Use of Patient-Centric Electronic Health Record and Big Data Analytics to Reduce Hospital Readmission

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Outlines

• Problem and Solution
• Big Data Analytics Prediction
• Patient Tracking System
  – Patient-Centric Electronic Health Record (PC-EHR)
• Clinical Results
• Summary
Problem

- 30-day hospital readmission:
  - reduce the quality of patients’ healthcare.
  - cost the nation over $26 billion every year, just for Medicare Patients

Solution

- Four (4)-week community-based care transition service
  - Coleman care transition model
  - Over 218 CMS-designated accountable care organizations (ACO) and 105 CMS-funded community-based organizations (CBO)

References:

- http://innovation.cms.gov/initiatives/CCTP/
Success Factors Enabled by Technologies

1. Identification of high risk patients
   – prior to enrollment
   – Specific for home visit
2. Timely appropriate services
3. Workflow efficiency
   – Patient centric
   – Service to as many patients as possible
4. Self sustainable

- "Hospitals and Care Systems of the Future," American Hospital Association; September 2011.
Middle Chesapeake Region
- 60x60 square miles area
- 10 hospitals
  - 3 providers / hospital
- Each year
  - 40,000 Medicare Patients
  - > 150,000 inpatient Pts

- Initial Site: Prince George Hospital Center, Cheverly, Maryland

Health Connect Care Transition Program by Medical Mall Health Services, Washington, DC
Data Source

• Hospital daily Admission/Discharge/Transfer (ADT) Data
  – sent at 4 am every weekday
  – Average ~1,100 patients/month (48 patients/day)

• EHR data
  – Different conditions for each patients
  – Interview notes (SOAP Notes)

• Exclusion:
  • Chemo/radiation; pregnant/prenatal; new born
  • Dialysis, mental health

• 3 months of ADT: Used as training set for machine learning of big data analytics

• Gold Standard: days from discharging to readmission
  – Hospital QA provided historical data
Characteristics of Data

• Structured Data (CPT/ICD 9 (10) Code):
  – Well-documented conditions:
    • CMS-recognized Congestive heart failure (CHF), Pneumonia (PN), acute myocardial infarction (AMI) Conditions and Better Outcomes by Optimizing Safe Transitions (BOOST) criteria to cause 30-day hospital readmission
    – Others somewhat documented conditions: cardiovascular disease (CVD), COPD, sepsis, and co-morbidities.

• Unstructured Data:
  – Freehand: Healthcare provider’s subjective and objective assessment, availability, impression, and plan (SOAP) Note
  – Mental illness and chronic physical conditions

• Incomplete data:
  • Availability of Discharged Medicine
  • Missed interviews

– Ingestion of data: daily

Big Data Challenge:
Volume, Velocity, Variety, Veracity
Architecture of Analytics Platform
- Based on Characteristics of Data -

- Traditional Well-know diagnosis (AMI, CHF, COPD, etc.)
- EHR Fields: ICD, encountered fields (Structured)
- Hospital Fields: (Structured)
- SOAP Notes impression; interview (unstructured)
- Take-home medication,
- Discharged interview (incomplete data)

Ingestion
Query & Retrieval

Knowledge Based-Multi-Layer Perception

Feature Selection & Support Vector Machine (SVM)

Natural Language Processing

Feature Selection & Statistical Analysis

Decision Fusion/Dash board

Red Flag (of high-risk patients) Prior to and during enrollments
Knowledge-Based Multi-Layer Perception

- Well-Known Conditions (pre-trained data)
  - Clinical Decision Support System (Decision Tree)
    - Nun-Uniform Binary Splitting
      - Binary Decision Diagram
        - Karnaugh Map
          - Multi-layer Perception (In-Memory Processing)

- Daily ADT Data
- Error Back-Propagation Training
- New Weights

Initial Weights
Natural Language Processing

Unstructured Notes → Co-occurrence Matrix → Sense Classifier → SVM Classifier

Named Entity Recognition for diseases & symptoms → Co-referenced Resolution → Word sense disambiguation

Medical Dictionary for Health Care Consumers, Coleman’s Terms → Weekly Consensus

Data Base (SQL & NoSQL) → Data Warehouse (NLP Library) → Data Warehouse
Receiver Operating Characteristic (ROC) Analysis of Prediction

- Development set: three months of de-identified ADT data from PGHC
  - Gold Standard: Hospital Historical QA Data
- Training/validation set: 201 positive and 2,023 negative cases
  - 50-50 split stratified randomization
  - Jack-knife re-randomization
- ROC Analysis on Validation Set
- End-point of Clinical Evaluation: Reduction in 30-day hospital readmission
ActiPatientCare
Manage Workflow
(Patients, Services, Providers)
Raise Red Flags
Distribution of Conditions for Selected Patients
(Oct – Nov 2012)

October
- HIV 0.00%
- Renal Failure 4.97%
- Sickle Cell 2.48%
- Diabetes 13.04%
- ACS/CVA 26.09%
- CAD 11.80%
- CHF 21.74%
- COPD 9.94%
- Pneumonia 9.94%

November
- HIV 0.71%
- Renal Failure 1.42%
- Diabetes 7.80%
- Sickle Cell 2.84%
- ACS/CVA 29.79%
- CAD 17.02%
- CHF 20.57%
- COPD 12.06%
- Pneumonia 7.80%

Big Data Analytics Selects More Than Top Three Conditions (CHF, AMI, PN)
Patients Selected for Services

- 30%-45% Patients selected during discharging for the care transition service
- Using same resources, more patients are served using tracking PC-EHR than without PC-EHR
  - No Tracking PC-EHR: 106.25 / month
  - With Tracking PC-EHR: 340.14 / month
### Patients Served in Health Connect in PGHC, Oct - Nov, 2012

<table>
<thead>
<tr>
<th>No. of Patients at Different Flows</th>
<th>October</th>
<th>November</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Patients Enrolled to Health Connect</td>
<td>387</td>
<td>339</td>
<td>726</td>
</tr>
<tr>
<td>Patients Referred to PCP</td>
<td>381</td>
<td>332</td>
<td>713</td>
</tr>
<tr>
<td>Patients Scheduled for Home Visit by CHW</td>
<td>89</td>
<td>168</td>
<td>257</td>
</tr>
</tbody>
</table>

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</thead>
<tbody>
<tr>
<td>Total Patients Enrolled to Health Connect (Percentage)</td>
<td>98.4%</td>
<td>97.9%</td>
<td>98.2%</td>
</tr>
<tr>
<td>Patients Referred to PCP (Percentage)</td>
<td>23.0%</td>
<td>49.6%</td>
<td>35.4%</td>
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</tbody>
</table>
Reduction of 30-day Re-admission (2011 vs. 2012)

- Using same resources, more reduction achieved using big data + tracking PC-EHR than traditional EHR
  - 37.1% Reduction: with PC-EHR and Prediction (254 to 160)
  - 24.81% Reduction: Without PC-EHR and Prediction (2/12-5/12 vs. 2/13 – 5/13)

Total Reduction: 37.1% (254 to 160)
Summary

• Analytics was developed to address not only the big volume but also the big velocity, variety, and veracity

• Combination of patient-tracking, EHR, and big data analytics can reduce ‘more’ hospital readmission

• Future Works
  – Need a fully integrated data collection (EHR) and tracking system
  – More data is needed to improve the analytics model
  – Use of standard tools
  – More clinical evaluation
THANK YOU!

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