MIDRC
MEDICAL IMAGING AND DATA RESOURCE CENTER.

Medical Physicists Enhance AI/ML for Medical Imaging and Therapy

APPM meeting

Session: Medical Physics in Clinical Trials: Design, Quality Assurance, and NIH Programs

Krishna Kandarpa, M.D., Ph.D.
Rui Pereira de Sa, Ph.D.
The National Institute of Biomedical Imaging & Bioengineering

Medical Imaging and Data Resource Center
THE ORIGINS

White House (OSTP) Intra-Agency Working Group on Medical Imaging recommends:
Establishing a public-private forum to coordinate efforts and interests in the artificial intelligence and medical imaging communities. (2017)

Congress, re. NIH-Common Fund, recognized
Insufficiency of platform technologies and inadequate physical sciences input towards emerging unmet needs in Medicine; Cited opportunities for NIH – CF and NIBIB! (2019)

Multi-society International Consensus Statement
Imaging community 'lacks dynamic secure networked systems' that "provide an ethical framework to help steer technological development, influence how different stakeholders respond to and use AI (artificial intelligence), and implement these tools to make the best decisions and actions for, and increasingly with, *patients*."

THERE WAS A MATURING CONSENSUS FOR A CENTRAL STATE-OF-THE-ART RESOURCE TO ACCELERATE REAL-WORLD CLINICAL APPLICATIONS OF AI IN MEDICAL IMAGING

Medical Imaging and Data Resource Center
NIBIB RESPONSE

NIBIB: Trans-NIH Workshops on AI in Medical Imaging

- **AI in Medical Imaging** (August 2018)
- **Acceleration of Clinical Applications of Machine Intelligence in Medical Imaging** (November 2019)

Concomitant WS by ARBIR/NIST, RSNA and AAPM (2018-2019) confirm current gaps & opportunities!

Medical Imaging and Data Resource Center
LESSONS FROM NIBIB WORKSHOPS

SEVERAL CRITICAL GAPS WERE IDENTIFIED:

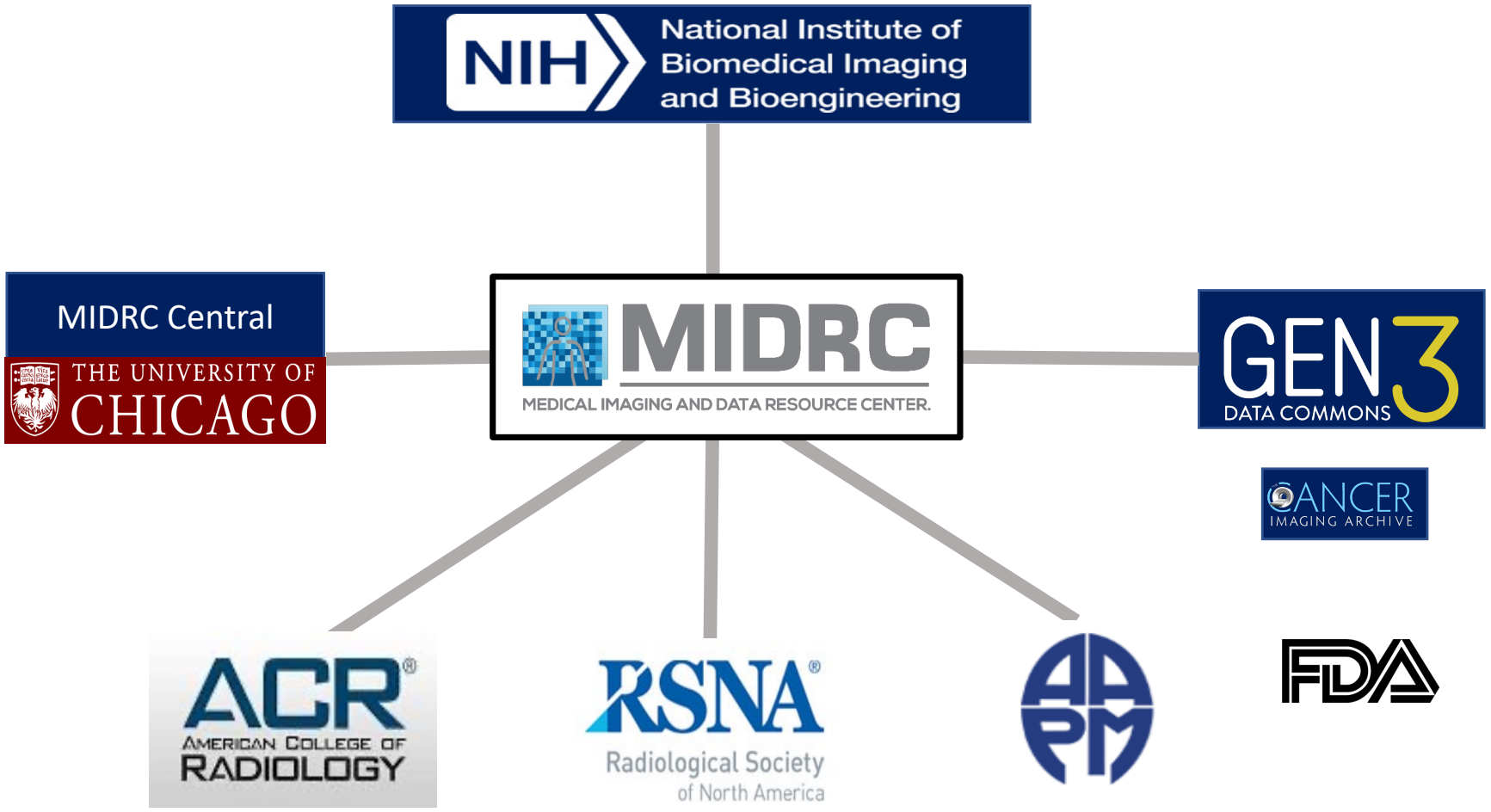
1) Absence of large, curated, inclusive & diverse medical image datasets
2) Need to integrate siloed databases & knowledgebases
3) Need to develop non-redundant efficient AI tools
4) Need to create an ecosystem of stakeholders to develop clinically validated AI applications that improve patient management and clinical outcomes

