A Claims-Based Predictive Model to Identify Orthopedic Surgeries

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Agenda

Overview of Resolution Health, Inc. (RHI)

Glidepath predictive modeling
- Potential targets: preference-sensitive procedures
- Clinical rationale
- Intervention framework

Methods, results & performance
- Low back surgery Glidepath
- Knee replacement surgery Glidepath
Resolution Health

Our Mission

Send a smarter patient to the doctor.

Provide a more informed doctor to the patient.
RHI Data Analytics

Data Standardization and Integration

Rules Engine: Glidepath Algorithm

Identify Actionable Opportunities

Targeted Interventions

Providers ➔ Members ➔ Providers ➔ Health Plans and Care Managers
Purpose of Glidepath Predictive Models

Objective:
- Help patients to be fully informed prior to making decisions about preference-sensitive elective procedures

Approach:
- Identify patients with high likelihood of proceeding to surgery utilizing logistic regression methods based on administrative claims data

Goal:
- Targeted patient-centric interventions for informed medical decision making
Glidepath Process

- Identify patients with high likelihood of undergoing preference-sensitive orthopedic surgery well in advance of the procedure

- Use multiple access channels to deliver the right intervention to the right member at the right time

- Monitor patient outcomes and report performance
- Modify future intervention strategies based on results
Trends in Musculoskeletal Procedures

Unwarranted Variation

Increased Utilization

Source: Preference-sensitive care
www.dartmouthatlas.org/topics/preference_sensitive.pdf

Figure 1. Trends in knee arthroplasty, hip replacement, and spinal fusion procedures, 1997–2005*

*Based on all-listed procedures.
Variation in Low Back Surgery Rates

Ratio of Total Rates of Spine Surgery to the U.S. Average
by Hospital Referral Region (2002-03)

- 1.30 to 2.36 (71)
- 1.10 to < 1.30 (56)
- 0.90 to < 1.10 (80)
- 0.75 to < 0.90 (47)
- 0.40 to < 0.75 (52)
- Not Populated

## Impact of low back pain

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>70%</td>
<td>Low back pain prevalence(^1)</td>
</tr>
<tr>
<td>10.2%</td>
<td>Chronic low back pain prevalence(^2)</td>
</tr>
<tr>
<td>650,000 and $20 Billion</td>
<td>Low back surgeries and health care spending(^3)</td>
</tr>
<tr>
<td>$16.9 B</td>
<td>Lost productivity dollars(^4)</td>
</tr>
</tbody>
</table>

1 Bernard BP, NIOSH: Musculoskeletal Disorders and Workplace Factors, 1997  
2 Carey T, Chronic Low Back Pain Is on the Rise, Archives of Internal Medicine, Feb 2009  
3 Katz JN, Cost-Effectiveness of Spine Surgery: The Jury is Out, Annals of Internal Medicine, Dec 2008  
Non-surgical Approaches are Effective

- Current LBP guidelines from the American College of Physicians (ACP) and American Pain Society (APS) emphasize patient education, self-management, pharmacologic and nonpharmacologic therapies before surgical referral.

- A 2007 systematic review of 4 randomized trials comparing lumbar fusion to nonoperative care for chronic back pain found only a modest difference in pain and functional outcomes at 1 and 2 years (Mirza and Deyo).

- The Spine Patient Outcomes Research Trial (SPORT) 2006-2008:
  - Challenges in interpreting RCT results due to high cross-over rates.
  - Considerable pain improvement with either surgery or conservative low back therapies for herniated disk, with surgery at slight advantage.
  - Spinal stenosis saw earlier and greater pain reduction with surgery; however, patients who choose not to have surgery were also likely to improve over time.
Calculating Glidepath Score

Mr. Smith

Identify Mr. Smith’s earliest visit for LBP

Mr. Smith’s LBP predictors
- 3 Office visits for LBP
- >2 NSAID prescriptions
- 1 opiate prescription
- 1 pain mgt injection
- 1 MRI image

RHI Glidepath Analytics

Score = 1.2

Risk stratification
- Low
- Medium
- High

Match with appropriate level of patient intervention
Glidepath Process

- Identify patients with high likelihood of undergoing preference-sensitive orthopedic surgery well in advance of the procedure

- Use multiple access channels to deliver the right intervention to the right member at the right time

- Monitor patient outcomes and report performance
- Modify future intervention strategies based on results
Glidepath Intervention Framework

Member is experiencing Low back pain (LBP)

Members identified by Glidepath

Risk Stratification

High

Mod

Low

Proactive nurse outreach

High

Coaching + Web Decision Support Program

Low touch outreach

Mod

Web Decision Support Program

LBP Information Webpage
Low Back Surgery
Glidepath Model
Study Population and Patient Identification

