



Building the Digital Infrastructure for Clinical Research and AI in Cardiovascular Medicine at Northwestern

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Disclosures

- Received consulting fees from Amgen
- Funded by PCORI, AHRQ, and NHLBI

Outline

- 1. Bluhm Cardiovascular Institute and the CARdiovascular Digital AI Core (CARDIAC)**
2. Progress and Challenges in Data Plumbing
3. Future Directions in AI in BCVI
4. Resourcing

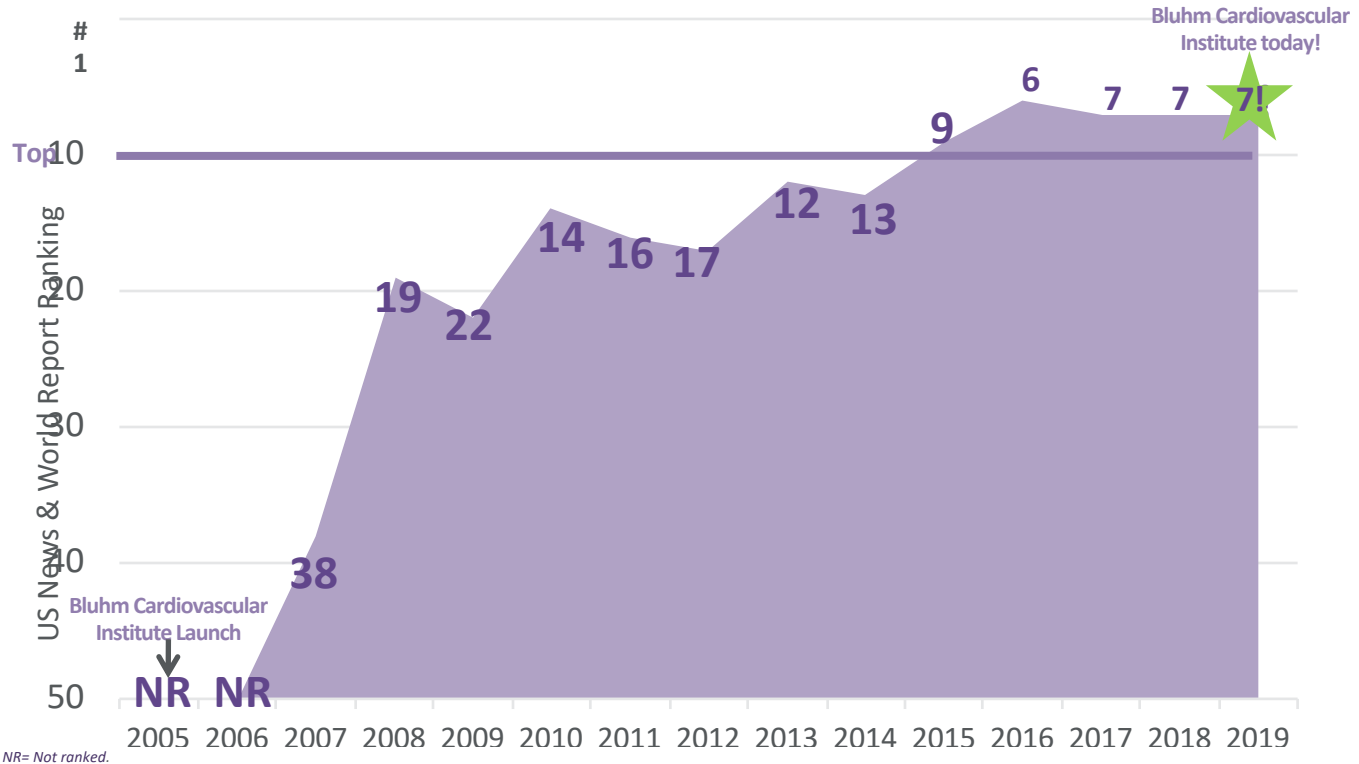
Bluhm Cardiovascular Institute



Depicts NM sites with cardiovascular presence

US News & World Report Cardiology and Heart Surgery Ranking

Goal: Top 10 by 2020



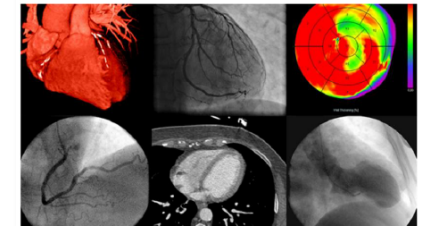
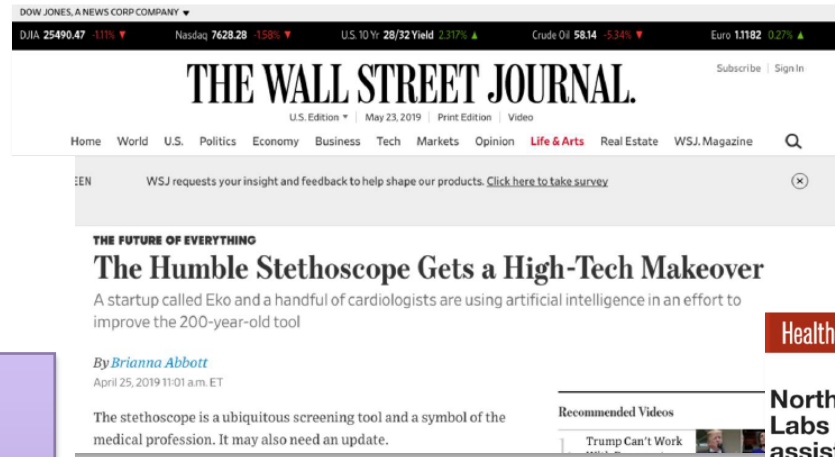
Bluhm Cardiovascular Center for Artificial Intelligence

Pioneering the future of artificial intelligence in cardiovascular medicine



Northwestern Medicine Launches New Center Using Artificial Intelligence and Machine Learning to Treat Cardiovascular Disease

Transformative \$25 million gift from the Bluhm Family Foundation helps fund new center

