VANDERBILT UNIVERSITY

Discovering Care Coordination Practice Patterns in the EHR: Interpretation and Impact on Patient Outcomes

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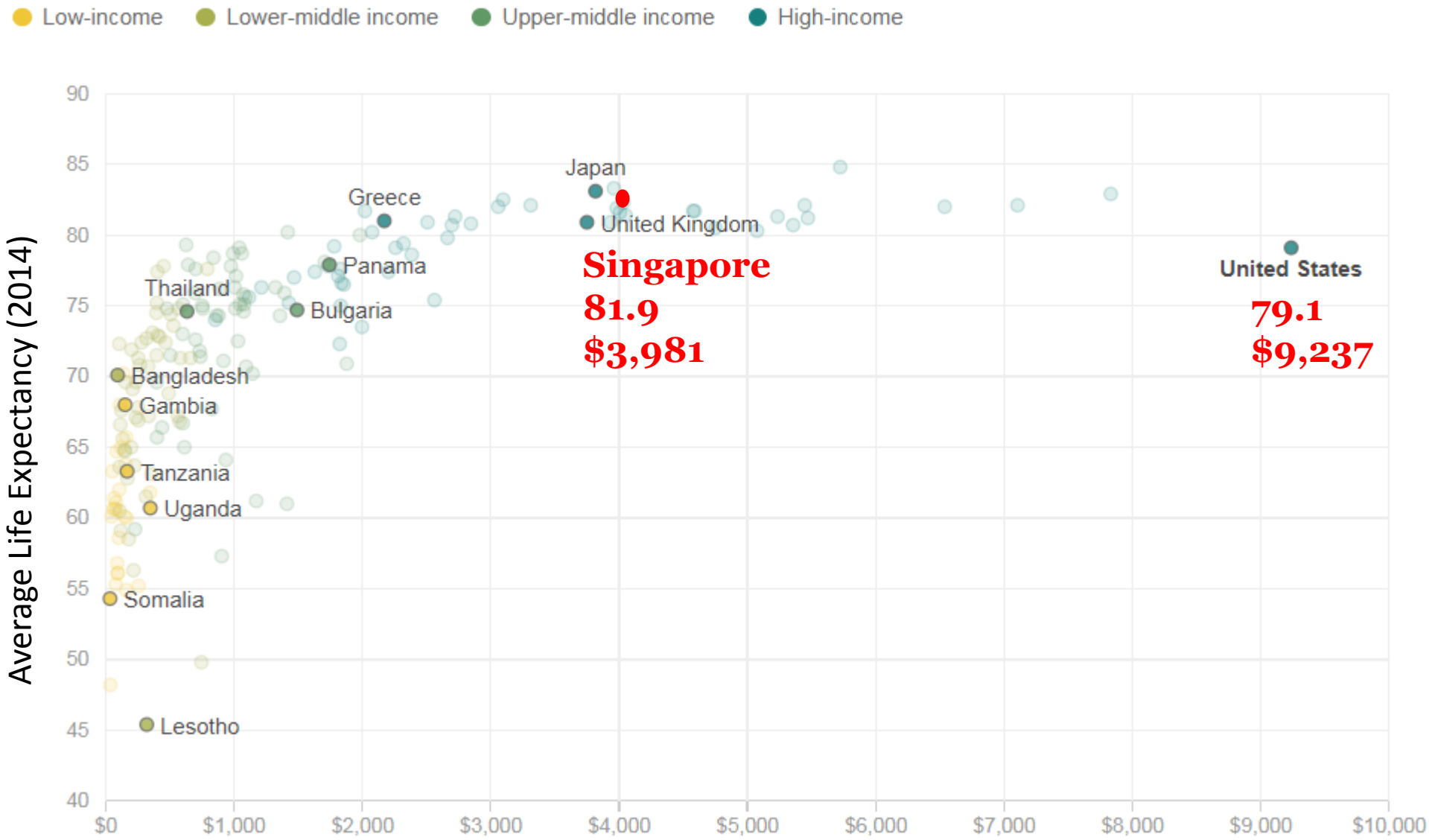
http://ohpenlab.org

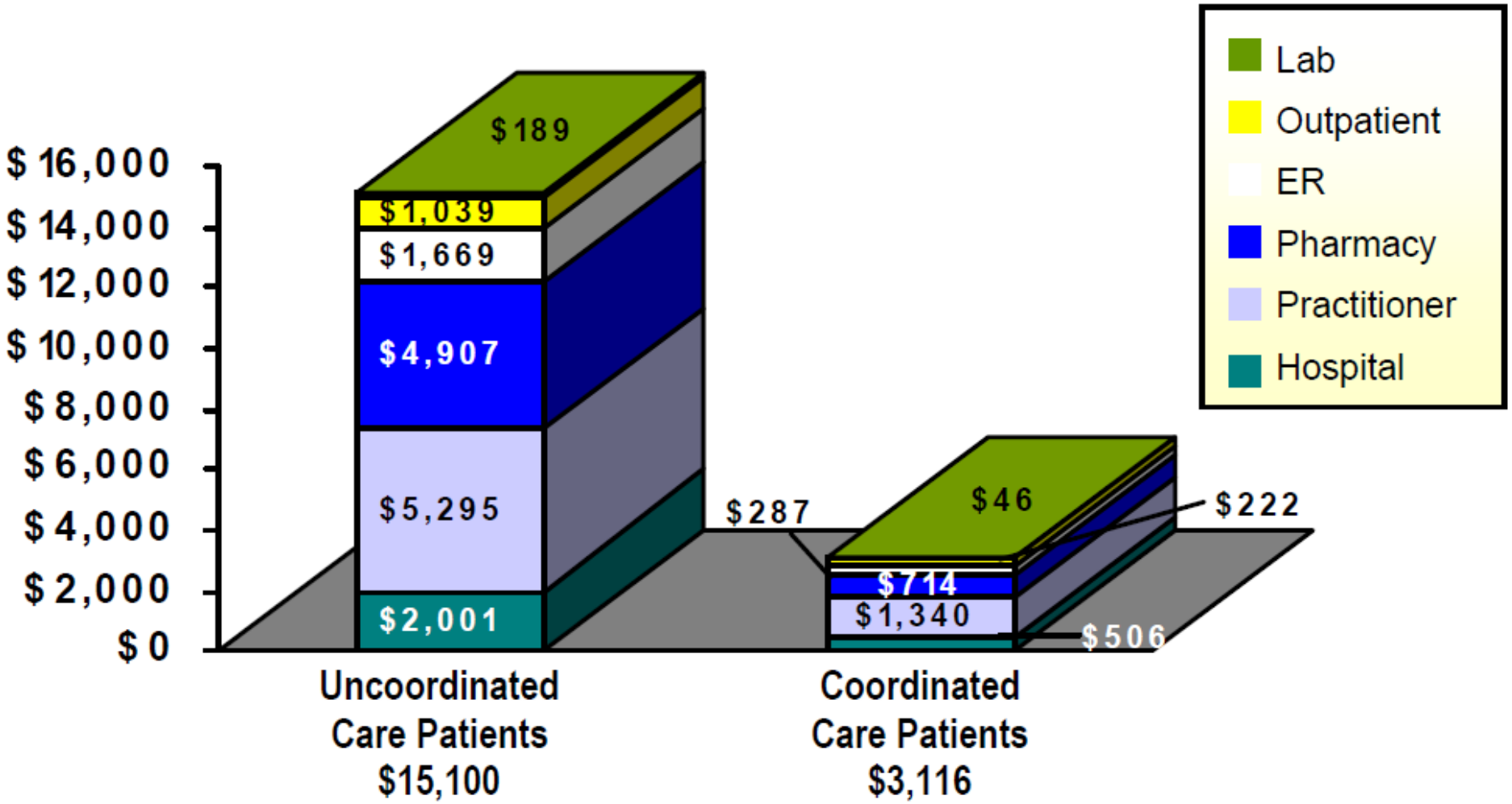
Per Capita Healthcare Costs — International Comparison



Per Capita Health spending (2014)

Source: Institute for Health Metrics and Evaluation, World Bank country classifications

Average Contribution of Cost Components for Uncoordinated and Coordinated Care Patients



Source: IOM (Institute of Medicine). The Healthcare Imperative: Lowering Costs and Improving Outcomes: Workshop Series Summary. Washington, DC: The National Academies Press, 2010.

The Sad State of Uncoordinated Care in the U.S.

"There's no reason that only **4.75%** of outpatient visits and **.08%** of my hospitalizations are spent actively treating my condition. There's no reason that I spent two solid months (1540 hours, 64.2 days) of this year waiting instead of healing. So, please, **stop wasting my time**. **Stop wasting my life**."

— Jess Jacobs "On Wasting My Time -- The Numbers"

What Can Uncoordinated Care Lead to?

Duplicative use of services

Lack of appropriate medication use and adherence

Increased healthcare expenditures

Transitions from uncoordinated care to coordinated care

What is the Key Component of Coordinated Care?

