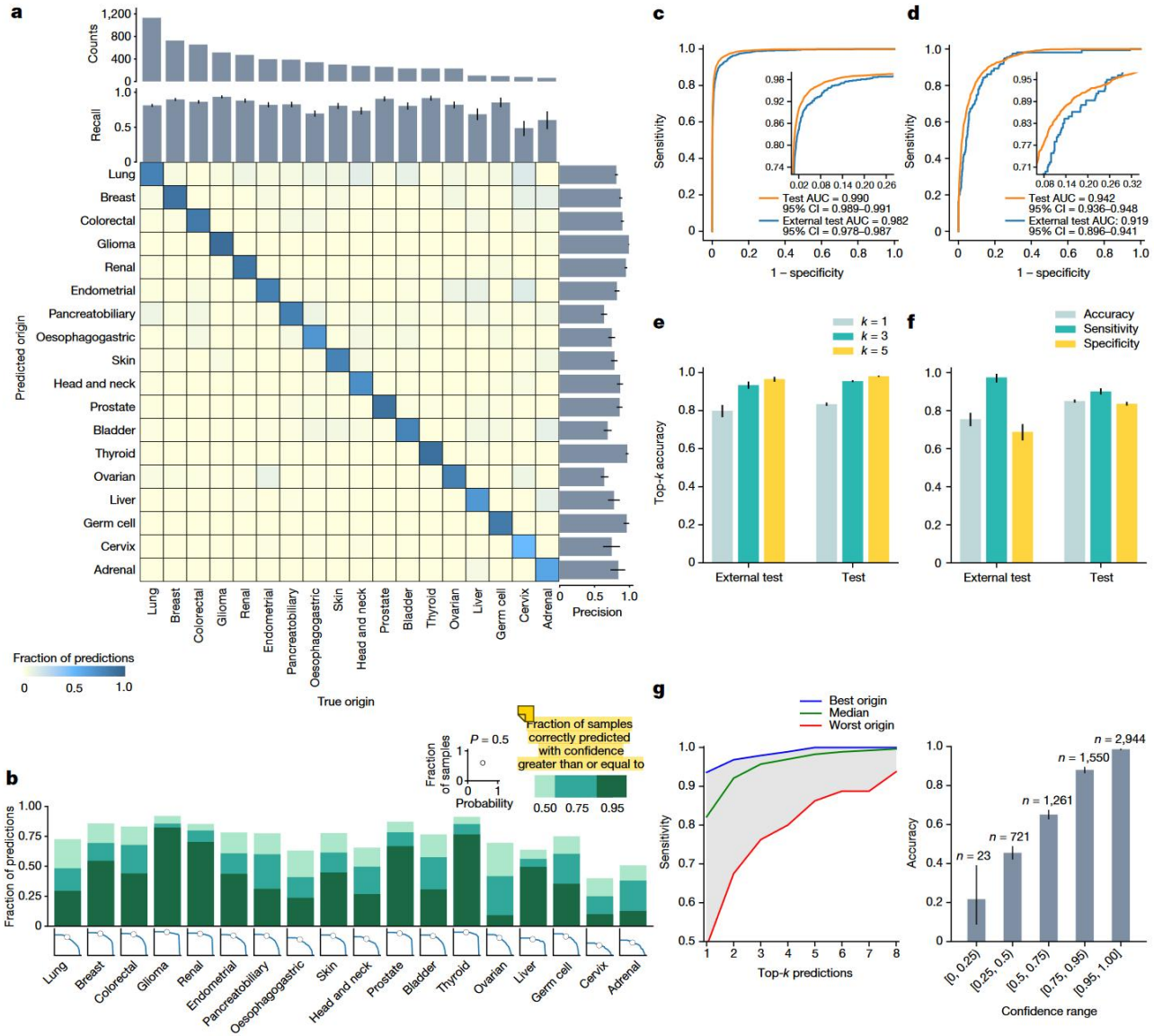
Background

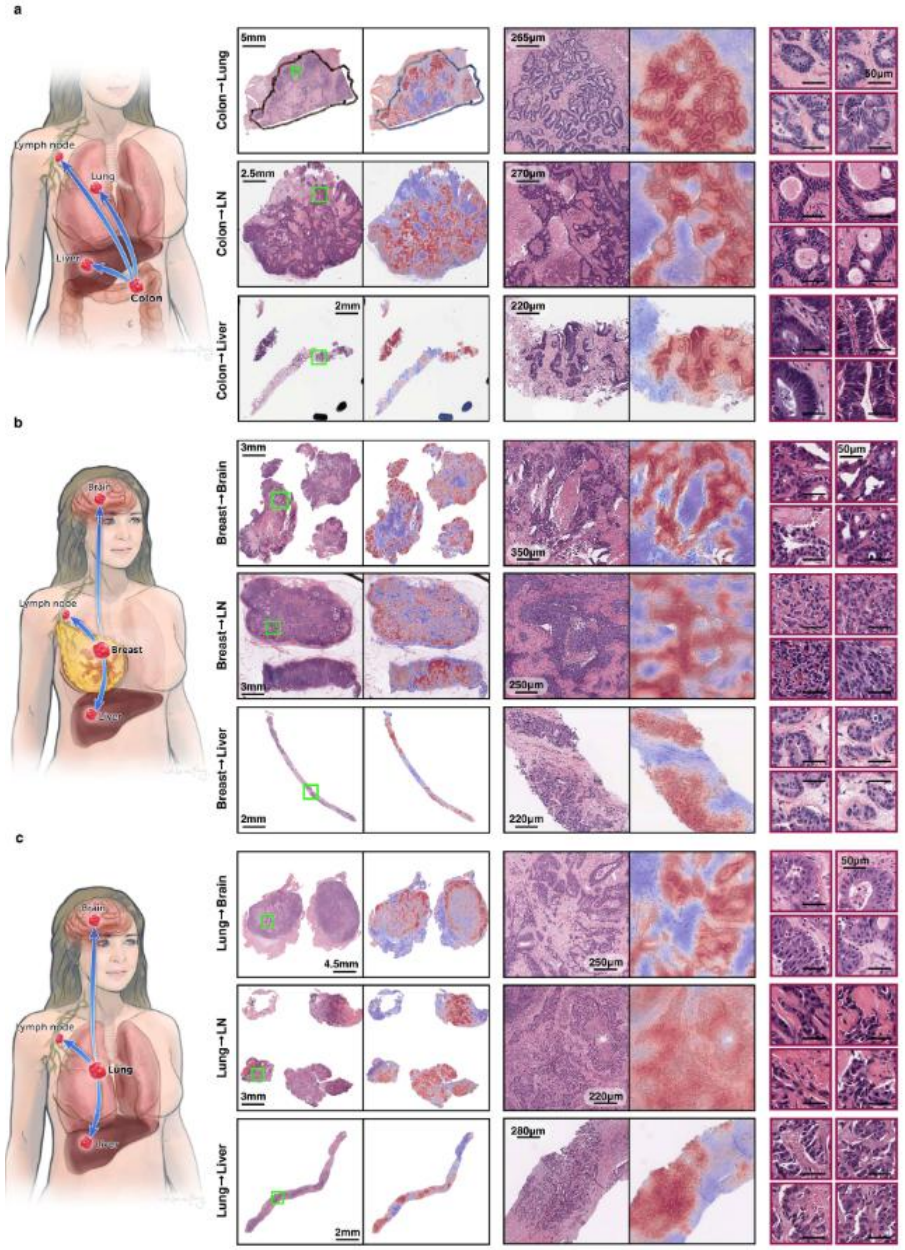
1. **The site of a primary tumor** is crucial for guiding clinical care in metastatic cancer cases.
2. Determining the site of origin is challenging despite histopathological examination and clinical/radiological assessments.
3. Cancers categorized as CUPs (Cancer of Unknown Primary) account for 1–2% and lack a definitive primary origin.
4. Comprehensive diagnostic work-ups are performed for CUP patients, but empirical chemotherapy is usually administered due to the lack of primary site identification.
5. **Genomics and transcriptomics** have been proposed to identify the primary origin, but molecular profiling is not routinely conducted, especially in low-resource settings.
6. Uncertainty in classifying tumors as primary or metastatic and misdiagnosing relapse are reported in the literature.

TOAD workflow



Results



