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


Benefits


Enrollment


Med Claims


Rx Claims


Lab Results


Providers


Member Info.

Data Standardization and Integration

Rules Engine: Glidepath Algorithm

Identify Actionable Opportunities

Targeted Interventions


Providers


Members


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

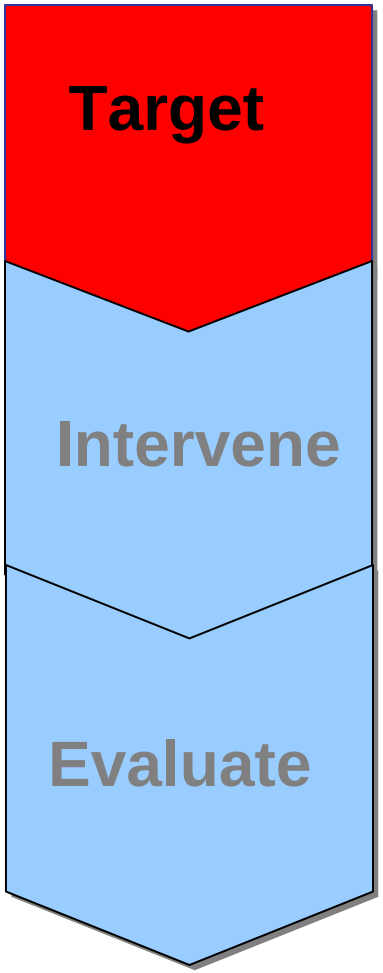
Approach:

- 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

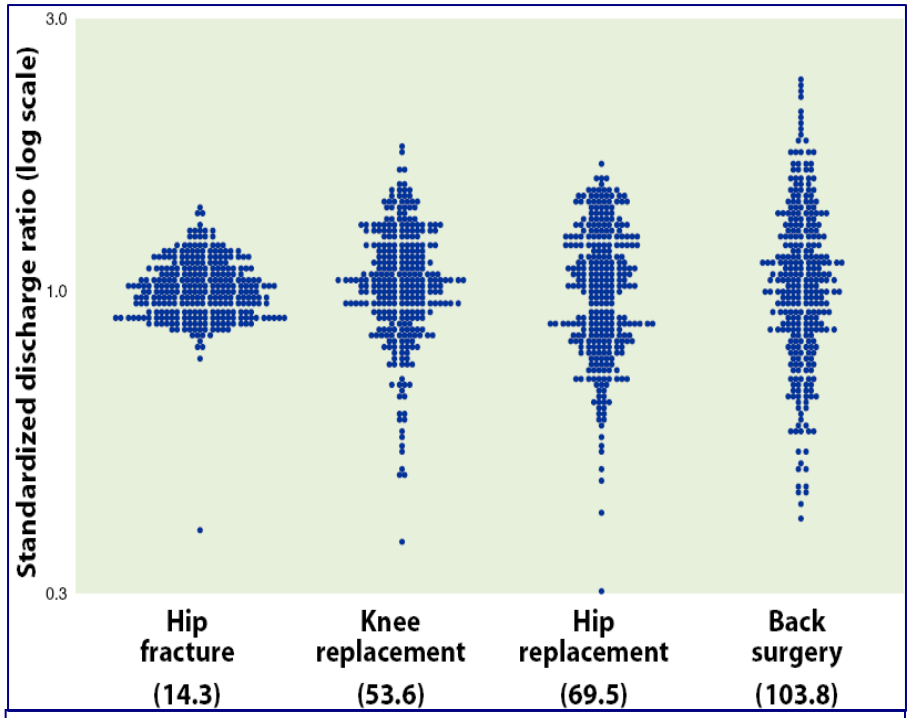
Glidepath Process



- **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**

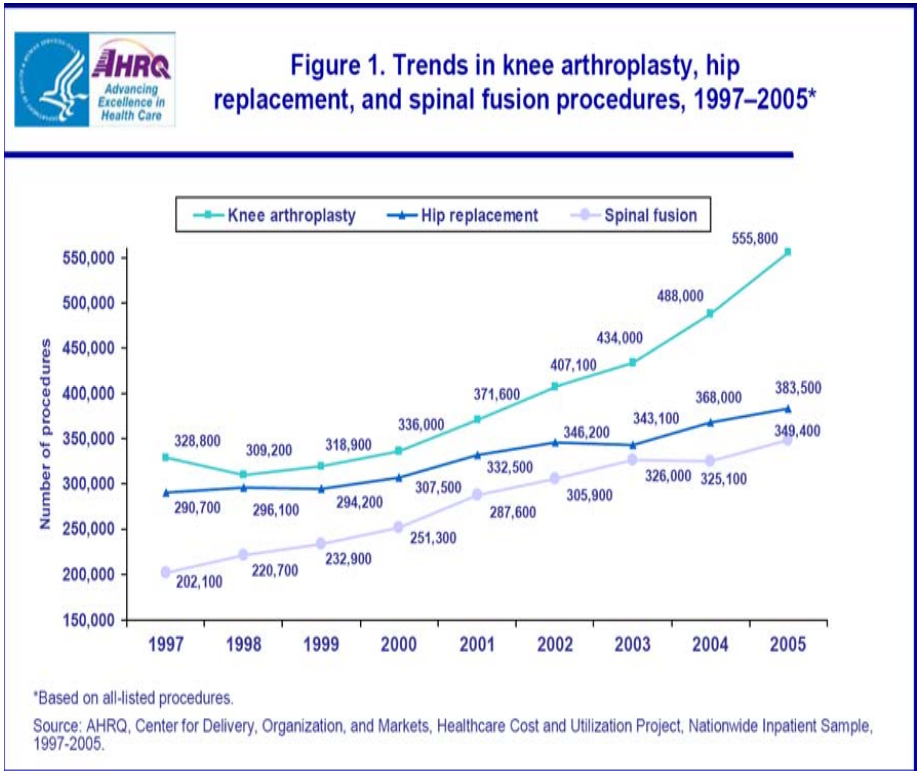
Trends in Musculoskeletal Procedures

Unwarranted Variation

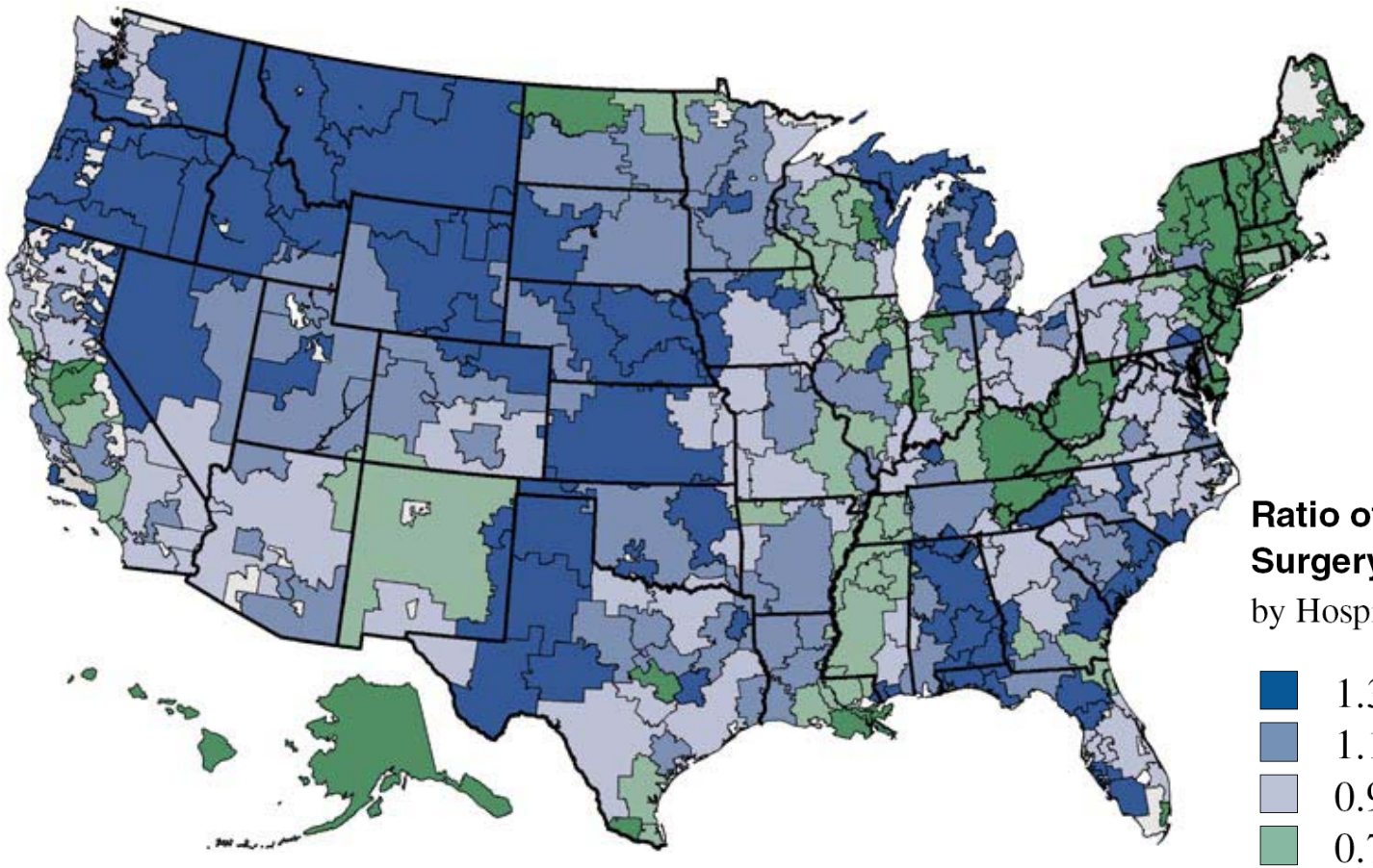


Source: Preference-sensitive care
www.dartmouthatlas.org/topics/preference_sensitive.pdf

Increased Utilization



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

Source: Spine Surgery *www.dartmouthatlas.org/atlases/Spine_Surgery_2006.pdf*

Impact of low back pain

70%	Low back pain prevalence[1]
10.2%	Chronic low back pain prevalence[2]
650,000 *and* $20 Billion	Low back surgeries and health care spending[3]
$16.9 B	Lost productivity dollars[4]

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
4 Ricci J, Back Pain Exacerbations and Lost Productive Time Costs in US Workers, Spine Journal, Dec 2006