Coordinated care is the idea that all specialists treating a patient should be communicating and sharing information to ensure that everyone is acting as a **team** to meet the patient's needs.

Primary care physicians, nurses, technicians, specialists, and caregivers collaborate with each other.

Unfortunately, this is far from what Jacobs experienced, and her situation is not uncommon

Defined Care Teams

Explicit care team: A small group of care providers work together within a department

Remote care team: care providers across departments or hospitals remotely work together

How is a Care Team Defined?

Expert-driven care team

Composing teams based on knowledgeable healthcare experts

Design and execution is relatively ad hoc

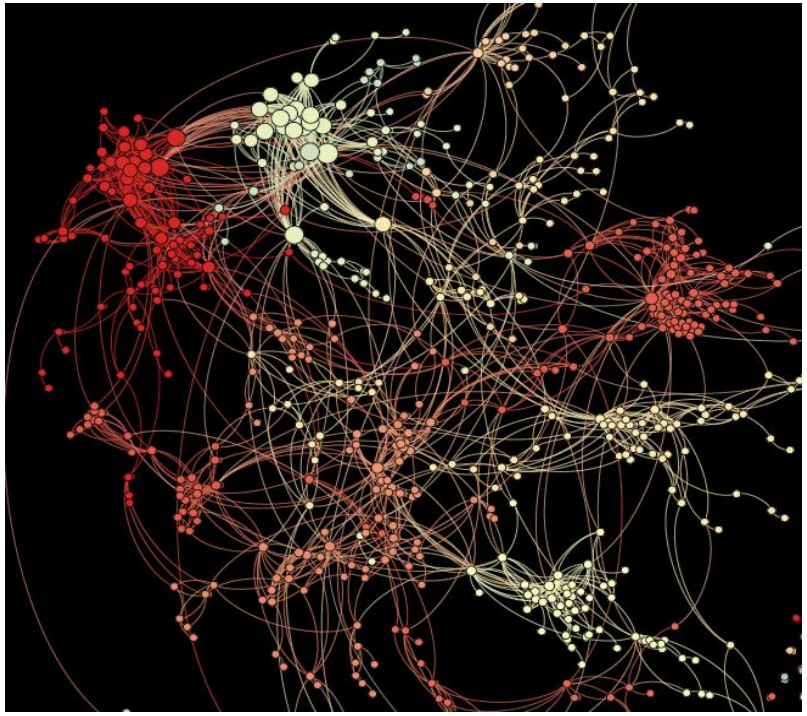
Neglect the dynamic aspect (self-organizing nature of care team) of modern healthcare environments

A substantial amount of human effort required to do assessment and optimization of care teams

Team Composition(cont.)

Data-driven care team

Networks of Care Providers

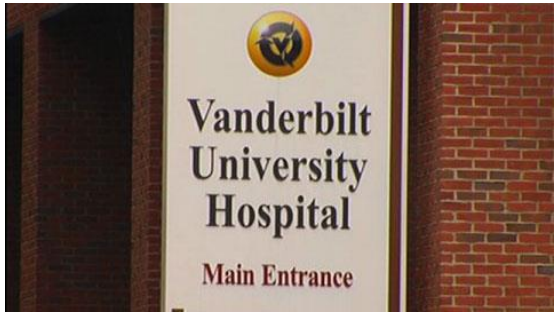


Automatic discovery of novel care teams

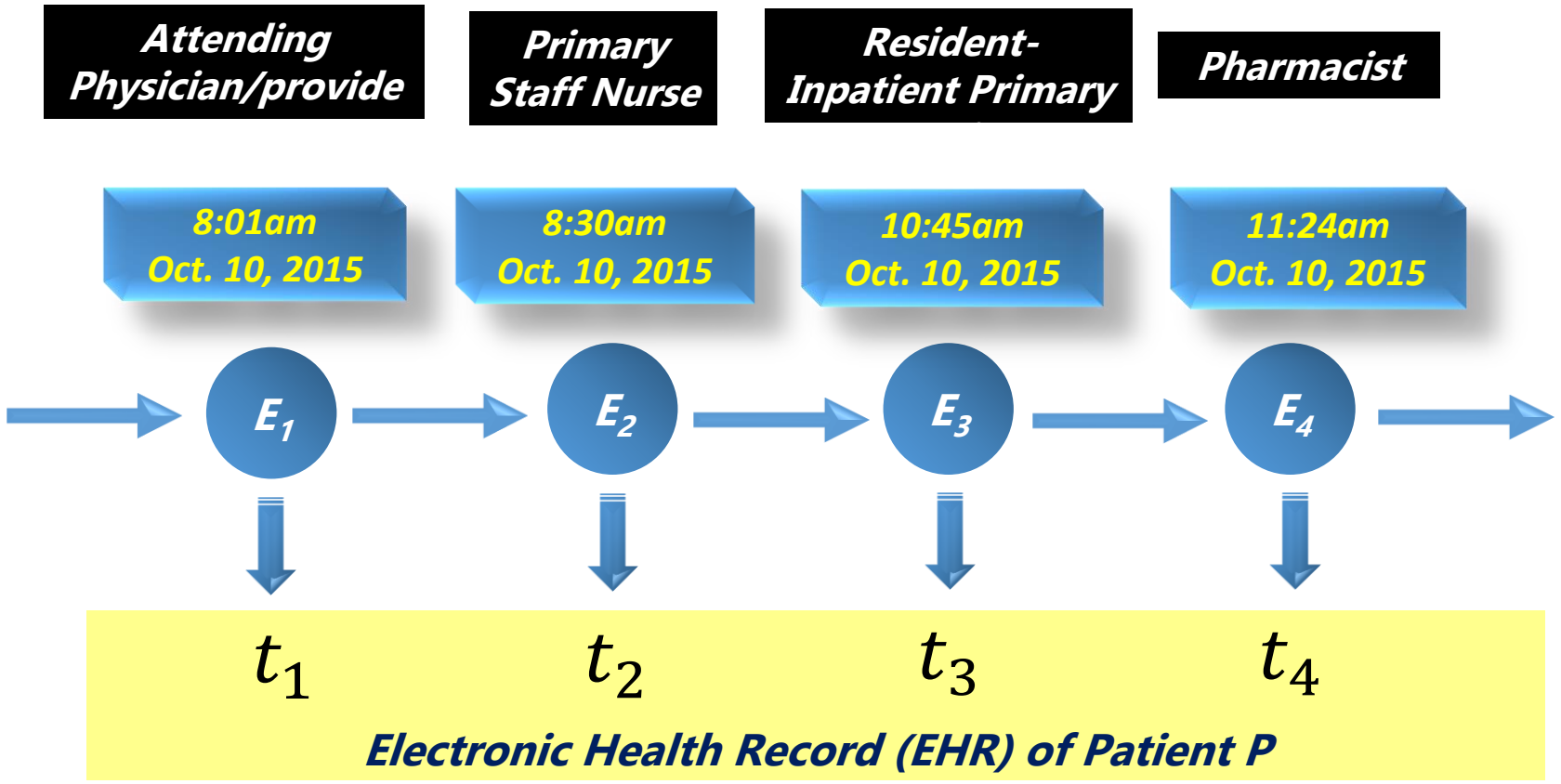
Establish a connection between care teams and patient (outcomes)

Improve work efficiency of care coordinators

Where Can We Get Data?
-Vanderbilt Electronic Health Record System-StarPanel



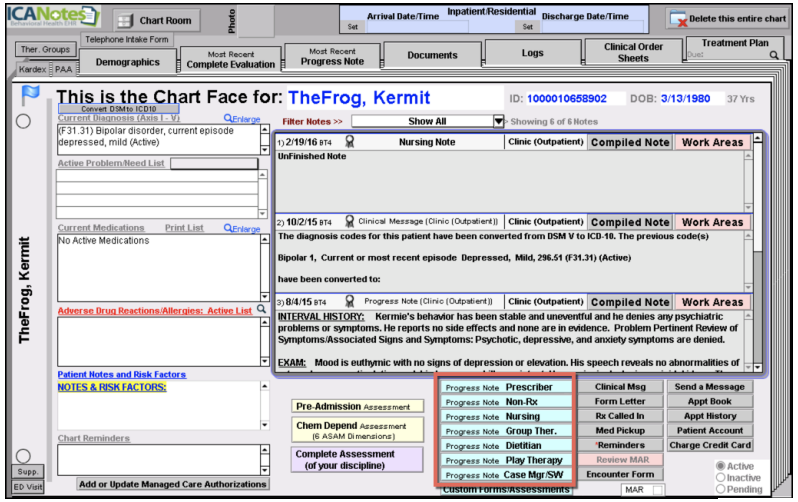
What does an Electronic Health Record System Contain? -Operational Actions of Care Providers on Patients

