Prediction & Optimization of Medical Billing Operations

INVITAE

MIT MANAGEMENT BUSINESS ANALYTICS

OPERATIONS RESEARCH CENTER
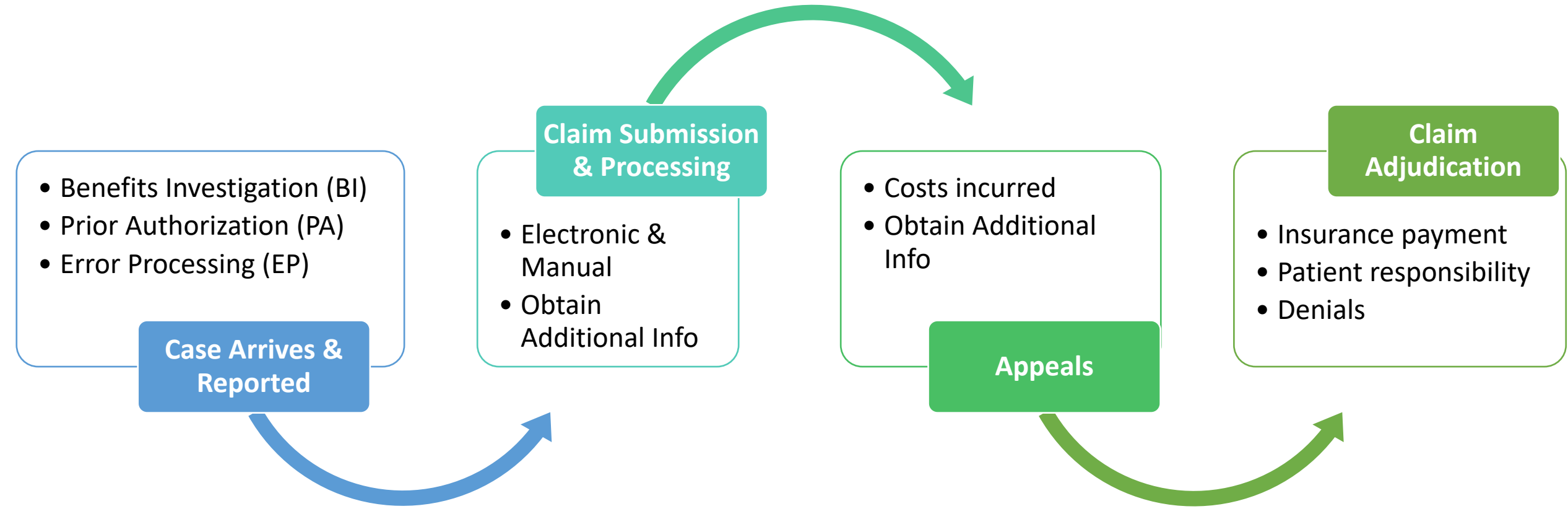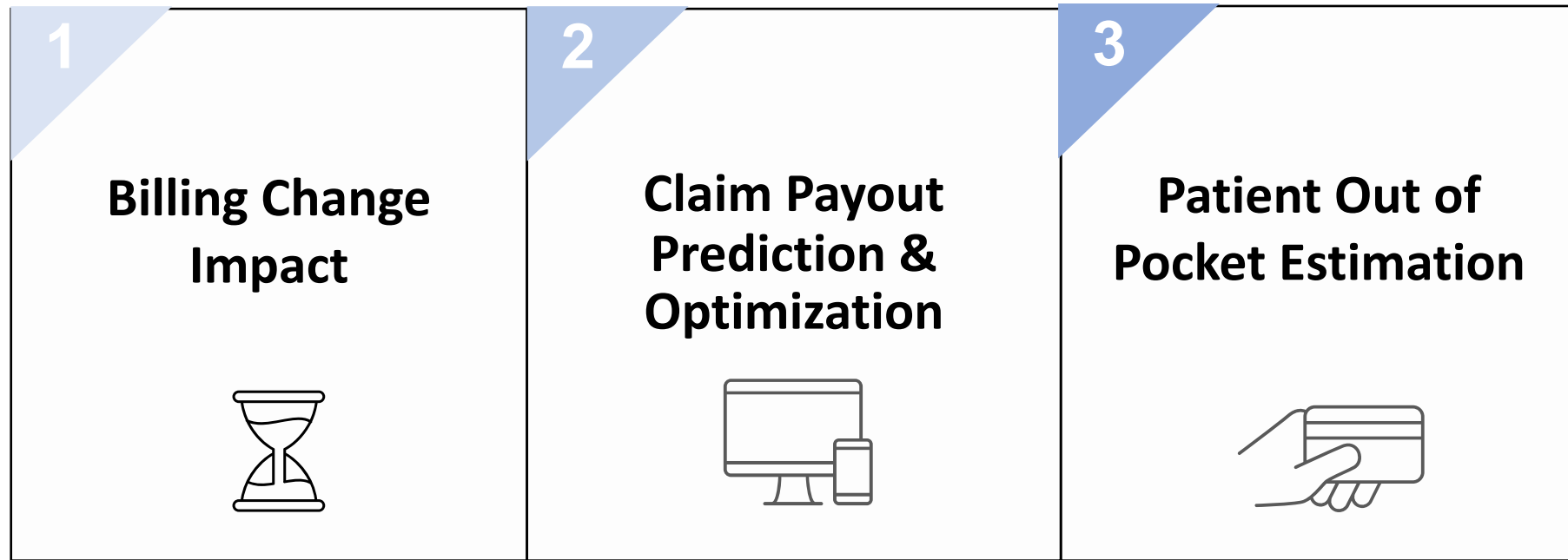
Xiaotong (Elaine) Chen   Yumin (Mindy) Lin