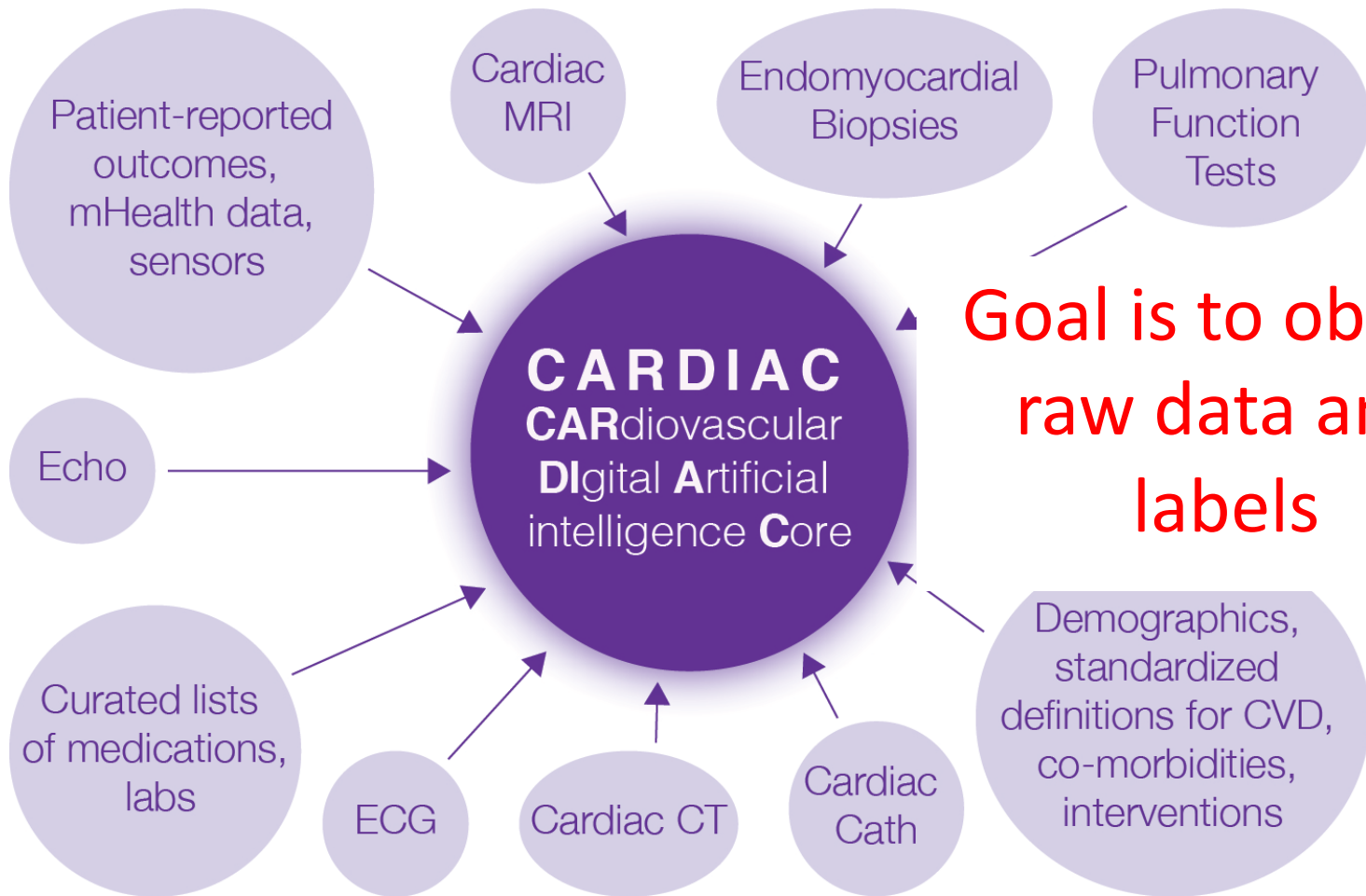


Institute for Augmented Intelligence in Medicine

Northwestern Medicine EDW Overview

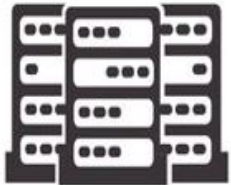
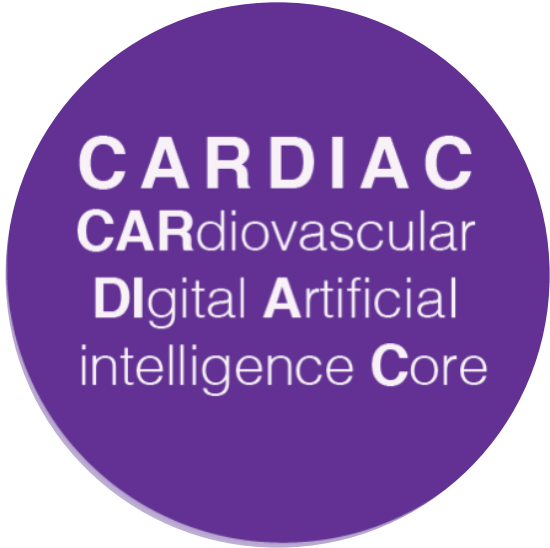
What is the EDW?

- The Northwestern Medicine® Enterprise Data Warehouse (NMEDW) is a joint initiative across the Northwestern University Feinberg School of Medicine (FSM) and Northwestern Memorial HealthCare (NMHC)
- **Mission Statement:**
 - To create a single, comprehensive, and integrated repository of all clinical and research data sources on the campus to facilitate research, clinical quality, healthcare operations, and medical education
- The EDW contains data from 140+ source systems, and is continuously loading data from new source systems

