COMPUTER AIDED DETECTION OF PULMONARY TUBERCULOSIS ON DIGITAL CHEST RADIOGRAPHS: A SYSTEMATIC REVIEW

TRIPTI PANDE

ADVANCED TB DIAGNOSTICS COURSE

MCGILL SUMMER INSTITUTE OF INFECTIOUS DISEASES AND GLOBAL HEALTH

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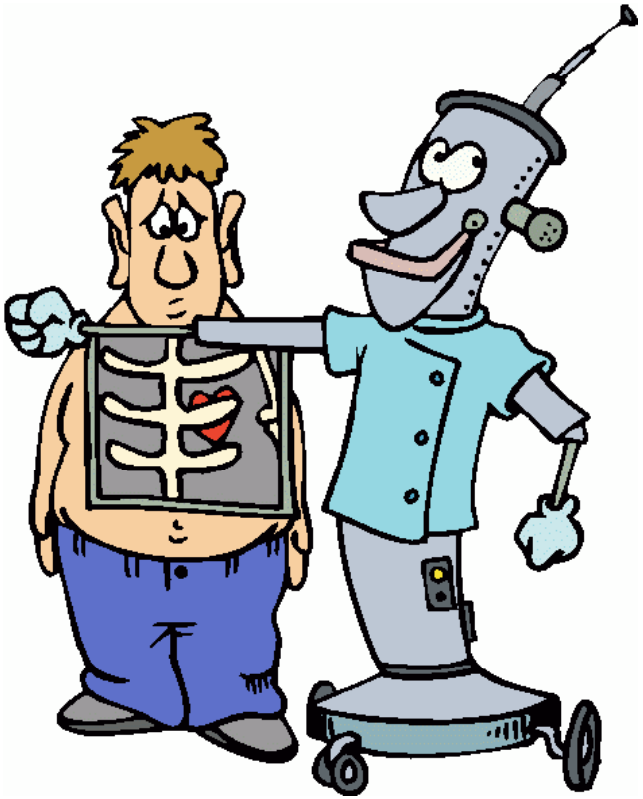
OUTLINE

- Chest radiography vs Computer aided-detection
- Study objectives
- Methods
- Results
- Analysis
- Final remarks
- Future work

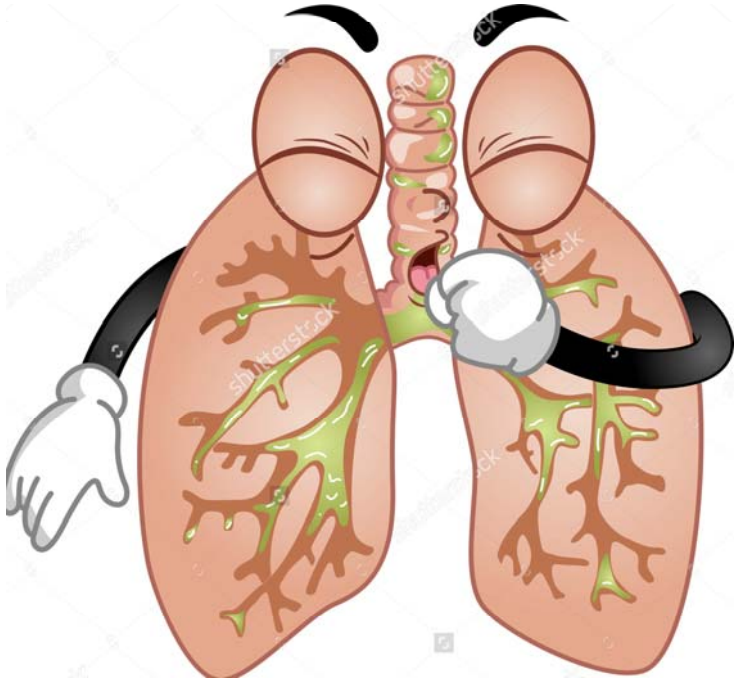


CHEST RADIOGRAPHY

PROS	CONS
Highly sensitive	High cost equipment
Moderately specific	Inter- professional variability
Useful screening tool	Intra- professional variability

COMPUTER AIDED DETECTION

- Definition:
  - Automated system which quantified various image characteristics of chest radiographs
- Functions of CAD:
  - Using DXR and software programs to detect radiographic abnormalities compatible with pulmonary TB
  - Can eliminate problems of delays in interpretation and poor inter-reader variability



PRIMARY AND SECONDARY OBECTIVES

- **Primary objective:** assess the accuracy for detection of microbiologically confirmed pulmonary TB
- **Secondary objective:** comparing CAD diagnosis to that of clinical officers diagnosing pulmonary TB via chest radiographs

