Introduction
Malawi has one of the highest national HIV prevalence rates in the world. In the rural southern district of Thyolo, with a population of around 600,000 people, HIV prevalence is 14.5%, more than double other regions in the country. Estimated HIV-tuberculosis (TB) co-infection is also higher (75.0% vs 63.0%). However, detection rates for sputum smear-negative pulmonary TB and extrapulmonary TB fall below expected WHO estimates. Malawi has no radiologists in public service, and most health facilities lack capacity for x-ray interpretation, delaying and hindering TB diagnosis. Furthermore, Malawian guidelines stipulate confirmation of a suspected TB diagnosis with chest x-ray before treatment initiation. To improve TB diagnostics, MSF initiated teleradiology—the electronic transmission of radiographic images to an off-site radiologist.

Methods
At the public hospital in Thyolo, MSF and the Malawi Ministry of Health implemented teleradiology in September, 2010, in patients undergoing x-ray. Using a Sony 10.1 megapixel digital camera fixed to a tripod, x-rays on a medical light box were photographed and downloaded to a computer as a 100–200 kB JPEG. The JPEGs and patient histories were emailed to a radiologist in the USA, who optimised the images using Adobe Photoshop CS4. The radiologist returned his findings, free-of-charge, to the Thyolo team. Information was exchanged initially via email and later using a web-based telemedicine service which allowed data uploading and downloading directly to a website with email notification of postings. To assess the effectiveness of teleradiology, we retrospectively analysed—using Microsoft Excel 2003—data from September 2010 to August 2011 extracted from the teleradiology register and database. We assessed delays between x-rays and teleradiology referrals, and between referrals and readings. If the radiologist reported at least one diagnosis also proposed by clinical staff, it was classified as matching. Final treatment decisions were categorised as according to the teleradiologist (ie, clinical staff agreed with the teleradiologist) or according to clinical staff (ie, clinical staff reached a different diagnosis than the teleradiologist). Clinical patient outcomes, assessed during the period of admission after a minimum of 48 h, were defined as: “improved” or “unchanged” after initiating treatment; “died”; and “transferred-out” if the patient was sent for further investigation at Queen Elizabeth Central Hospital.

Results
142 images from 141 patients were reviewed by teleradiology (one patient presented with two distinct medical conditions on hospital admissions five months apart). The median time between x-ray and teleradiology request was 2 days (interquartile range [IQR] 1–5 days). The median time between teleradiology request and reading was 0 days (IQR 0–1 day). Patient management was changed due to teleradiology in 34 (23.9%) cases. Of these, two cases (1.4%) were diagnosed with pulmonary TB by the radiologist; both were initiated on TB treatment. The radiologist also corrected misdiagnosis of TB in 16 (11.3%) cases. Overall, 85 (59.9%) patients improved with treatment, 22 (15.5%) died, 28 (19.7%) were transferred-out, and 7 (4.9%) had an unknown outcome.

Conclusions
Teleradiology reduced delayed and missed diagnosis of TB, likely decreasing patient morbidity and mortality. A limitation of our evaluation is that most diagnoses were presumptive, due to lack of capacity for confirmatory TB culture or biopsy; however, most patients improved with treatment, suggesting the accuracy of the presumptive diagnoses. Our findings support the feasibility and utility of teleradiology for TB diagnosis in rural Africa and suggest that if implemented judiciously, other resource-limited settings with a high HIV-TB co-infected population might also benefit from this service.