Digital Twin for Precision Health

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Financial disclosures: None

My background

- Clinical role: heart failure (HF) cardiologist in Tucson Veterans Affairs Medical Center
  - Clinical management of HF and general heart conditions
  - User of video telehealth to support patients in rural AZ
  - User of population dashboards to manage HF
  - Not focused on procedures or imaging; not using ML yet
- Research role: Clinical cardiovascular research, ASU
- Experience in pharmaceutical utilization management, CVS Health

My background – Research focus

- Epidemiology, outcomes, and prediction of cardiac amyloid in U.S. Veterans
  - Cardiac amyloid due to protein buildup in heart; 10% of HF patients
  - Emerging cause of cardiac and neurologic disease
- Implementation science to promote to early diagnosis of amyloid
  - Development of screening interventions
  - Qualitative research - Focus group, interviews

'Nudge' interventions to increase adoption of treatments for HF

  - Behavioral nudges frame information without limiting autonomy (e.g., information alert, peer comparison)

Impact of AI in Diagnostic Imaging

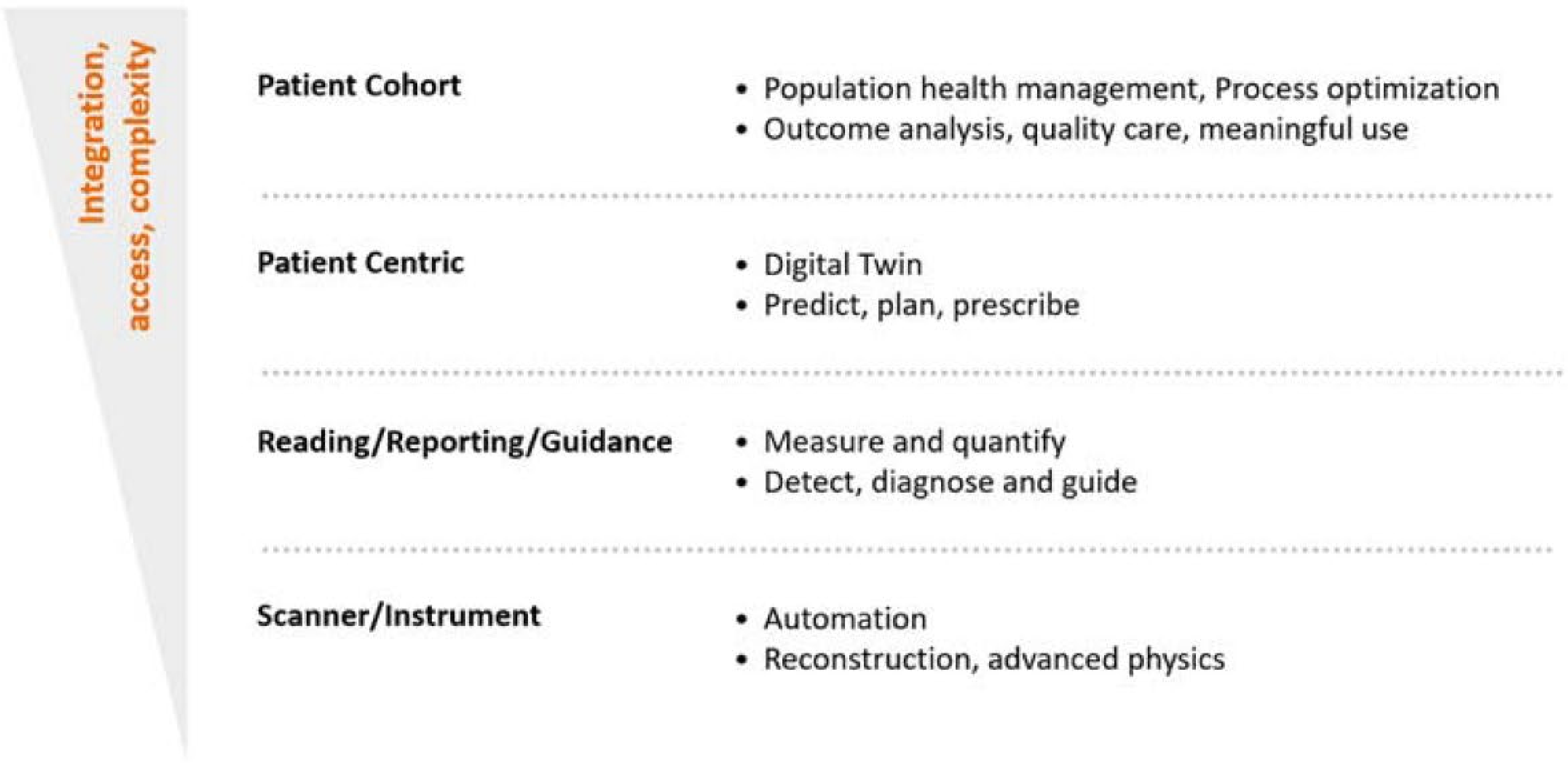

FIGURE 1. Impact of AI at multiple levels along the value chain of diagnostic imaging.