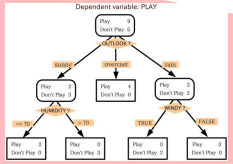


Discussion

北京大学 PEKING UNIVERSITY

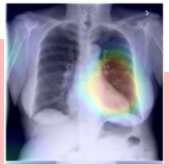
Human Doctor

Medical AI

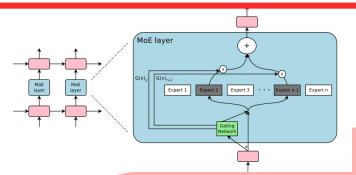


Interpretablity

Interpretable Model/Interface



Attention Map



Mixture of AI-Experts

Task

Pulmonary Nodule Localization

1. Pancreatic Cancer Detection; (HARD)
2. Breast Cancer Diagnosis; (HARD)
3. CUP Diagnosis; (REALLY HARD)
4. Alzheimer's Early Detection; (REALLY HARD) ...

Challenge: Misleading & Trust
Why AI can assist doctors in diagnosis?
How does AI assist doctors in diagnosis?
Why do we trust senior doctors more?

Engineering

Research

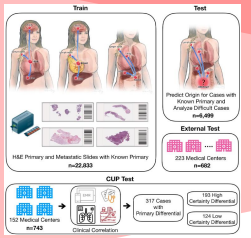
Target

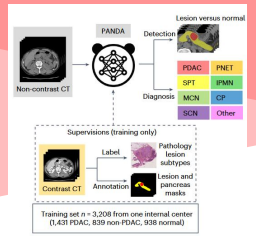
Beyond Experts

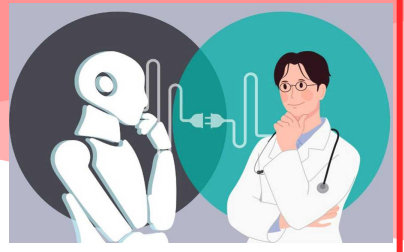
Hybrid Enhanced

AI assist Human Doctors
> AI and Human Doctors

Events







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