# Use of computer aided detection to support triage for efficiency at the MBOD

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# CAD - general methodological considerations

- Developed as proprietary radiological software for TB by different commercial enterprises.

- Sources of bias and variation
  - Machine vs deep learning
  - How trained - How were CXRs selected, how many?
  - How validated – Source of CXRs ? Human or laboratory reference( for TB)

- *Innovation* in this project was application to a unique population:
  - High prevalence of silicosis
  - High prevalence of prior TB.
  - First studies to include silicosis as an outcome
  - First studies in a compensation adjudication setting.

# Two validation studies of CAD

- Young et al. 2020 - MBOD certification as the reference.

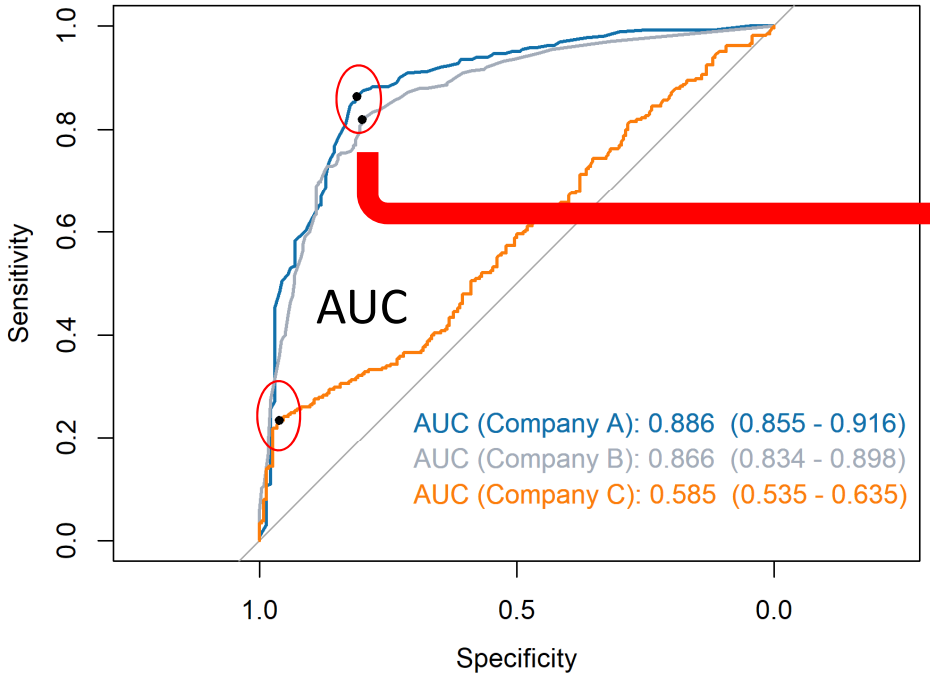
- Field study (unpublished) – Alice, Bizana, Stilfontein BMEs; 3 external readers (OM specialists) as reference.
- Three CAD systems (A, B and C), with outputs:
  - TB (0-100)
  - Silicosis (0-100)
  - "No TB or silicosis"(0-100 ) (Problematic category – not same as "normal")
- Between the 1st and 2nd studies, B and C "dropped" silicosis. Only system A directed at silicosis in 2nd study. (Also only system trained on *active* TB).
- Results of both studies used for efficiency project.

## Performance = "accuracy against a reference standard" (relative!).

- Receiver operating curve (ROC) - *plots* agreement.
- Area under the curve (AUC) *quantifies* overall agreement between tests ("readers")
- *Sensitivity* – ability of test system to identify true positives (no false negatives).

  *Specificity* – ability of a test system to identify true negatives (no false positives)
- Each point on the ROC is a unique combination of sensitivity and specificity
  - Sensitivity and specificity are *complementary* – one comes up, other goes down.

