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Islands of Information: Linking Clinical Data

J. Marc Overhage

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Islands of Information: Linking Clinical Data

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Indiana Health Information Exchange
Regenstrief Institute, Inc.
Indiana University School of Medicine

Current Status of Medical Records

Decade of Health Information Technology

Registration Cross-over

<table>
<thead>
<tr>
<th>Hospital systems</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40%</td>
</tr>
<tr>
<td>2</td>
<td>39%</td>
</tr>
<tr>
<td>3</td>
<td>18%</td>
</tr>
<tr>
<td>4</td>
<td>3%</td>
</tr>
<tr>
<td>5</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

Emergency Department Cross-over

<table>
<thead>
<tr>
<th>Hospital System</th>
<th>Number of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hosp A</td>
<td>25000</td>
</tr>
<tr>
<td>Hosp B</td>
<td>20000</td>
</tr>
<tr>
<td>Hosp C</td>
<td>15000</td>
</tr>
<tr>
<td>Hosp D</td>
<td>10000</td>
</tr>
<tr>
<td>Hosp E</td>
<td>5000</td>
</tr>
</tbody>
</table>

*More than one visit
The Indiana Network for Patient Care (INPC)

An operational community wide electronic medical record

Indianapolis, Indiana
- 1.5 million population base
- 12th largest city in U.S.A.
- Home to Indiana’s only medical school
- State Department of Health
- Referral center for entire state (7 million)

Initial RMRS Aims
- Eliminate the logistic problems associated with the paper record
- Standardize the care process. Deliver information in a more organized and useful way. Actively process this record and provide decision support to clinicians.
- Analyze and understand the data to improve the health of populations

INPC Project Goal
Demonstrate the feasibility and benefit of a community wide electronic medical record system in acute care situations.

INPC Project Motto
Resistance is futile!
You will be assimilated
**Pilot Project**

- Participants
  - Methodist
  - Community East
  - Wishard
- Data - Wishard only
- Outcomes
  - Charges
  - ED visits
  - Admissions

**Pilot Emergency Departments**

<table>
<thead>
<tr>
<th>Institution</th>
<th>ED Visits</th>
<th>Beds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wishard</td>
<td>100,000</td>
<td>350</td>
</tr>
<tr>
<td>Methodist</td>
<td>90,000</td>
<td>800</td>
</tr>
<tr>
<td>Community</td>
<td>48,000</td>
<td>350</td>
</tr>
</tbody>
</table>

**Pilot patient demographics**

<table>
<thead>
<tr>
<th>Study ED</th>
<th>Methodist Hospital</th>
<th>Community Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Control</td>
<td>Intervention</td>
</tr>
<tr>
<td>Patients (N)</td>
<td>10,526</td>
<td>10,694</td>
</tr>
<tr>
<td>Age years</td>
<td>32.7 ± 21</td>
<td>32.7 ± 21</td>
</tr>
<tr>
<td>Female %</td>
<td>56.9%</td>
<td>56.1%</td>
</tr>
<tr>
<td>Black %</td>
<td>56.4%</td>
<td>56.3%</td>
</tr>
</tbody>
</table>

**Pilot ED visit charges**

- **Legend**
  - Control
  - Intervention

- **Graph**
  - Community
  - Methodist
  - Wishard

October 2004
Islands of Information: Linking Clinical Data

Clinical INPC functions

- Results retrieval
- Clinical messaging/document delivery
- Data entry
- Reporting
- Clinical decision support
- Public health surveillance
- Medical reference access

Consolidating the Silos

INPC Storage Strategy

- Separate medical record vault per institution
- Each vault in separate physical files
- Standardized data structure – All use same software and observation codes.
- Combine on the fly when needed
- Patient linking

Indiana Network for Patient Care (INPC)

- A local health information infrastructure (LHII)
- We serve as the “Data Switzerland” for the city of Indianapolis and the state
- Up and running for more than 9 years
- Started with a modest goal (Emergency Care)
- Extended by adding projects one step at a time
- Focus on clinical and public health issues, particularly electronic laboratory reporting

