

# Computer Aided Diagnosis (CAD4WHOKids) for WHO Primary Endpoint Pneumonia on Chest X-Ray in Children

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## INTRODUCTION

- The chest X-ray (CXR) remains the most readily available and common imaging modality for the assessment of childhood pneumonia.
- Standardization of CXR interpretation is important to allow comparison between studies.
- The number of paediatric radiologists in low income countries is limited, as are the number of paediatricians with training and expertise in standardized CXR interpretation recommended by the WHO methodology.
- Computer-aided diagnostic (CAD) approaches to the interpretation of paediatric CXR have the potential to overcome these barriers for the interpretation of CXR in children with pneumonia.

## OBJECTIVES

To determine the sensitivity and specificity of CAD (CAD4WHOKids) for:

- Chest X-ray primary end-point pneumonia (CXR-PEP) vs. non CXR-PEP;
- Chest X-ray PEP vs. Other Infiltrate Only.

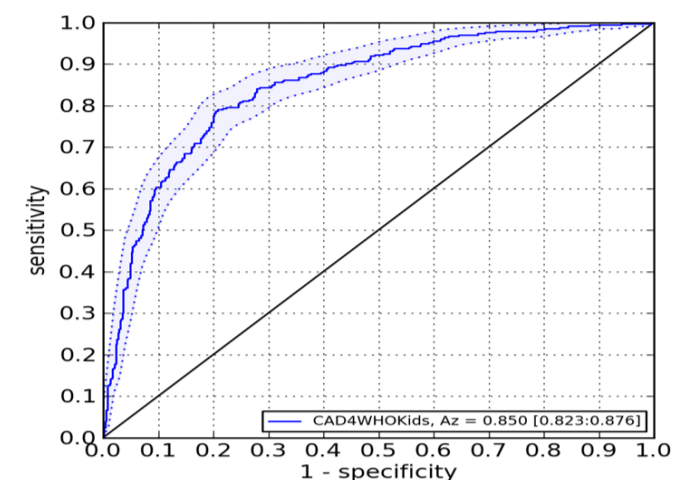
## METHODS

- This study was nested within the cross sectional PERCH study, South African site.
- Chest X-rays were independently evaluated by 3 radiologists in South Africa using WHO standardized interpretation criteria.
- The majority consensus reading was used as the reference standard.
- The work-flow adopted for CAD in our study entailed:
  1. **Automatic lung field segmentation**, followed by manual inspection and correction;
  2. **Training**- Areas of CXR-PEP were manually outlined in a sub-set of training CXRs. Pixels in outlined regions were used as positive examples. Training and testing was done in 10-fold cross validation;
  3. **Feature extraction**; Pixel data was filtered with Gaussian derivatives on multiple scales, extracting texture features to classify each region;
  4. **Classification**- To obtain an image score, the 95th percentile score of the pixels was used.

## RESULTS

- 858 interpretable CXR: 333 with CXR-PEP, 208 with other infiltrate only and 317 were Normal based on a 3 reader consensus reading.
- Lung fields were manually outlined in 25% (n=214) of randomly selected CXRs.
- Automatic lung field segmentation was used
- On manual inspection, lung fields had to be manually outlined in 37% (237/644) of the CXR with CXR-PEP.

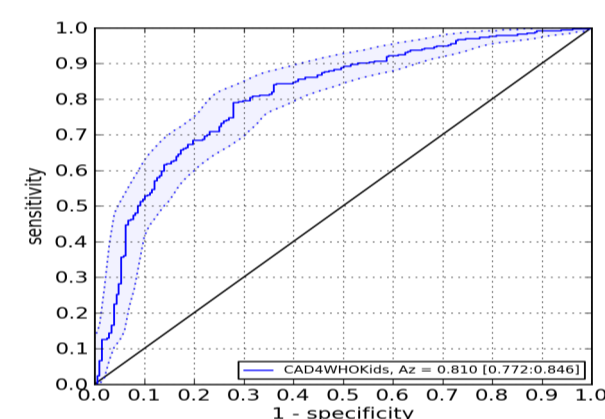
FIGURE 2. ROC curve for using computer aided diagnosis (CAD) to differentiate CXR-PEP vs non CXR-PEP\*



For CXR-PEP vs non CXR-PEP, from 858 chest X-rays where 333 had CXR-PEP, CAD4WHOKids had a sensitivity of 76%, specificity of 80%, and **area under the ROC curve of 0.850** (95% CI 0.823-0.876)

\*Non CXR-PEP: includes chest X-rays with OI only and normal chest X-rays

FIGURE 3. ROC curve for using computer aided diagnosis (CAD) to differentiate CXR-PEP vs. OI only



For CXR-PEP vs other infiltrate only, where normal chest X-rays were excluded, from the 541 chest X-rays CAD4WHOKids had a sensitivity of 77%, specificity of 73%, and **area under the ROC curve of 0.810** (95% CI 0.772-0.846)

## LIMITATIONS

- JPG format chest X-rays used, results in loss of image information in the reduction to 8 bit (256) gray values.
- Dicom data could have provided better resolution.
- Lung fields were manually corrected in 37% (237/644) of the chest X-rays with CXR-PEP.
- Need for improvement of automatic lung field segmentation.