Medical Imaging and Data Resource Center
Rapid Response to Covid-19 Pandemic

THE QUEST FOR A USE CASE: COVID ARRIVES

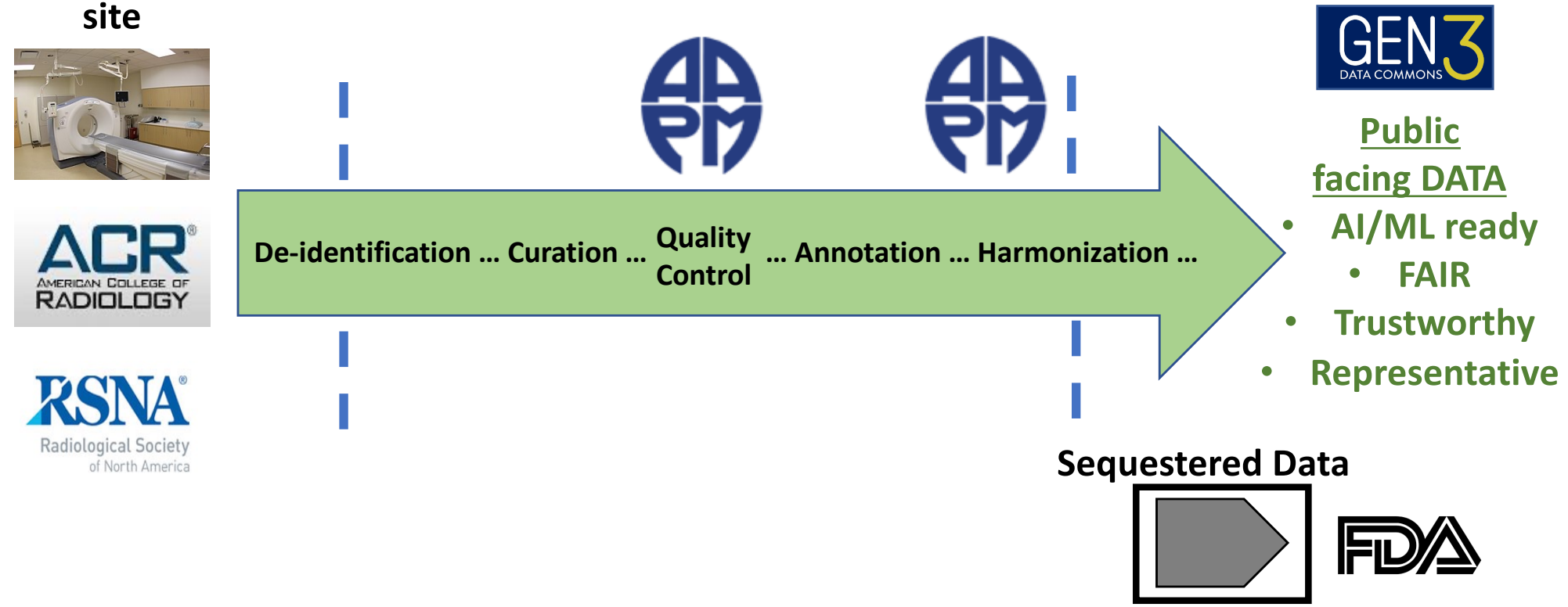
PURPOSE: **Collect and curate medical imaging** along with **adjunct clinical data** and **develop artificial intelligence** (AI / ML) **methods** to aid in the analysis & interpretation of medical images in response to Covid-19 pandemic

Medical Imaging and Data Resource Center
Rapid Response to Covid-19 Pandemic



Data Ingestion, Infrastructure and standardization of processes

- Infrastructure & standardization:
  - Harmonization of data ingestion, quality control, data flow, common data model, de-identification procedures,…



