Automated Intelligent Image Diagnostics, LLC

AIID

Operation Deep(Learning) Breath

Saving Lives by Increasing Access to Healthcare Diagnostics Technology

Roadmap for today

AIID

- **Problem Overview** – No child should die from pneumonia
- **Partner Background** – The Gates Foundation is well-positioned to make a difference
- **AIID's Solution & Demo** – We have developed an app that can save lives
- **Next Steps & Deployment** – Our solution is relatively cheap and scalable
- **Q&A**

We have options

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MedExpress URGENT CARE Great Care. Fast.

CVS minute clinic™

afc URGENT CARE american family care

Concentra®

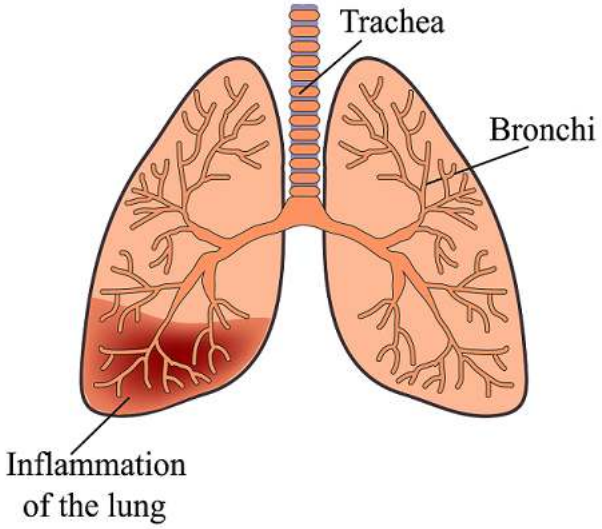
Walgreens healthcare clinic

U.S. HealthWorks® MEDICAL GROUP
A Dignity Health Member

Image Source:
Company websites

Pneumonia is a serious problem

- Pneumonia is the leading cause of death in children worldwide
- Although most cases of pneumonia can be easily treated with antibiotics, “only one third of children with pneumonia receive the antibiotics they need”
- Most prevalent in South Asia and sub-Saharan Africa
- Causes: Viruses, bacteria, or fungi



Sources:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5508893/
https://www.who.int/en/news-room/fact-sheets/detail/pneumonia

Protect, prevent, treat framework

Global Action Plan for Pneumonia and Diarrhea created by the WHO and Unicef

The Gates Foundation's Global Health Division Strategy

- Increase access to pneumococcal and meningococcal vaccines
- Improve access to appropriate diagnostic and treatment options
- Improve quality of pneumonia-related data collection
- Researching links between pneumonia and indoor air pollution

Areas of Focus

- Countries where the introduction to vaccines is lagging
- Prioritizing children under the age of 5

Sources:
https://www.gatesfoundation.org/What-We-Do/Global-Health/Pneumonia

How can we make a difference? Scalable solutions...

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Current

Widespread lack of access to:

- X-ray facilities
- Doctors who can interpret X-rays
- Speedy diagnosis

Future

- Mobile X-Ray Pop-Up Shops
  - Low capital expenditures and allows for easy and configurable deployment
- Machine Learning
  - Remove bottleneck and quickly scale up
- Easy-to-use Dashboard
  - Identify areas in greatest need of mobile X-rays
  - Measure performance, bring accountability

Labeled images from UCSD used to train & test CNN

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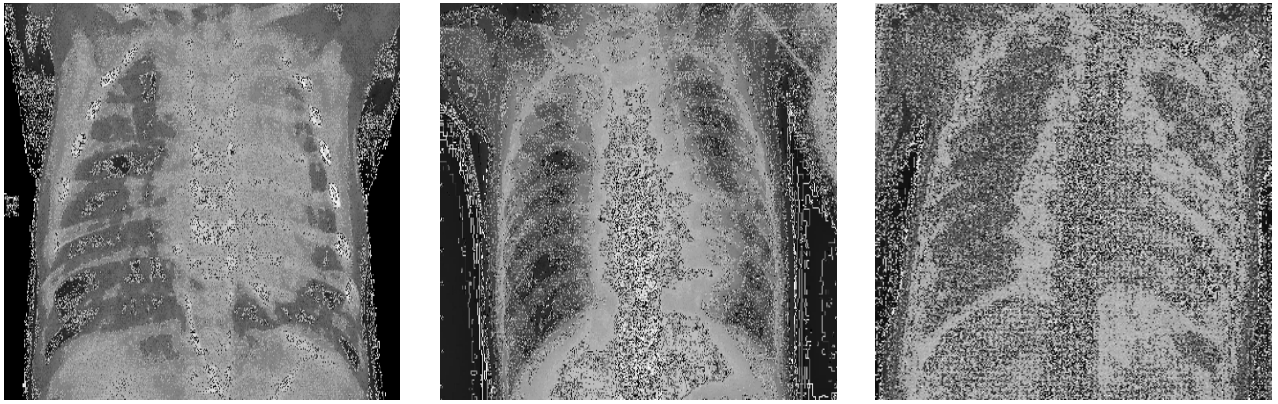
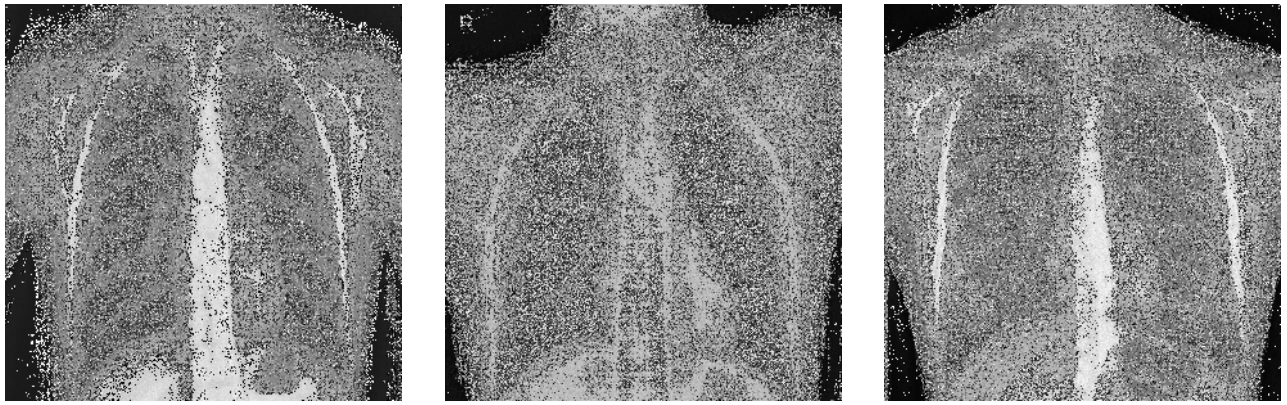
Pneumonia