# Detecting TB using CAD (field study)[1,2]



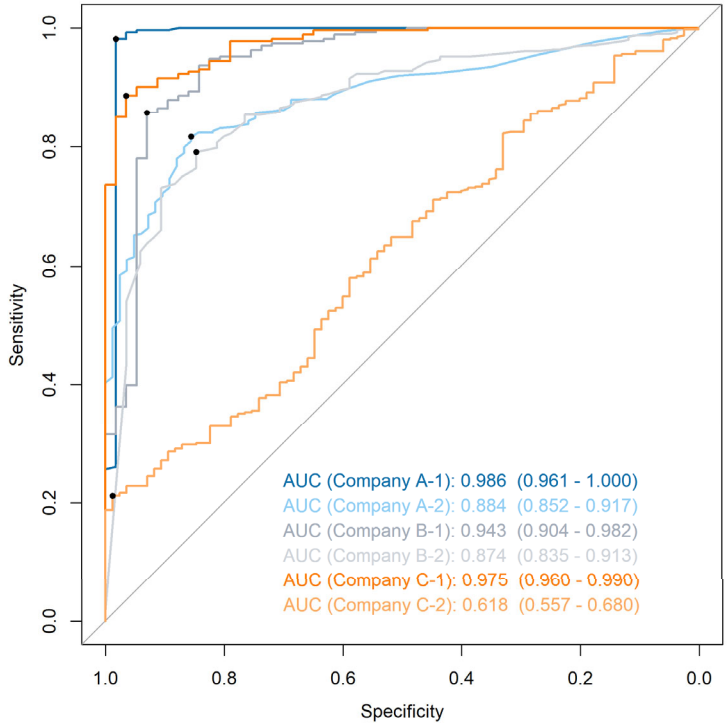

| System | Sensitivity | Specificity |
|---|---|---|
| At Youden-index[3] maximum: | | |
| A | 81.6% | 85.5% |
| B | 79.1% | 84.7% |
| C | 21.2% | 98.8% |
| At fixed minimum 90% sensitivity: | | |
| A | 91.1% | 55.4% |
| B | 90.1% | 58.8% |
| C | 90.1% | 17.6% |

[1] External reader 2 as the reference standard.

[2] A and B had reasonably good performance when detecting TB image, and not significantly different from one another

[3] Youden index is the point at which the combination of [sensitivity + specificity – 100] (%) is maximised.

# System performance declined between trials – example: detection/ exclusion of "abnormality")[1,2]




| System | Study | Sensitivity | Specificity |
|---|---|---|---|
| **Fixed at minimum 90% sensitivity:** | | | |
| A | 1: (Young 2020) | 90.1 % | 98.2% |
| A | 2: (Field study) | 91.1% | 55.4% |
| B | 1: (Young 2020) | 90.1% | 84.2% |
| B | 2: (Field study) | 90.1% | 58.8% |
| C | 1: (Young 2020) | 90.10% | 94.70% |
| C | 2: (Field study) | 90.10% | 17.60% |

[1] External reader 2 as reference standard in field study. MBOD classification reference in Young et al.

[2] Statistically significant performance decline across all systems.

# Efficiency gains - different years of service thresholds vs CAD[1]

| | Referral rule or threshold | No. of expert reviews | Efficiency gain [2] |
|---|---|---|---|
| 1 | No triage (reference category): All cases go the full panel | 47,275 | - |
| 2 | Hypothetical maximum: all TB-flagged claims are sent to the TB panel, all normal claims (non-compensable without disease) are sent to the reduced panel, and all other claims are sent to the full panel. | 29,144 | 38.4% |
| 3 | 10-year service threshold, no CAD (actual triage, not simulated) | 37,657 | 20.3% |
| 4 | 15-year threshold, no CAD | 36,747 | 22.3% |
| 5 | 20-year threshold, no CAD | 35,865 | 24.1% |
| 6 | No CAD, no triage based on years of service: **All TB cases routed to TB panel, all others to reduced panel.** | 34,015 | 28.0% |
| 7 | CAD triage: sensitivity 98.2%, specificity 98.2% (Youden)[3] | 30,231 | 36.1% |
| 8 | CAD triage: sensitivity 100%, specificity 86.0% (Sensitivity fixed) | 31,504 | 33.4% |
| 9 | CAD triage: sensitivity 90.4% and specificity 60.6% (Youden)[4] | 34,702 | 26.6% |
| 10 | CAD triage: sensitivity 70.5% and specificity 90.4% (Specificity fixed) | 32,214 | 31.9% |

[1] All TB cases to TB panel, all deceased cases to full panel. [2] CAD efficiency gains are an *alternative* to the routing options presented separately. The two are not additive. [3] Young et al. [4] Field trial, system B vs reader 2

# Decisions facing users re CAD

- Choice of CAD system. Need to understand criteria include performance metrics and potential bias – on whom trained, against whom/what validated.
  - In the field trial, the agreement between CAD and external readers for "any abnormality" for "TB" met or were close to WHO screening tests guidelines (90/60) for systems A and B.
  - C performed very poorly.
  - Only A reads for silicosis

- Choice of optimisation point - trade-off of false negatives against false positives [cost and time efficiency as well as "risk" (ethical, legal, reputational)]. E.g. 100% efficiency, with substantial false positives. Or lower sensitivity, leaving it to reduced panel to pick up false negatives?

# Other considerations re CAD

- Manage CAD- medical adjudicator interface.  How will it be used in day to day practice? Triage or backup?
- Need continuous monitoring of quality (by radiologist and MOs) and consider incremental improvements over time,  i.e. not a once off decision.
- Manage relationship with vendors
  - Facilitate further machine learning by providing images
  - Manage IP issues
- Are there legal issues in use of CAD?

# Recommendations re pre-panel improvements in efficiency

- Educate referring physicians
  - "TB wage loss only" to be clearly marked on the claim documentation.
  - Clinical skills in diagnosing silicosis and TB (prior or active) in miners and ex-miners
  - Understanding of ODMWA, including possible discretion in not submitting the results of medicals where there is evidence of compensable disease. (Needs legal clarification of sections 32 and 33)
- Train MBOD clerical staff

  Ensure that TB claims are accurately routed to TB panel.