Medical Imaging and Data Resource Center
Rapid Response to Covid-19 Pandemic

Two Major Scientific Components

Creation of Open Discovery Data Repository:

5 Technology Development Projects

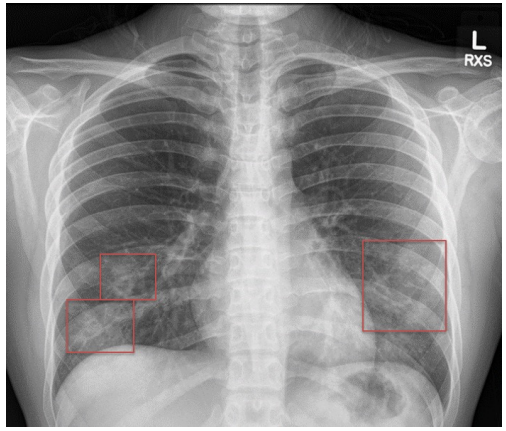
Machine Intelligence Computational Capabilities:

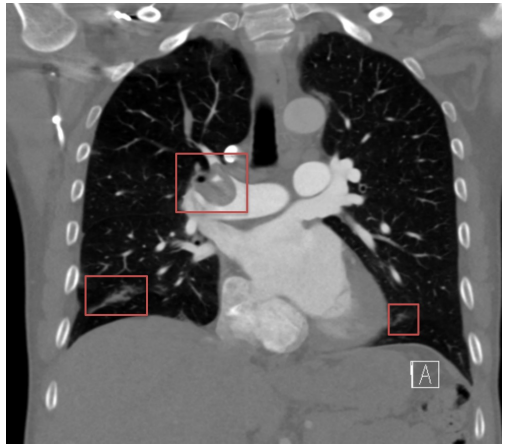
12 Collaborative Research Projects

And multiple trans-MIDRC scientific workgroups

MIDRC: Beyond Acute Covid-19 Long-Covid

MIDRC
MEDICAL IMAGING AND DATA RESOURCE CENTER.



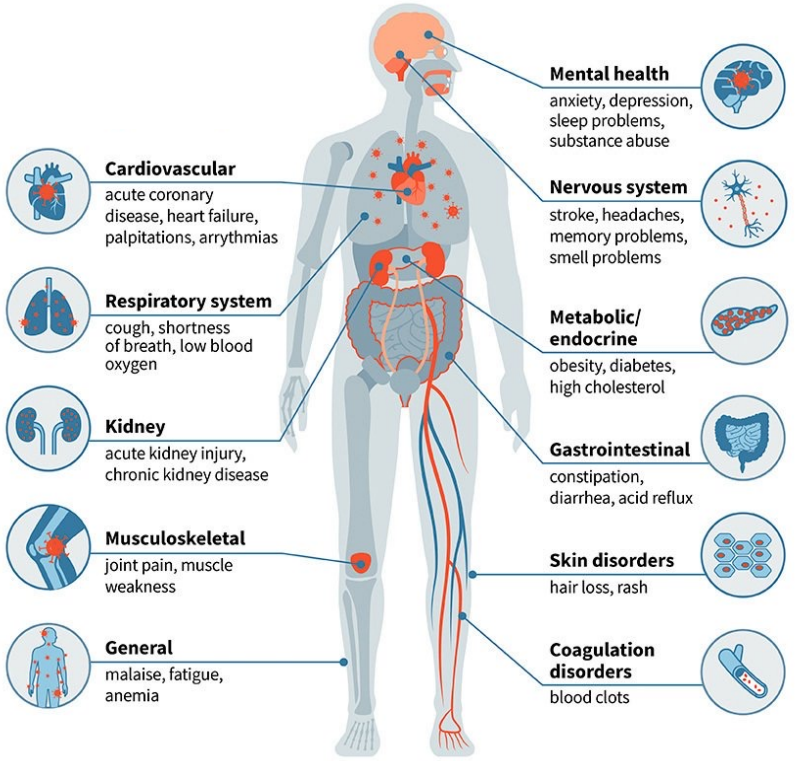


Acute Covid

AI / ML

- Identify infection
- Diagnose disease
- Assess extent
- Monitor therapy
- Detect complications
- Predict outcome / PASC

PASC



nature
https://doi.org/10.1038/s41586-021-03553-9
Accelerated Article Preview

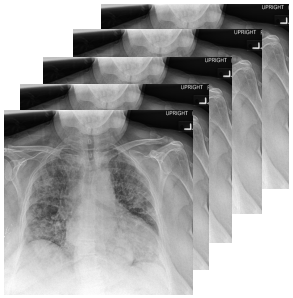
High-dimensional characterization of post-acute sequalae of COVID-19

