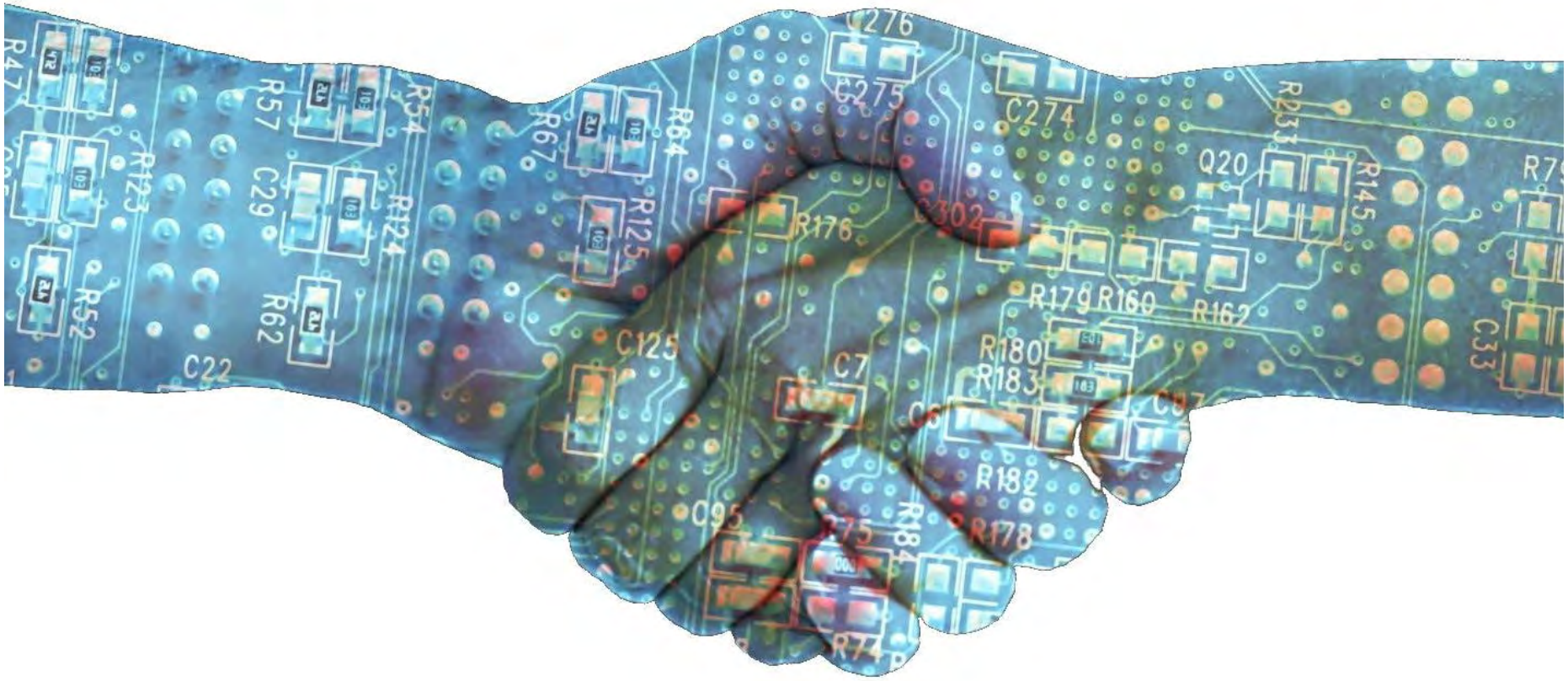
AI in radiology

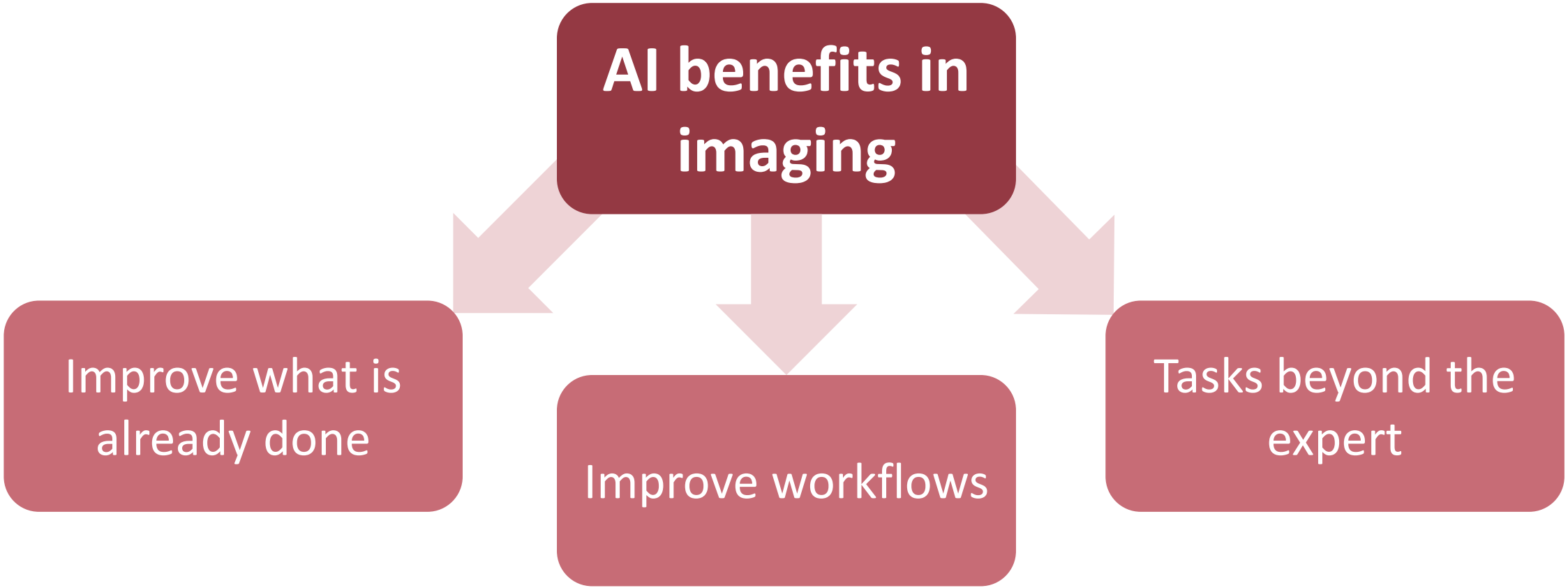
SOPHIA ZACKRISSON, PROFESSOR, SENIOR CONSULTANT RADIOLOGIST

Conflicts of interest

- Speaker’s fees from Siemens Healthineers, Pfizer, Bayer AG
- Research agreement ScreenPoint Medical
- Patent (US patent no PCT/EP2014/057372)

How should we use AI in radiology?

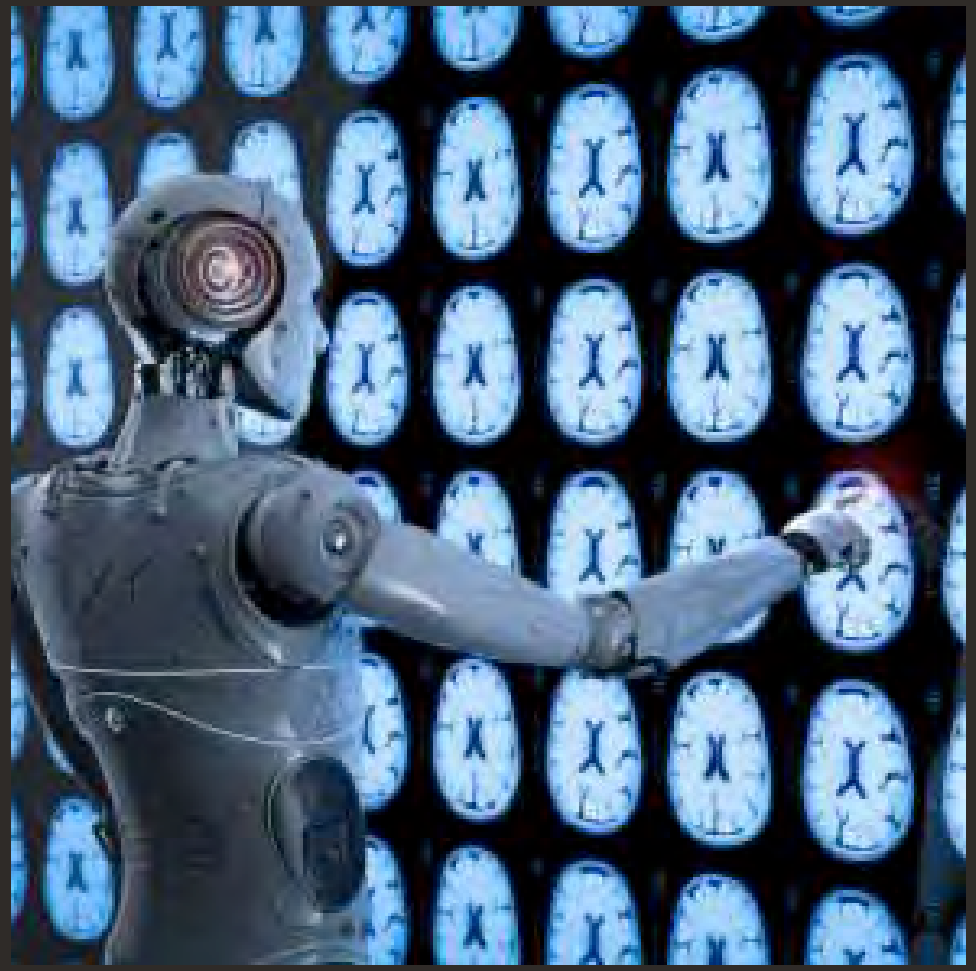



AI benefits in imaging
Improve what is already done
Improve workflows
Tasks beyond the expert