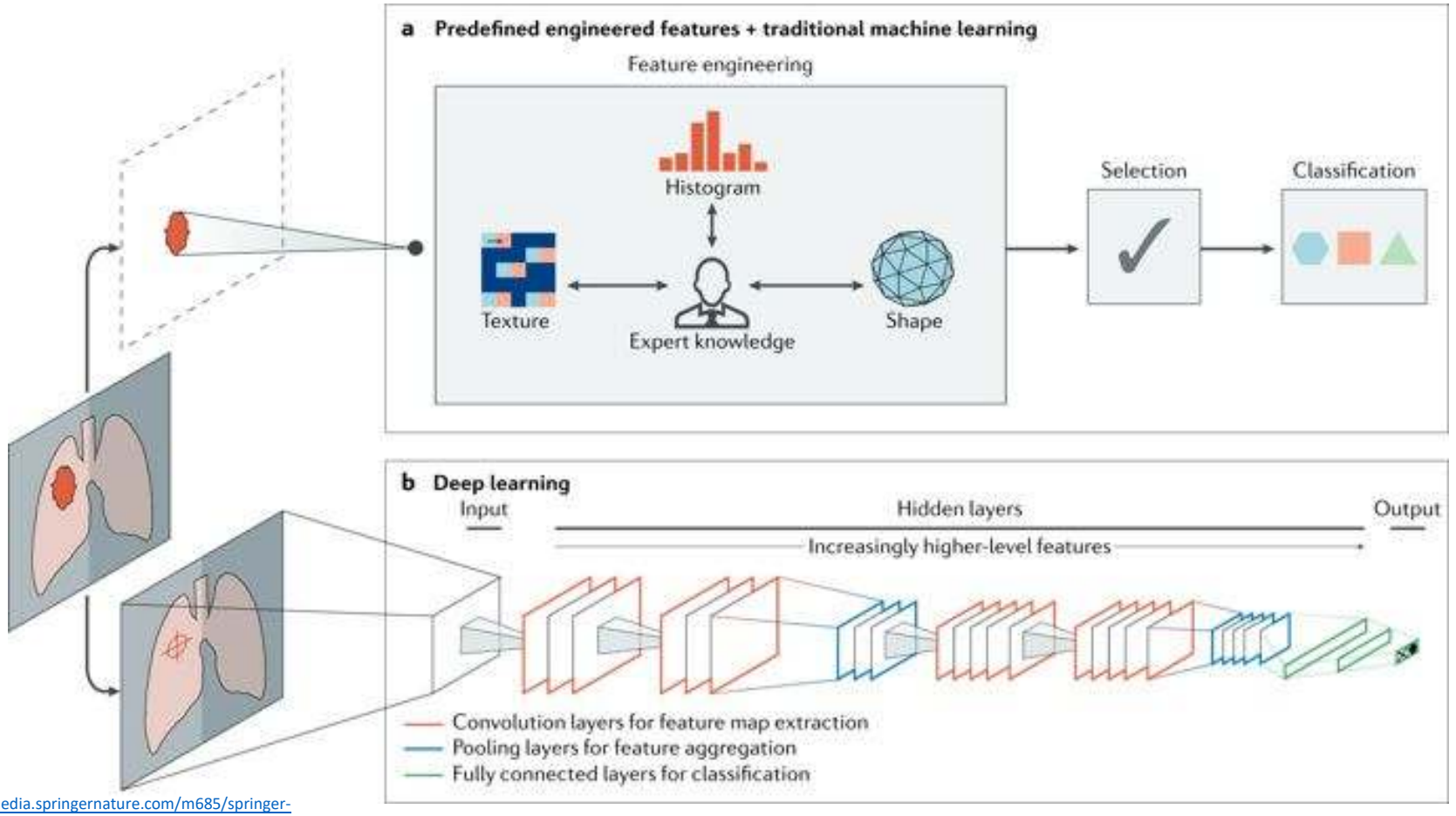


Healthy



Sources:
https://data.mendeley.com/datasets/rscbjbr9sj/2
University of California San Diego

CNN model architecture predicting pneumonia



Source: https://media.springernature.com/m685/springer-static/image/art%3A10.1038%2Fs41568-018-0016-5/MediaObjects/41568_2018_16_Fig2_HTML.jpg

Heat map allows doctors to interpret the X-ray image

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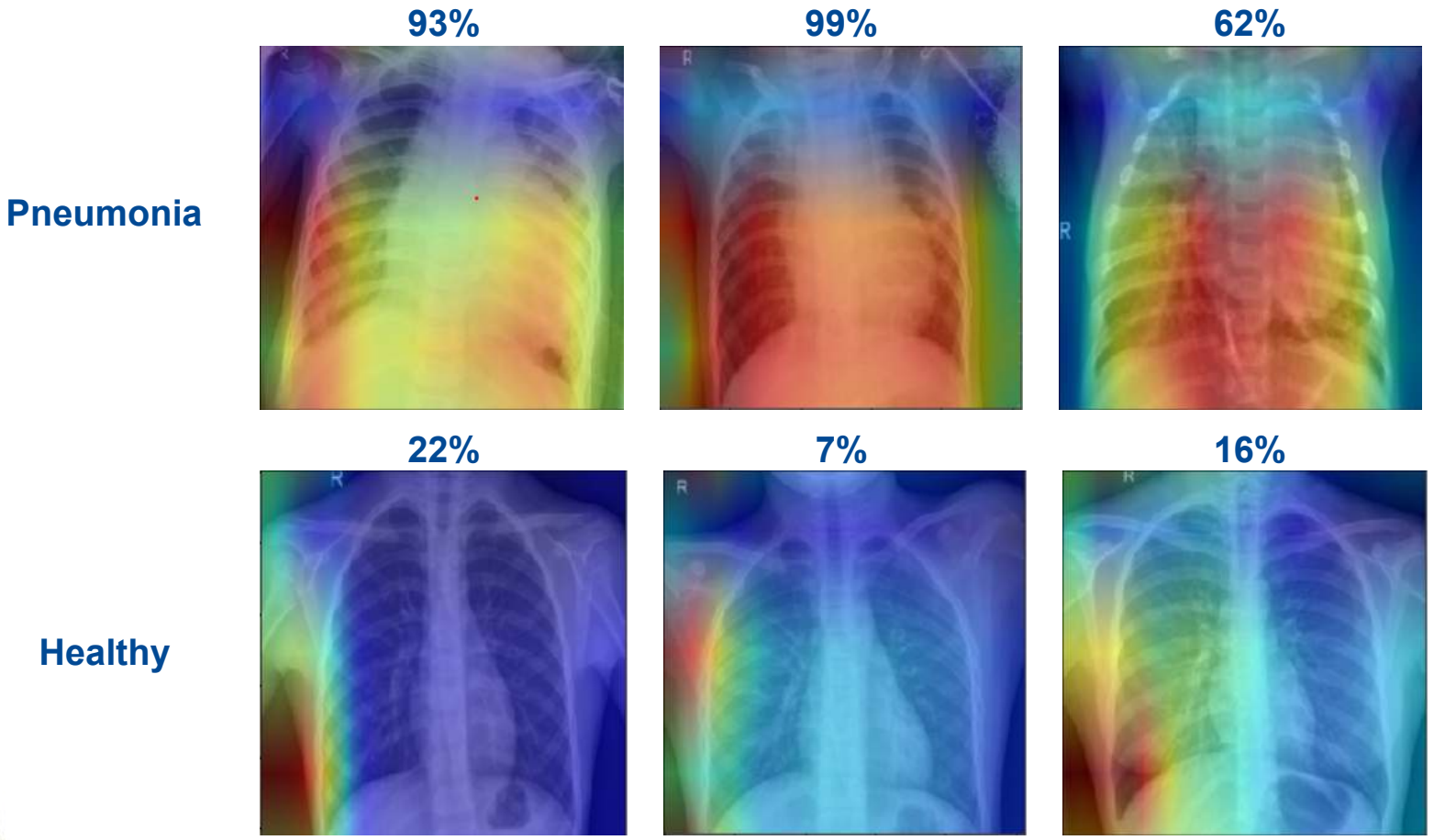
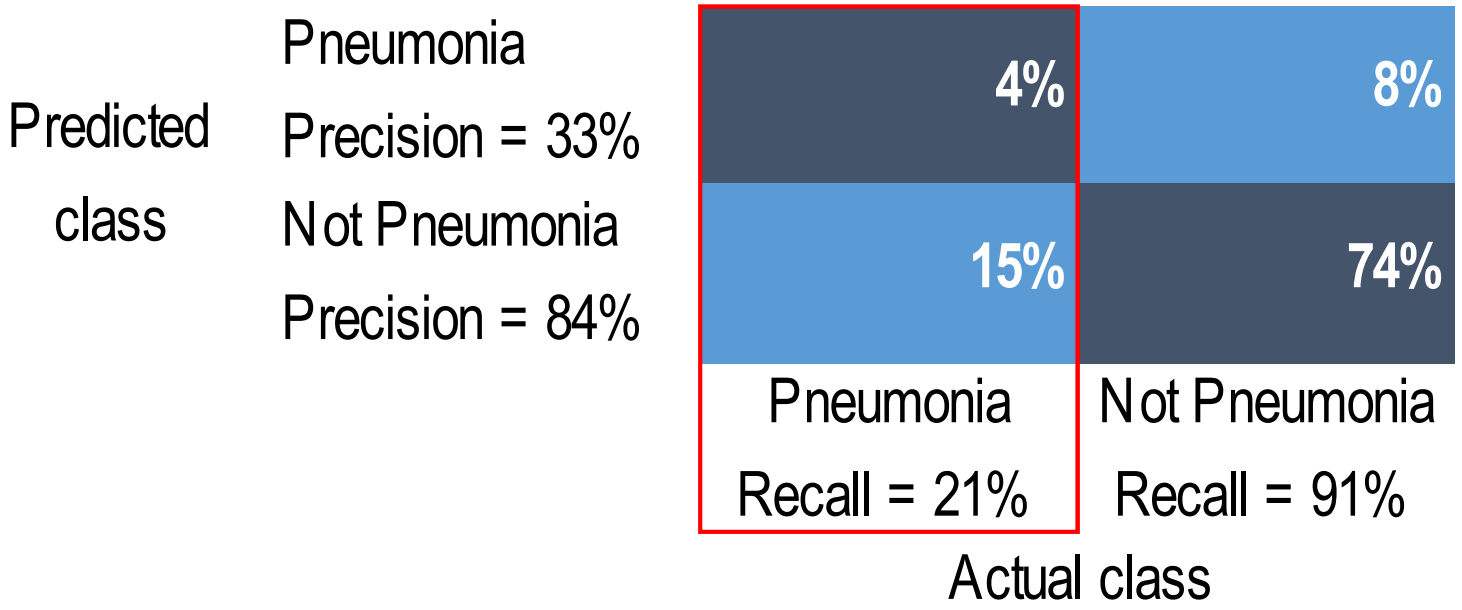