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AI for Image Processing and Reporting is Robust

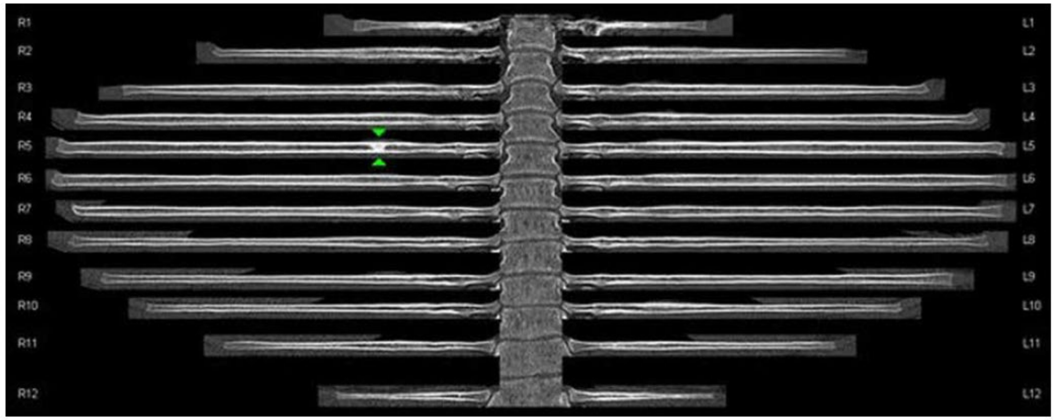
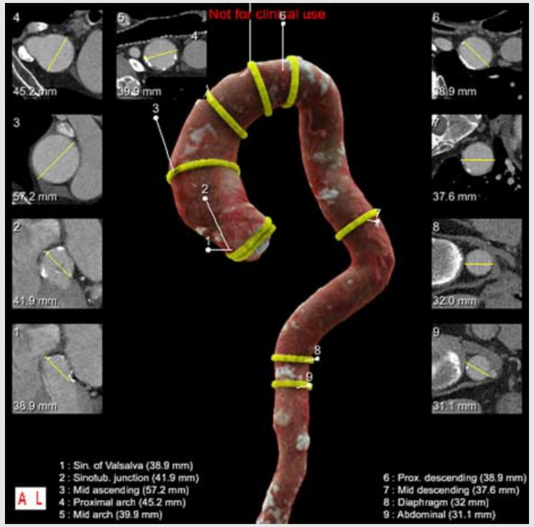
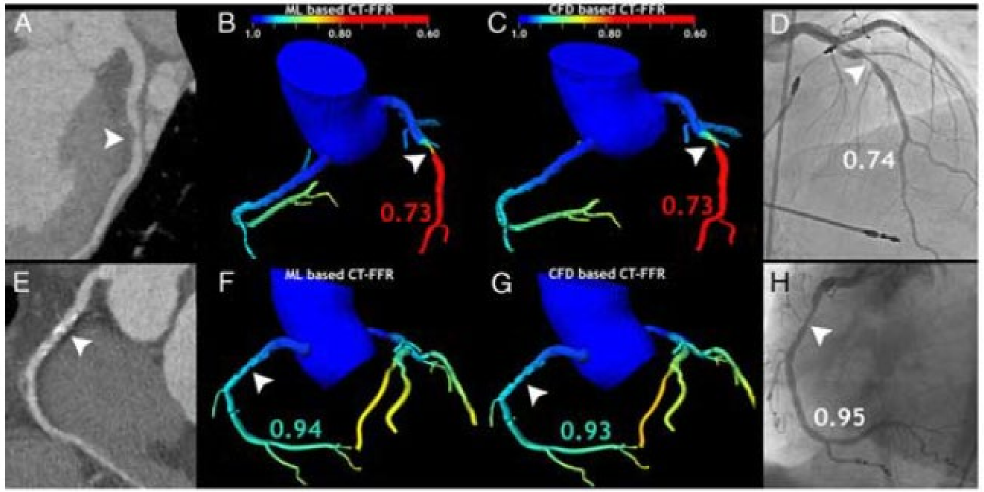
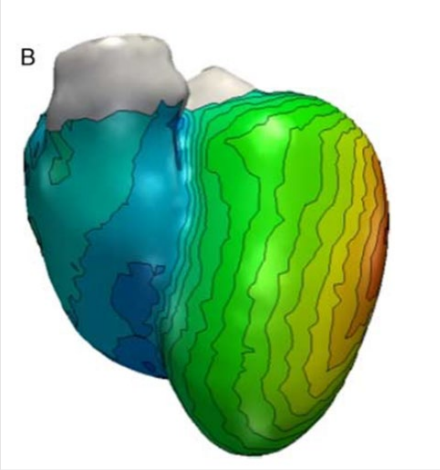


FIGURE 2. Unfolded views of the ribs that were produced by an automatic machine-learning algorithm. (Data courtesy of Medical University of Vienna, Austria).







. *J Thorac Imaging.* 2020;35 Suppl 1:S11-S16.

VHA Innovation Ecosystem

ARCHES

CENTER FOR CARE AND PAYMENT INNOVATION

ARCHES

The Data & Analytics Development, Testing & Validation Platform

Amanda Purnell

Nov 2022

Critical Feedback and support from:

Angela Gant-Curtis, Michael Harry, Blake Henderson, Arash Harzand

VA | U.S. Department of Veterans Affairs

What is ARCHES?