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

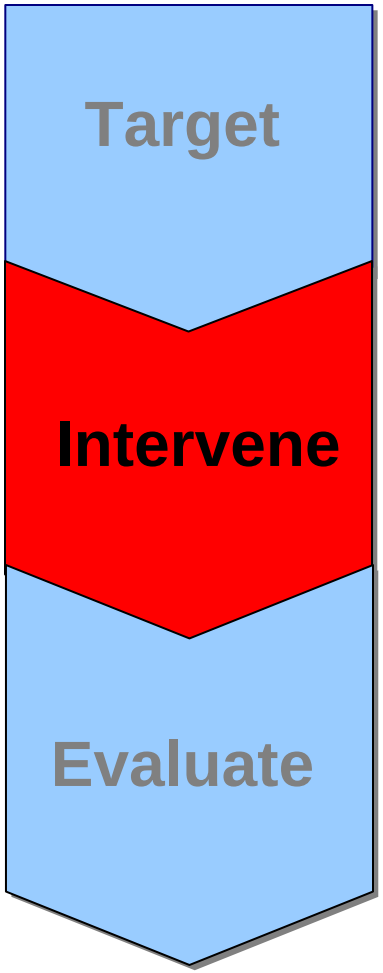
RHI Glidepath Analytics

Score = **1.2**

Risk stratification: Low | Medium | **High**

Match with appropriate level of patient intervention

Glidepath Process

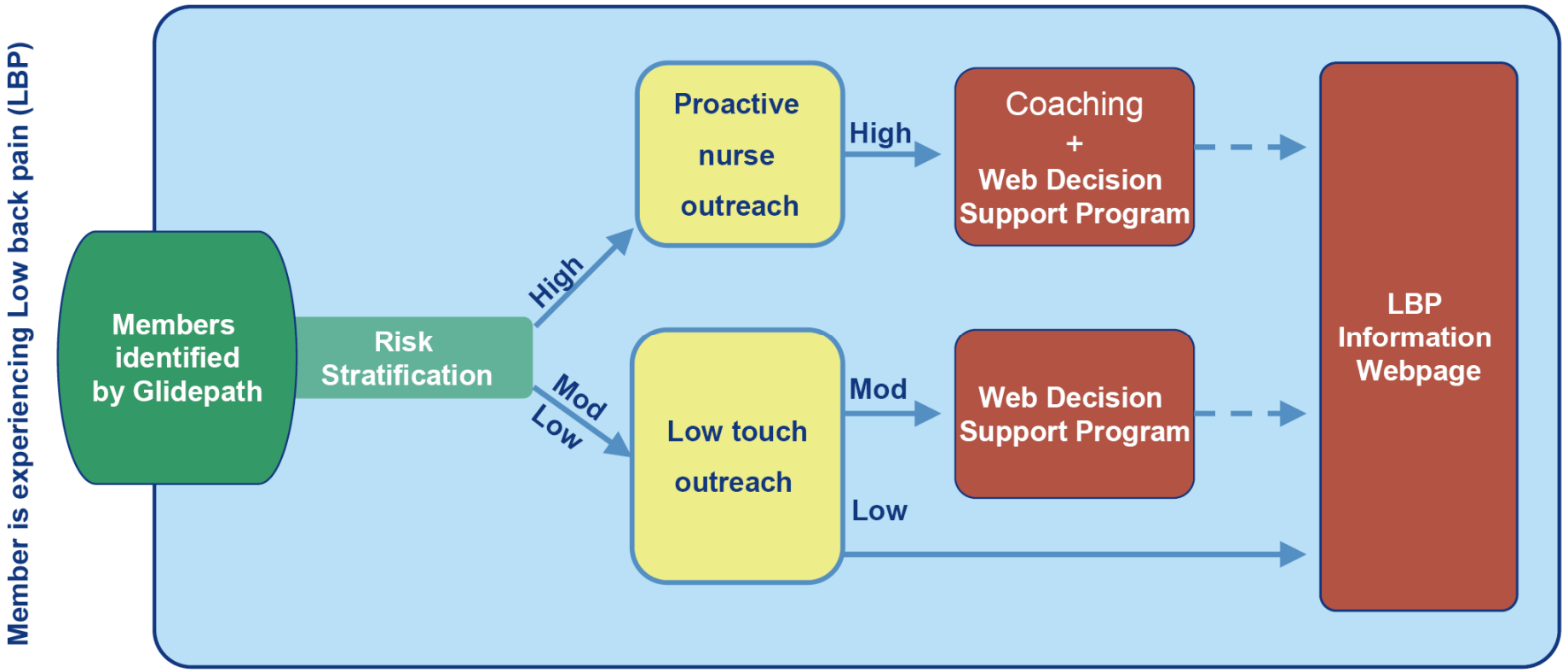


- Identify patients with high likelihood of undergoing preference-sensitive orthopedic surgery well in advance of the procedure

- **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



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Low Back Surgery Glidepath Model

Study Population and Patient Identification

Study Population

- Administrative claims data for 1.2 million health plan members between November 1st, 2005 – October 31st 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