Improper diagnoses are common – a low bar

A recent Harvard study showed that an astounding **79%** of children in Malawi with pneumonia were **misdiagnosed**



Source:
https://gh.bmj.com/content/bmjgh/3/2/e000506.full.pdf

Our model diagnosed 88% of children with pneumonia correctly

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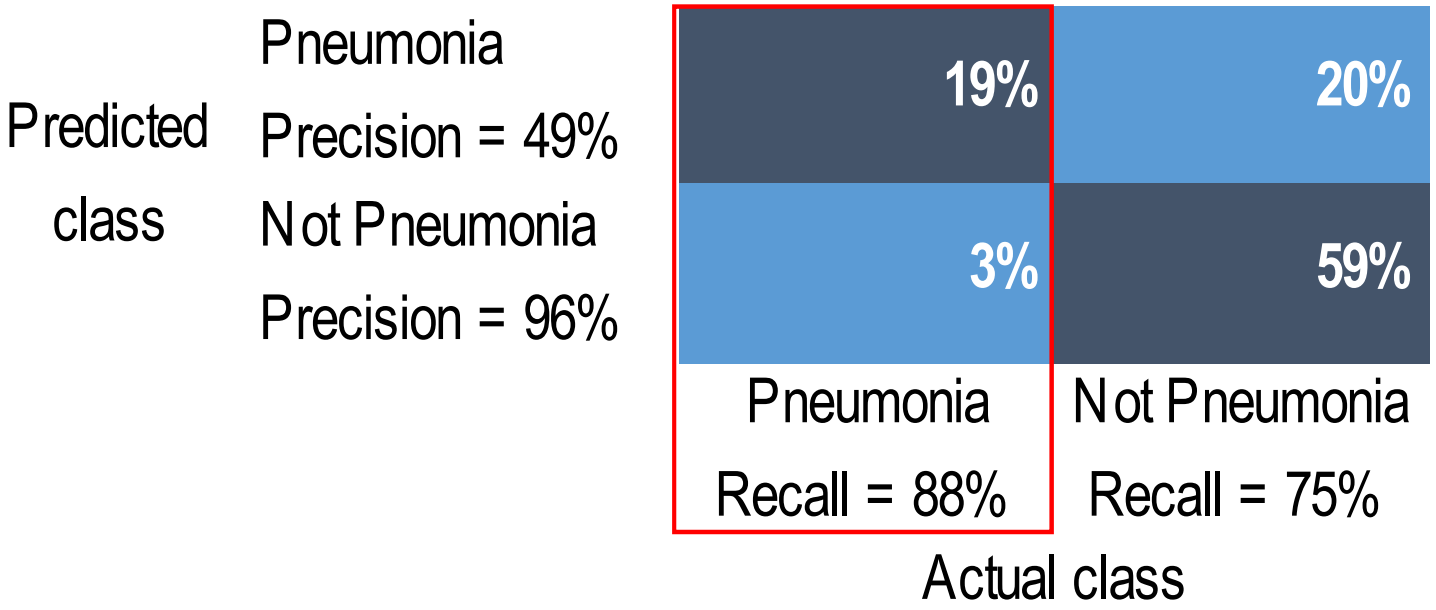
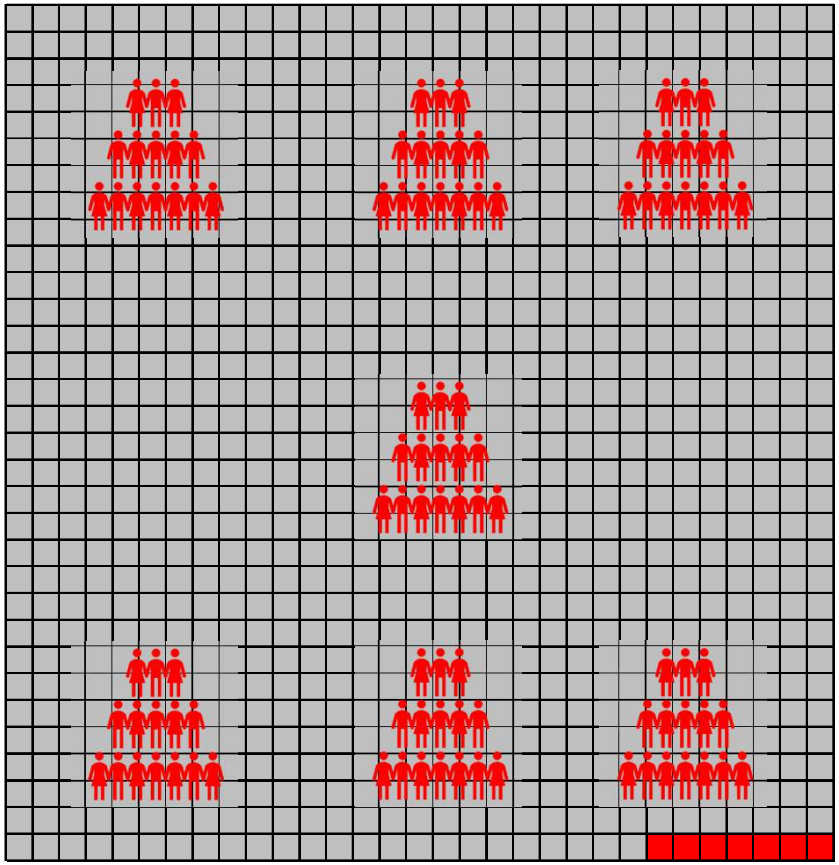
Our model only misdiagnosed **12%** of children.



