Secondary use of EHR data

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Kansas City
Disclosures

• Employed by Children’s Mercy

• Former employee of Cerner Corporation (1997-2013)
  • Inventor on 19 issued patents and multiple pending patents, no ownership stake
  • Divested stock options and liquid stocks
  • Retain limited 401k holdings

• Board member Lee’s Summit Healthcare Foundation

• Some work funded by Centers for Disease Control and Prevention
  • Grant NU47OE000105-01-01
Primary uses of EHR data

• Support point of care decisions
• Enable immediate access to documentation
• Promote compliance
• Protect patient privacy
• Automate and streamline clinical operations
• Billing
The “Meaningful” in Meaningful Use
Value of secondary use

- Surveillance – early warning
- Investigate patterns in patient outcomes
- Inform quality improvement
- Improve operational efficiencies
- New discoveries
- Prediction
Disease Surveillance – Public Health

• Some pathogens require notification of public health
  • Highly contagious
  • Food poisoning
  • Bioterrorism

• Requirements vary by jurisdiction

• Historically notification was by FAX, mail or phone call

• Electronic reporting directly from EHR offers multiple benefits
2001 - Anthrax

- Anthrax contaminated letters sent to news media and U.S. Senators
- 5 fatalities, 17 infections
- Kansas City Health Department and Cerner agreed to collaborate
Improved public health reporting

**DATA COMPLETENESS**

- Reportable cases (non-STD): March-Sept 2002
- *Average over 6 key data fields

**TIMELINESS**

- *Average over all reportables

**UNDER-REPORTING**

- *Increased overall reporting by 96%

Public Health Network: 2009 Influenza initiative

- Opt-in at project level
- 850+ facilities, 48 States
- 57 million cases processed
- Positive influenza A results, ILI, ED utilization
- Worked with CDC, state and local public health
Public Health – The Garden

• Data capture instruments are designed by experts
• Weeds are pruned out
• Data is “validated”
• Labor intensive
• With few exceptions, small size
NHANES – A very lovely garden

• National Health and Nutrition Examination Survey (NHANES)
• CDC managed
• Approximately 5000 people surveyed every year
• Socioeconomic
• Demographic
• Health
• Some lab tests
# NHANES Survey Topics

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Acculturation (ACQ)</td>
<td>12 years and over</td>
<td></td>
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<tr>
<td>Allergy (AGQ)</td>
<td>1 year and over</td>
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<td>Air quality (AQI)</td>
<td>16 years and over</td>
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<td>Balance (BAQ)</td>
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<tr>
<td>Blood pressure and cholesterol (BPQ)</td>
<td>16 years and over</td>
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<tr>
<td>Cardiovascular disease (CDQ)</td>
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<tr>
<td>Cognitive functioning (CFQ)</td>
<td>60 years and over</td>
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<tr>
<td>Demographic background (DMQ)</td>
<td>Birth and over</td>
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<td>Dermatology (DEQ)</td>
<td>6 years and over</td>
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<tr>
<td>Diabetes (DIQ)</td>
<td>1 year and over</td>
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<tr>
<td>Diet behavior and nutrition (DBQ)</td>
<td>Birth and over</td>
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<tr>
<td>Dietary screener module (DTQ)</td>
<td>2–11 years</td>
<td></td>
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<tr>
<td>Dietary supplements (DSQ) and medications (RXQ)</td>
<td>Birth and over</td>
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<tr>
<td>Disability status (DLQ)</td>
<td>1 year and over</td>
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<td>Early childhood (ECQ)</td>
<td>Birth–15 years</td>
<td></td>
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<tr>
<td>Health insurance (HIQ)</td>
<td>Birth and over</td>
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</tbody>
</table>

Note: 1. This data point is marked with a note indicating a change from the original sample description. It is important to consult the NHANES documentation for the most accurate and up-to-date information.
Survey example

• Tightly structured

• Every surveyor asks same questions

• Coding consistent
Limitations of public health model

• Small sample size
• Difficult and expensive to scale
• Discord with practice
Healthcare – The Jungle

