USAID Support to End Tuberculosis

CAD-AI to improve TB case detection in Vietnam
Background

- Project: USAID Support to End TB in Vietnam, implemented by FHI 360 from August 2020-July 2025

- # of UP-XRs and CAD devices used in Vietnam
  - UP-XRs: 10 UP-XR machines, donated through iNTP (with technical assistance from USAID IDDS project)
  - CAD devices procured by USAID Support to End TB:
    - Qure.ai’s qXR software and hardware
    - A total of 9 qBoxes deployed in 2022: 5 qBoxes in 5 District health facilities; 4 qboxes in NTP/GF mobile CXR vans for community campaigns.
Program planning

• Stakeholder engagement: NTP approval to pilot the technology
• Customs clearance approval:
  • 1st procurement:
    • qBoxes were already available in Vietnam at time of purchase
    • 2nd procurement required importation of four new qBoxes, which was handled by Qure.ai
  • Customs clearance was handled by Qure.ai: qBoxes are considered routine CPU/IT computer equipment.
Program planning: Site and population selection

- **7 provinces under USAID Support to End TB** selected for TB burden (~20% of Vietnam’s notified TB cases) and representation of 3 regions of the country
- **Community campaigns**: household contacts and other populations known to be at high risk for TB (smokers, diabetics, elderly, underlying lung disease, PLHIV)
- **Health facilities**:  
  - Facility selection: 5 facilities selected among 35 with digital Xray in 7 provinces  
    - Selected districts had highest number of CXR/month and high commitment from facilities’ leadership and healthcare workers  
  - Patient selection:  
    - Respiratory outpatients; diabetic outpatients; inpatients with lung disease/symptoms  
    - For CAD implementation: expanded to all patients with CXR (with and without respiratory symptoms or diseases)
Program planning: deployment and training

- On site deployment
  - Coordinated with Qure.ai team for remote, online technical support
  - Key personnel from NTP and FHI 360 were onsite for deployment in mobile CXR vans to connect radiology PACS system and qBoxes

- Training overview:
  - **TB screening** (“Double X” algorithm) standard operating procedure integrated CAD into workflow
  - **On-site training** to transfer DICOM files from radiology PACS system to qBox
  - **qXR TB user guide**: written by Qure.ai and translated into Vietnamese
  - **Troubleshooting guide**: “frequently asked questions” document developed by FHI 360, identifying issues that have arisen throughout implementation
Program planning - vendor selection and product costs

- CAD vendor options were limited to Asia region to comply with USAID requirements for procurement.
  - Products were not limited to GDF procurement as the purchase was through the USAID funded project and not by the NTP/GF.

- The procurement included
  - One-time deployment
  - License activation and license fee for CXR interpretation, with license validity for 6 months (and recently extended to 8 months for remaining 50,000 CXR)

Only one system was procured to date by USAID Support to End TB, and no additional items were procured locally.
Programmatic implementation with CAD devices

• Stage 1: retrospective qBox analysis of CXR from TB community ACF campaigns conducted in 2020

• Stage 2: Real-time qBox analysis of CXR (2021-2022)
  • ACF: campaign implementation started in 2021 and continued in 2022
  • ICF in health facilities: qBoxes deployed in 5 health facilities in 2022

For both community and facility implementation, on-site radiologists have access to information about symptoms and history.
Screening algorithm

- **Threshold scores and models:**
  - 0.40: AI first, followed by a human reader
  - 0.60: AI and human readers in parallel

- **Confirmatory diagnostic tests: Xpert**
  - <10% of CXR triaged for Xpert testing by symptoms
  - Sputum produced on site and either analyzed onsite (if Xpert available) or transported by motorbike to facility with Xpert

- **QC/QA for CAD:** comparison with central/national level radiologists and bacteriologic confirmation

---

**CAD first model**

1. **CXR**
2. **CAD**
   - **CXR abnormal for TB**
     - **Provincial radiologist**
       - **CXR abnormal for TB**
         - **GeneXpert**
           - **Xpert MTB+**
             - **TB diagnosis**

**CAD parallel model**

1. **CXR**
2. **CAD**
   - **CXR not TB**
   - **Provincial radiologist**
     - **CXR abnormal for TB**
       - **GeneXpert**
         - **Xpert MTB+**
           - **TB diagnosis**

---

Two primary objectives for AI/DL interpretation of CXR for TB
- Maximize TB detection
- Minimize unnecessary GeneXpert testing
Threshold score selection

• Threshold scores and selection
  • Initial CAD retrospective analysis score = 0.50, pre-set from manufacturer
  • Threshold score for real-time analysis:
    • 2021: planned for two scores (0.40 CAD first and 0.60 CAD parallel)
    • 2022: utilized one score (0.40, CAD first)
  • Main variables for selecting the threshold score
    • Xpert capacity, Xpert cartridge availability
    • Target Xpert positivity rate

• Threshold score performance
  • False negatives on CAD are difficult to ascertain as we are not Xpert testing below the radiology threshold (CAD or human)
  • False positives on CAD: currently using radiologists to “re-read” abnormal CXR, to improve specificity of CAD interpretation.

