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Session: Hospital Without Borders — Transforming Rural Health Through Connection

Transforming Rural Healthcare Paradigms

Designing Radiology Without Borders: AI-Enabled Community Tuberculosis Screening, a Malaysian Borneo Case Study.

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Introduction

TB remains a heavy burden, highest in Sarawak

10.7M

new TB cases worldwide in 2024; **2.4M** undiagnosed

(WHO, 2025)

1.23M

TB deaths worldwide in 2024

(WHO, 2025)

26,183

cases in Malaysia in 2024; **7.58 deaths per 100,000**

(MOH, 2025)

12.07

deaths per 100,000 in Sarawak, highest in Malaysia

CodeBlue, 2025

2030 target

Reduce TB deaths to **2.2 per 100,000** (SDG; NSP to End TB 2021–2030).

(MOH, 2025)

Find cases earlier

Active case finding cuts transmission, yet most cases are still found **passively**.

(WHO, 2021; Oxford Academy, 2025)

Introduction

Chest X-ray, AI and ultraportable devices are proven tools

1. **Chest X-ray** is the initial screening test for TB because it can detect **asymptomatic TB** (WHO, 2021).
2. **Artificial intelligence (AI) is increasingly utilized globally** for automated interpretation of CXR in TB screening (Khan et al., 2023).
3. Studies demonstrated promising results with reported **sensitivities ranging from 80%-94% and specificities from 65%-85%** (Zhan Y et al., 2023; Jaeger et al., 2023).
4. Implementing AI-enabled clinical decision support systems (CDSSs) improve **efficiency , accuracy, inter-reader variability**, as well as medical care in resource constrained environments (Elhaddad et al., 2024)
5. AI systems with deep learning techniques, showed performance **comparable** to that of expert radiologist (Malhotra et al., 2019; Hwang et al., 2019; Nitta et al., 2020, Portela et al., 2022).
6. However, there is **no real-world evidence yet from Malaysian Borneo**.

Statement of Problem

Static X-ray services leave rural communities behind

1. X-ray is tied to facilities, and **the lack of on-site X-ray hinders TB contact investigation** (Goroh et al., 2023).
2. The **TB close contact screening is largely dependent** on the availability of X-ray machines in healthcare facilities and its logistic distance (Mase et al., 2018; WHO, 2023).
3. TB contacts need **4 clinic visits over 2 years**, and many drop out of follow-up (MOH, 2021; Sumi et al., 2024).
4. There are **few radiologists**, so slow formal reports delay diagnosis (WHO,2021).
5. Readers often disagree, which makes **diagnosis inconsistent** (Balabanova et al., 2005).
6. The consequence is **late diagnosis and ongoing TB transmission**.

The Innovation

Bringing the X-ray to the community, first in Malaysia

1st

ultraportable AI chest X-ray for TB screening in Malaysia

PUBLIC-PRIVATE PARTNERSHIP

Bintulu Divisional Health Office × Press Metal Sdn Bhd

Paradigm shift: from static to ultraportable

	Static X-ray	Ultraportable + AI
Location	Hospital radiology room	Village, longhouse, workplace
Equipment	Fixed, shielded room	3.5 kg battery unit
First read	Formal report, delayed	AI score on the spot
Who travels	The patient	The screening team
Radiologist	Reads every film	Focuses on flagged films

Device weight and set-up: Vo et al., 2021; MaHTAS, 2025

Research Objective

How sensitive, specific and concordant is the AI?

GENERAL OBJECTIVE

To determine the concordance of radiology reports and AI software for thoracic abnormalities on CXR in enhancing TB screening programme in Bintulu, Sarawak.

SPECIFIC OBJECTIVES

1. To determine the sensitivity and specificity of the AI software reporting.
2. To determine the concordance between AI interpretation of CXR and interpretation (radiologist reports) for TB screening.
3. To describe lesion-level concordance and discordance between AI and radiologist findings.

Methodology

Study Design

- Cross sectional retrospective study.

Target Population

- Community in Bintulu Division.

Sampling Frame

- Villages that had TB screening program using Fujifilm FDR Xair ultraportable Xray in Bintulu.

Sampling Unit

- Community that participated during TB screening program in Bintulu.

Methodology

Inclusion criteria

- All subjects aged 18 and above.
- Posterior-anterior CXR using Fujifilm FDR Xair ultraportable x-ray unit.