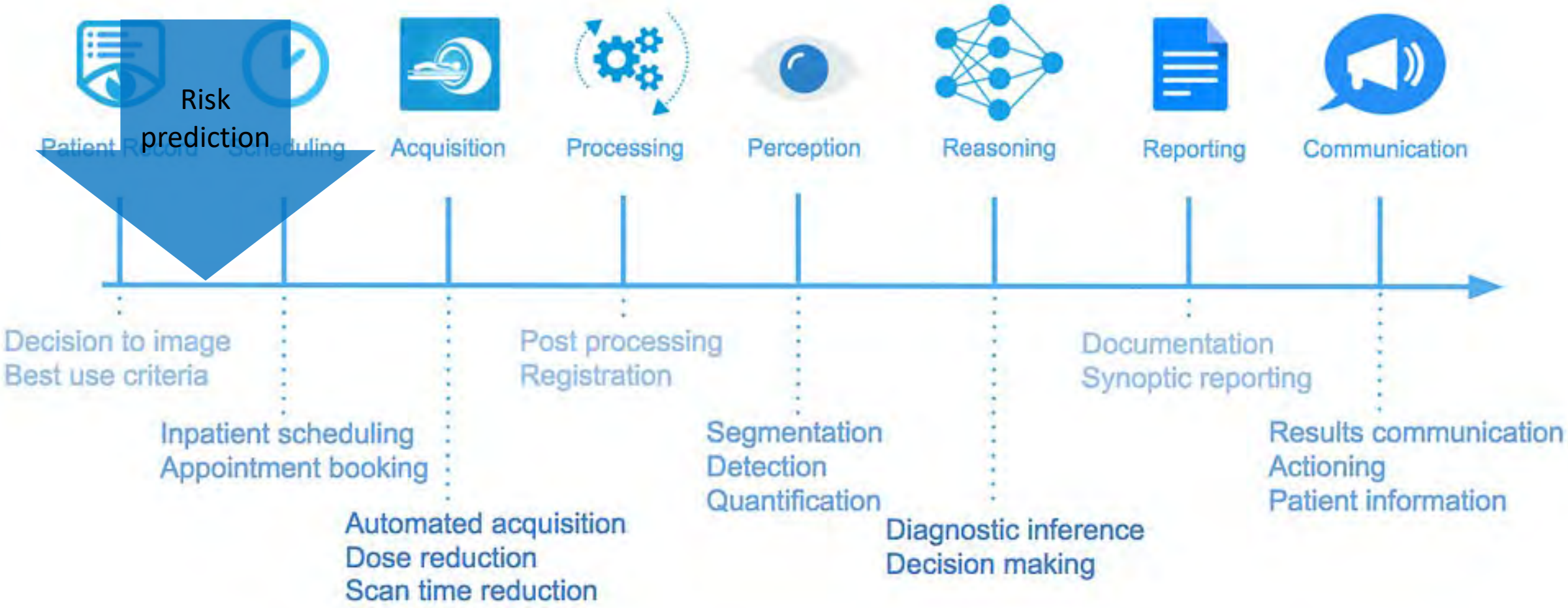
"It's quite obvious that we should stop training radiologists"

Professor Geoffrey Hinton, godfather of neural networks, in 2016

"It's quite obvious that we should stop training radiologists"



Professor Geoffrey Hinton, godfather of neural networks, in 2016



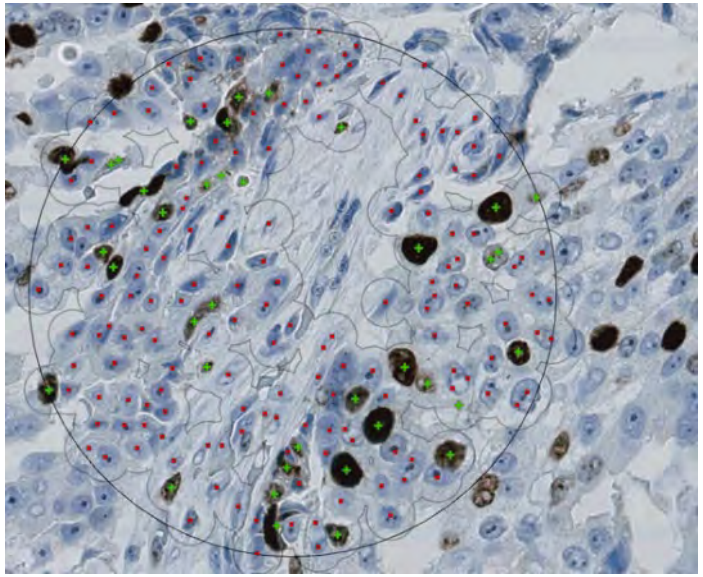
Simplified schematic of the diagnostic radiology workflow, with examples of where AI systems can be implemented.
Image copyright @drhughharvey.

https://towardsdatascience.com/why-ai-will-not-replace-radiologists-c7736f2c7d80

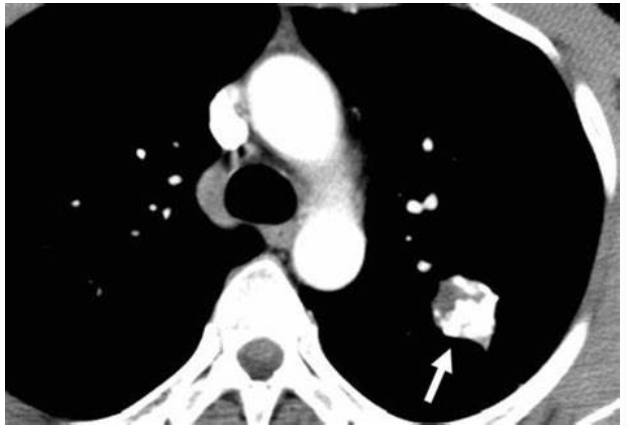
Improve what is already done

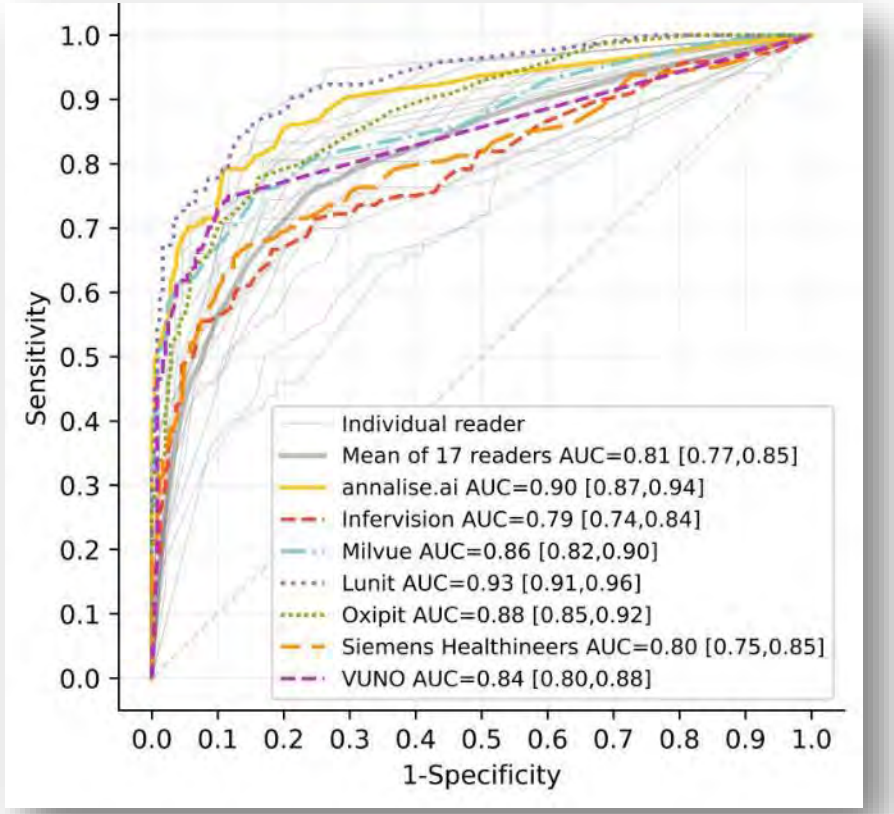
Higher quality and/or efficiency

- Find lung nodules
- Count positive cells



Jesper Molin,
PhD Dissertation 2016





Van Leeuwen et al., Comparison of commercial AI software performance for radiograph lung nodule detection and bone age prediction, Radiology, 2024

Improve what is already done and more!

Detect cancers at screening, interval cancers, next round cancers, exclude normals (up to 50%!)

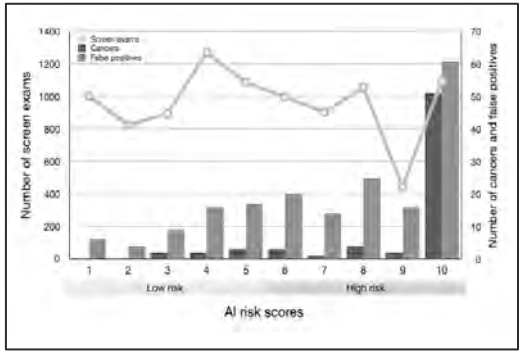
Article

International evaluation of an AI system for breast cancer screening

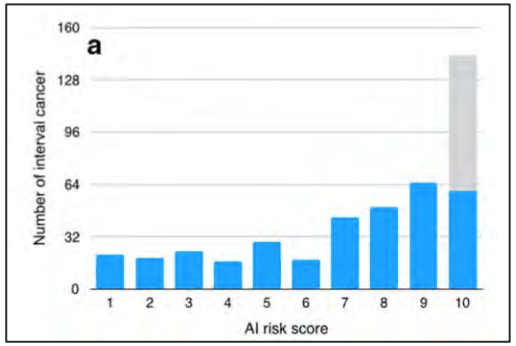
https://doi.org/10.1038/s41586-019-1799-6
Received: 27 July 2019
Accepted: 5 November 2019
Published online: 1 January 2020

Scott Mayer McKinney[1,14]*, Marcin Sieniek[1,14], Varun Godbole[1,14], Jonathan Godwin[2,14], Natasha Antropova[2], Hutan Ashrafian[3,4], Trevor Back[2], Mary Chesus[2], Greg C. Corrado[1], Ara Darzi[3,4,5], Mozziyar Etemadi[6], Florencia Garcia-Vicente[6], Fiona J. Gilbert[7], Mark Halling-Brown[8], Demis Hassabis[2], Sunny Jansen[9], Alan Karthikesalingam[10], Christopher J. Kelly[10], Dominic King[10], Joseph R. Ledsam[2], David Melnick[6], Hormuz Mostofi[1], Lily Peng[1], Joshua Jay Reicher[11], Bernardino Romera-Paredes[2], Richard Sidebottom[12,13], Mustafa Suleyman[2], Daniel Tse[1]*, Kenneth C. Young[8], Jeffrey De Fauw[2,15] & Shravya Shetty[1,15]*

McKinney et al, Nature 2019



Lång K. Eur Radiol 2020



Lång K, Eur Radiol 2021

Articles

Effect of artificial intelligence-based triaging of breast cancer screening mammograms on cancer detection and radiologist workload: a retrospective simulation study

Karin Dembrower, Erik Wåhlin, Yue Liu, Mattie Salim, Kevin Smith, Peter Lindholm, Martin Eklund, Fredrik Strand