Given 100,000 children are seen, we estimate…



= 100 patients diagnosed
= 100 patient deaths due to misdiagnosis

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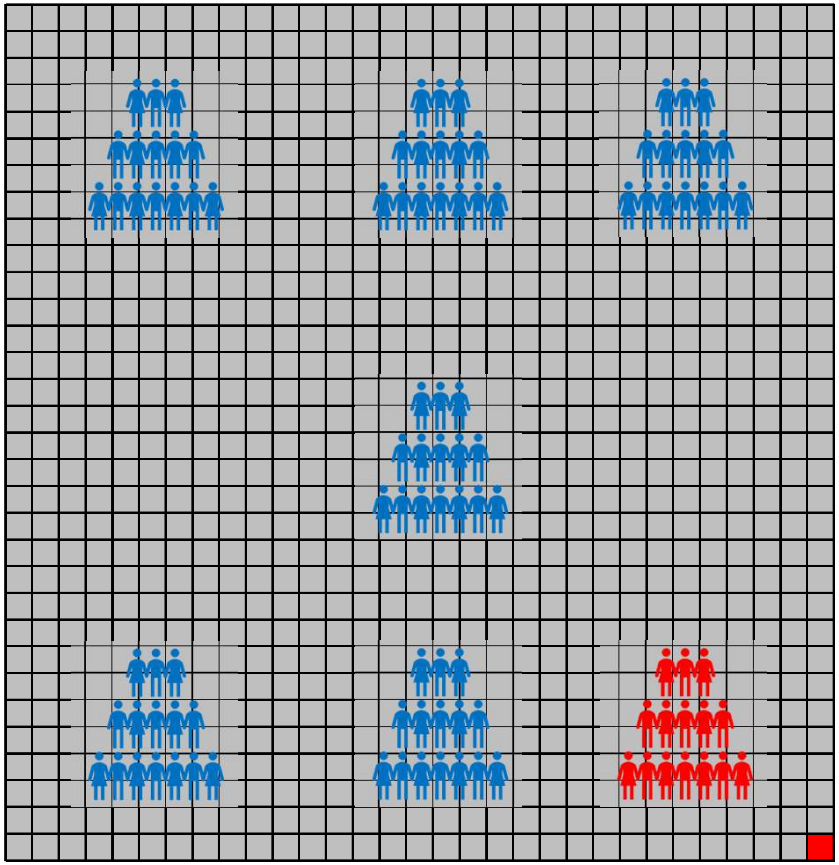

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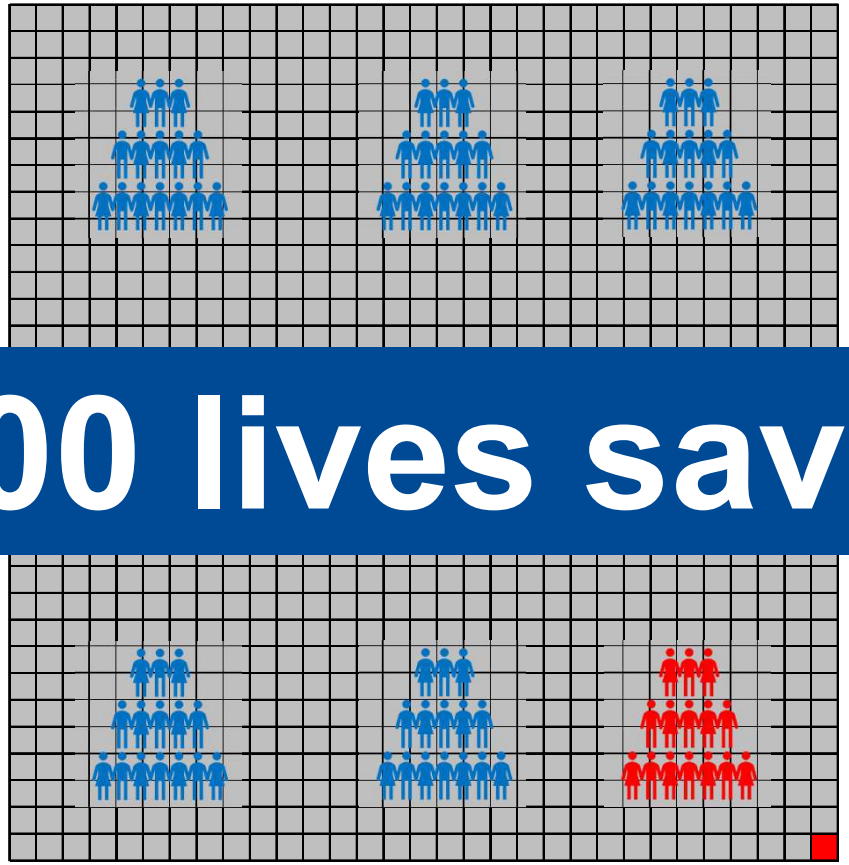
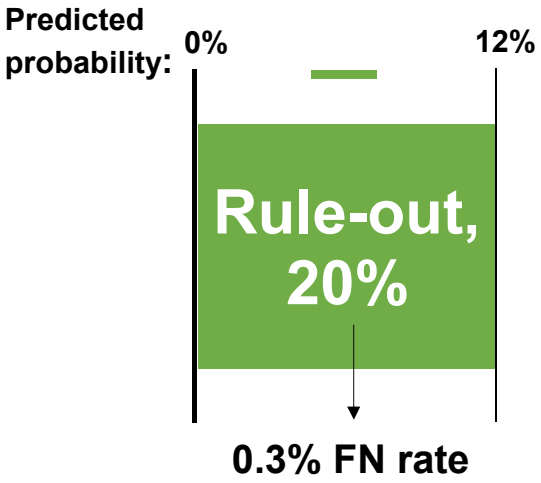


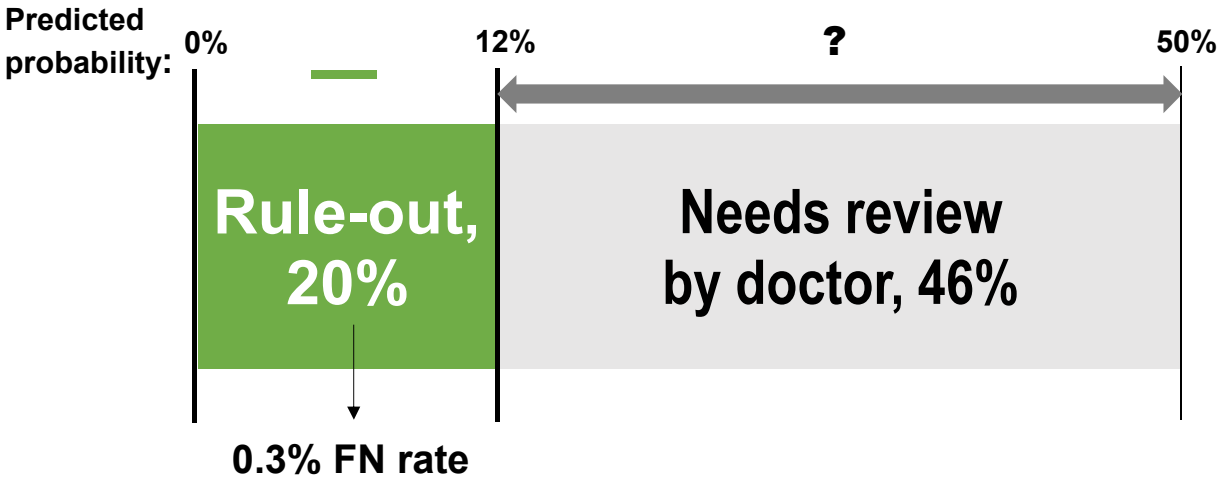
600 lives saved.