Study Population

- Administrative claims data for 1.2 million health plan members between November 1\textsuperscript{st}, 2005 – October 31\textsuperscript{st} 2008

Patient Identification

- Based on previously published definition of mechanical low back problems, which describes ICD-9 codes for pain conditions originating in lumbar and sacral spine (Cherkin, Deyo, et al.)
- Excluded patients with complications due to: pregnancy; major trauma; revision of previous back surgery; hospice care, and neoplastic, infectious, or inflammatory etiologies
Key Variables

**Dependent Variable**
- CPT4 codes for lumbar spine surgery
  - laminectomy, discectomy, spinal fusion and disc arthroplasty

**Independent Variables**
- **Demographics**: age, gender, zip code
- **Radiology**: XR, CT, MRI
- **Medical conditions**: sciatica, neurologic deficit, spinal stenosis, Cauda equina syndrome
- **Medications**: NSAIDs, muscle relaxants, narcotics, benzodiazepines
- **Treatments**: Physical therapy, occupational therapy, epidural steroid or anesthetic injections
- **Co-morbidities**: depression, obesity, rheumatoid arthritis, Elixhauser score
- **Visits for low back pain**: office, ER, inpatient hospitalization
Model Framework

- **Index visit**: earliest visit for LBP identified in claims
- **Surveillance**: 60 day window during which predictors for surgery were identified
- **Prediction period**: Period of time when LBP surgeries were observed

A. Earliest index visit

B. Latest index visit
Statistical Analysis Overview

- Performed analysis using logistic regression to identify predictors of surgery such as demographic, clinical, and service utilization variables.

- Used split-sample method for model development and validation by randomly allocating patients into development (67%) and validation (33%) datasets.

- Developed score index from the final model that assigns weights based on the relative strength of each significant predictor.
Results

- 34,044 (2.8%) patients identified with an episode of uncomplicated LBP
- 2078 (6.1%) proceeded to back surgery within 34 months of the LBP index visit
- patients who proceeded to surgery were less likely to be women

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Surgery (n=2078)</th>
<th>No Surgery (n=31,966)</th>
<th>% Diff</th>
<th>Adj. Odds Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
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<tr>
<td>Women (%)</td>
<td>48.2</td>
<td>55.3</td>
<td>-7.1</td>
<td>0.79</td>
<td>†</td>
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<td>Men (%)</td>
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<td>44.7</td>
<td>7.1</td>
<td>1.0 (Ref)</td>
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<td>Age (mean in years)</td>
<td>48.9</td>
<td>49.8</td>
<td>-0.9</td>
<td>0.99</td>
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</tr>
</tbody>
</table>

† p ≤ 0.001
* Model adjusts for age, gender, MRI, NSAIDs, narcotics, spinal stenosis, sciatica, and office visits
Results

- NSAID and narcotics utilized far more among patients proceeding to surgery
- Use of pain management injections more than 2-fold higher among patients proceeding to surgery

<table>
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<tr>
<th>Characteristics *</th>
<th>Prescribed medications</th>
<th>Surgery (n=2078)</th>
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<th>% Diff</th>
<th>Adj. Odds Ratio</th>
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<td></td>
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<tr>
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<td>≥ 2</td>
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<td>7.3</td>
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<tr>
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<td>12.7</td>
<td>8.6</td>
<td>4.2</td>
<td>1.45 †</td>
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<td>Pain management injections</td>
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</tr>
<tr>
<td></td>
<td>1</td>
<td>16.2</td>
<td>6.2</td>
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<td>≥ 2</td>
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<td>2.84 †</td>
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</table>

† p ≤ 0.001

* Model adjusts for age, gender, MRI, NSAIDs, narcotics, spinal stenosis, sciatica, and office visits
### Results

- Spinal stenosis and sciatica were strong predictors of low back surgery.
- Patients with follow-up office visits were very likely to undergo surgery.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Surgery (n=2078)</th>
<th>No Surgery (n=31,966)</th>
<th>% Diff</th>
<th>Adj. Odds Ratio</th>
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<td>Sciatica</td>
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<td>MRI</td>
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<td>19.6</td>
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<td>1.52 †</td>
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</table>

† p ≤ 0.001

* Model adjusts for age, gender, MRI, NSAIDs, narcotics, spinal stenosis, sciatica, and office visits
Final Regression Model

