Initial incremental cost-effectiveness of AI-driven CXR screening for tuberculosis among prisoners in Southern Thailand

Nyi Nyi Zayar[1], Kyaw Ko Ko Htet[1], Rassamee Chotipanvithayakul[1], Wiwatana Tanomkiat[2], Prapon Keawkong[3], Virasakdi Chongsuvivatwong[1]

[1] Department of Epidemiology, Faculty of Medicine, Prince of Songkla University, Thailand, [2] Radiological Society of Thailand, [3] Department of Radiology, Songkhla Hospital, Thailand

Background

- **Thailand** → one of the top leading countries in **Universal Health Coverage for tuberculosis (TB)**
- **Prisoners** → Major high-risk group of TB (2.7% prevalence in Southern Thailand)
- **TB Screening using mobile Chest X-rays (CXR)** in prisoners is interpreted by **Artificial intelligence (AI)**, and **Radiologists**, parallelly
- A **cost-effectiveness comparison** between AI-driven CXR and radiologists can highlight potential health and economic benefits

Objective

To evaluate the additional cost per additional disability-adjusted life years (DALYs) averted for TB case detection using AI-driven CXR compared to radiologists

Methodology

Study design - A model-based simulation

Study setting - Four prisons in Songkhla Province in Southern Thailand in year 2023

Study sample

Prisoners in four selected prisons	N = 15,000

Cost-effectiveness analysis

Cost estimation - calculated based on the standardized framework for cost evaluation on TB screening program

Human resource costs	Capital costs	Recurrent costs	Overhead costs
Monthly salaries of • Radiologist • CXR technician • Microbiologist • Health Assistant	• Mobile chest Xray • AI software • Gene Xpert machine	• Travel cost • Sputum collection • Gene Xpert cartridge	• Maintenance for quality control • Electricity charges

Effectiveness estimation – effectiveness is calculated based on per DALY averted, representing the reduction of one year of full health lost due to TB, which can be prevented through screening

DALY value per TB patient = 0.29 year (Source: WHO Global Health Estimates)

Table 1. Other parameters influences the effectiveness of TB screening

Parameters	Estimates, mean (range)	Sources
TB screening with CXR interpreted with AI		Qin ZZ et.al (2019), Khan FA et.al (2020), Nash M et.al (2020)
• Sensitivity	0.88 (0.71 to 0.97)	
• Specificity	0.79 (0.69 to 0.88)	
TB screening with CXR interpreted by radiologist		Qin ZZ et.al (2019)
• Sensitivity	0.89 (0.80 to 0.96)	
• Specificity	0.61 (0.48 to 0.74)	
Gene Xpert MTB/Rif		Reechaipichitkul W et.al (2017)
• Sensitivity	0.83 (0.73 to 0.92)	
• Specificity	0.90 (0.83 to 0.97)	

Outcome variable – Incremental cost-effectiveness ratio (ICER) of AI-driven CXR screening over CXR interpreted by radiologist using the following formula,

$$\frac{\text{Cost of screening using AI-driven CXR} - \text{Cost of screening by radiologist reading}}{\text{DALY identified by AI-driven CXR} - \text{DALY identified by radiologist reading}} = \text{ICER for AI-driven CXR screening}$$

Data analysis – The willingness to pay (WTP) threshold for cost per DALY averted by AI-driven CXR was taken as twice of value of GDP per capita in Thailand in 2023 (USD 7801.4 x 2 = USD 15602.8)

Sensitivity analysis - 10,000 iterations in Monte Carlo simulation to evaluate the variation of parameter values

Results

Cost and effectiveness comparison

**Table 2. Comparison of operational cost and DALYs averted between the AI-driven CXR and CXR interpreted by radiologist**

	CXR read by AI (N = 15,000)	CXR read by radiologist (N = 15,000)	Difference between two methods
Total operational costs*	79,379.4	184,277.0	-104,897.6
Total DALYs averted	86.2	87.2	-1.0
Costs* per DALY averted	920.9	2,113.3	-

* – cost in US dollar

Cost-effectiveness analysis

- AI-driven CXR had lower costs but fewer DALYs averted than radiologist-interpreted CXR
- ICER of AI-driven CXR was USD 104,897.6 per DALY averted, which reflects loss in extra unit of DALY averted by using AI-driven CXR could save USD 104,897.6