INPC – Participants

- Includes 11 hospitals from the 5 major Indianapolis hospital systems (95% of non-office care)
- Includes all four homeless care systems
- Includes county and state public health departments
- Many outpatient practices
- Both major cardiology referral centers
Clinical INPC Users

- Almost all med/surg hospital EDs
- Hospital based providers (expanding)
- Ambulatory physicians (approximately 35%)
- Homeless care network
- Public school clinics
- Marion County Health Department
- Indiana State Department of Health

INPC Contents

- In the system:
  - 1.3 million patients, 5 million registration "events"
  - 24 million orders
  - 489 million coded results
  - 12 million dictated reports
  - 8.8 million radiology reports
  - 25 million prescriptions
  - 480,000 EKG tracings
  - 45 million radiology images
- Added Per Year:
  - 600,000 ambulatory encounters
  - 50,000 inpatient encounters

Clinical Data Standards

- Current
  - HL7 messages for most as the envelope
  - DICOM messages for images as the envelope
  - LOINC for laboratory results content
  - CPT-4 for procedures content
  - ICD-9 for diagnoses content
  - NDC and RxNorm for medications content
- Evolving
  - Organisms for microbiology content
Patient Linkage

- When data is returned from multiple sites, it will need to be combined and linked.
- For example, if “John Doe” is seen for various aspects of his colon cancer at different institutions, the data must be aggregated.

Linkage Methodologies - Deterministic

- “All-or-None”
- Rules based on exact agreement or disagreement
- Match first on a reliable and discriminating identifier (Such as SSN)
- Verify link using additional parameters (Such as LN, FN)

Linkage Methodologies - Probabilistic

- Use statistical methods to generate frequency ratios, similar to likelihood ratios, for each variable

\[
\text{Agreement Ratio} = \frac{\text{frequency of agreement among linked records}}{\text{frequency of agreement among non-linked records}}
\]

\[
\text{Disagreement Ratio} = \frac{\text{frequency of disagreement among linked records}}{\text{frequency of disagreement among non-linked records}}
\]

Example: Assume 94.1% of last names agree among true links, and last names randomly agree among non-links with a frequency of 0.1%

\[
\text{Agreement Ratio} = \frac{.941}{.001} = 941, \log_2(941) = 9.88
\]

\[
\text{Disagreement Ratio} = \frac{1 - .941}{1 - .001} = .059, \log_2(.059) = - 4.08
\]

Linkage Methodologies

Deterministic
- Rapid implementation
- Simple calculations
- Relies on accurate data
- May not function well with other data sets

Probabilistic
- Complex implementation
- Computationally intensive
- More forgiving of data errors
- Algorithm is customized to data being linked

Global Patient Registry

<table>
<thead>
<tr>
<th>Assigning Authority</th>
<th>Global #</th>
<th>Local Pat #</th>
<th>Patient Name</th>
<th>Birthdate</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital A</td>
<td>99-1</td>
<td>231456</td>
<td>Sinkwell, Ralph J</td>
<td>12-2-59</td>
<td>M</td>
</tr>
<tr>
<td>Hospital B</td>
<td>123-0</td>
<td>A47239</td>
<td>Sinkwell, RJ</td>
<td>2-12-59</td>
<td>M</td>
</tr>
<tr>
<td>Hospital A</td>
<td>99-1</td>
<td>1032115</td>
<td>Sinkwell, Ralph</td>
<td>12-2-59</td>
<td>M</td>
</tr>
<tr>
<td>Hospital C</td>
<td>101-0</td>
<td>A3276</td>
<td>Fredrick, Alice</td>
<td>4-14-78</td>
<td>F</td>
</tr>
<tr>
<td>Hospital A</td>
<td>101-0</td>
<td>2314590</td>
<td>Fredrick, Alyce</td>
<td>4-14-78</td>
<td>F</td>
</tr>
</tbody>
</table>
INPC - Confidentiality