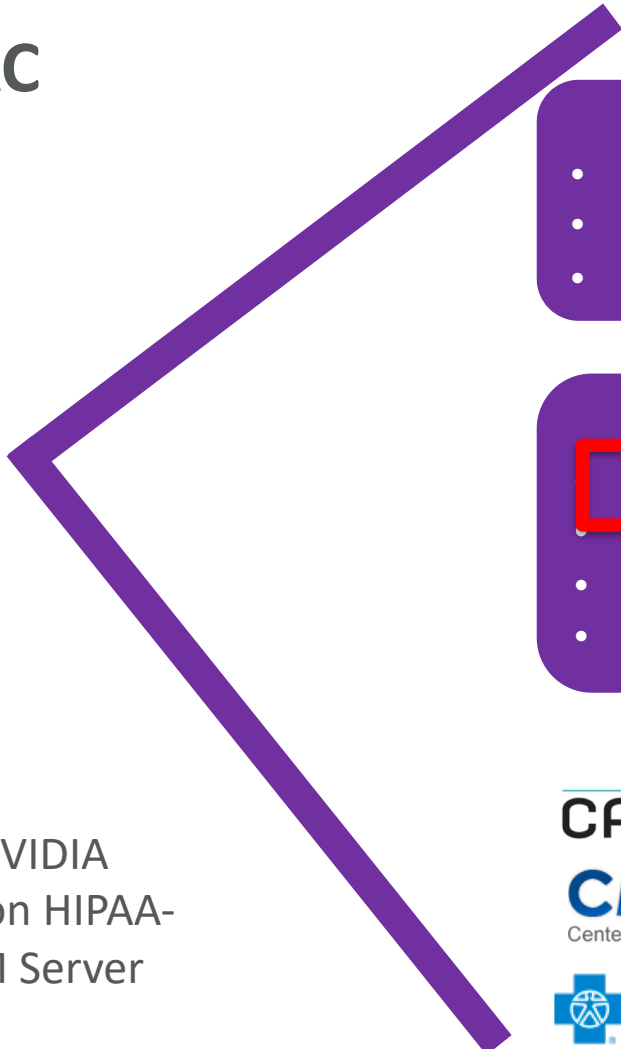


**Goal is to obtain
raw data and
labels**

Use Cases of CARDIAC



The SA Node: 2 NVIDIA
TITAN RTX GPUs on HIPAA-
compliant on FSM Server



Patient Care and Operations

- Population Health Datamarts
- Analytics
- Quality Reporting

Clinical Research

AI/Machine Learning Studies

- Trial Eligibility
- Pragmatic Trials
- Epidemiological Studies



Centers for Medicare & Medicaid Services



BlueCross BlueShield
of Illinois



Diverse expertise required to solve data problems

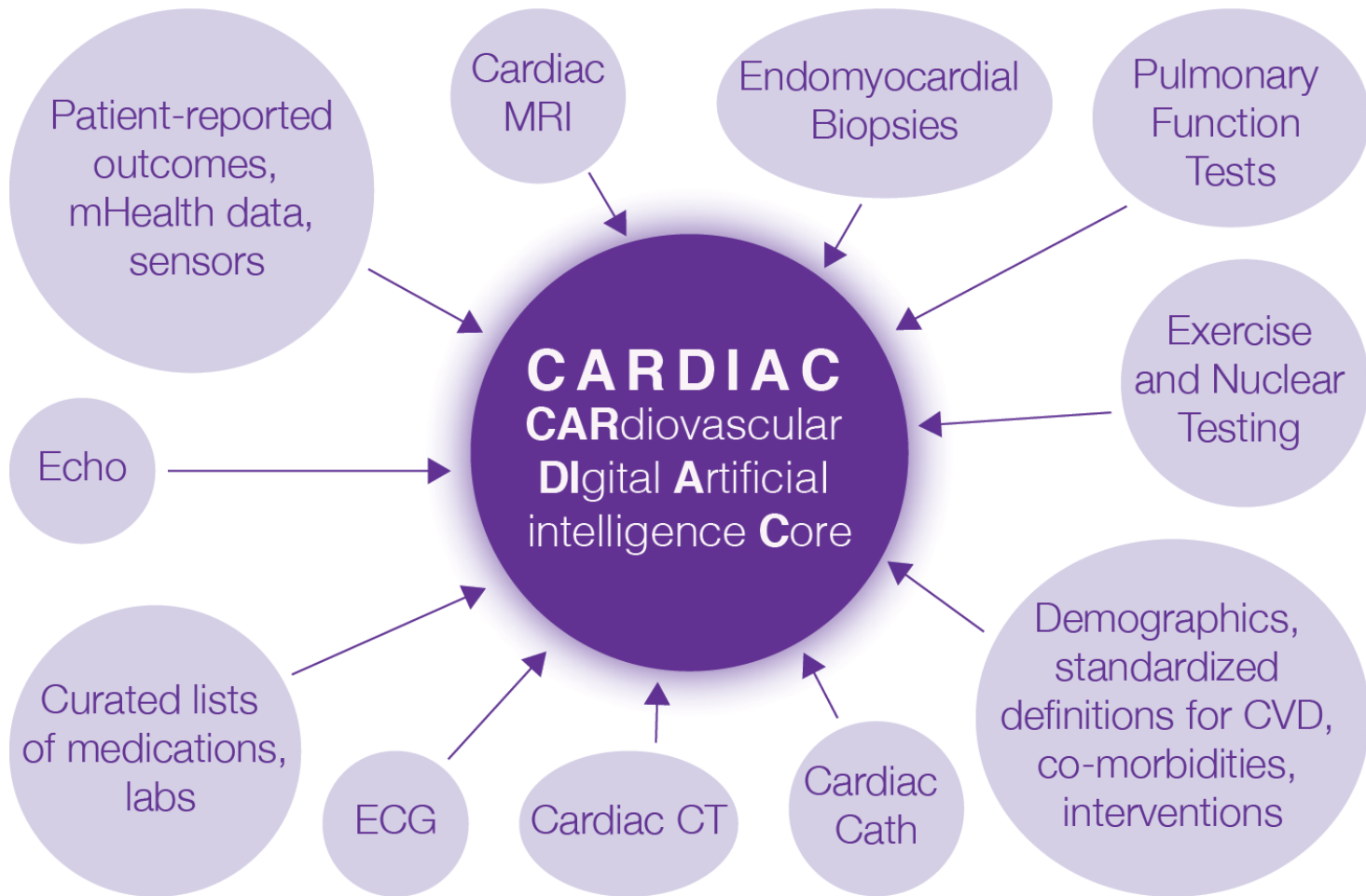


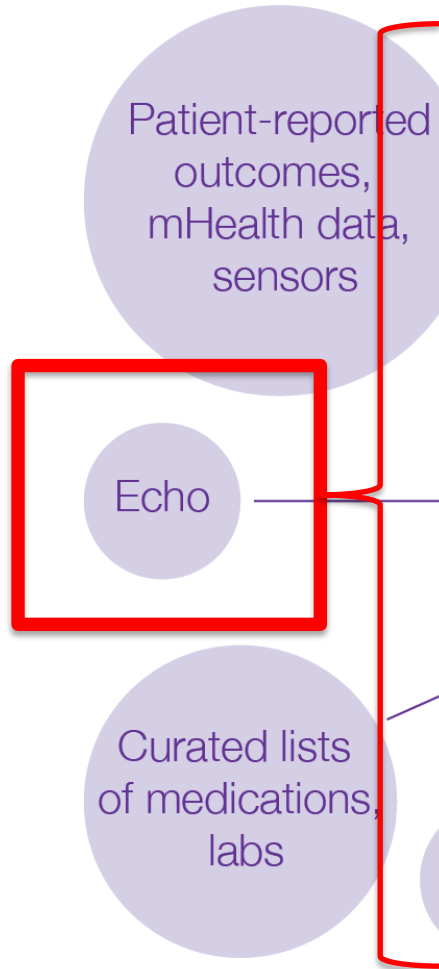
CARDIAC
CARdiovascular
Digital **A**rtificial
intelligence **C**ore

- Clinicians
- Informaticists
- Computer Scientists
- Data Architects and Analysts
- IT Administrators
- Operations, Registry, and Quality Leaders
- Health System Administrators
- Data Privacy and Security Experts
- More...

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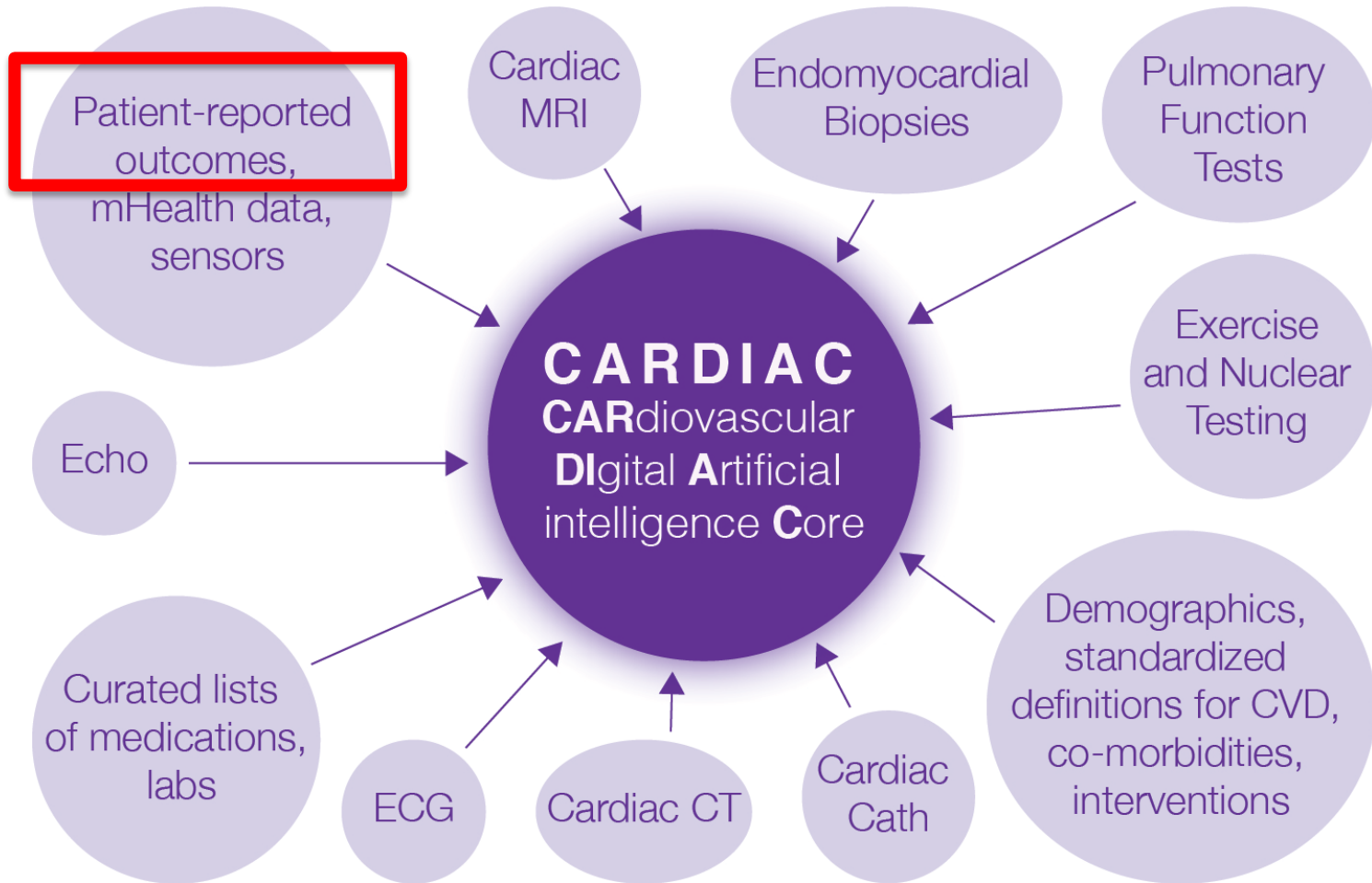