Figure 1. Cost-effectiveness plane showing ICER values of AI-driven CXR using Monte Carlo simulation
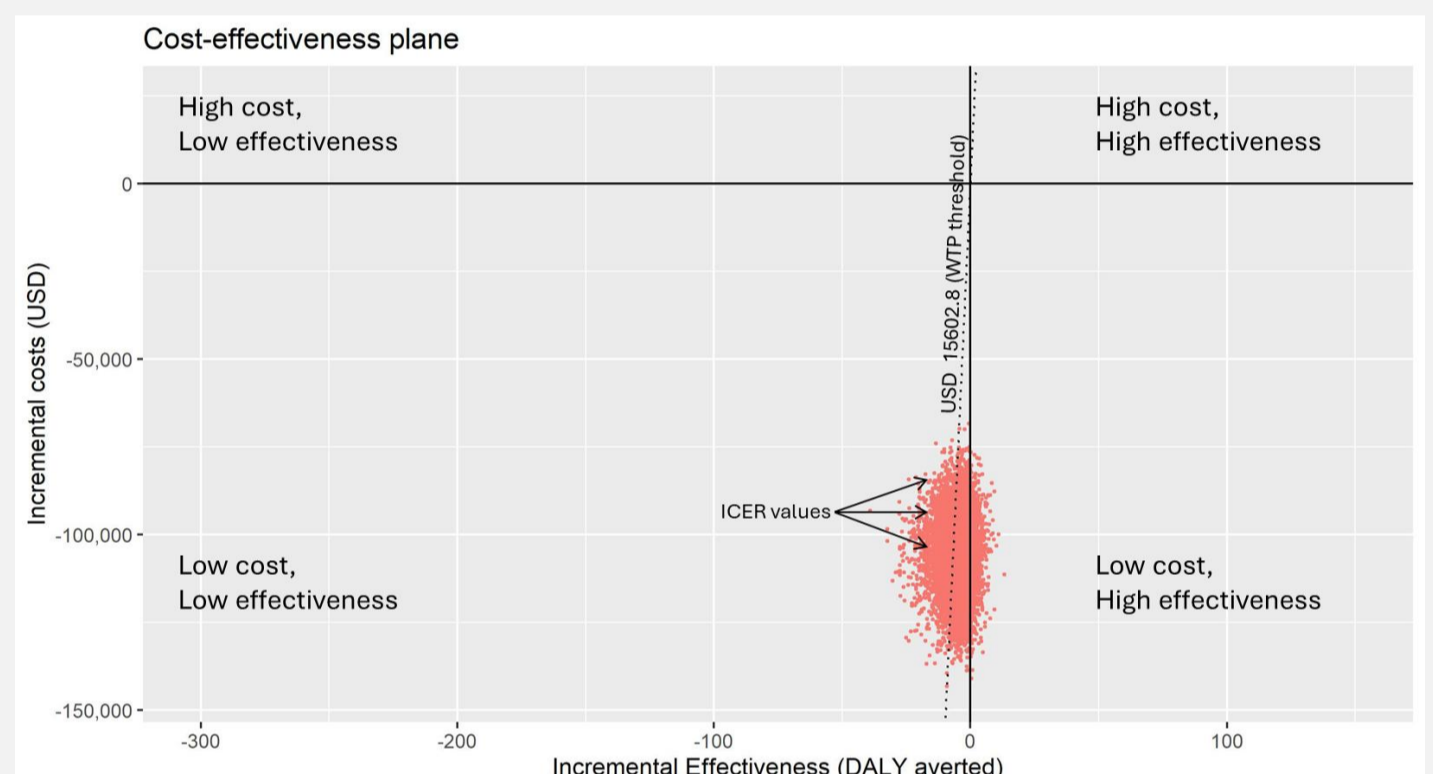
There is 49.2% probability that losing one DALY averted by AI-driven CXR could save the cost more than the WTP threshold value

