KEEPING AN EYE ON HEALTHCARE COSTS
The D2Hawkeye Story
D2Hawkeye

- Founded by Chris Kryder, MD, MBA in 2001

- Combine expert knowledge and databases with analytics to improve quality and cost management in healthcare

- Located in Massachusetts USA, grew very fast and was sold to Verisk Analytics in 2009
D2Hawkeye

Data Sources

- Diagnoses
- Procedures
- Drugs
- ...

Aggregate Clean Normalize

Secure Database

Reports

Predictive Models
Healthcare Case Management

- D2Hawkeye tries to improve healthcare case management
  - Identify high-risk patients
  - Work with patients to manage treatment and associated costs
  - Arrange specialist care

- Medical costs often relate to severity of health problems, and are an issue for both patient and provider

- Goal: improve the quality of cost predictions
Impact

• Many different types of clients
  • Third party administrators of medical claims
  • Case management companies
  • Benefit consultants
  • Health plans

• Millions of people analyzed monthly through analytic platform in 2009

• Thousands of employers processed monthly
Pre-Analytics Approach

- Human judgment – MDs manually analyzed patient histories and developed
- Limited data sets
- Costly and inefficient
- Can we use analytics instead?
Data Sources

- Healthcare industry is data-rich, but data may be hard to access
  - Unstructured – doctor’s notes
  - Unavailable – hard to get due to differences in technology
  - Inaccessible – strong privacy laws around healthcare data sharing

- What is available?
Data Sources

• Claims data
  • Requests for reimbursement submitted to insurance companies or state-provided insurance from doctors, hospitals and pharmacies.

• Eligibility information

• Demographic information
## Claims Data

<table>
<thead>
<tr>
<th>ClaimType</th>
<th>ProviderName</th>
<th>DiagCode</th>
<th>DiagDesc</th>
<th>SourceDiagCode</th>
<th>SourceDiagDesc</th>
<th>ProcNDCCode</th>
<th>ProcNDCDesc</th>
<th>ServiceDate</th>
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<td>DD0238</td>
<td>Dental Diseases</td>
<td>5206</td>
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<td>DD007</td>
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<td>Dental Diseases</td>
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<td>Dental Diseases</td>
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<td>Med</td>
<td>ALPHARETTA INTERNA</td>
<td>DD0004</td>
<td>ENT and Upper Resp Disorders</td>
<td>4610</td>
<td>Acute Maxillary Sinusitis</td>
<td>DD147</td>
<td>Office Visit - Established Patient</td>
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<td>Neurotic and Personality Disorders</td>
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<td>DD0102</td>
<td>Screening</td>
<td>V776</td>
<td>Special Screening for Cystic Fibrosis</td>
<td>DD077</td>
<td>Lab - Blood Tests</td>
<td>7/29/2005</td>
<td>$1.52</td>
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</table>
Claims Data

• Rich, structured data source

• Very high dimension

• Doesn’t capture all aspects of a person’s treatment or health – many things must be inferred

• Unlike electronic medical records, we do not know the results of a test, only that a test was administered
D2Hawkeye’s Claims Data

- Available: claims data for 2.4 million people over a span of 3 years

“Observation” Period 2001-2003

“Results” Period 2003-2004

- Include only people with data for at least 10 months in both periods – 400,000 people
Variables

- 13,000 diagnoses
- 22,000 procedures
- 45,000 prescription drugs
- 217 diagnosis groups
- 213 procedure groups
- 189 therapeutic groups
Variables – Cost Profiles

Patient 1

Patient 2
Additional Variables

• Chronic condition cost indicators

• 269 medically defined risk rules
  • Interactions between illnesses
  • Interactions between diagnosis and age
  • Noncompliance to treatment
  • Illness severity

• Gender and age
Cost Variables

- Rather than using cost directly, we bucket costs and consider everyone in the group equal in each bucket.

Bucket

- <$3000: 78.0%
- $3000-$8000: 13.8%
- $8000-$19000: 5.5%
- $19000-$55000: 2.1%
- >$55000: 0.5%
Medical Interpretation of Buckets

Bucket

1. Low
   - Candidate for Wellness Programs

2. Emerging
   - Candidate for Disease Management Programs

3. Moderate
   - Candidate for Case Management

4. High

5. Very High

15.071x – Keeping an Eye on Healthcare Costs: The D2Hawkeye Story
Error Measures

• Typically we use $R^2$ or accuracy, but others can be used

• In case of D2Hawkeye, failing to classify a high-cost patient correctly is worse than failing to classify a low-cost patient correctly

• Use a “penalty error” to capture this asymmetry
Penalty Error

- Key idea: use asymmetric penalties
- Define a “penalty matrix” as the cost of being wrong

<table>
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<tr>
<th>Forecast</th>
<th>Outcome</th>
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<th>2</th>
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<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
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</table>
Baseline

- Baseline is to simply predict that the cost in the next “period” will be the cost in the current period
  - Accuracy of 75%
  - Penalty Error of 0.56
Multi-class Classification

- We are predicting a bucket number
- Example

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```

- 5
- 3
- 1

C.A.D.  No C.A.D.

Diabetes  No diabetes
Most Important Factors

- First splits are related to cost

1. $\text{Paid} \leq 4000$
2. $\text{Paid} > 4000$
3. $\text{Paid} \leq 40000$
4. $\text{Paid} > 40000$
Secondary Factors

- Risk factors
- Chronic Illness
- “Q146”
  - Asthma + depression
- “Q1”
  - Risk factor indicating hylan injection
  - Possible knee replacement or arthroscopy
Example Groups for Bucket 5

- Under 35 years old, between $3300 and $3900 in claims, C.A.D., but no office visits in last year

- Claims between $3900 and $43000 with at least $8000 paid in last 12 months, $4300 in pharmacy claims, acute cost profile and cancer diagnosis

- More than $58000 in claims, at least $55000 paid in last 12 months, and not an acute profile
## Results

<table>
<thead>
<tr>
<th>Bucket</th>
<th>Accuracy</th>
<th>Penalty Error</th>
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<tbody>
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<td></td>
<td>Trees</td>
<td>Baseline</td>
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<tr>
<td>All</td>
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<tr>
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<tr>
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<td>19%</td>
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<tr>
<td>5</td>
<td>30%</td>
<td>23%</td>
</tr>
</tbody>
</table>
Insights

• **Substantial improvement** over the baseline

• **Doubled accuracy** over baseline in some cases

• Smaller accuracy improvement on **bucket 5**, but much lower penalty
Analytics Provide an Edge

• Substantial improvement in D2Hawkeye’s ability to identify patients who need more attention

• Because the model was interpretable, physicians were able to improve the model by identifying new variables and refining existing variables

• Analytics gave D2Hawkeye an edge over competition using “last-century” methods