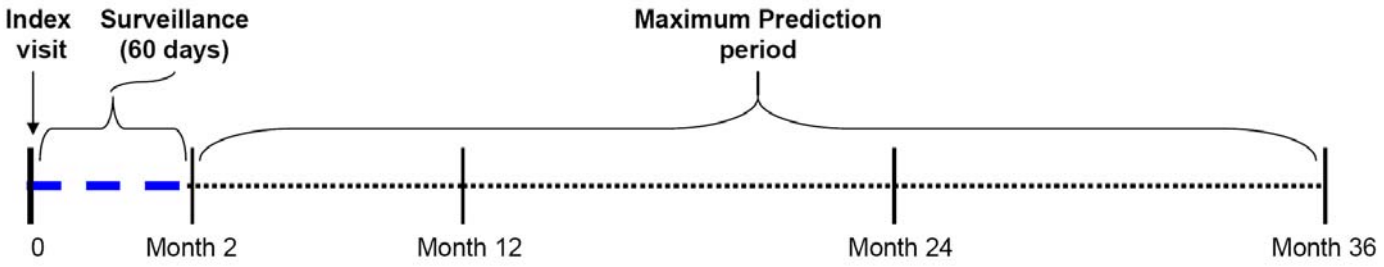
Independent Variables

- 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

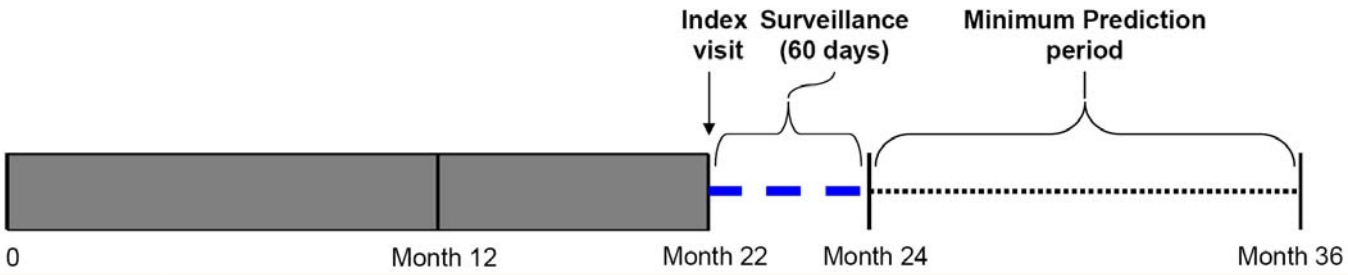
Model Framework

- **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

Characteristics *	Surgery (n=2078)	No Surgery (n=31,966)	% Diff	Adj. Odds Ratio	*p*
Demographics					
Women (%)	48.2	55.3	-7.1	0.79	†
Men (%)	51.8	44.7	7.1	1.0 (Ref)	
Age (mean in years)	48.9	49.8	-0.9	0.99	†

† $p \leq 0.001$

* 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

Characteristics *	Surgery (n=2078)	No Surgery (n=31,966)	% Diff	Adj. Odds Ratio	*p*
Prescribed medications					
NSAIDs					
1	15.4	10.8	4.6	1.30	†
≥ 2	9.9	5.3	4.5	1.63	†
Narcotics					
1	14.1	6.8	7.3	1.86	†
≥ 2	12.7	8.6	4.2	1.45	†
Treatments					
Pain management injections					
1	16.2	6.2	10.0	1.96	†
≥ 2	7.5	2.0	5.5	2.84	†

† $p \leq 0.001$

* 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

Characteristics *	Surgery (n=2078)	No Surgery (n=31,966)	% Diff	Adj. Odds Ratio	*p*
Medical conditions					
Stenosis	18.0	6.0	12.0	2.45	†
Sciatica	14.4	7.5	6.9	1.49	†
Physician encounters					
Office visits					
1	41.7	27.5	14.1	1.59	†
≥ 2	19.0	10.1	8.9	1.67	†
Diagnostic					
MRI	37.6	19.6	18.0	1.52	†

† $p \leq 0.001$

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

Final Regression Model

Strongest predictor

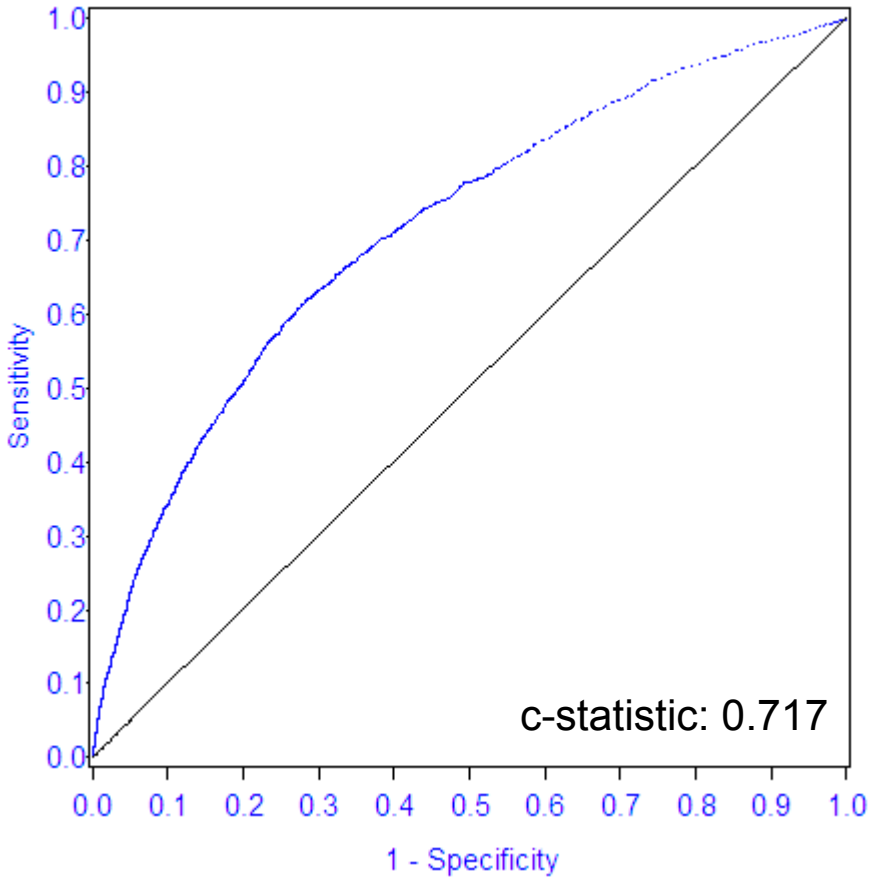
- Receipt of pain management injections

Other significant predictors

- Prescriptions for NSAIDs & narcotics
- Diagnoses of spinal stenosis & sciatica
- MRI imaging
- Follow-up office visits
- Gender and Age

Final Regression Model

Variable	OR	95% CI
Age	0.99	(0.99, 0.99)
Women	0.79	(0.72, 0.86)
NSAIDS		
1	1.3	(1.14, 1.49)
≥ 2	1.63	(1.39, 1.92)
Narcotics		
1	1.86	(1.62, 2.14)
≥ 2	1.45	(1.26, 1.68)
MRI (Yes/No)	1.52	(1.37, 1.70)
Pain management injections		
1	1.96	(1.71, 2.24)
≥ 2	2.84	(2.38, 3.45)
Sciatica (Yes/No)	1.49	(1.32, 1.68)
Spinal Stenosis		
1	2.45	(2.18, 2.8)
≥ 2	2.51	(1.99, 3.18)
Follow-up office visits		
1	1.59	(1.43, 1.77)
≥ 2	1.67	(1.48, 1.92)