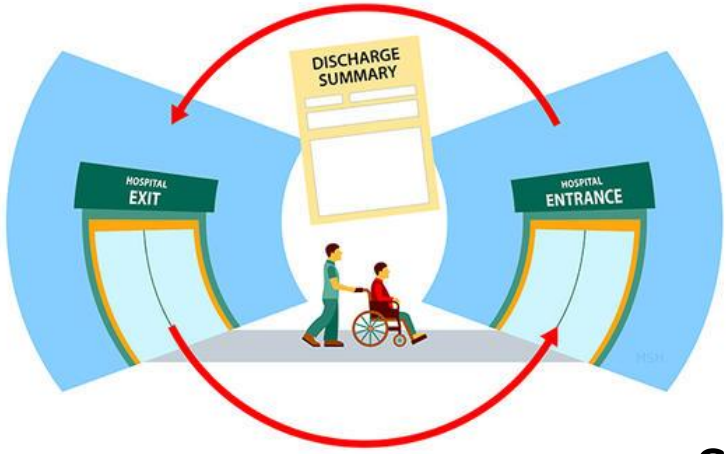


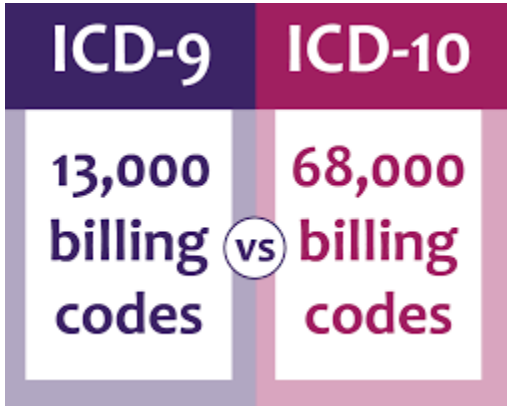
This type of data can be leveraged to learn relationships between healthcare professionals.

Care team

What does an Electronic Health Record System Contain?
-Patients' Diagnosis Data







Such type of data can be leveraged to learn patient phenotypes and analyze patient outcomes?

What Types of Researches Can be Done on Care Coordination via the EHR?

Identifying Care Teams through Operational Actions

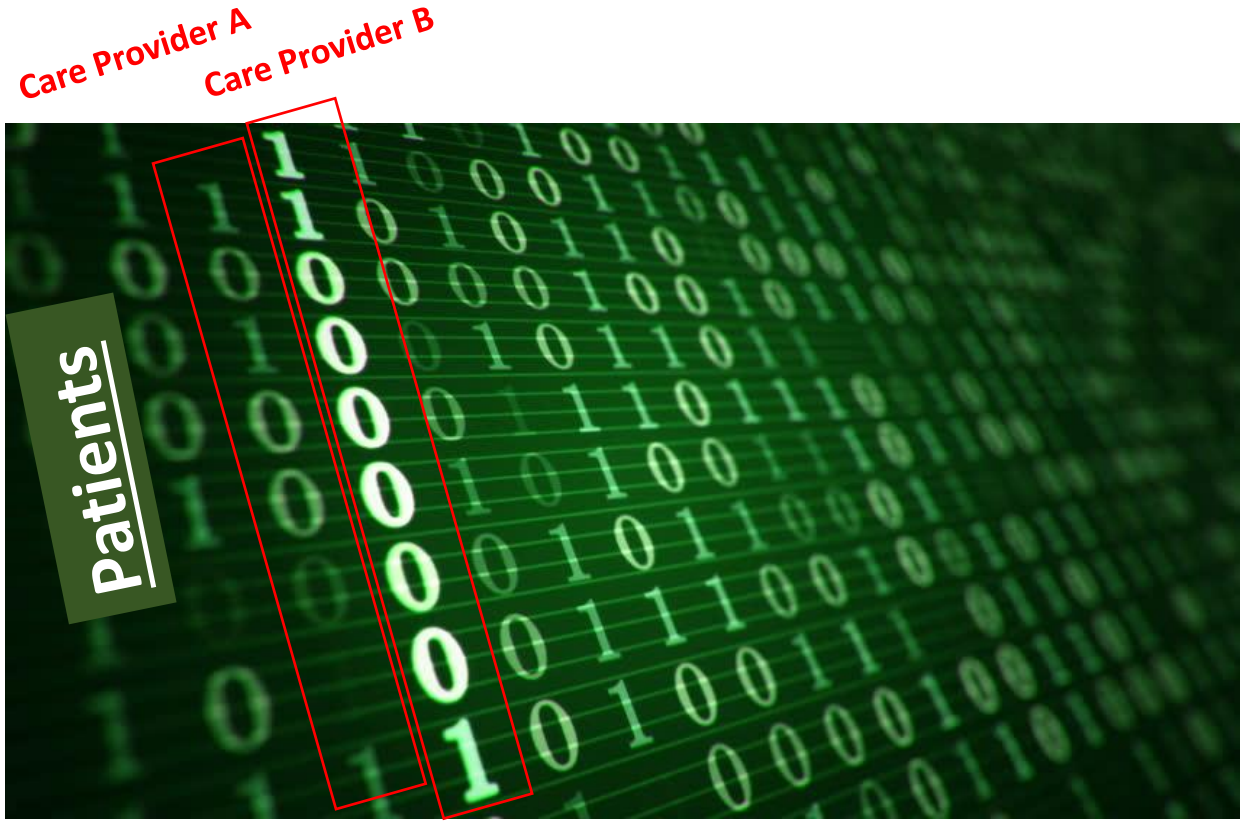
Building Bridges to Put The Right Care Team in Place for the Right Patients

Grouping Patients According to their Phenotypes

Identifying Care Teams Across An Entire Healthcare System

Chen Y et al. Identifying collaborative care teams through electronic medical record utilization patterns. Journal of the American Medical Informatics Association, 2017, 24(e1): e111-e120.

