

The Value and Use of Ultraportable X-ray device and AI/CAD for TB Detection

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Stop TB Partnership
July 1-2, 2021

Stop TB Partnership

Disclosure

No conflict of interest to disclose

A healthcare professional wearing a white lab coat, a green surgical mask, and glasses is looking at a laptop. The laptop screen displays a chest X-ray. In the background, there are medical posters on the wall, including one with a list of conditions (g. Fracture, h. Pneumothorax, i. Obstruction, j. Vascular injury, k. Haemothorax, l. Subdural Haemorrhage, m. Subarachnoid Haemorrhage, n. Acute Apendicitis) and a 'CAUTION' sign that says 'PREGNANT WOMEN SHOULD NOT ENTER'.

Introduction, Global Policy and Recommendation & Product landscape

AI-powered computer aided detection (CAD) software provides new opportunities and challenges in public health

Chest-X-ray (CXR) is an important tool for screening and may contribute to finding the missing millions

- CXR is sensitive tool for screening for active TB
- CXR can pick up asymptomatic patients with TB
- CXR can improve efficiency of Xpert MTB/RIF use

Use and access to CXR is hampered by

- Sufficient trained radiologists
- Intra- & inter-reader variability

CAD systems have potential as a screening or triaging tool for TB

- Automatically 'read' CXR
- Generate a standardized interpretation of CXR in the form of a heatmap/bouncing box combined with an abnormality score



What is CAD?

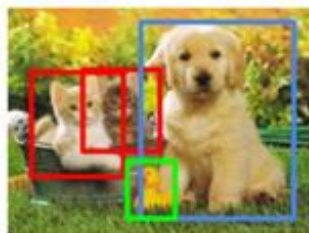
- CAD uses a type of **artificial intelligence** (AI) known as machine learning to read chest x-rays and identify signs of TB.
- The technology behind current CAD is **neural networks**. These take inspiration from the human brain to allow machines to learn to perform specific tasks. The **deeper** the network, the more complex the task it can perform.
- In medical imaging they are particularly used for **classification**, **detection**, and **segmentation** of images
- Stop TB's TB REACH has supported pilot and roll out projects since 2013 in Bangladesh, India, Pakistan, Zambia, Nepal, Cameroon, Philippines, Cambodia, Vietnam, Myanmar, Peru, Afghanistan

Classification



CAT

Object Detection



CAT, DOG, DUCK

Instance Segmentation




CAT, DOG, DUCK

Most commercial CAD products can perform **classification** (whether TB-related abnormalities are present or absent) and **detection** (providing a heatmap indicating the location of abnormalities).

What CAD products exist on the market?

A recent landscape report identified **28 CAD** developers and **12 TB-specific** products already on the market. At least **7 with CE-marks**.


A useful online resource: www.ai4hlth.org, developed by Stop TB and FIND.



Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Tuberculosis

journal homepage: <http://www.elsevier.com/locate/tube>



A new resource on artificial intelligence powered computer automated detection software products for tuberculosis programmes and implementers



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Welcome to the [Stop TB Partnership](#) and [FIND](#) resource center on computer-aided detection products for the diagnosis of tuberculosis

In recent years, the tuberculosis (TB) field has welcomed several computer-aided detection (CAD) products that provide an automated and standardized interpretation of digital chest X-rays based on artificial intelligence. This resource centre from the Stop TB Partnership and the Foundation for Innovative New Diagnostics (FIND) provides implementation-relevant information for a number of CAD products to assist country decision-making. Learn more about the features of available and upcoming CAD products for TB in the Products section below. [Read more >](#)

