<<November 6th, 2018>>

Fostering a Strong Ecosystem for AI in Medical Imaging

Dr. Geraldine McGinty, MD, MBA, FACR

- Chair, Board of Chancellors, American College of Radiology
- Chief Strategy and Contracting Officer, Weill Cornell Medicine
- Assistant Professor of Radiology and Healthcare Policy and Research, Weill Cornell Medical College

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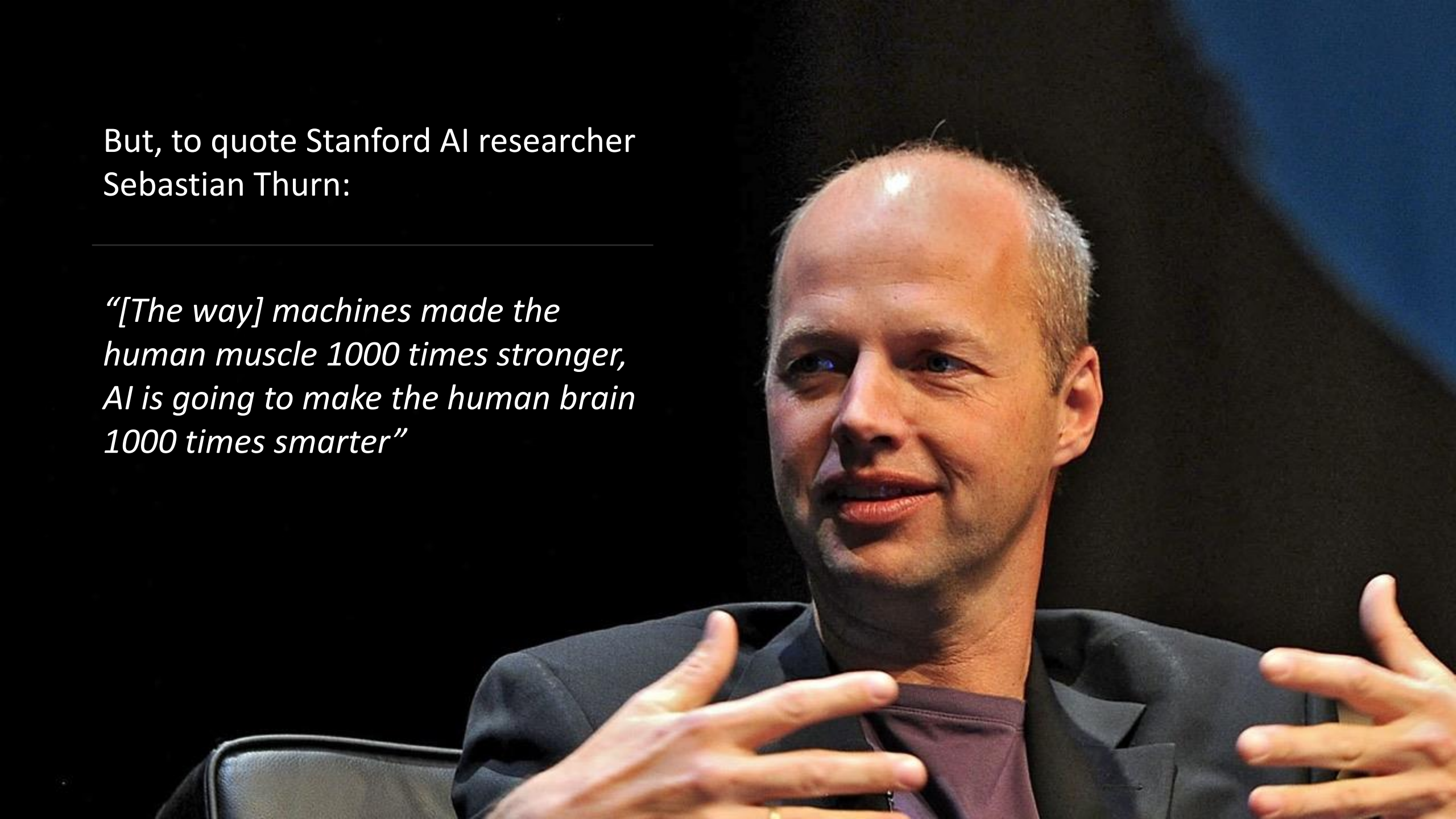
Disclosures [Blank]

AI presents a once-in-a-generation opportunity to dramatically improve patient care and lower the costs of high quality healthcare.

Not because AI is going to create a genius robot that is a far superior replacement to the radiologist.

But, to quote Stanford AI researcher Sebastian Thurn:

“[The way] machines made the human muscle 1000 times stronger, AI is going to make the human brain 1000 times smarter”



Inertia

Hype that can’t live up to reality

Misalignment of financial incentives

Fear of change

Decentralized healthcare

Complex AI and medical informatics

The path doesn’t look like an expedition party climbing Mt. Everest.

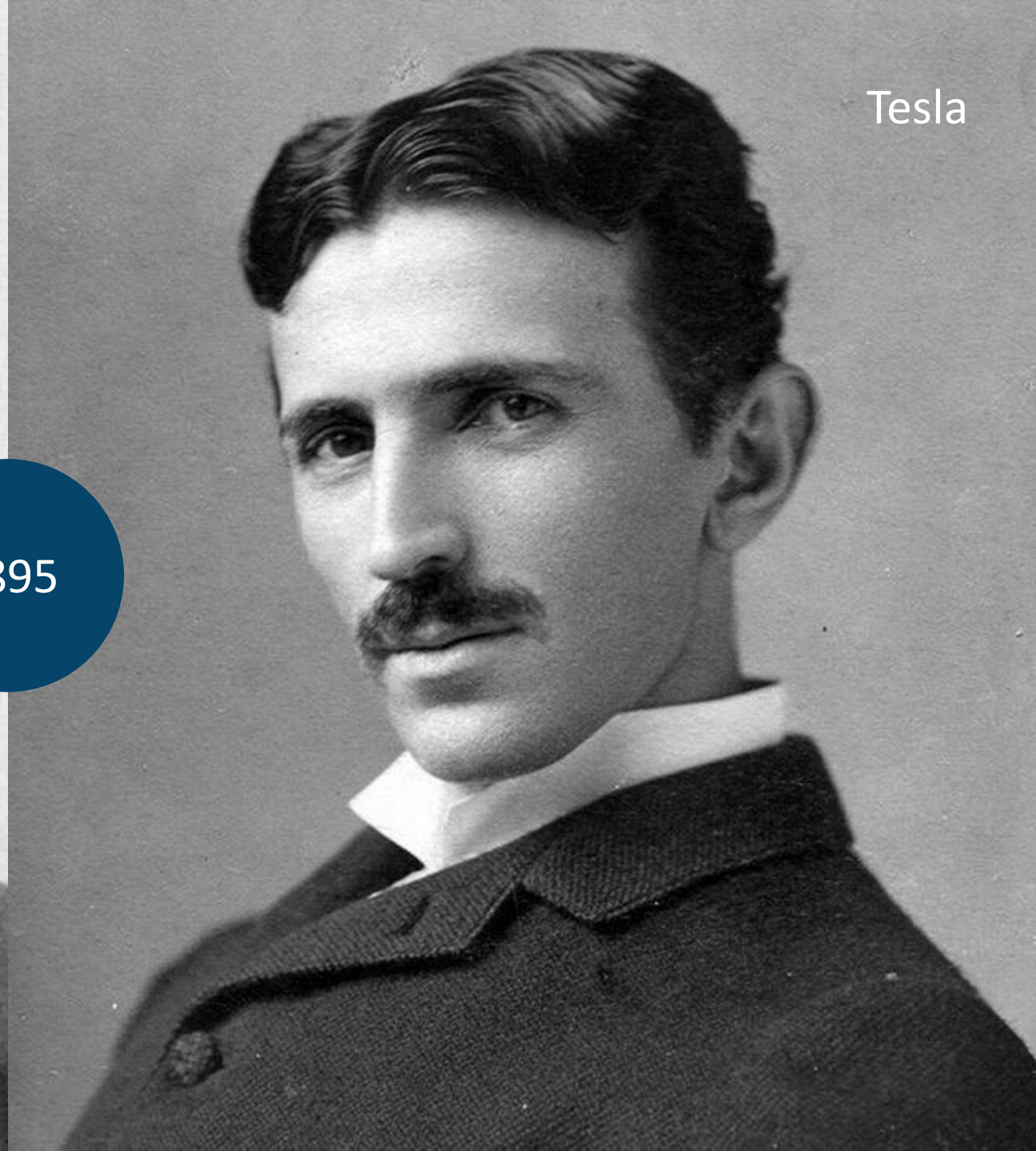
X-Ray as a Case Study
in Rapid Adoption

Innovation in healthcare can be lightning fast but often fraught with errors and missed opportunities that cost lives.

Röntgen

1895

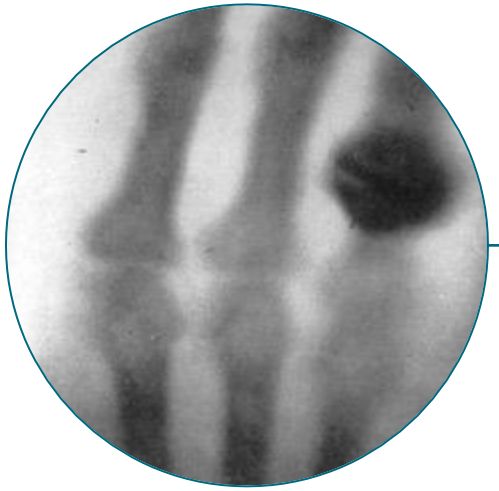
Tesla



First x-ray image in Ohio 4 months later

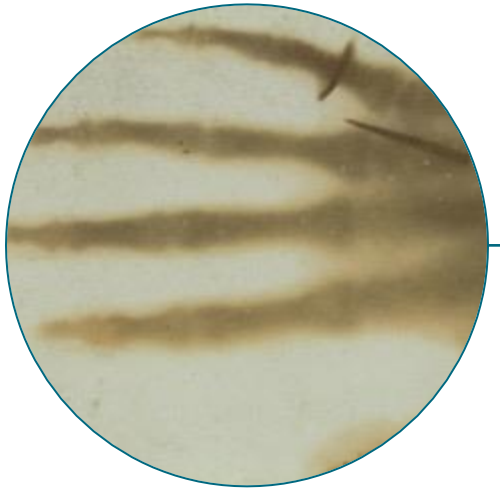
Wilhelm Roentgen discovers X-rays Wuerzburg Germany - 1895

1895

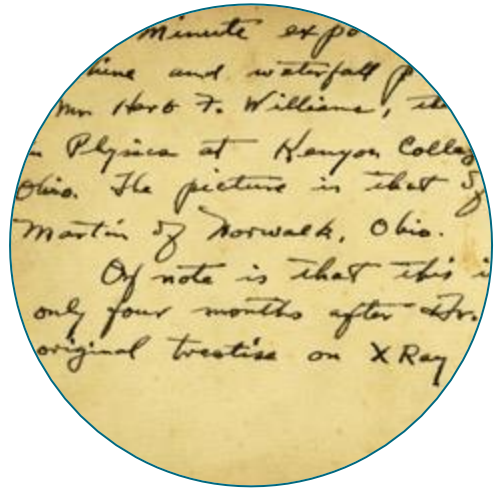


Hand of Roentgen's wife.
*Note wedding ring

1896



4 months later Kenyon College, Ohio judge- nail in hand.



1st description of Physicists and physician partnership in imaging research?

Thanks to Dr. Jeffrey Duerk

No innovation is without risk or unintended consequences


VOL. 100. NO. 160.

Mme. Curie of Radium Fame, Dead

Co-Discoverer With Her Husband of Priceless Curative Agent, She Becomes Its Victim—Its Rays Induce Pernicious Anemia


RADIUM v. GREY HAIR

Who'd Dream she was 50?

50—and not a grey hair to be seen. Wonderful! Yet an absolute fact. Let 'CARADIUM' do for you what it has done for thousands of our clients in all parts of the world.

Apple Ecosystem

Infrastructural Components

Third-party Applications and Services

Applications and Services

THE VERGE TECH SCIENCE CULTURE CARS REVIEWS LONGFORM VIDEO

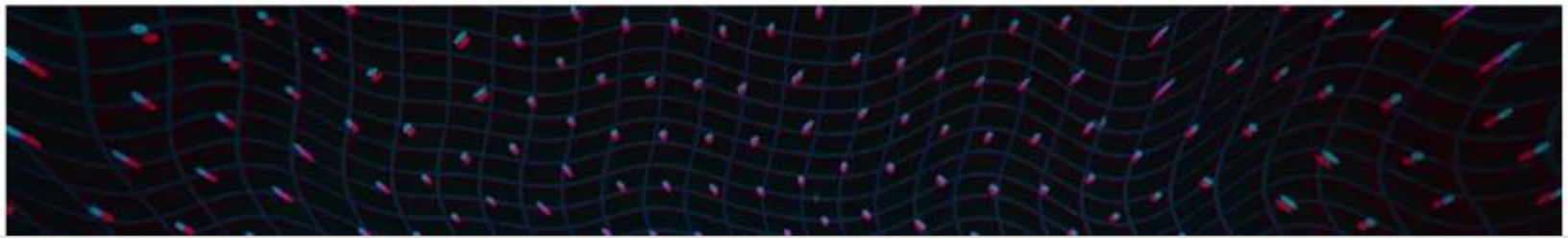
APPLE BUSINESS TECH

Apple is now a $1 trillion company

'A billion dollars isn't cool. You know what's cool? A trillion dollars'

By Chaim Gartenberg | @cgartenberg | Aug 2, 2018, 11:53am EDT

SHARE



Apple Ecosystem

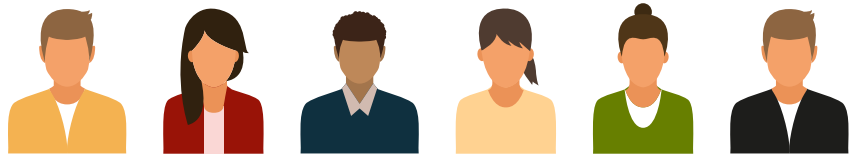
Primary Beneficiary

Apple's Shareholders

Other Beneficiaries

Apple's Users, Partners and Employees

AI in Medical Imaging Ecosystem



Primary Beneficiary

Patients

Other Beneficiaries

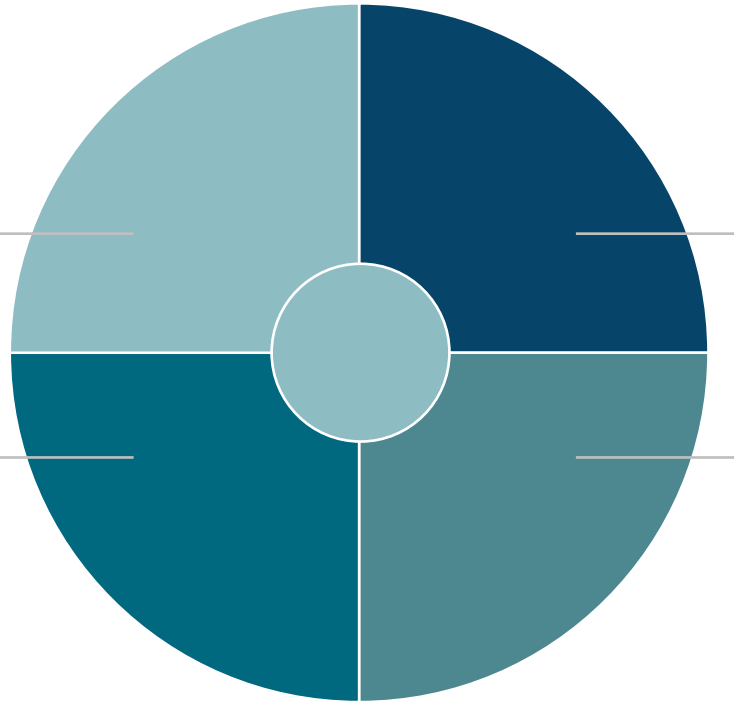
Those who serve the patients
(Providers and Provider Organizations, Vendors, Insurers, Regulators, Associations/Societies)

1. Prevent illness
2. Help sick patients get healthy as soon as possible
3. Stabilize & manage patients with chronic conditions

Doing *Better* With Less…

Improving the work life of those who deliver care

Improving the individual experience of care



Improving the health of populations

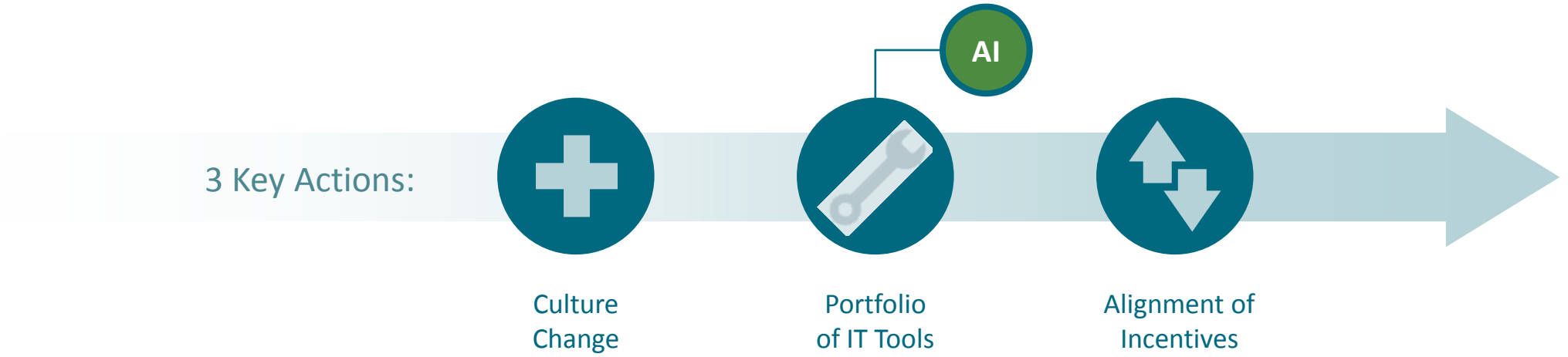
Reducing the per capita costs of care

… Through Medical Imaging.

