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# Evaluation of a chest radiograph reading and recording system for tuberculosis in a HIV-positive cohort

C.S. Kosack<sup>a,\*</sup>, S. Spijker<sup>a</sup>, J. Halton<sup>a</sup>, M. Bonnet<sup>b,c</sup>, S. Nicholas<sup>b</sup>,  
K. Chetcuti<sup>d</sup>, A. Mesic<sup>e</sup>, W.E. Brant<sup>f</sup>, E. Joeke<sup>g</sup>, S. Andronikou<sup>h</sup>

<sup>a</sup> Médecins Sans Frontières, Diagnostic Network, Amsterdam, The Netherlands

<sup>b</sup> Epicentre, Paris, France

<sup>c</sup> Institute of Research for Development, UMR233, University of Montpellier, INSERM U1175, France

<sup>d</sup> Department of Radiology, Alder Hey Children's Hospital, Liverpool, UK

<sup>e</sup> Médecins Sans Frontières, Public Health Department, Amsterdam, The Netherlands

<sup>f</sup> Department of Radiology and Medical Imaging, University of Virginia Health System, Charlottesville, VA, USA

<sup>g</sup> Diagnostic Imaging department, Royal Liverpool University Hospital & Liverpool School of Tropical Medicine, Liverpool, UK

<sup>h</sup> Department of Paediatric Radiology, University of Bristol and Bristol Royal Hospital for Children, Bristol, UK

## ARTICLE INFORMATION

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**AIM:** To assess the impact of introducing a chest radiograph reading and recording system (CRRS) with a short training session, on the accuracy and inter-reader variability of tuberculosis (TB) interpretation of chest radiographs (CXR) by a group of non-expert readers in a human immunodeficiency virus (HIV)-positive cohort.

**MATERIALS AND METHODS:** A set of 139 CXRs was reviewed by a group of eight physicians pre- and post-intervention at two clinics in Shan State, Myanmar, providing HIV/TB diagnosis and treatment services. The results were compared against the consensus of expert radiologists for accuracy.

**RESULTS:** Overall accuracy was similar pre- and post-intervention for most physicians with an average area under the receiver operating characteristic curve difference of 0.02 (95% confidence interval: -0.03, 0.07). The overall agreement among physicians was poor pre- and post-intervention (Fleiss  $\kappa=0.35$  and  $\kappa=0.29$  respectively). The assessment of agreement for specific disease patterns associated with active TB in HIV-infected patients showed that for intrinsically subtle findings, the agreement was generally poor but better for the more intrinsically obvious disease patterns: pleural effusion (Cohen's kappa range = 0.37–0.67) and milliary nodular pattern (Cohen's kappa range = 0.25–0.52).

**CONCLUSION:** This study demonstrated limited impact of the introduction of a CRRS on CXR accuracy and agreement amongst non-expert readers. The role in which CXRs are used for TB diagnosis in a HIV-positive cohort in similar clinical contexts should be reviewed.

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\* Guarantor and correspondent: Cara Kosack, Médecins sans Frontières, Plantage Middenlaan 14, 1018 DD Amsterdam, The Netherlands. Tel.: +31 20 520 8700.

E-mail address: [cara.kosack@oca.msf.org](mailto:cara.kosack@oca.msf.org) (C.S. Kosack).

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## Introduction

Tuberculosis (TB) is a major global health hazard. The majority of reported cases are from low and middle income countries. Immunosuppressed patients, such as those with human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS), are particularly at risk with the majority of these patients living in Asia and sub-Saharan Africa.<sup>1</sup>

Confirming TB in HIV-positive patients with microbiological tests in resource-constrained settings is particularly challenging due to higher rates of smear negative results, difficulties in obtaining sputum specimens, limited access to molecular testing, such as GeneXpert and mycobacterial culture, and the time taken for culture results.<sup>2,3</sup> In many settings, a chest radiograph (CXR) remains the primary diagnostic tool and provides an important contribution to the combined criteria for diagnosing TB in this patient group, and is therefore endorsed by the World Health Organization (WHO).<sup>4</sup>

