

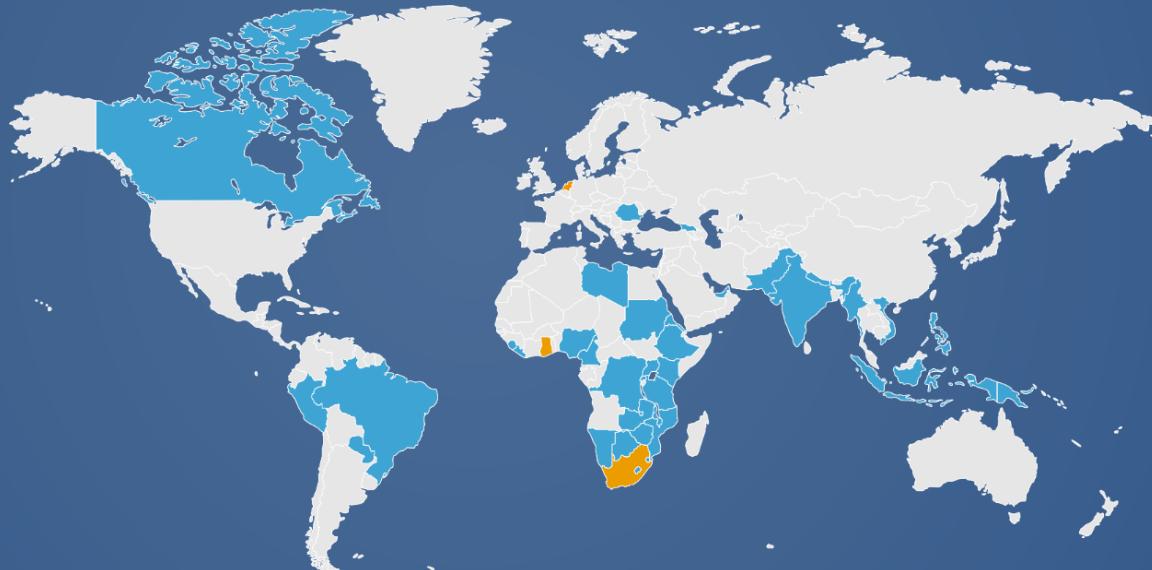
# X-ray and AI in triaging for TB and COVID-19

April 22nd, 2020

By Guido Geerts, President & CEO of Delft Imaging  
& Thirona and Dr. Rick Philipsen, Head of  
Development

[www.delft.care](http://www.delft.care)

- Introduction Delft Imaging
- History and implementation of CAD4TB (AI)
- The role of X-ray in COVID-19
- Validation & implementation of CAD4COVID (AI)
- Conclusion



40 countries



150+ projects

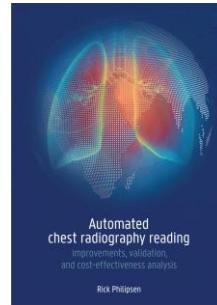
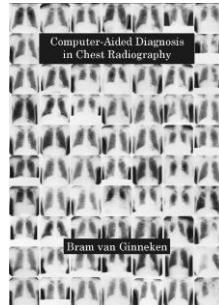


250+ installations



6 million+  
TB screenings

# How it all started: AI for TB (CAD4TB)



**1996** Delft launches first digital X-ray for TB screening; Dutch grant to develop software to analyze radiographs

**2001** First publications on automated detection of TB from chest radiographs

**2007** CAD4TB project by Delft and Radboud University starts in cooperation with Lung Institute in Cape Town

**2011** First prototype tested in South Africa and Zambia

**2015** CAD4TB CE certified and used in SA prisons

**2016** Launch of CAD4TBbox for full offline use

**2020** CAD4TB is being used to screen over 7,000+ people every day, with more than 1.5 million people screened in 2019 alone. CAD4TB is active in 40 countries.

# Our solutions for TB

## Delft Light

Portfolio of portable X-ray



Fits within a backpack

## EasyDR

Stationary X-ray systems



250+ installations

## Mobile clinics

TB, Laboratories (UN supplier)