COLLABORATE
Users can build models and share resources with security and protection

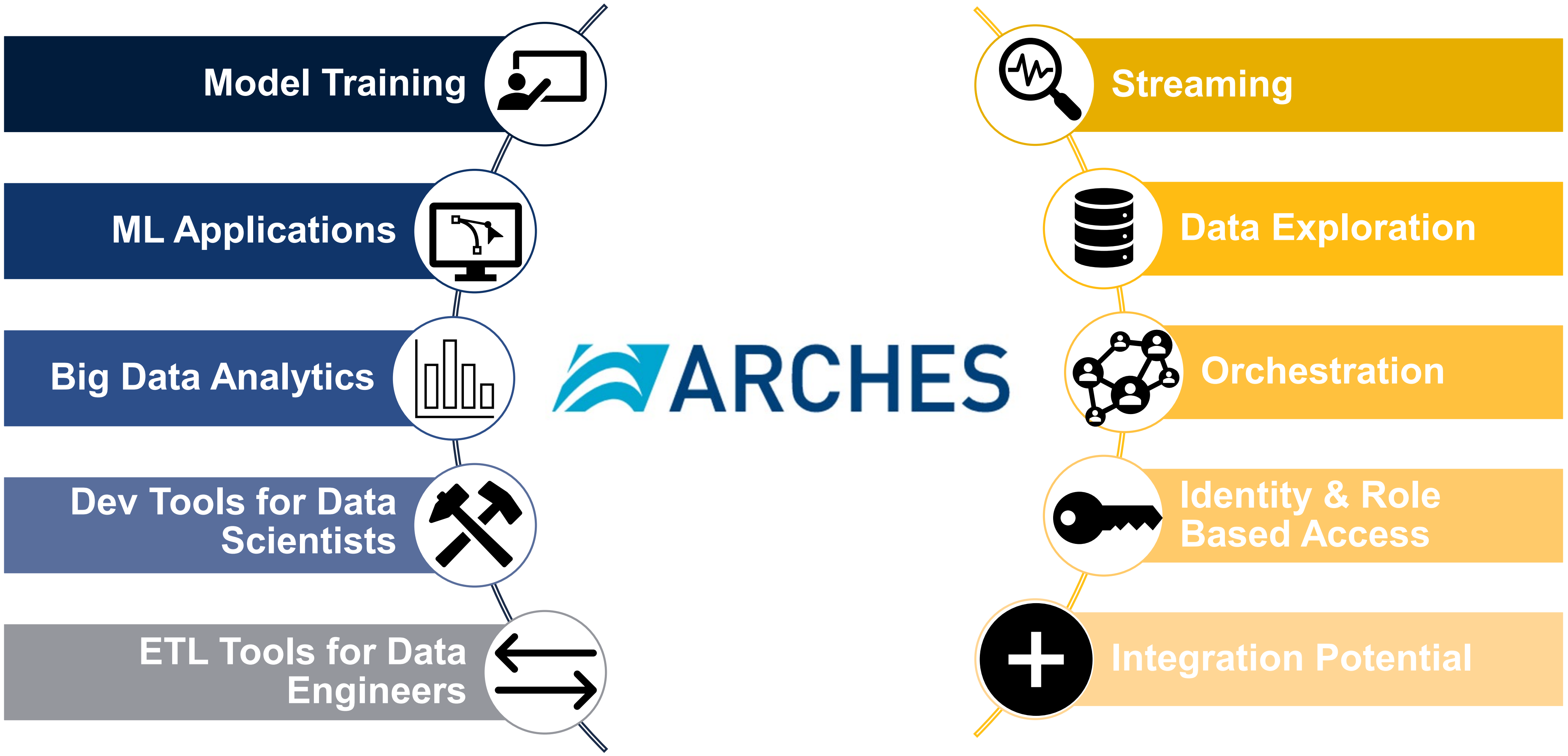
INNOVATE
Modern practices and faster IT infrastructure create an agile environment for innovation

SOLVE
Our network of innovators can use Arches to create data-driven solutions that improve patient care and treatments

- The cloud-native platform, complete with a rich set of computational tools, provides a **development, testing, and validation** environment for VA employees and partners.
- In addition to real patient data, Arches makes **synthetic patient data** readily available as a reliable and accurate alternative.

Tools

Features



What ARCHES Offers

Freedom to Explore Data Driven Solutions

ARCHES' 'walled playground' design philosophy provides users unequaled freedom to solve problems within the platform

Data Access & Flexibility

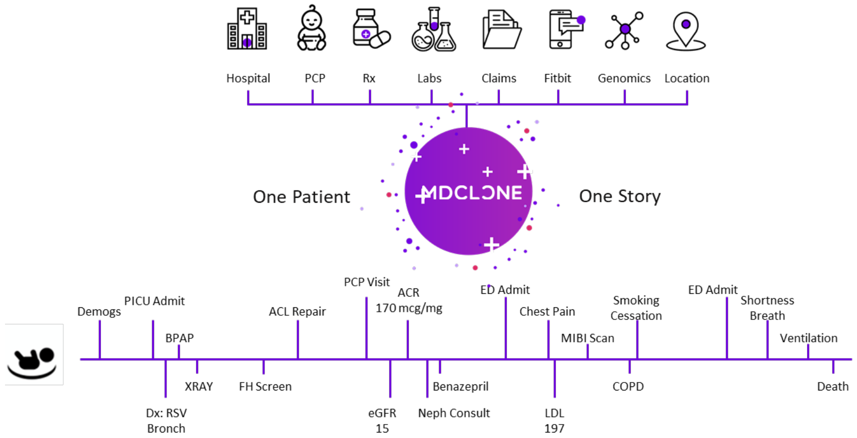
Users can leverage existing data sets, synthetic data, or bring in data and use analytics tools to test commercial value