INCLUSION AND EXCLUSION CRITERIA

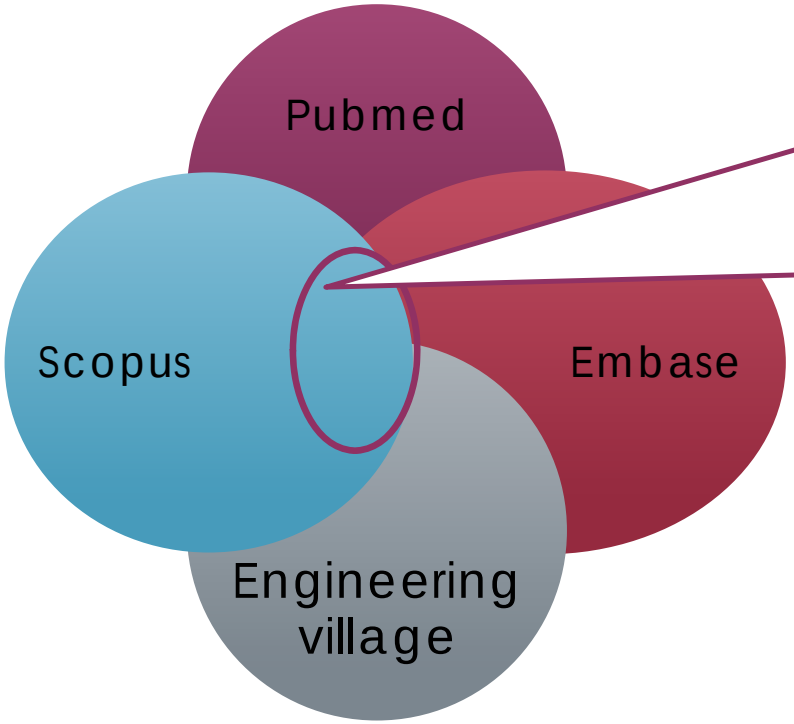
Inclusion

- Estimating diagnostic accuracy of CAD software
- Detecting pulmonary tuberculosis (PTB)
- Comparing to a microbiologic reference standard

Exclusion

- CAD used for diagnostic modalities other than CXR
- Did not use microbiological reference standard
- Studies involving children

SEARCH STRATEGY



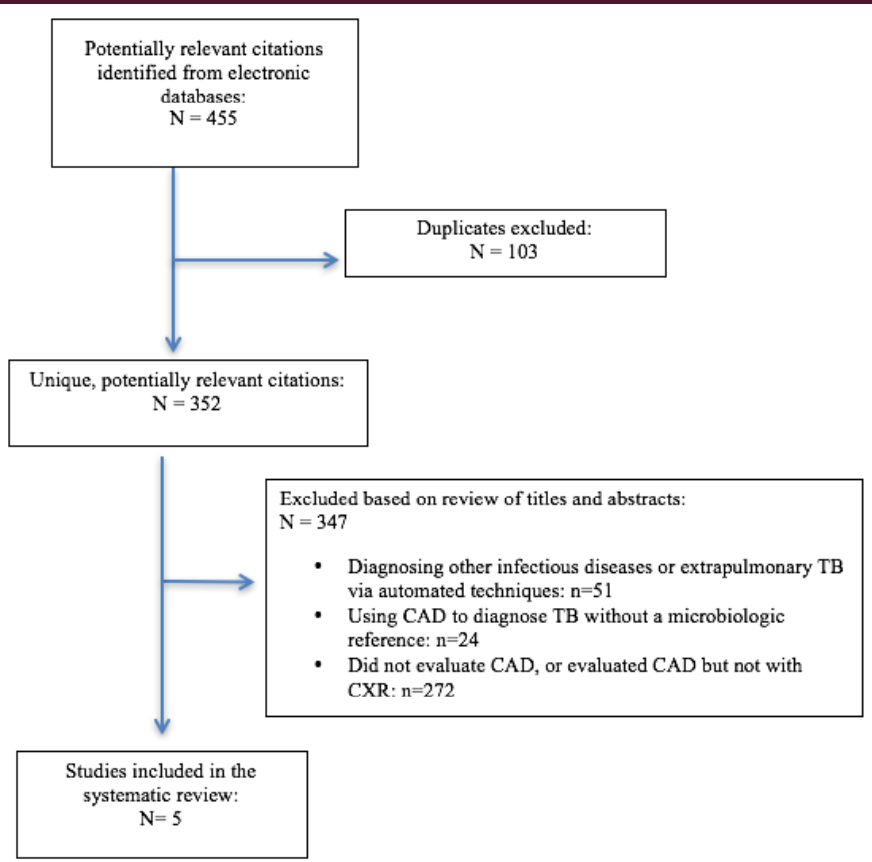
Search limitations:

- No language restriction
- January 1st, 2010 – December 31st, 2015

Search terms:

- Validated by medical librarian
- Broad search terms used

RESULTS



Pande, Cohen et al. 2016 (accepted)