Model Performance

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

Intervention Intensity	Score	Identified (TP + FP)	Sensitivity	Specificity	PPV	NPV
High	≥ 1.5	2264	23.1	94.7	22.2	95.0
	≥ 1.4	2558	26.5	93.6	21.1	95.1
	≥ 1.3	3113	29.6	92.2	19.9	95.3
	≥ 1.2	3660	33.2	90.7	18.8	95.4
	≥ 1.1	4188	36.2	89.0	17.7	95.6
	≥ 1.0	5133	40.4	86.9	16.7	95.7
Low	≥ 0.9	5668	44.4	84.5	15.7	95.9
	≥ 0.8	6967	48.5	81.8	14.8	96.1
	≥ 0.7	7501	52.7	78.8	13.9	96.3
	≥ 0.6	9487	57.4	75.3	13.1	96.5
	≥ 0.5	10264	62.1	71.3	12.3	96.7
	≥ 0.4	12090	65.9	66.8	11.4	96.8
	≥ 0.3	13439	70.2	61.6	10.6	96.9
	≥ 0.2	15805	73.9	56.4	9.9	97.1

Model Performance

High risk threshold: score ≥ 1.0

1 in 6 (16%) of *high* risk members undergo surgery

		Surgeries			PPV
		Yes	No		
Glidepath score	≥ 1.0	**840**	4293	**5133**	16.4
	< 1.0	1238	27673	28911	
		2078	31966		

40% of total surgeries identified

		Surgeries			Sensitivity
		Yes	No		
Glidepath score	≥ 1.0	**840**	4293	5133	40.4
	< 1.0	1238	27673	28911	
		2078	31966		

Model Performance

Low risk threshold: score ≥ 0.2

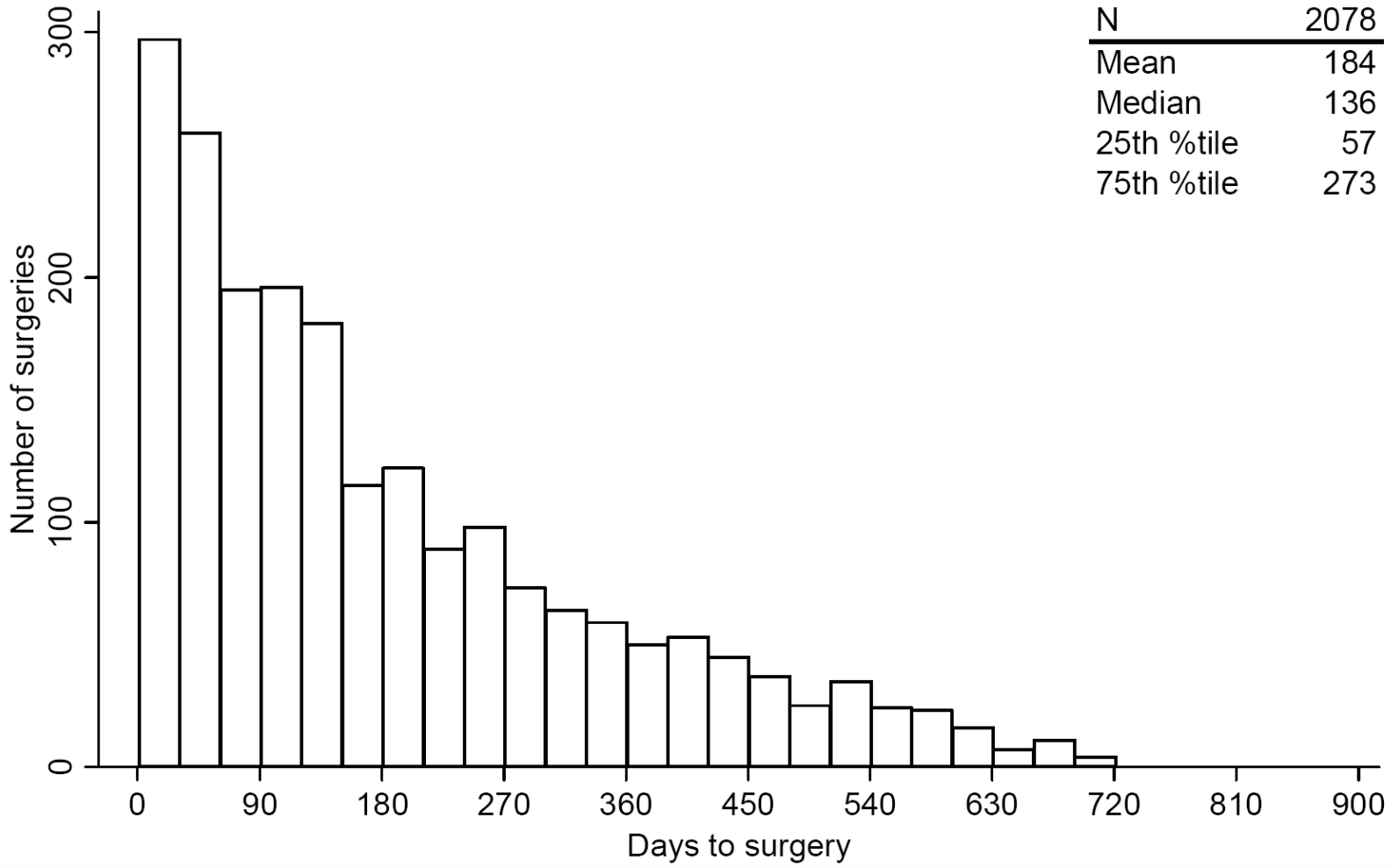
1 in 10 (10%) of *low* risk members undergo surgery

		Surgeries			PPV
		Yes	No		
Glidepath score	≥ 0.2	**1536**	14269	**15805**	9.7
	< 0.2	542	17697	18239	
		2078	31966		

74% of total surgeries identified

		Surgeries			Sensitivity
		Yes	No		
Glidepath score	≥ 0.2	**1536**	14269	15805	73.9
	< 0.2	542	17697	18239	
		2078	31966		