• What future plans are there for the localization of the threshold? Pending discussions with NTP.
Using CAD-AI software to optimize CXR interpretation for triaging Xpert testing in 7 provinces of Vietnam

- Objective: to develop CAD-AI analysis programmatic framework that will facilitate
  - Selecting AI threshold score and model: pragmatic and adaptable for different provinces and settings (communities, facilities, UP CXR)
  - Interpreting AI results post-implementation for optimal TB case detection yield and to improve quality of CXR interpretation by human physicians
The background CXR abnormality as measured by median/IQR qXR score and % CXR abnormality by humans: some provinces are “mis-matched” on CXR abnormality and Xpert positivity.

### Campaign Xpert Positivity (%)

- An Giang: 13.90%
- Can Tho: 13.20%
- Dong Nai: 6%
- Nghe An: 5%
- Tay Ninh: 6.60%
- Thai Binh: 7.60%
- Tien Giang: 4.30%
- Total: 8.60%

### Provincial Abnormal CXR (%)

- An Giang: 12.10%
- Can Tho: 23.10%
- Dong Nai: 16.80%
- Nghe An: 6.60%
- Tay Ninh: 23.90%
- Thai Binh: 6.60%
- Tien Giang: 27.70%
- Total: 14.40%

### Median qXR Score

- An Giang: 0.03
- Can Tho: 0.05
- Dong Nai: 0.04
- Nghe An: 0.03
- Tay Ninh: 0.12
- Thai Binh: 0.06
- Tien Giang: 0.05
- Total: 0.05

---

2020: retrospective CAD, qXR score 0.50
2021: real-time CAD/AI with multiple models (CAD 1st and parallel) and scores

ACF 2021 (n=17,090 CXR, n=3740 Xpert tests)

2022: real-time CAD/AI with one model (CAD 1st) and score (0.40)

ACF 2022 (n=28,112 CXR, n=4302 Xpert tests)
Observations from 3 years of ACF implementation with CAD-AI

• How does CAD-AI optimize Xpert positivity? *By improving precision around a “target” PPV?*
  • Variance in Xpert positivity rate appears higher in campaign without CAD (2020) and with variable CAD application (2021), and lower with one CAD model and score (2022)

• Several demographic/clinical characteristics likely affect Xpert positivity yield, independent of AI score triaging Xpert testing:
  • e.g., % old TB, % smoker, % male, % cough or with any symptom

• Without Xpert testing below the CXR threshold (CAD or human), it is only possible to *estimate* sensitivity and Xpert positivity rate
  • Sample below CAD threshold at start of implementation?
  • Target CXR abnormality rate rather than Xpert positivity rate?
Operational set-up

- **Location:**
  - Community screening: mobile CXR vans either at commune health posts or district health centers
  - Health facilities: qBox on radiology computer

- **Radiation protection methods used/ required**
  - Radiation protection: CXR machine is enclosed in a separate partition within the mobile van
  - Radiologist and radiology tech stand/sit behind the protective partition, separated from CXR machine.

- **Set-up:**
  - Connecting the qBox with the laptop via secure router
  - After CXR is completed, DICOM file automatically transferred to qBox. Within 1-2 minutes, CAD results are read on qXR portal.
Equipment for setting up qBox with PACS system

- qBox hardware
- External monitor connected to qbox via HDMI/Thunderbolt
- Keyboard and mouse connected via USB 3.0 port
- Secure router:
  - Connect qBox & PACS system with static IP;
  - Connect to internet for online technical support for deployment and troubleshooting
- LJ45 Lan Wires: To transfer DICOMs to qBox from client system which has PACS software
Equipment set-up and system in use
Interoperability with health information systems

Routine TB surveillance in Vietnam is managed through NTP’s VITIMES system: DS-TB, DR-TB, and LTBI

- **CAD and ACF** data are entered into an online platform (ACIS) which is bidirectionally linked with VITIMES
- **Health facility ICF/CAD**: CXR results are manually entered into HIS in each facility, which are then extracted by VITIMES
Data storage and privacy

- **CAD data storage and back-up:**
  - Data are downloaded onto a password protected external hard drive and then uploaded onto a secure password-protected server

- **Data privacy measures**
  - qBoxes are offline
  - Mobile CXR vans: all CXR are deidentified
  - Facility CXR: image sent to CAD software is de-identified
Scaling up: NTP Vietnam plans to expand CAD nationally

- Scale-up will include:
  - Both community and facility CAD implementation and expansion to additional provinces
  - Ultra-Portal CAD AI for targeted ACF campaigns

- Preparation
  - Develop national guideline and SOP: for both community and facility implementation
  - Selection of CAD software, CAD model, and threshold score:
    - Balance between sensitivity and specificity may be more critical with national scale-up (will need cost effectiveness analyses)
    - Score selection: will continue to refine methods for analysis framework; piloting Iterative Threshold Score Calibration
Challenges

• **Total processing time is slow**: 1.5-2 minutes is very slow for busy community campaigns. Radiologists in health facilities have not complained about this (yet).
• **qXR connectivity starts very slowly** in the beginning of the day in mobile CXR van.
  • Despite connections confirmed (ping, qXR login), the first image of the day may take 15-25 minutes.
• **Intermittent lost connectivity** from PACS system to qBox: requires radiologists to reset the system, which delays processing
• **Different time zone** with CAD provider: this is critical for on-line, real-time support
What would you do differently next time?

• Prepare for technical needs during set-up and ongoing troubleshooting; tech team from manufacturer must be available for real-time support

• Consider cloud CAD as opposed to offline qBox
  • qBox and PACS system currently both connect using the cables to the same router
  • With CAD cloud, we may face new type of delay due to internet connectivity, especially when the van door is closed