AI Products for TB Compare Products

<p>ARTELUS</p> <p>TXnet</p> <p>Certification: Pending Development Stage: Validation Intended Age Group: 18+ years</p>	<p>DEEPTeK</p> <p>DxTB</p> <p>Certification: Pending (expected Q2 2021) Development Stage: On the market Intended Age Group: 14+ years</p>	<p>DELFT IMAGING</p> <p>CAD4TB</p> <p>Certification: CE-marked Development Stage: On the market Intended Age Group: 4+ years</p>	<p>Dr CADx</p> <p>Dr CADx</p> <p>Certification: Pending (expected in 2021) Development Stage: Validation Intended Age Group: 16+ years</p>
<p>EPCON epidemic control systems</p> <p>XrayAME</p> <p>Certification: Pending (expected Q1 2021) Development Stage: On the market Intended Age Group: 18+ years</p>	<p>inferVISION</p> <p>InferRead DR Chest</p> <p>Certification: CE-marked Development Stage: On the market Intended Age Group: 16+ years (approved), 12-18 years</p>	<p>九峰医疗 JF HEALTHCARE</p> <p>JF CXR-1</p> <p>Certification: Pending (China NMPA-tier 3 expected in mid-2020) Development Stage: On the market Intended Age Group: 15+ years</p>	<p>Lunit</p> <p>INSIGHT CXR</p> <p>Certification: CE-marked Development Stage: On the market Intended Age Group: 14+ years</p>
<p>quire.ai</p> <p>qXR</p> <p>Certification: CE-marked Development Stage: On the market</p>	<p>RadiSen</p> <p>AXIR</p> <p>Certification: Pending Development Stage: Validation</p>		

Common product characteristics

Suitable population

- Almost all products are only certified for use in adult or young adolescent populations.

Input

- All products read either antero-posterior or postero-anterior CXRs.
- Most products have flexibility with regard to file input type, parsing a combination of DICOM, PNG and JPEG, usually all three.

Output

- Output varies slightly between products, but always includes a classification (TB-abnormalities present or no TB-abnormalities present) and a numerical abnormality score, as well as a heatmap or a similar format.
- Products also provide abnormality scores for a number of recognized abnormalities.
- Outputs are commonly presented in a structured 'radiologist-style' report.

Integrations

- Most products can integrate with X-ray platforms of any brand or model, but some may require validation with the equipment.
- Most products can integrate with health facility picture archiving and communications systems (PACS) and radiological information system (RIS) and radiological information system (RIS).

Deployment

- All products are designed for online deployment.
- Offline products are increasingly common.

Additional features

1. **Generating results in standard radiology report formats**
2. **Providing real-time data dashboards**
3. **Ability to digitize analog CXRs:**
4. **Ability to detect an expanded range of diseases and abnormalities:**

However, there is a lack of independent evaluation data on the performance of CAD for differential diagnosis and how accurately it localizes abnormalities.

Global Policy

In March 2021, the World Health Organization (WHO) recommended the use of CAD for the **first time**.

10. Among individuals aged 15 years and older in populations in which TB screening is recommended, computer-aided detection software programmes may be used in place of human readers for interpreting digital chest X-rays for screening and triage for TB disease (new recommendation: conditional recommendation, low certainty of evidence).

From WHO Consolidated Guidelines on Tuberculosis Screening

The WHO recommends CAD to **replace** human in two broad situations:



Screening: CAD can be a valuable tool for screening asymptomatic individuals without significant risk factors (e.g., active case finding).



Triage: CAD can be useful in identifying TB in individuals with TB symptoms, risk markers, or other positive test results (e.g., in healthcare facilities).

CAD can also work **with** humans :

- Helping radiologists to optimize their workflow
- Alerting human readers to abnormal images requiring prioritization
- Providing reporting assistance
- Providing quality control
- Performing pre-reading assistance

There is insufficient evidence to support the use of CAD with CXR alone for TB diagnosis

Introducing Ultraportable Digital X-ray Systems



Ultra-portable Digital X-ray (DXR)

Advances in X-ray technology have produced DXR devices that are more suitable for use in peripheral field settings.

Devices are:

- ✓ Lightweight
- ✓ Carried in a case or handheld
- ✓ Emit less radiation
- ✓ Product high quality images
- ✓ Battery powered



When combined with CAD software, this means radiological assessments can now be conducted in remote areas cut off from vehicle access.

Core component and accessories of a ultraportable X-ray system

Core system consists of an X-ray generator, X-ray detector, and a console laptop, and accompanying software package.

Supporting frames: for both the generator and detector

- Generator frame allows for operation at a distance using a hand switch.
- Detector frame helps stabilize detector, prevent breakage from fall

Replacement detector battery and charger

Solar panel and power bank to recharge all electrical components in remote screening situations is provided.

Suitcase or transportation bag

Ongoing work

WHO is working with IAEA on updating the technical specifications of this new class of x-ray systems

Selected ultraportable x-ray systems and CAD products will be soon available in GDF catalogue for procurement