Received: 18 January 2021
Accepted: 14 April 2021

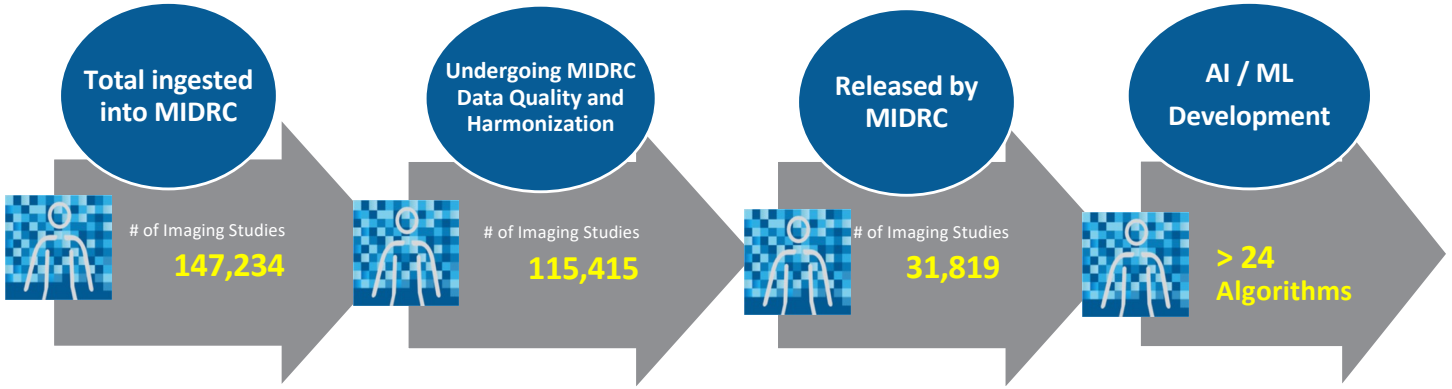
Ziyad Al-Aly, Yan Xie & Benjamin Bowe

Medical Imaging and Data Resource Center

MIDRC
MEDICAL IMAGING AND DATA RESOURCE CENTER



Deidentification



- **Open commons: released ~ 2.5Tb of data**
  - ~32,000 imaging studies, ~12,000 patients
- **150 data users, from 110 institutions**
- **13 publications**
- **40 contributing sites ~ 23 US states**
- **Interoperability:**
  - Successful pilot with BioData Catalyst (NHLBI)
  - Ongoing pilot with N3C (NCATS)
  - Federated learning pilot - Argonne National Lab

- **Sequestered commons ***
  - ~5,000 imaging studies, ~2,500 patients

* Real world assessment of algorithmic performance, accelerating clearance and clinical deployment

AMERICAN ASSOCIATION of PHYSICISTS IN MEDICINE

ACR AMERICAN COLLEGE OF RADIOLOGY

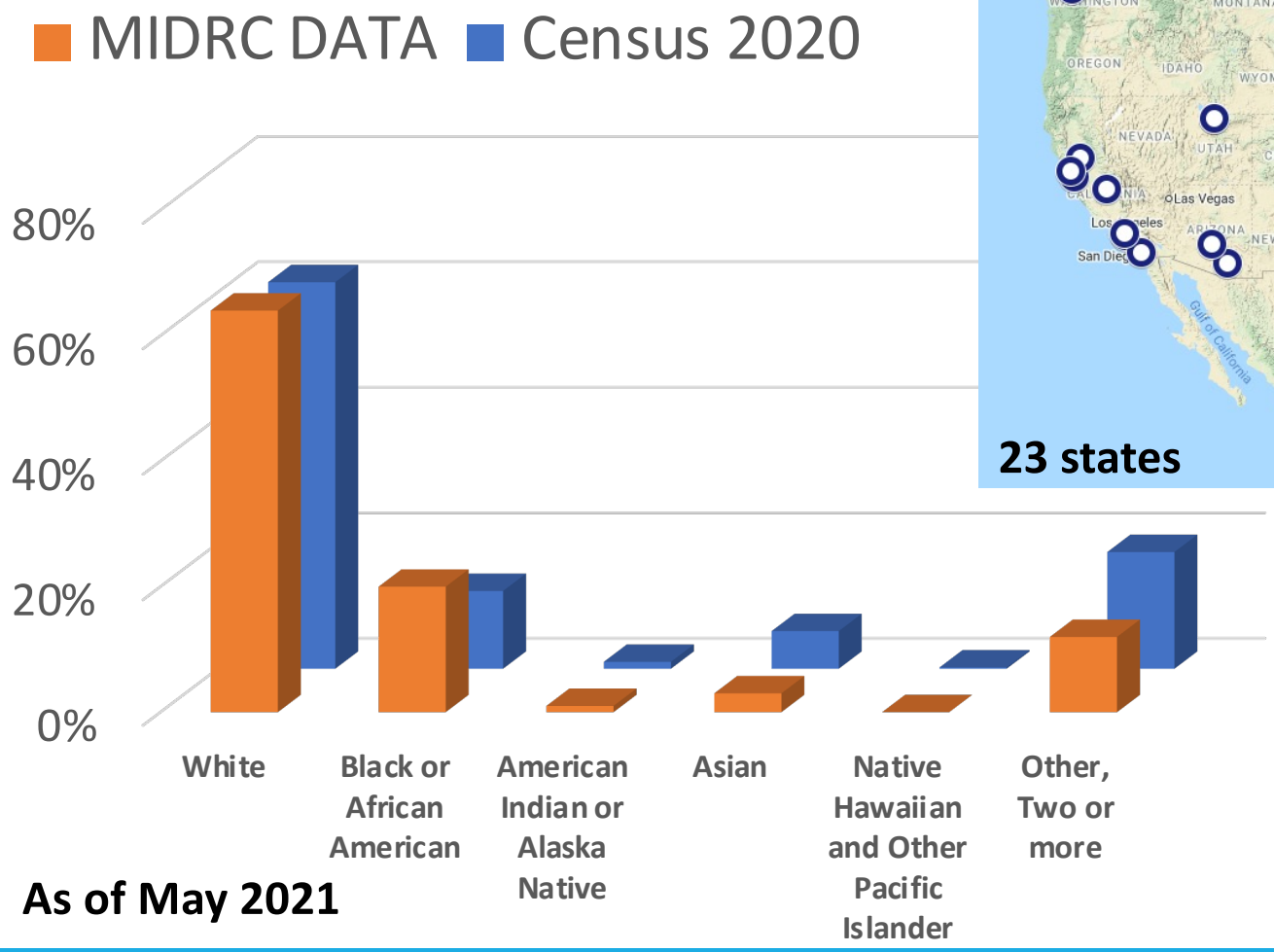
RSNA Radiological Society of North America