Model Relationship Among Care Providers



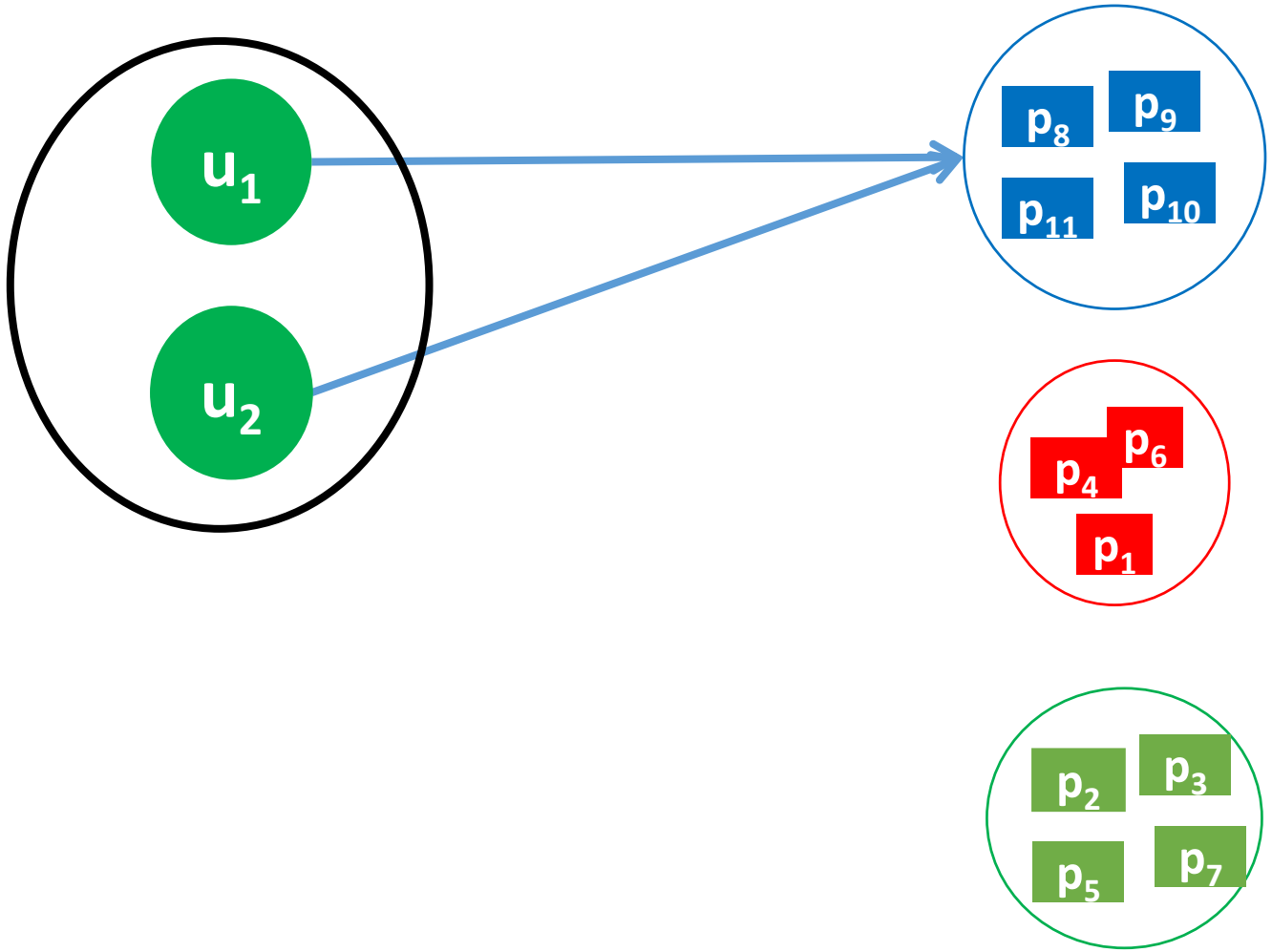
Principal Component Analysis

Topic Modeling

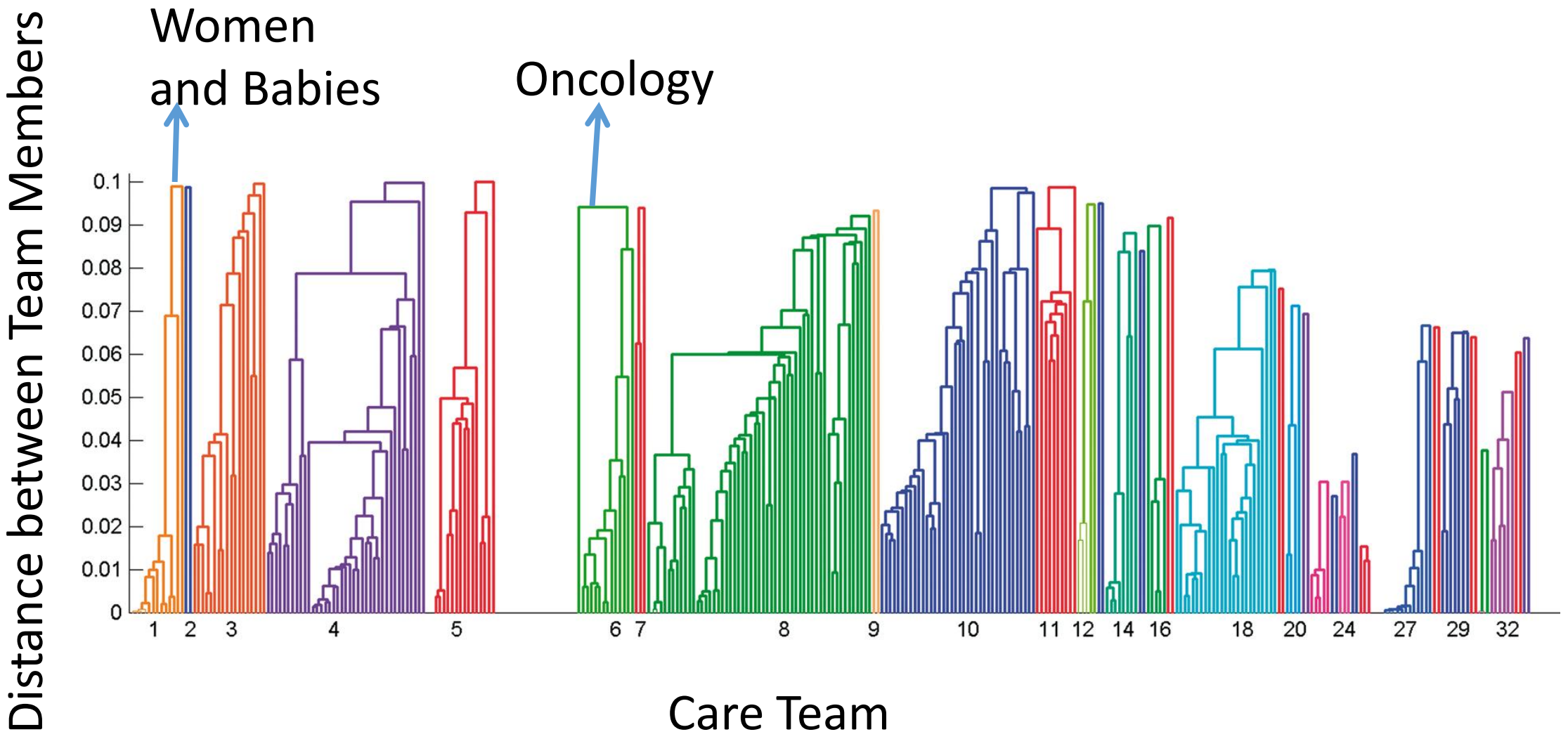
Non-negative matrix factorization

$\boldsymbol{R}$ (u_1, u_2) = $\boldsymbol{F}$(Interactions of Users on Patients)

Model Relationship Among Care Providers (cont.)

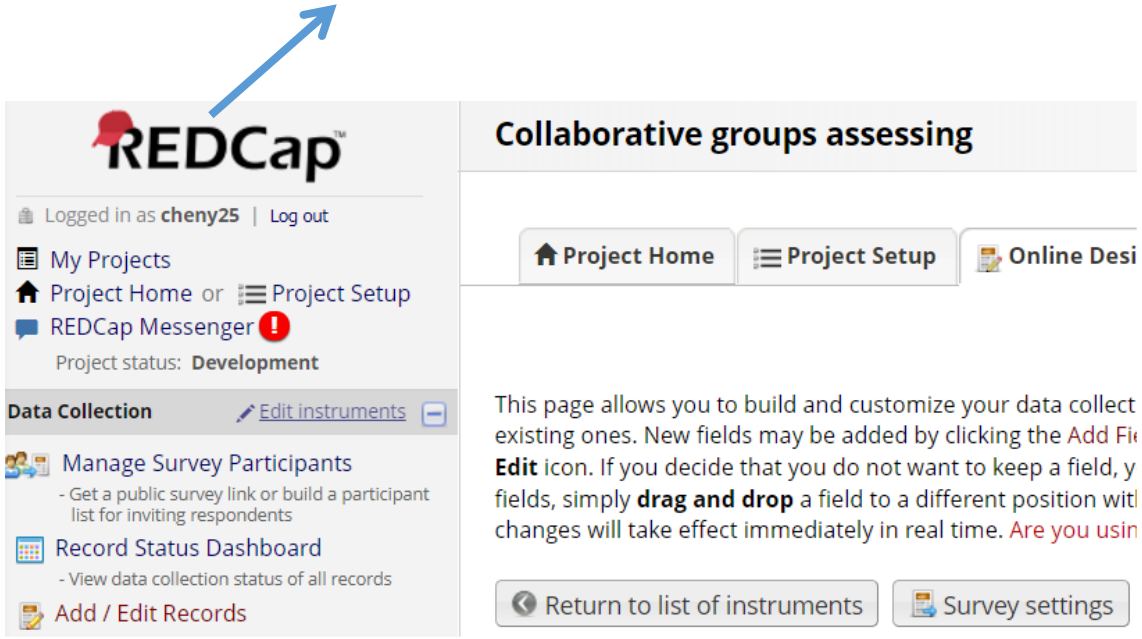


34 Care Teams were Discovered at Vanderbilt Medical Center



Interpretation of Care Team- Do We Believe the Learned Care Team?

Online Survey System



Survey Question: To what extent do you believe VUMC employees in the displayed care team collaborate to manage patients?

☐Not at all likely
☐Slightly likely
☐Moderately likely
☐Very likely
☐Completely likely

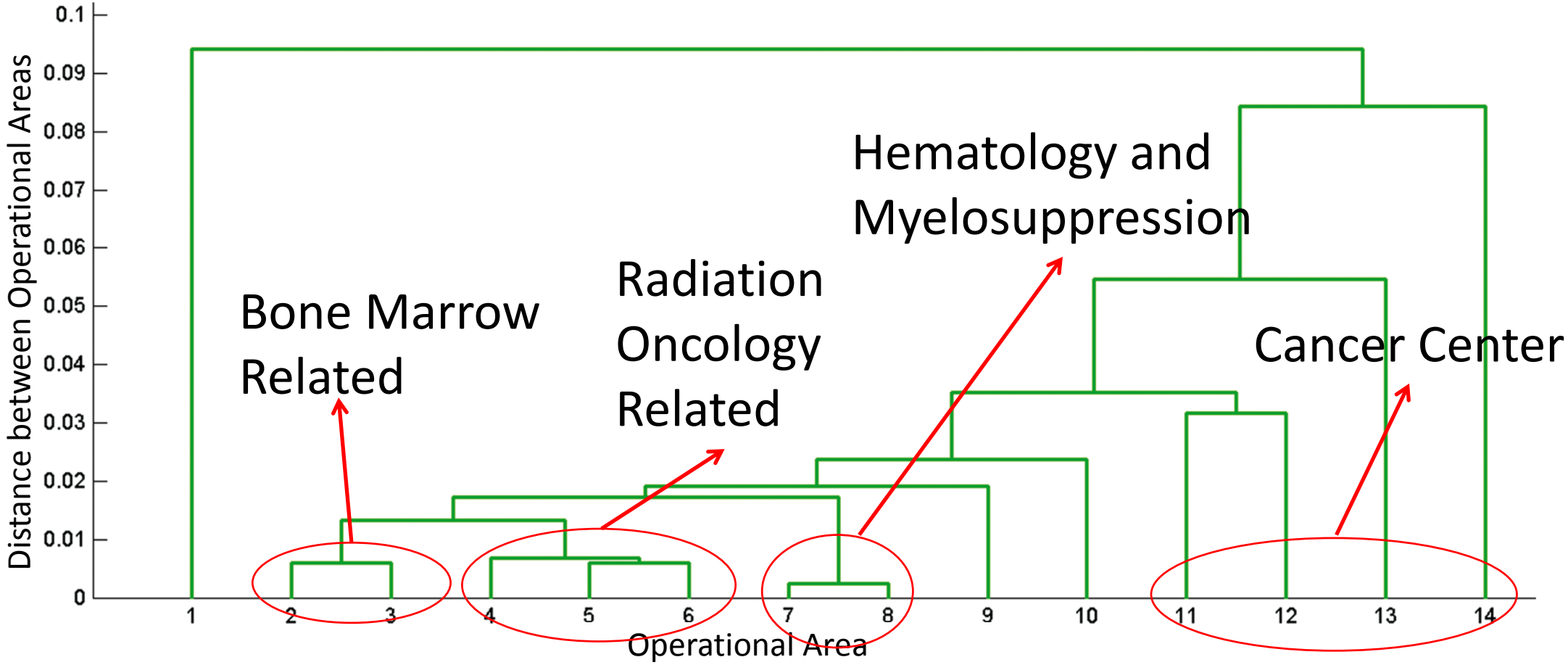
23 Clinical and Administrative Experts Who are Knowledgeable on Interactions of Health Workers in Healthcare System Completed the Survey