100+ mobile TB clinics globally

## Artificial intelligence

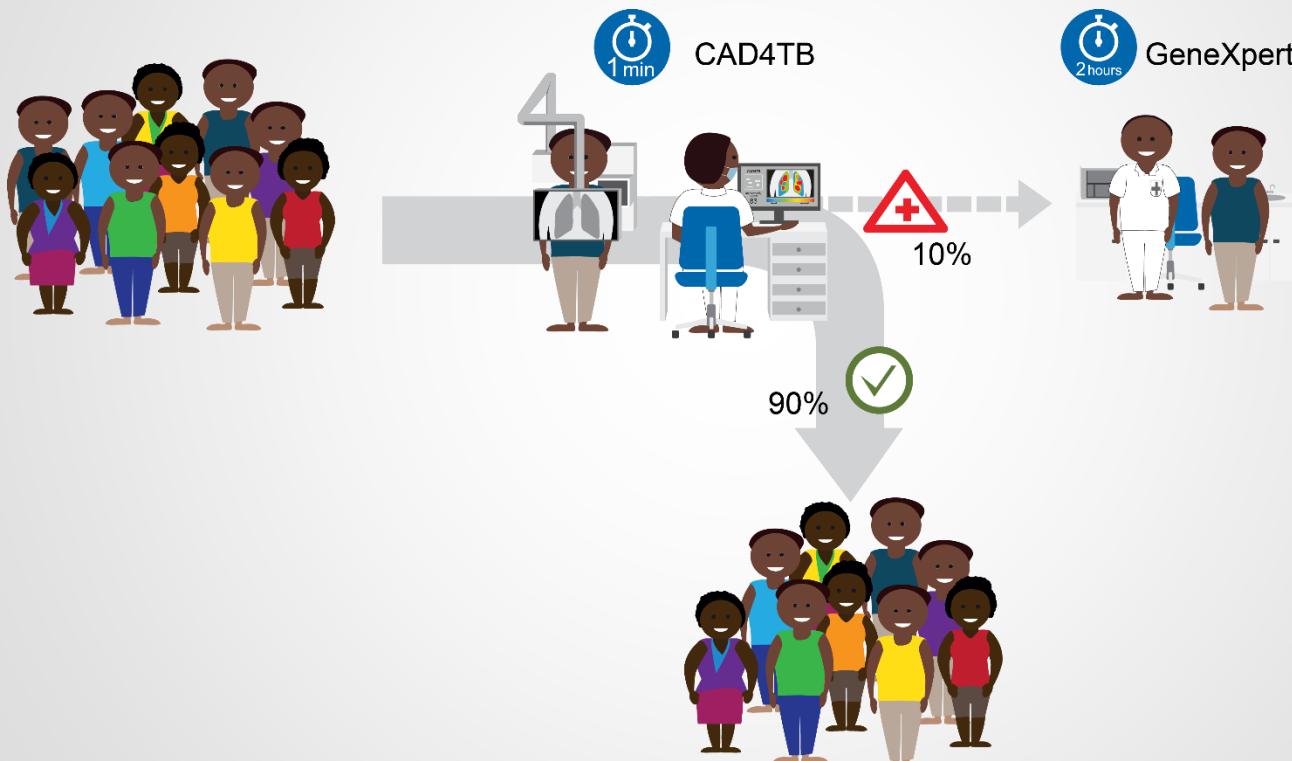
CAD4TB, CAD4COVID



Over 6M+ people screened

# Combining CAD4TB and GeneXpert

## Saving both time and costs in screening programs



# Publications and studies (40+)



- Useful **where trained human readers are scarce**, [Muyoyeta et al., PLOS One, 2014]
- In Tanzania, **CAD4TB performance was significantly better than a clinical officer** [Breuninger et al., PLOS One, 2014]
- **Reduces cost per identified TB case and the cost per screened subject by almost half**, [Philipsen et al., Nature Scientific Reports, 2015]
- **CAD4TB on par with human expert readers**, [South Africa; Hogeweg et al., IEEE Trans Med Imaging, 2015], [Tanzania; Steiner et al., Public Health Action, 2015], [Zambia; Melendez et al., IJTL, 2017], [London; Melendez et al., IJTL, 2018]
- In Pakistan, **cost per screened subject using CAD4TB is almost half** in comparison to screening without, while **doubling daily throughput** [Murphy et al., Nature Scientific Reports, 2020]
- Offers good **diagnostic accuracy** as triage for TB screening among **diabetes patients** [Habib et al., Nature Scientific, 2020]

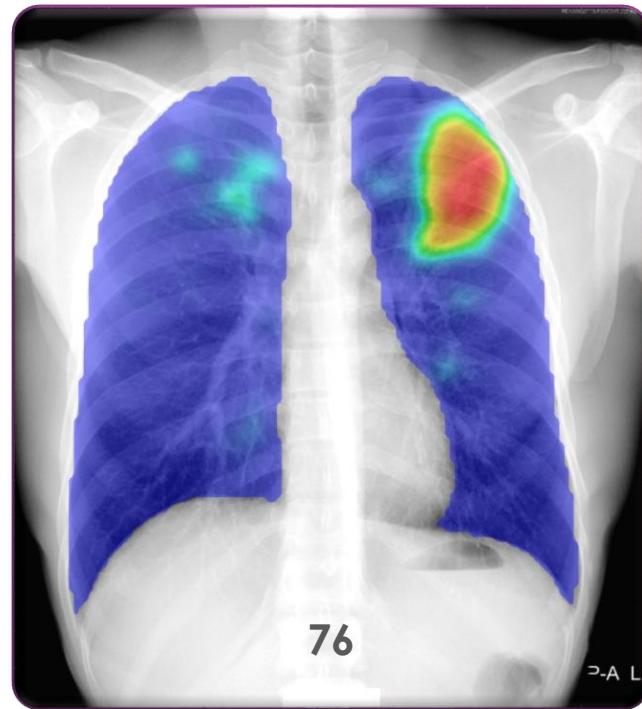
# AI for COVID-19/TB screening; how does it work?



INPUT



OUTPUT



76

1963: The first paper on Computer-Aided Diagnosis



VOL. 81 NO. 2

# Radiology

AUGUST 1963

*a monthly journal devoted to clinical radiology and allied sciences*  
PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA, INC.