Dembrower K et al. Lancet Digital Health 2020

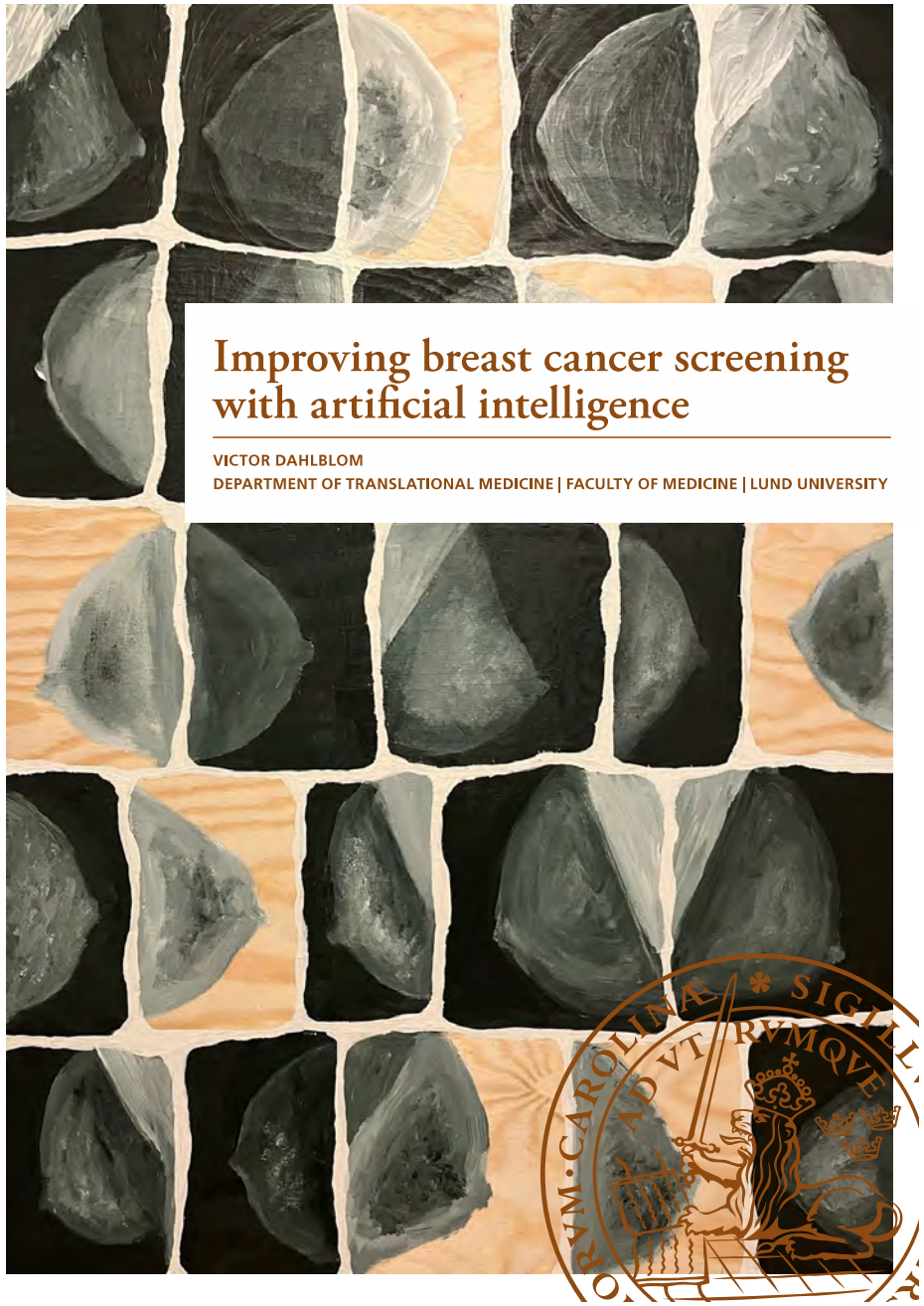
Radiology

ORIGINAL RESEARCH • BREAST IMAGING

An Artificial Intelligence–based Mammography Screening Protocol for Breast Cancer: Outcome and Radiologist Workload

Andreas D. Lauritzen, MSc • Alejandro Rodríguez-Ruiz, PhD • My Catarina von Euler-Chelpin, PhD • Elsebeth Lynge, PhD • Ilse Vejborg, MD • Mads Nielsen, PhD • Nico Karssemeijer, PhD • Martin Lillholm, PhD

Lauritzen A et al. Radiology 2022



Victor Dahlblom, MD, PhD student

Thesis to be defended on April 5th!

Improved workflows – mammography screening

Two radiologists vs AI + one radiologist

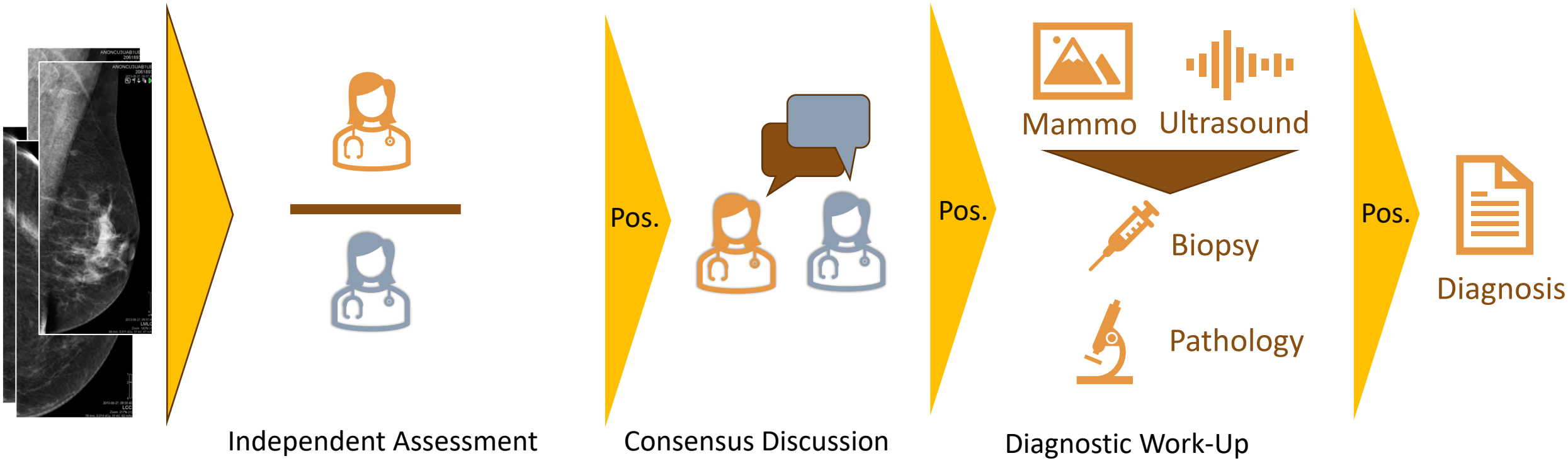
MASAI
(Lång et al., 2023, Lund)

- 80.000 women
- Equal detection (or higher with AI)
- 44% workload reduction

ScreenTrustCAD
(Dembrower et al., 2023, KI)

- 56.0000 women
- Equal detection
- 50% workload reduction

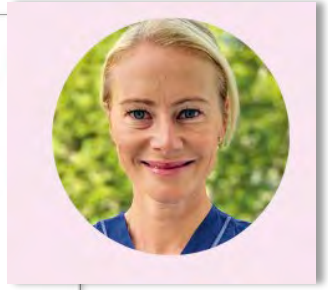
Screening Workflow and AI – Replace One Radiologist's assessment



Courtesy: VAI-B consortium/Dr F. Strand

Artificial intelligence for breast cancer detection in screening mammography in Sweden: a prospective, population-based, paired-reader, non-inferiority study

*Karin Dembrower, Alessio Crippa, Eugenia Colón, Martin Eklund, Fredrik Strand, and the ScreenTrustCAD Trial Consortium**