IMAGING3.0™

Imaging 3.0 is a vision and game plan for providing optimal imaging care.

"Our goal is to deliver all the imaging care that is beneficial and necessary and none that is not."

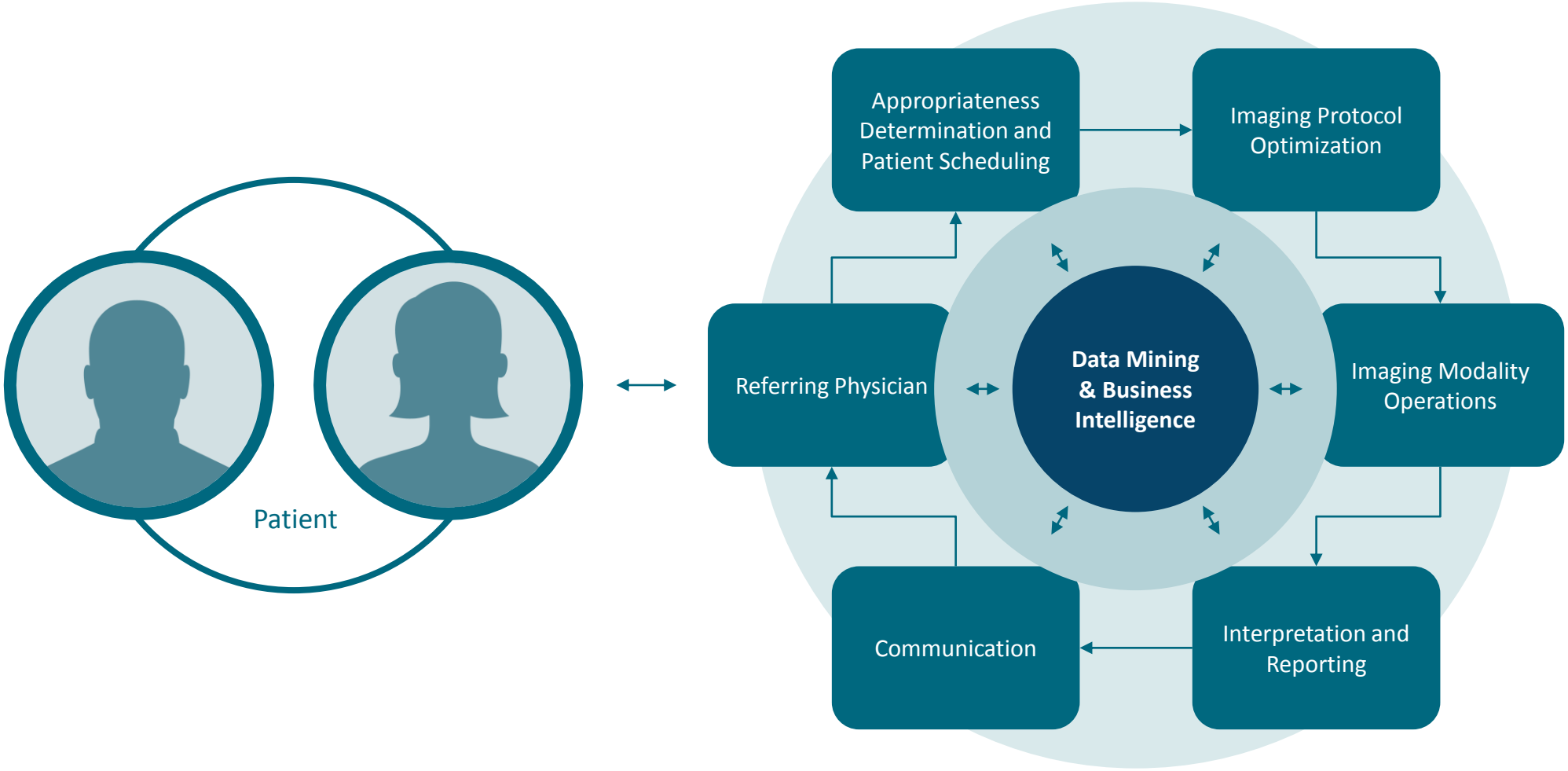


Radiologists: Medicine's earliest (and best known) data scientists

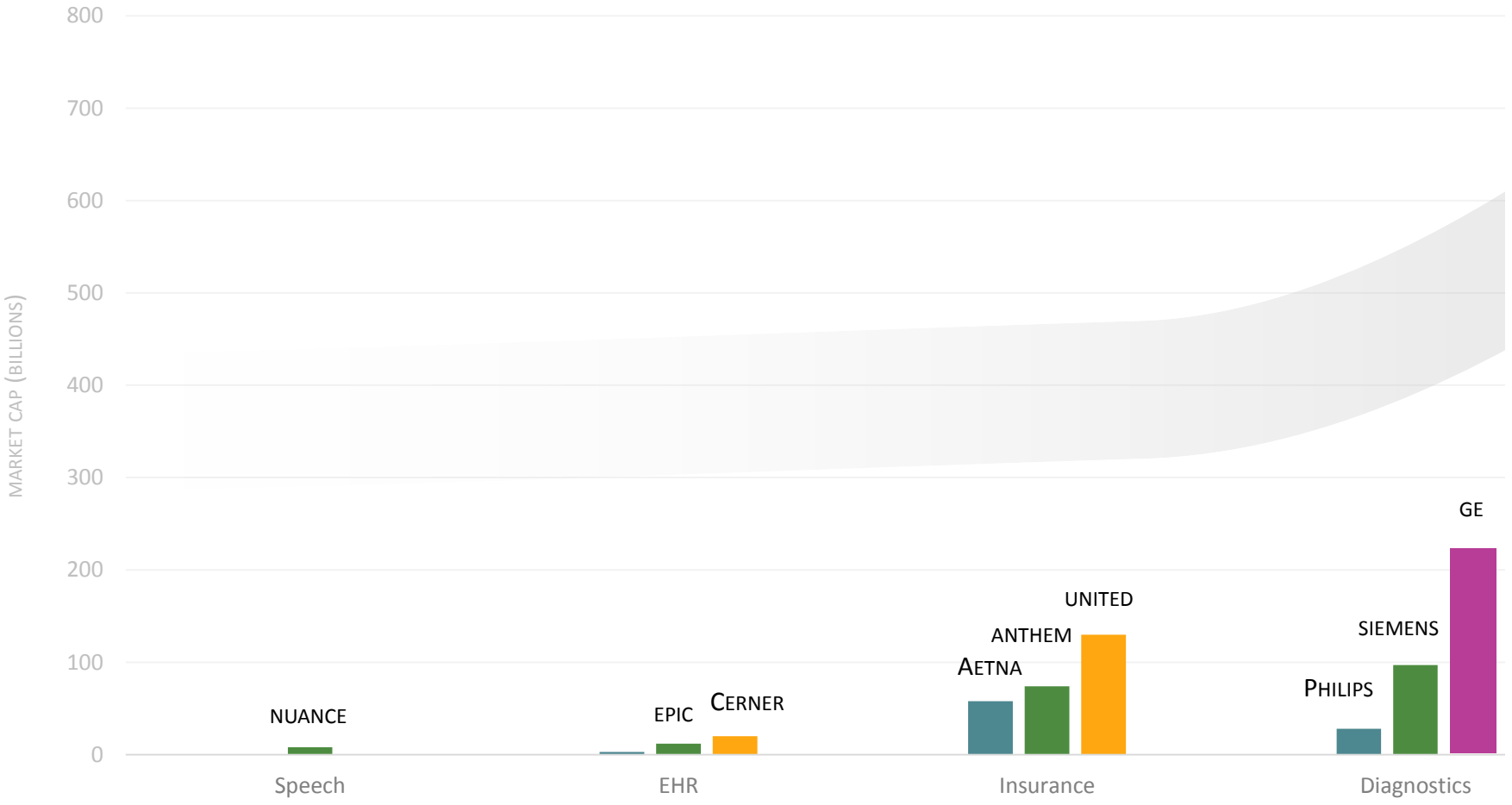
Improving care for 100+ years by embracing new technologies and approaches to medicine.

Since 1895, to name just a few innovations we've adopted…

- X-Ray
- Contrast Agents
- Ultrasound
- Nuclear Medicine
- Computed Tomography (CT)
- Magnetic Resonance Imaging (MRI)
- Interventional Radiology (IR)
- Evidence-Based Clinical Guidelines
- Picture Archiving and Communications Systems (PACS)
- Computerized Voice Recognition and Transcription
- Electronic Health Records
- Value-Based Medicine
- *Artificial Intelligence & Data Science*



Financial Power: Corporate Valuations by Sector



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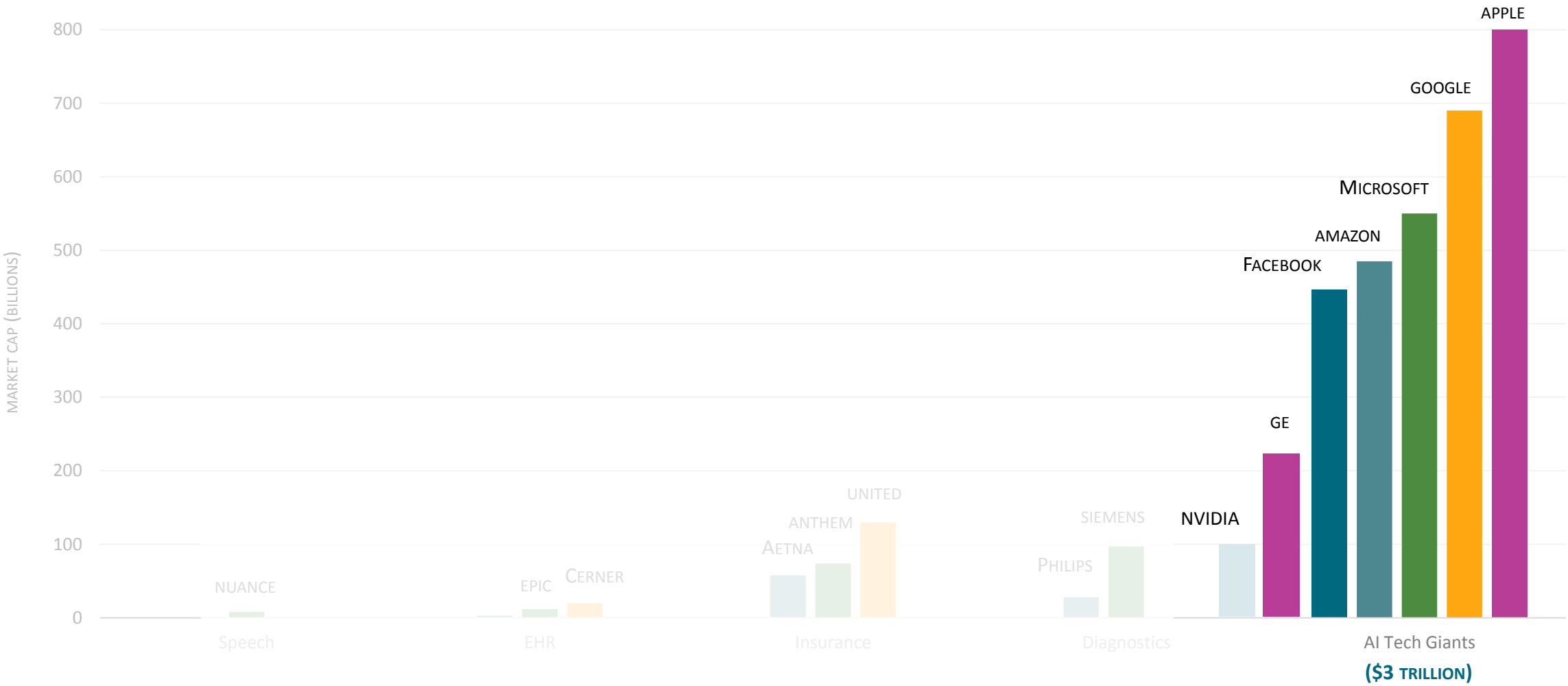


Hype?

Yes.

Real Substance and Impact?

Yes.

Medscape Tuesday, August 7, 2018

NEWS & PERSPECTIVE DRUGS & DISEASES CME & EDUCATION ACADEMY VIDE

News > Medscape Medical News > Oncology News

Big Data Bust: MD Anderson-Watson Project Dies

Top Cancer Center Spent $62M

Nick Mulcahy

February 22, 2017

0 Read Comments

After 4 years of spiralling costs that now total at least $62 million, a grandiose big-data project that was a collaboration between MD Anderson Cancer Center and IBM's Watson artificial intelligence system is over. The details emerged in a 48-page audit report from the University of Texas System that surfaced last week in news stories.

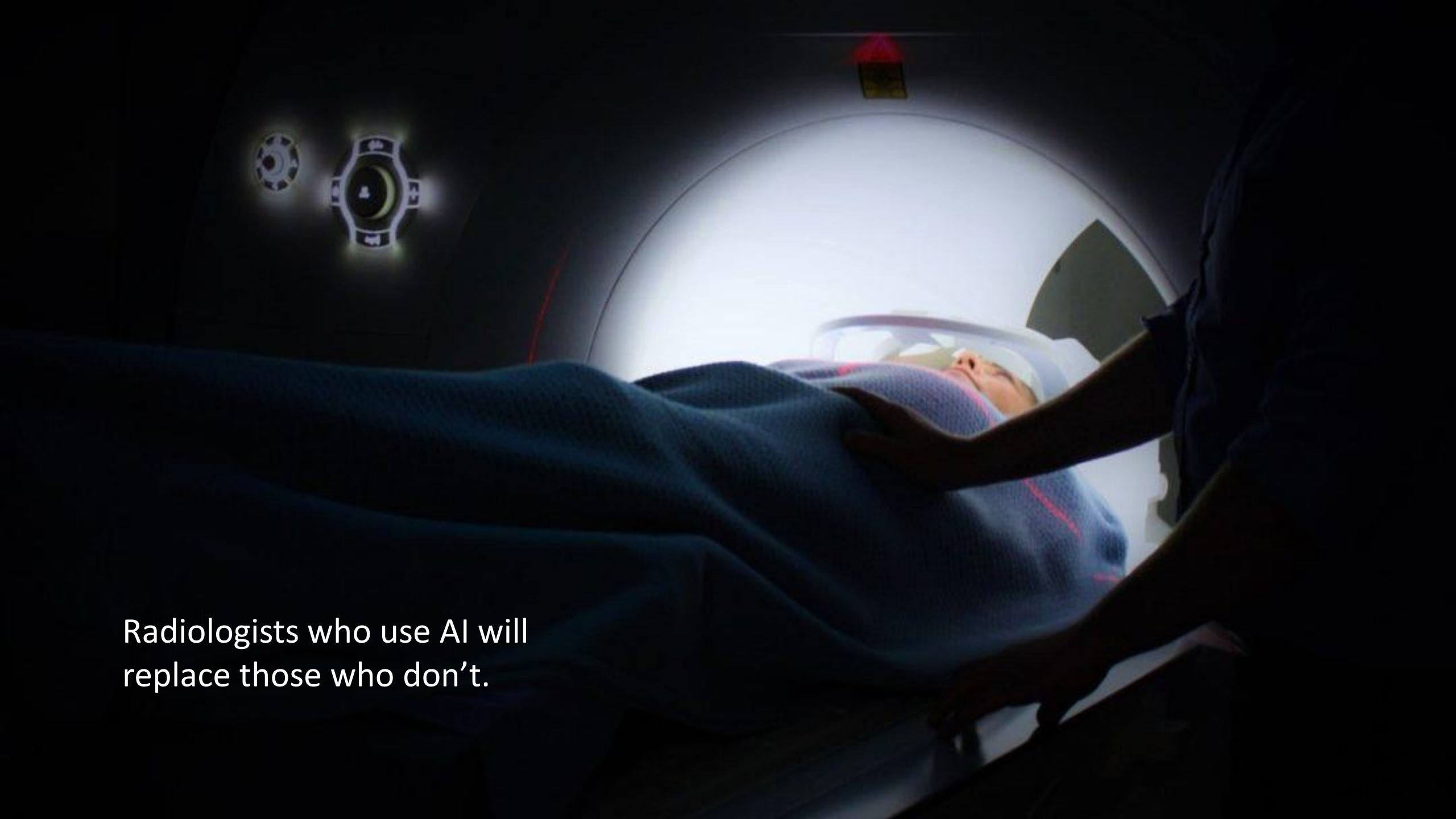

Radiologists who use AI will
replace those who don’t.