- Health care professions (physicians, nurses, pharmacists), 52%
- Healthcare system professionals (biomedical or system engineering, hospital administration), 35%
- Healthcare business management (project management and business management), 13%

Average number of years working at the Vanderbilt is 12.39.

27 of 34 care teams were confirmed

Oncology Care Team



1: Phlebotomy; 2: Bone Marrow Processing Lab; 3: Bone Marrow Registry; 4: Rad Oncology Housestaff; 5: Radiation Oncology Housestaff;

6: Radiation Oncology; 7: Hematology/Stem Cell Clinic; 8: Myelosuppression; 9: Cytogenetics; 10: Outpatient Clinic Pharmacy; 11: Cancer Call Center;

12: Hematology/Oncology; 13: Vanderbilt-Ingram Cancer Center Clinical Trials Shared Resource; 14: Cancer Infusion Center

Phenotypes of Associated Patient Groups

Code	Description	Predicted probability
585.1	Acute renal failure	1.000
197	Chemotherapy	0.769
204.21	Myeloid leukemia, acute	0.688
288.11	Neutropenia	0.534
509.1	Respiratory failure	0.506
284	Aplastic anemia	0.496
480	Pneumonia	0.489
401.1	Essential hypertension	0.478
198.2	Secondary malignancy of lung	0.463
198	Secondary malignant neoplasm	0.443

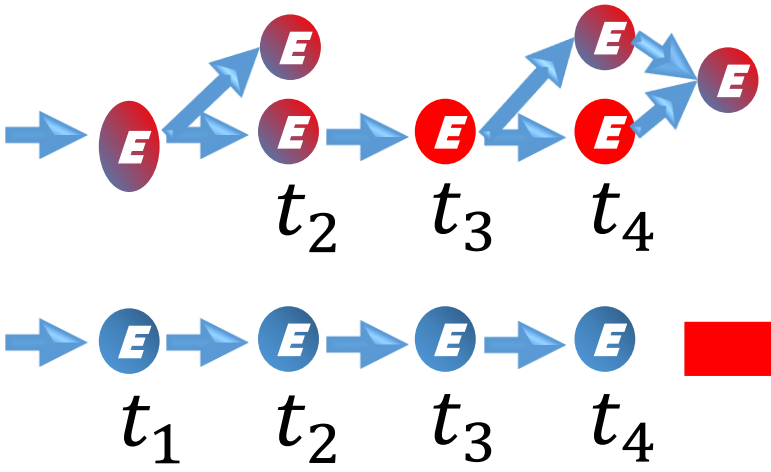
Identifying Clinical Workflows for Heart Failure Patients

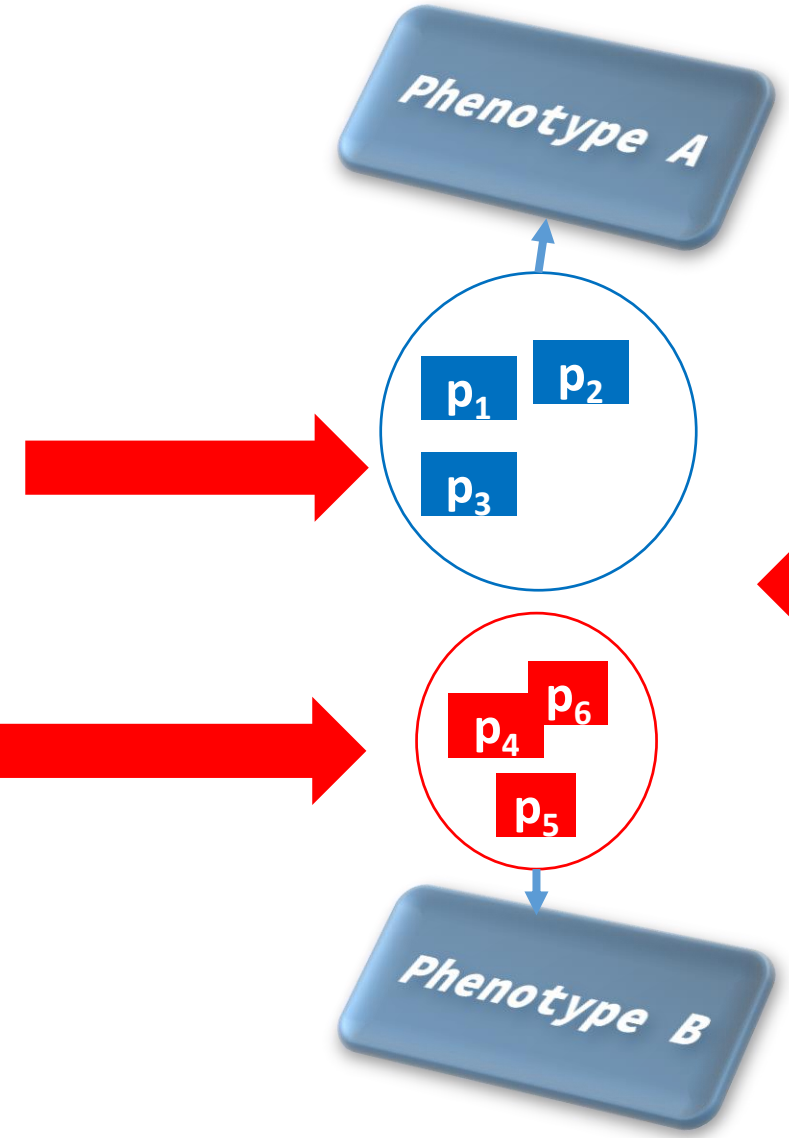
Yan C et al. Learning Clinical Workflows to Identify Subgroups of Heart Failure Patients. AMIA Annual Symposium Proceedings. American Medical Informatics Association. 2016: 1248.

Different Strokes for Different Folks

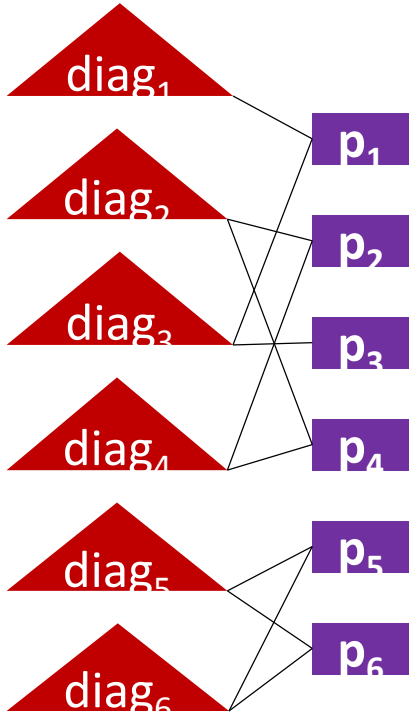
– Right Workflows are in Place for Right Patients

Operational action data (e.g., a user invoked an action at a patient's record at specific time)