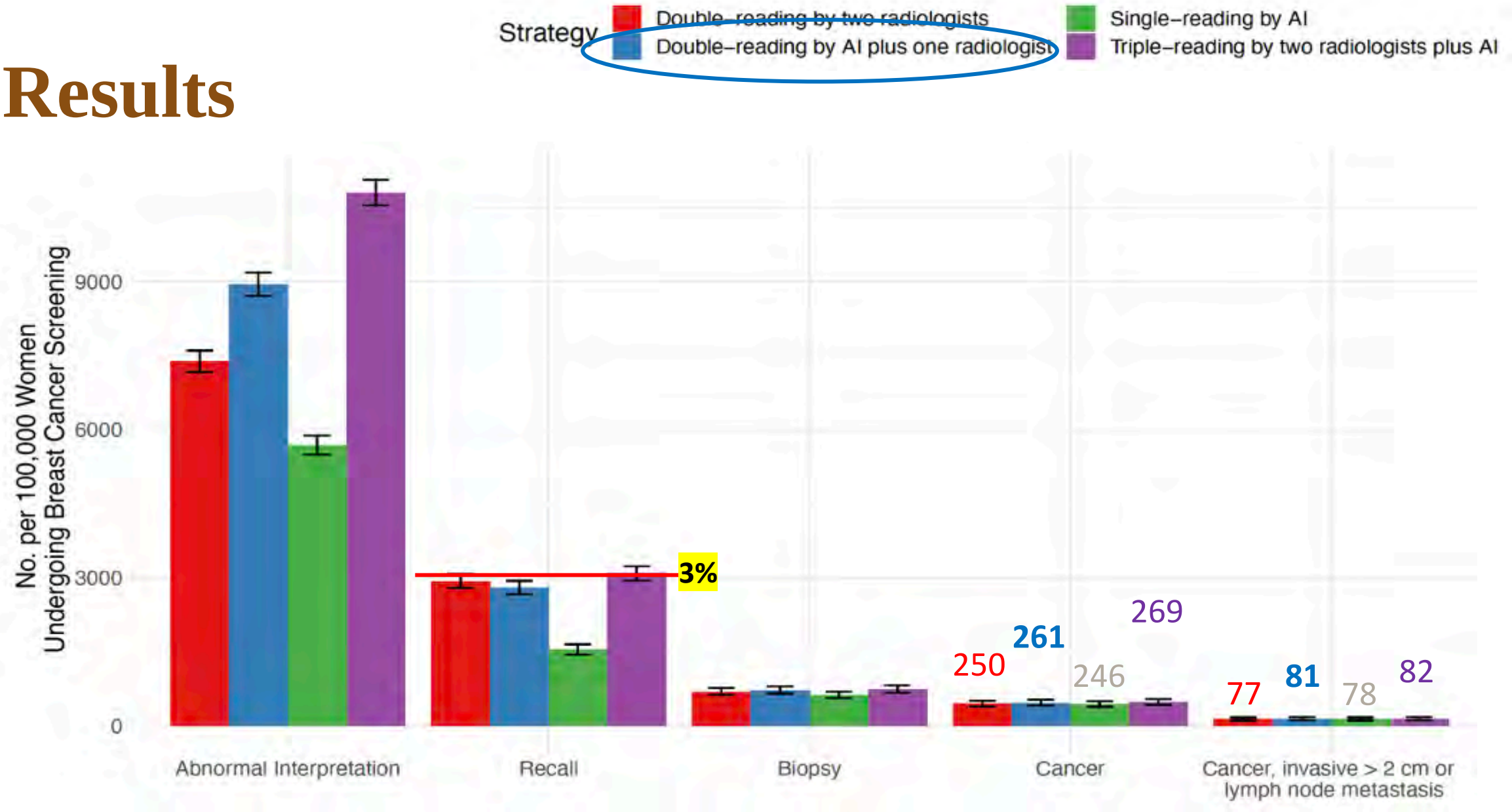


Standard of care: two radiologists

New strategy: AI and one radiologist

Dembrower *et al.* Lancet Digital Heatlh 2023

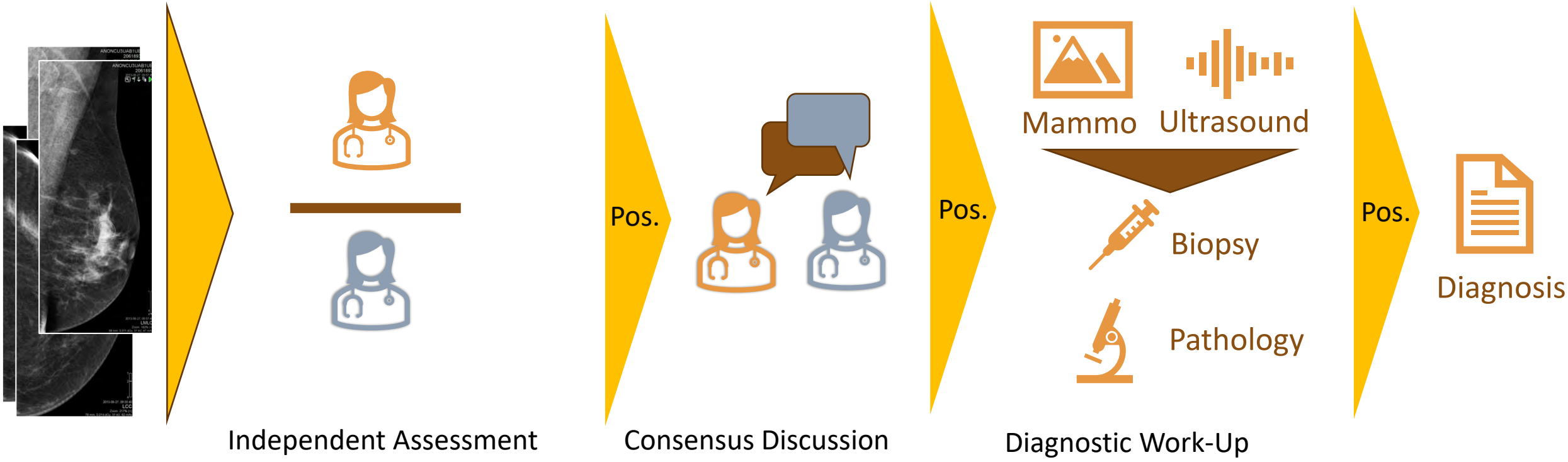
Results



Courtesy: K. Dembrower *et al.*

Capio
S:t Görans Sjukhus

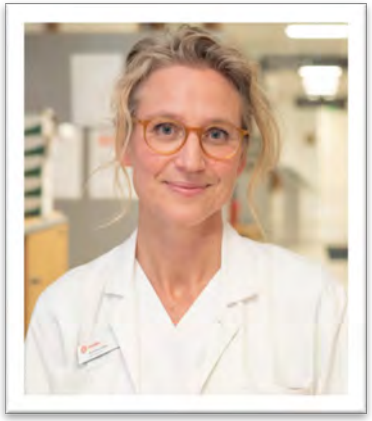
Screening Workflow and AI – Triage to One or Two Radiologists



Courtesy: VAI-B consortium/Dr F. Strand

Artificial intelligence-supported screen reading versus standard double reading in the Mammography Screening with Artificial Intelligence trial (MASAI): a clinical safety analysis of a randomised, controlled, non-inferiority, single-blinded, screening accuracy study

Kristina Lång, Viktoria Josefsson, Anna-Maria Larsson, Stefan Larsson, Charlotte Högberg, Hanna Sartor, Solveig Hofvind, Ingvar Andersson, Aldana Rosso



- Similar cancer detection rate
- Similar recalls, FP
- 44% reduced workload

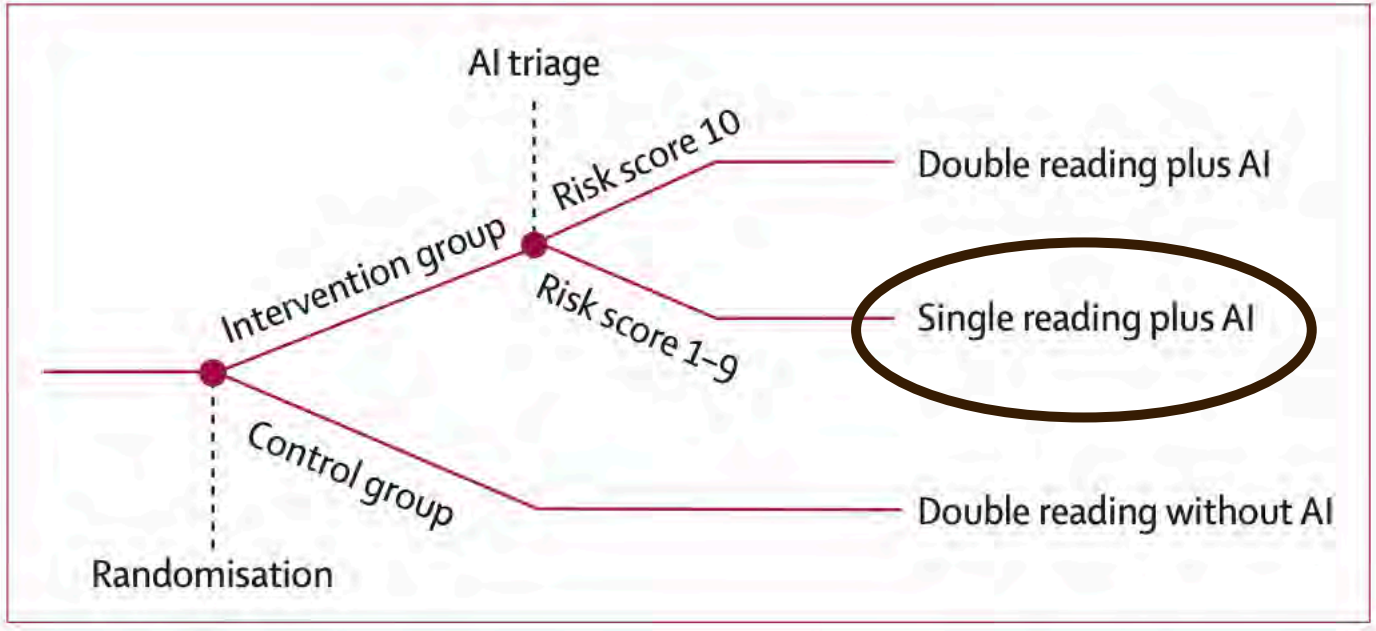


Figure 1: **Overview of trial intervention**
AI=artificial intelligence.

Lång K *et al.* The Lancet Oncol 2023

- Similar cancer detection rate
- Similar recalls, FP
- 44% reduced workload

➢ AI is safe

	Intervention group (n=39 996)	Control group (n=40 024)
Early screening performance		
Number of recalls	861	817
Recall rate, %	2·2% (2·0–2·3)	2·0% (1·9–2·2)
Number of screen-detected cancers	244	203
Cancer-detection rate, per 1000 participants screened	6·1 (5·4–6·9)	5·1 (4·4–5·8)
False positive rate, %	1·5% (1·4–1·7)	1·5% (1·4–1·7)
Positive predictive value of recall, %	28·3% (25·3–31·5)	24·8% (21·9–28·0)
Workload		
Number of screen readings	46 345	83 231
Number of consensus meetings	1584	1576
Consensus meeting rate	4·0% (3·8–4·2)	3·9% (3·8–4·1)

Data are n or point estimate (95% CI).

Table 2: **Early screening performance and workload measures, modified intention-to-treat population**

Lång K *et al.* The Lancet Oncol 2023

AI implemented in screening

- Region Värmland, Sweden
- St Göran's Hospital, Sweden
- Copenhagen, Denmark

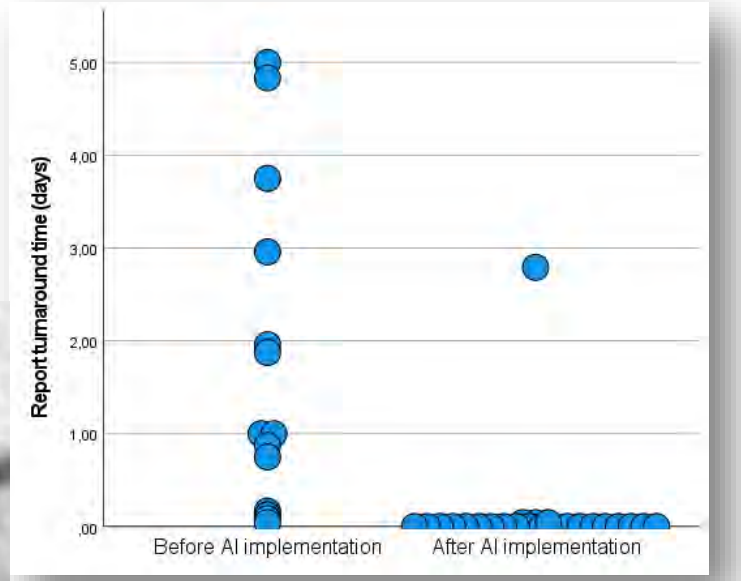
More regions in Sweden
soon to come…

Improved workflows

- Flag potential intracerebral hemorrhage

Dennis Dunker, Sahlgrenska, Implementation 2022

- Shorten report turnaround time for pulmonary embolism

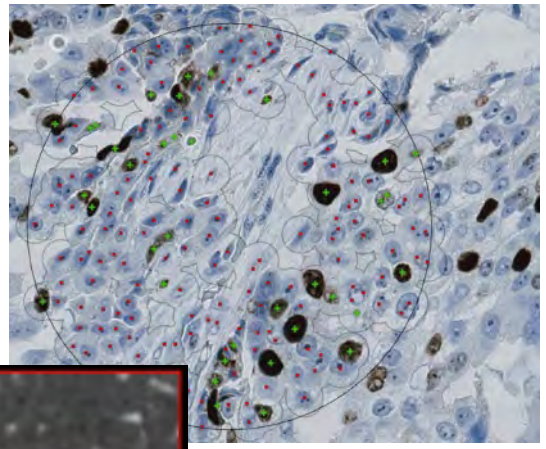


Peder Wiklund, Region Halland, Implementation 2022.