Patient-reported
outcomes,
mHealth data,
sensors

Echo

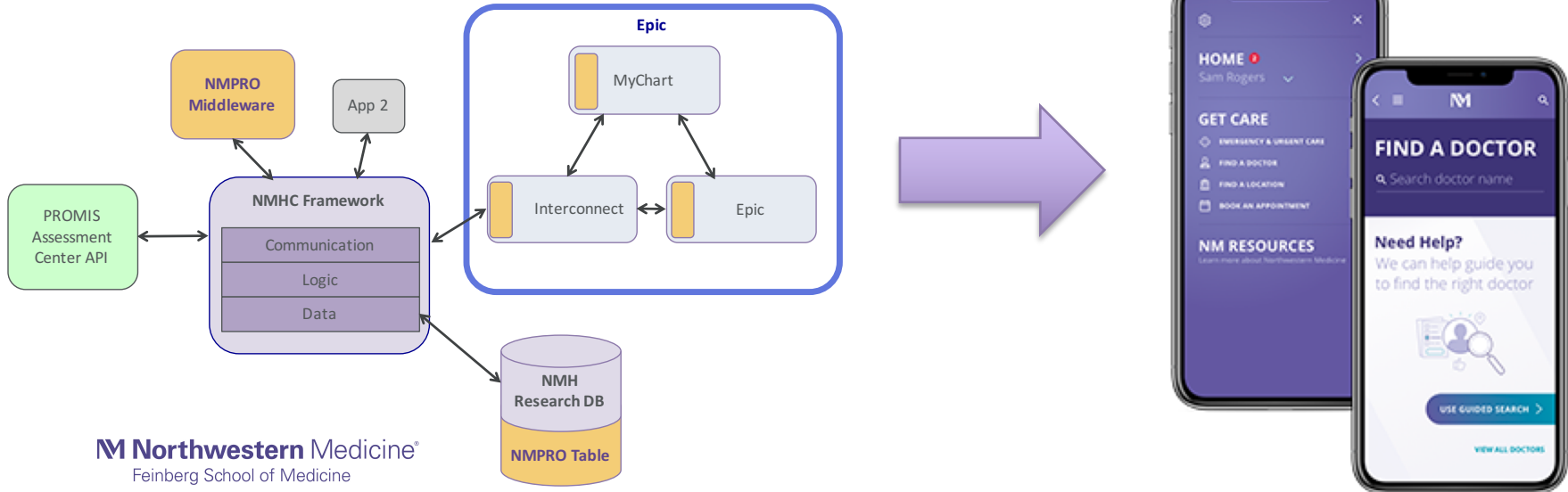
Curated lists
of medications,
labs

- Different systems before and after 2017
- Since 1/2017, 250,000+ echos under 70+ different names and over 1700 unique data elements
- Images stored in health system imaging archive



NMPRO PROGRAM MISSION

Define, expand, and continuously improve the Patient Reported Outcome infrastructure and systems to improve delivery of clinical care and outcomes, engage patients in their care, and accelerate innovation and research.



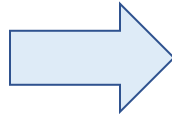
Heart Failure PROM Pilot Program

- Created process map of clinic workflow with key stakeholders
- Selected and programmed two measures
 - Kansas City Cardiomyopathy Questionnaire – 12
 - PROMIS Global Physical and Mental Health (10 questions)
- Launched pilot in two HF clinics in September 2019
 - Completion via portal/NM app or tablet in clinic
- COVID-19 impacted evaluation, transitioned to NM App/Portal completion

The PROMIS-Plus-HF Profile Measure

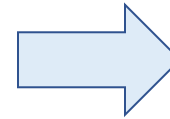
Development

- ✓ In-person focus groups (8 groups; 61 patients) and clinician (n=10) phone interviews to identify content themes
- ✓ Mapping of themes to existing PROMIS domains/items and drafting with cognitive testing of new domains/items



Validation

- ✓ Good psychometric properties (reliability, validity, and responsiveness) in cross-sectional sample of 600 patients and longitudinal sample of 75 patients

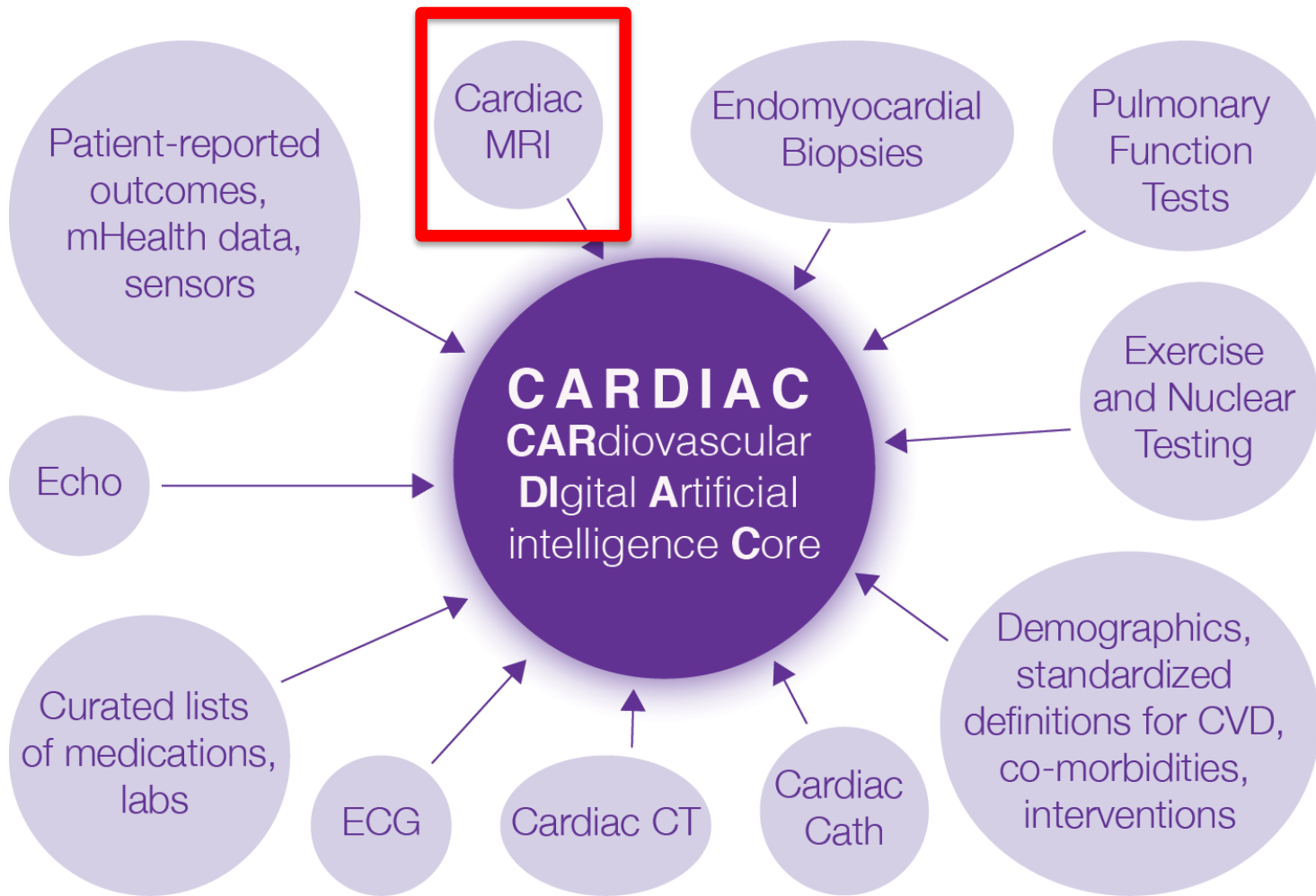


Key Properties

- ✓ Complete assessment of physical, mental, and social health
- ✓ Leverages existing, extensively tested PROMIS items with new content specific to heart failure
- ✓ Entire instrument or subsets of domains can be used depending on clinical or research purpose