**Strongest predictor**
- Receipt of pain management injections

**Other significant predictors**
- Prescriptions for NSAIDs & narcotics
- Diagnoses of spinal stenosis & sciatica
- MRI imaging
- Follow-up office visits
- Gender and Age
# Final Regression Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>95% CI</th>
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<tbody>
<tr>
<td>Age</td>
<td>0.99</td>
<td>(0.99, 0.99)</td>
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<tr>
<td>Women</td>
<td>0.79</td>
<td>(0.72, 0.86)</td>
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<tr>
<td>NSAIDS 1</td>
<td>1.3</td>
<td>(1.14, 1.49)</td>
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<td>NSAIDS ≥ 2</td>
<td>1.63</td>
<td>(1.39, 1.92)</td>
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<tr>
<td>Narcotics 1</td>
<td>1.86</td>
<td>(1.62, 2.14)</td>
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<td>Narcotics ≥ 2</td>
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<td>(1.26, 1.68)</td>
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<td>MRI (Yes/No)</td>
<td>1.52</td>
<td>(1.37, 1.70)</td>
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<td>Pain management injections 1</td>
<td>1.96</td>
<td>(1.71, 2.24)</td>
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<td>Pain management injections ≥ 2</td>
<td>2.84</td>
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<td>Sciatica (Yes/No)</td>
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<td>(1.32, 1.68)</td>
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<tr>
<td>Spinal Stenosis 1</td>
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<td>(2.18, 2.8)</td>
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<td>2.51</td>
<td>(1.99, 3.18)</td>
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<td>Follow-up office visits 1</td>
<td>1.59</td>
<td>(1.43, 1.77)</td>
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<td>Follow-up office visits ≥ 2</td>
<td>1.67</td>
<td>(1.48, 1.92)</td>
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</table>

C-statistic: 0.717
Patients with higher scores are more likely to undergo surgery
Model enables us to identify patients at various risk thresholds

<table>
<thead>
<tr>
<th>Intervention Intensity</th>
<th>Score</th>
<th>Identified (TP + FP)</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
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<td>73.9</td>
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<td>97.1</td>
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Model Performance

High risk threshold: score ≥ 1.0
1 in 6 (16%) of high risk members undergo surgery

<table>
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<tr>
<th>Glidepath score</th>
<th>Surgeries</th>
<th>PPV</th>
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<tbody>
<tr>
<td>≥ 1.0</td>
<td>840</td>
<td>5133</td>
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<tr>
<td>&lt; 1.0</td>
<td>1238</td>
<td>28911</td>
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40% of total surgeries identified

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<thead>
<tr>
<th>Glidepath score</th>
<th>Surgeries</th>
<th>Sensitivity</th>
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</thead>
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<tr>
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<td>28911</td>
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<tr>
<td></td>
<td>2078</td>
<td>31966</td>
</tr>
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</table>
# Model Performance

**Low risk threshold: score ≥ 0.2**

1 in 10 (10%) of low risk members undergo surgery

<table>
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<tr>
<th>Glidepath score</th>
<th>Yes</th>
<th>No</th>
<th>PPV</th>
<th>Sensitivity</th>
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<tr>
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<td>1536</td>
<td>14269</td>
<td>15805</td>
<td>9.7</td>
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<td>&lt; 0.2</td>
<td>542</td>
<td>17697</td>
<td>18239</td>
<td>73.9</td>
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74% of total surgeries identified
Time to Low Back Surgery

<table>
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<tr>
<th>Statistic</th>
<th>Value</th>
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<td>N</td>
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<td>Mean</td>
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<td>25th %tile</td>
<td>57</td>
</tr>
<tr>
<td>75th %tile</td>
<td>273</td>
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</table>
Knee Replacement
Glidepath Model
Need for Knee Replacement Alternatives

Procedures: 1990 – 2002

- Primary knee arthroplasty surgeries (TKA) increased from 129,000 to 402,000 from 1990 to 2003
- By 2030, the demand for primary TKRs is projected to grow by 673% to 3.48 million procedures per year

Projections: 2005 - 2030

- Alternative therapies which can postpone or prevent the need for knee replacement surgery include:
  - Pharmacological modalities
  - Referral to a physical therapist
  - Exercise and weight loss
Study Population and Patient Identification

**Study Population**
- Administrative claims data for 1.2 million health plan members between November 1\(^{st}\), 2005 – October 31\(^{st}\) 2008

**Patient Identification**
- Select earliest office, ER, or hospital visit for knee pain
- Restrict to patients with knee osteoarthritis (KOA)
Key Variables Specific to Knee

**Dependent Variable**
- Knee arthroplasty or hemi-arthroplasty

**Independent Variables**
- **Treatments:** Knee injections, physical therapy, casting, knee orthosis
- **Medical conditions:** Knee derangements, inflammation, late effects of injury
- **Knee procedures:** Arthroscopy, debridement synovectomy, meniscus, patella
Results

- Model identifies 12,355 patients (1%) with a new episode of knee pain
- 1,574 (12.7%) proceeded to knee replacement surgery within 34 months of index visit
- Adults 55 and older were 2 times more likely to proceed to surgery compared to 45-55 year olds