THE UNIVERSITY OF CHICAGO

MIDRC
MEDICAL IMAGING AND DATA RESOURCE CENTER.

Data contributors

Diversity and Representativity of MIDRC Data



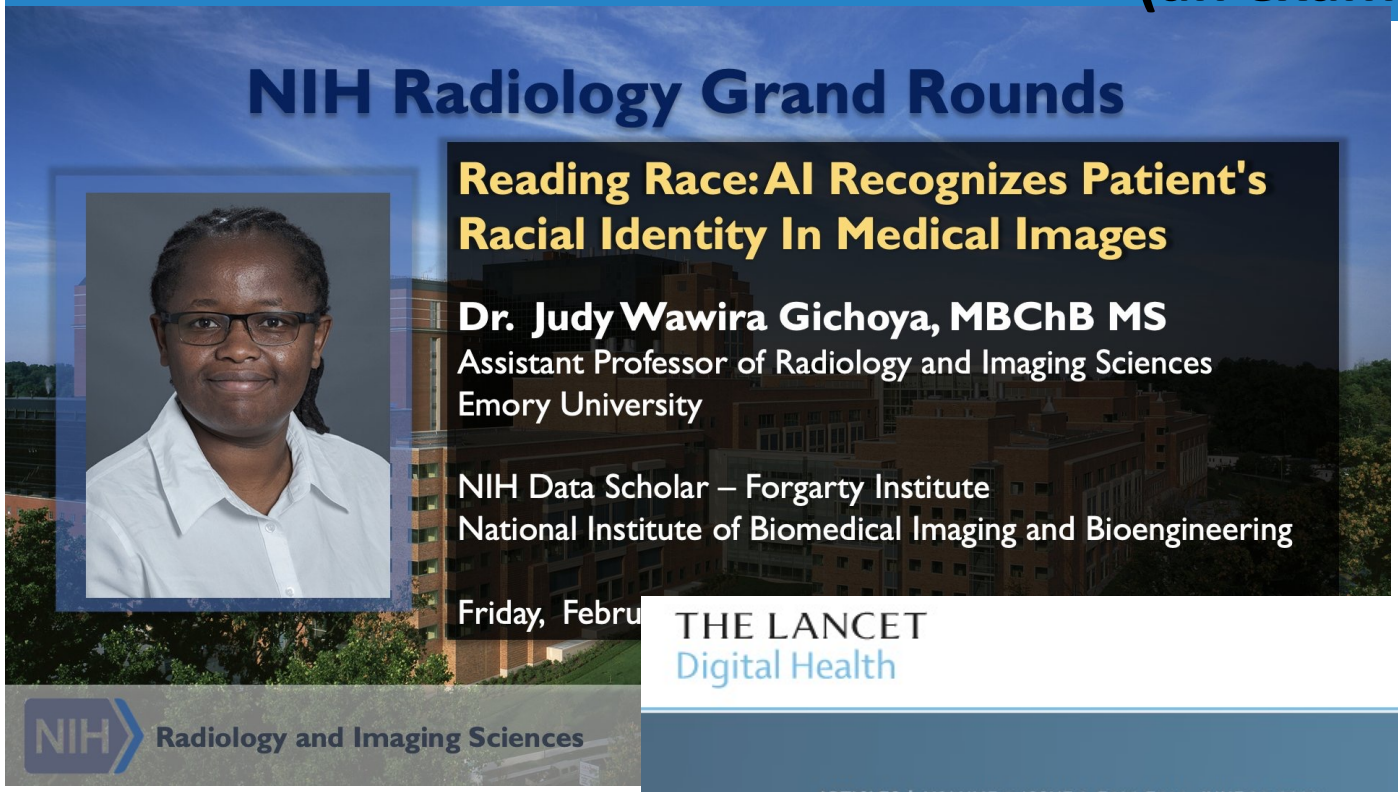
As of May 2021

MIDRC Accomplishments
AI/ML algorithms by MIDRC investigators (selected)