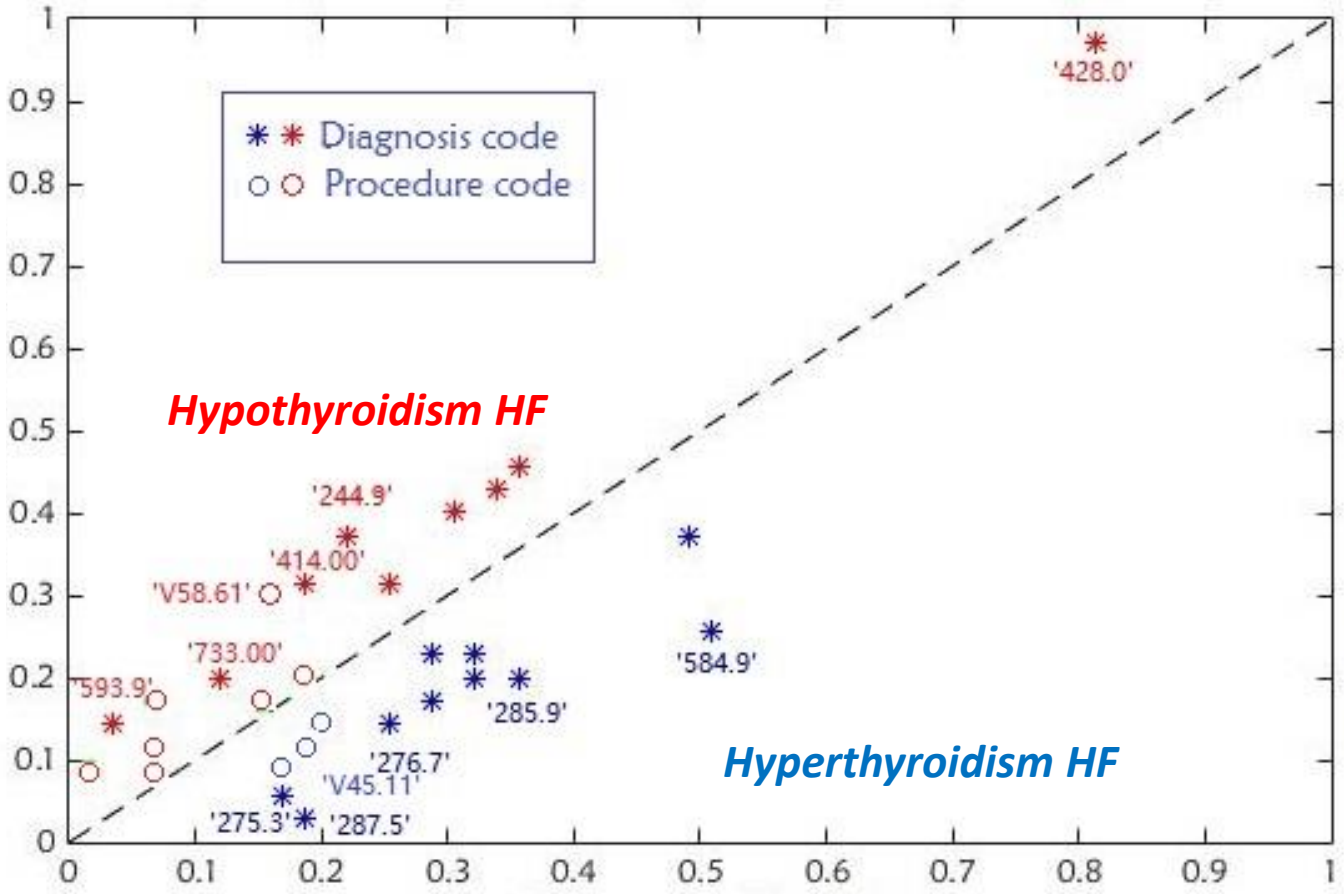




Diagnosis data (e.g., ICD-9 codes, medications, lab tests, and notes)



Phenotypes of Two Patient Groups
-Hyperthyroidism and Hypothyroidism HF

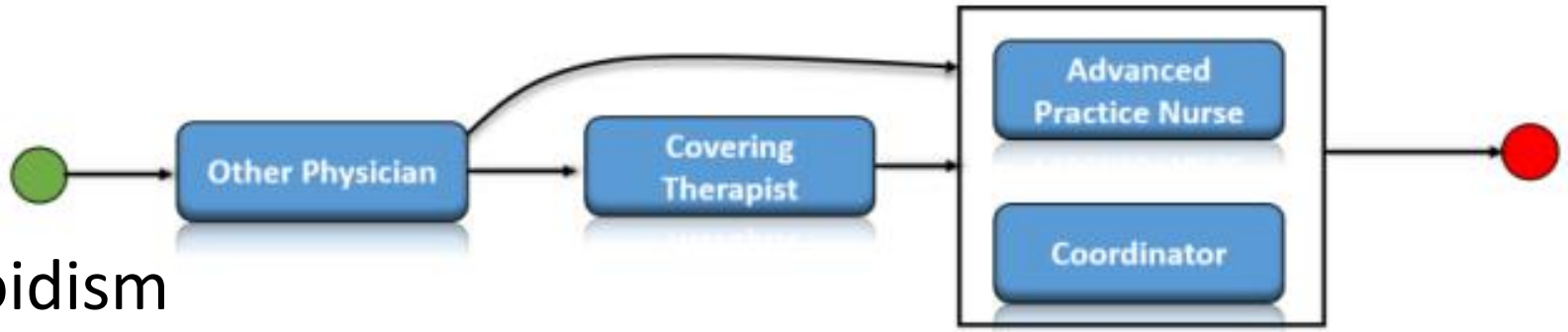


'244.9': Unspecified acquired hypothyroidism
'593.9': Unspecified disorder of kidney and ureter
'733.00':Osteoporosis, unspecified
'414.00':Coronary atherosclerosis of unspecified type of vessel, native or graft
'428.0': Congestive heart failure, unspecified
'V58.61':Long-term (current) use of anticoagulants

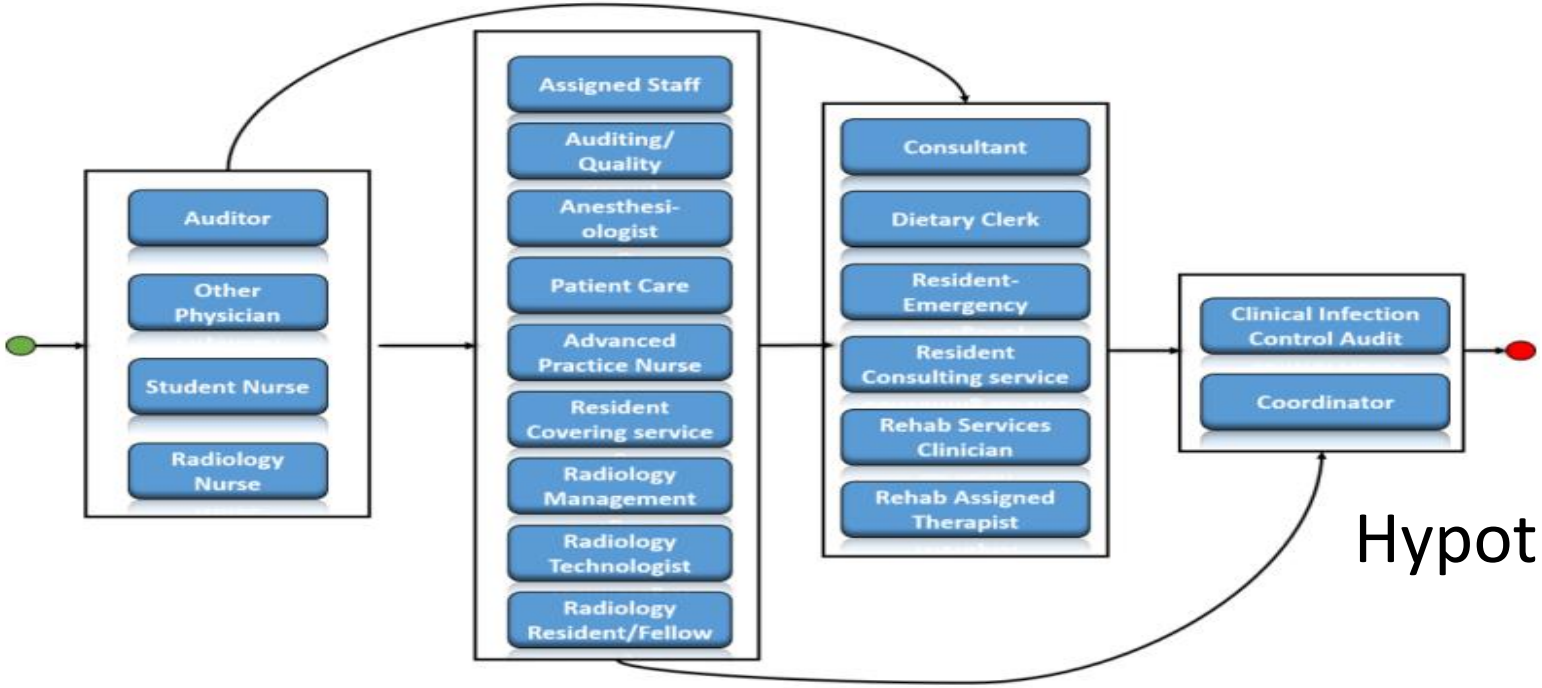
'275.3': Disorders of phosphorus metabolism
'287.5': Thrombocytopenia, unspecified
'276.7': Hyperpotassemia
'285.9': Anemia, unspecified
'584.9': Acute kidney failure, unspecified
'V45.11':Renal dialysis status