• While numerous measures in place to protect confidentiality of patient’s data, the provider has to know who the patient is.
  – Secure physical network
  – Encryption
  – Authentication
  – Agreements
  – Device controls

Participants’ Agreement

• How can participants share health data to treat patients?
• Who may have access to PHI for treatment purposes?
• What information is to be stored on the network?
• How may the PHI be used for research purposes?
• What are other considerations?
  – Equipment
  – Consistency of data
  – Other uses of information
  – Indemnification
  – Governance
  – Disposition of information upon termination
  – Security
Video Records

- Implement video-based teleconferencing between health providers and patients in a nursing facility
- Measure impact on health outcomes
Winston Niles Rumfoord had run his private space ship right into the heart of an uncharted chrono-syn-clastic infundibulum two days out of Mars. Only his dog had been along. Now Winston Niles Rumfoord and his dog Kazak existed as wave phenomena -- apparently pulsing in a distorted spiral with its origin in the Sun and its terminal in Betelgeuse.

INFUNDIBULUM

- A funnel-shaped cavity.
- It's the Latin word for a funnel, derived from infundere, "to pour".
- In English, it turns up in various anatomical contexts for something funnel-shaped. For example, in the human body it describes the outermost section of the fallopian tubes, a structure in the cochlea of the ear, and a formation in the brain close to the pituitary, among others.
- Science-fiction fans may have come across the splendid phrase chronosynclastic infundibulum that was invented by Kurt Vonnegut in The Sirens of Titan, which he explained, perhaps less than helpfully, as being "those places ... where all the different kinds of truths fit together".

Data reuse

- Clinical care
  - Emergency room
  - Primary care
  - Inpatient
- Public health (state and local HD)
  - Immunization registry
  - Reportable conditions
  - Surveillance
- Health services research
- Clinical research
- Accreditation reports
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The “Killer App” – Reusable Data

- Increasingly structured clinical data
- Patient data
- Application & Tools
  - Results delivery
  - Clinical data screening & management

Public Health Outcomes

- Reliable
  - Real time delivery
  - 100% received (for participants)
- Reporting completeness (capture/recapture)
  - Greatly increased case reporting
- Reporting timeliness (versus result dates)
  - 8.4±15.4 days faster than HD
  - 1.4±2.0 days faster than hospital
**Islands of Information: Linking Clinical Data**

**Healthcare Collaborative Network**

- **Data Source Organizations**
  - Legacy Systems (Diagnosis, Lab, Pharmacy, Other?)
  - HCN Gateway
  - Data Review Organization

**Data Source Organizations**

- **Legacy Systems**
  - Diagnosis
  - Lab
  - Pharmacy
  - Other?

**Data Source Organizations**

- **Legacy Systems**
  - Diagnosis
  - Lab
  - Pharmacy
  - Other?

**Data Source Organizations**

- **Legacy Systems**
  - Diagnosis
  - Lab
  - Pharmacy
  - Other?

**HCN HUB**

**Data Review Organizations**

- **Agencies**
  - Payers and others who analyze clinical data

**Integration Broker**

- **Internet Portal**
  - HCN Gateway
  - Firewalls

**Internet Portal**

- **CMS, FDA, CDC**
  - HCN Gateway
  - Firewalls

**C!TL HIE economic model**

- **Total value:** $87 billion
  - $13.1B Provider
  - $34B Payer
  - $0.09B Other Provider
  - $0.04B Provider
  - $1.3B Pharmacy
  - $13.9B Laboratory
  - $12.2B Radiology
  - $8.8B N/A
  - $1.0B $0.0B

**Achieving full value requires structured data**

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Non-electronic data</td>
<td>No PC/information technology</td>
</tr>
<tr>
<td>2</td>
<td>Machine-transportable data</td>
<td>Fax/Email</td>
</tr>
<tr>
<td>3</td>
<td>Machine-organizable data</td>
<td>Structured messages, non-standard content/data</td>
</tr>
<tr>
<td>4</td>
<td>Machine-interpretable data</td>
<td>Structured messages, standardized content/data</td>
</tr>
</tbody>
</table>