Image interpretation

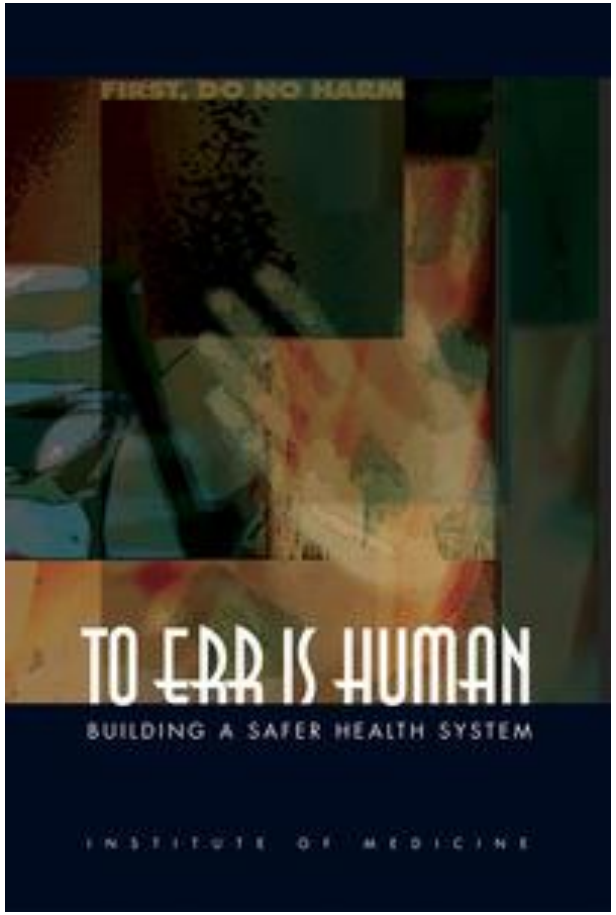
- Quantification of findings
- Quantified comparison between multiple studies
- Multiparametric analysis across multiple modalities
- Volumetric analysis
- Textural analysis
- Automation of Region Of Interest targeting and measuring

Patient care and safety

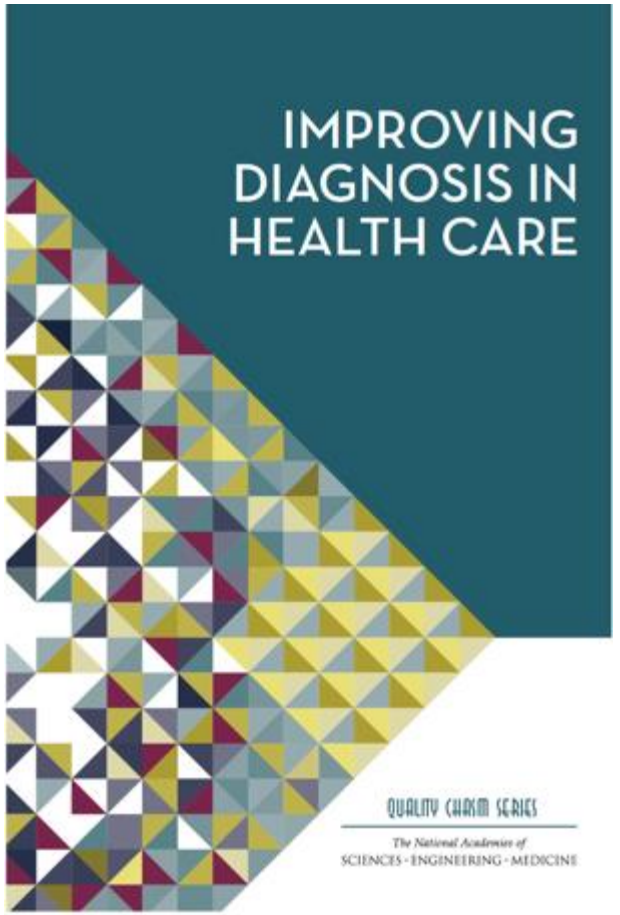
- Detection and prioritization of potentially critical results
- Radiation dose optimization
- Pre-test probability assessment of patient risk of positive findings and contrast reactions
- Cancer and mammography screening
- Automatic protocoling of studies from EMR data

Practice optimization for productivity and quality

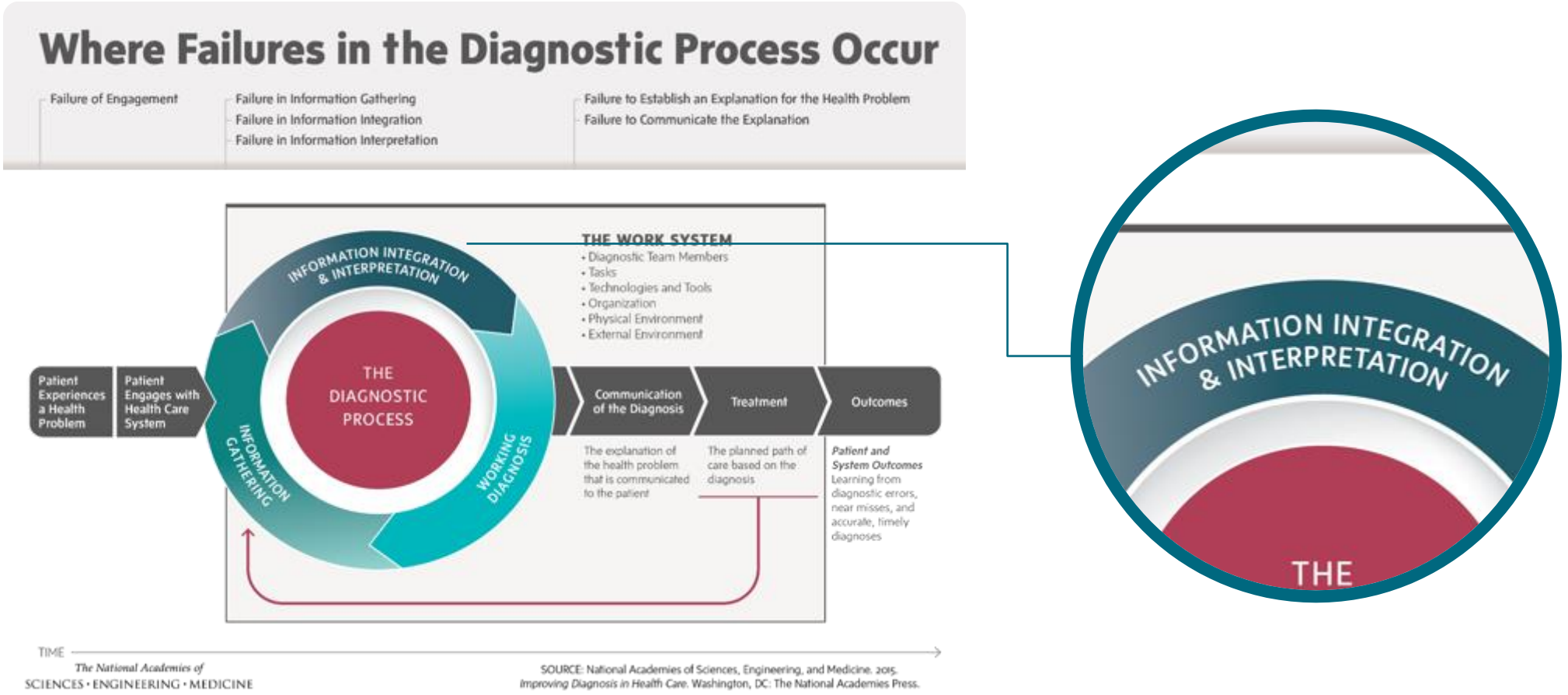
- Automated transcription of audio narration
- Automated population of structured reports
- Optimization for case assignment across teams
- Increased accuracy of coding
- Smarter PACS hanging protocols and synchronization protocols
- Communication and tracking of primary and incidental findings
- Decreased patient waiting times
- Quality improvement in scanning
- Prediction and prevention of missed patient appointments
- Preventing imaging machine outages