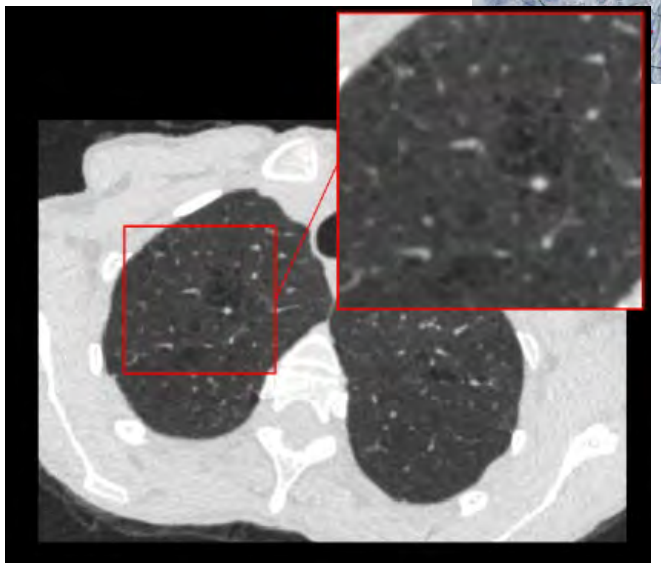
Wiklund et al., Incidental pulmonary…, Eur Radiol. 2022

Tasks beyond the experts

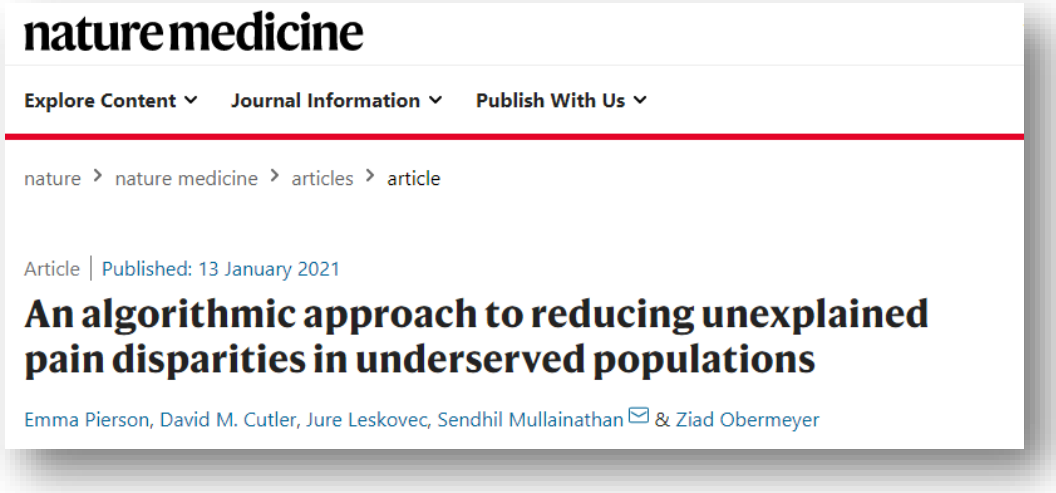
- Count >1000 cells
- Mitigate subjectivity in classification of emphysema
- Mitigate bias in assessment of knee pain and osteoarthritis



Jesper Molin,
PhD Dissertation 2016



Lidén et al., Machine learning slice-wise…,
Eur Radiol, 2023



nature medicine

Explore Content · Journal Information · Publish With Us

nature › nature medicine › articles › article

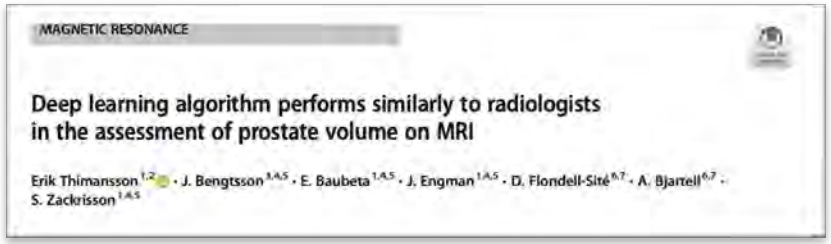
Article | Published: 13 January 2021

An algorithmic approach to reducing unexplained pain disparities in underserved populations

Emma Pierson, David M. Cutler, Jure Leskovec, Sendhil Mullainathan & Ziad Obermeyer

Tasks beyond the experts

- Prostate MRI – segmentation and volume by AI works well and saves time
- Pivotal for implementing early MRI in prostate cancer testing programmes


MAGNETIC RESONANCE

Deep learning algorithm performs similarly to radiologists in the assessment of prostate volume on MRI

Erik Thimansson [1,2] · J. Bengtsson [1,4,5] · E. Baubeta [1,4,5] · J. Engman [1,4,5] · D. Flondell-Sité [6,7] · A. Bjartell [6,7] · S. Zackrisson [1,4,5]

Eur Radiol 2023

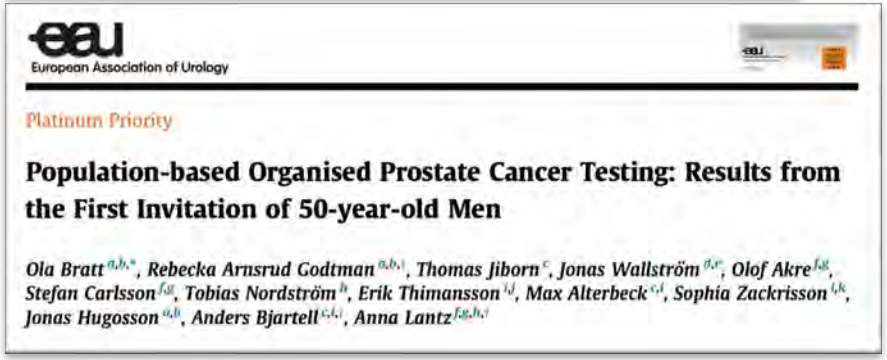

JMI Journal of Medical Imaging

RESEARCH PAPER

Deep learning performance on MRI prostate gland segmentation: evaluation of two commercially available algorithms compared with an expert radiologist

Erik Thimansson [a,b,*] Erik Baubeta [a,c] Jonatan Engman [a,c] Anders Bjartell [d,e] and Sophia Zackrisson [a,c]

JMI 2024

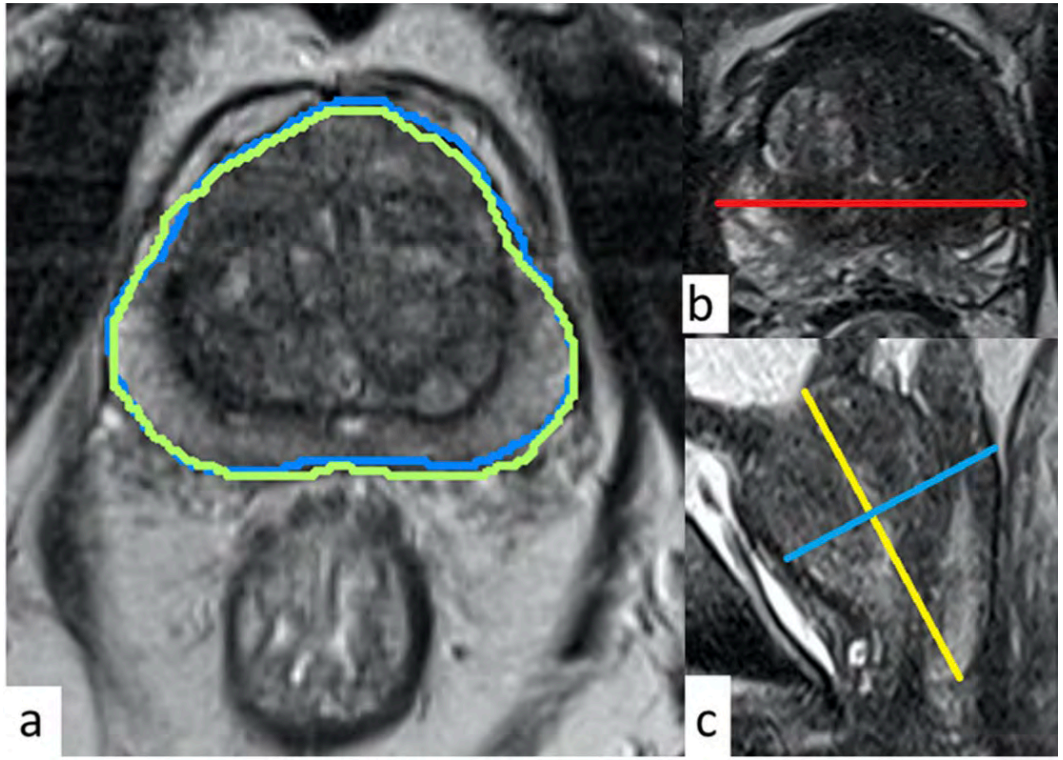

European Association of Urology

Platinum Priority

Population-based Organised Prostate Cancer Testing: Results from the First Invitation of 50-year-old Men

Ola Bratt [a,b,], Rebecka Arnsrud Godtman [a,b,1], Thomas Jiborn [c], Jonas Wallström [d,e], Olof Akre [f,g], Stefan Carlsson [f,g], Tobias Nordström [h], Erik Thimansson [i,j], Max Alterbeck [c,i], Sophia Zackrisson [i,k], Jonas Hugosson [a,b], Anders Bjartell [c,i,l], Anna Lantz [f,g,h,1]*