Integration Potential

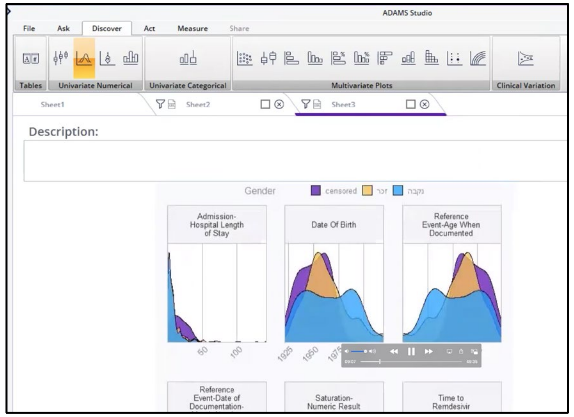
Containerization allows proven models and data driven research to be migrated to production platforms or reproduced in other systems

Increasing access: self-service and synthetic data

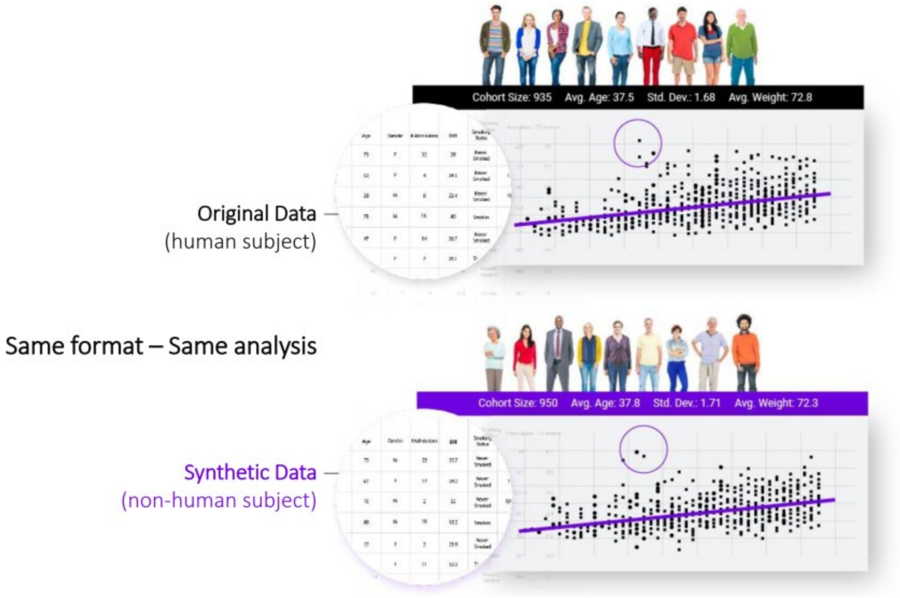
Organize patient data



Facilitate data insights

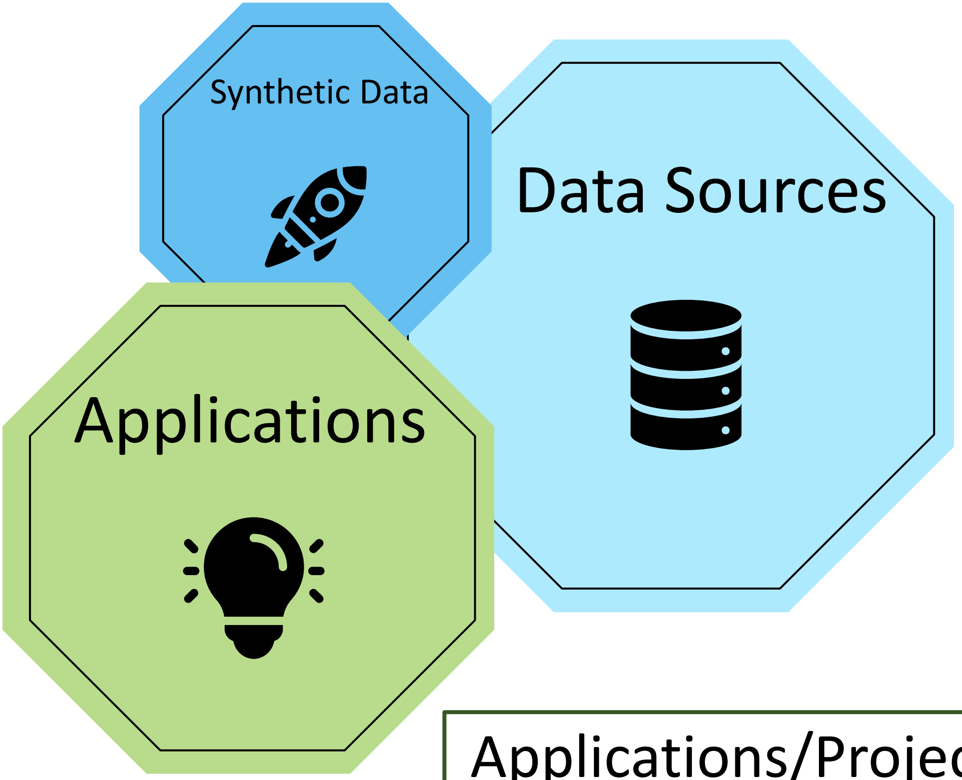


Generate sharable synthetic data



ARCHES

What's on the Menu?