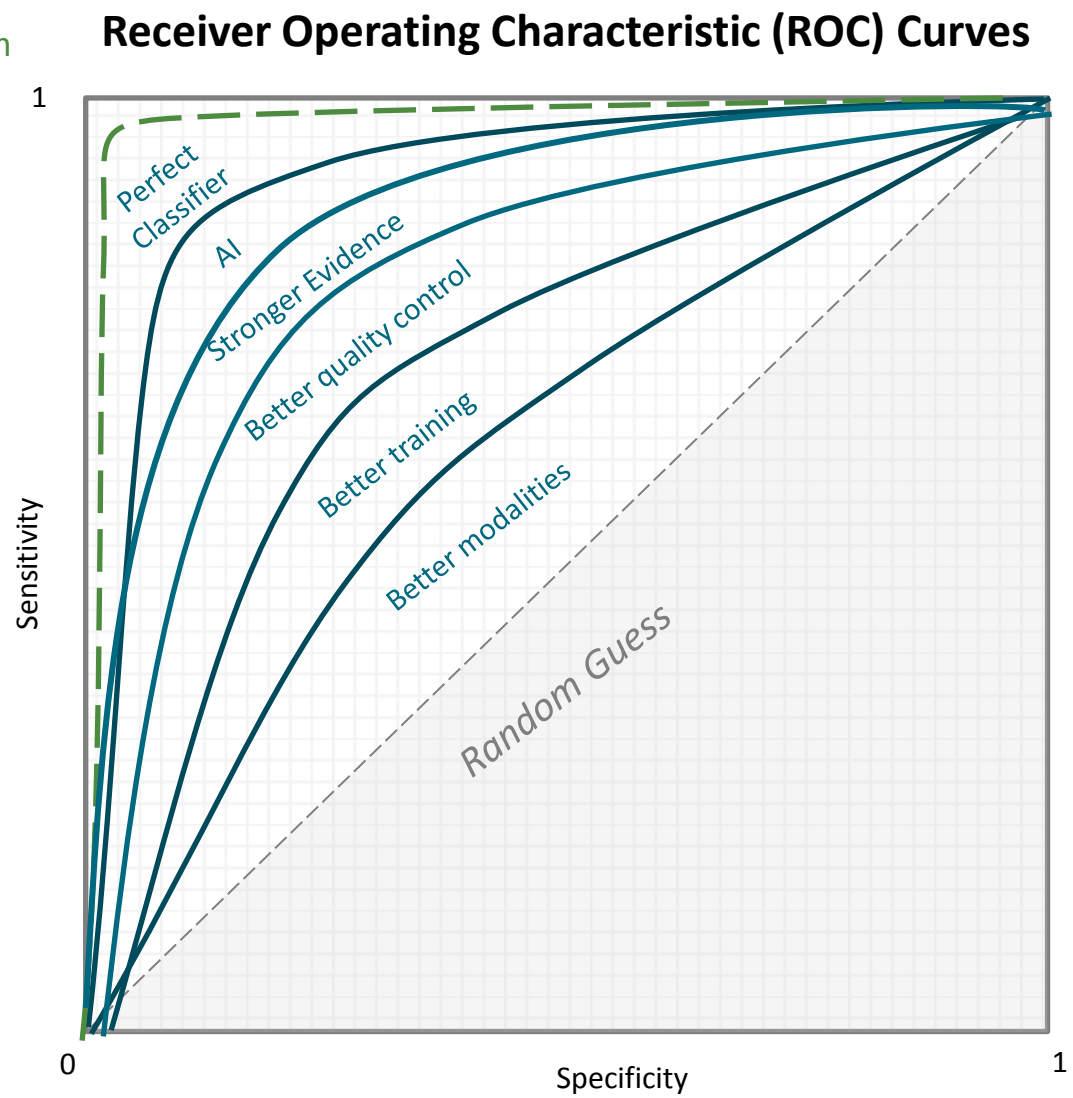
1999



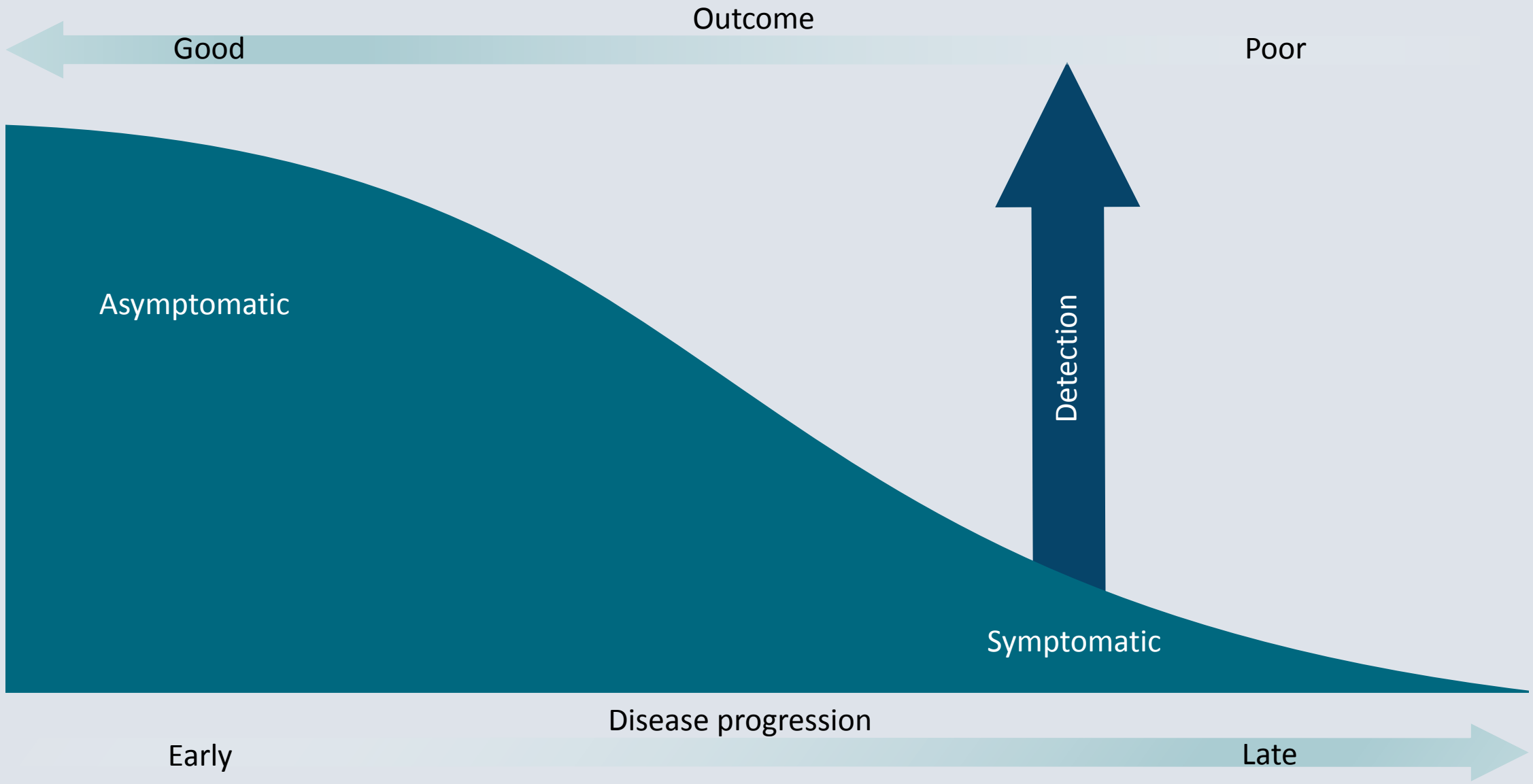
2015



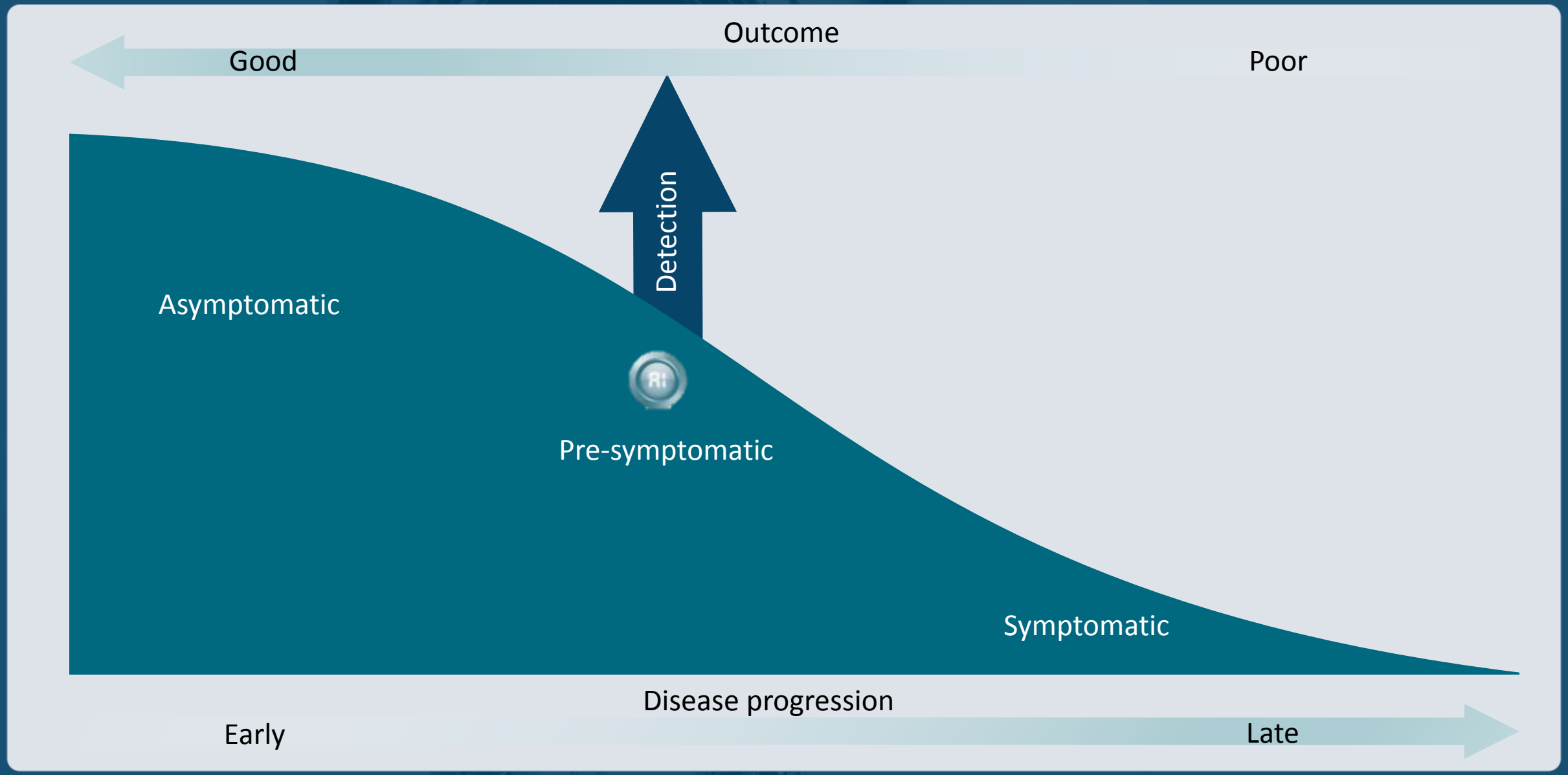
A Long Term Goal for Radiology



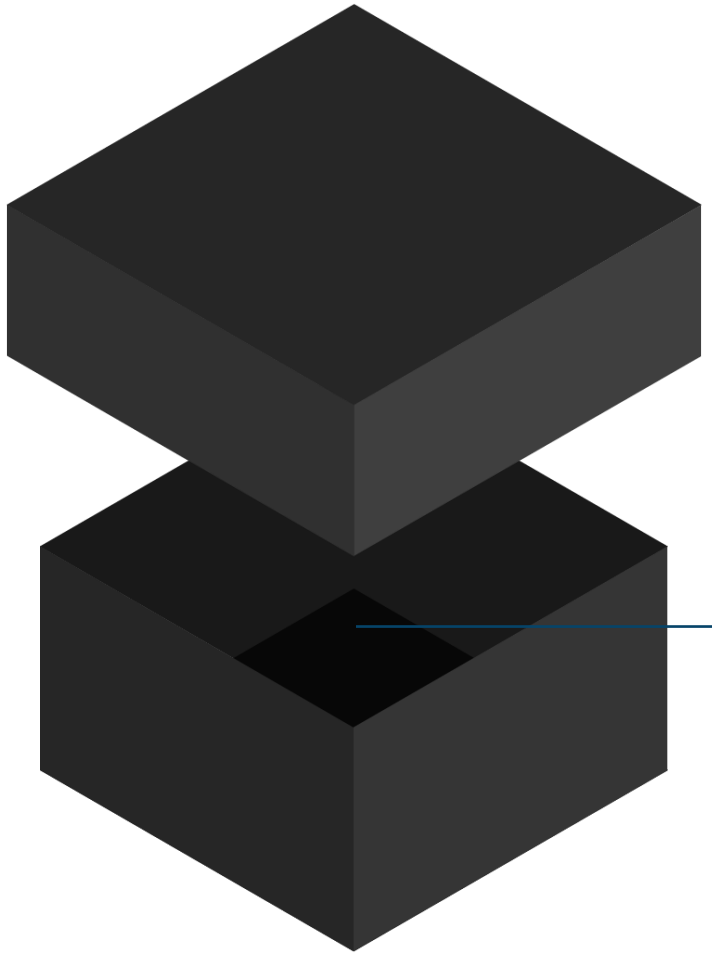
Diagnostic Imaging, AI & Population Health



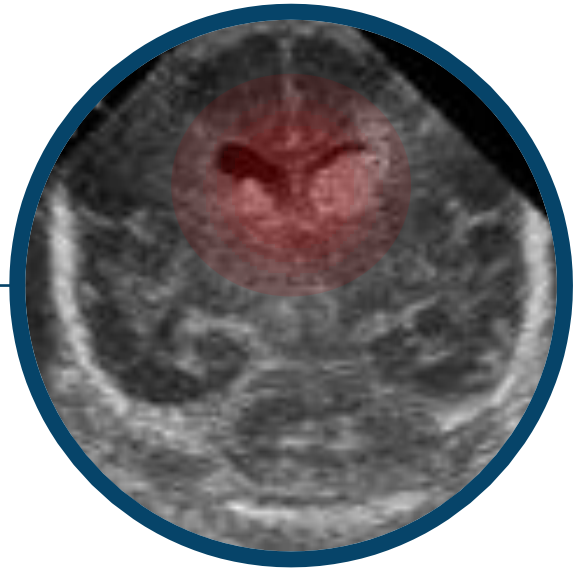
Diagnostic Imaging, AI & Population Health



A challenge to radiologists embracing AI in practice is that we don’t really understand how AI arrives at a particular conclusion.

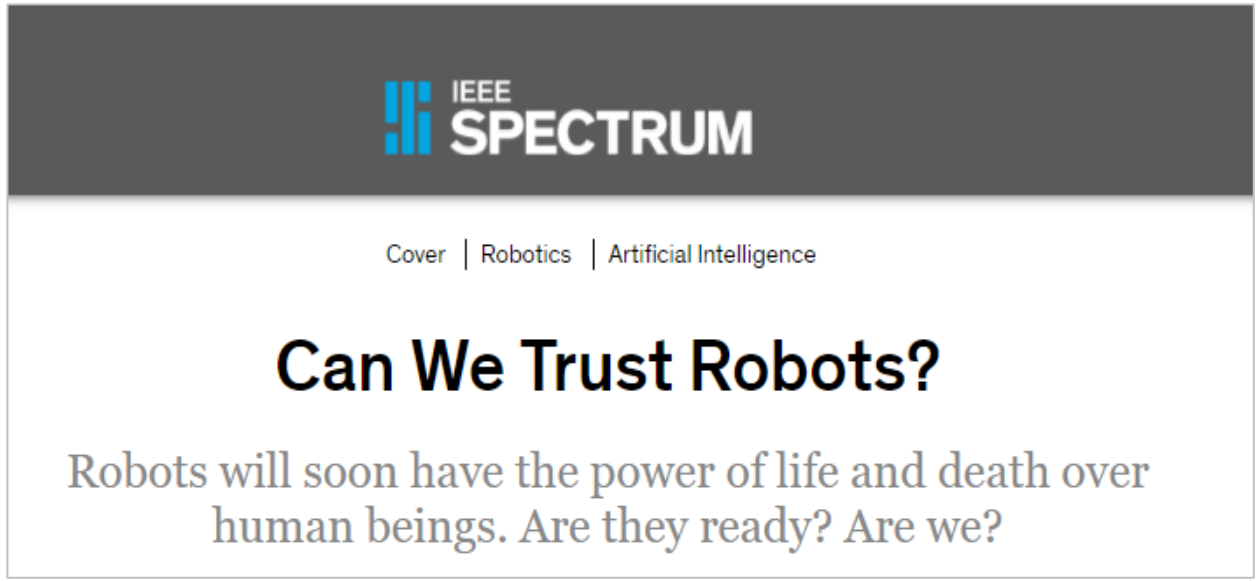


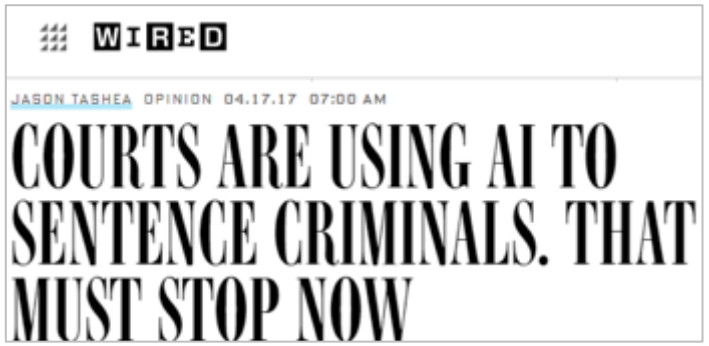
Explicability



Neonatal Intraventricular Hemorrhage

Why is the algorithm effective?
What's inside the black box?





■ June 26, 2018, 4:00 AM CDT ■ Corrected June 26, 2018, 10:20 AM CDT

A.I. Has a Race Problem

● Facial recognition software still gets confused by darker skin tones.

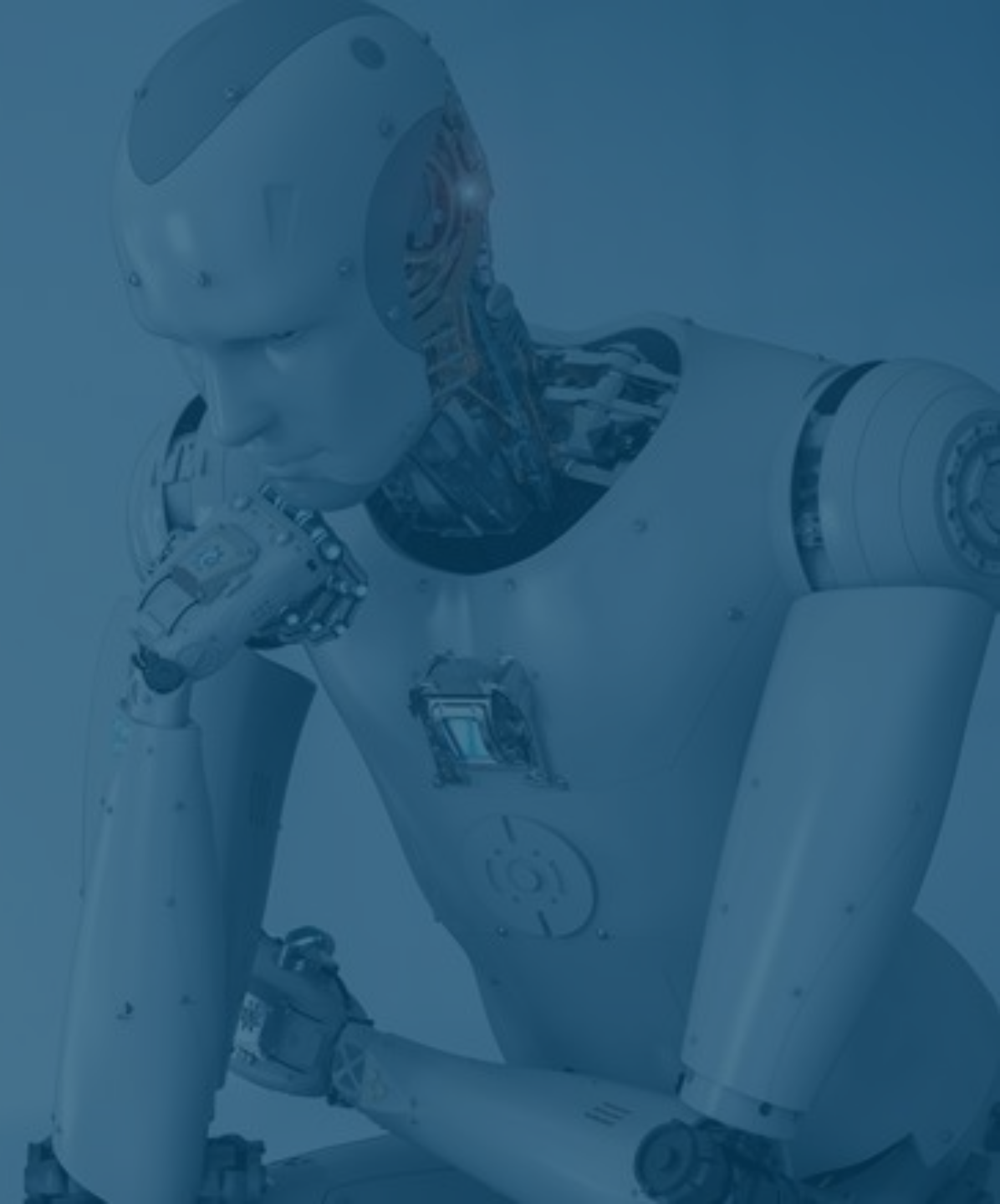
By Lizette Chapman and Joshua Brustein

MIT Researcher: Artificial Intelligence Has a Race Problem, and We Need to Fix It

The next generation of AI is poisoned with bias against dark skin, Joy Buolamwini says.

Some rewards that computer has a hard time weighing:

- The patient's prior radiation dose exposure is unknown, which can this impact a decision of CT vs. MRI?
- Does the patient have to drive 3 hours to get to a more advanced imaging machine?
- Does the patient have claustrophobia that makes it hard to go in certain machines?
- The patient is losing her insurance at the end of the month, so a follow-up exam in the future may not be feasible.
- The patient suffers from multiple, co-morbid conditions so how sure can we be that any one condition is the cause of the finding?
- How much might we learn from an immediate follow-up study and what are the cost-benefit factors of how this might impact decisions about the course of treatment?



Using Representative/Diverse Training Data: Multiple Dimensions of Image Variation

Anatomy

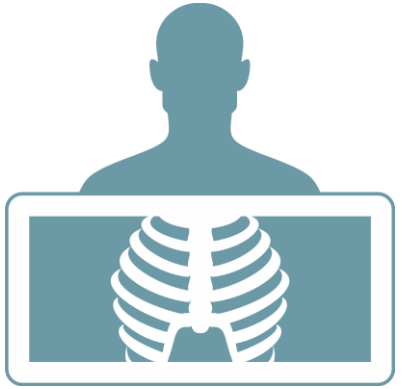
(e.g., body part)

Patient demographics

(e.g., gender, age)

Pathology

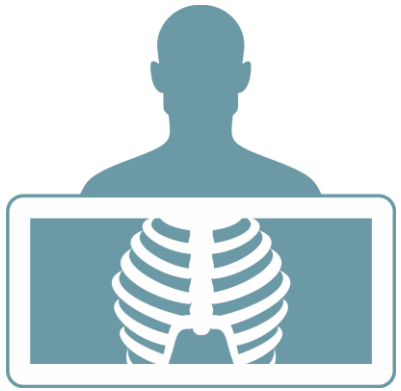
(e.g., degree of tear)



Modality

(e.g., X-Ray, MRI, CT, PET, Ultrasound)

Using Representative/Diverse Training Data: Multiple Dimensions of Image Variation



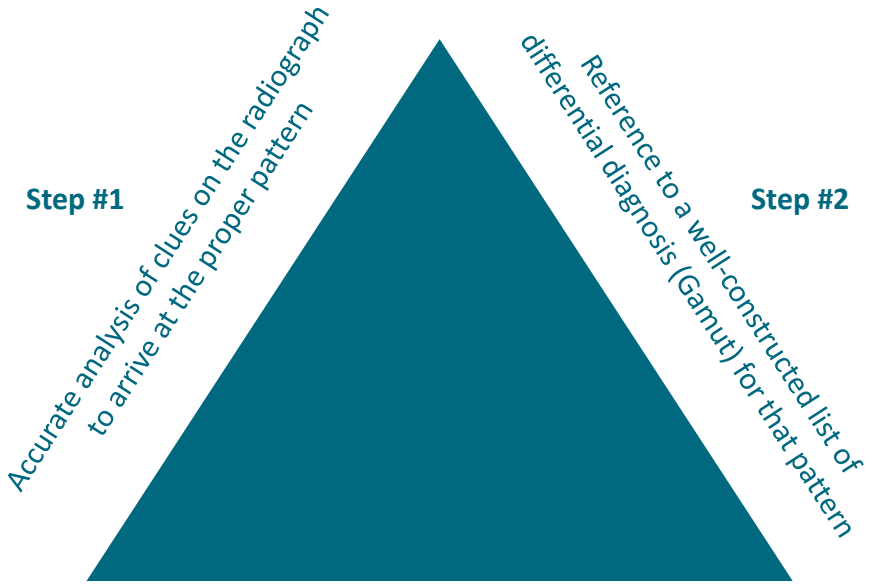
Modality

(e.g., X-Ray, MRI, CT, PET, Ultrasound)