Time to Low Back Surgery



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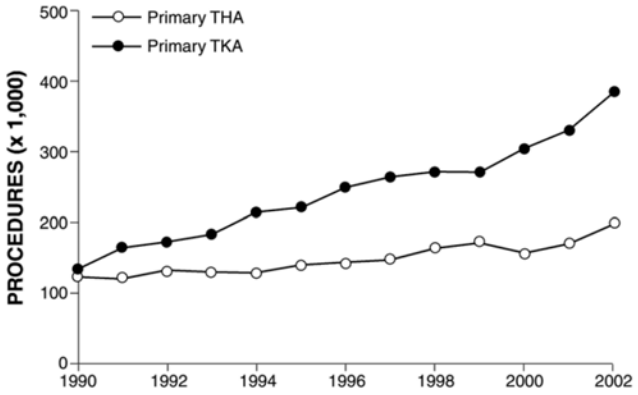
Knee Replacement Glidepath Model

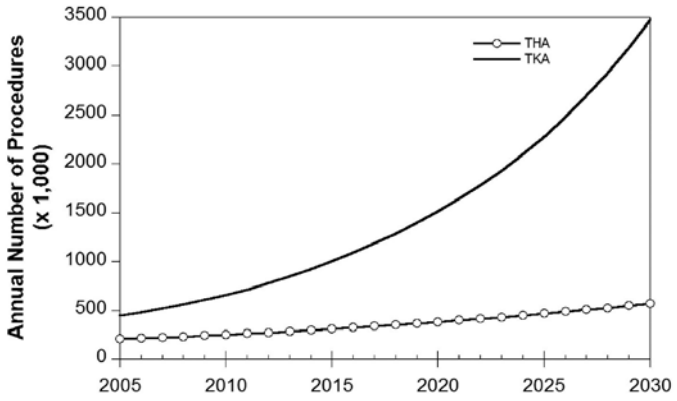
Need for Knee Replacement Alternatives

Procedures: 1990 – 2002



Kurtz et al. J Bone Joint Surg Am. 2005 Jul;87(7):1487-97

Projections: 2005 - 2030



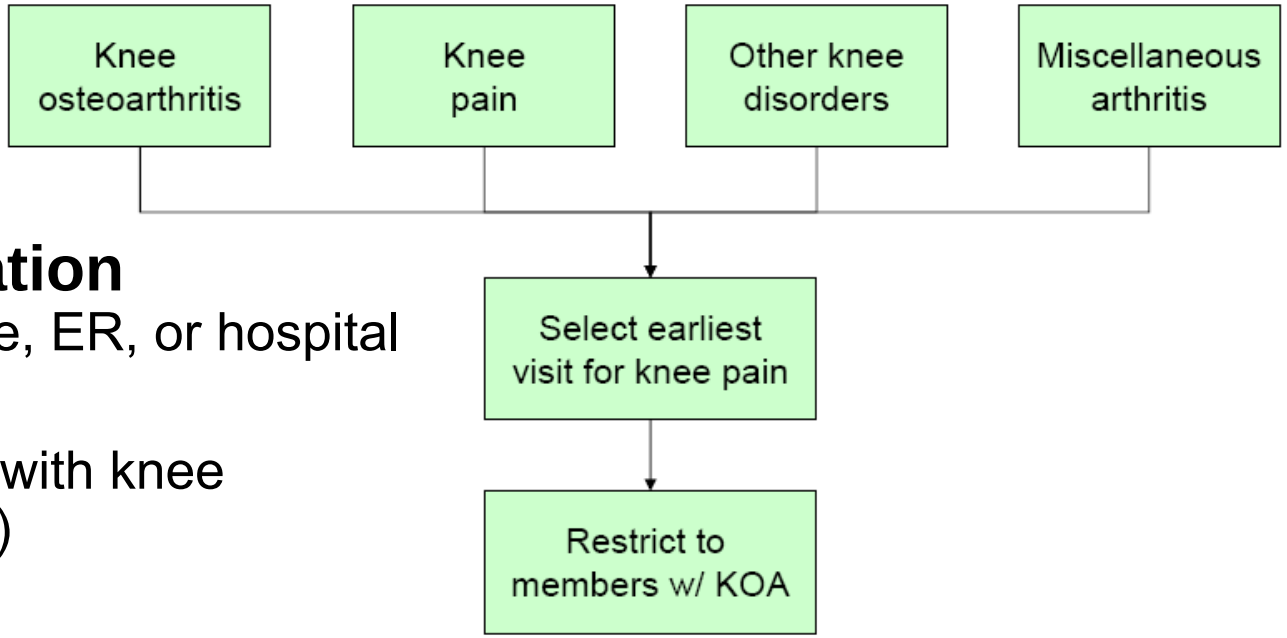
Kurtz et al. J Bone Joint Surg Am. 2007 Apr;89(4):780-5.

- 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
- 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 1st, 2005 – October 31st 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-arthoplasty

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

Characteristics	Knee replacement surgery Yes (n=1,574)	No (n=10,781)	% Diff	Adj. OR *	p
Demographics					
% Women	60.8	59.1	1.7	----	0.191
% Men	39.2	40.9			
Age group (years)					
<45	2.0	15.6	-13.6	0.22	†
45-54	21.0	31.8	-10.7	1 (Ref)	
55-64	49.4	35.0	14.4	2.03	†
≥ 65	27.5	17.6	9.9	2.04	†

† p ≤ 0.001

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

- 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

Results

Characteristics	Knee replacement surgery Yes (n=1,574)	No (n=10,781)	% Diff	Adj. OR *	*p*
Prescribed medications					
NSAIDs					
1	13.5	14.2	-0.7	0.96	0.643
≥ 2	13.2	8.1	5.1	1.40	†
Narcotics	13.0	8.8	4.2	1.42	†
Treatments					
Knee injections					
1	8.3	6.3	2.0	1.46	†
≥ 2	30.9	18.5	12.4	1.83	†
Physical therapy	9.9	15.8	-5.9	0.72	†