Concordance in the frequency of the diagnosis and procedural codes between two subgroups

Work Flow of Hypothyroidism is More Complex than Hyperthyroidism



Hyperthyroidism

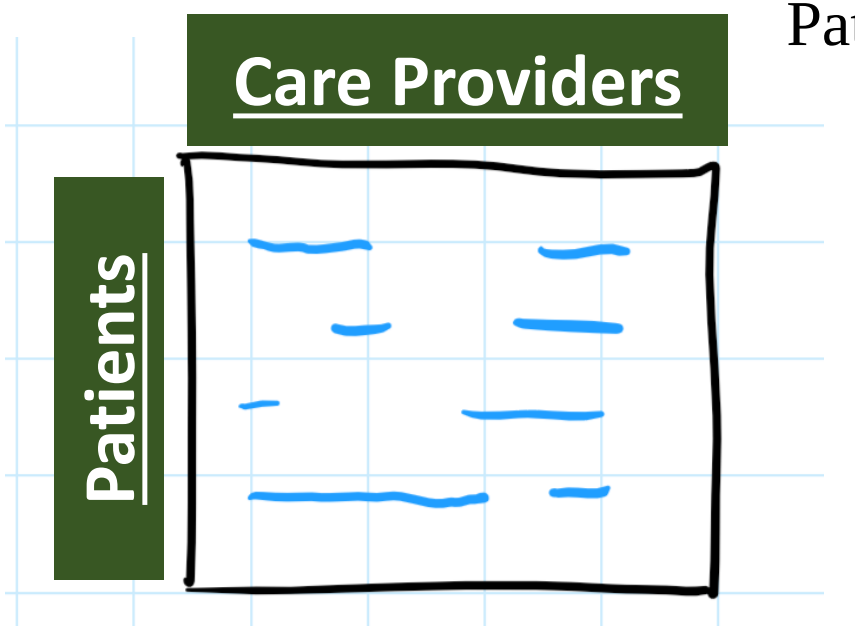


Hypothyroidism

Interaction Networks of Trauma Providers Are Associated with Length of Stay

Authors: You Chen PhD; Mayur B. Patel MD, MPH; Candace D. McNaughton MD, PhD; Bradley A. Malin PhD

Observational study of 5,588 adult inpatient episodes hospitalized survivors of trauma at Vanderbilt



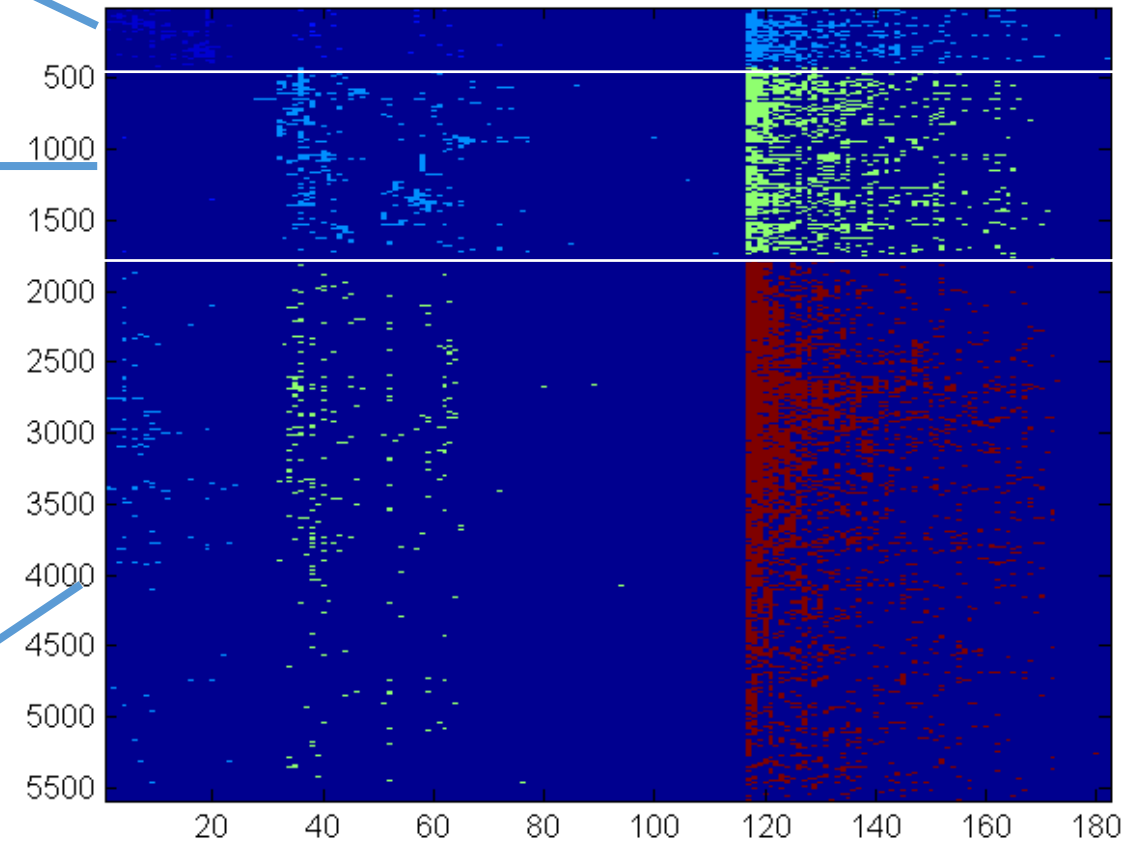
Patient-Care Provider Interaction Matrix