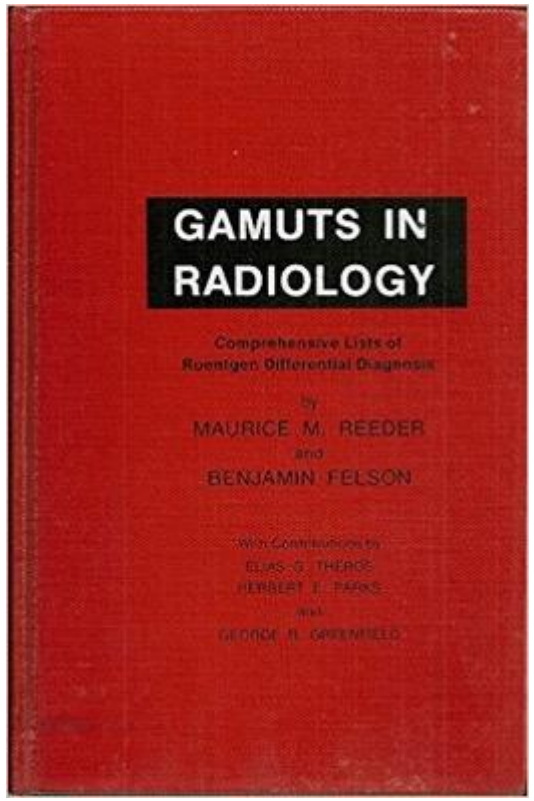
Modality-specific variations

- MRI – For example:
  - Techniques (Pulse Sequences, Field of View)
  - Anatomic planes (axial, sagittal, coronal)
  - Equipment variation (Manufacturer, Product Version and Firmware/Software Version, Field Strengths, Signal-to-Noise Ratio)
- CT – For example:
  - Exposure parameters
  - Slice thickness
  - Number of detectors
  - Equipment variation

The Triangulation Approach to Radiographic Diagnosis



Correlation of radiographic findings and Gamut with patients' clinical and lab findings to arrive at the most likely diagnosis



www.gamuts.net contains:

4,600

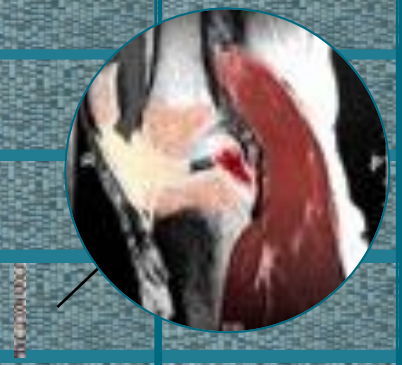
Unique imaging findings

13,000

Unique conditions that cause findings

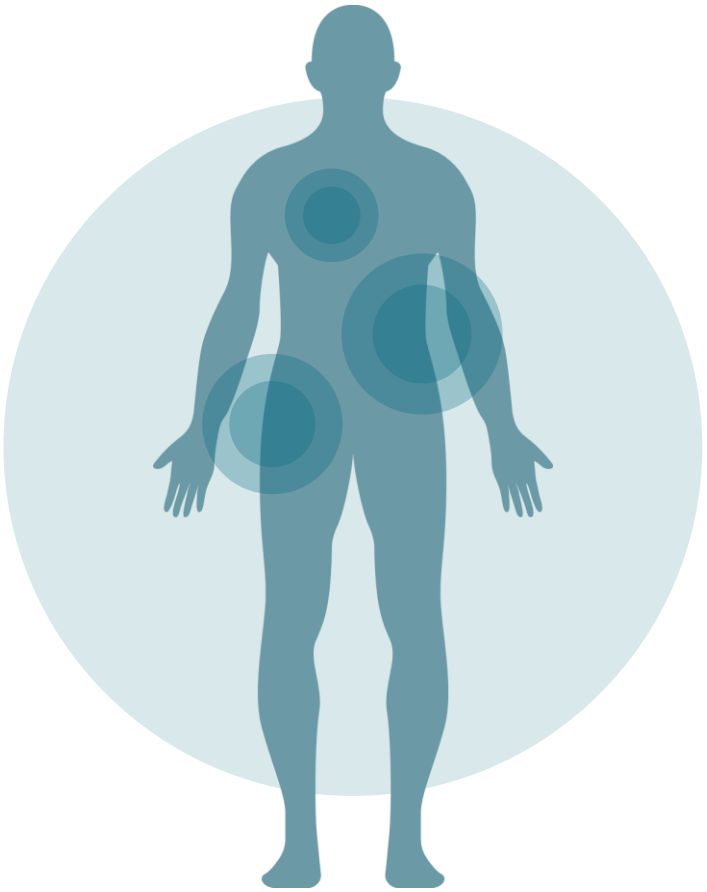
57,000

Linkages between findings and conditions

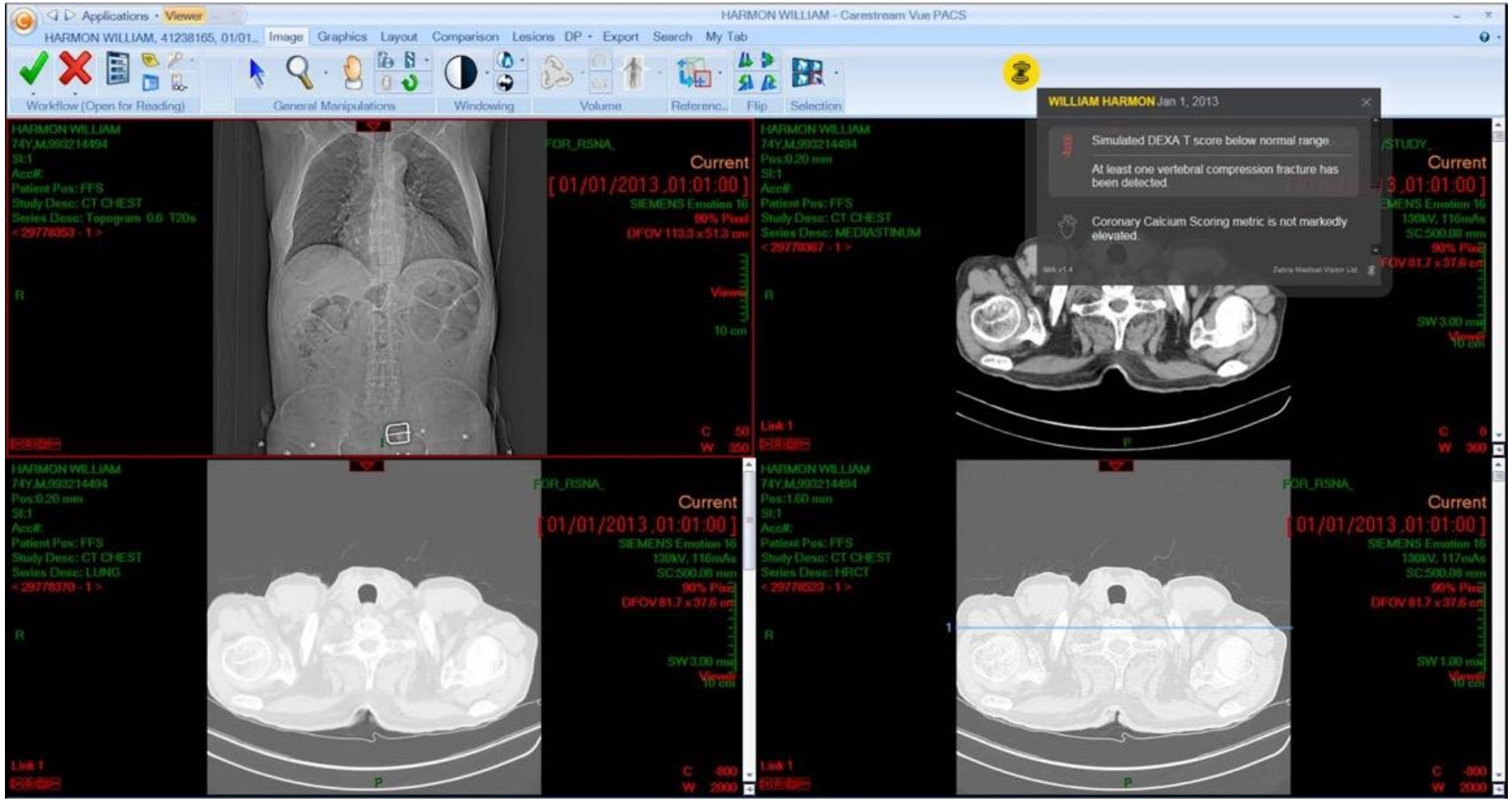
	COMPUTED TOMOGRAPHY	MAGNETIC RESONANCE	POSITRON EMISSION	RADIOGRAPHY	ANGIOGRAPHY	ULTRASOUND	FLUOROSCOPY	
ABDOMINAL IMAGING								FINDINGS
BREAST IMAGING								FINDINGS
CARDIAC IMAGING								FINDINGS
EMERGENCY IMAGING								FINDINGS
MUSCULOSKELETAL								FINDINGS
NEURORADIOLOGY								FINDINGS
NUCLEAR MEDICINE								FINDINGS
PEDIATRIC IMAGING								FINDINGS
THROACIC IMAGING								FINDINGS
INTERVENTIONAL								FINDINGS
	ANATOMY	ANATOMY	ANATOMY	ANATOMY	ANATOMY	ANATOMY	ANATOMY	

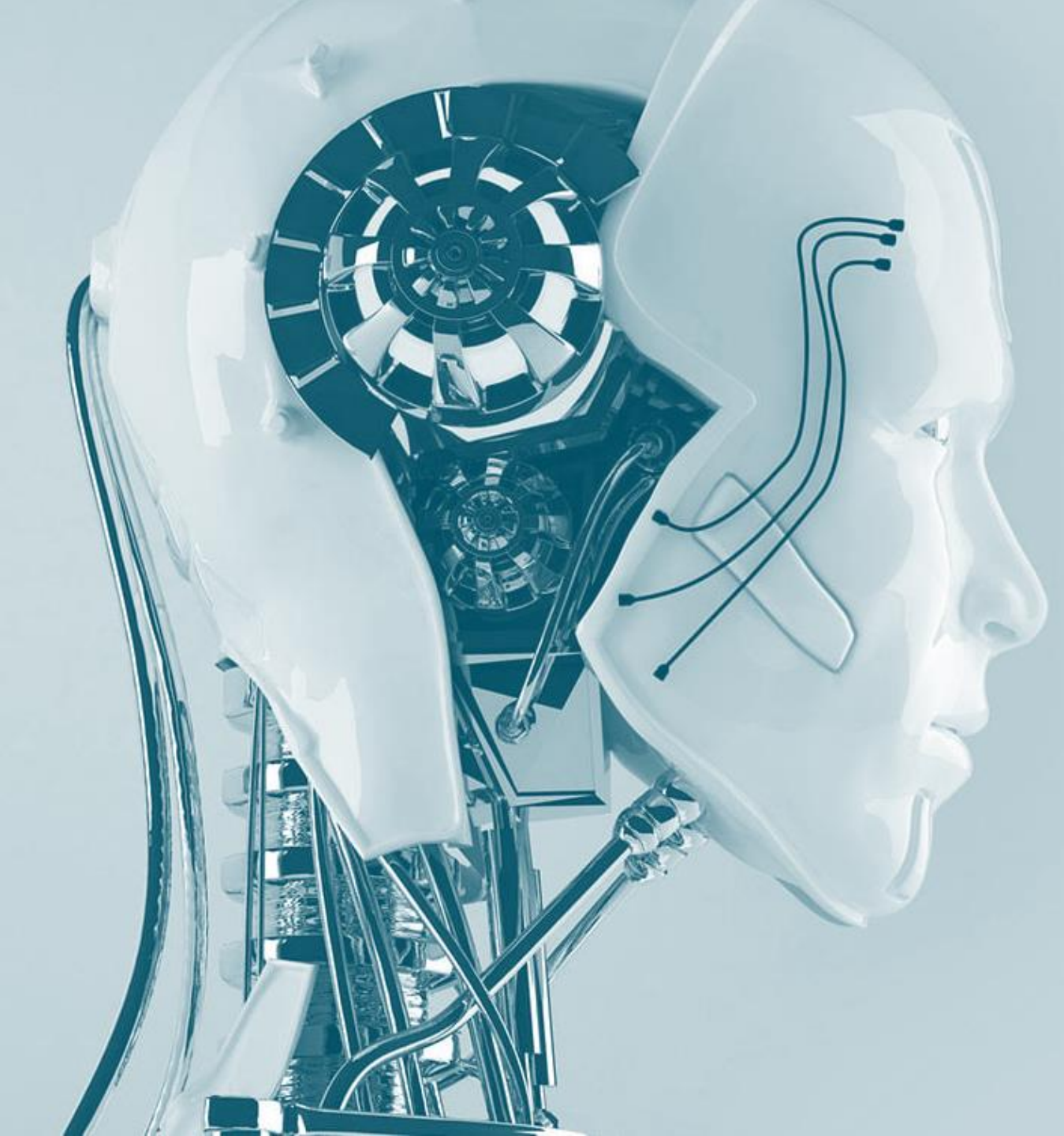
CITY BRAKE CONTROL

What will it be like when AI is an indispensable tool for radiology professionals?



- Partnered with company developing algorithms looking for five findings on chest, abdomen, and pelvis CT scans:
  1) coronary calcium scores, 2) pulmonary emphysema, 3) liver steatosis, 4) spine compression fractures, and 5) bone mineral density
- Automatically scans images when received by the PACS and notifies radiologists when they enter the case with a green light/red light indicator if it identifies something
- Phased testing and adoption to obtain confidence in software and buy-in from clinicians
- Benefits found with:
  - Incidental findings that can be overlooked
  - Potentially problematic bone mineral density readings that are too early stage to be identified by the human eye





“It’s like having an extra set of eyes to help us provide additional information to referring physicians for optimal patient care.”

– Dr. Arun Krishnaraj

Deep Learning: A Modern Approach to Early Breast Cancer Detection

Connie Lehman MD PhD
Professor of Radiology
Harvard Medical School
Director of Breast Imaging
Massachusetts General Hospital

Wide Variation in Radiologists' Assessment of Mammograms as "Dense"

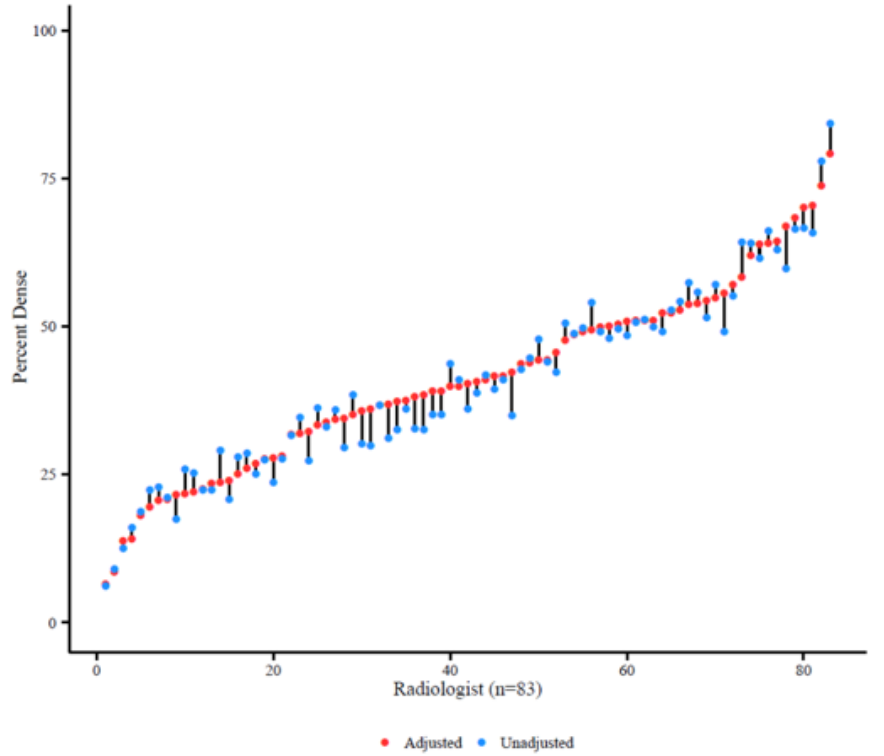
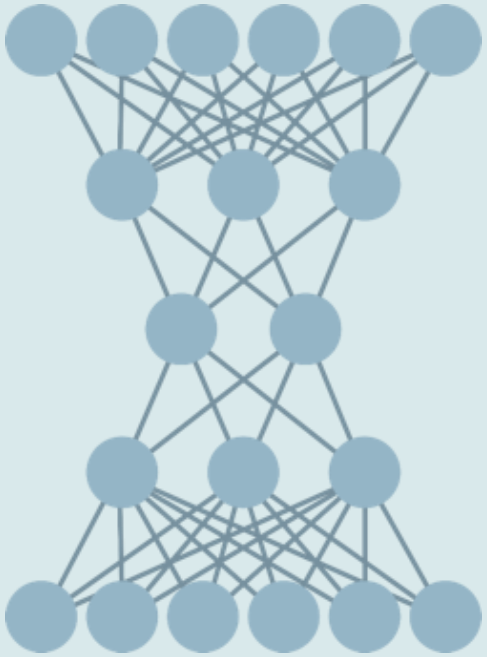
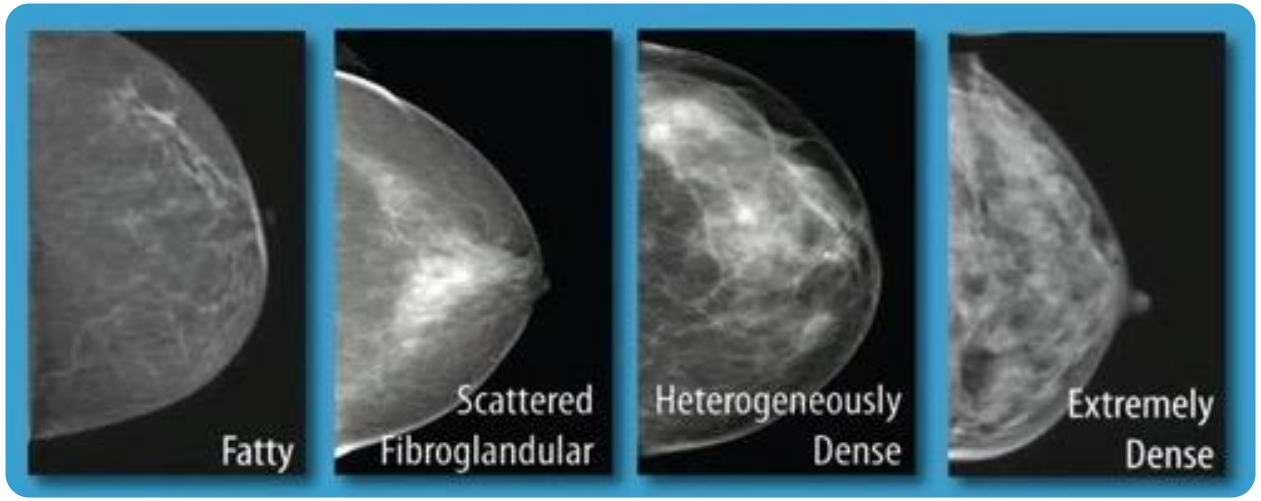


Figure 2. Paired unadjusted and multivariable-adjusted percent of patients with dense breasts (heterogeneously or extremely dense), by radiologist.