The usefulness of CXRs in the diagnosis of TB, however, is complicated by the non-specific presentation of the disease in HIV-positive patients, and more so if the technical quality of the CXR is limited.<sup>5–7</sup> CXR interpretation is prone to high subjectivity, inter- and intra-reader variability and over-reading, especially when read by less experienced, non-expert readers, who are largely responsible for reporting in resource-constrained settings.<sup>2,3,8–11</sup>

Aside from the provision of training, the use of a CXR reading and recording system (CRRS), in prevalence studies by non-expert readers, has demonstrated improvements and satisfactory inter- and intra-reader agreement.<sup>12</sup> CRRS encourages a systematic approach to reporting using identical descriptive terms by all readers. The resultant data can be used for follow-up and comparative studies. Thus, CRRS could potentially improve the diagnostic clinical validity of CXRs.<sup>10–12</sup>

The aim of the present study was to determine if the introduction of a CRRS improves the interpretation accuracy of CXRs for TB, by non-radiologist physicians, against interpretation by expert radiologists, in an HIV-positive cohort in a resource-constrained setting. Furthermore, a further aim was to assess whether the application of a CRRS reduces the inter-reader variability of CXR interpretation, in the group of non-radiologist physicians by comparing the inter-reader agreement, before and after the intervention.

## Materials and methods

### Study population

Myanmar has one of the highest TB burdens in the world with an estimated 525 cases per 100 000 reported in 2010.<sup>13</sup> In addition, the HIV/AIDS burden is among the most serious in Asia, with an estimated 216,000 adults and children living with HIV in 2011.<sup>14</sup> A medical humanitarian non-governmental organisation, supports the Lashio and Muse

clinics, in Shan state, Myanmar, where this study was conducted.

### Study procedures

A sample of 139 CXRs was calculated from the receiver operating characteristic (ROC) diagnostic accuracy table proposed by Obuchowsky for area under the curve (AUC), assuming an expected pre-intervention AUC for CXR reading of 0.75, a 10% difference of AUC between post- and pre-intervention, a 25% frequency of TB suggestive CXR, a correlation of 0.47 between the pre- and post-intervention measure and a 5% alpha risk and 80% power.<sup>15</sup>

The 139 CXRs were randomly selected from a total of 618 conventional screen-film CXRs of HIV-infected adults who came to either clinic for TB screening within the last 12 months. All CXRs were performed at external facilities, not at the clinics. The result of smear microscopy was unknown. TB culture or molecular testing for TB infection was not available.

Eight non-radiologist physicians from Myanmar without a specialisation, whose work currently includes interpreting CXRs at either clinic were recruited. The physicians were asked to record in writing any radiological features detected and whether the CXR was “normal”, “abnormal but not suggestive of TB”, or “abnormal and suggestive of TB”. They subsequently received a four-hour group training session on CXR interpretation of TB and the application of the CRRS (Fig 1). After a period of at least 1 month to avoid recall, the CXRs were reported again in a random order utilising the CRRS.

### Reference standard

One hundred and thirty-nine CXRs were digitised following standardised instructions for the digitisation of film images and sent via the internet to three consultant radiologists, all with extensive experience of reading TB films. The CXRs were read digitally permitting the readers any digital enhancement. The reference standard was the consensus opinion of two independent, expert radiologists. The third radiologist was consulted in the case of discrepancies. CXRs were excluded from analysis if the consensus was overall “poor quality” (Fig 1).<sup>16</sup> All readers were blinded to clinical findings, laboratory results, and any previous diagnosis; however, all were aware that CXRs were from patients with presumptive TB from a high prevalence area.

### Data collection and statistical analysis

Data were collected from the CRRS forms and double-entered using EpiData 3.1 software (EpiData, Odense, Denmark) and analysis carried out using STATA version 13 (StataCorp, College Station, TX, USA).

The reference standard was classified as radiologically “TB positive” if the expert consultant radiologists interpreted the CXR as “abnormal and TB suggestive” and “TB negative” if interpreted as “normal” or “abnormal but not TB suggestive”.

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