Eur Urol In press



Large language models

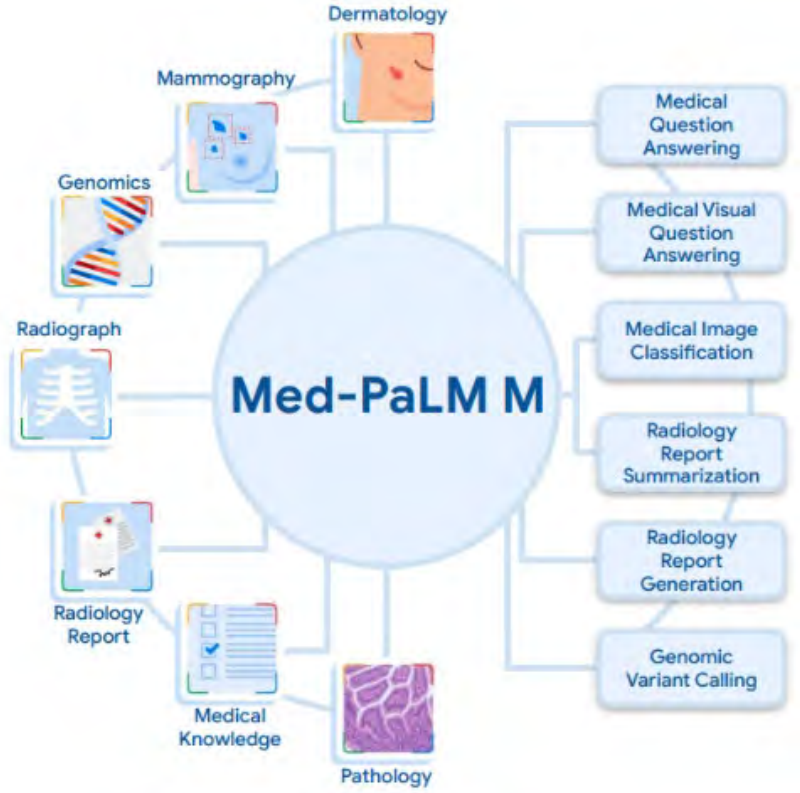
- (RSNA 2023) GPT4 extracted measurements in lung cancer radiology reports with 98% precision
- Works well for well-defined and framed tasks:
  - Free reporting, get structured report
  - Interpret free text ➔ Local statistics
  - Chat interface to user guide

- Impressive even without frames, but risk for hallucinations (facts fabrication)

Bhayana R. Chatbots and Large Language Models in Radiology: A Practical Primer for Clinical and Research Applications. Radiology 2024

Generalist multimodal systems

- Foundation models for medicine
- Combines text and images
- Easy to adjust general models
- Easy to create step-by-step solutions

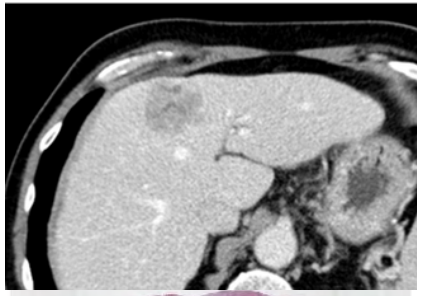


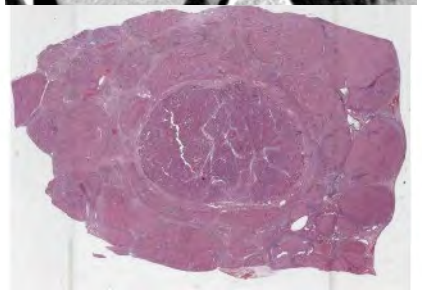
Tu et al., Towards Generalist Biomedical AI, arXiv, 2023

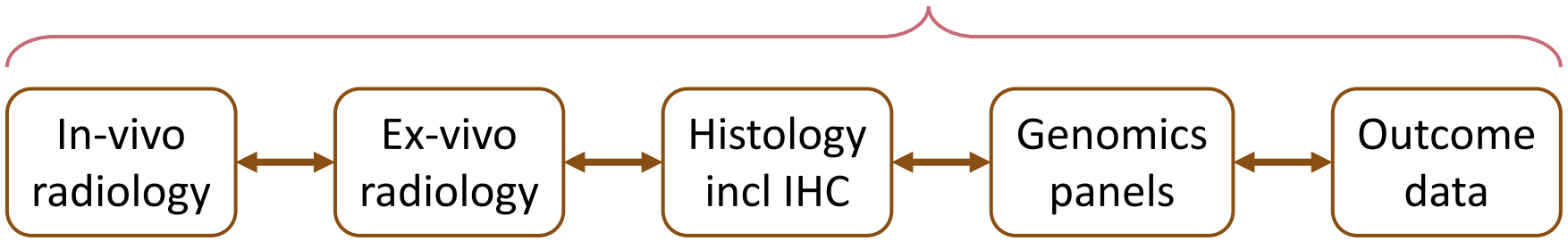
- Medicine: not publicly available data – different from other areas in society
- Legal uncertainties also regarding open source data

Future potentials: Multimodal AI

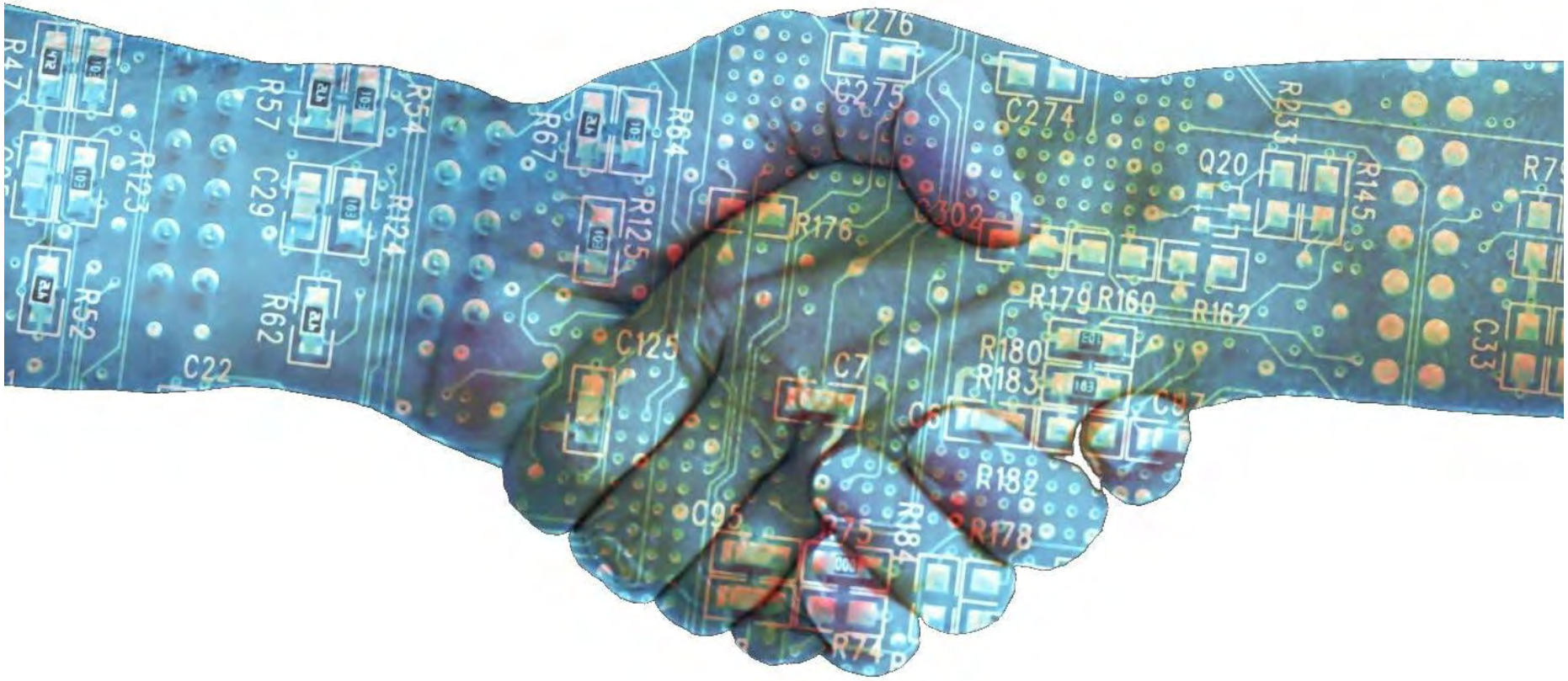
- AI can easily combine several data sources
- (RSNA 2023) Greatly improved precision for AI using both mammography and ultrasound images
- Several CMIV/Sectra (Linköping) research projects for multimodal AI
  - AI for histology fed by histology and genomics
  - AI combining radiology och histology







How to implement AI



218 CE-marked AI products in radiology

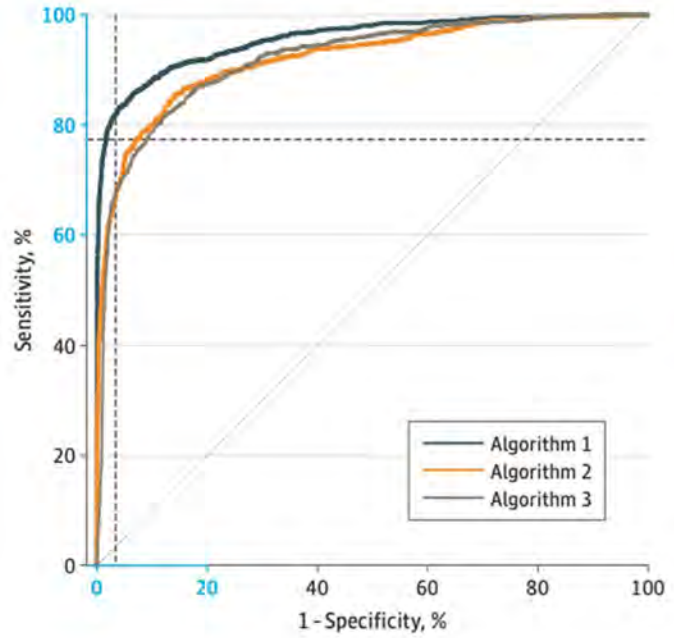
https://radiology.healthairegister.com

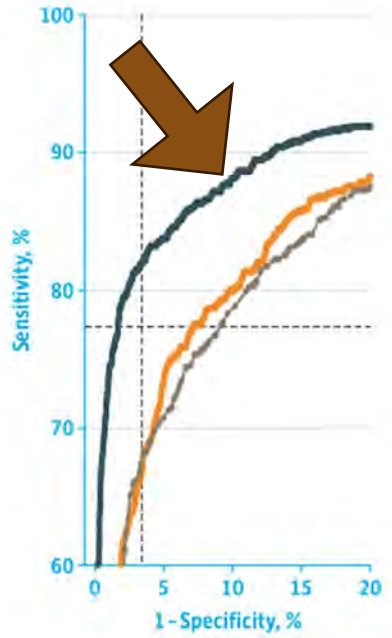
JAMA Oncology | Original Investigation

External Evaluation of 3 Commercial Artificial Intelligence Algorithms for Independent Assessment of Screening Mammograms