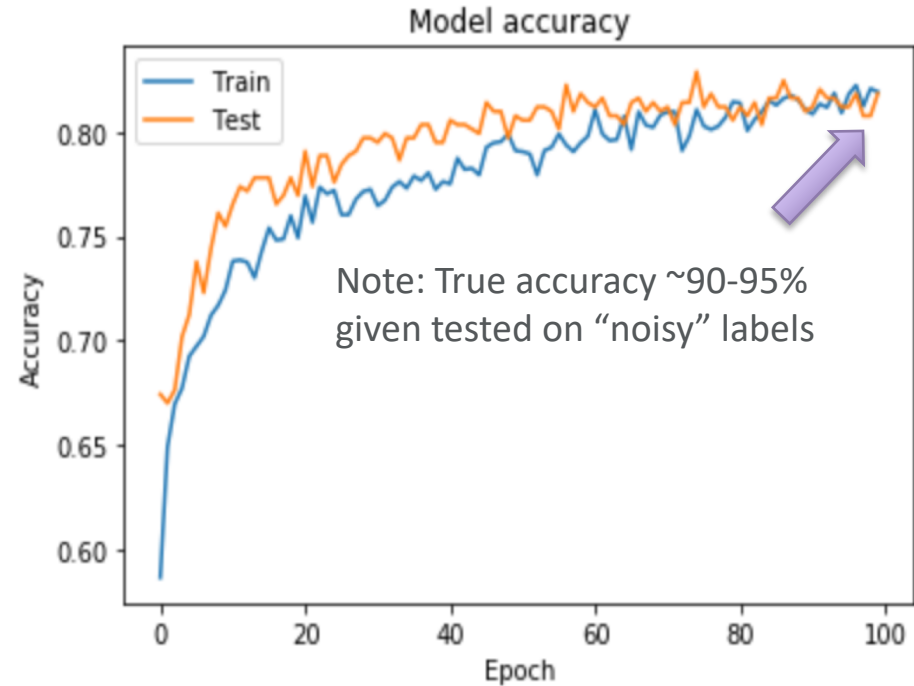
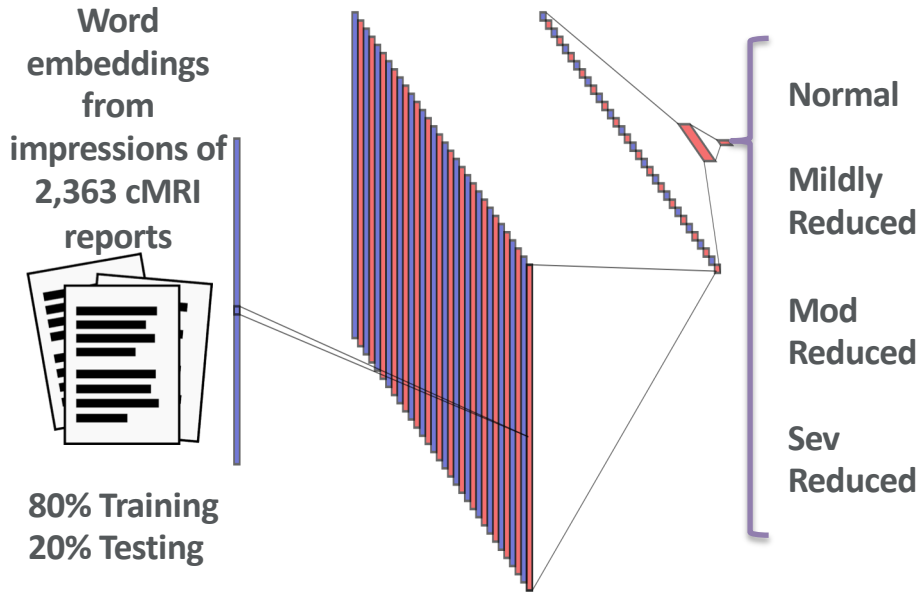
The 10-item PROMIS-Plus-HF Clinical Profile

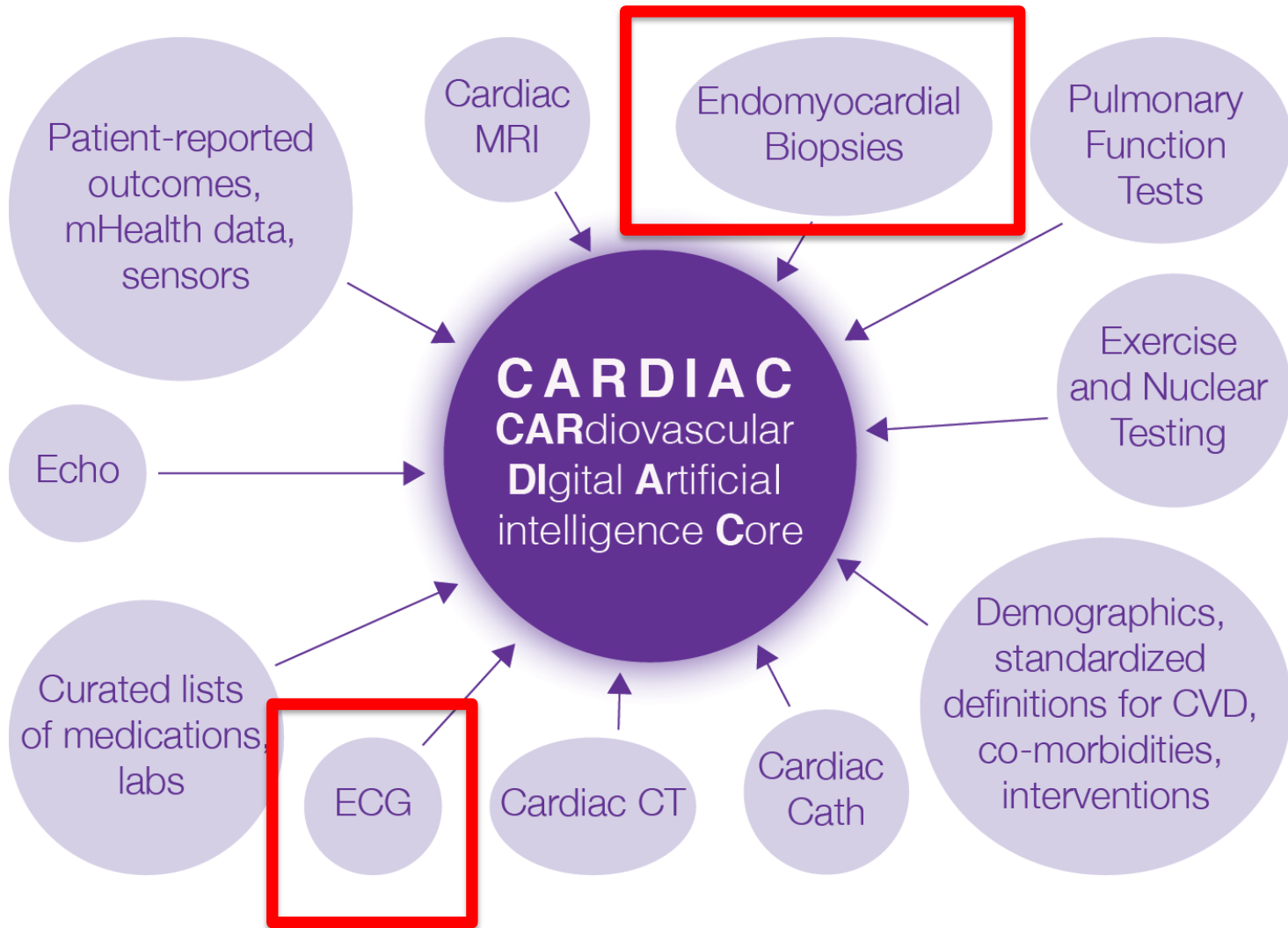
	Subdomain	Item
PHYSICAL	Dyspnea	Over the past 7 days, how short of breath did you get while walking 50 steps/paces on flat ground at a normal speed without stopping
	Fatigue	In the past 7 days, how often were you too tired to do your household chores?
	Physical Function	Does your health now limit you in walking about the house?
	Symptoms	In the past 7 days... Did you feel dizzy or lightheaded?
	Symptoms	In the past 7 days... Did you have swelling in your feet or legs?
	Sleep Disturbance	In the past 7 days... My sleep quality was...
MENTAL	Depression	In the past 7 days... I felt that I wanted to give up on everything
	Anxiety	In the past 7 days... I worried that my health would get worse
SOCIAL	Ability to Participate in Social Roles and Activities	I am limited in doing my work (include work at home)
	Independence	In the past 7 days... Were you dependent on others to get things done?