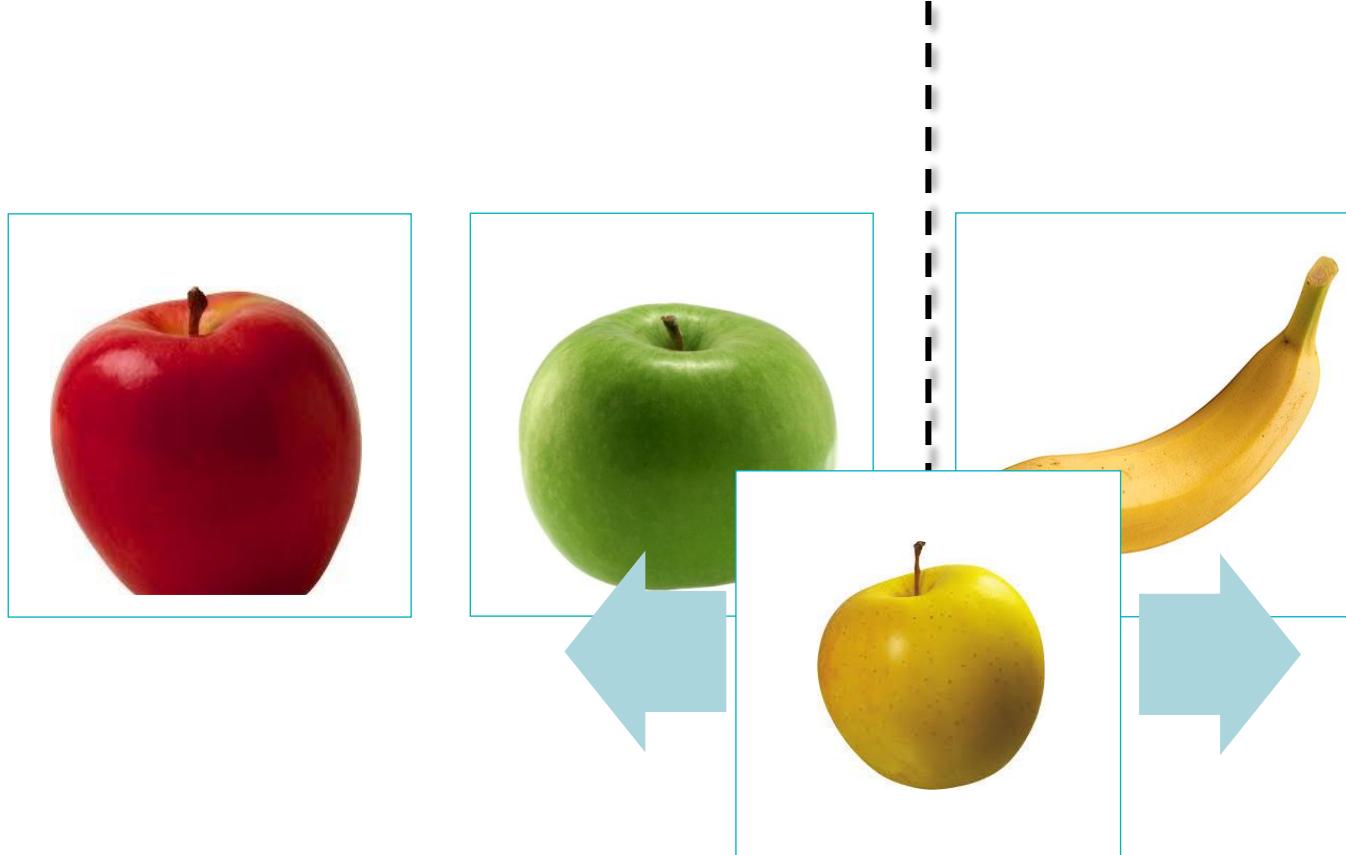
## The Coding of Roentgen Images for Computer Analysis as Applied to Lung Cancer<sup>1</sup>

GWILYM S. LODWICK, M.D., THEODORE E. KEATS, M.D., and JOHN P. DORST, M.D.

THIS PAPER WILL DESCRIBE a concept of converting the visual images on roentgenograms into numerical sequences that can be manipulated and evaluated by the digital computer and will report the results of employing this system to

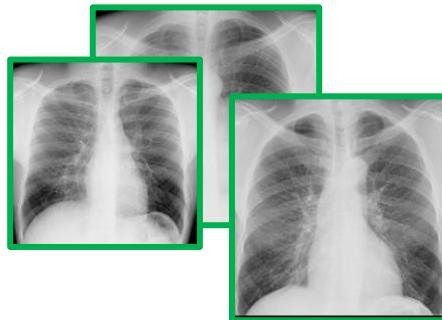
cause, against a background of air density, the intimate details of the relationship between tumor and host may be faithfully reproduced roentgenographically. Parenthetically, it may be stated that similar density ranges exist in the relationships between bone and soft tissue and that

