AI TB Screening Tool: Development of a novel, easy-to-use digital tuberculosis screening tool informed by machine learning approaches

Project type

☐ interdisciplinary pilot project ☒ cross-sector project ☐ global health postdoc fellowship

Research areas involved (check all that apply)

☒ Biomedical sciences ☒ Public health
☐ Social sciences and humanities ☐ Engineering and other sciences

Project duration

June 2022 – May 2024

Project team[1]

Name	Organization	Discipline(s)
Claudia Denkinger	Heidelberg University	TB diagnostics development & evaluation
Lena MaierHein	DKFZ	Machine learning
Alexandra Zimmer	Heidelberg University	TB diagnostics, data management, data analysis
Lisa Koeppel	Heidelberg University	Data management, data analysis
Seda Yerlikaya	Heidelberg University	Project management
Henry Loharja	Heidelberg University	Data analysis, AI
Eva Christodoulou	Heidelberg University	Machine learning
Maria del Mar Castro Noriega	Heidelberg University	Qualitative research, Implementation science
Monde Muyoyeta	Center for Infectious Disease Research in Zambia (CIDRZ)	TB diagnostics, TB case-finding strategies

[1] This list may differ from your original application and will appear in the report on our website. Please include all core team members, including (if applicable) international and/or cross-sector partners.

Minyoi Maimbolwa	Center for Infectious Disease Research in Zambia (CIDRZ)	TB diagnostics, TB case-finding strategies
Chris Isaacs	Connected Diagnostics	App development
Andrew Kerkhoff	University of California, San Francisco	TB diagnostics, evaluation, implementation science
Irwin Law	World Health Organization	Country prevalence surveys

Case study

Introduction: Tuberculosis (TB) remains the leading infectious cause of death globally. The WHO's current symptom screen lacks specificity, while other screening methods like chest X-rays are resource-intensive and inaccessible. To achieve SDG3, there's an urgent need for strategies that rapidly and accurately identify TB cases for prompt treatment initiation. Clinical risk scores and prediction models offer a promising approach to systematic TB screening. This project aimed to develop a risk score prediction algorithm and embed the algorithm within a user-friendly mobile app that combines clinical, demographic, and epidemiological data to generate individualized TB risk scores. The specific research objectives were:

> Objective 1. Develop and validate a predictive risk model for active TB disease using machine learning.
>
> Objective 2. Design a digital TB screening tool incorporating a machine learning-derived TB predictive risk model for use in resource-limited settings.
>
> Objective 3. Facilitate interoperability and integration of the digital TB screening tool into relevant information systems.

Project activities:

Objective 1: We compiled a large, geographically diverse dataset from prevalence surveys obtained through WHO and independent community-based studies. The harmonized dataset included individuals aged ≥15 years, totaling over 900,000 entries. Using this data, we developed and trained various algorithms, including machine learning and Bayesian methods, to predict individual TB risk.

Objective 2: We developed 'mTBScreen', a mobile app that will incorporate the TB risk algorithm from Objective 1, in partnership with Connected Diagnostics. To evaluate its usability and acceptability, healthcare providers in Zambia tested data entry with the app using clinical patient vignettes. Their feedback was collected through interviews and used to refine the app's user interface.

Objective 3: Connected Diagnostics mapped electronic TB tools and databases in High Burden TB countries, ranking their API capabilities. This informed potential data flow between the

mTBScreen app and TB databases. Additionally, regulatory needs for the mTBScreen app were explored.

Findings:

Objective 1: A preliminary algorithm was developed using machine learning. Validation of the algorithm has only been performed using the secondary prevalence survey data, achieving a balanced accuracy of approximately 60%. Further training and validation are underway.

Objective 2: A proof-of-concept mTBScreen app was developed (Figure 1), incorporating demographic, clinical, and epidemiological inputs for the TB risk algorithm. A usability study with 30 Zambian health workers found the app acceptable and comparable to routine screening procedures. Users expressed motivation to transition from paper-based to digital solutions. Usability varied among different user types, with community health workers taking longer to enter data than clinical officers and nurses.