Density



Deep Learning density assessment to reduce human variation

Connie Lehman MD PhD MGH
Regina Barzilay PhD MIT

Bahl et al, Radiology (2017)

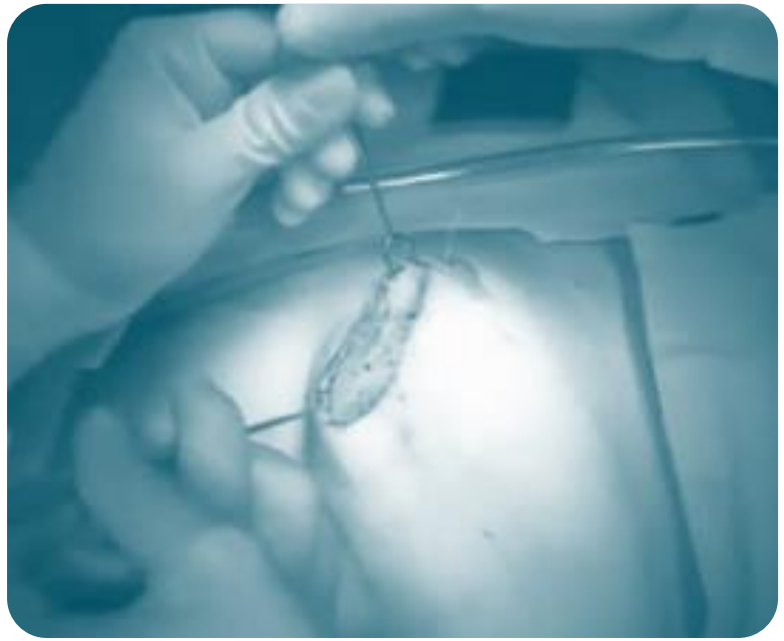
Radiology

High-Risk Breast Lesions:

A Machine Learning Model to Predict Pathologic Upgrade and Reduce Unnecessary Surgical Excision[1]

Purpose: To develop a machine learning model that allows high-risk breast lesions (HRLs) diagnosed with image-guided needle biopsy that require surgical excision to be distinguished from HRLs that are at low risk for upgrade to cancer at surgery and thus could be surveilled.

Reducing Overtreatment: High Risk Lesions



100% Excised | 87% Benign

ML Model

Benign / Malignant

30%

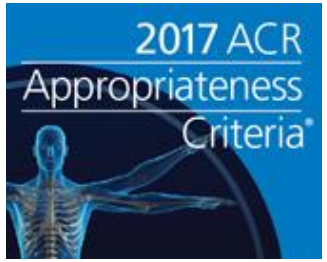
Surgery Reduction

Bahl et al, Radiology (2017)

How can we make AI an indispensable tool for radiology professionals, referring physicians and patients?

- Industry vendors
- Data scientists
- Physicians
- Informaticists
- Patient advocates
- Healthcare executives
- Regulators and policy makers
- Insurers
- Patients

DICOM℠
Digital Imaging and Communications in Medicine



ACRselect™

NRDR™
National Radiology Data Registry
American College of Radiology

NRDR
LCSR™
Lung Cancer Screening Registry
American College of Radiology

NRDR
DIR™
Dose Index Registry
American College of Radiology

IMAGING3.0®

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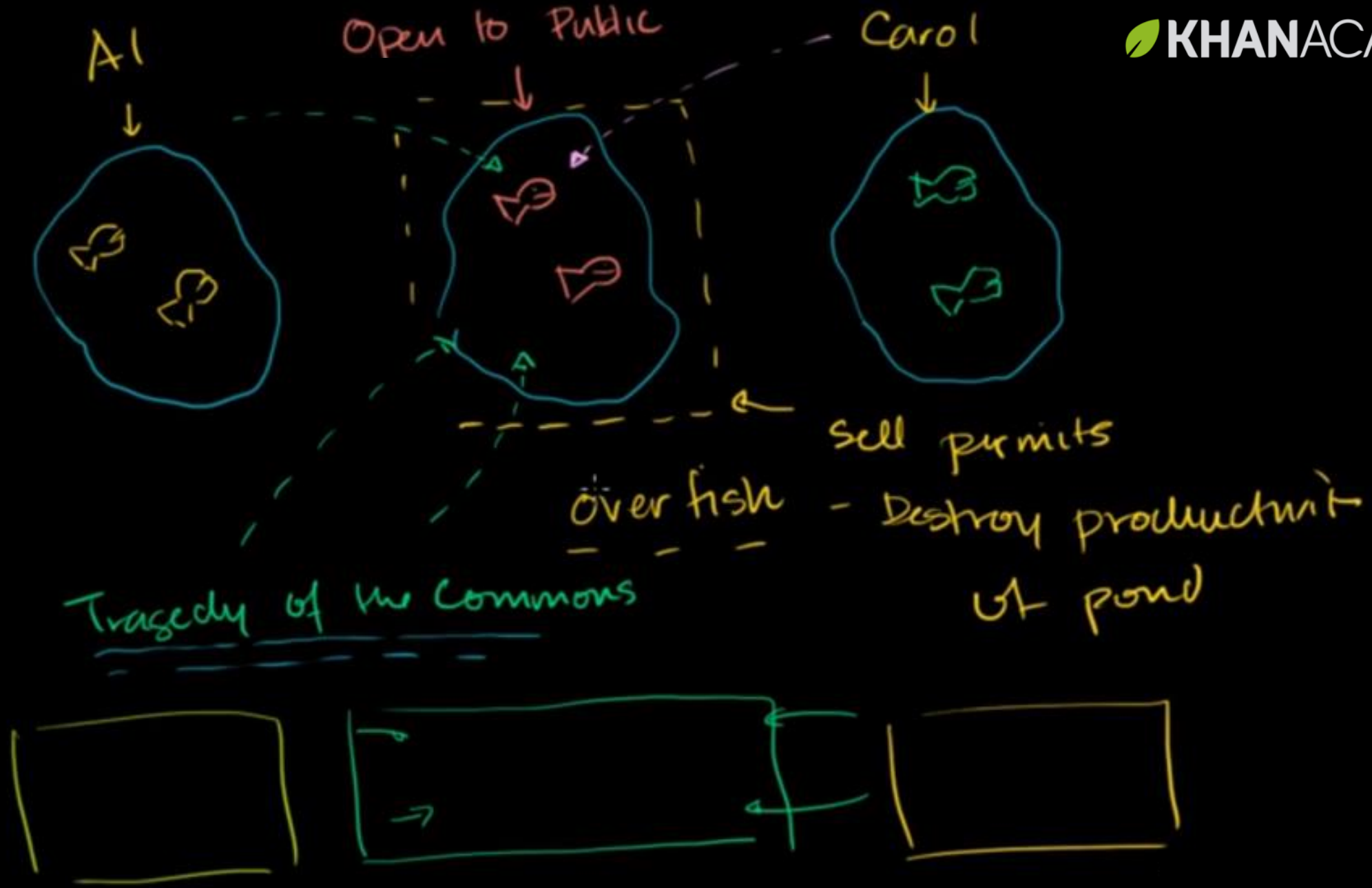
The Tragedy of the Commons



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http://www.acrdsi.org/

ACR DSI Mission

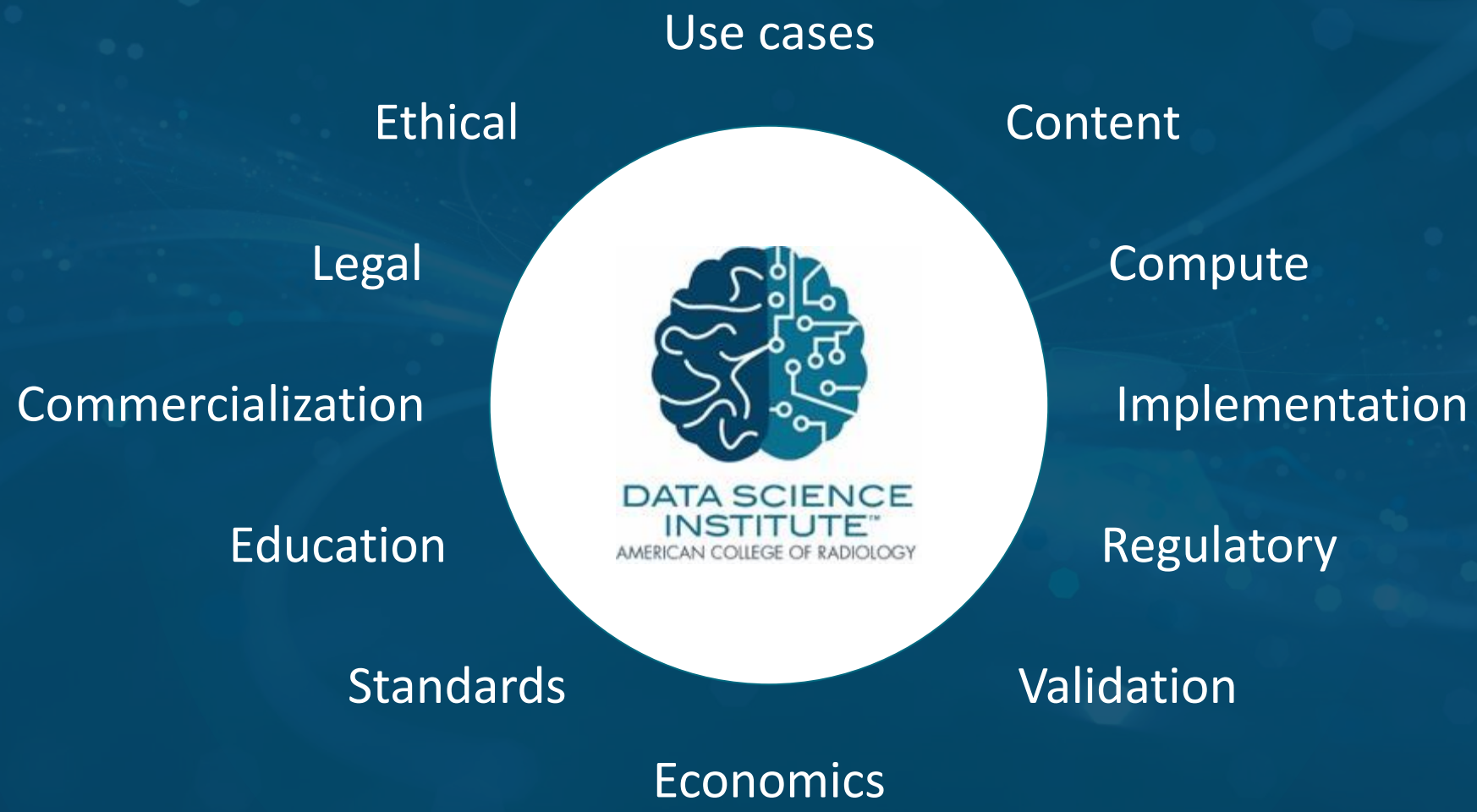
Ensure the value of radiologists as AI evolves through the development of appropriate use cases and workflow integration

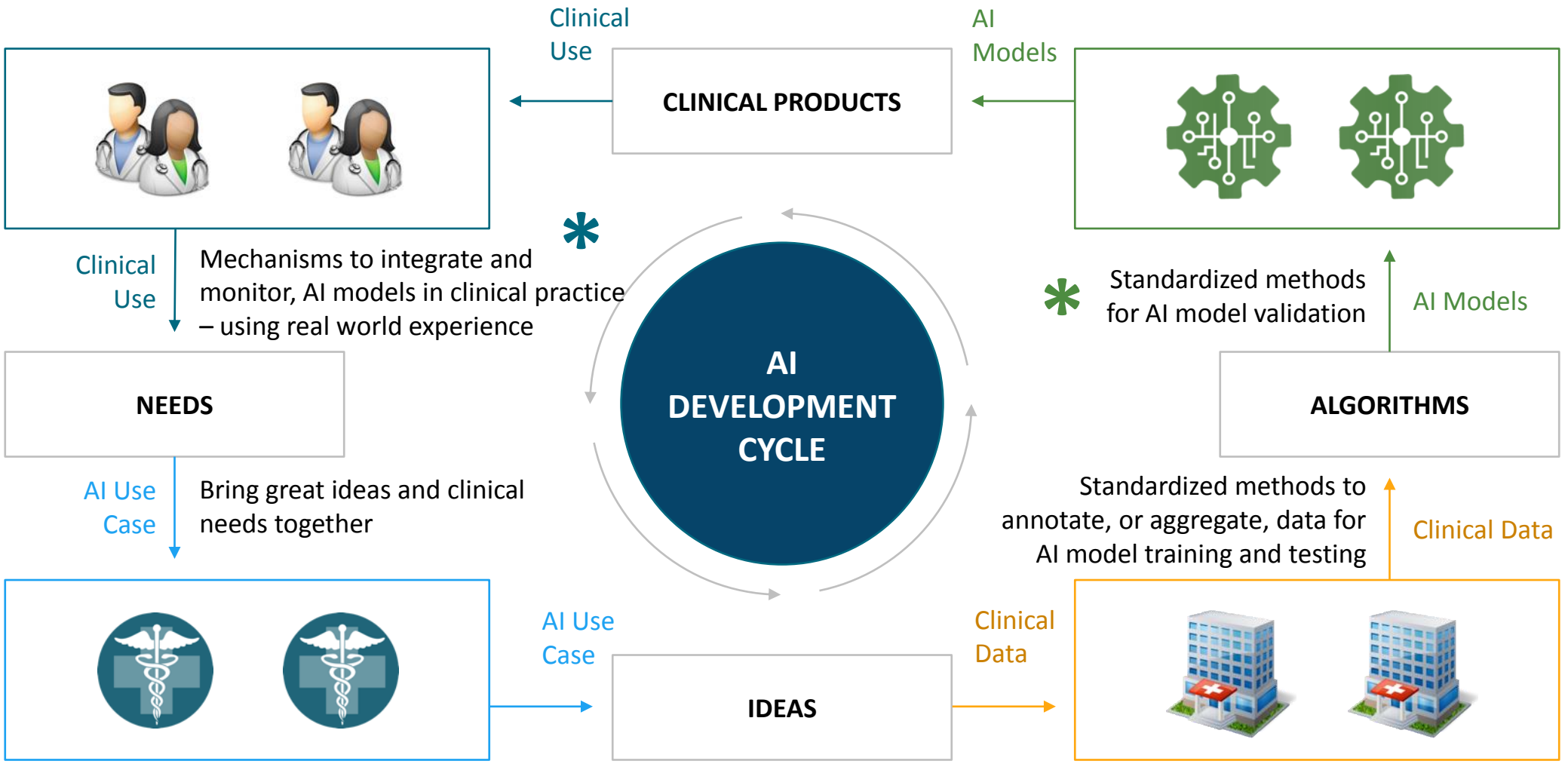
Establish industry relationships by providing credible use cases, help with FDA and other government agencies, and pathways for clinical integration

Protect patients through leadership roles in the regulatory process with government agencies and validation of algorithms

Educate radiologists, other physicians and all stakeholders about AI and the ACR's role in data science for the good of our patients