= 100 patients diagnosed
= 100 patient deaths due to misdiagnosis

We utilize the ROC curve to risk-stratify patients



We utilize the ROC curve to risk-stratify patients



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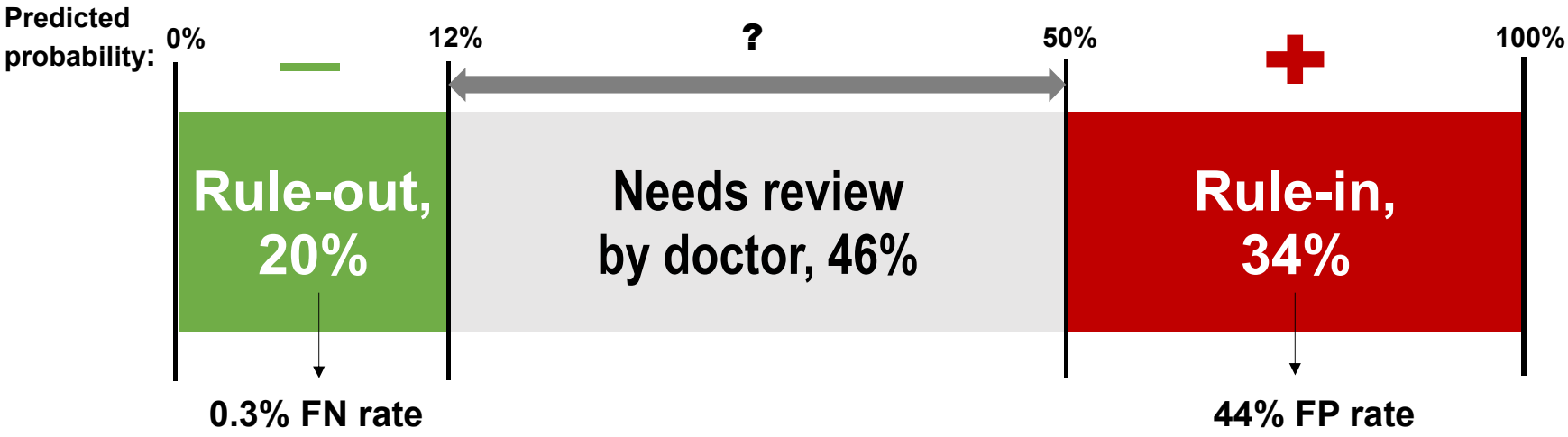
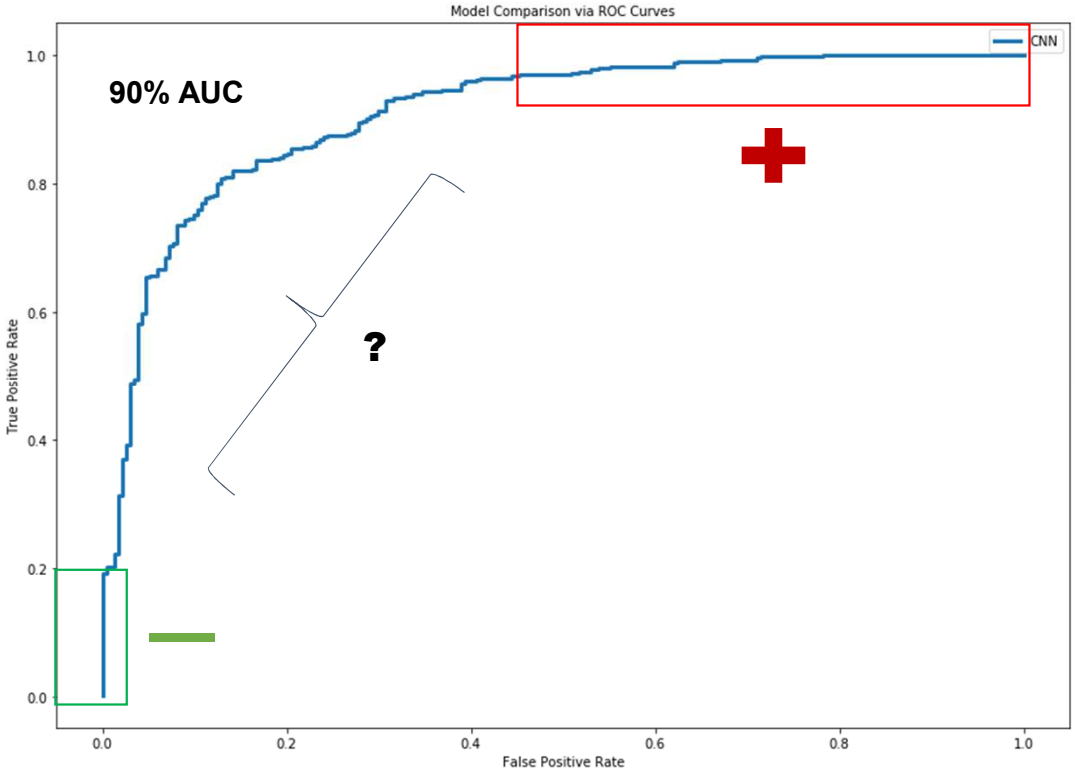


For a subset of medium-risk patients, the algorithm does not perform as well



Epic	As Tara the technician, I want to upload an X-ray image of a child presented with pneumonia symptoms to an internet portal and immediately receive an automated pneumonia diagnosis, such that I can determine whether the patient needs antibiotics.

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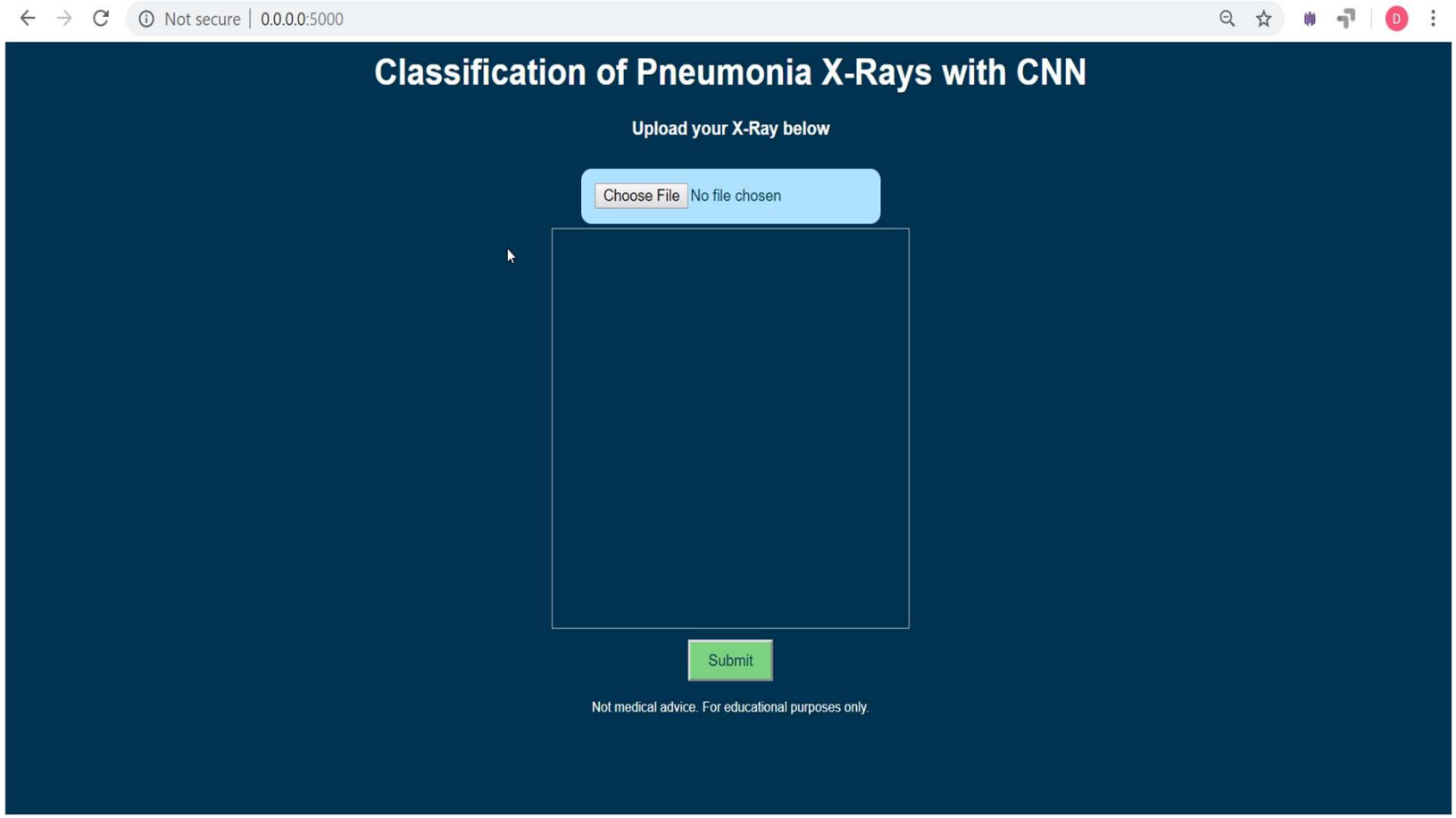

Dashboard Demo

Iterative Process

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We will continue to iterate and improve our app based on the following KPIs:

1. # of images successfully evaluated / # of total attempts (app opened)
2. # of images successfully evaluated after an error message is presented (are people giving up after 1 attempt?)
3. # of X-rays scanned
4. # of patients seen
5. Average wait time of patients
6. Miles traveled by pop-ups

Next Steps

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- Roll out an initial test pilot phase
  - Identify five areas where:
    - Pneumonia deaths are forecasted to be higher than average
    - Infrastructure is in place to easily deploy mobile X-ray pop-ups (roads, safe to travel, etc.)
    - Gates Foundation already operates in
  - Identify technicians who can operate X-rays
  - Train technicians on using AIID's app
- Track pneumonia deaths for one year and compare against control areas

Sources:
https://www.gatesfoundation.org/What-We-Do/Global-Health/Pneumonia

Longer-Term Solution?