• Limited standardization
• Limited “data validation”
• Wide variation locally and regionally
• Far more coverage
• Many hazards
Jungle – life saving, dangerous

- Digitalis - digoxin
- Cinchona calisaya - Quinine

- Dangers
Health Facts – one corner of the jungle

- Voluntary data rights agreement between Cerner and subset of U.S. clients
- Began in 2000
- More than 860 healthcare facilities represented
- More than 100 organizations
- Epic Cosmos sounds similar
Health Facts™

EHR Vendor clients

- No data rights
- Data rights

De-ID, Mapping, normalization

Health Facts™
## Cerner Health Facts - Summary

<table>
<thead>
<tr>
<th>Data type</th>
<th>Current release</th>
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<tbody>
<tr>
<td>Unique patients</td>
<td>63 million</td>
</tr>
<tr>
<td>Total laboratory results</td>
<td>4.3 billion</td>
</tr>
<tr>
<td>Total facilities</td>
<td>863</td>
</tr>
<tr>
<td>Total medication orders</td>
<td>734 million</td>
</tr>
<tr>
<td>Total diagnoses</td>
<td>489 million</td>
</tr>
</tbody>
</table>

- Actual, not potential data
Other data in Health Facts

- Vitals
  - BP, temp, respiratory rate, pulse
- Pain scale
- Falls
- BMI
- Provider specialty

- Apgar
- Smoking
- Surgery
- ASA
- Charges
Health Facts Examples
Mg and AMI - Mortality

• Mg supplementation recommended after AMI but little evidence

• After inclusion/exclusion – 11,683 HF patients with AMI and Mg results

• Both Low and High Mg levels correlate with higher risk of in-hospital mortality

Shafiq et.al. – J. Amer. Coll. Card. June 2017
HF: Drug safety

Table 4 Nephrotoxicity and Comparison of Outcomes: Conventional and Lipid-Based Amphotericin

<table>
<thead>
<tr>
<th>Nephrotoxicity, Scr, and Related Outcomes</th>
<th>LF-AMB (n = 327)</th>
<th>CAB/LF-AMB (n = 81)</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scr, post-amphotericin B peak (absolute value)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak &gt; 1.5 mg/dl (n [%])</td>
<td>120 [47.4]</td>
<td>36 [63.2]</td>
<td>0.032</td>
</tr>
<tr>
<td>Peak &gt; 2.0 mg/dl (n [%])</td>
<td>90 [35.6]</td>
<td>23 [40.4]</td>
<td>0.498</td>
</tr>
<tr>
<td>Peak &gt; 2.5 mg/dl (n [%])</td>
<td>63 [24.9]</td>
<td>18 [31.6]</td>
<td>0.300</td>
</tr>
<tr>
<td>Peak &gt; 3.0 mg/dl (n [%])</td>
<td>46 [18.2]</td>
<td>13 [22.8]</td>
<td>0.422</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scr, post-amphotericin B peak (relative change)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak 1.5 x pre-amphotericin B (n [%])</td>
</tr>
<tr>
<td>Peak 1.5 x pre-amphotericin B &gt; 1.5 ULN (n [%])</td>
</tr>
<tr>
<td>Peak 2 x pre-amphotericin B (n [%])</td>
</tr>
<tr>
<td>Peak 3 x pre-amphotericin B (n [%])</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scr, post-amphotericin B peak*</th>
</tr>
</thead>
<tbody>
<tr>
<td>% change (relative change) (mean [SD])</td>
</tr>
<tr>
<td>Other Adverse Events</td>
</tr>
<tr>
<td>Hypokalemia during amphotericin B therapy* (n [%])</td>
</tr>
<tr>
<td>Hypomagnesemia during amphotericin B therapy* (n [%])</td>
</tr>
<tr>
<td>New-onset AST elevation following amphotericin B therapy* (n [%])</td>
</tr>
<tr>
<td>Infusion reaction requiring treatment* (n [%])</td>
</tr>
<tr>
<td>Mortality*</td>
</tr>
<tr>
<td>Overall hospital LOS (days) (mean [SD])</td>
</tr>
<tr>
<td>Post-amphotericin B hospital LOS (mean [SD])</td>
</tr>
</tbody>
</table>

