Improving Palliative Care Using Patient Level Prediction

Nigam Shah
nigam@stanford.edu
90 percent of hospitals (with > 300 beds) offer palliative care.
3.4 percent of admissions get palliative care.
7.5 - 8.0 percent of admissions need palliative care.
Palliative care at Stanford

*Screening admissions over 2 weeks using the INOVA palliative care tool*
Mortality as a surrogate for need

Patient’s Medical Record

<table>
<thead>
<tr>
<th>Risk prediction</th>
<th>Time of “X”</th>
<th>Classification</th>
</tr>
</thead>
</table>

Deceased | 131,006 |
with V66.7 | 4,657 | 3.55% |
with V66.7 at least 6 mon prior to death | 105 | 0.08% |
Problem set up

Patient’s Medical Record

Observation Window

Prediction date

Time of death
3-12 months

Fraction of patients

Number of days

Deceased patients (days until death)
Alive patients (guaranteed survival time)
Separating boundary
Minimum survival time
A predictive model for mortality

Avati et al, IEEE International Conference on Bioinformatics and Biomedicine
Kansas City, MO, USA, November 13 - 16, 2017
We have a model, what next?

- Can we explain the predictions?
- What would the intervention be?
- Who dispenses the intervention?
- What are the mechanics of dispensing the intervention?
  - What is the capacity to intervene?
- What is the threshold for action?
  - How many false positives can there be in the top k predictions?
- What performance measure do we use?
  - Physician agreement | useful consult | or accuracy (F1 etc.)
- What are the outcomes we track?
  - Consult rates | time between AD setup and death | Rate of AD set up | Increase in no. of in home deaths | ?
- Where would we deploy the model (in SHC, or SOM)?
Explaining the predictions

<table>
<thead>
<tr>
<th>Factors</th>
<th>Code</th>
<th>Value</th>
<th>Influence</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Top Diagnostic factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V10.51</td>
<td></td>
<td>4</td>
<td>0.0051</td>
<td>Personal history of malignant neoplasm of bladder</td>
</tr>
<tr>
<td>V10.46</td>
<td></td>
<td>5</td>
<td>0.0019</td>
<td>Personal history of malignant neoplasm of prostate</td>
</tr>
<tr>
<td>518.5</td>
<td></td>
<td>1</td>
<td>0.0012</td>
<td>Pulmonary insufficiency following trauma and surgery</td>
</tr>
<tr>
<td>518.82</td>
<td></td>
<td>1</td>
<td>0.0008</td>
<td>Other pulmonary insufficiency</td>
</tr>
<tr>
<td>88.75</td>
<td></td>
<td>1</td>
<td>0.0006</td>
<td>Diagnostic ultrasound of urinary system</td>
</tr>
<tr>
<td><strong>Top Procedural factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>88331</td>
<td></td>
<td>1</td>
<td>0.0017</td>
<td>Pathology consultation during surgery with FS</td>
</tr>
<tr>
<td>75984</td>
<td></td>
<td>1</td>
<td>0.0014</td>
<td>Transcatheter Diagnostic Radiology Procedure</td>
</tr>
<tr>
<td>72158</td>
<td></td>
<td>1</td>
<td>0.0013</td>
<td>MRI and CT Scans of the Spine</td>
</tr>
<tr>
<td>Code_Type_Count</td>
<td></td>
<td>76</td>
<td>0.0011</td>
<td>Summary statistic (count of all ICD/CPT codes)</td>
</tr>
<tr>
<td>76005</td>
<td></td>
<td>1</td>
<td>0.0007</td>
<td>Fluroscopic guidance and localization of needle or catheter tip for spine</td>
</tr>
<tr>
<td><strong>Top Medication factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Top Encounter factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Hx Scan</td>
<td></td>
<td>21</td>
<td>0.0012</td>
<td>Number of scan encounters of all types</td>
</tr>
<tr>
<td>Inpatient</td>
<td></td>
<td>60</td>
<td>0.0004</td>
<td>Number of days patient was admitted</td>
</tr>
<tr>
<td>Var_Codes_per_Day</td>
<td></td>
<td>8</td>
<td>0.0002</td>
<td>Summary statistic (variance in number of codes assigned per day)</td>
</tr>
<tr>
<td>Code_Day_Count</td>
<td></td>
<td>88</td>
<td>0.0001</td>
<td>Number of days any encounter code was assigned</td>
</tr>
<tr>
<td><strong>Top Demographic factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td>81</td>
<td>0.0010</td>
<td>Age of patient in years at <em>prediction time</em></td>
</tr>
</tbody>
</table>
Taking prediction models into practice

• Ask what would you do with the prediction in hand?
• Look for situations where the NNT for an action is 1-3 : 100 and a model can get it to 3-5 : 10
• Think of the model output as a ranking metric
• Think of the model as a screening test
  – Don’t get hung up on AUROC, AUPRC, the exact probabilities.
• Understand your capacity for action
  – Focus on precision @ K.
• Explanation of the prediction is over-rated
  – Separate prediction from action
Pilot project participants

- **People**
  - Stephani Harman, Medical director of Palliative Care services at SHC
  - Yohan Vetteth, VP of Analytics at SHC
  - Topher Sharp, CMIO at SHC
  - Kenneth Jung, Dept of Medicine
  - Lance Downing, Dept of Medicine
  - Anand Avati, Dept of Computer Science
  - Andrew Ng, Dept of Computer Science

- **Funding**
  - Seed funding from Dept.
  - Stanford Data Science Institute