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

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Per Capita Healthcare Costs — International Comparison

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

Per Capita Health spending (2014)

- **Singapore**
  - 81.9
  - $3,981

- **United States**
  - 79.1
  - $9,237
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
Data-driven care team

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.
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?

ICD-9 vs ICD-10

13,000 billing codes vs 68,000 billing codes
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

Model Relationship Among Care Providers

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

- Principal Component Analysis
- Topic Modeling
- Non-negative matrix factorization
Model Relationship Among Care Providers (cont.)
34 Care Teams were Discovered at Vanderbilt Medical Center
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

Bone Marrow Related

Radiation Oncology Related

Hematology and Myelosuppression

Cancer Center

Distance between Operational Areas

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

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<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Predicted probability</th>
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<tbody>
<tr>
<td>585.1</td>
<td>Acute renal failure</td>
<td>1.000</td>
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<tr>
<td>197</td>
<td>Chemotherapy</td>
<td>0.769</td>
</tr>
<tr>
<td>204.21</td>
<td>Myeloid leukemia, acute</td>
<td>0.688</td>
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<tr>
<td>288.11</td>
<td>Neutropenia</td>
<td>0.534</td>
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<tr>
<td>509.1</td>
<td>Respiratory failure</td>
<td>0.506</td>
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<tr>
<td>284</td>
<td>Aplastic anemia</td>
<td>0.496</td>
</tr>
<tr>
<td>480</td>
<td>Pneumonia</td>
<td>0.489</td>
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<tr>
<td>401.1</td>
<td>Essential hypertension</td>
<td>0.478</td>
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<tr>
<td>198.2</td>
<td>Secondary malignancy of lung</td>
<td>0.463</td>
</tr>
<tr>
<td>198</td>
<td>Secondary malignant neoplasm</td>
<td>0.443</td>
</tr>
</tbody>
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Identifying Clinical Workflows for Heart Failure Patients

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

Concordance in the frequency of the diagnosis and procedural codes between two subgroups
Work Flow of Hypothyroidism is More Complex than Hyperthyroidism
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]

- Patient Group 1
- Patient Group 2
- Patient Group 3

Co-clustering
The interaction network of Patient Group 1 has the highest degree of collaboration between care providers.
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.
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
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