# Deep learning



# Deep Learning

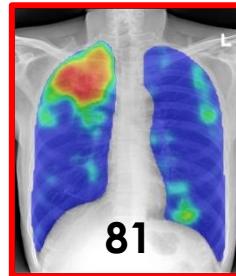
Healthy



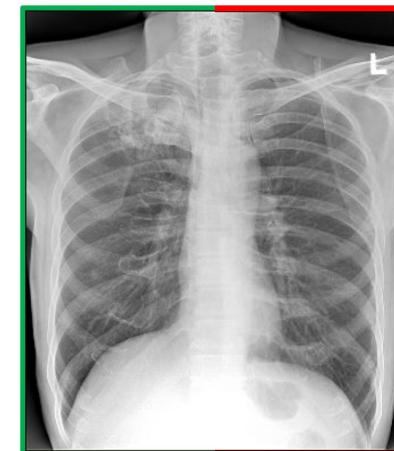
Diseased



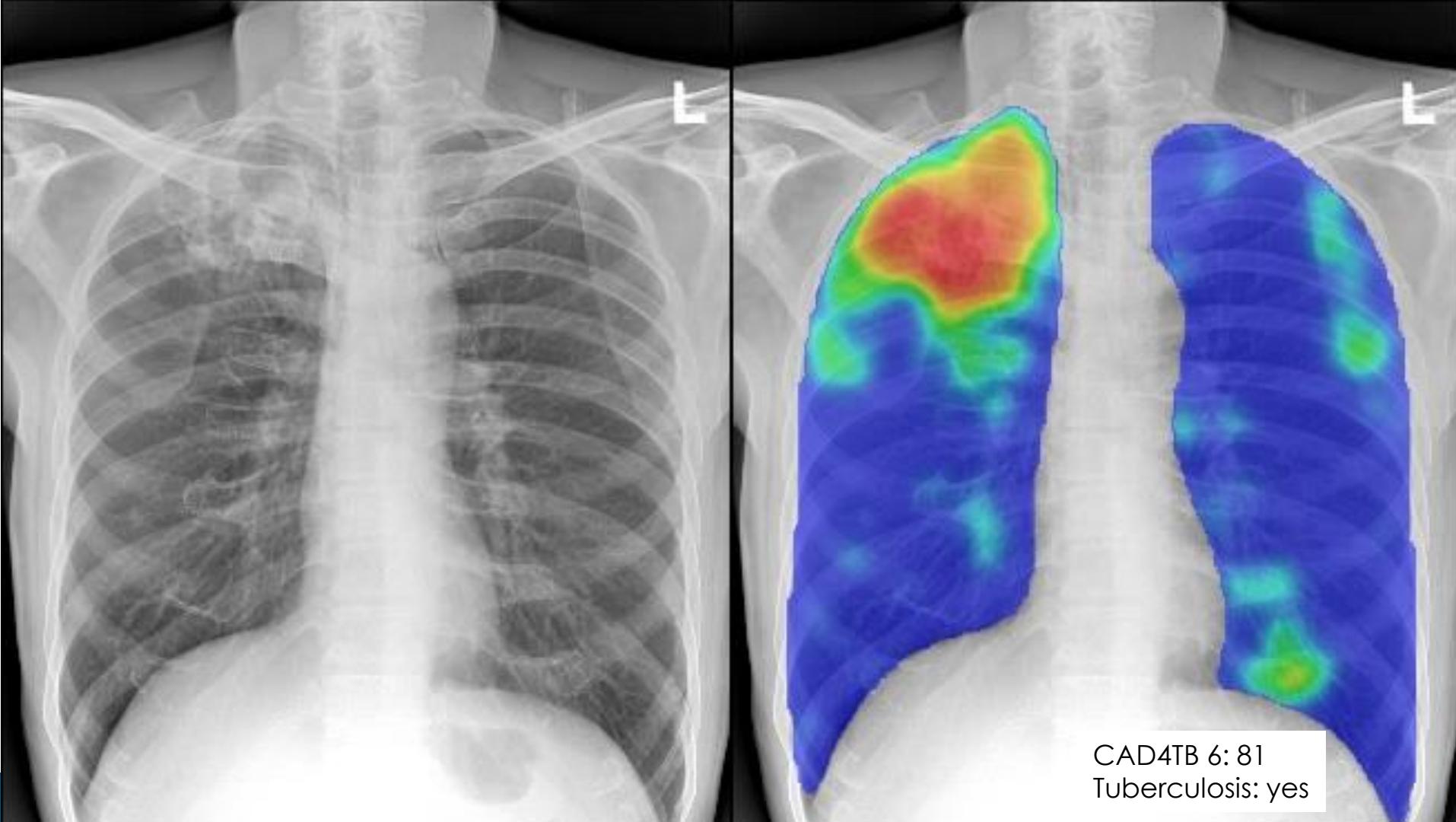
Training images



CAD



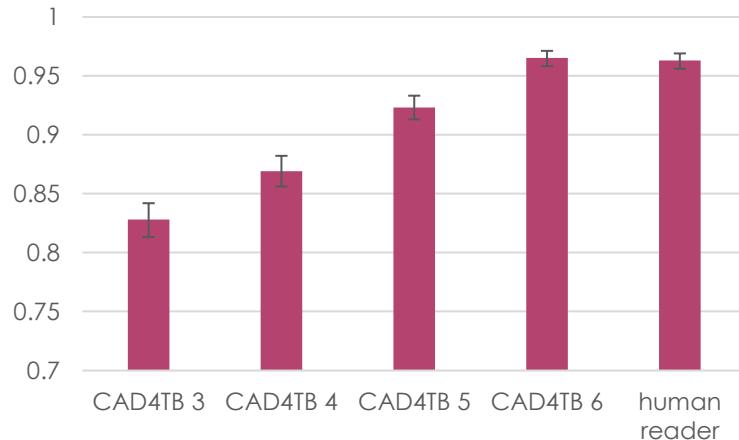
Test image



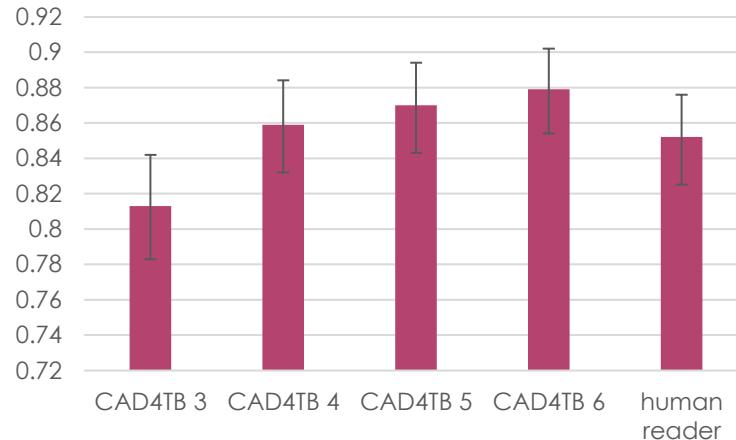
CAD4TB 6: 81  
Tuberculosis: yes

# Continuously being improved

Radiological reference

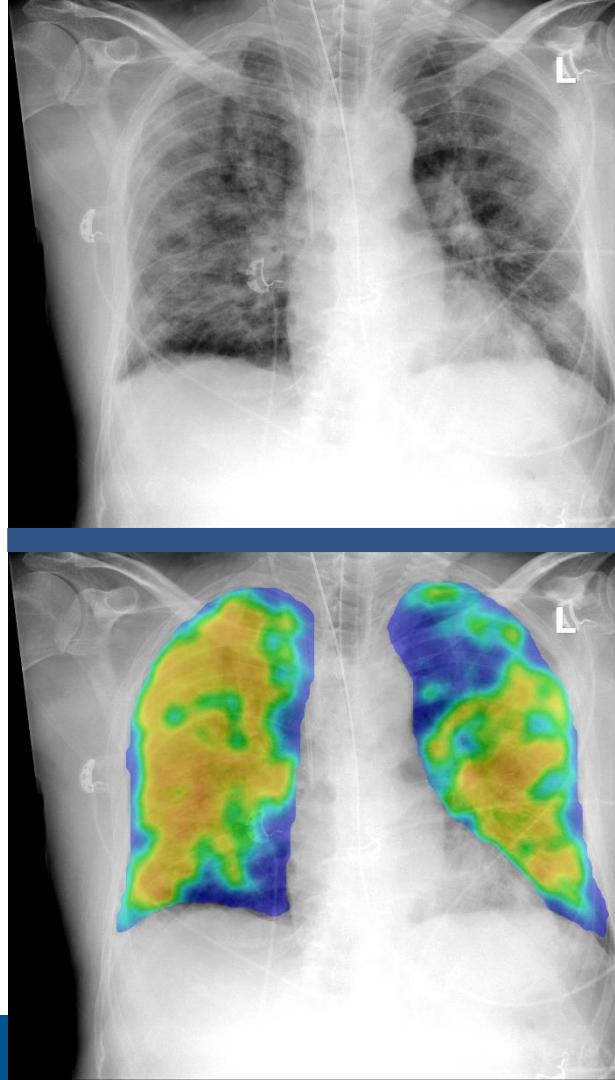


Bacteriological reference



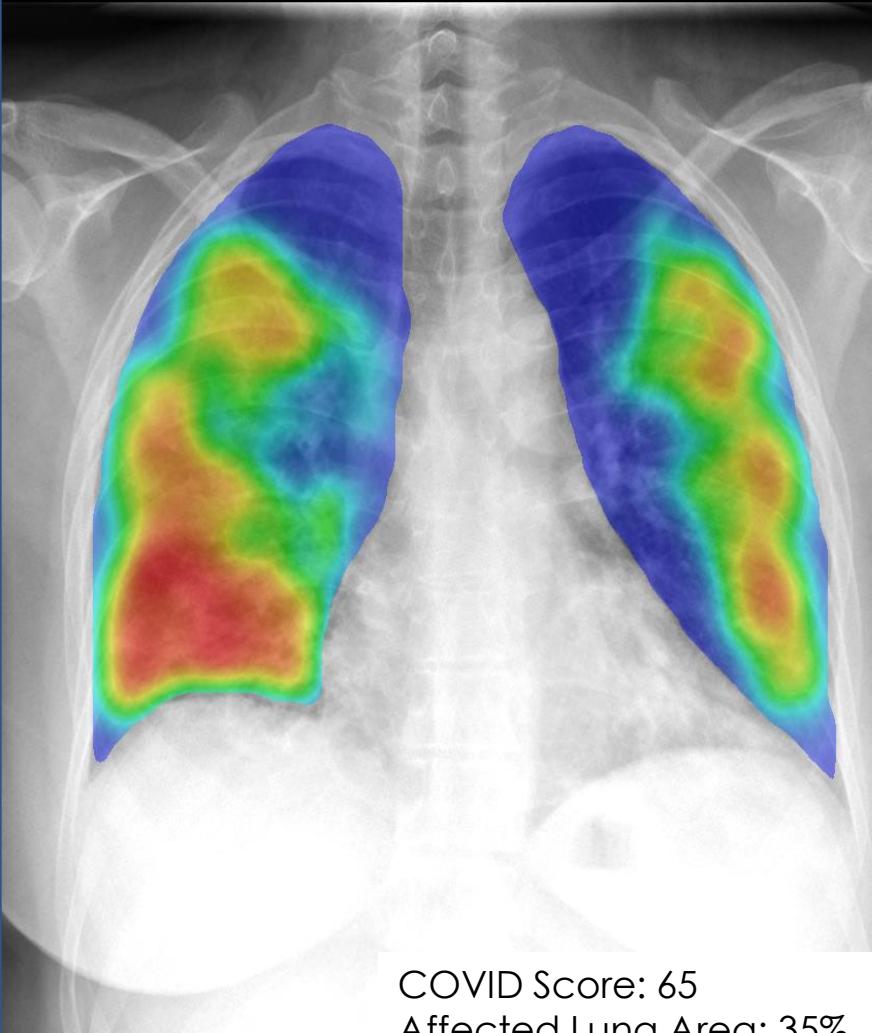
