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

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<thead>
<tr>
<th>Radiologist CAD Software</th>
<th>CXR Abnormal</th>
<th>CXR Normal</th>
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</thead>
<tbody>
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<td>CXR Abnormal</td>
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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
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?