Stethoscope with Built-In Machine Learning App

- Diagnoses pneumonia based on the sound of patient breathing
- Cheaper in the longer-term and even more scalable
- Potentially just as effective as X-rays in diagnosing pneumonia

Sources:
https://www.healio.com/cardiology/arrhythmia-disorders/news/online/%7B94f1d946-dea6-4f39-9d2c-696991403b32%7D/digital-stethoscope-with-artificial-intelligence-may-detect-aortic-stenosis
https://www.dreamstime.com/royalty-free-stock-photos-robot-doctor-stethoscope-screen-indicator-show-cardiogram-vector-illustration-image39816998

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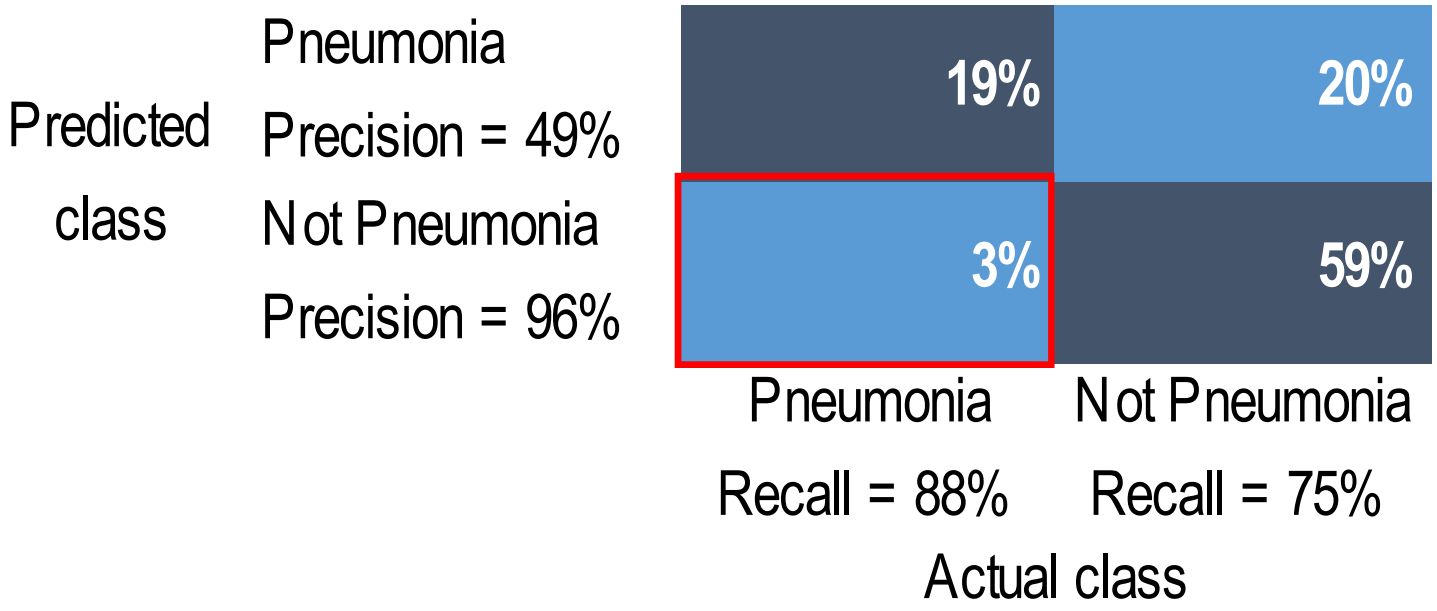
Q&A

Supplemental material

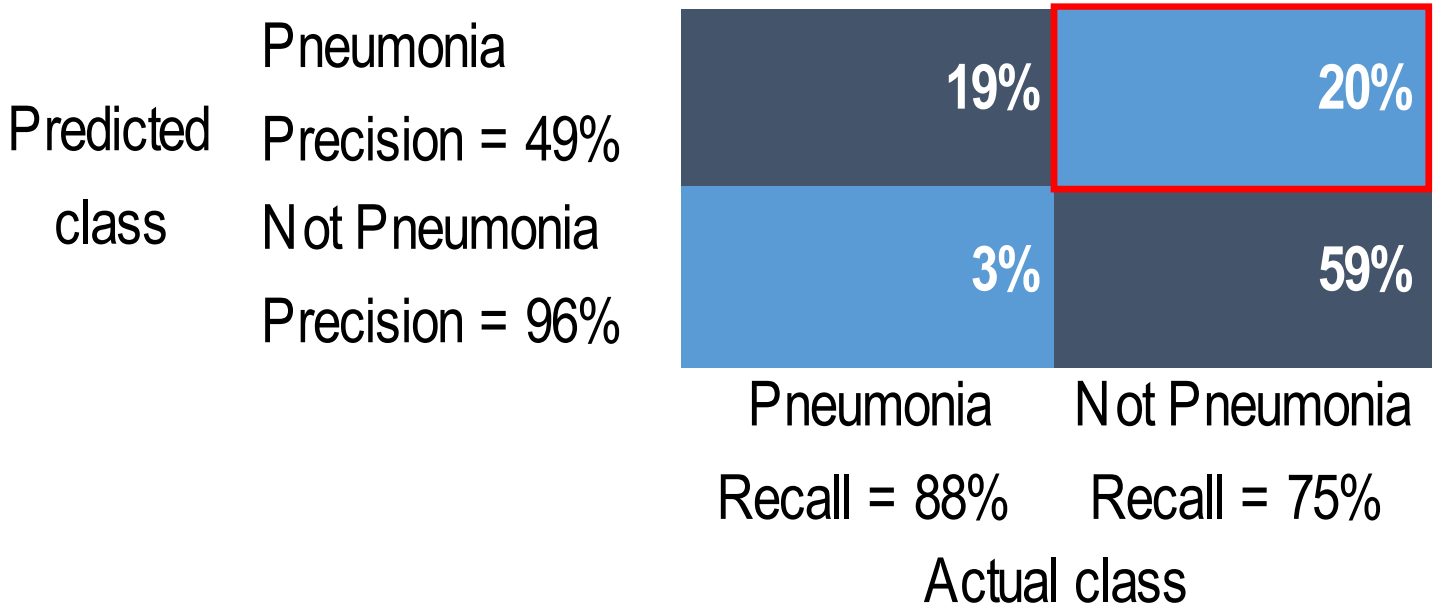
Backup for 600 lives calculation

False negatives: patient does not receive antibiotic and has a 5% chance of fatality



Source: https://www.healthline.com/health/pneumonia/can-you-die-from-pneumonia#risk

False positives: 0.3% change of drug resistance and 29% chance of developing pneumonia again



Sources:
https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1004340
https://www.panafrican-med-journal.com/content/article/13/45/full/

We estimate our lung scans will save over 600 lives if 100,000 patients are seen

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Currently in Malawi: 727 deaths given 100,000 patients