# The role of X-ray in COVID-19

- RT-PCR is the gold standard to confirm COVID-19, so where does radiology come in?
- Early stages can be undetected by the lab test; CT imaging has found to be a highly sensitive method to detect COVID-19<sup>1</sup>
- X-ray is not as sensitive as CT, but uses less radiation, is often cheaper, easier to use and generally more available in TB-burdened countries
- A positive diagnosis from radiology (CT) is definitive, even when a lab test is negative<sup>2</sup>
- Moreover, radiology allows for tracking disease progression & recovery
- But, X-ray is not a diagnostic tool for COVID-19; it is a triage tool

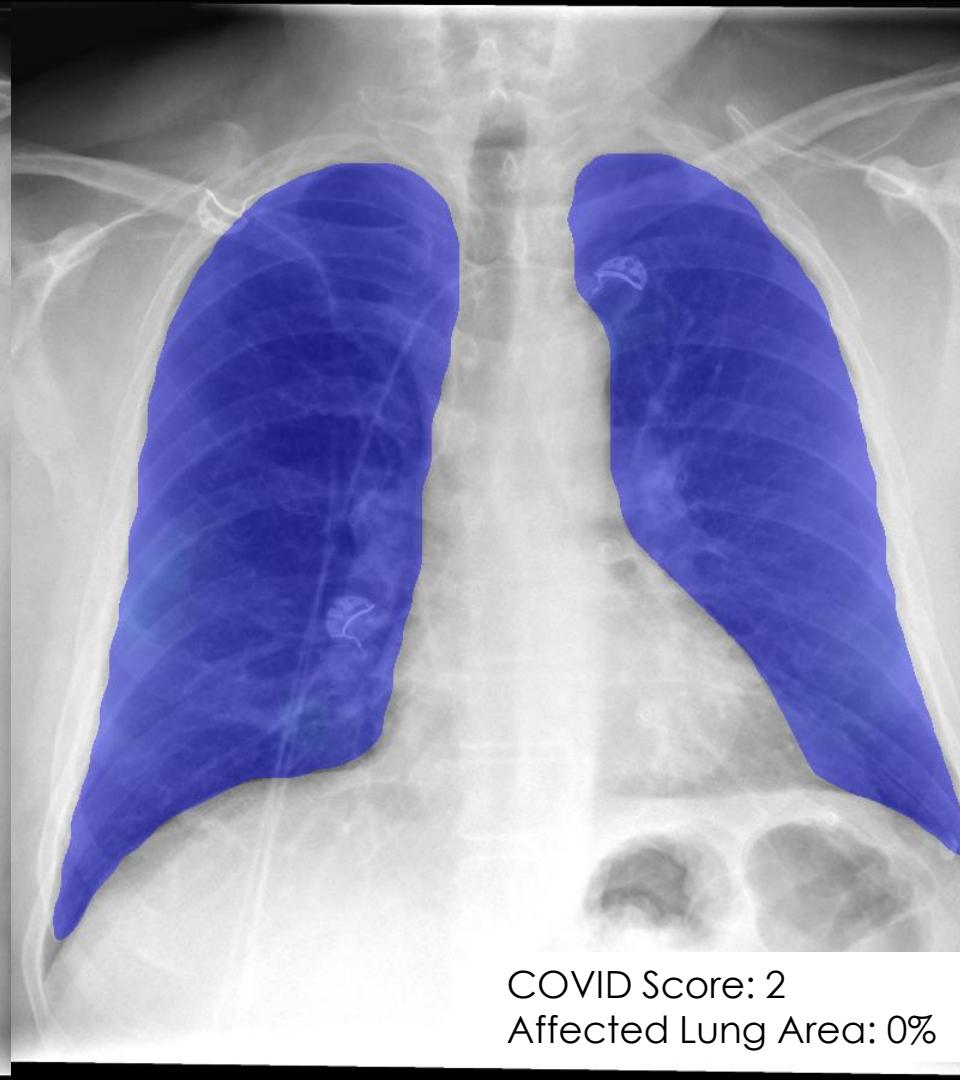


<sup>1</sup> Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases, Radiological Society of North America, February 26 2020; <https://doi.org/10.1148/radiol.20200642>

<sup>2</sup> CT Imaging and Differential Diagnosis of COVID-19, Canadian Association of Radiologists Journal, March 4 2020; <https://doi.org/10.1177/0846537120913033>