Exclusion Criteria

- Pregnant females.
- Missing or corrupted DICOM images.
- Duplicated cases.
- CXR done at healthcare facilities.

Sampling Size

- 350 CXRs .

Methodology

Reports standardised, then compared pair by pair

Radiologist report categories (Kim et al., 2022)

Category	Example findings	Result
Inactive	Calcification, pleural thickening, bulla	Positive
Insignificant	Bronchiectasis, emphysema, tiny nodule	Positive
Significant	Focal opacity, nodule, consolidation	Positive
Normal	Normal chest X-ray	Negative

Data analysis

- Built-in AI Software (Lunit Insight Version 3.1.4.12).
- Abnormality findings with score ≥ 15% were classified as "Lunit Positive".

Ethics approval: MREC, Ministry of Health Malaysia (NMRR ID-24-03550-JKT(IIR)).

Result

Screening reached Indigenous, low-income communities

Table 1. Demographic and socioeconomic characteristics of participants (n = 350)

Variable	Category	n (%)
Age group, years	20 and below	6 (1.7)
	21–30	50 (14.3)
	31–40	80 (22.9)
	41–50	96 (27.4)
	51–60	59 (16.9)
	61–70	43 (12.3)
	70 and above	16 (4.6)
Ethnicity	Malay	37 (10.6)
	Chinese	35 (10.0)
	Iban	221 (63.1)
	Kenyah	40 (11.4)
	Melanau	10 (2.9)
	Foreigners	7 (2.0)
Marital status	Single	77 (22.0)
	Married	273 (78.0)

Note: mean age 45.1 years (SD 14.4), range 19–91.

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Variable	Category	n (%)
Education	None	70 (20.0)
	Primary	92 (26.3)
	Secondary	148 (42.3)
	Tertiary	40 (11.4)
Occupation	Unemployed	96 (27.4)
	Pensioner/housewife/student	99 (28.3)
	Self-employment	58 (16.6)
	Non-professional	73 (20.9)
	Professional	24 (6.9)
Household income, RM	1,999 and below	160 (45.7)
	2,000–3,999	78 (22.3)
	4,000–5,999	52 (14.9)
	6,000–7,999	40 (11.4)
	8,000 and above	20 (5.7)
Religion	Christianity	185 (52.9)
	None	83 (23.7)
	Islam	52 (14.9)
	Buddhist	30 (8.6)

Age 31–50 50.3%

Iban 63.1%

≤ Primary 46.3%

Not working 55.7%

≤ RM1,999 45.7%

Result

AI and radiologists agreed on 303 of 350 films

Table 2. Cross-classification of AI-assisted interpretation relative to radiologist interpretation (n = 350)

Radiologist classification	AI positive	AI negative	Total
CXR-positive	**56**	7	63
CXR-negative	40	**247**	287
Total	96	254	350

Concordant 303/350 (86.6%) *k=0.622*

Discordant 40 vs 7, McNemar's (*p< 0.001*)

Sensitivity of 88.9% and specificity of 86.1% for CXR abnormality (reference standard : radiologist report, not microbiological TB confirmation), *p-value <0.001*.

Result

Table 3 : Concordance and discordance of Radiologist and AI interpretation (Lunit) across the CXR lesion categories (*n*=350).

CXR Lesion Category	Total	Concordant, n(%)	Discordant, n(%)
Overall	350	286 (81.7)	64 (18.3)
Normal	254	247 (97.2)	7 (2.8)
Inactive	12	3 (25.0)	9 (75.0)
Insignificant abnormal	20	6 (30.0)	14 (70.0)
Significant abnormal	64	30 (46.9)	34 (53.1)

Result

Most shared findings matched; missed films were not TB

Table 4. Image-level comparison, films positive by both methods (n = 56)

Category	Definition	n (%)
Accept	AI and radiologists described similar lesions or radiographic findings	21 (37.5)
Edit	Partial agreement, with radiologist modification, refinement or reclassification of the AI-described finding	11 (19.6)
Addition	The radiologist identified additional relevant findings not detected or reported by AI	7 (12.5)
Reject	Radiologist's interpretation did not support the AI-described lesion	17 (30.4)
Total	56 (100.0)	

Categories adapted from Kim et al. (2022); descriptive only, not used for binary concordance.