Objective 3: The TB database mapping revealed potential for streamlined operations through data integration, but highlighted challenges due to varying API capabilities across systems. This emphasizes the need for careful planning and customized integration design to ensure seamless interoperability. mTBScreen requirements and architecture documentation was created, including exploration of ISO IEC 62304 Medical Device Data Systems compliance.

Lessons learnt:

Working with prevalence survey data presents significant challenges. While these large datasets appropriately target community-based populations in high TB burden settings, the data quality varies considerably between surveys. This variability creates downstream difficulties when developing models using harmonized datasets, particularly due to inconsistencies in variables across individual datasets. Regarding the mTBScreen app development, early engagement with end users proved crucial. Obtaining feedback on usability and acceptability not only provided insights into potential downstream uptake but also guided the refinement of the user interface. This iterative process was instrumental in creating a user-friendly product that meets the needs of healthcare providers in the field.

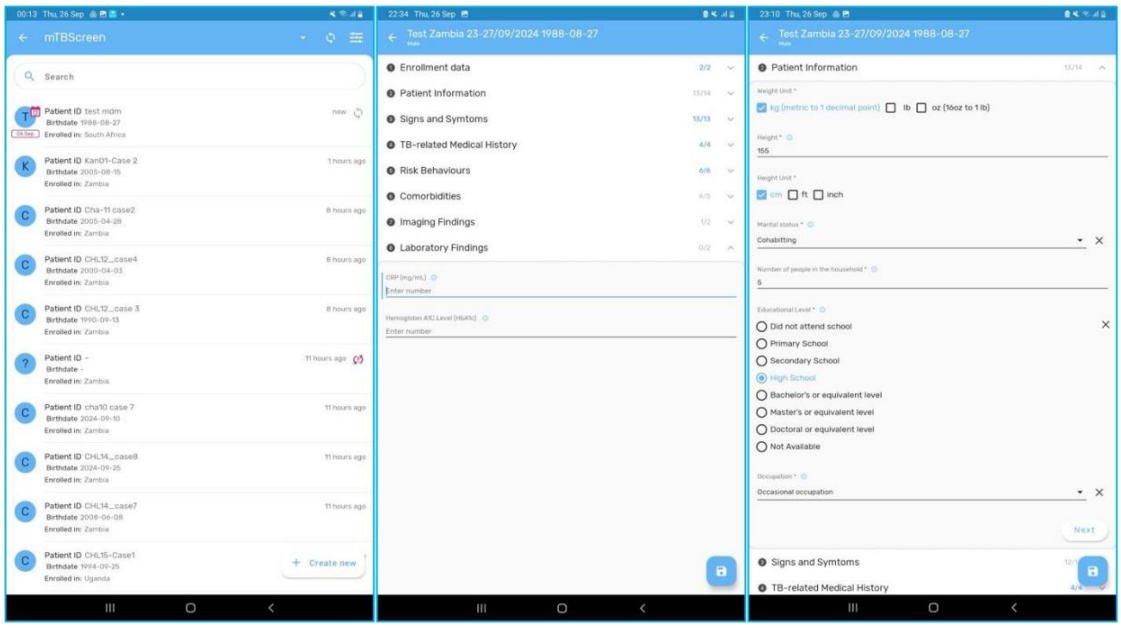

Figure 1. User interface pages of the mTBScreen mobile application. All information presented belongs to generated clinical vignettes and is not from a real patient. Left) Overview of different patient profiles that have been entered into the app. Middle) Overview of the different fields used for data entry. Right) Example of data entry for a clinical vignette.

Contact

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Funding

AI-TB Screening tool is supported by the German Alliance for Global Health Research with funds from the German Federal Ministry of Education and Research (BMBF) and the German Federal Ministry for Economic Cooperation and Development (BMZ).

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Federal Ministry for Economic Cooperation and Development

Last updated: 18/02/2025
File name: Dokument4