Selected examples:

- AI/ML algorithms for:
  - Covid-19 diagnosis from chest radiographs
  - Predict severity (from chest CT, radiographs, based on outcomes, intubation, ICU, steroid use)
  - Assess extent of lesions, image segmentation (Chest CT, radiographs)
- Predictive model of the need for intensive care from chest radiographs
- Natural Language Processing (NLP) for extracting information from radiological reports
- Outcome prediction from medical imaging alone, clinical data alone, and fusion models combining imaging and clinical data.

MIDRC Accomplishments
AI/ML algorithms by MIDRC investigators (an example)



THE LANCET
Digital Health

ARTICLES | VOLUME 4, ISSUE 6, E406-E414, JUNE 01, 2022

AI recognition of patient race in medical imaging: a modelling study

Judy Wawira Gichoya, MD • Imon Banerjee, PhD • Ananth Reddy Bhimireddy, MS • John L Burns, MS • Leo Anthony Celi, MD • Li-Ching Chen, BS • et al. Show all authors

Open Access • Published: May 11, 2022 • DOI: https://doi.org/10.1016/S2589-7500(22)00063-2 •

MIDRC: Merging Medical Imaging and Clinical data

MIDRC
MEDICAL IMAGING AND DATA RESOURCE CENTER.

Integrating Medical Imaging and Clinical data

Interoperability

NIH National Heart, Lung, and Blood Institute | BioData CATALYST

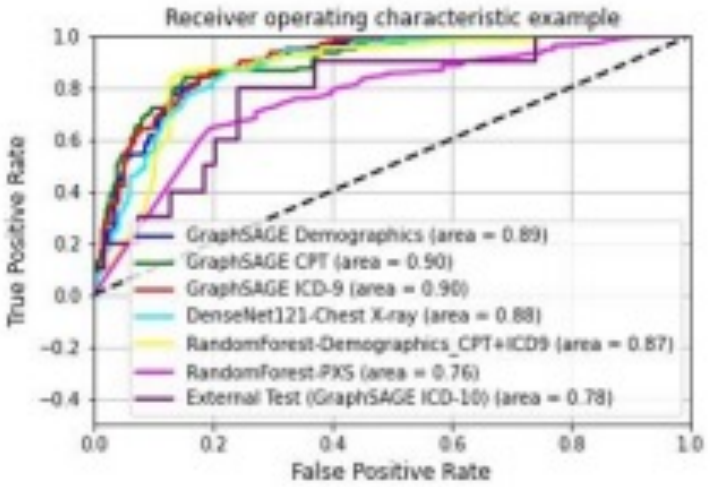
NIH National Center for Advancing Translational Sciences — N3C

All of Us RESEARCH PROGRAM

NIH National Institute of General Medical Sciences — IDeA-CTR

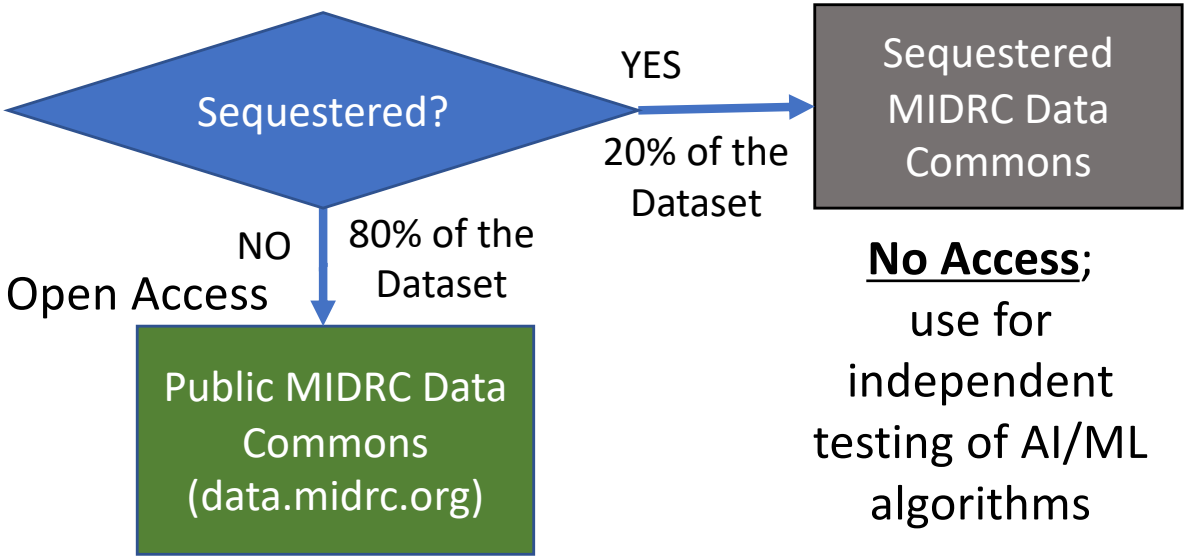
Clinical data (EHR / EMR)
Pathology data
Genomics data
Metabolomics data
Mobile health data, ...