FN Cost = 100,000 × 15% FN × 5% = 725 deaths

FP Cost = 100,000 × 8% FP × 0.3% × 29% × 25% = 2 deaths

727 total deaths

After our scans: 104 deaths given 100,000 patients

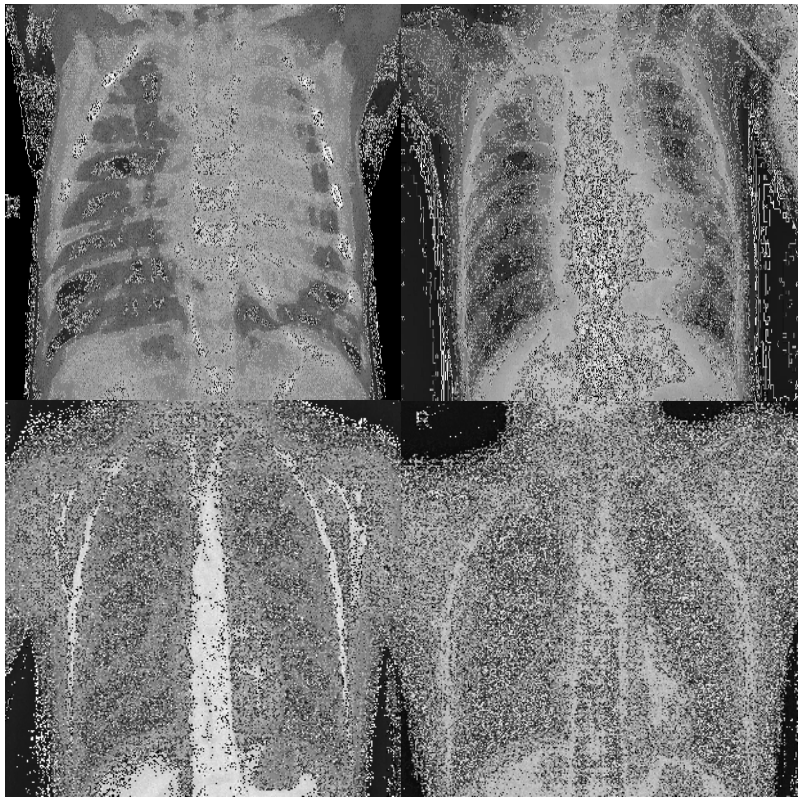
FN Cost = 100,000 × 3% FN × 5% = 99 deaths