Leveraging Synthetic Data

- Clostridium Difficile (C-DIFF)
- Suicide Prevention Grand Challenge
- COVID Modeling Challenge
- Heart Failure
- Alzheimer's
- Cardiac Amyloidosis
- Frailty
- Virtual BP

Adding New data Sources

- DICOM
- E-Screening
- Suicide Hotline Data
- CCPI Dental

Applications/Projects

- MDClone
- ADAMS
- NLP Studio
- Cloudera
- *AgileMD
  eCART

- Cogitativo
- ETS
- SymphonyAI
- HyperScience
- OpenShift
- *SIC

- *SSIE
- CareCentra
- Alteryx
- TIBCO
- *H20 AI
- CCPI

Leveraging Synthetic Data

VHA Accounts
75

VHA Users Provided Training
35

VHA Active Studies
11

3m

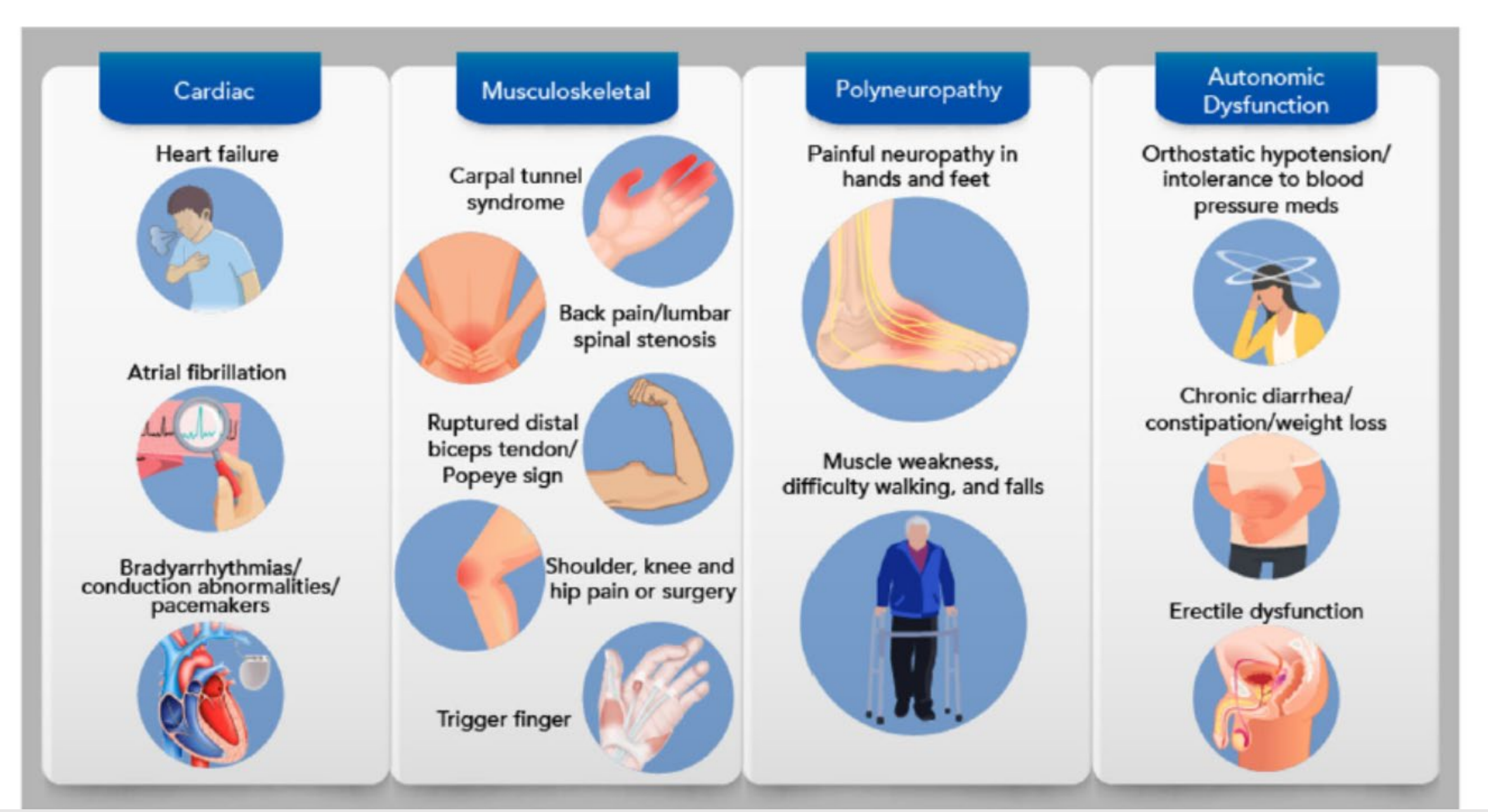
6m

12m

18m

- Telehealth
- Sleep Apnea
- Alzheimer’s
- Cardiac Amyloidosis
- Heart Failure Prediction
- Suicide Prevention
- Preventable Clinical Trial
- COVID Variations
- Virtual BP Visits
- Sarcoidosis
- Spinal Stenosis
- Long COVID
- Lung Cancer

