Death-on-FHIR: Analytics-Driven Mortality Reporting Using a SMART-on-FHIR App
Outline

Goal: Next-Generation Mortality Reporting System

Application Design
  Key Component – Wireframe of App (User-Interface)

Data Transfer from EHR to reporting jurisdiction
  Key Component – Death Certificate System Design using SMART on FHIR (Communications)

Analytics Engine
Our Goal

**FHIR** – Define new and standardized death certificate reporting system by developing common, national FHIR profiles

**APP** – Develop FHIR-based death registration application with interactive interface for data analysis and entry

**ANALYTICS** – Develop decision support systems to enable provide timely, accurate, and complete reporting
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Analytics System
Proposed Cause of Death Reporting Application Infrastructure

SMART-on-FHIR App Launch

EHR

App

FHIR Death Certificate

State Health Department

FHIR Data

EHR Back-End Database

FHIR-Enabled EHR Server

FHIR

App Launch

App Launch

FHIR Data

FHIR Resources

Advanced Analytics

Cause-of-Death Rules Ontology

NIH UMLS Metathesaurus Adapter

Application Server
Proposed Cause of Death Reporting Application Infrastructure

**EHR Neutral:**
Any SMART-on-FHIR compliant EHR (e.g., our in-house synthetic data FHIR server)

**FHIR-Enabled EHR Server**

**Web App:**
Runs on any modern browser

**App Server:**
The web application server, decision support engine, and UMLS interface middleware are implemented on our lab’s application server

**Package and Submit:**
Final DC transmitted to remote server

**Advanced Analytics**

**FHIR Resources**
Proposed Cause of Death Reporting Application Infrastructure

- EHR
- Back-End Database
- SMART-on-FHIR App Launch
- FHIR-Enabled EHR Server
- App
- FHIR Data
- FHIR Death Certificate
- FHIR Document Bundle
- State Health Department
- NIH UMLS Metathesaurus Adapter
- Advanced Analytics
- FHIR Resources
- Cause-of-Death Rule Mining Results
- Application Server
- Unimplemented
Johnston, Jonathan -- ID 100001

Patient Details
Name: Jonathan James Johnston
Age at death: 64.5 years
Residence: Everytown, USA 99999

Patient History

Cause of Death:
Rupture of heart
Acute myocardial infarction
Diffuse disease of coronary artery
Diabetes mellitus

Onset to Death:
13 minutes
3 days
16 years
29 years

Other Significant Conditions

Demographic Information  Validate and Submit
App Interface Design

- Automatically extract patient data from EHR
- Patient history information
- Scaled timeline of reportable conditions
- Analytical assessment of possible sequences
- Familiar interface for cause-of-death documentation
- Bundle results in FHIR format
Interface Demo

Please sign in above to get started

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Backup Link: https://www.youtube.com/watch?v=PIBoRspEzbA
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Analytics System
FHIR Profiling for Death Certificates

Key infrastructure question: how to represent death certificate objects best using the FHIR framework? Should be:

- Simple to implement
- Idiomatically correct in FHIR
- Include machine-searchable and human-readable representations

Implementation priorities:
1. Ensure mapping for all fields of the HL7 VR DAM to our representation
2. Use native FHIR Resources and fields for as much data as possible
3. Reuse public profiles where possible
4. Develop new profiles only where necessary
2003 US Standard Certificate of Death

- Patient Info
- Funeral Home Contacts
- Manner of Death
- Demographic Data
- Circumstances of Death
- Pronouncing Clinician
- Causes of Death
- Certifying Medical Professional
Some Sections Map Naturally to FHIR Resources