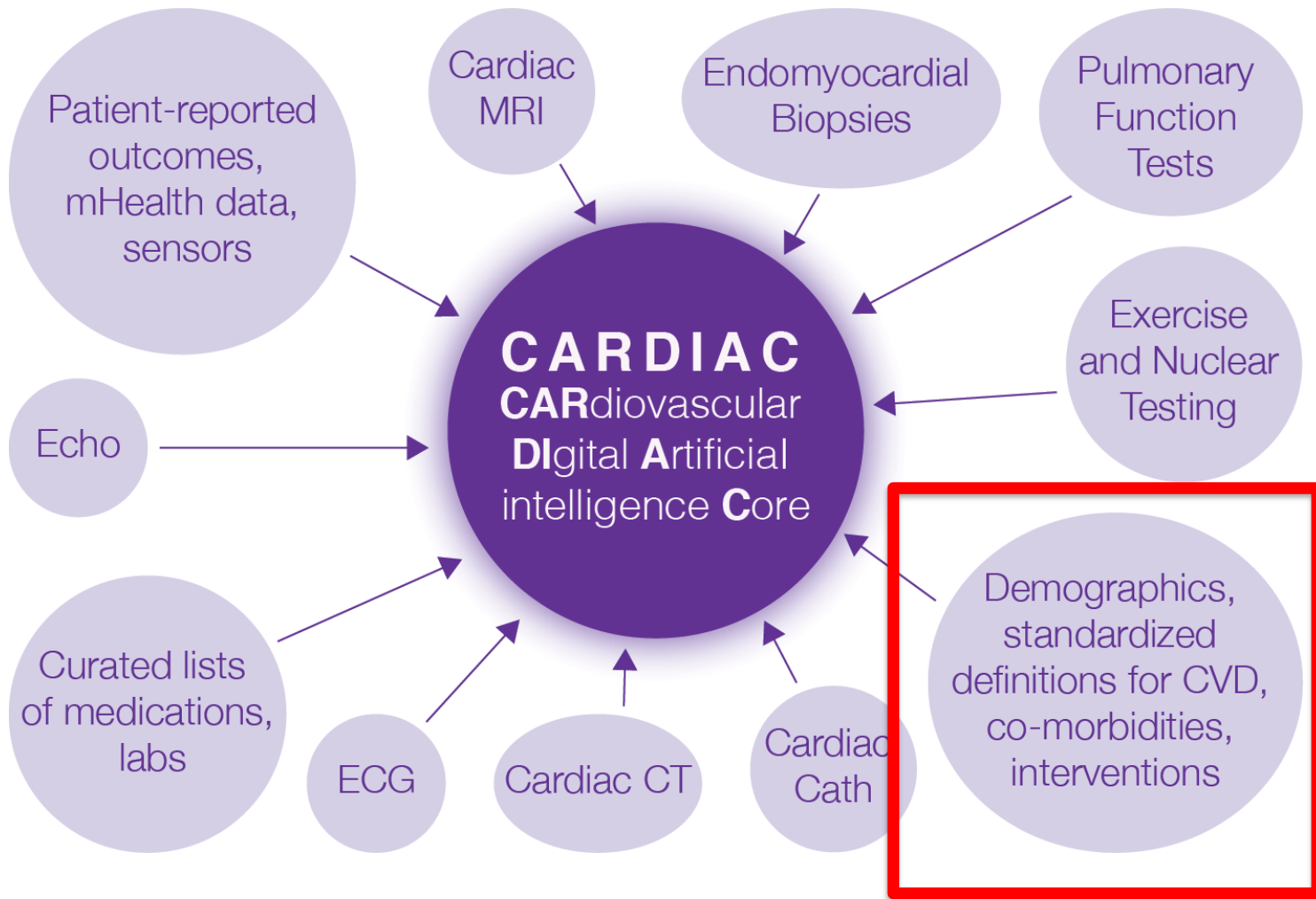


NLP for Cardiac MRI Reports

Collaborating with McCormick AI students, Hammond, Luo, Naidech Labs, NMEDW







OMOP
vs
PCORnet
CDM

Important Question to the Heart Failure Team

- Can we identify patients who are the highest risk in our health system and would benefit from our advanced therapies, such as heart transplant, heart pumps, and investigational devices?

Building Relationships that are Data Driven to Optimize longevity in Heart Failure

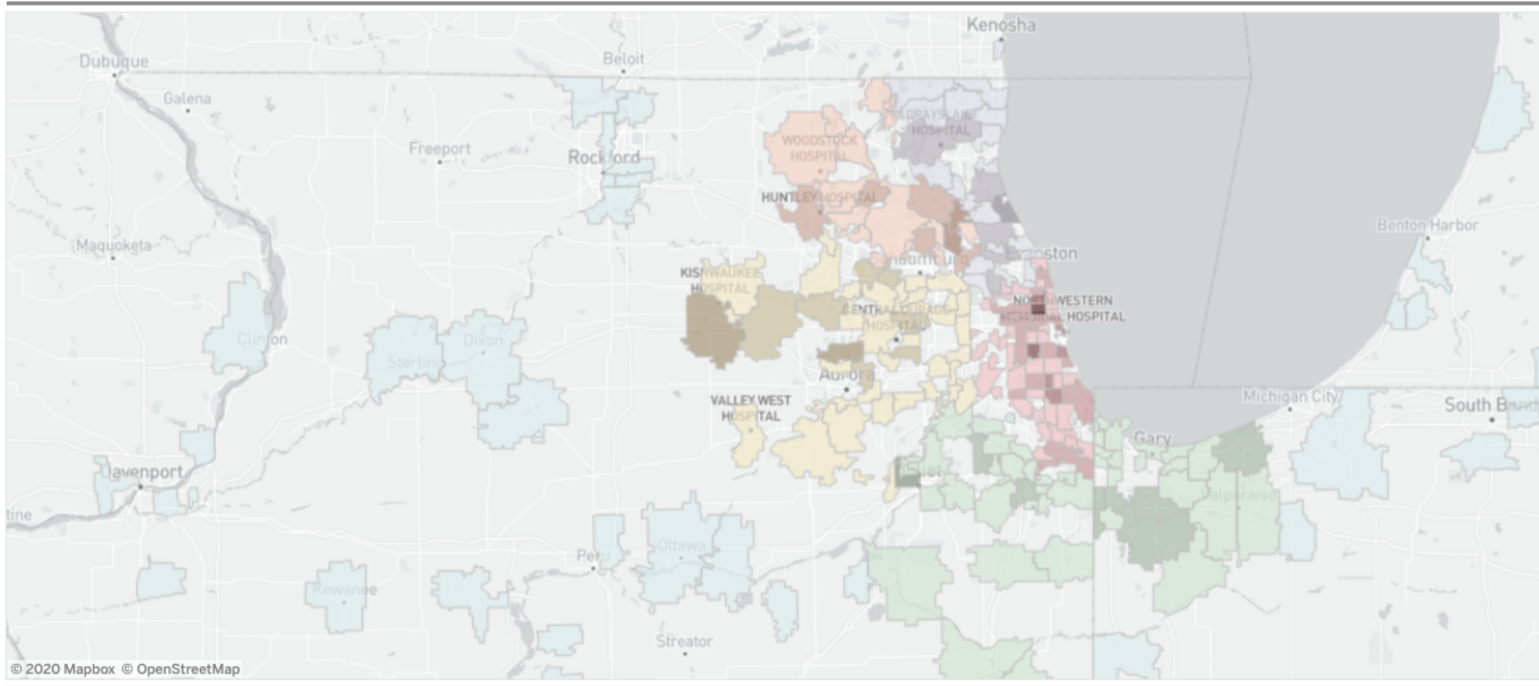
BIRD DOG - HF

- Inclusion
 - At least one code for heart failure
 - LVEF \leq 40% by echo (most recent)
 - At least one encounter with NM within the 18 months
 - At least on high risk features:
 - \geq 2 HF hospitalizations, ED visits within one year of last encounter
 - Hospitalization with IV inotropes use within one year of last encounter
 - Most recent Creatinine $>$ 1.6 and $<$ 4.0
 - Most recent Sodium $<$ 133
 - Most recent systolic BP $<$ 90
 - On high dose diuretic as outpatient at any time
 - Absence of beta blocker or RAAS (ACE/ARB) inhibition (currently)

