Experiences with CAD-assisted TB screening using ultraportable X-ray devices in Viet Nam

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CAD & X-ray History at FIT

- Community-based CXR screening at FIT began in 2017-Q4 in Ho Chi Minh City

- 239,020 people screened by CXR over 850 days across nine provinces to date
    - Primarily using rented X-ray trucks
    - Three Fujifilm CALNEO Xair devices procured in 2021

- Four different CAD software have live deployments (qXR, CAD4TB, Genki & DrAid)
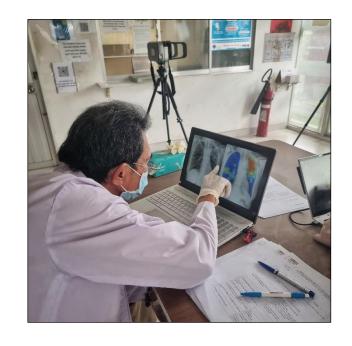   - Experience evaluating 18 different CAD software

Program Planning

- FIT has received Xair and CAD funding from:
    - Stop TB/TB REACH
    - USAID/LON
    - CRDF Global, with support from US CDC
    - Embassy of Japan in Viet Nam

- Fujifilm Xair chosen because the device is locally registered; no need for special import permits from MOH

- CAD software procured after a FIT landscape assessment; based on performance
    - Independent evaluation of 12 artificial intelligence solutions for the detection of tuberculosis (DOI: 10.1038/s41598-021-03265-0)

Screening Algorithm

- FIT always has a radiologist present at all screening events

- CAD software integration:
  - **Normal triage** – CAD software removes all images which are 100% normal/clear, leaving a small subset for the human reader; OR to be presented at 2022 Union
  - **CAD-assisted reading** – Radiologist see CAD results and sputum collected for any abnormal; live deployment using qXR and DrAid

Radiologist	CXR Abnormal		CXR Normal	
CAD Software	CXR Abnormal	CXR Normal	CXR Abnormal	CXR Normal
	↓	↓	↓	↓
	Sputum Test	Sputum Test	Sputum Test	No Sputum Test

CAD Threshold Selection

- Currently using default software settings (qXR ≥ 0.5 and DrAid ≥ 0.5)
  - CAD4TB and DeepTek deployments are only used for operational research studies

- Continuous monitoring of data to assess optimal threshold
  - Currently no people with TB in CAD normal, radiologist abnormal cohort
  - There is sufficient diagnostic capacity to handle extra specimens and these thresholds seem to be working well for our programs

Operational Set Up

- **Locations**: Commune Health Stations, government offices, schools, pagodas, etc

- **Radiation Protection**: Lead vests and distancing

- **CAD Software**:
  - Online qXR and DrAid deployments; CAD4TB & Genki processed in the FIT office
  - Requires a separate laptop because you cannot modify Xair laptop

Xair Image Quality

- FIT conducted an independent assessment of Xair (DOI: 10.3390/tropicalmed6030163)
  - Mean image quality rating for Xair was significantly lower than the reference radiography system (3.71 vs. 3.99, p < 0.001)
  - No significant differences in CAD scores (p = 0.571)
  - No significant differences between TB care cascade during an ACF campaign

Data Systems

- Project data are stored in the ACIS mHealth system
  - Demographic, symptom, CXR, Xpert (& other sputum tests) and treatment linkage
  - ACIS is bi-directionally linked to VITIMES, the electronic TB notification system
  - Accessed via an Android or iOS app and a website
- CAD software bulk uploads into ACIS

Data Storage and Privacy

- **CXR DICOM Files**: Archived on hard drives in the FIT office for permanent storage

- **CAD Data**:
  - FIT does not use CAD software platforms for data management
  - No image de-identification before CAD processing
  - CAD score data are exported, cleaned and merged with ACIS data
  - ACIS offers role-based access to data for individual users

TB Screening in Ethnic Minorities

Funded by the Embassy of Japan in Viet Nam and CRDF Global, with support from US CDC

- Over 20,000 people screened by Xair in extremely remote districts/provinces
  - X-ray trucks could not travel to these sites
  - Over 160 people detected and treated for TB – 4.6x national incidence rate

- CAD software inconsistently used because remote setting; challenges with training and 4G connections