Clinical Data Science: Considerations

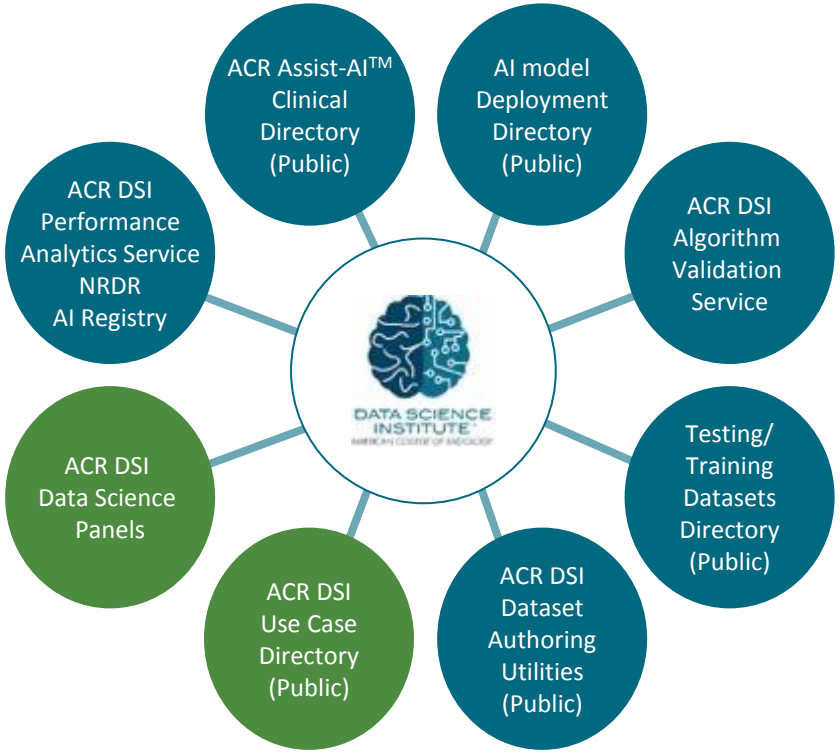




Protecting Patients From Unintended Consequences Of AI

- Algorithms useful, safe and effective
- Clinically validated
- Transparency in algorithm output
- Monitored in practice
- Free of unintended bias
- Medicare and insurance coverage issues

The Radiology AI Ecosystem
Ideas To Clinical Practice



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ACR® TOUCH-AI

Radiology's Value Proposition

- Trusted partnerships with industry and regulators
- Ensure patient safety
- Increase radiology professionals' value in healthcare

Use Case Development

- Use case authoring platform
- Human language to machine language

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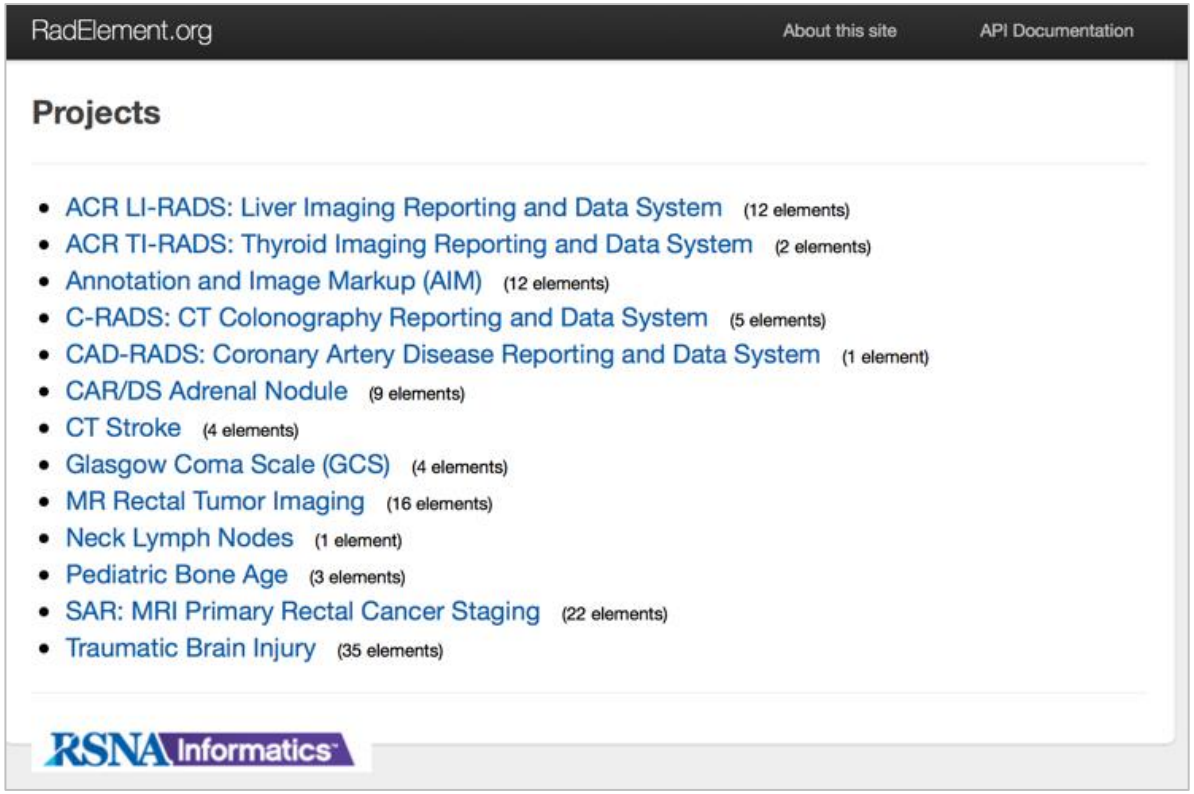
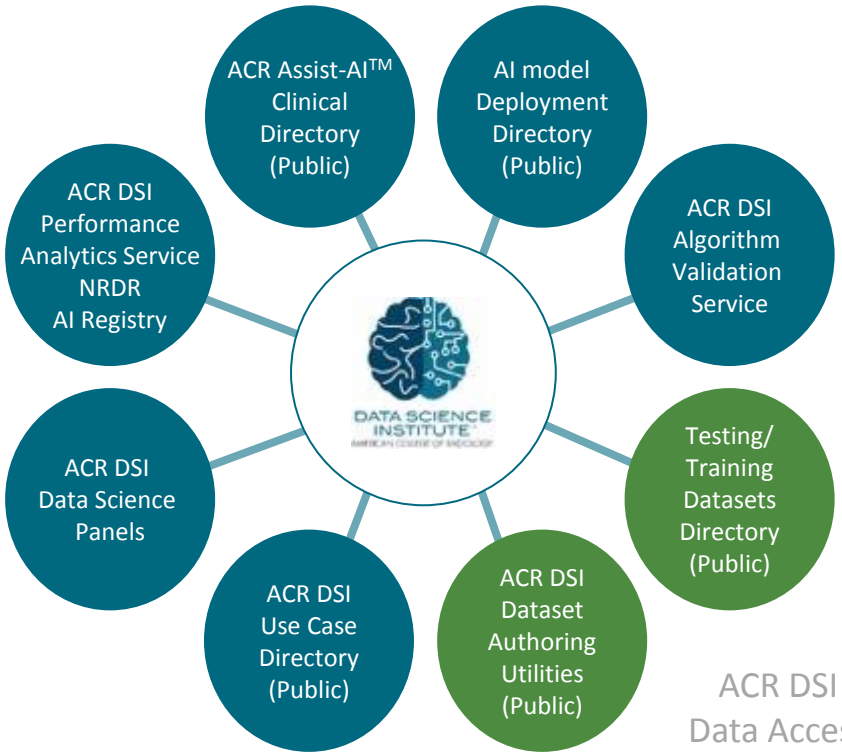
AI Data Elements

RSNA Informatics™

RadElement.org



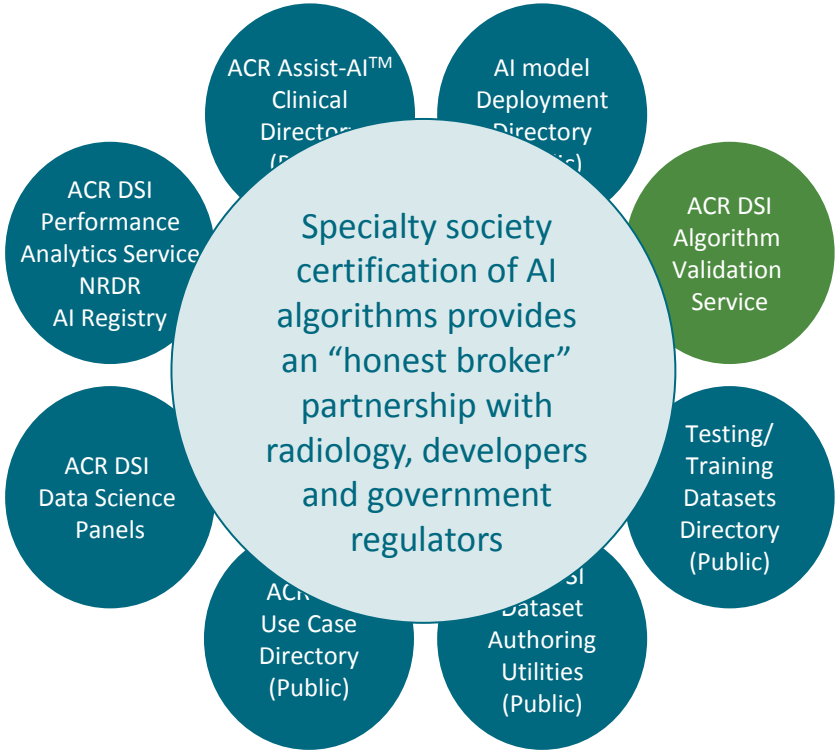
Making Datasets For AI Training
Available To Developers



Specifications For Data Access

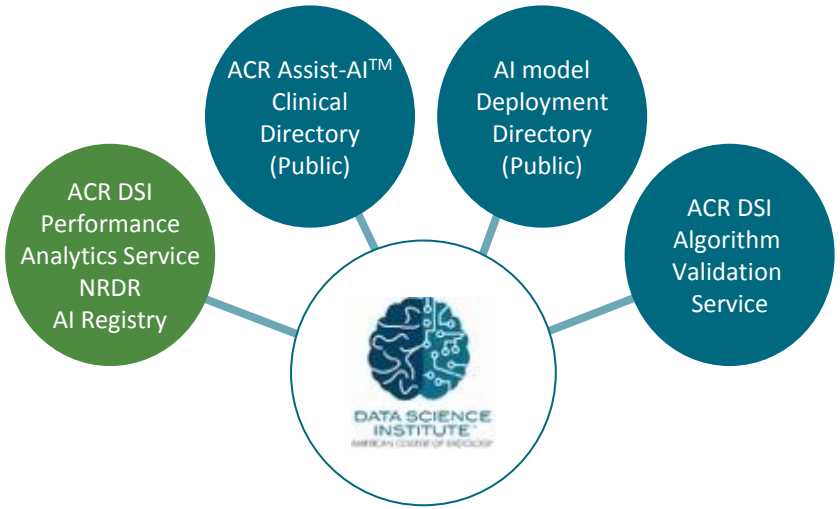
- **Standardized definitions and data elements allow multiple institutions to use these standards to create datasets that developers can use for algorithm training and testing.**
- Specifications include standardized tools and methods for image annotation.
- **Using multiple sites as data sources for these datasets provides technical, geographic and patient diversity to prevent unintended bias in algorithm development.**
- Allows more individuals and institutions to participate in AI development.
- The ACR DSI will house a freely available **public directory** of institutions that have created these datasets around ACR DSI Use Cases to inform the developer community.

ACR Data Science Institute Certified Algorithms



Specifications For Algorithm Validation

- **Centralized assessment of algorithm performance** will be performed according to the statistical metrics metrics specified in the use case using novel datasets.
- These validation datasets are created **at multiple institutions** to ensure geographic, technical and patient **diversity** within the validation dataset.
- Multiple readers and guidelines for data quality to ensure "ground truth" **consistency between sites**, consistent metrics for measuring performance across sites and standards to protect developers' intellectual property, ensure patient privacy and diminish bias.
- Reports are generated for developers



AI Monitoring Program

- Patient safety and FDA surveillance
- Algorithm transparency and radiologist acceptance
- Developer improvements

Specifications For Monitoring In Clinical Practice

- Data elements in each use case specify how the algorithm will be monitored in clinical practice.
- **Radiologist input is gathered as the case is being reported,** and if the radiologist does not incorporate the algorithm inferences into the report, this change is captured in the background by the reporting software. If the radiologists agrees changes the output of the agrees with algorithm, this is also noted and transmitted to the registry.
- **Specified metadata about the exam such as equipment vendor, slice thickness and exposure exposure are also transmitted to the registry.**
- Algorithm assessment **reports include algorithm performance metrics** and the exam parameters affecting the algorithms' performance.
- These reports are used **by the developers to report to the FDA and for algorithm improvement.**

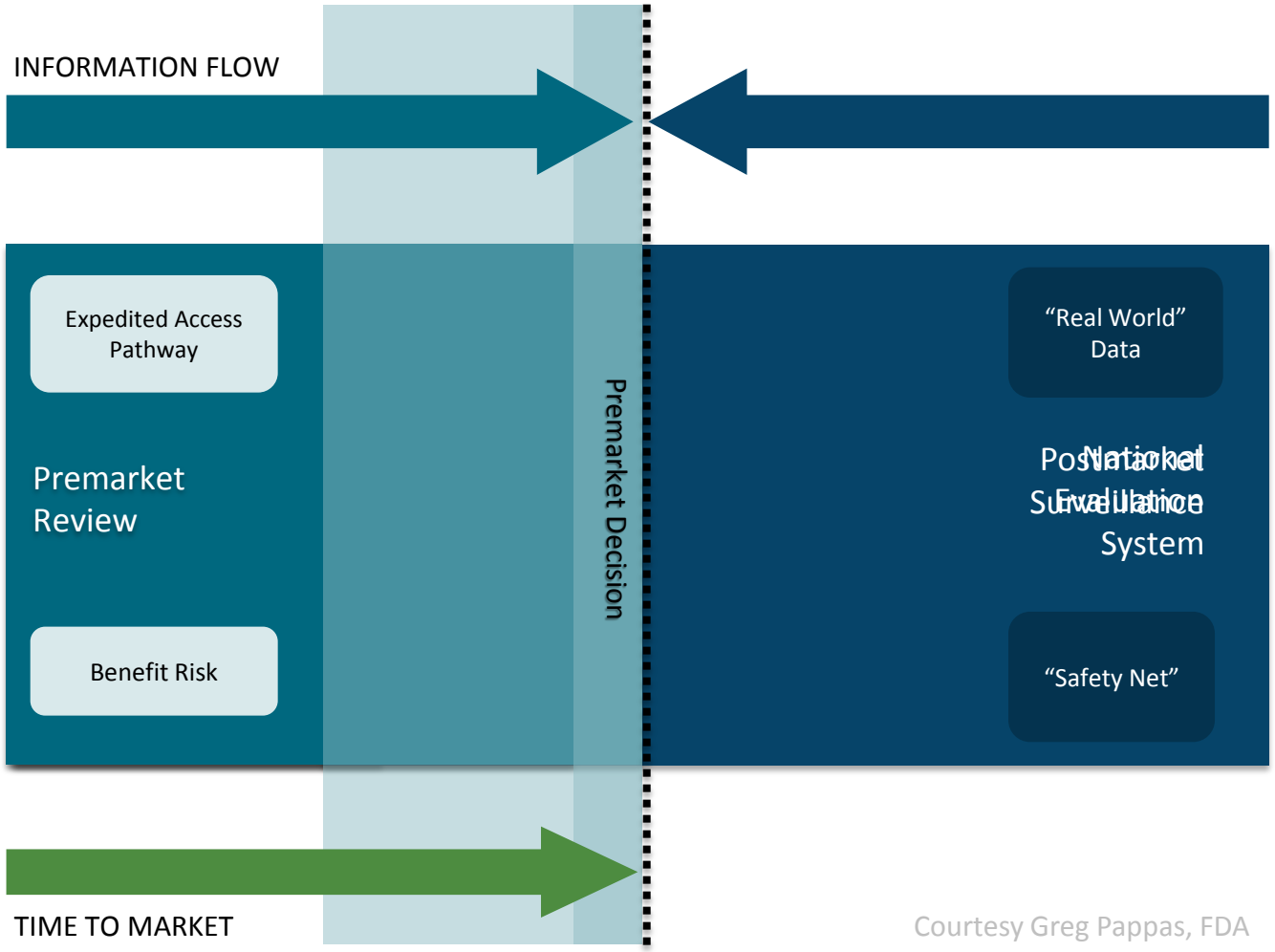
Raw Data Captured In Reporting Software And Transmitted To An AI Registry

Raw Data From Reports And Modalities Aggregated In Registry

AI Algorithm Assessment Reports For Each Developer And Site

Working Example of Monitoring Algorithm Performance Using An AI Data Registry

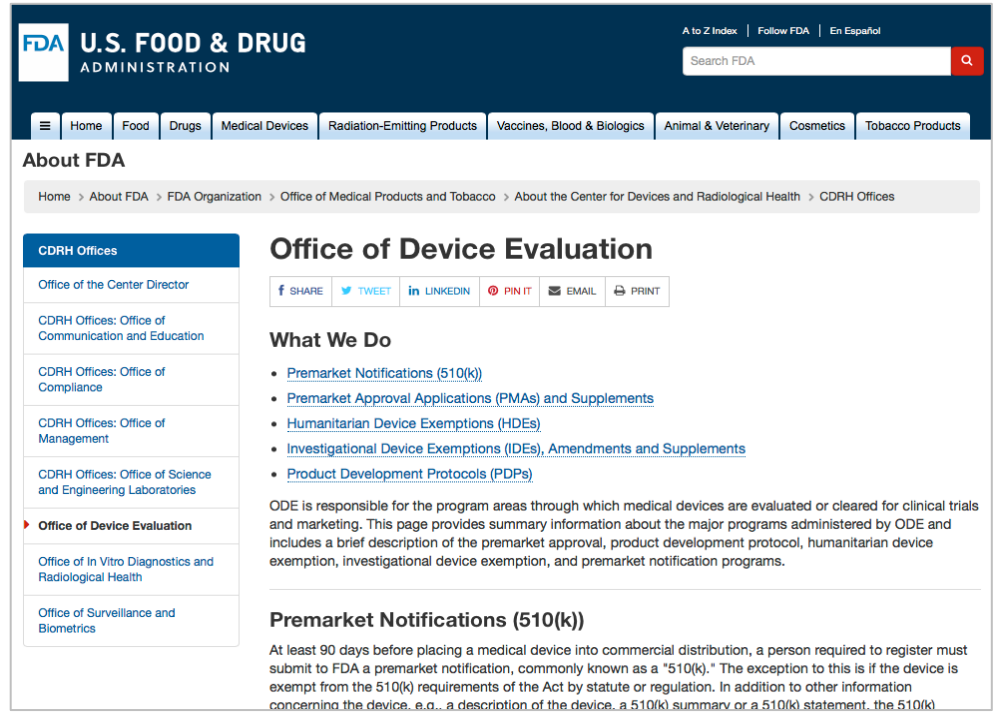
- This example is from a pediatric bone age classification algorithm. The reporting software, PACS or the modality transmits information about the radiologist's agreement or disagreement with the algorithm along metadata about the examination to the AI data registry.
- The raw data are complied in the registry and reports are aggregated and developer specific reports are generated for developers for use in FDA post-market surveillance reports and to improve the algorithm.
- Site reports are provided to provide AI performance metrics to the clinical practices.