Mattie Salim, MD; Erik Wåhlin, MSc; Karin Dembrower, MD; Edward Azavedo, MD; Kevin Smith, MSc, PhD; Martin Eklund, MSc, PhD; Fredrik Strand, MD, PhD

Figure. Receiver Operating Characteristic Curves for the 3 Artificial Intelligence Computer-Aided Detection Algorithms





Salim M *et al.* JAMA Oncol 2020

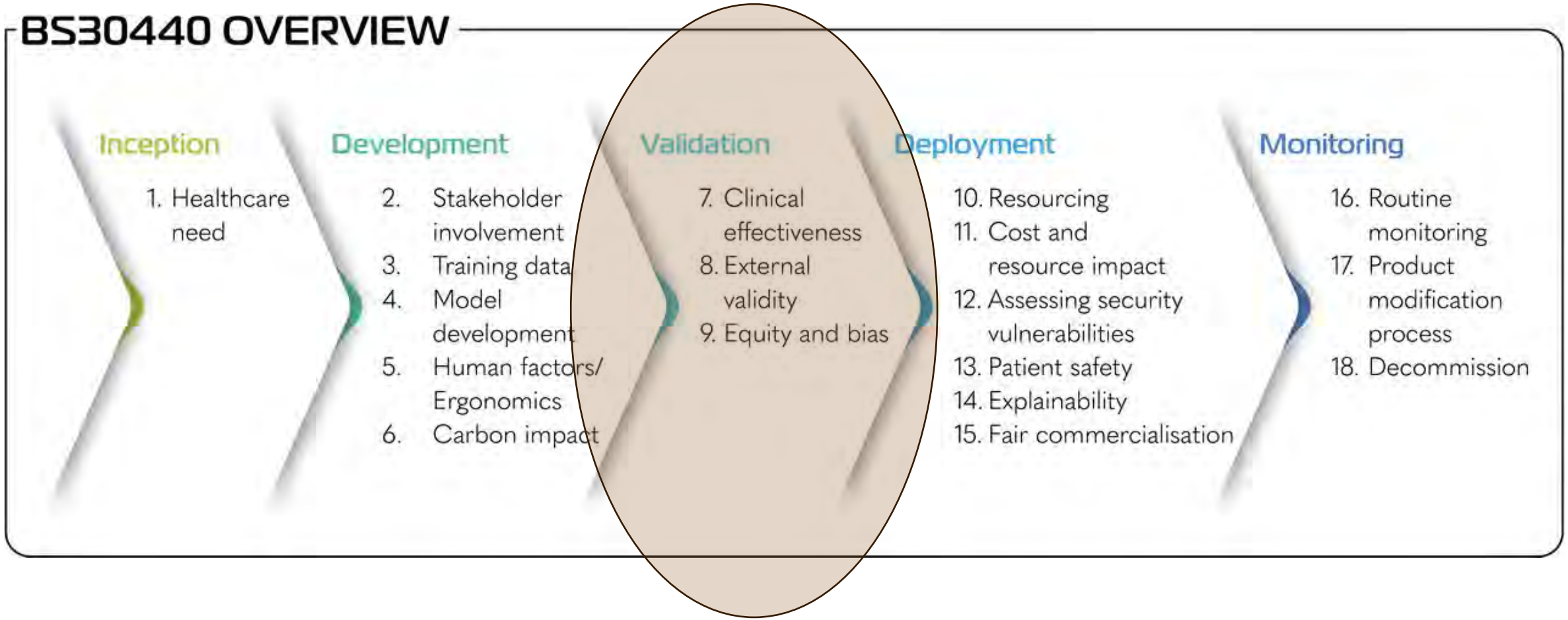
Open access Communication

BMJ Health & Care Informatics

Validation framework for the use of AI in healthcare: overview of the new British standard BS30440

Mark Sujan ,[1,2] Cassius Smith-Frazer,[3] Christina Malamateniou,[4] Joseph Connor,[5] Allison Gardner,[6] Harriet Unsworth,[7] Haider Husain[3]

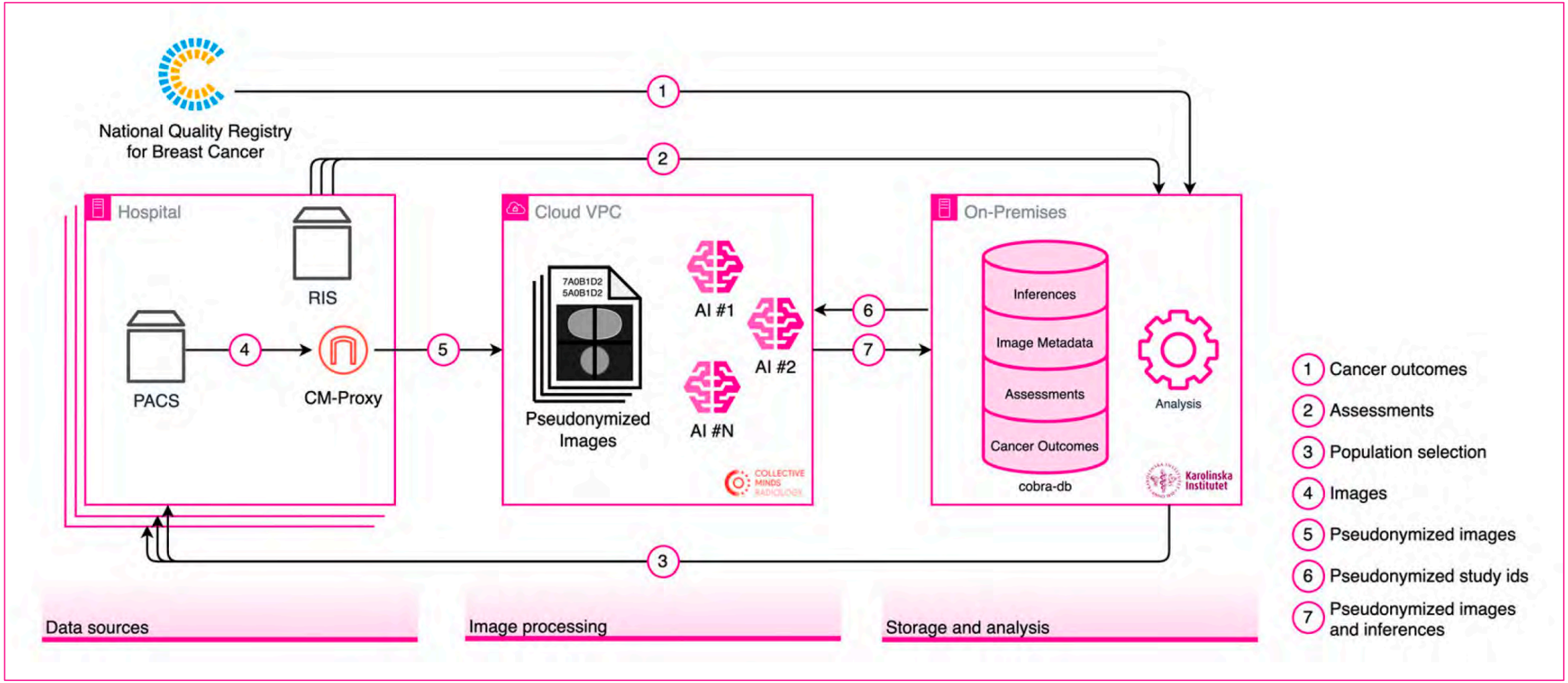
To have a strategy…



Sujan M, et al. BMJ Health Care Inform 2023;**30**:e100749. doi:10.1136/bmjhci-2023-100749

https://www.lakemedelsverket.se/sv/medicinteknik/anvanda/anvandning-av-ai-i-sjukvarden#hmainbody1

VAI.B Validation Platform for AI in Breast Imaging



Cossío, F., Schurz, H., Engström, M., Barck-Holst, C., Tsirikoglou, A., Lundström, C., Gustafsson, H., Smith, K., Zackrisson, S., & Strand, F. (2023). VAI-B: A multicenter platform for the external validation of artificial intelligence algorithms in breast imaging. *Journal of Medical Imaging*.