CAD-Assisted Contact Investigation

Funded by the USAID Erase TB Activity

- Xair and CAD software being used to screen contacts for TB in Ha Noi and Ho Chi Minh City; overcoming access barriers at higher-level facilities

- **CAD software**: Systematically used as reading tool by radiologist

- **Initial Findings**: There have been zero missed people with TB, but a substantial opportunity to reduce 'over reading' by radiologist

- **Evaluation plans**: Mixed methods evaluation assessing yields, turn-around-time, reliability and health worker and policy maker perceptions about scalability

Xair Screening During COVID-19 Vaccinations

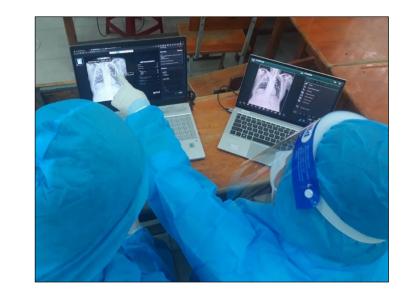*Funded by the USAID Erase TB Activity*

- During the acute COVID-19 lockdown in 2021, TB notifications declined by -80% as health staff were reassigned to pandemic control tasks

- FIT pushed to integrate TB screening during the COVID-19 vaccination campaign; the only legal mass gathering of people at the time

- Over 40,000 people screened by CXR, only possibly thanks to flexibility provided by Xair

- Detection rate 2.5x higher than national incidence rate, despite being "general population" screening

- 60% of people with TB detected did not have a cough and would've been missed or had a delayed diagnosis

- Detailed results to be presented at the 2022 Union conference

CAD at a PPM Facility

Funded by the Stop TB Partnership's TB REACH initiative

- FIT installed a qBox in a private multi-clinic that is part of a Global Fund PPM project

- It was very difficult to install (e.g. third part PACS, data privacy, etc), and even harder to get the clinic to use the qXR score to collect sputum

- After much persistence… the qXR software has now detected more TB in the clinic than the radiology staff (57.1% of all TB detected due to CAD software)
  - Radiologist interpretations at this site are too specific, resulting in missed opportunities to diagnose TB

- **Evaluation plans**: CAD vs radiologist yield assessment and a comparison of historical detection rates vs CAD-assisted detection rates

Scale Up

- Xair has provided our teams with a lot of implementation flexibility and cost savings that we did not have when renting X-ray trucks

- Community screening events require a lot of pre-event planning and mobilization and a real funding source

- Looking towards TB and NCD integrated service delivery, particularly for malignant nodule (lung cancer) detection, and more campaigns in remote areas

Experience with Vendors

- Fujifilm and Qure.ai have been excellent partners for live screening
    - Fujifilm has a team in country who have provided us with replacement and loaned machines to meet capacity needs and support for CAD software integration
    - Qure.ai is extremely responsive and has always been available for system installations/configurations and troubleshooting

- Other CAD vendors:
    - DrAid is a Vietnamese product and not yet fully commercially available
    - CAD4TB has been flexible with our license durations during the COVID-19 pandemic, allowing them to be extended
    - DeepTek has been excellent with troubleshooting and support for evaluations

Xair Learnings

- Xair emitter battery not as strong as manufacturer claims (42 vs reported 100 images)

- Early models require the X-ray emitter to be turned off in order to charge; issue fixed with later models

- X-ray plate can be used for 200-250 images before requiring a charge; often charged during lunch or extended breaks

- The tripods which came with the Xair device were not very strong or sturdy; FIT purchased new tripods to better cope with outdoor screening sites

- The box the Xair comes in weighs ~30Kgs total and cannot be transported very easily on a motorbike

CAD Implementation Learnings (1/2)

- Low sputum collection rates for Radiologist normal, CAD abnormal participants; radiologists unwilling to accept discordant abnormal CAD result

- Radiologists change their CXR results based on CAD outputs, making documentation of CAD software utility difficult in evaluation studies

- CAD software tends to be slower than the human reader, creating backlog of participants that must be managed carefully

- CAD software deployment requires on-demand IT support to ensure smooth implementation

CAD Implementation Learnings (2/2)

- CAD software not always able to distinguish foreign objects inside the lung field (e.g. pacemaker, buttons, zippers, etc.), which can be difficult to avoid in context of high-volume, community-based TB screening

- CAD software platform currently only available in English; some CAD outputs are coded into the CXR image file so you cannot use Google translate

Questions?