Fusion of Imaging and Non-Imaging Data for Disease Trajectory Prediction for COVID-19 Patients. Tariq A et al. (UNDER REVIEW) https://www.medrxiv.org/content/10.1101/2021.12.02.21267211v1

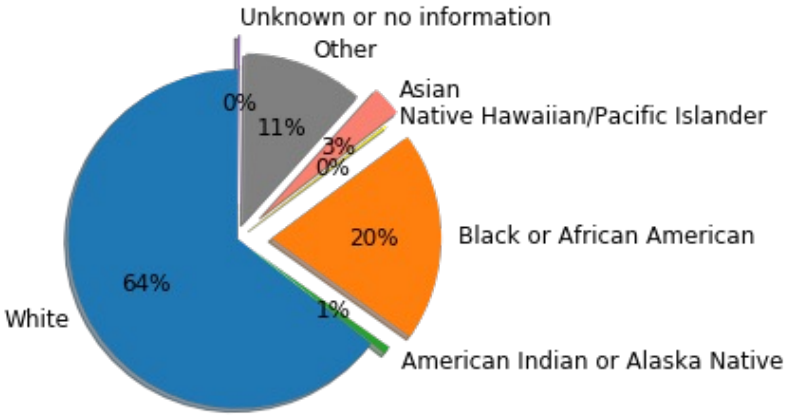


Covid-19 three-day trajectory prediction (discharge, ICU admission and mortality), based on **combined imaging and non-imaging data outperforms single modality data**. Shown, ROC for mortality.

MIDRC: Valuing translation

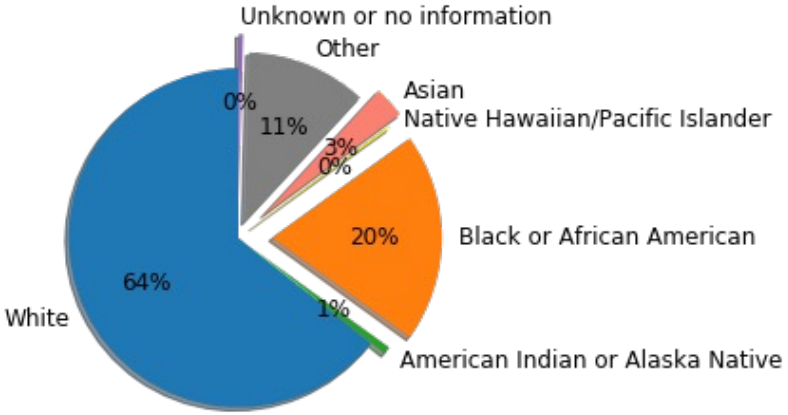


No Access; use for independent testing of AI/ML algorithms



Sequestered Commons

MIDRC Public Commons

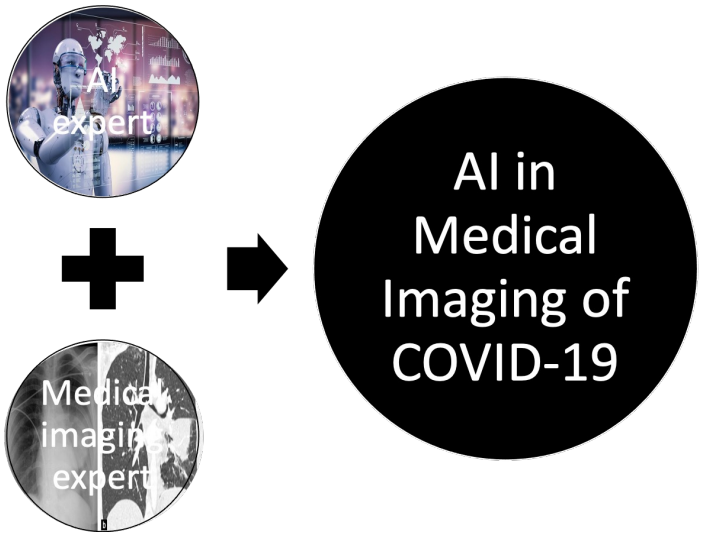


- Facilitate regulatory (**FDA**) clearance, post-market evaluation, accelerate clinical usage
- Independent test set, sequestered to maintain its integrity (prevent training to the test)
- Independent testing requires an appropriate task-based distribution of cases, matched to the clinical claim, and intended patient population, randomly drawn from the sequestered dataset.