† 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

Characteristics	Knee replacement surgery Yes (n=1,574)	No (n=10,781)	% Diff	Adj. OR *	*p*
Radiology					
X-Rays	51.3	48.5	2.8	1.21	†
MRI	8.4	20.1	-11.7	0.49	†
Physician encounters					
Office visits (Yes/No)	45.0	40.3	4.7	1.18	0.006
Medical conditions					
Knee derangements					
1	7.5	13.2	-5.7	0.60	†
≥ 2	9.8	17.7	-7.9	0.76	†

† $p \leq 0.001$

*** 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

Final Regression Model

Strongest individual predictor

- Receipt of knee injections

Other positive predictors:

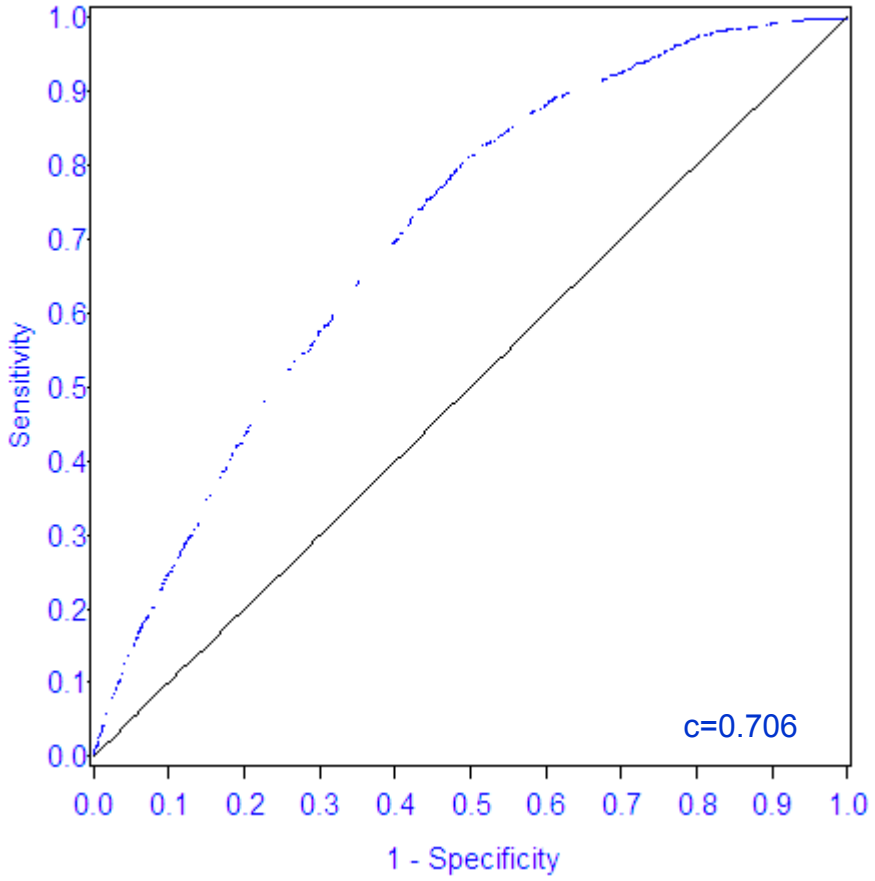
- Age 55 or older
- Prescriptions for NSAIDs & narcotics
- Follow-up office visits
- X-ray imaging

Negative predictors:

- MRI imaging
- Physical therapy
- Knee derangements

Final Regression Model

Variable	OR	95% CI
Age group		
<45	0.22	(0.15, 0.32)
55-64	2.03	(1.77, 2.33)
≥ 65	2.04	(1.75, 2.39)
Knee injections		
1	1.45	(1.18, 1.79)
≥ 2	1.81	(1.60, 2.06)
MRI (Yes/No)	0.49	(0.39, 0.60)
Knee derangements		
1	0.60	(0.49, 0.74)
≥ 2	0.76	(0.62, 0.93)
Narcotics (Yes/No)	1.42	
X-ray (Yes/No)	1.21	(1.08, 1.36)
NSAIDS		
1	0.96	(0.82, 1.13)
≥ 2	1.40	(1.18, 1.65)
Physical therapy (Yes/No)	0.72	(0.60, 0.86)
Follow-up office visits (Yes/No)	1.18	(1.05, 1.33)
Hosmer-Lemeshow Goodness of Fit:		p = 0.067



Model Performance

Classification table

Intervention Intensity	Score	Identified (TP + FP)	Sensitivity	Specificity	PPV	NPV
High	≥ 1.5	570	11.1	96.3	30.7	88.1
	≥ 1.4	970	17.5	93.5	28.5	88.5
	≥ 1.3	1308	22.6	91.1	27.2	88.9
	≥ 1.2	1703	27.9	88.2	25.8	89.3
	≥ 1.1	1851	29.6	87.1	25.2	89.4
Low	≥ 1.0	2707	42.1	80.9	24.5	90.5
	≥ 0.9	3587	52.3	74.2	22.9	91.4
	≥ 0.8	3988	55.9	71.0	22.1	91.6
	≥ 0.7	5359	69.6	60.2	20.4	93.1
	≥ 0.6	5679	73.0	57.7	20.2	93.6
	≥ 0.5	6163	77.1	53.8	19.7	94.1
	≥ 0.4	6403	79.5	51.9	19.6	94.5

Model Performance

High risk threshold: score ≥ 1.1

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

		Surgeries			PPV
		Yes	No		
Glidepath score	≥ 1.1	**466**	1385	**1851**	25.2
	< 1.1	1108	9396	10504	
		1574	10781		