Cardiac Amyloid is a Rare, Nonspecific Disease and Potential Candidate for Machine Learning



Early diagnosis is critical in cardiac amyloid: Red flags often predate diagnosis by years

Cardiac Amyloid Research

- Describe incidence and prevalence of disease in entire VA population
  - From 25 million, we identified 14 million between 2012-2022
  - VA Data warehouse (via MDClone): Diagnosis, labs, utilization, medications, demographics
  - Not utilizing : ECG, images, unstructured data
- Develop a predictive model of future cardiac amyloid at time of HF diagnosis

- Next steps:
  - Explore use of ML to discover new predictors, prognosis
  - Develop decision support / nudge interventions to facilitate early diagnosis

Advantages: No SQL coding required using MDClone; rapid access to complete, original data

Clinical Translation: Pre-symptomatic diagnosis (population health)

- How many patients could have this disease in my health system?
- What is the likelihood of an individual patient having the disease ?
- For patients with these characteristics what is the cost effectiveness of screening based on my health system?
- Who is falling through the cracks / no show?
- Who needs a phone call checkup?

Clinical Translation
Initial presentation of HF Patient

- Does this patient truly have HF?
- What is the underlying, causative disease ?
  - e.g., sarcoid heart disease
- Prognosis ?
  - Personalized risk: How much will defibrillator reduce risk for this patient?
  - Do we need a continuous risk predictor or static?
- What diagnostic information is missing, needed?
- What treatments are missing compared to similar patients?
- What is the most efficient pathway to diagnose in my health system?
  - E.g., centers preferring invasive strategy have quicker time to diagnosis

Clinical Translation
6-month Follow up of same HF patient

- Compared to similar patients in my health system, should treatment be changed?
- Was the diagnosis correct?
- What is the prognosis at this time point?
- What test should I order now?
  - E.g. repeat echocardiogram, renal function

Much of daily clinical practice behavior guided by consensus, expert guidance, experience and not data

Is a digital twin applicable at the level of a health system / population?

Components of digital twin	
Computational model	Yes
Represent behavior of physical system/process	Yes – entire population is the 'system'
Two-way flow of information	Yes ?
Physiological model	No

At health system level, improve processes for staff allocation, visitor/patient flow, waiting time, equipment and other internal resource provision, emergency vehicle access and other service-related operations