Comparison of Adverse Events and Hospital Length of Stay Associated With Various Amphotericin B Formulations

Sequential Conventional Amphotericin B/Lipid Versus Lipid-Only Therapy For the Treatment of Invasive Fungal Infections in Hospitalized Patients

Rolin L. Wade, RPh, MS; Paresh Chaudhuri, PharmD, MPH; Jaime L. Noto, MS, MPH; Robert J. Taylor, AS; Brian H. Nathanson, PhD; and David Horn, MD
Data-informed selection of QI projects

Candidate projects:
- Project 1
- Project 2
- Project 3
- Project 4
- ...

Local data analysis

Can quality concern be confirmed and quantified locally?
- No: Defer candidate project
- Yes:
  - Explore national warehouse

Does Truman rank in bottom 25% of sites?
- No: Assign lower rank to project
- Yes: Cerner Health Facts
  - Characterize top 25%

Measure impact of QI project

Design and implement intervention

Truman i2b2
Let the data speak

- Risk factors associated with hospital acquired *C. diff* infections
- Regression analysis
- Does not require a narrow question

Dean B., Campbell R., Nathanson B. et. al. “Risk factors associated with hospital-origin vs community-origin *Clostridium difficile*-associated diarrhea” ID week 2012
What do we need for safety analysis?

- Hepatitis

T₀: Key strength of EHR data – precise dt/tm
Tₓ: Before med

Exclusions
- Hepatitis

Medication order

Favorable response

Adverse response

Failure to benefit

Dx code
- Stephens-Johnson syndrome

Proxy
- Benadryl
- Liver tox
- Cardiac

Unexpected

Cardiac Failure to benefit
What’s missing from de-identified EHR data?

• New medications take time to be included
• INDs are not represented unless included in RxNorm
• Text notes that could identify adverse events
  • Can’t reliably de-identify text notes
• Outpatient scripts
  • Could be addressed in future releases
• Compliance data (fills)
## Comparison of HF with HCUP NIS