FP Cost = 100,000 × 20% FP × 0.3% × 29% × 25% = 5 deaths

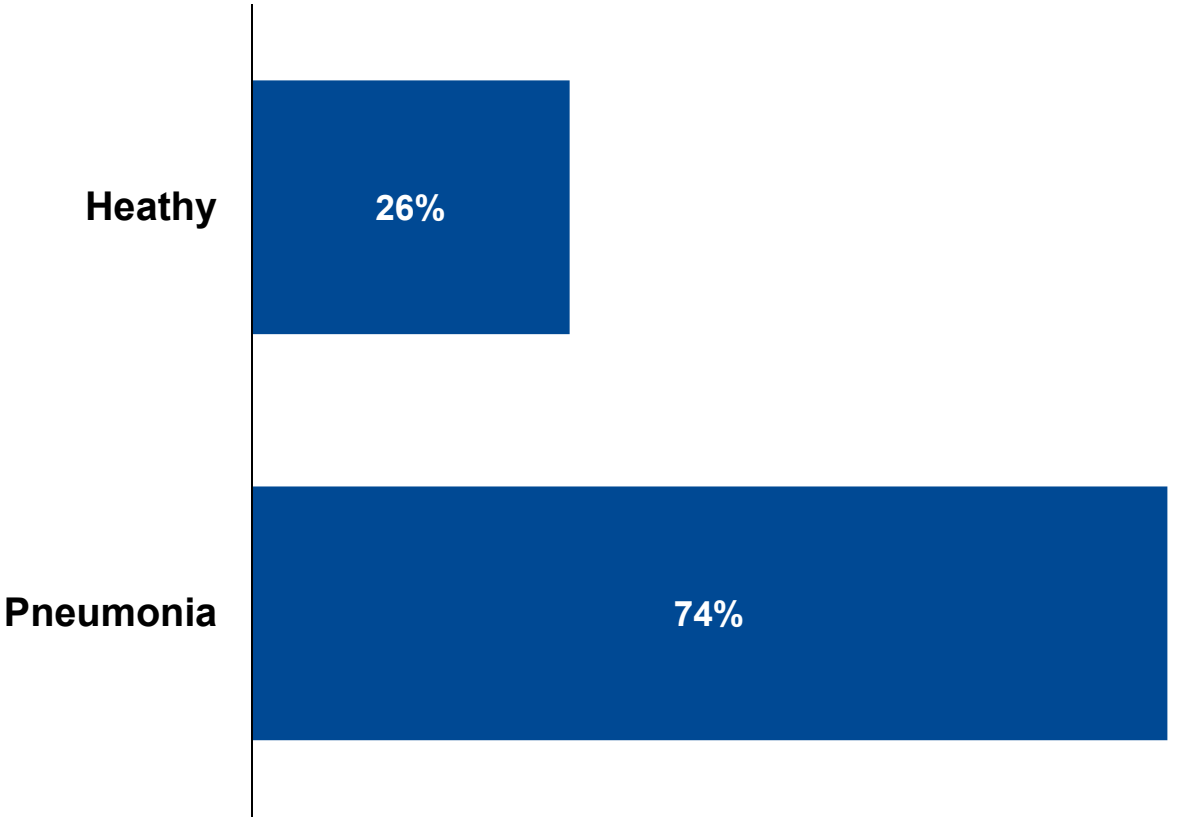
104 total deaths

Additional information on treatment of data

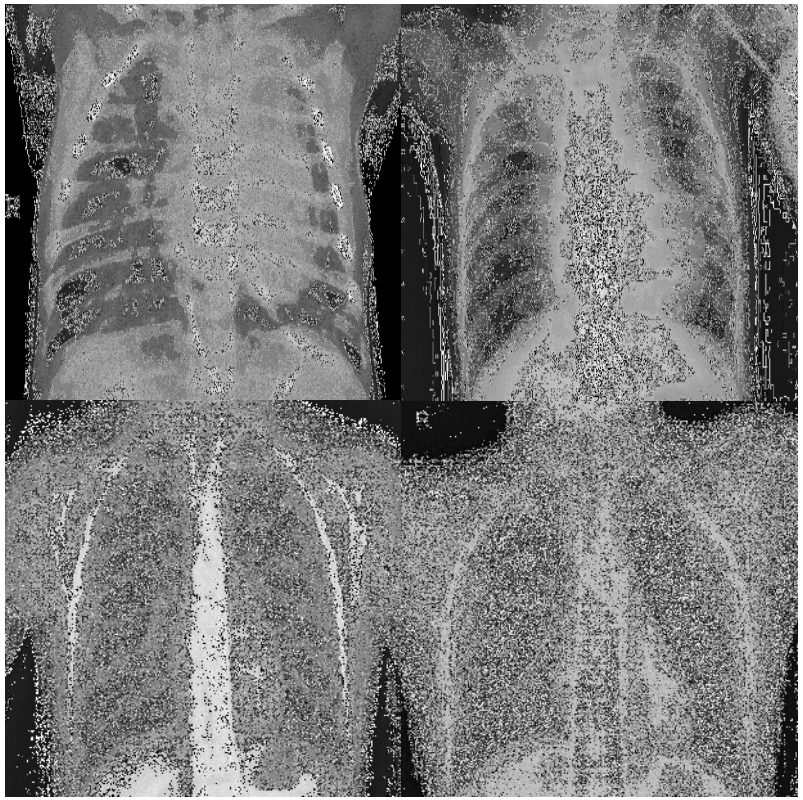
The majority of samples are pneumonia

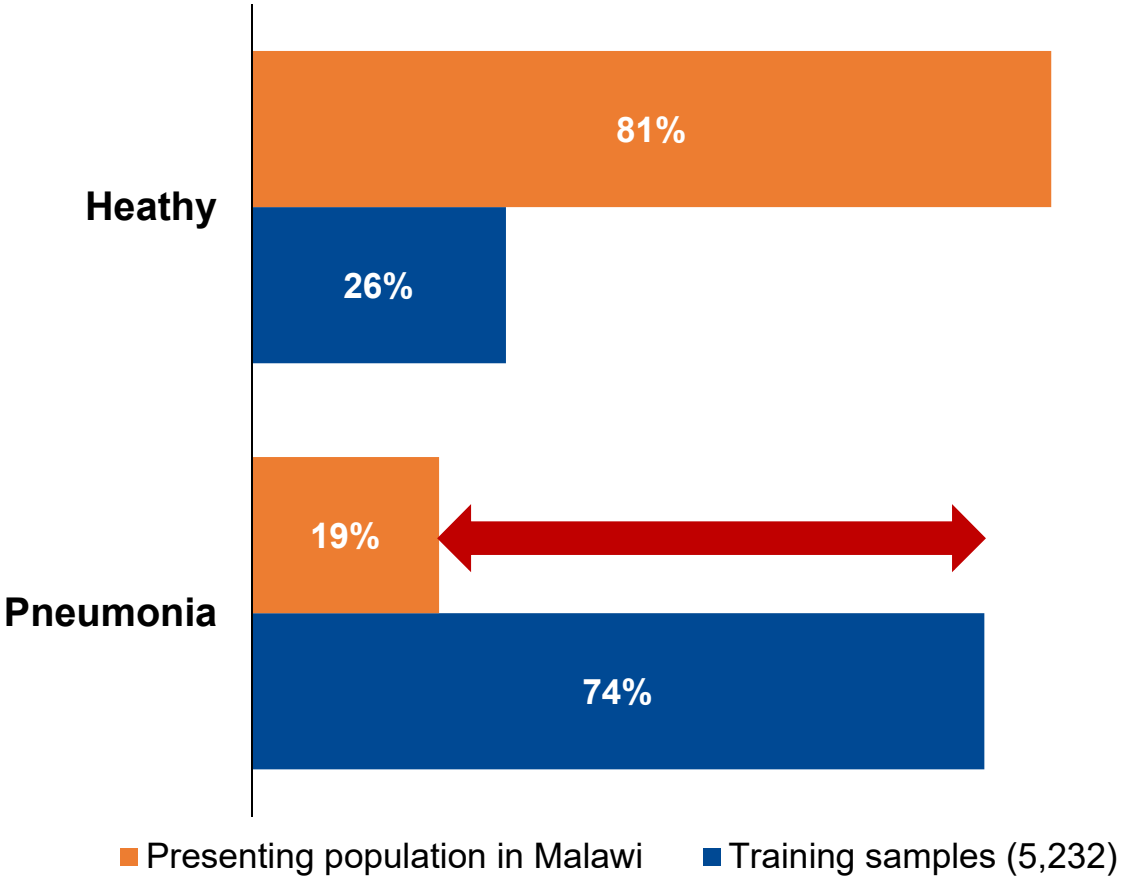


Sources:
https://data.mendeley.com/datasets/rscbjbr9sj/2



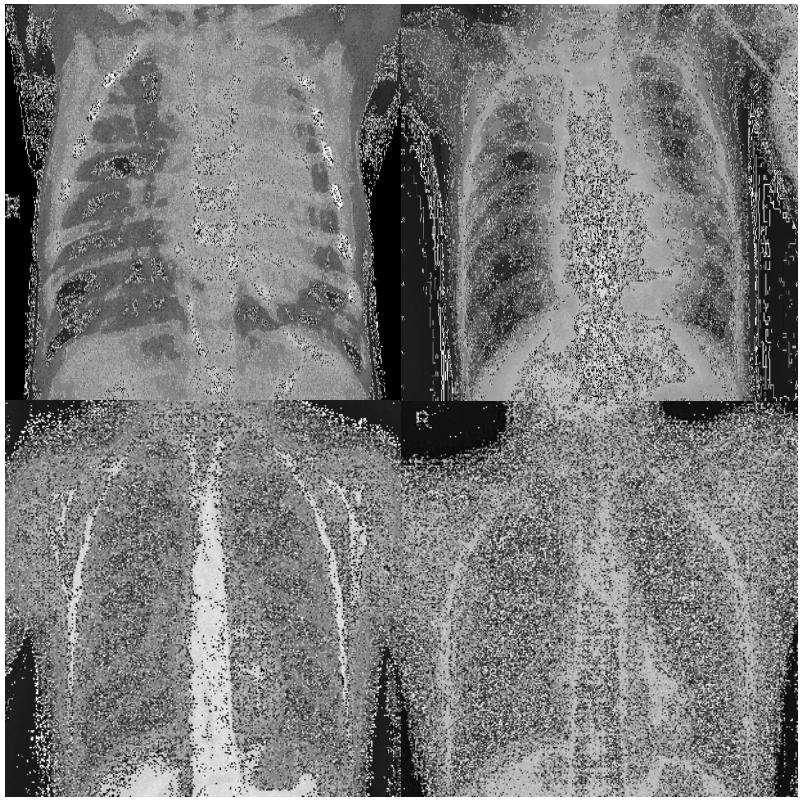
Our sample is a much different population than those patients actually presenting with pneumonia

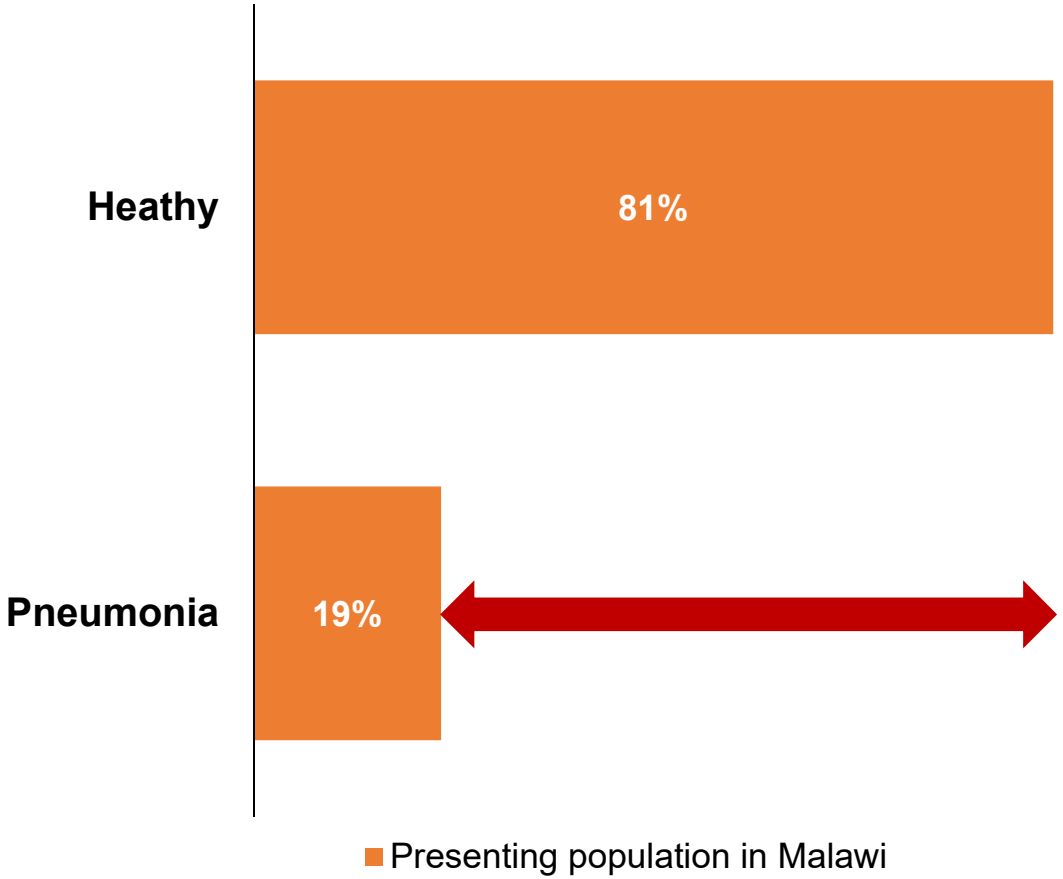




Sources:
https://data.mendeley.com/datasets/rscbjbr9sj/2
https://gh.bmj.com/content/bmjgh/3/2/e000506.full.pdf

There is a class imbalance between healthy and pneumonia patients





Sources:
https://data.mendeley.com/datasets/rscbjbr9sj/2
https://gh.bmj.com/content/bmjgh/3/2/e000506.full.pdf

We correct for the sample bias and class imbalance

(1) We evaluate model performance by reweighting the test sample to reflect the presenting population.

(2) We apply class weighting to apply a greater weight on pneumonia than healthy samples, putting greater emphasis on FN than FP.