Social network analysis supports innovation and improvement in a collaborative chronic care network

Shannon Provost, Francesca Grippa, Molly McKean, Sunny Thakkar, Michael Seid, Peter Margolis, Peter Gloor, and Reubens McDaniel

April 10, 2014
Agenda

Motivation

Methods

Results

Implications
Motivation

"These complex conditions are beyond the skills of any one scientist or single institution to solve. We need to harness the collective intelligence of large communities of researchers, entrepreneurs, clinicians and patients."

- Peter Margolis, MD, PhD
Collaborative Innovation Networks (COINs)

A COIN is a cyberteam of self-motivated individuals with a collective vision, enabled by the web to collaborate in achieving a common goal.

Example:
- Linux Creators
- Linux Maintainers
- Linux Users
Research Question

In communities-of-practice, how do interactions within and between nested collaboration networks create conditions for the diffusion of innovations?

Today’s Objective

To what extent does social network analysis effectively detect and characterize variation in health care collaborative innovation networks?
Team-level variables in 104 studies that display a strong and generalizable relationship with innovation:

- vision,
- **external communication**,  
- support for innovation,
- task orientation,
- **internal communication**,  
- cohesion,
- goal interdependence

<table>
<thead>
<tr>
<th>Team-Level Characteristics</th>
<th>ρ with innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team size</td>
<td>0.172</td>
</tr>
<tr>
<td>Team longevity</td>
<td>0.02</td>
</tr>
<tr>
<td>Job-relevant diversity</td>
<td>0.155</td>
</tr>
<tr>
<td>Background diversity</td>
<td>-0.133</td>
</tr>
<tr>
<td>Task interdependence</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>Goal interdependence</strong></td>
<td><strong>0.276</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input variables</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Support for innovation</td>
<td></td>
<td><strong>0.47</strong></td>
</tr>
<tr>
<td>Participative safety</td>
<td></td>
<td>0.148</td>
</tr>
<tr>
<td><strong>Vision</strong></td>
<td></td>
<td><strong>0.493</strong></td>
</tr>
<tr>
<td>Task orientation</td>
<td></td>
<td>0.415</td>
</tr>
<tr>
<td>Cohesion</td>
<td></td>
<td>0.307</td>
</tr>
<tr>
<td>Internal communication</td>
<td></td>
<td>0.358</td>
</tr>
<tr>
<td><strong>External communication</strong></td>
<td></td>
<td><strong>0.475</strong></td>
</tr>
<tr>
<td>Task conflict</td>
<td></td>
<td>0.067</td>
</tr>
<tr>
<td>Relationship conflict</td>
<td></td>
<td>-0.092</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Process variables</th>
<th></th>
<th></th>
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<td>Task conflict</td>
<td></td>
<td>0.067</td>
</tr>
<tr>
<td>Relationship conflict</td>
<td></td>
<td>-0.092</td>
</tr>
</tbody>
</table>
Social network analysis offers visibility into social and communication networks

- June 2010
- August 2010
- October 2010
- December 2010

Image from Peter Gloor, PhD, MIT Center for Collective Intelligence
Research Question

In communities-of-practice, how do interactions within and between nested collaboration networks create conditions for the diffusion of innovations?

Today’s Objective

To what extent does social network analysis effectively detect and characterize variation in health care collaborative innovation networks?

- Are we measuring what we intend to measure?
- Are we seeing variation over time and groups?
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Implications
A social, technical, and scientific platform for a new system of chronic illness care.

Research setting
Designing for Health Care Innovation

Low Degree of belief that the ideas will lead to improvement

High
Potential Impact

<table>
<thead>
<tr>
<th>Current Knowledge</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Low Knowledge:
  - Current Knowledge: Low
  - Potential Impact: Low

- High Knowledge:
  - Current Knowledge: High
  - Potential Impact: High
Improved Outcomes in a Quality Improvement Collaborative for Pediatric Inflammatory Bowel Disease

PEDIATRICS Volume 129, Number 4, April 2012

AUTHORS: Wallace V. Crandall, MD, Peter A. Margolis, MD, PhD, Michael D. Kappelman, MD, MPH, Eileen C. King, PhD, Jesse M. Pratt, MS, MA, Brendan M. Boyle, MD, MPH, Lynn F. Duffy, MD, John E. Grunow, MD, Sandra C. Kim, MD, Ian Leibowitz, MD, Bess T. Schoen, MD, and Richard B. Colletti, MD, for the ImproveCareNow Collaborative
COINs (aka Innovation Teams)
n = 12
# Data sources

<table>
<thead>
<tr>
<th>Data sources</th>
<th>Data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Archival record</strong></td>
<td>Email messages from digital archives</td>
</tr>
<tr>
<td>Pre-existing records for purposes other than those related to research</td>
<td>Project documents and artifacts</td>
</tr>
<tr>
<td><strong>Social report</strong></td>
<td>Semi-structured interviews</td>
</tr>
<tr>
<td>Observations come from a third party regarding properties of focal entities</td>
<td>Team ratings from project leadership</td>
</tr>
<tr>
<td><strong>Self-report</strong></td>
<td>Semi-structured interviews</td>
</tr>
<tr>
<td>Focal entity provides observations on their own processes or behaviors</td>
<td>Innovation rating scale scores</td>
</tr>
<tr>
<td><strong>Direct observation</strong></td>
<td>Field research; ethnographic immersion</td>
</tr>
<tr>
<td>The researcher observes behavior of focal entities or events</td>
<td></td>
</tr>
</tbody>
</table>
**Data Collection**

**Incoming Mail**
Redirect e-mail to IMAP folder via Outlook Rule; Filtered by specified conditions

Through IS, participants obtain their own individual IMAP account, and then use redirect/CC: Outlook rules for continuous email collection.

