Predicting Hospital Readmissions from Claims Data
Deloitte Analytics

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In-patient Readmissions

Motivation

**Problem Statement**

- Nearly 20% of in-patient admissions result in a readmission
- 90% of readmissions are *preventable*
- Unplanned readmissions cost approx $16,000 per instance
- $42 billion / year nationally

**Solution Benefits**

- Lower direct medical expense and care management costs
- Improved patients’ quality of care and satisfaction
- Improved quality metrics due to lower readmission rates
Overview

• Readmissions analytics: From Hindsight to Insight to Foresight

• Predictive Model and Results

• Experience with a Managed Care Application
Understanding In-patient Readmissions
Analytical Solutions

<table>
<thead>
<tr>
<th>Hindsight</th>
<th>Insight</th>
<th>Foresight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broad historical reporting on key performance indicators.</td>
<td>Statistical analyses (e.g. profiling and segmentation) help organizations understand historical performance.</td>
<td>Advanced analysis, machine learning and modeling predict future performance.</td>
</tr>
<tr>
<td>Macro analysis of process</td>
<td>Macro analysis of populations</td>
<td>Micro analysis of individuals</td>
</tr>
</tbody>
</table>

What happened? | Why did it happen? | What could happen?
Readmission Rate by Provider ID

- **Alpha**
- **Bravo**
- **Charlie**
- **Delta**

**Hindsight**

Charts and Reports
Insight
Dashboard with Factors

**Age**

- Readmission Rate: 0% to 30%
- Length of Stay: 1 to 29

**Length of Stay**

- Readmission Rate: 0% to 70%

**DRG**

- Readmission Rate: 0% to 50%
- Spinal Fusion
- Back & Neck Proc
- Chest Pain
- Joint Replacement
- PTCA
- Esophagitis and Gastroenteritis
- Psychoses
- Heart Failure & Shock

**Rx History**

- Readmission Rate: 0% to 70%
- Antiplatelets
- Diuretics
- G.I. Drugs
- Nitrates
- Hyponotics
- Antiepileptics
- Anticoagulants
- Antipsychotics
- Antiparkinsonian
- Antifibrinolytics
Foresight
Readmission Prediction

Patient ID: X12345
Age: 29 Sex: Male
Primary DX: 996.12
(Mechanical Complication of vascular device / implant)

History: Anemia, Congestive heart failure, Hypertension
Rx History: G.I. Drugs, Beta blockers, Diuretics, Antihypertensives, Nitrates, Anticoagulants, Hypnotics
Service History: Excess Transport, Durable medical equipment (DME)
Foresight
Readmission Prediction

**Patient ID:** X12345
**Age:** 29  
**Sex:** Male
**Primary DX:** 996.12  
(Mechanical Complication of vascular device / implant)

**History:** Anemia, CHF, Hypertension
**Rx History:** G.I. Drugs, Beta blockers, Diuretics, Antihypertensives, Nitrates, Anticoagulants, Hypnotics

**Readmission Propensity:** 84%

**180 day horizon**

**Transport Claims**

**Readmission Rate**

**CHF**

**DRG 144 – Other Circulatory System Diagnosis with CC**

**Readmission Rate**

48%
Data for Creating the Prediction Model
Sourced from Thompson-Reuters MarketScan (Redbook)

Timeline

<table>
<thead>
<tr>
<th>History</th>
<th>Claims</th>
<th>Prediction Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Jan 2006</td>
<td>01 Apr 2006</td>
<td>01 Jul 2006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>31 Dec 2006</td>
</tr>
</tbody>
</table>

Dataset

- 237,129 commercial claims from 212,955 members
- Set is a 5% de-identified national sample
- Claims from 30% of members held back for cross validation

Exclusions

- Claims with Transfer as discharge status
- Claims with Mortality as discharge status
- Claims associated with pregnancy and childbirth
Readmission Model
Data Sources and Model Variables

In-patient Data
- Demographics
- Admission Status
- Type of Admission
- DRG / Primary Dx
- Secondary Dx
- Discharge Status
- Service / Revenue Codes

Out-patient Data
- Demographics
- Procedure Code
- Diagnosis Code
- Service / Revenue Codes

Pharmacy Data
- NDC / Therapeutic Class
- Quantity dispensed

Model Variables
- Age
- Sex
- DRG on present claim
- Type of admission
- Discharge status
- Clinical history
  - Diabetes, Hypertension, Depression, etc
- Prescription history
  - Nitrites, Beta blockers, Lipid regulators, etc
- Service history
  - Transport, Physiotherapy, Laboratory test, etc

Extract
Transform
Load
+
Feature
Derivation

Readmission model has 50+ variables
Data Characteristics

Age and Gender

Number of claims = 237,129
Number of members = 212,955
Observed readmission rate = 19%
Data Characteristics

Time between admissions

80% of readmissions are after 15 days.
There is sufficient time for intervention and possible avoidance of a readmission.

Too early for intervention
Prediction Model
C5.0 Decision Tree

• A Decision Tree is a series of closely linked questions that can be sequentially answered to arrive at a conclusion
• Decision trees can be automatically generated using statistical methods
• We use a consolidated result from twenty decision trees to improve accuracy
Prediction Model Characteristics

Important Variables

- DRG Code
- Hx Psychoses
- Excess Transport
- Hx Solid Tumor
- Hx Metastatic Cancer
- Hx Anemia
- Rx Antibiotics
- Discharge Status
- Rx Analgesics
- Hx Electrolytes
- Hx CHF
- Rx Antipsychotics

Rx – Excessive prescription history
Hx – Clinical history
Prediction Model Performance

Precision and Sensitivity

Precision = True Positives / (True Positives + False Positives)
Sensitivity = True Positives / (True Positives + False Negatives)
Specificity = True Negatives / (True Negatives + False Positives)
Prediction Model Performance

Receiver Operating Characteristic (ROC)

Training Area Under Curve = 0.8612
Testing Area Under Curve = 0.8127
# Managed Care Application

## Member selection for managed care

<table>
<thead>
<tr>
<th>Client Experience</th>
<th>Benefits</th>
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<td>Client used the model to streamline and optimize member selection for managed care</td>
<td>Better visibility of factors that drive utilization and program participation</td>
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<tr>
<td>Client increased the member pool size being actively managed to leverage early detection of complex chronic conditions</td>
<td>Model provided a boost of 50x in selection rates – the selection rate went from 1:100 to 1:2</td>
</tr>
<tr>
<td>Nurses use the model predictions in a ranked list to assess care management and coordination needs</td>
<td>Lowered direct medical cost $12,000 per member on average</td>
</tr>
<tr>
<td>Members received telephonic intervention (health coaching, referrals, care coordination, etc)</td>
<td>Lowered effort in identification of appropriate members for managed care</td>
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<tr>
<td>Length of care management is 3-4 months</td>
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Summary

**Providers**
- Readmission can be predicted with present claim data
- Improved pay for performance can be achieved with increased quality metrics
- Timely intervention improves patient satisfaction

**Payers**
- Avoidable readmissions can be predicted with over 80% precision with claims history
- Improved accuracy in member selection for care management
- Reduced medical costs and care management costs
Related Efforts

• Published Literature

• Acknowledgements – Jason Chiu, Carter (Todd) Shock, Kevin Hua, Stephen Bay