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Yes (n=1,574)</th>
<th>No (n=10,781)</th>
<th>% Diff</th>
<th>Adj. OR *</th>
<th>p</th>
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<tr>
<td>Demographics</td>
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<td></td>
</tr>
<tr>
<td>% Women</td>
<td>60.8</td>
<td>59.1</td>
<td>1.7</td>
<td>----</td>
<td>0.191</td>
</tr>
<tr>
<td>% Men</td>
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<td>40.9</td>
<td>1.7</td>
<td>----</td>
<td>0.191</td>
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<tr>
<td>Age group (years)</td>
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<td>≥ 65</td>
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<td>9.9</td>
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* Model adjusts for age, X-rays. MRI, NSAID & narcotic use, knee injections, physical therapy, office visits, and knee derangements

† p ≤ 0.001
## Results

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Knee replacement surgery</th>
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<td>No (n=10,781)</td>
<td>% Diff</td>
<td>Adj. OR *</td>
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</table>

† p ≤ 0.001

* Model adjusts for age, X-rays, MRI, NSAID & narcotic use, knee injections, physical therapy, office visits, and knee derangements

- Higher utilization of NSAIDS and narcotics among surgeries
- Proportion of patients requiring knee injections 14% greater among surgeries (39% vs. 25%)
- Physical therapy far less common in those heading towards surgery
## Results

### Knee replacement surgery

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Yes (n=1,574)</th>
<th>No (n=10,781)</th>
<th>% Diff</th>
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<th>p</th>
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</table>

* Model adjusts for age, X-rays. MRI, NSAID & narcotic use, knee injections, physical therapy, office visits, and knee derangements

- 21% higher odds of surgery among members with an X-Ray image
- 51% lower odds of surgery among members with an MRI image
- Knee derangements 13.6% less common among surgery patients

† p ≤ 0.001
Final Regression Model

Strongest individual predictor
- Receipt of knee injections

Other positive predictors:
- Age 55 or older
- Prescriptions for NSAIDs & narcotics
- Follow-up office visits
- X-ray imaging

Negative predictors:
- MRI imaging
- Physical therapy
- Knee derangements
### Final Regression Model

<table>
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<th>OR</th>
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<td>55-64</td>
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<td>(1.77, 2.33)</td>
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<td>≥ 65</td>
<td>2.04</td>
<td>(1.75, 2.39)</td>
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<td><strong>Knee injections</strong></td>
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<tr>
<td>1</td>
<td>1.45</td>
<td>(1.18, 1.79)</td>
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<td>(0.39, 0.60)</td>
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<td><strong>NSAIDS</strong></td>
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<td>0.96</td>
<td>(0.82, 1.13)</td>
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<td>(1.18, 1.65)</td>
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<td><strong>Physical therapy (Yes/No)</strong></td>
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<tr>
<td><strong>Follow-up office visits (Yes/No)</strong></td>
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<td>(1.05, 1.33)</td>
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</table>

Hosmer-Lemeshow Goodness of Fit: $p = 0.067$

---

![ROC Curve](image)
## Model Performance

### Classification table

<table>
<thead>
<tr>
<th>Intervention Intensity</th>
<th>Identified (TP + FP)</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
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</table>
# Model Performance

**High risk threshold: score ≥ 1.1**

1 in 4 (25%) of high risk members undergo surgery

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30% of total surgeries are identified

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<td>1851</td>
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<td>&lt; 1.1</td>
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</table>

Surgeries
Model Performance

Low risk threshold: score ≥ 0.4
1 in 5 (20%) of low risk members undergo surgery

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80% of total surgeries are identified

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<td>&lt; 0.4</td>
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<td>No 10781</td>
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</table>
Time to Knee Replacement Surgery

- N: 1574
- Mean: 281
- Median: 233
- 25th %tile: 93
- 75th %tile: 429
Strengths

Innovative application of predictive modeling
- Predicting discretionary procedures rather than costs
- Identifying patients well in advance of surgery

Models built on administrative claims data
- Readily available and wide applicability

Targeted patient-centric interventions
- Improves medical decision making

Address unwarranted variation in surgery rates
- Avoid potential overuse of procedures
Limitations

Administrative claims data are not clinically rich
- Utilization of HRA and lab data in future models
- Incorporation of pre-authorization data (e.g. MRI)

Models built on commercial health care population claims data
- Expansion of models to include Medicare population

Statistical modeling approaches to consider
- Inclusion of time-dependent covariates
Next Steps

- Identify patients with high likelihood of undergoing preference-sensitive orthopedic surgery well in advance of the procedure

- Use multiple access channels to deliver the right intervention to the right member at the right time

- Monitor patient outcomes and report performance
- Modify future intervention strategies based on results
Thank you