Challenges

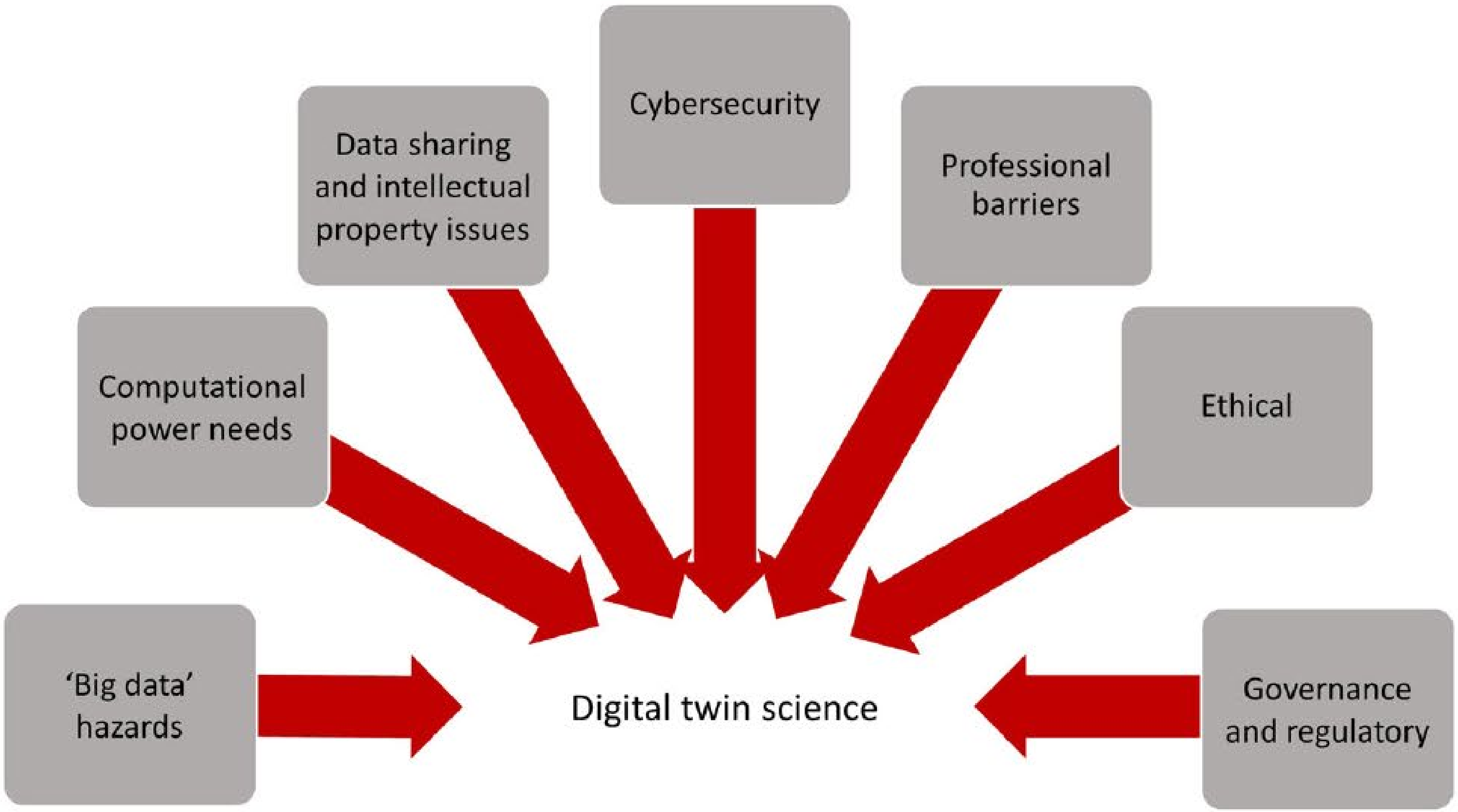
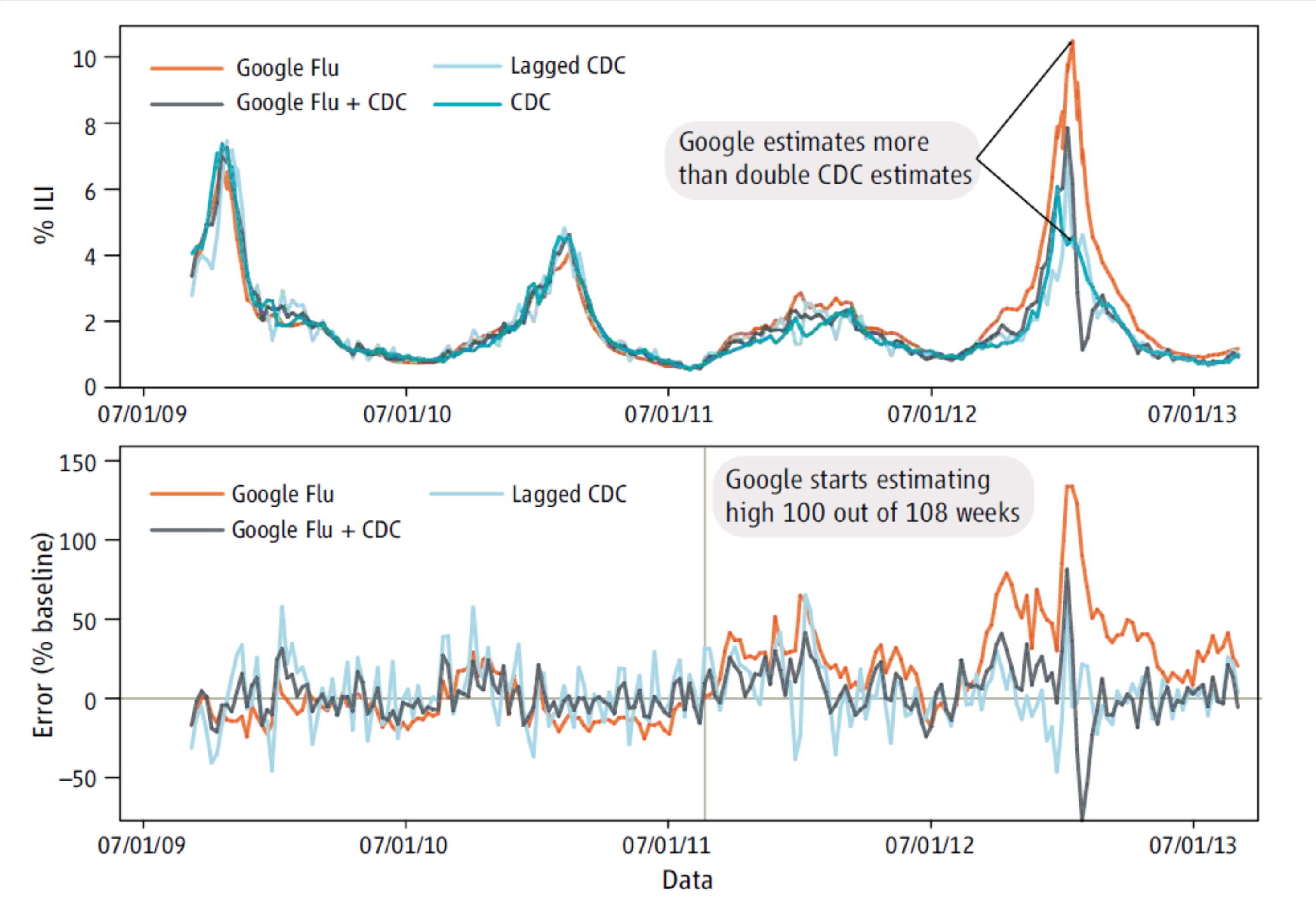


Fig. 4 Translation issues in digital twin science.