Initial Stats (n=2148)

Map Selector

Filled Map



Patient Type

(All)

Is Alive

(All)

Region

(All)

Alert Date/Transplant Date

10/5/1985 7/6/2020

Region

- Central
- North
- Northwest
- Other
- South
- West

Total Patients

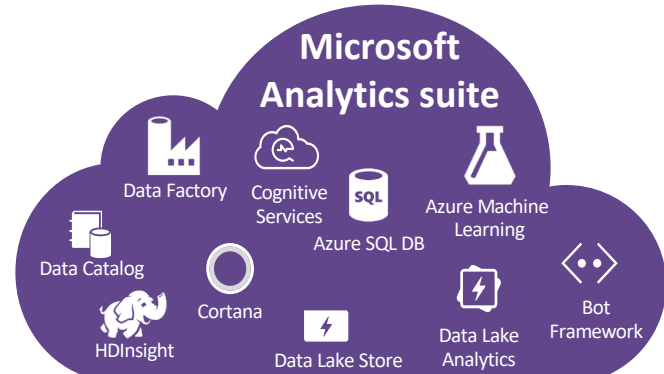
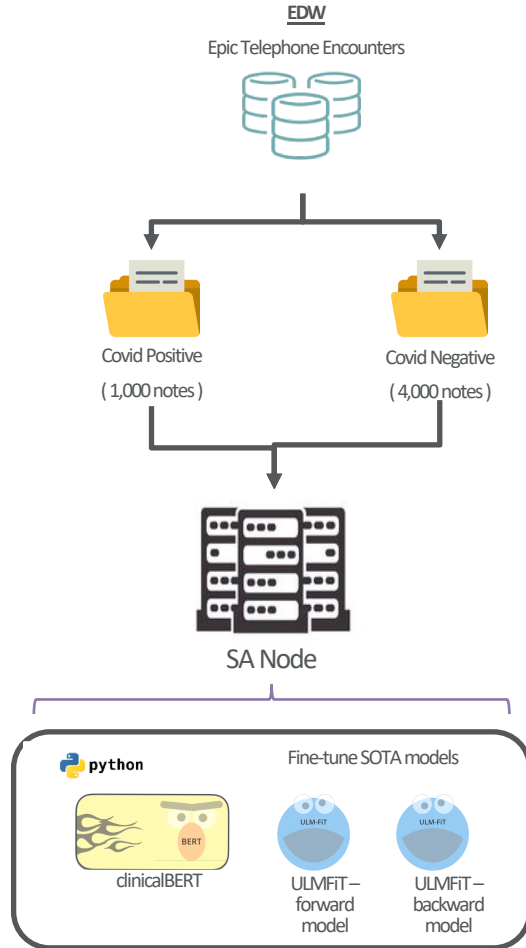
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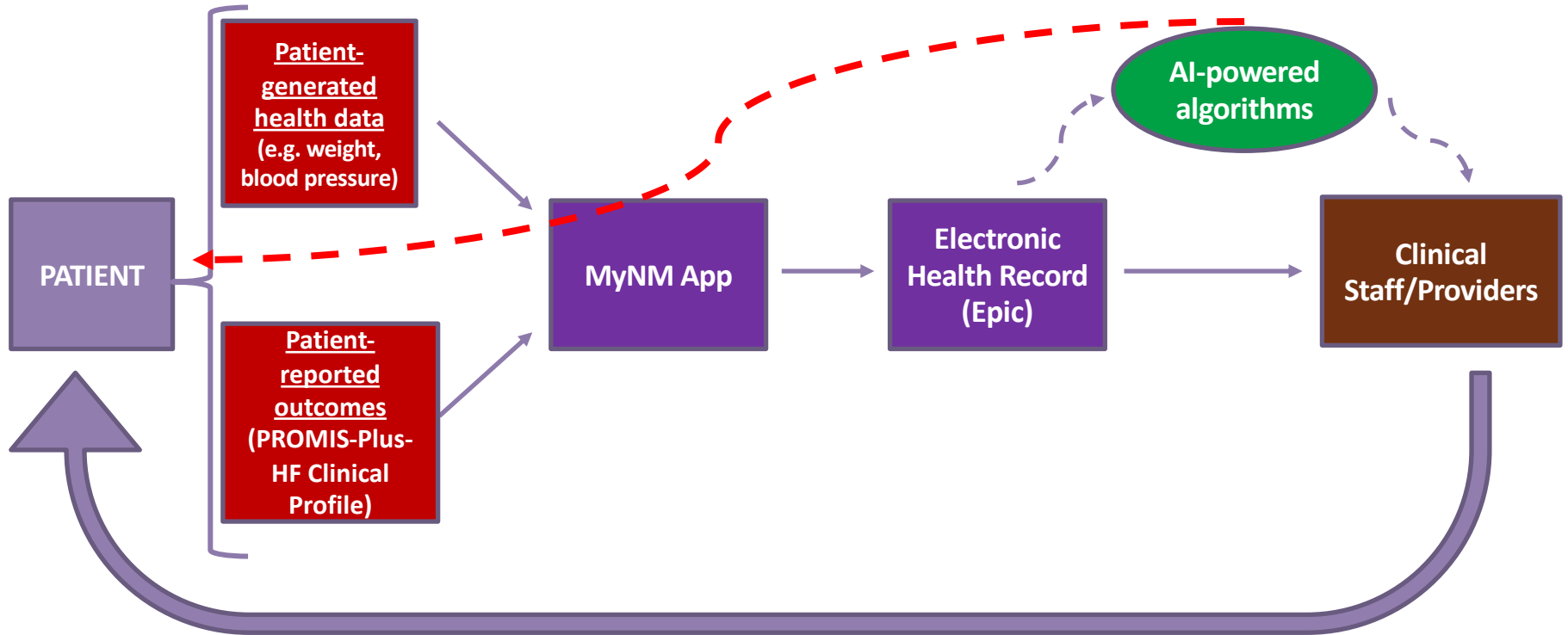
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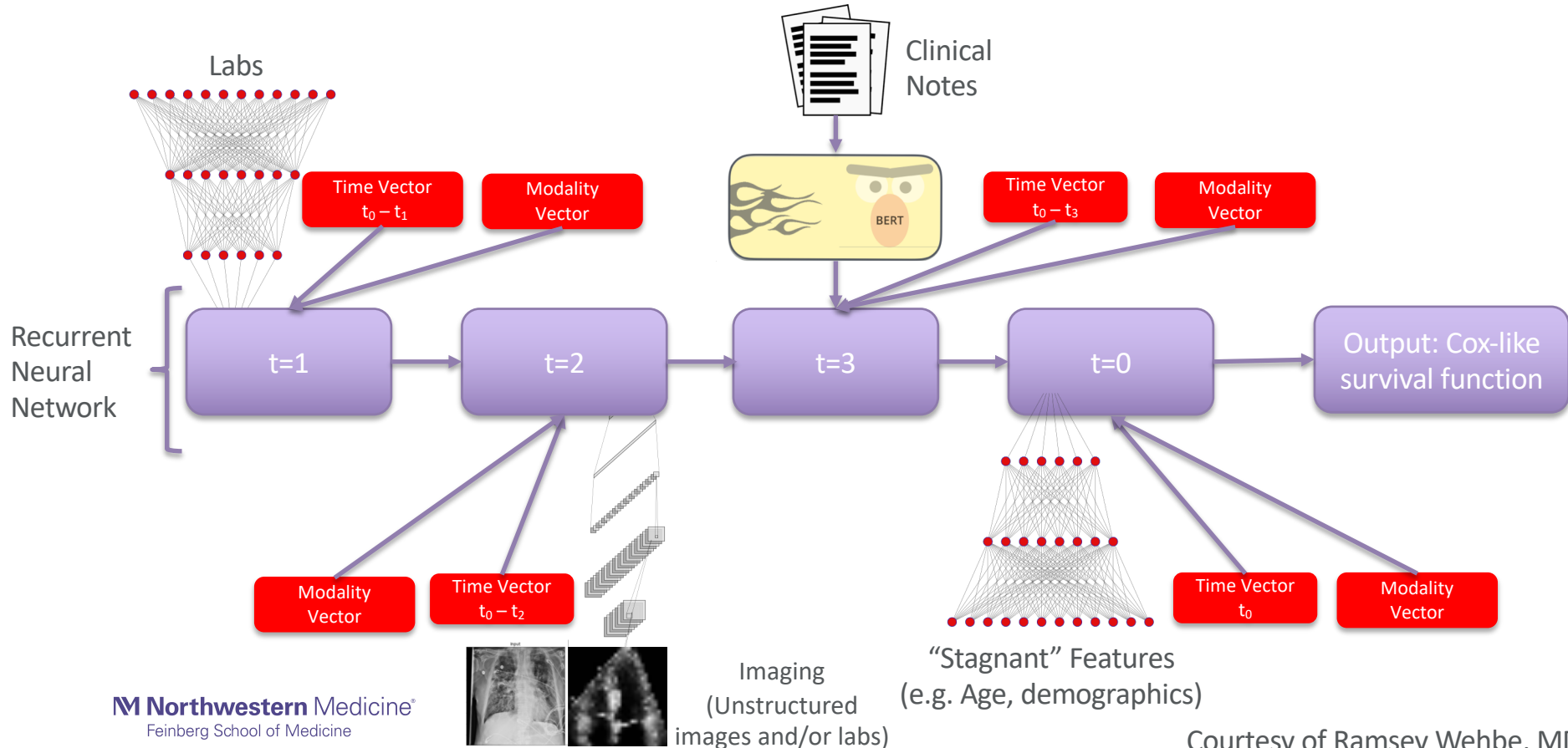
Real-time NLP Pipelines for COVID-19 Case Identification