VAI.B Validation Platform for AI in Breast Imaging

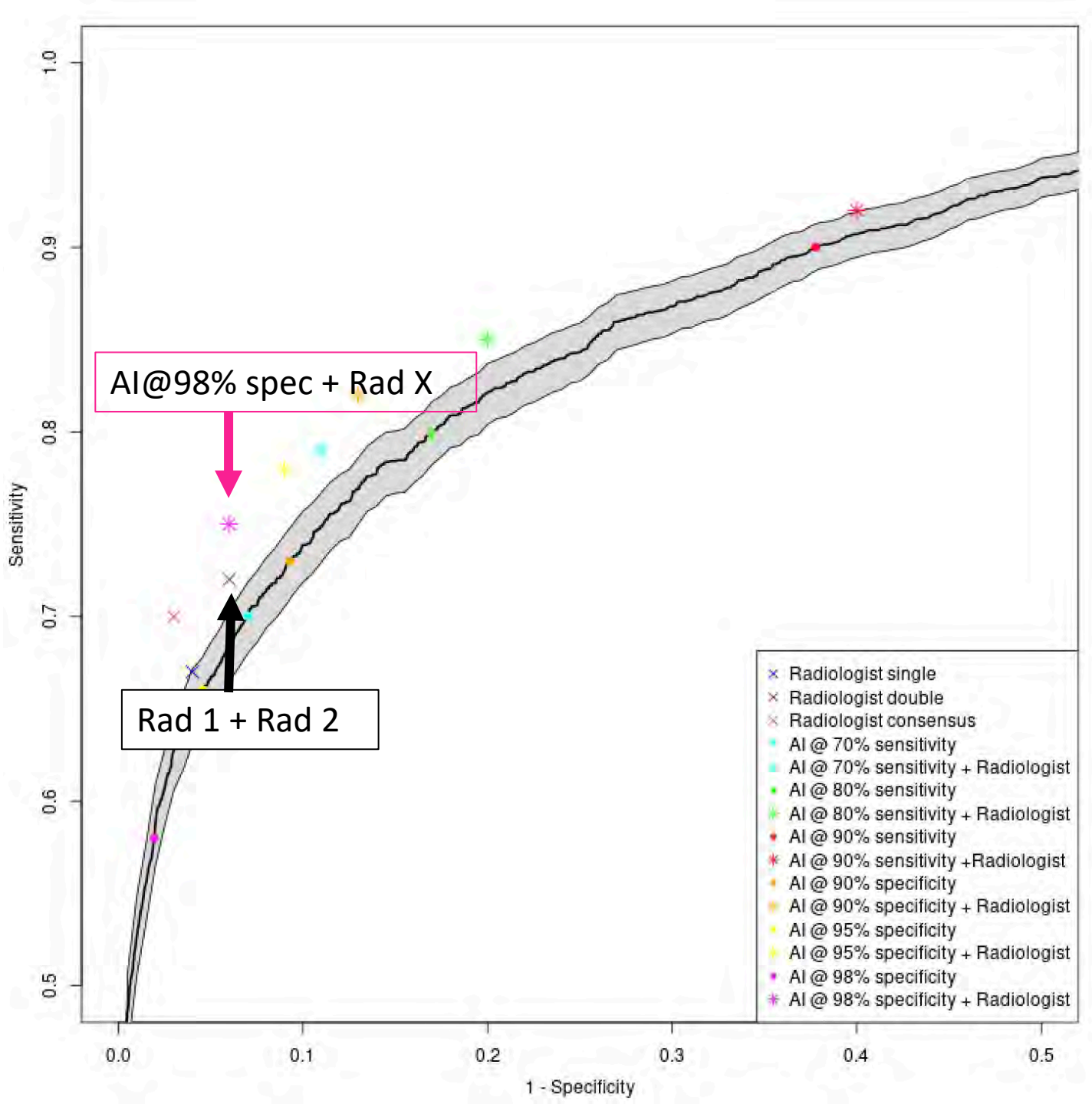
Does it work equally well in all situations?

- Cancer characteristics (e.g., histology)
- Breast characteristics (e.g., density)[1]
- Population characteristics (e.g., ethnicity proxy by parents' geographic origin)
- Acquisition[2] characteristics – adding:
  - Equipment Software upgrades
  - Detector plate replacements
  - Compression plate varities

1,2. H. Schurz et al. VAI-B preliminary analysis RSNA 2023

VAI.B Validation Platform for AI in Breast Imaging

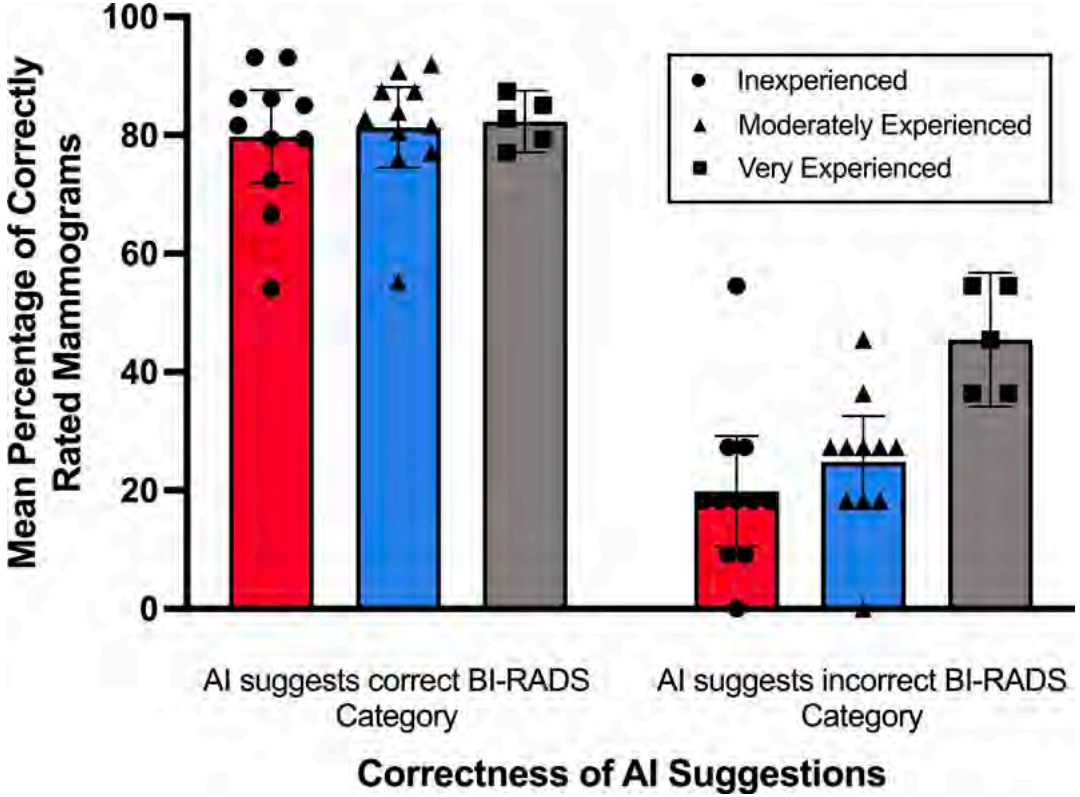
What is the estimated effect of AI?



Source: VAI-B preliminary analysis

Future of AI – How much can we rely on AI?

- Automation bias
- Less experienced radiologists are more likely to follow the incorrect suggestions of AI



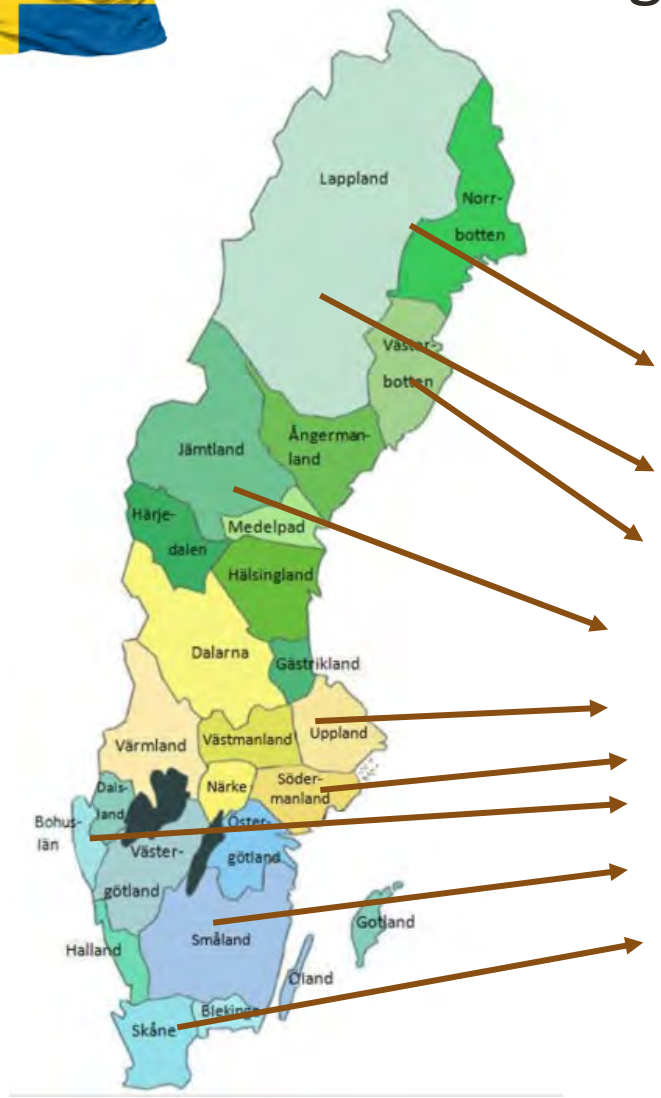
Dratsch et al, Radiology 2023

HUMAN IN THE LOOP

Next steps for implementation in healthcare

- Don’t wait – let’s go!
  - Mature techniques
  - Don’t overdo (RCTs etc) – BUT quality assure!
  - Actual implementation and local validation will inform us
- Clinical needs should guide us
- Easiest possible governance

Regional testing of DM+AI or AI+DBT in Sweden



Knowledge transfer network

NUB

Nationellt utvecklingsnätverk för bröstcancerscreening

VAI.B Validation Platform for AI in Breast Imaging

AIDA Analytic Imaging Diagnostics Arena

REGIONALA CANCERCENTRUM I SAMVERKAN

Information/interaction
Health authorities, profession and ”end users”

Socialstyrelsen

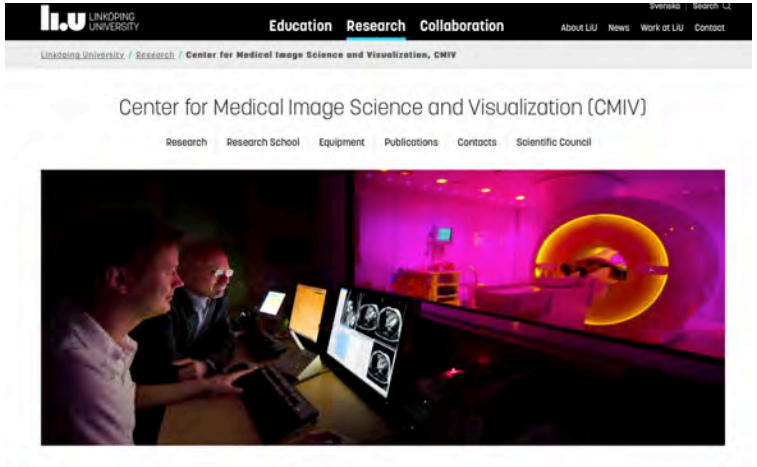
SFBR Svensk Förening för Bröstradiologi

BRÖSTCANCER FÖRBUNDET

PI: Sophia Zackrisson, co-PI Fredrik Strand

Thanks to:

- A/Prof Claes Lundström, Center for Medical Image Science and Visualization (CMIV), Linköping University, Research Manager Sectra
  Leader, Analytic Imaging Diagnostic Arena (AIDA)
- VAI-B consortium
- Karin Dembrower, MD, PhD, St Göran's hospital, Stockholm
- A/Prof Fredrik Strand, MD, PhD, Karolinska, Stockholm



VAI.B Validation Platform for AI in Breast Imaging


THAT'S ALL
FOLKS !

LUND
UNIVERSITY