30% of total surgeries are identified

		Surgeries			Sensitivity
		Yes	No		
Glidepath score	≥ 1.1	**466**	1385	1851	29.6
	< 1.1	1238	9396	10504	
		1574	10781		

Model Performance

Low risk threshold: score ≥ 0.4

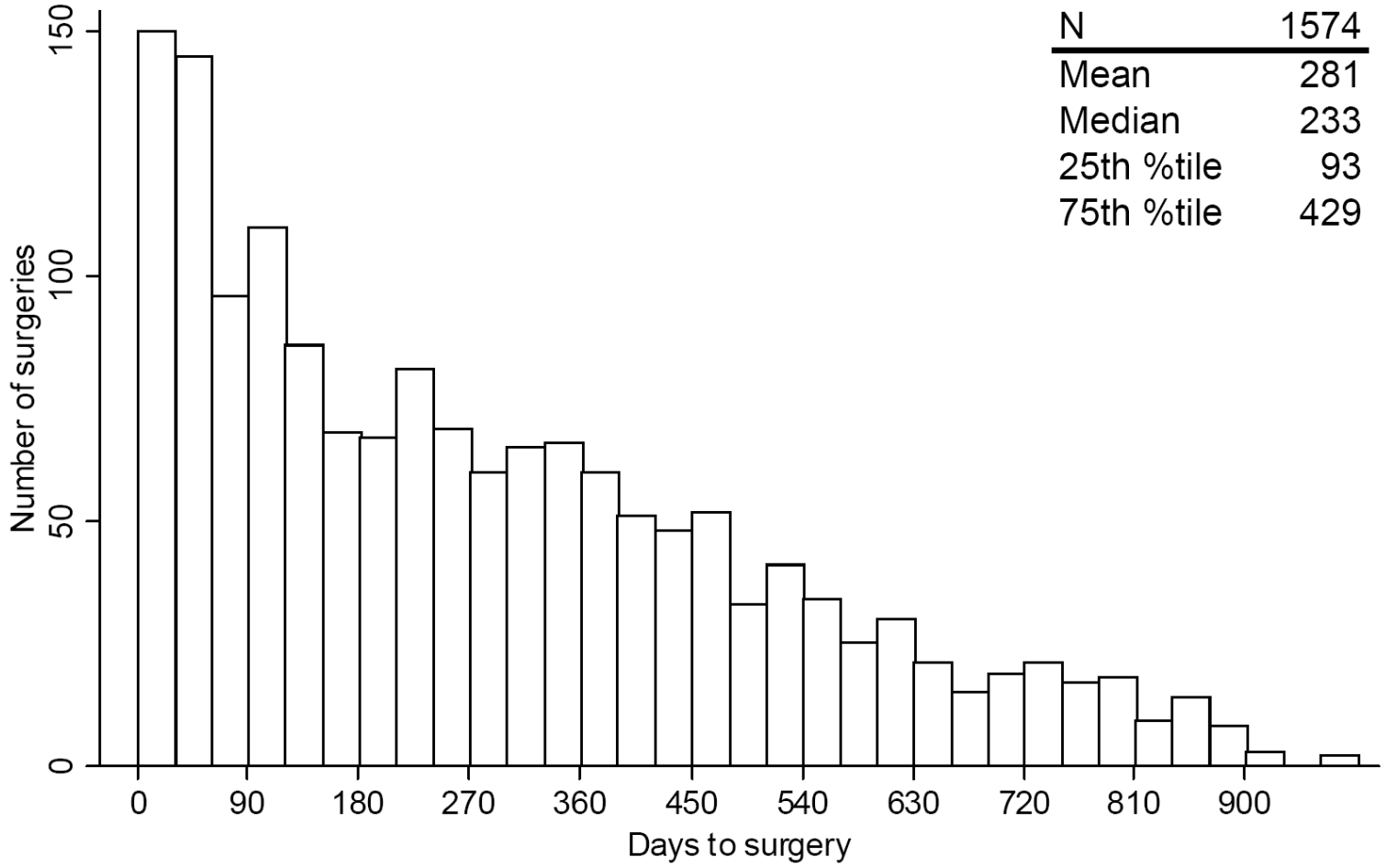
1 in 5 (20%) of *low* risk members undergo surgery

		Surgeries			
		Yes	No		PPV
Glidepath score	≥ 0.4	**1252**	5151	**6403**	19.6
	< 0.4	322	5630		
		1574	10781		

80% of total surgeries are identified

		Surgeries			
		Yes	No		Sensitivity
Glidepath score	≥ 0.4	**1252**	5151	6403	79.5
	< 0.4	322	5630		
		1574	10781		

Time to Knee Replacement Surgery



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)

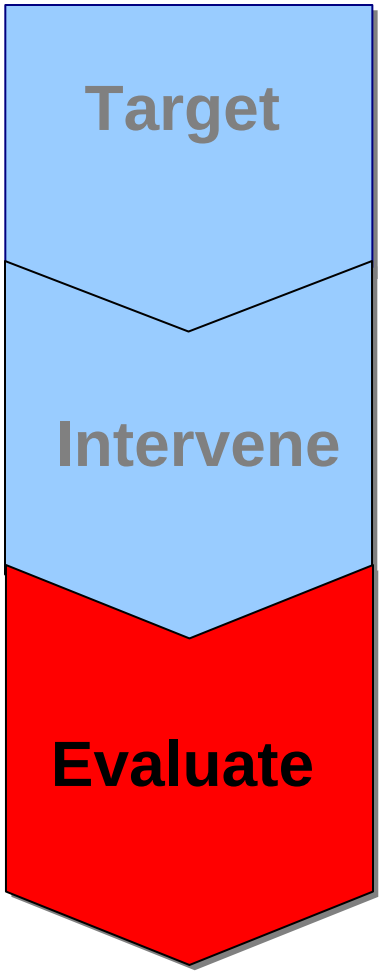
Models built on commercial health care population claims data

- 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