### U.S. STANDARD CERTIFICATE OF DEATH

<table>
<thead>
<tr>
<th>LOCAL FILE NO.</th>
<th>STATE FILE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DECEDENT'S LEGAL NAME (Include AKA's if any) (First, Middle, Last)</td>
<td>2. SEX</td>
</tr>
<tr>
<td>3. SOCIAL SECURITY NUMBER</td>
<td></td>
</tr>
<tr>
<td>4a. AGE-Last Birthday (Years)</td>
<td>4b. UNDER 1 YEAR Months</td>
</tr>
<tr>
<td>4c. UNDER 1 DAY Days</td>
<td>5. DATE OF BIRTH (Mo/Day/Yr)</td>
</tr>
<tr>
<td>6. BIRTHPLACE (City and State or Foreign Country)</td>
<td></td>
</tr>
<tr>
<td>7a. RESIDENCE-STATE</td>
<td>7b. COUNTY</td>
</tr>
<tr>
<td>7c. CITY OR TOWN</td>
<td></td>
</tr>
<tr>
<td>7d. STREET AND NUMBER</td>
<td>7e. APT. NO.</td>
</tr>
<tr>
<td>7f. ZIP CODE</td>
<td>7g. INSIDE CITY LIMITS? □ Yes □ No</td>
</tr>
<tr>
<td>8. EVER IN US ARMED FORCES? □ Yes □ No</td>
<td></td>
</tr>
<tr>
<td>9. MARITAL STATUS AT TIME OF DEATH □ Married □ Married, but separated □ Widowed □ Divorced □ Never Married □ Unknown</td>
<td></td>
</tr>
<tr>
<td>10. SURVIVING SPOUSE’S NAME (If wife, give name prior to first marriage)</td>
<td></td>
</tr>
<tr>
<td>11. FATHER’S NAME (First, Middle, Last)</td>
<td></td>
</tr>
<tr>
<td>12. MOTHER'S NAME PRIOR TO FIRST MARRIAGE (First, Middle, Last)</td>
<td></td>
</tr>
<tr>
<td>13a. INFORMANT’S NAME</td>
<td></td>
</tr>
<tr>
<td>13b. RELATIONSHIP TO DECEDENT</td>
<td></td>
</tr>
<tr>
<td>13c. MAILING ADDRESS (Street and Number, City, State, Zip Code)</td>
<td></td>
</tr>
<tr>
<td>14. PLACE OF DEATH (Check only one; see instructions)</td>
<td></td>
</tr>
<tr>
<td>15. FACILITY NAME (If not institution, give street &amp; number)</td>
<td></td>
</tr>
<tr>
<td>16. CITY OR TOWN, STATE, AND ZIP CODE</td>
<td></td>
</tr>
<tr>
<td>17. COUNTY OF DEATH</td>
<td></td>
</tr>
<tr>
<td>18. METHOD OF DISPOSITION: □ Burial □ Cremation □ Donation □ Entombment □ Removal from State □ Other (Specify):</td>
<td></td>
</tr>
<tr>
<td>19. PLACE OF DISPOSITION (Name of cemetery, crematory, other place)</td>
<td></td>
</tr>
<tr>
<td>20. LOCATION-CITY, TOWN, AND STATE</td>
<td></td>
</tr>
<tr>
<td>21. NAME AND COMPLETE ADDRESS OF FUNERAL FACILITY</td>
<td></td>
</tr>
<tr>
<td>22. SIGNATURE OF FUNERAL SERVICE LICENSEE OR OTHER AGENT</td>
<td></td>
</tr>
<tr>
<td>23. LICENSE NUMBER (Of Licensee)</td>
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</tbody>
</table>

**Patient**

**RelatedPerson**

**Location**

**Practitioner**
Other Sections Do Not Map as Elegantly

**Questionnaire** / **QuestionnaireResponse? Observations?**

Practitioner (one of many)
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Sequential Pattern Mining

Data from the National Vital Statistics System’s 2012 multiple causes of death data set

Over 2.5M death events

Data was mined for temporal patterns with a high degree of support

That is to say, relationships which were common in the data

Results

Discovered 65,915 rules meeting minimum support of 50 occurrences

Top 5 rules of length 2:

<table>
<thead>
<tr>
<th>Rule</th>
<th>Length</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Mental and behavioral disorders due to use of tobacco -&gt; Other chronic obstructive pulmonary disease</td>
<td>100920</td>
<td>3.96%</td>
</tr>
<tr>
<td>Chronic ischemic heart disease -&gt; Cardiac arrest</td>
<td>85952</td>
<td>3.37%</td>
</tr>
<tr>
<td>Essential (primary) hypertension -&gt; Chronic ischemic heart disease</td>
<td>77249</td>
<td>3.03%</td>
</tr>
<tr>
<td>Mental and behavioral disorders due to use of tobacco -&gt; Malignant neoplasm of bronchus and lung</td>
<td>73212</td>
<td>2.87%</td>
</tr>
<tr>
<td>Chronic ischemic heart disease -&gt; Heart failure</td>
<td>63283</td>
<td>2.48%</td>
</tr>
<tr>
<td>Essential (primary) hypertension -&gt; Cardiac arrest</td>
<td>59771</td>
<td>2.35%</td>
</tr>
<tr>
<td>Mental and behavioral disorders due to use of tobacco -&gt; Chronic ischemic heart disease</td>
<td>58130</td>
<td>2.28%</td>
</tr>
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Table 4: Rules from 2012 NCHS Mortality Data
This work was supported in part by grants from the National Institutes of Health (NHLBI 5U01HL080711, T32 GM105490 Traineeship to Dr. Greg Gibson, Georgia Tech, for trainee R. A. Hoffman, Center of Cancer Nanotechnology Excellence U54CA119338), Georgia Cancer Coalition (Distinguished Cancer Scholar Award, Professor May D. Wang), Microsoft Research, and Hewlett Packard. This research was also supported by a contract (HHSD2002015F62550B) from the US Department of Health and Human Services (HHS) Centers for Disease Control and Prevention (CDC). This article does not reflect the official policy or opinions of the CDC or the US Department of HHS and does not constitute an endorsement of the individuals or their programs.