Full or partial match: 33/56 (58.9%)

Reject 30.4%: radiologist stays in the loop

AI-negative / radiologist-positive films (n = 7)

Radiologist finding	n
Bronchiectatic changes	4
Linear opacity	1
Minimal nodular/reticular chronic change	1
Focal lower-zone consolidation	1
Final programme diagnosis of pulmonary TB	**0**

None of the 7 missed films was diagnosed with pulmonary TB

Result

Programme context: 1 TB case per 105 people screened

Table 5. TB case finding in the ultraportable AI screening programme, 2024–2026 (ongoing)

Indicator	Estimate
People screened, 2024–2026	6,479
TB cases detected	**62**
Yield, % (95% CI)	**0.96 (0.75–1.22)**
Yield per 100,000 screened (95% CI)	**957 (747–1,225)**
Number needed to screen	**105**

1 TB case per 105 people screened

Descriptive programme data, separate from the agreement study (n = 350); not a controlled comparison. Wilson 95% CI.

Discussion

Reliable enough to triage, with radiologists in the loop

1. The study found substantial agreement between AI and radiologists interpretation with an **overall agreement** of **86.6%** (k=0.622) with sensitivity **(88.9%)** and specificity **(86.1%) for CXR abnormality.**

2. The study also reported that **concordance was notably higher for normal CXRs (97.2%)** compared to significant abnormalities (46.8%).

3. High agreement on normal cases significantly **reduces** radiologist workload, allowing them to **focus on more complex or abnormal studies**, leading to **faster reporting** for a large proportion of cases.

4. The reading time decreased with AI support, and this indicate that AI can facilitate the detection of abnormalities for radiologist.

Discussion

1. Discordance may be explained by two factors :
   - A **low AI threshold (score ≥15)** makes the AI very cautious, so it flags more films, producing false positives (43 in the current study).
   - **Subtle or chronic lesions** (eg. Bronchiectasis) are **harder for the AI to detect**, producing false negatives (7 in the current study).

2. Variability in **image acquisition**, **patient positioning**, and inherent limitations of ultraportable devices can **introduce noise or artifacts** that confuse the AI, leading to discordance.

3. These discordances can still contribute to **radiologist workload** (reviewing and dismissing false positives) and potentially lead to **unnecessary** follow-up imaging or patient anxiety.

Discussion

Access, equity and implementation

1. **Access and equity:** the screening reached Iban ethnic group (**63.1%**), low-income (**45.7%**) and non-working (**55.7%**) groups.
2. **Same-visit triage:** an on-site AI score supports **prioritisation for radiologist** review and Xpert testing (WHO, 2021).
3. **More cases found:** the programme yield of **957 per 100,000** (**62/6,479**) exceeds the **759** reported in Vietnam and is **≈12×** the national notification rate (programme records; Vo et al., 2021; MOH, 2025; DOSM, 2024).
4. **Safe direction of error:** AI over-called (**40 vs 7 in this current finding**) rather than missed cases, and the threshold should be calibrated locally (WHO, 2021).
5. **Design for context:** the SOP turned community venues into safe screening stations.

Implication

What this means for services and the community

Earlier detection

1 TB case per **105** screened (programme records).

No borders

Imaging goes **to the village**, closer to patients.

Less burden

Radiologists focus on abnormal films.

Consistency

A standardised first read across the programme.

Scalable model

Adaptable to other rural and remote settings.

Limitation & Recommendation

Each limitation points to the next step

Limitation

- Radiologist report used as reference standard; no microbiological confirmation.
- Single division, retrospective, modest sample (n = 350)
- Differences in radiologist experience and interpretation thresholds

Recommendation

- Prospective study with Xpert and culture as reference. (current ongoing screening)
- Multi-site prospective study across Sarawak
- Blinded consensus reading by radiologists

Conclusion

A reliable triage-support tool for a hospital without borders

1. Ultraportable AI chest X-ray **moved TB screening into the community**: **62** cases in **6,479** screened.
2. **Reliable**: **sensitivity 88.9%** , **specificity 86.1%**, particularly in resource-limited and high-volume settings.
3. Reached **Indigenous, low-income and rural** communities.
4. AI **assists, not replaces**: radiologists stay in the loop.
5. A **scalable model** for rural TB screening.

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Thank You

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