---

**Outgoing Mail**
CC’d to IMAP email Using Outlook Rule Filtered by specified conditions

Participants can check their own email in their IMAP accounts, and remove any emails that are not appropriate for project-related analysis.
Generating team-specific networks

- February 2012
- March 2012
- April 2012
Characterizing communication networks

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Variables</th>
<th>Operationalization</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connectivity</td>
<td>Group Density</td>
<td>$\frac{\text{# relational network ties}}{\text{total # of possible network ties}}$</td>
<td>Dense networks are more resilient; sparser networks have greater potential to access variable sources of information</td>
</tr>
<tr>
<td>Group Centrality</td>
<td>Group Betweenness Centrality</td>
<td>Fraction of shortest paths between every possible pair of nodes that pass through at least one node in the group</td>
<td>Identify stages of team development and characterize team leadership structures.</td>
</tr>
<tr>
<td>Rotating Leadership</td>
<td>Oscillations in Actor Centrality</td>
<td>Oscillations in Actor Betweenness Centrality, how often an actor connects a pair of actors who would not otherwise be connected</td>
<td>Indicative of changes in leadership structures and deference to expertise</td>
</tr>
<tr>
<td>Contribution Symmetry</td>
<td>Average Weighted Variance in Contribution Index</td>
<td>$CI = \text{an individual's proportion of sent-to-received email messages}$</td>
<td>Low variance in CI of team members indicate comparable levels of interactivity in which no one actor dominates</td>
</tr>
<tr>
<td>Responsiveness</td>
<td>Average Response Time</td>
<td>Average of team members’ average response times for email messages in time $t$</td>
<td>Responsiveness within a COIN may predict performance</td>
</tr>
<tr>
<td>Group Emotionality</td>
<td>Emotionality Ratio</td>
<td>$\frac{% \text{ positive words in email messages}}{% \text{ negative words in email messages}}$</td>
<td>The extent to which the words used are emotionally charge; balance between positivity and negativity</td>
</tr>
</tbody>
</table>
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How will we know if our method is valid?

**Criterion Validity**
To what extent are measures demonstrably related to other concrete criteria?

**Common and special cause variation**
- Are we seeing variability across COINs on critical network dimensions?
- Do these measures discriminate across entities and time?
Group Centrality

Actor Betweeness Centrality measures the extent to which an individual lies “between” others in a network.

Perfect star structure with one central actor

Democratic group structure in which communication patterns are identical
Temporal View of Group Centrality

September 2012

Sept 2012: New team leader; shifting roles

May 2013

Higher GBC

May 2013: Grant application

Group Betweenness Centrality
Contribution Index = \[
\frac{\text{Messages sent} - \text{messages received}}{\text{Messages sent} + \text{messages received}}
\]

Adapted from Gloor 2006: 148
Contribution Indices in a COIN: January – April 2013

- Communicator, Connector, Gatekeeper
- Collaborator, Expeditor, Administrator
- Creator, Guru, Salesman
- Subject-matter expert, Knowledge Broker

Volume of email messages sent and received
How will we know if our method is valid?

Criterion Validity
To what extent are measures demonstrably related to other concrete criteria?

Common and special cause variation
- Are we seeing variability across COINs on critical network dimensions?
- Do these measures discriminate across entities and time?
I-Chart - Group Centrality
February 2012 - December 2013

Communications  Patient Activation  EMMA  IBD Volunteers  Enhanced Registry  ICN Exchange

Patient Advisory Council  Passive PRO  Personalized Learning System  PM & PVP  Chicago SNA  YouMelBD

GBC

UCL  LCL
I-Chart - Contribution Symmetry
February 2012 - December 2013

Communications
Patient Activation
EMMA
IBD Volunteers
Enhanced Registry
ICN Exchange

Patient Advisory Council
Passive PRO
Personalized Learning System
PM & PVP
Chicago SNA
YouMeIBD
Investigating special causes

<table>
<thead>
<tr>
<th>team</th>
<th>measure</th>
<th>directionality</th>
<th>month</th>
<th>notes</th>
<th>update</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICN2</td>
<td>GBC</td>
<td>high</td>
<td>Feb-12</td>
<td>looks normal; check center node</td>
<td>valid</td>
</tr>
<tr>
<td>ICN2</td>
<td>GBC</td>
<td>high</td>
<td>Oct-12</td>
<td>scattergun - remove node and recalculate</td>
<td>deleted 'jcchdqi' scattergun; replaced Oct12 and Nov12 observations</td>
</tr>
</tbody>
</table>

ICN2 February 2012

ICN2 October 2012
Learning from variation within and across COINs

X-bar Chart: GBC for 12 C3N Teams | February 2012 - December 2013

X-bar Chart: AWVCI for 12 C3N Teams | February 2012 - December 2013

Time periods:
1: Feb - July 2012
2: Aug 2012 - Jan 2013
3: Feb - July 2013
4: August - Dec 2013
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Rigor AND Relevance

Descriptive relevance – real world phenomenon

Nonobviousness – exceeding common sense theories already in use

Goal relevance – variables the practitioner wishes to influence

Timeliness – availability in time to solve today’s problems

Operational Validity – actionable and implementable for practice

That’s Interesting! MURRAY S. DAVIS Phil. Soc. Sci. 1 (1971), 309-344
Digital traces promise new forms of intelligence for innovation in complex health care systems
What questions are there?