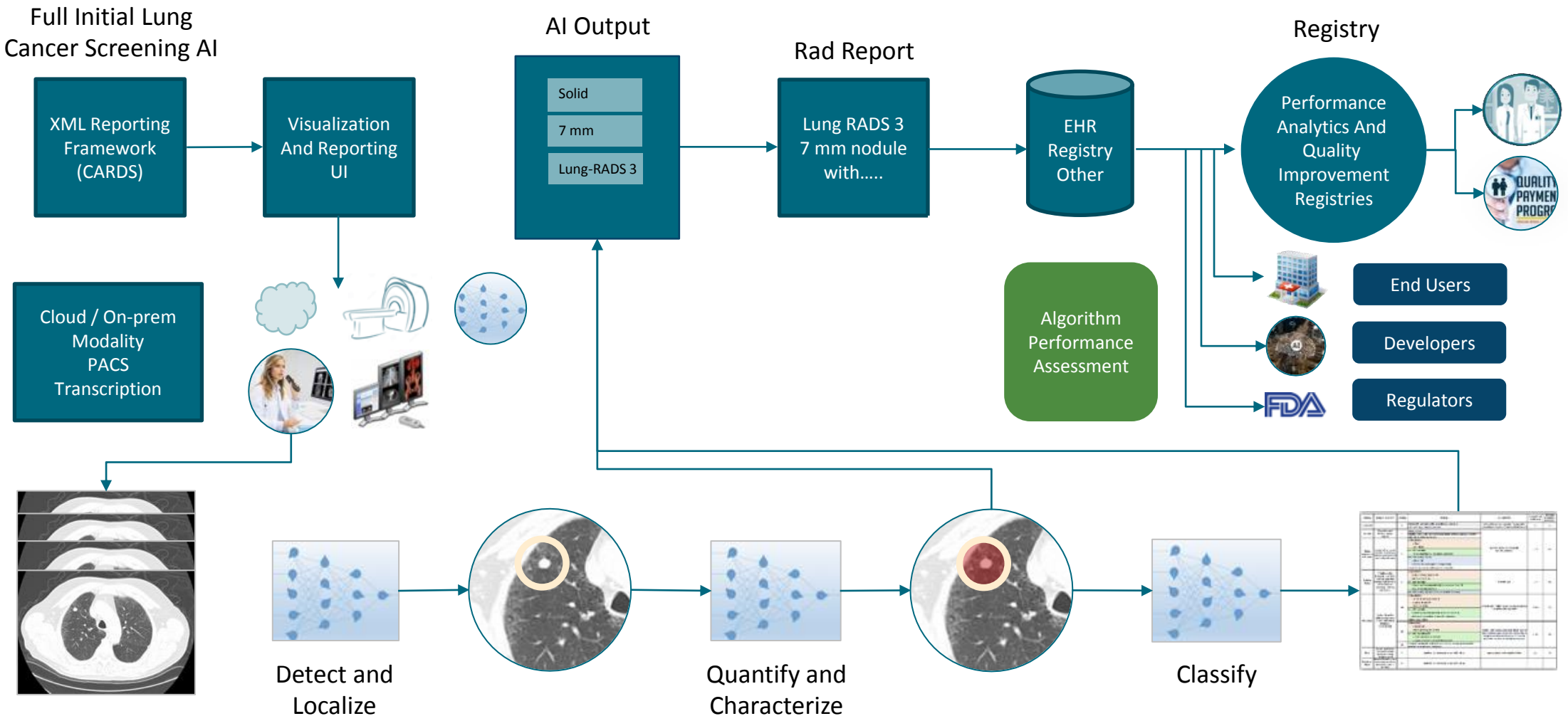


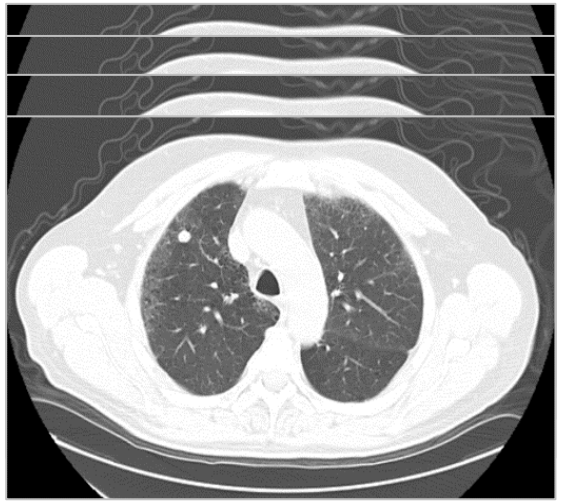
Courtesy Greg Pappas, FDA

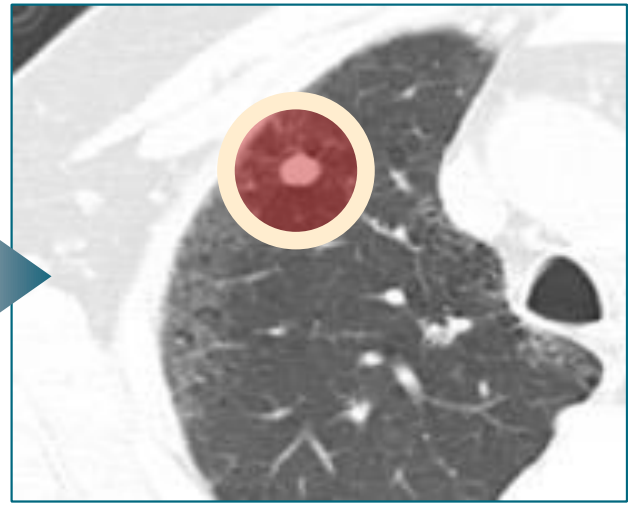
Office of Science And Engineering Labs

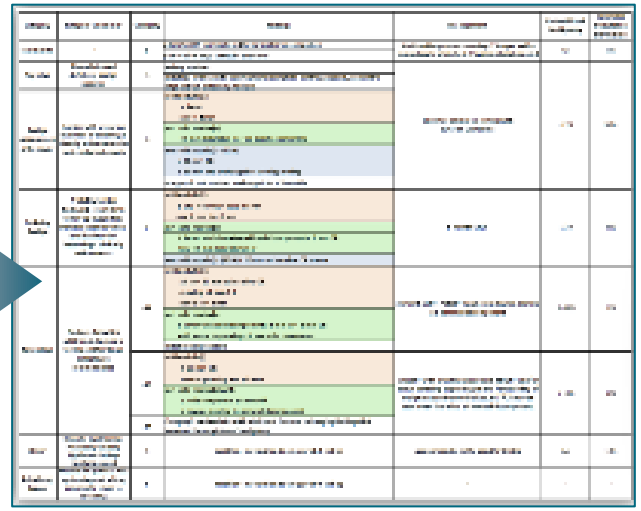
FDA Center For Devices And Radiological Health











Moving AI From Concept To Clinical Practice

Use Cases	Content	Validation	Implementation	Regulatory	Safety
Economics	Standards	Education	Facilitation	Legal	Ethical

DSI and Healthcare AI Industry

Services to assist industry deliver successful AI solutions to clinical practices

- AI Use Case Development (ACR TOUCH-AI)
- AI model Certification (ACR CERTIFY-AI)
- AI model Integration (ACR ASSIST)
- AI model Assessment (ACR DSI ASSESS and ACR AI REGISTRY)

ACR DSI Use Cases

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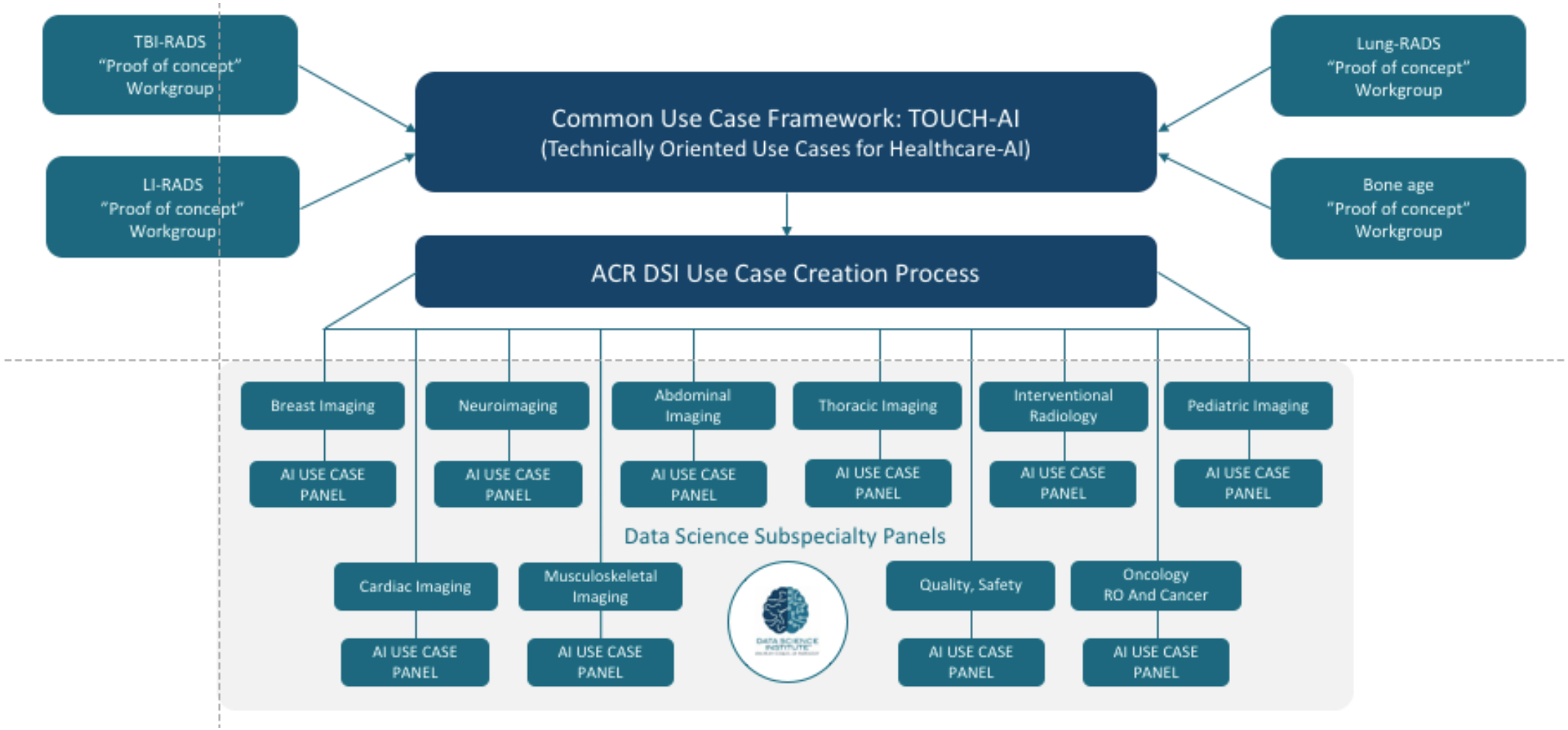
USE CASES

AI

Use Case Prioritization

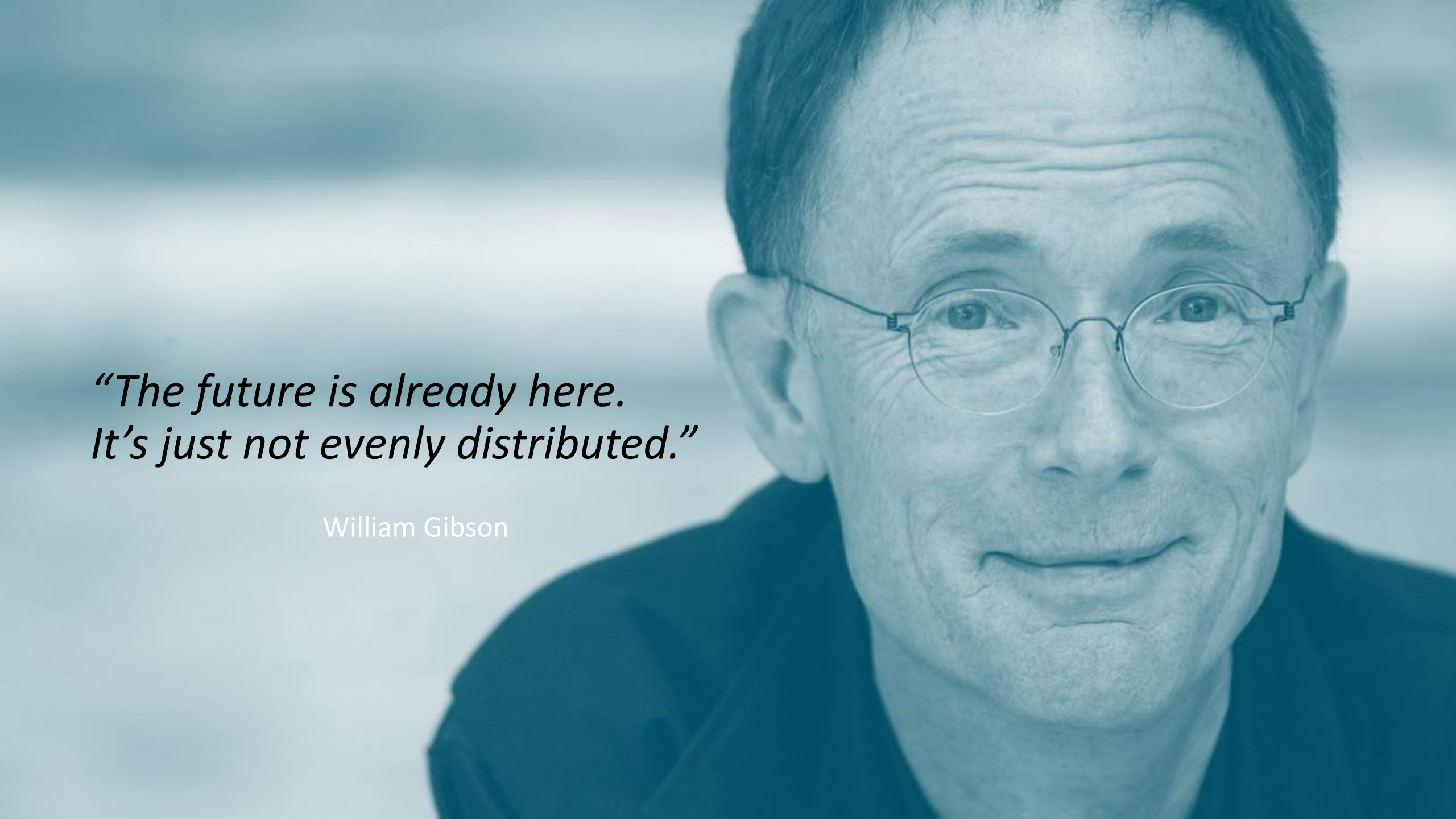
Highest clinical value

Solvable by artificial intelligence



Summary Of ACR DSI Objectives

- Useful
- Safe and effective in clinical practice
- Performance monitored and improvements made based on real world data
- Transparent
- Ensure diversity and preventing unintended bias


*“The future is already here.
It’s just not evenly distributed.”*
William Gibson