# Next steps

1. Decision making by CCOD/MBOD

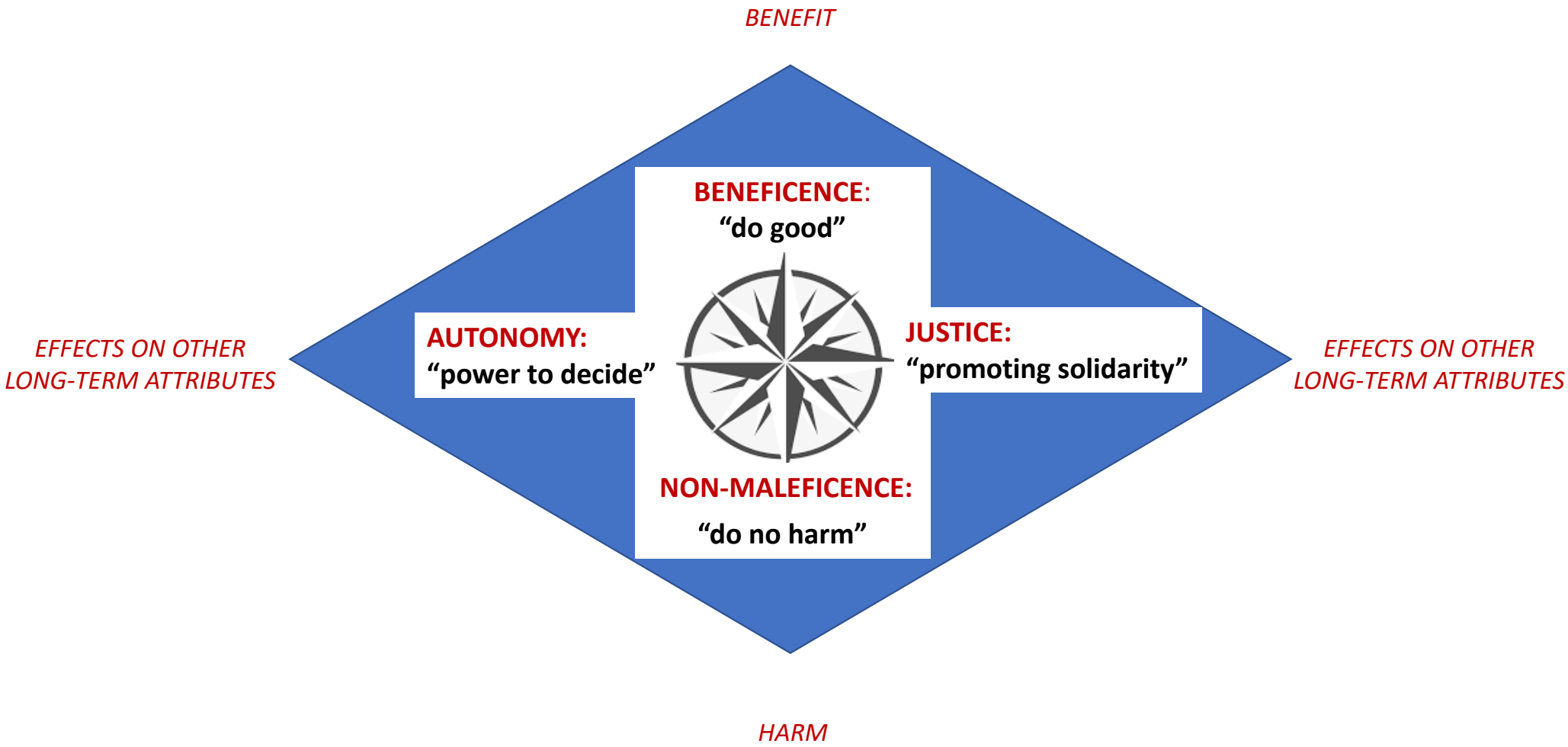
- Primary routing - Whether a change in living claims processing should be implemented, whereby, for example, *all* claims are routed to either the TB panel or the reduced panel initially, *with only those determined by those two* 2-person panels to needing the full-panel assessment referred upwards.

- CAD – as above

2. Submission of draft publication for peer review. (WHO funded field study article will follow).

3. A cost or cost-benefit analysis of the financial savings in adopting various options.

# Principles of Bio-ethics



# Reflecting on principles of Bio-ethics in relation to our CAD application

Will anyone eligible for benefits be excluded?
Minimisation of "false negatives", i.e. incorrect rejection of eligible claims

*Choice of sensitivity/specificity combination, monitoring by users of CAD outcomes*

**BENEFICENCE**:
**"do good"**

Is intellectual property creation managed?

Will public sector retain access?

Will experts lose roles, be deskilled?

*Clarity re triage and role of adjudicators*

**AUTONOMY:**
**"power to decide"**


**JUSTICE:**
**"promoting solidarity"**

*A priori* agreement

Is there transparency & accountability of procurement, application and performance of system?

*Regular reporting by management*

**NON-MALEFICENCE:**

**"do no harm"**

Could information be misused?

*Provisions for privacy & security*

Contribute to ongoing training of CAD?

*Share databases of images and readings*