DATA EXTRACTION

- Year of publication, geographic location
- Study design (retrospective, prospective)
- Inclusion/exclusion criteria
- Method of generating digital radiographs
- Name, version and method for scoring CAD
- Microbiologic reference
- Diagnostic accuracy; sensitivity, specificity, AUC
- Studies comparing to humans: number of human readers and their experience
- Quality assurance: QUADAS 2

GENERAL RESULTS

Study	Country	Study design	Microbiologic reference standard
Maduskar et al.	Zambia	Retrospective	Smear or culture
Muyoyeta et al.	Zambia	Prospective	Xpert MTB/RIF
Breuninger et al.	Tanzania	Retrospective	Positive culture result
Hogeweg et al.	England South Africa	Retrospective	Smear or culture
Philipsen et al.	South Africa	Prospective	Culture and clinical criteria

Pande, Cohen et al. 2016 (accepted)

Year of study‡	CAD software, version	Country	Reference standard	Number enrolled	Sample size for diagnostic accuracy	HIV, n (%)	PTB, n (%)	Diagnostic accuracy of CAD for microbiologically confirmed PTB			
								AUC (95%CI)	Threshold score (scale of 0-100)	Rationale for selection of threshold score	Sensitivity & Specificity
2011[8]	CAD4TB, 1.08	Zambia	Smear & Culture	161††	161	110 (68%)	97 (60%)	0.73 (0.64–0.80)	NR	Set to achieve the same specificity as the field officer (0.41)	Sn: 0.86 (0.75-0.94) Sp: 0.41¥
2013[9]	CAD4TB, 1.08	Zambia	Xpert MTB/RIF	458	350	190 (54%)	96 (33%)	0.71 (0.66–0.77)	≥ 61	Threshold score selected based on AUC generated in pilot study	Sn: 1.0 (0.96-1.0) Sp: 0.23 (0.18-0.29)
NR[10]	CAD4TB, 3.07	Tanzania	Culture	894	427	177	194	0.84 (0.80–	> 23	NR	Sn: 0.95 (0.91-0.98) Sp: 0.33 (0.27-0.39)
										NR	Sn:0.91 (0.86-0.94) Sp: 0.52 (0.46-0.59)
									6	NR	n:0.85 (0.79-0.90) : 0.69 (0.62-0.75)
										NR	:0.77 (0.71-0.83) 0.79 (0.74-0.84)
										NR	0.62 (0.55-0.69) 0.85 (0.80-0.89)
									5	NR	0.47 (0.40-0.54) 0.94 (0.91-0.97)
2013[6]	CAD4TB, version not reported	England	Culture & Clinical							Not applicable	NR
		South Africa	Culture							Not applicable	NR
NR[7]	CAD4TB, 3.07	South Africa	Culture	419	388	128 (33%)	71 (18%)	0.79 (NR)	NR	Not applicable	NR

Pande, Cohen et al. 2016 (accepted)

ANALYSIS - CAD VS HUMAN INTERPRETATION

Older version (v. 1.07) performed similar to clinical officers

Newer version (v. 3.08) performed similar to expert radiologists

- CAD set to achieve same specificity as non-expert clinician→ CAD achieved same sensitivity as other non-experts
- Threshold set to achieve same sensitivity as human readers → CAD achieved lower specificity than radiologist BUT greater than clinical officer

ANALYSIS- QUADAS-2

STUDY AUTHORS	RISK OF BIAS				APPLICABILITY CONCERNS		
	Patient selection	Index test	Reference standard	Flow and timing	Patient selection	Index test	Reference standard
Maduskar et al.[8]	U	L	L	U	H	H	L
Breuninger et al.[10]	H	L	H	H	H	L	H
Muyoyeta et al.[9]	L	L	L	L	U	U	L
Hogeweg et al.[6]	H	L	U	U	U	U	L
Philipsen et al.[7]	L	L	L	L	L	L	L

*Legend: L = low, H= high, U= unclear

Pande, Cohen et al. 2016 (accepted)

FINAL REMARKS

- Important point to remember: evidence base to support the use of CAD is quite limited (n=5)
- High sensitivity threshold → substantial fall in specificity (vice versa)
- CAD software achieving high sensitivity and specificity would be major leap for this technology
- Our systematic review mainly highlights;
  - Uncertainty in the nascent evidence base
  - Help guide the direction for future evaluative studies for CAD4TB
  - Accepted for publication in IJTLD (May 2016)

FUTURE WORK

- Study design:
  - Minimize risk of bias using prospective designs
  - Pre-specified threshold scores
  - Microbiologically defined case definitions
- Generalizability:
  - Diverse settings and populations

WHO-CAD REVIEW

- Including unpublished studies to increase the study database
- Revised data extraction form
- Performing a meta-analysis as well

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THANK YOU!

QUESTIONS?