Figure 2. One-way sensitivity analysis for changes in ICER value with different level of sensitivity of AI-driven CXR
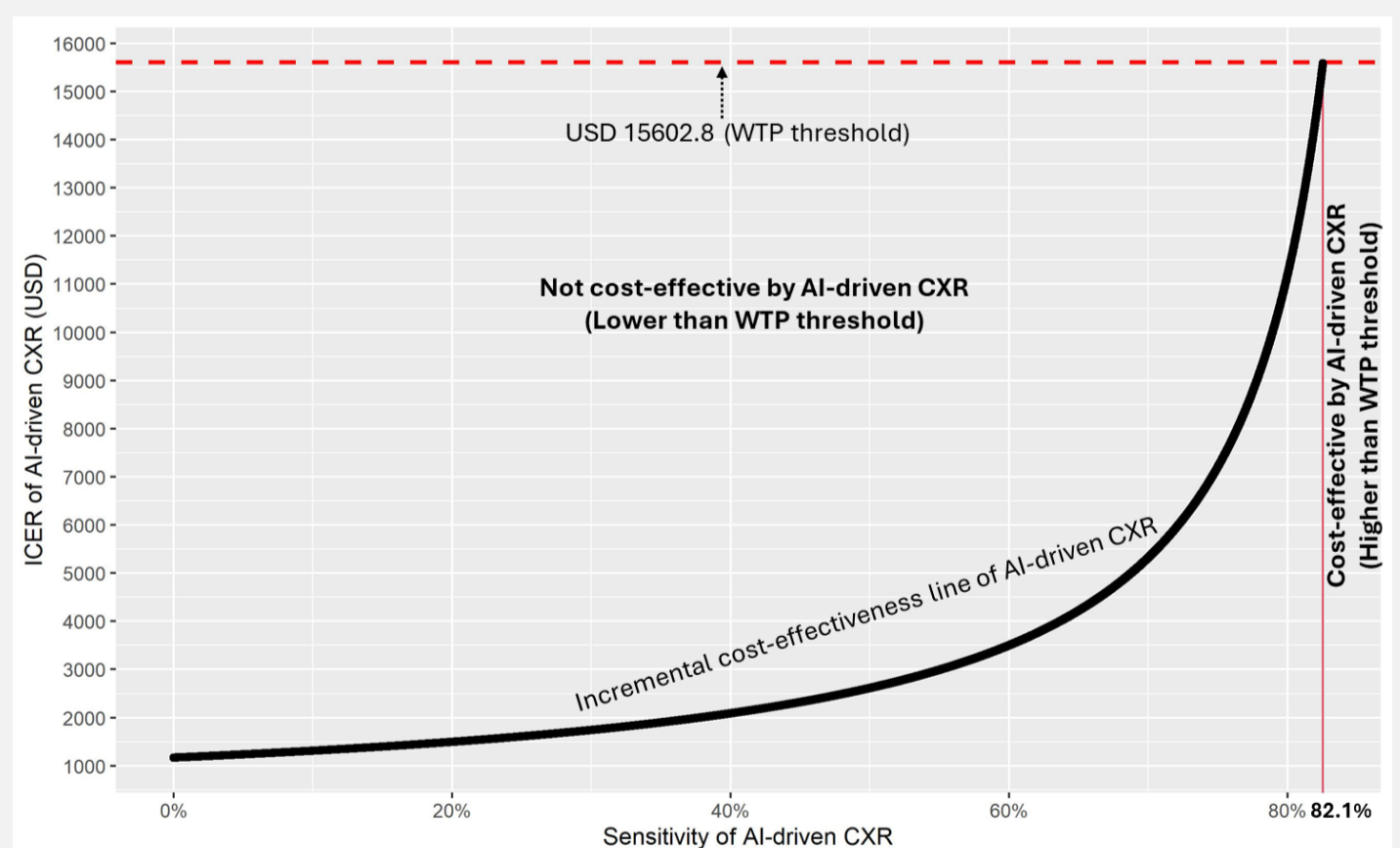
AI-driven CXR would save more than WTP threshold when the sensitivity of AI is more than 82.1% and specificity remains at the reference level

Conclusion

- AI-driven CXR screening saves costs, but lost DALY averted due to limited sensitivity compared to radiologist interpretation
- The loss from this initial estimation would be increased if transmission from false negative cases had been considered

Recommendation

- TB screening program using CXR among prisoners requires AI with sensitivity superior to that of radiologists to achieve extra effectiveness