Machine Learning-Based Prediction of Active Tuberculosis in People with HIV using Clinical Data

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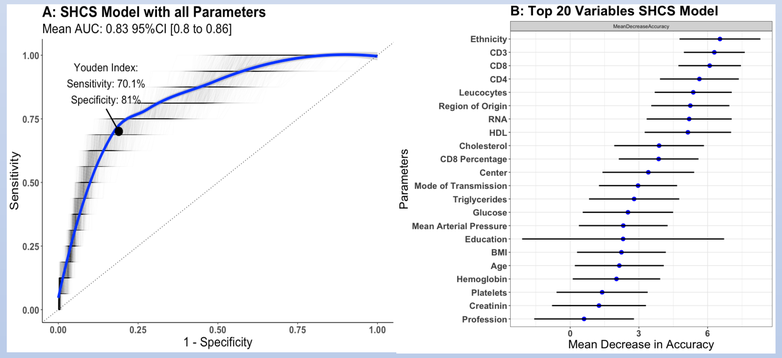
BACKGROUND

- **Coinfections** of Mycobacterium tuberculosis (**MTB**) and human immunodeficiency virus (**HIV**) impose a substantial **global health burden.**
- Patients with HIV infection face **a heightened risk of progression** to active TB
- Current testing methods often **fail to identify individuals who** subsequently **develop active TB**

METHODS

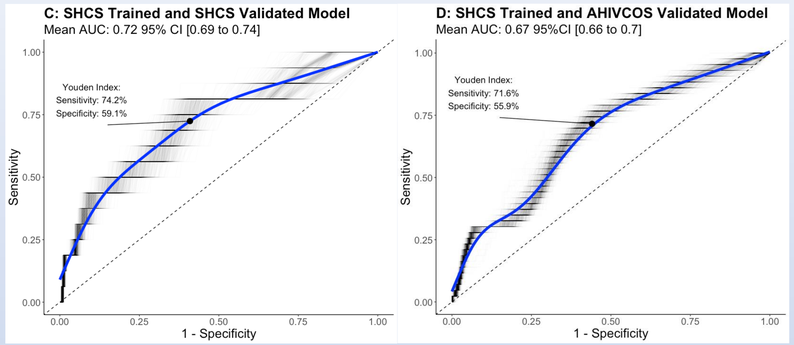
- **Study Population** was selected in the Swiss HIV Cohort Study (**SHCS**).
- **55 PWH** who developed **active TB** six months post-enrollment and **1432** matched **controls** without active TB enrolled between 2000 – 2023.
- **External validation** utilized data from the Austrian HIV Cohort Study (**AHIVCOS**), comprising **43 incident TB cases and 1005 controls**.
- We **developed random forest models** to predict active TB progression
- We assed **model performance** through:
  - **ROC-Curves** with their AUC and the **optimal point** (Youden-Index)
  - **Number Needed to Diagnose**
  - **AUPRC** which analysis the positive predictive power of the model.

RESULTS

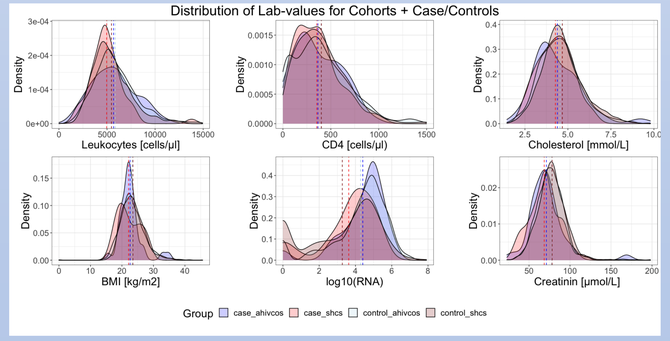


- **Random forest model** utilizing all eligible SHCS parameters (43 predictors), to predict the occurrence of **incident active TB**
- The mean AUC for the ROC curve of was **0.83 [95% CI 0.8 to 0.86].** (A)
- Variable Importance Analysis revealed that **Demographic parameters, immune status** as well as **overall health** were important for predicting our outcome (B)

Algorithm with the Potential to identify People with HIV at high risk of active TB in low transmission settings, surpassing the current clinical standard, without requiring additional laboratory testing



- **External Validation** with the AHIVCOS Data
- Reapplying the model to SHCS data using the **Top 20 variables** and validating on either SHCS or AHIVCOS data.
- SHCS validation **AUC** of **0.72 CI [0.69 to 0.74]** (C) and for AHIVCOS of **0.67 CI [0.66 to 0.70]** (D



For the **externally validated** score, we observed significant influences on predicting future active incident TB, such as:

- **immune system parameters**
- General well-being: such as **BMI** or **creatinine levels** (E).

STUDY AIM

Create a **prognostic score** for predicting the occurrence of **incident active tuberculosis (TB) in people living with HIV**

CONCLUSIONS

- Potential to **diagnose People with HIV at high risk of active TB** in low transmission settings, surpassing the current clinical standard
- Does **not** require any additional laboratory tests
- Holds promise as a **highly effective screening method**

	Training Data	Validation Data	Number Needed to Diagnose (NND)	Mean Area under the curve	Positive Predictive Value (PPV)
SHCS Total	SHCS with all parameters	SHCS with all parameters	1.96	0.83	10.3%
SHCS external	SHCS Top 20 predictors	SHCS Top 20 predictors	2.99	0.72	5.3%
AHIVCOS external	SHCS Top 20 predictors	AHIVCOS Top 20 predictors	3.64	0.67	4.9%
SHCS Time to TB under 4 years	SHCS cases with time to TB under 4 years with all parameters	SHCS with all parameters	1.70	0.85	14.4%
MTB-infection Test	Clinical standard (IGRA and TST combined)	Clinical standard	4.00		

Our model surpasses the current testing standard (IGRA and TST) with the **data** of the **SHCS for the IGRA and TST (NND 4.00).**

- **complete model (NND of 1.96**)
- **external validation (NND 2.99/ 3.64)**

ADDITIONAL INFORMATION

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SWISS HIV COHORT STUDY

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