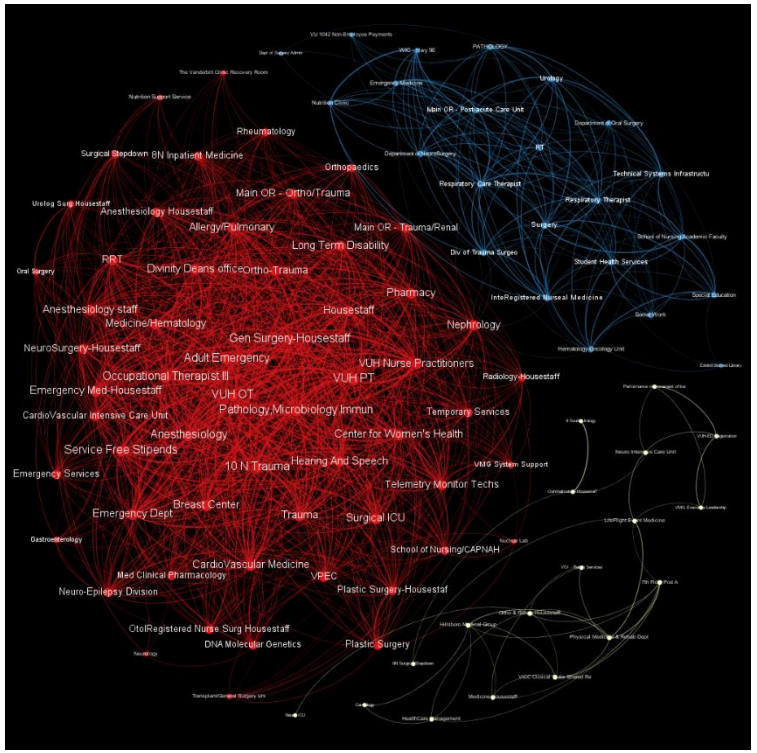
Co-clustering

Patient Group 1

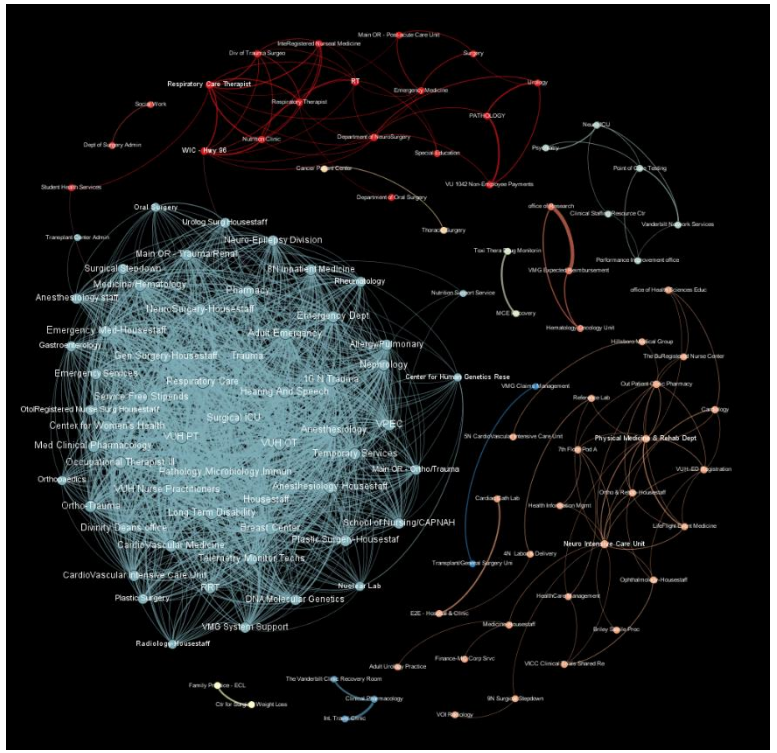
Patient Group 2

Patient Group 3

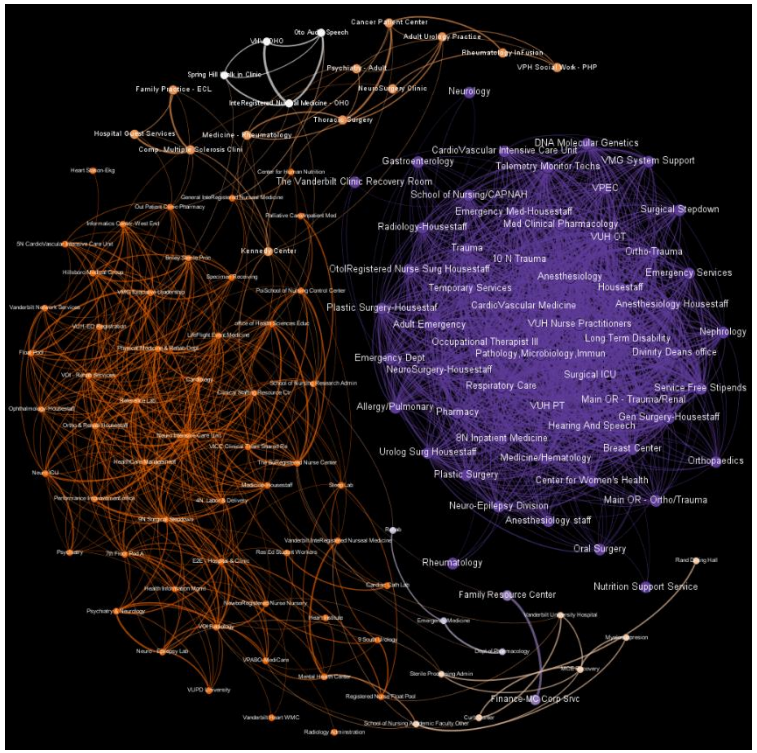




Patient Group 1



Patient Group 2



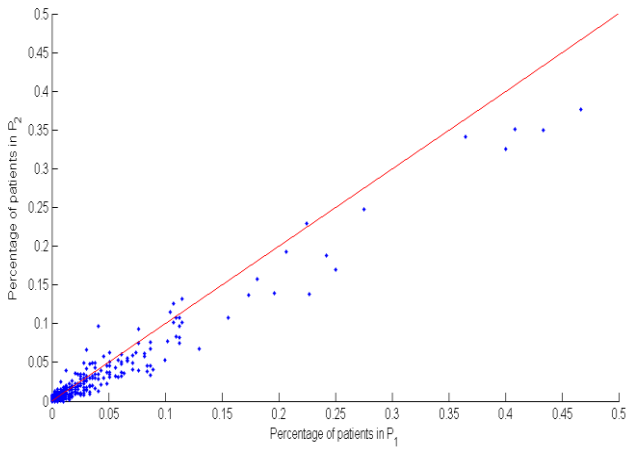
Patient Group 3

The interaction network of Patient Group 1 has the highest degree of collaboration between care providers

Network Metric	Patient Group		
	P_1	P_2	P_3
Degree Average	**27.14**	23.38	22.47
Weighted Degree Average	**7.02**	5.78	5.31
Graph Density	**0.27**	0.17	0.18
Cluster Coefficient Average	**0.77**	0.70	0.73

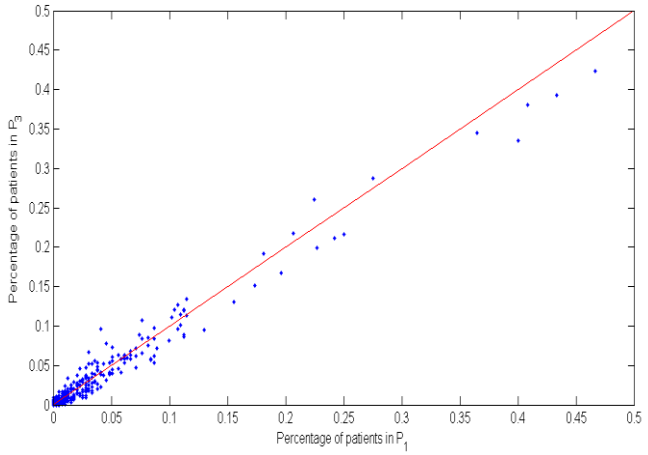
Distributions of PheWAS codes between patient groups

Percentage of patients in P_2



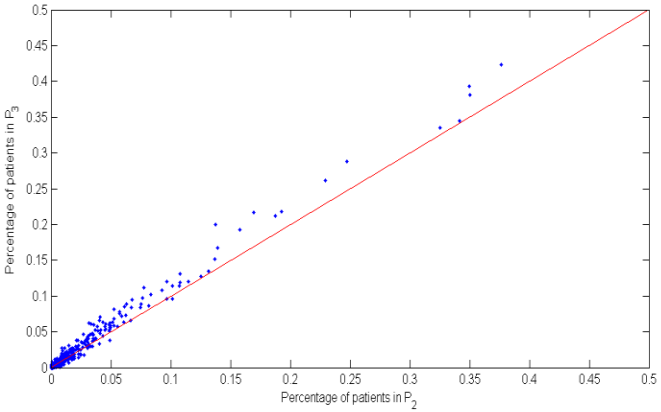
Percentage of patients in P_1

Percentage of patients in P_3



Percentage of patients in P_1

Percentage of patients in P_3

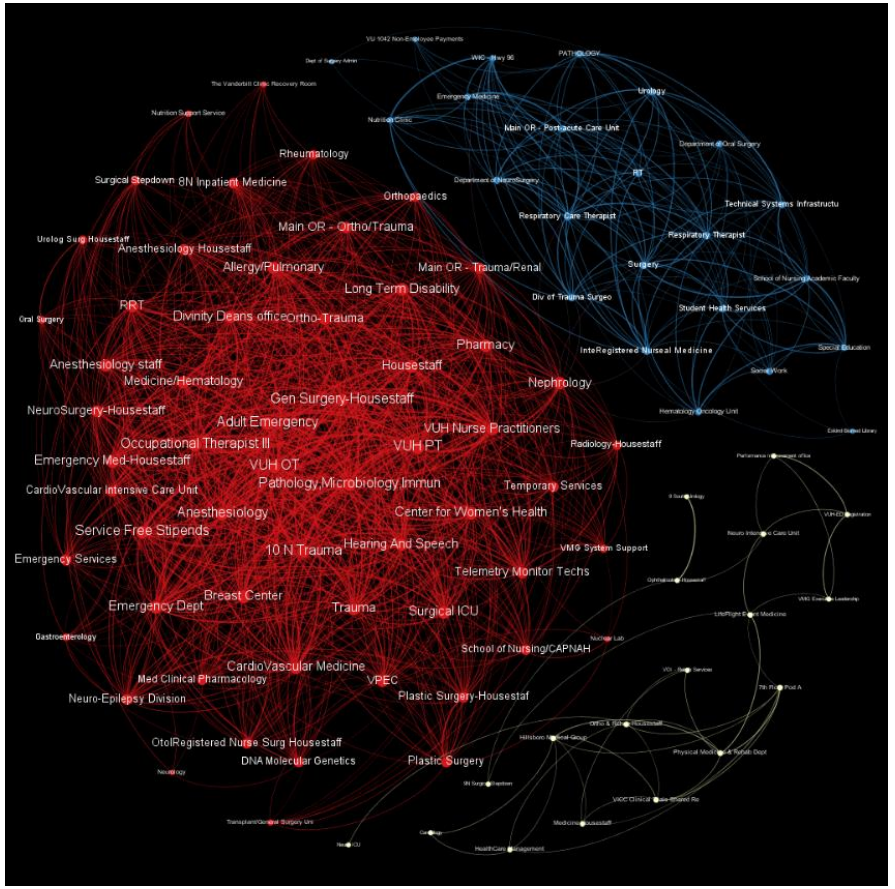


Percentage of patients in P_2

The three patient groups were discovered without differences in PheWAS codes, procedural codes, age and insurance status

What are the differences in LOS for trauma inpatients with similar age, illness, procedural burden, and insurance type, but were managed by different care team structures?

The hospital length of stay for the interaction network of trauma providers with the highest degree of collaboration was **14 hours shorter** than other interaction networks



Patient Group 1

Conclusions

Findings

- Identified care teams were accepted by administrative and clinical experts
- Care teams were associated with LOS
- Automated identification of efficient care team may be possible

Future works

- Translating automatic learned care team structure into actionable clinical practice
- Establishing novel care coordination infrastructure or refining existing care coordination structure

Acknowledgements

Collaborator

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Q&A

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