**Benefits Accrue to Stakeholders Across System**

- **LONG-TERM ECONOMIC BENEFIT TO CENTRAL INDIANA WILL EXCEED $120M ANNUALLY**

**HIEI Taxonomy**

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<th>Level</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
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**Source:** Source: Center for Information Technology Leadership, IHIE calculations

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1 year RCT done!
- 80% intervention/20% control
- Intervention
  - Printed abstract
  - On-line access for 24 hours
- Additional covariates

Tentative Results

<table>
<thead>
<tr>
<th></th>
<th>Mean Charge</th>
<th>Charge Savings*SE</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All visits w/o covariates</td>
<td>572.93</td>
<td>563.23</td>
<td>-9.70±4.74</td>
<td>-0.01</td>
</tr>
<tr>
<td>All visits w/ covariate</td>
<td>571.19</td>
<td>561.58</td>
<td>-9.55±4.56</td>
<td>-0.06</td>
</tr>
</tbody>
</table>

Indiana Health Information Exchange

- Founded in 1999 by 50 community physicians – Central Indiana Coalition to Reinvent Health Care
- Early seed funding from Health & Hospital Corporation of Marion County
- Initiated community clinical messaging concept

BioCrossroads
- Founded in 2002 by the Central Indiana Corporate Partnership
- Economic development organization promoting academic/industry collaboration in life sciences
Founding Members

- Hospital systems
  - Clarian Health Partners
  - St. Francis Hospital and Health System
  - St. Vincent Health Care
  - Wishard Health Services
  - Community Hospitals of Indiana
- Government
  - City of Indianapolis
- Public Health
  - Marion County Health Department
- Research
  - IU School of Medicine
  - Regenstrief Institute
- Medical societies
  - Indianapolis Medical Society
  - Indiana State Medical Association
- Economic development
  - BioCrossroads / Central Indiana Corporate Partnership

Acknowledgement

- National Library of Medicine
- Agency for Healthcare Quality and Research
- National Cancer Institute
- Regenstrief Foundation
- Eli Lilly and Company INGEN grant
- BioCrossroads

Three Hypothetical Communities Were Modeled

<table>
<thead>
<tr>
<th>Community Size</th>
<th>Constituent Type</th>
<th>Participation</th>
<th>Physician Adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>Major hospital</td>
<td>35%</td>
<td>15%</td>
</tr>
<tr>
<td>Medium</td>
<td>Diagnostic imaging center</td>
<td>25%</td>
<td>10%</td>
</tr>
<tr>
<td>Small***</td>
<td>Independent laboratory</td>
<td>15%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Value Increased w/Community Size & Penetration

- Large
  - Costs: $1,200,000
  - Benefits: $2,200,000
  - Net: $1,000,000

- Medium
  - Costs: $900,000
  - Benefits: $1,300,000
  - Net: $400,000

- Small
  - Costs: $600,000
  - Benefits: $1,000,000
  - Net: $400,000

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Facsimile: 317-630-6962
E-mail: moverhage@regenstrief.org
Web address: www.regenstrief.org
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Number of Constituents</th>
<th>Per Constituent</th>
<th>Total for All Constituents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital</td>
<td>7</td>
<td>$130,000</td>
<td>$810,000</td>
</tr>
<tr>
<td>Imaging</td>
<td>8</td>
<td>$110,000</td>
<td>$960,000</td>
</tr>
<tr>
<td>Laboratory</td>
<td>2</td>
<td>$110,000</td>
<td>$220,000</td>
</tr>
<tr>
<td>Physician</td>
<td>3</td>
<td>$120,000</td>
<td>$360,000</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>$40</td>
<td>$40</td>
</tr>
<tr>
<td>PBM</td>
<td>3</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>LARGE COMMUNITY, HIGH PENETRATION</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>