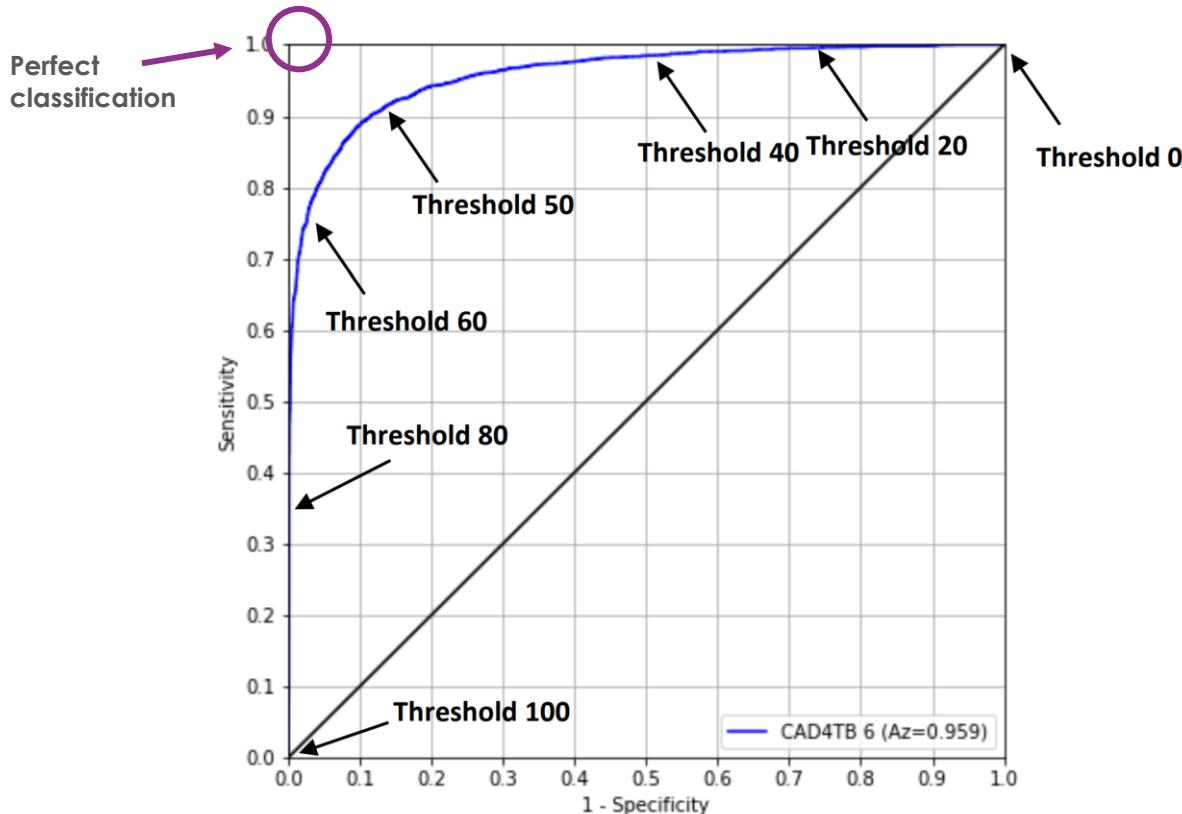


COVID Score: 65  
Affected Lung Area: 35%



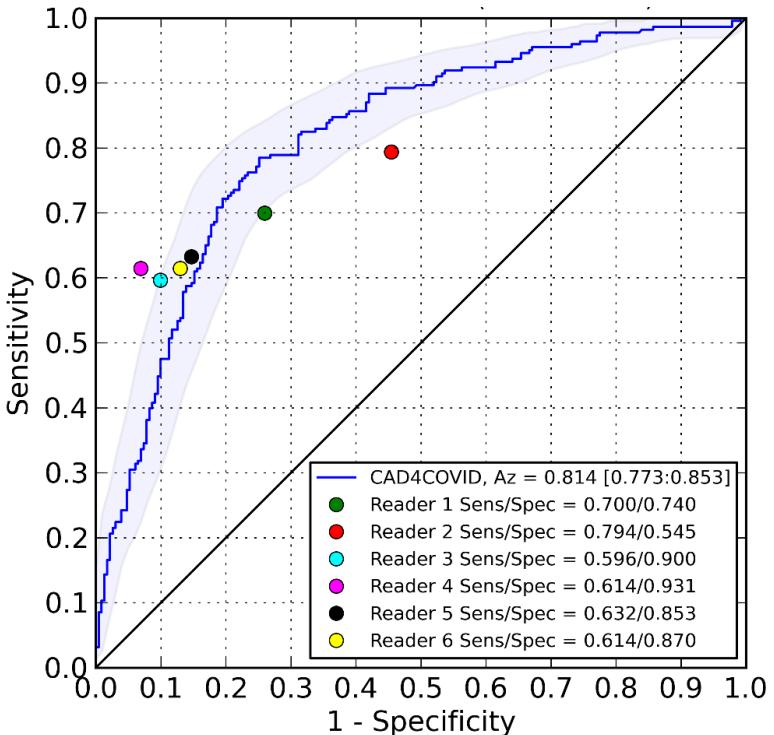
COVID Score: 2  
Affected Lung Area: 0%

# ROC curve: explained



# Scientific validation CAD4COVID

- Single center study
- 454 COVID suspects
  - 223 PCR positive
  - 231 PCR negative
- 6 radiologists from hospitals in the Netherlands

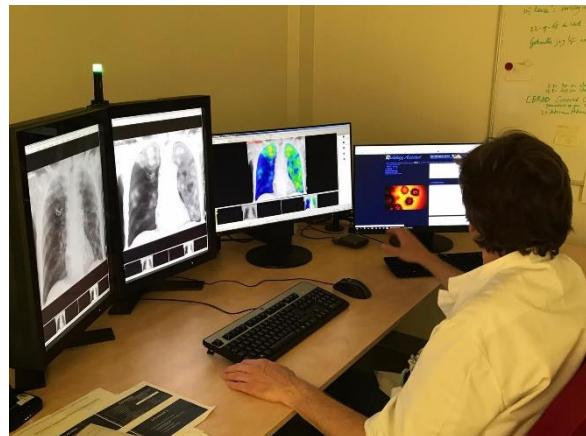


- Performance among radiologists differ
- CAD4COVID has similar performance to radiologists
- For COVID-19, limit to what can be seen on CXR (also for radiologists). Different for TB.
- Sensitivity and specificity depend on threshold and dataset
- Paper submitted to Radiology journal