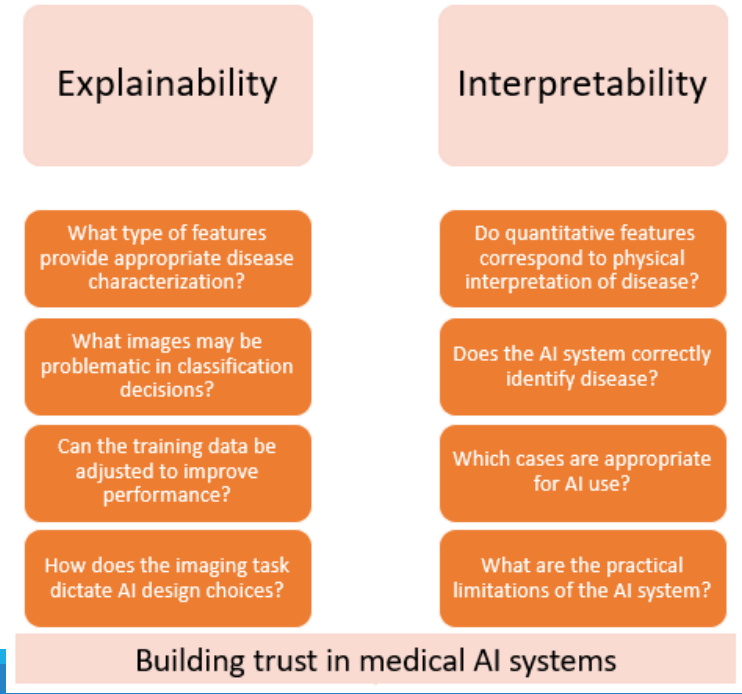
MIDRC
Promoting standards & best practices

Promoting standards, sharing, transparency, best practices

El Naqa I et al. **Lessons learned in transitioning to AI in the medical imaging of Covid-19**. Journal of Medical Imaging, 2021.



Fuhrman JD et al. **A review of explainable and interpretable AI with applications in COVID-19 imaging**. Medical Physics, 2021.

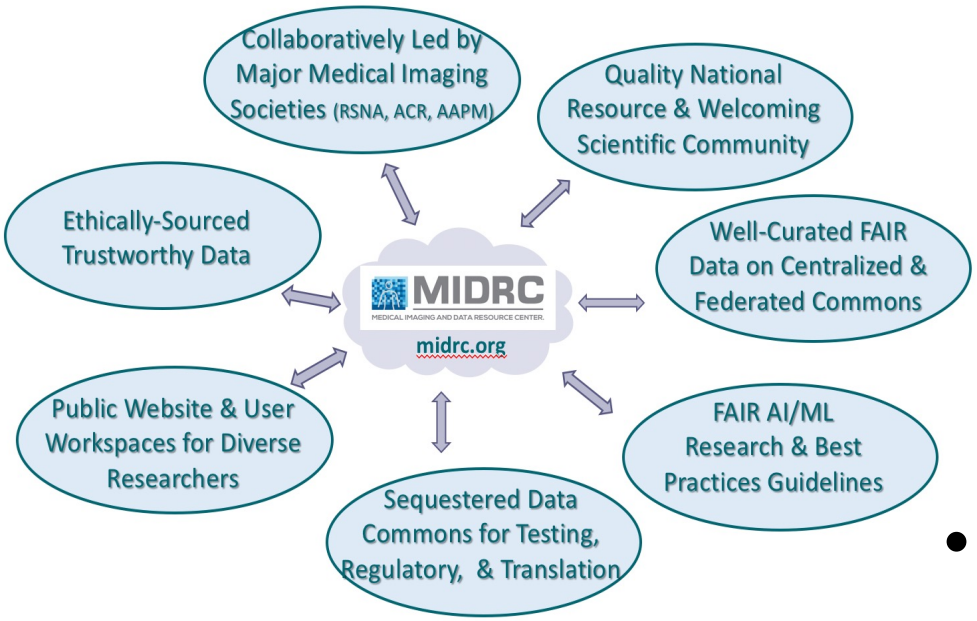


MIDRC
MEDICAL IMAGING AND DATA RESOURCE CENTER.

What comes next?

- **Support Post Acute Sequelae of SARS-CoV-2 infection (PASC)** response, including longitudinal monitoring
- Expand to additional **organs/systems** (heart, brain, …)
- **Increase the range of modalities** (MRI, ultrasound, …)
- Expand to other **acute and chronic diseases**
- Continue to pursue **interoperability** with other data commons
- **Develop, validate and help deploy AI/ML algorithms for medical imaging**

Sustainability: MIDRC as a National resource



- Support the Medical Imaging AI/ML ecosystem
  - High quality, representative, trustworthy data
  - Culture of collaboration
  - Promote standards, sharing, transparency, best practices
  - Lower barrier of access
- Accelerate translation of AI/ML
  - Real-world quantification of algorithm performance (sequestered dataset)