## CONCLUSIONS

- CAD4WHOKids texture analysis is promising for identifying WHO CXR-PEP in children and differentiating from other infiltrate and normal chest X-rays.
- Further multicentre studies with larger sample sizes are required for optimization of automatic lung fields segmentation, validation of the CAD4WHOKids software, and subsequent use in clinical studies.

### References

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### Funding

PERCH was supported by grant 48968 from The Bill & Melinda Gates Foundation to the International Vaccine Access Center, Department of International Health, Johns Hopkins Bloomberg School of Public Health.

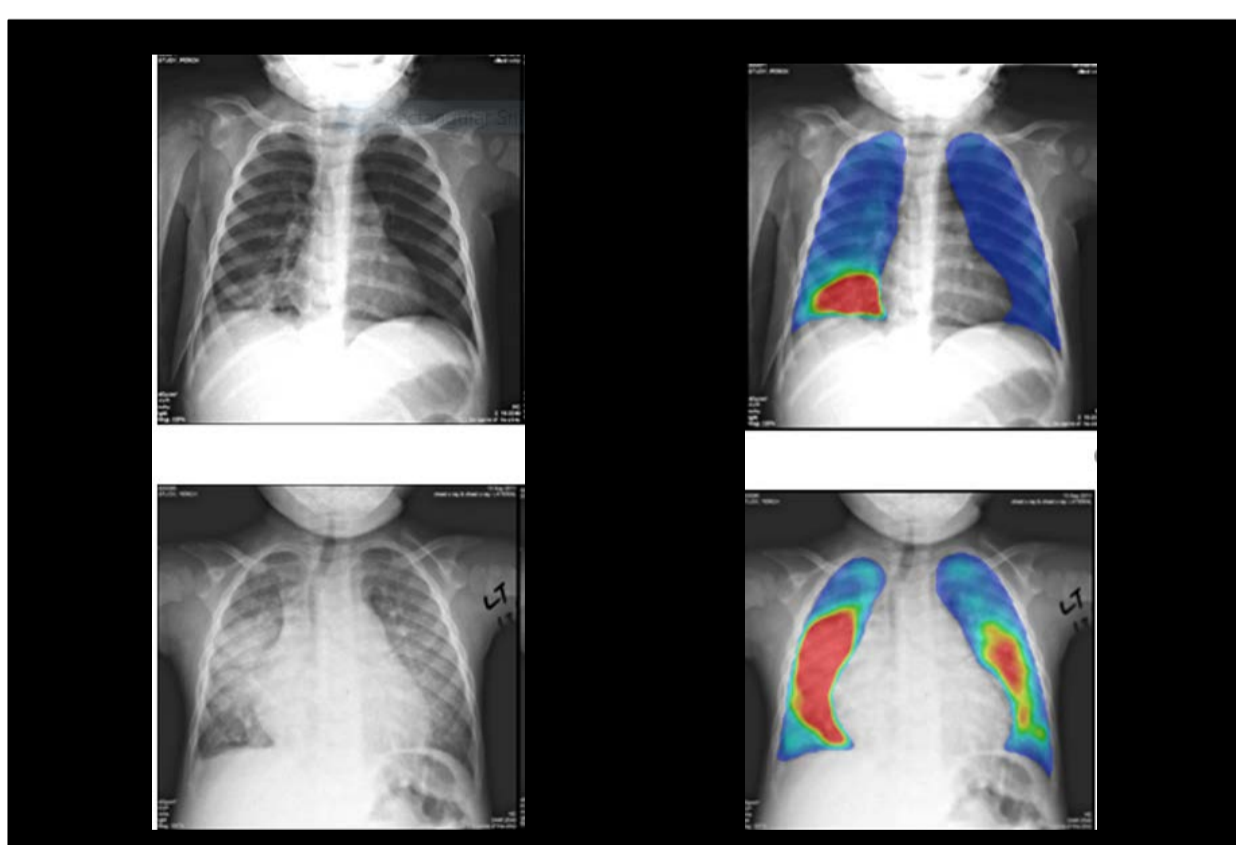


Figure 1: To visualise the working of the texture system, for each image a colour heat map was generated with red representing high likelihood of being abnormal, yellow intermediate, green low, and blue very low. The 2 examples represented here demonstrate good correlation between CAD4WHOKids colour heat map and the areas of CXR-PEP on the test images.