# Case study – Bernhoven (Netherlands)



- One of the highest-burdened hospitals in the Netherlands.
- Triage tent upon entering hospital. Selection for radiology based on symptoms (e.g. fever, cough). First-line triage with digital X-ray;
  - If CXR is abnormal -> RT-PCR
  - If CXR is normal -> CT (before RT-PCR)
- Highly prevalent setting: 90% of patients with symptoms had COVID-19
- In 60-70% of cases, COVID-19 abnormalities were visible on the CXR
- A number had COVID-19 (abnormalities), but negative 1<sup>st</sup>/ 2<sup>nd</sup> RT-PCR
- Currently, exploring different use cases for TB-burdened countries (e.g. Peru/SA/Nigeria)



# CAD4COVID Partners

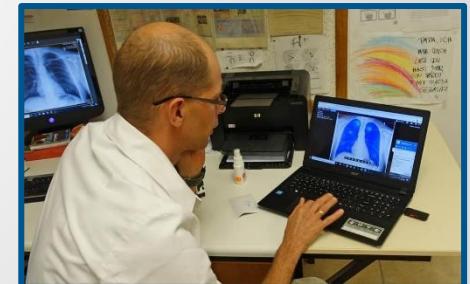


**Radboudumc**  
university medical center



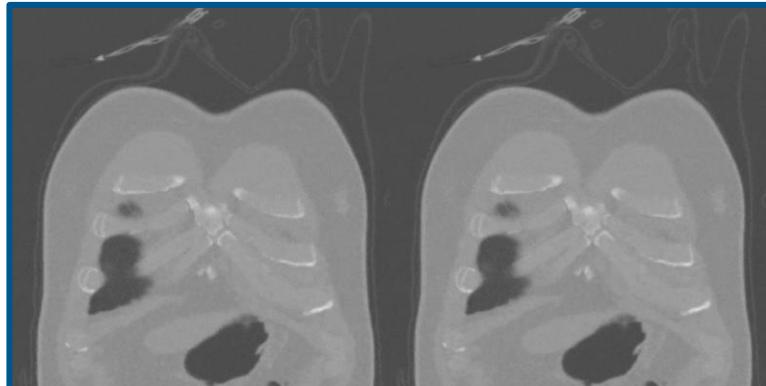
**thirona**

CAD4COVID: accessible already to  
healthcare facilities in twelve  
countries (Left: Hungary, Right: Peru)



# CAD4COVID-CT

- CAD4COVID-CT is now also available, live April 20<sup>th</sup>
- Also free-of-charge during the crisis
- Output:
  - Severity score
  - Heatmap
  - % of lung tissue affected
- Cloud-based, and available to 10,000+ radiologists globally through partnership with German company Smart Reporting
- For access, go to [www.thirona.eu/cad4covid](http://www.thirona.eu/cad4covid)



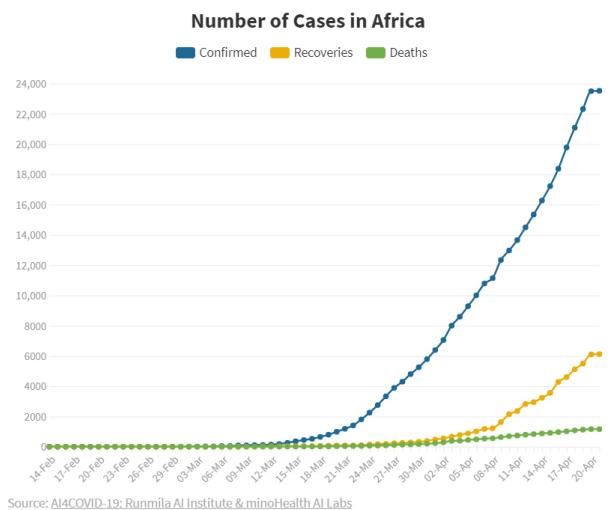
## Considerations on implementing AI for TB/COVID-19

- The algorithm is only part of the solution; also consider factors like
  - Extent of scientific validation
  - Ease-of-use
  - Offline availability
  - Service & support
- Take privacy and data security in consideration



# Key takeaways

- Overall, AI tools are not diagnostic tools, but intended as a triage tool
- **X-ray for TB:** highly sensitive, and reasonably specific
- **AI for TB** (with CAD4TB): extensively validated: 6M+ screenings, 40+ publications, CE certified
- **X-ray for COVID-19:** limited sensitivity; needs to be in combination with symptoms / rapid POC tests
- **AI for COVID-19:** useful in high-prevalent settings. Comparable to human reader. Exploring screening for COVID-19 & TB. Further validation needed.
- For access to CAD4COVID (free-of-charge during crisis), go to [www.delft.care/cad4covid](http://www.delft.care/cad4covid)



Source: AI4COVID-19: Rummila AI Institute & minoHealth AI Labs



NEWS / AFRICA

## Africa coronavirus cases could hit 10 million in six months: WHO

COVID-19 cases on the continent may shoot up from thousands to millions if models are accurate, UN health agency says.

17 Apr 2020





# Thank you for your attention

For more information,  
visit [www.delft.care](http://www.delft.care)