Future of AI in home heart failure care at Northwestern



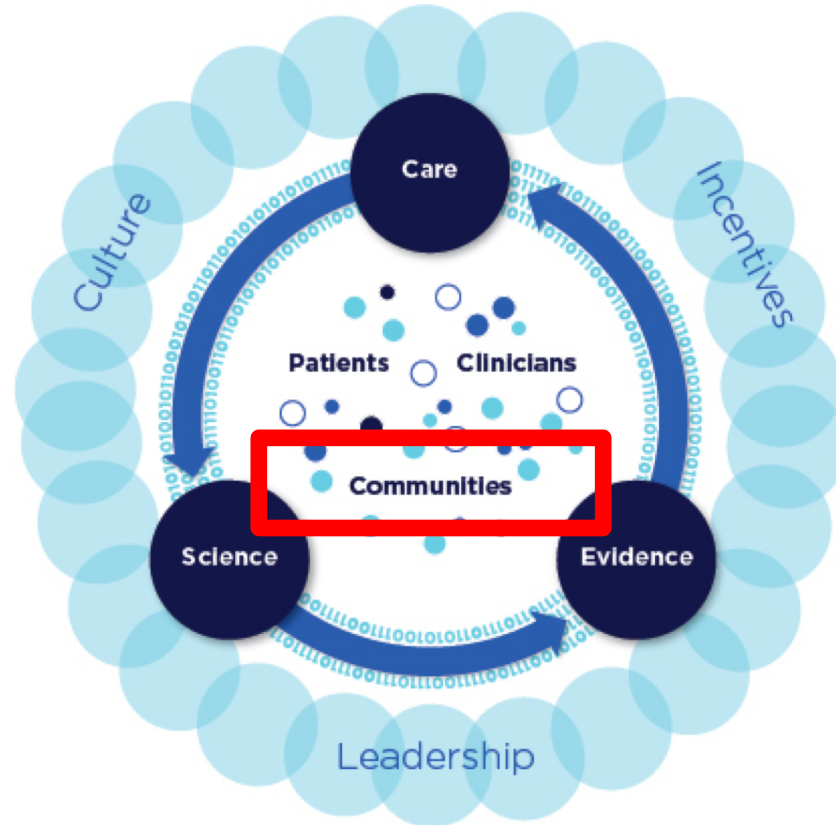
Theoretical Deep Learning Risk Prediction for COVID-19 & Heart Failure



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The Dream: The Learning Health System

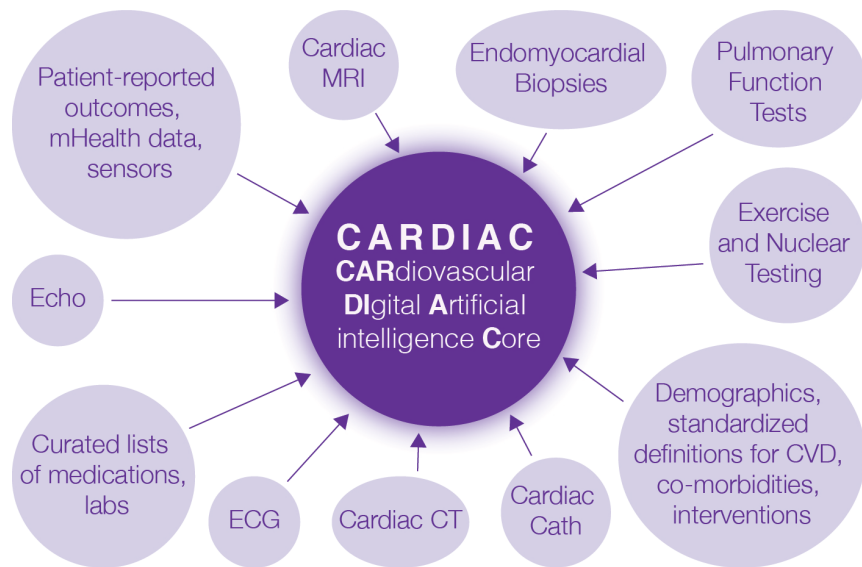


Aligning with Priorities of Stakeholders with Shared Interests

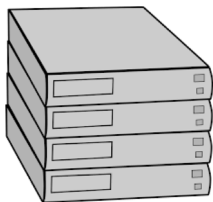
Bootstrapping CARDIAC over 2 years

- Me (on K12, donated time)
- NMEDW Research Manager: Dan Schneider (donated time)
- NMEDW Data Architect (10% on sponsored project)
- NMEDW Research Analyst (20% on sponsored project/my start-up)
- NM BCVI Architect and Analyst (contribute time around specific projects)
- NM Information Services
 - Research and Development Team
- Yuan Luo, Andrew Naidech (donated time) and their pre-doctoral students
- Several additional BCVI collaborators: Sanjiv Shah, Kannan Mutharasan, Shruti Cruz
- Med students, fellows
- PROs
 - K12 Team, NM PRO Steering Committee, and the NM Quality Innovation Center

People and Data are key to the CV Informatics Program



- A curated, updating CV data core will be the foundation for the Center for AI and CVD and many larger BCVI and NM initiatives.
- Diverse expertise and creativity are needed:
 - Clinicians
 - Informaticists
 - Computer Scientists
 - Data Architects and Analysts
 - IT Administrators
 - Operations, Registry, and Quality Leaders
 - Health System Administrators
 - Data Privacy and Security Experts
 - More...



The SA Node: A HIPAA-compliant, 2 GPU, 15 CPU Core on FSM Server

Proposed Staffing for Cardiovascular Informatics Program

- Leadership: Clinical, research, and informatics expertise
- Program Manager, ideally with informatics background
- 1-2 Data Engineers embedded with NMEDW and NM R&D teams
- 1 Data Analyst
- Funding for informatics pre- and post-docs
- Center for AI and CVD AI fellows
- Continued partial support (financial or informatics) of collaborators

Acknowledgements

- Abel Kho
- Patrick McCarthy
- Sanjiv Shah
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- Ramsey Wehbe
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- Martin Borsje
- Aditya Sharma
- Anna Pawlowski
- Kris Hammond
- Yuan Luo
- Mozzi Etemadi
- NM Research and Development Team
- Han Liu, Kevin Yu, Ted Hu
- Andrew Naidech
- Lacey Gleason
- David Cella
- Karl Bilimoria
- Nan Rothrock
- Kristina Davis
- Clyde Yancy
- Susan Yount
- Martha-Margaret Cotton
- Leilani Lacson



Questions?

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