<table>
<thead>
<tr>
<th>Category of condition</th>
<th>HCUP</th>
<th>HF</th>
<th>tValue</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Skin, Subcutaneous Tissue &amp; Breast</td>
<td>2.58</td>
<td>2.58</td>
<td>0.20</td>
</tr>
<tr>
<td>Blood, Blood Forming Organs &amp; Immunological Disorders</td>
<td>1.36</td>
<td>1.36</td>
<td>0.29</td>
</tr>
<tr>
<td>Nervous System</td>
<td>6.03</td>
<td>6.12</td>
<td>0.39</td>
</tr>
<tr>
<td>The Kidney &amp; Urinary Tract</td>
<td>4.32</td>
<td>4.30</td>
<td>0.45</td>
</tr>
<tr>
<td>Burns</td>
<td>0.11</td>
<td>0.12</td>
<td>0.50</td>
</tr>
<tr>
<td>Myeloproliferative Disease &amp; Disorders Poorly Differiantiated Neoplasms</td>
<td>0.91</td>
<td>0.86</td>
<td>0.70</td>
</tr>
<tr>
<td>The Hepatobiliary System and Pancreas</td>
<td>2.94</td>
<td>3.03</td>
<td>1.02</td>
</tr>
<tr>
<td>The Ear, Nose, Mouth and Throat</td>
<td>1.10</td>
<td>1.17</td>
<td>1.49</td>
</tr>
<tr>
<td>The Eye</td>
<td>0.15</td>
<td>0.14</td>
<td>1.53</td>
</tr>
<tr>
<td>The Male Reproductive System</td>
<td>0.50</td>
<td>0.55</td>
<td>2.23</td>
</tr>
<tr>
<td>Endocrine, Nutritional &amp; Metabolic Disease &amp; Disorders</td>
<td>3.26</td>
<td>3.45</td>
<td>2.44</td>
</tr>
<tr>
<td>The Respiratory System</td>
<td>9.79</td>
<td>10.29</td>
<td>2.46</td>
</tr>
<tr>
<td>Multiple Significant Trauma</td>
<td>0.27</td>
<td>0.21</td>
<td>3.08</td>
</tr>
<tr>
<td>The Digestive System</td>
<td>8.91</td>
<td>9.51</td>
<td>3.10</td>
</tr>
<tr>
<td>The Circulatory System</td>
<td>13.64</td>
<td>14.82</td>
<td>3.27</td>
</tr>
<tr>
<td>Injuries, Poisonings &amp; Toxic Effects of Drugs</td>
<td>1.56</td>
<td>1.44</td>
<td>3.49</td>
</tr>
<tr>
<td>Human Immunodeficiency Virus Infections</td>
<td>0.20</td>
<td>0.13</td>
<td>3.58</td>
</tr>
<tr>
<td>The Musculoskeletal System &amp; Connective Tissues</td>
<td>9.06</td>
<td>8.15</td>
<td>3.82</td>
</tr>
<tr>
<td>Infectious &amp; Parasitic Diseases, Systemic/Unspecified Sites</td>
<td>3.23</td>
<td>2.85</td>
<td>5.12</td>
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<tr>
<td>Newborns &amp; Other Neonates w/ Condition Originating in Perinatal Period</td>
<td>10.42</td>
<td>8.04</td>
<td>6.94</td>
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<tr>
<td>Mental Diseases &amp; Disorders</td>
<td>3.89</td>
<td>2.22</td>
<td>7.10</td>
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<tr>
<td>Factors Influencing Health Status &amp; Other Contacts with Health Services</td>
<td>1.67</td>
<td>2.28</td>
<td>7.22</td>
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<tr>
<td>Alcohol/Drug Use &amp; Alcohol/Drug Induced Organic Mental Disorders</td>
<td>1.24</td>
<td>0.47</td>
<td>7.68</td>
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<tr>
<td>Pregnancy, Childbirth &amp; The Puerperium</td>
<td>11.09</td>
<td>4.15</td>
<td>18.67</td>
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<tr>
<td>The Female Reproductive System</td>
<td>1.75</td>
<td>0.55</td>
<td>24.04</td>
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</tbody>
</table>

*DeShazo, J; Hoffman, MA “A comparison of a multistate inpatient EHR database to the HCUP nationwide inpatient sample” BMC Health Services Res. 2015 15(1):384 PMID: 26373538*
Pitfalls of EHR data

- Variability at every level
  - Individual practitioner
  - Department
  - Organization
  - Region

- Subtle but significant issues

- Configuration changes over time
  - Not always documented, tracked or associated with data distributions
One very ill woman

Q Fever

Lymphosarcoma

Peripheral Neuropathy
Patient type categories (subset)

<table>
<thead>
<tr>
<th>Code</th>
<th>Category</th>
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<tbody>
<tr>
<td>77</td>
<td>Client</td>
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<tr>
<td>78</td>
<td>Clinic</td>
</tr>
<tr>
<td>76</td>
<td>Cerner test patient – not valid patients</td>
</tr>
<tr>
<td>122</td>
<td>HLA QC</td>
</tr>
<tr>
<td>123</td>
<td>Home health</td>
</tr>
<tr>
<td>109</td>
<td>Test</td>
</tr>
</tbody>
</table>

Update: Cerner has removed many Non-patient encounters in latest HF data cut
Conclusion

• Aggregate EHR data offers significant opportunity to perform novel safety analysis and surveillance
• Requires deep and practical understanding of EHR content and workflow
  • Theoretical understanding is limited value
  • Implementation science should be represented
• Requires recognition of strengths and limitations of de-identified EHR data
• Statistical methods are still evolving
Thank you!

• Contact:
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  @markhoffmankc
  816-302-1310

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