Perils of Big Data – Google Flu Trends



Lazer D, Kennedy R, King G, Vespignani A. The Parable of Google Flu: Traps in Big Data Analysis. *Science.* 2014;343(14 March):1203-1205.

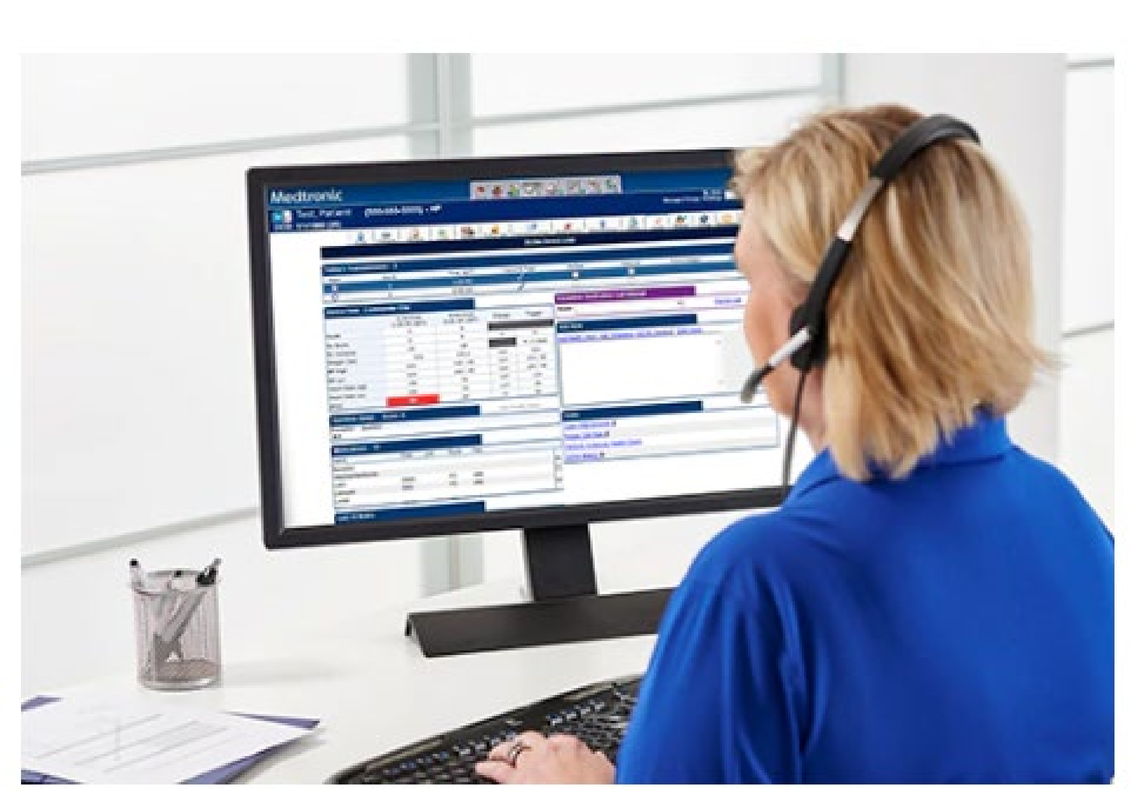
Perils of Big Data – Google Flu Trends

- Even 3-week-old CDC data do a better job of projecting current flu prevalence than GFT
- Several changes in Google's search algorithm and user behavior likely affected GFT's tracking
  - This could happen with digital twin
- Recommendations:
  - Transparency and duplication
  - Use Big Data to Study the Unknown

The Parable of Google Flu: Traps in Big Data Analysis. *Science.* 2014;343(14 March):1203-1205.

Challenges of Technology Integration:

Despite Promise of Remote Monitoring, Clinicians May View as Extra Burden



Can remote monitoring talk back ? Prescribe and Predict

Challenges

- Clinician and patient behavior change is difficult
- Clinicians are overworked, often with low-value work
    - E.g., additional alerts / nudges in EMR system will trigger clinician pushback due to information overload / burnout
- Digital twin designed for a repeated workflow that reduces clinician workload is easier to adopt
    - E.g., coronary CT angiography flow assessment (CT FFR) for severity of stenosis; pulmonary nodule detection

Who benefits from the innovation and are they included in some way?

Application Drivers

What would you see as most important application drivers?	Integration of health care data silos, interoperability, incremental progress, implementation science (e.g., workflow), behavior
What actionable information do you see DT can provide that is not feasible today?	Real-time updates, address different problems within a single platform, use all available data and make actionable insights

Technical gaps and opportunities

Technical gaps?	External generalizability; as an emerging field, the digital twin needs guidelines, gold-standards, and benchmark tests (e.g., MINIMAR)
How would you see your work or the work of the community to contribute to this? Modeling, Sensor Design, AI or other matters?	Implementation science- (reach, implementation, effectiveness, adoption, maintenance)

Teaming and timeline

What kind of team would you expect to address the technical challenges? What disciplines?	Don’t forget ethics, real-world clinicians, social science / qualitative, geriatrics, implementation scientist
What is the timeline for your potential directions? 2 years, 5 years or 10 years?	2 years with focus on ML models in cardiac amyloid