Invitae Corporation:
Joseph Kim
Matthew Davis
Sima Bouzid
Faculty Advisor:
Retsef Levi

Project Overview: Improve the Scalability & Efficiency of Billing Operations

Goal:
- Help Invitae improve healthcare for billions with genetics
- Provide payment estimations on insurance & patients
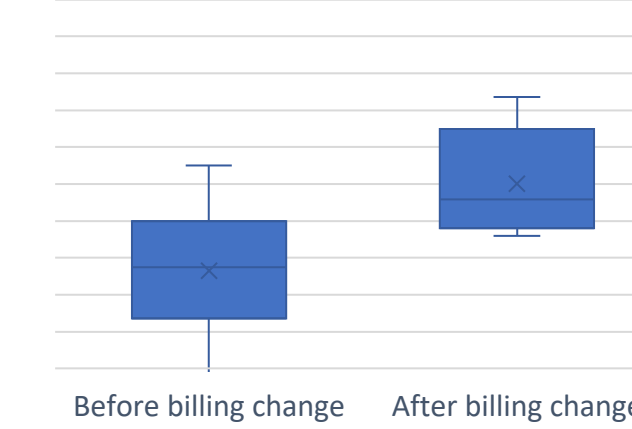- Optimize billing for higher scalability & efficiency

1 Billing Change Impact

2 Claim Payout Prediction & Optimization

3 Patient Out of Pocket Estimation

Case Arrives & Reported
- Benefits Investigation (BI)
- Prior Authorization (PA)
- Error Processing (EP)

Claim Submission & Processing
- Electronic & Manual
- Obtain Additional Info

Appeals
- Costs incurred
- Obtain Additional Info

Claim Adjudication
- Insurance payment
- Patient responsibility
- Denials

Medical Billing is a complex and uncertain process!

Objective 1: Revenue Analysis with Change in Billing Process

Recent Billing Process Revision

Understand how the change impacts billing results

Adjust billing process further to improve billing outcome

Compare payment amount on all RQs before vs after the change

Before billing change   After billing change

Investigate metrics change before vs after the change under different groups of RQs

Metrics of interest
- Average payment amount over everything
- Average payment amount when paid
- Payment rate

Payor Group 1   Payor Group 2   Payor Group 3   Payor Group 4
■ Before billing change   ■ After billing change
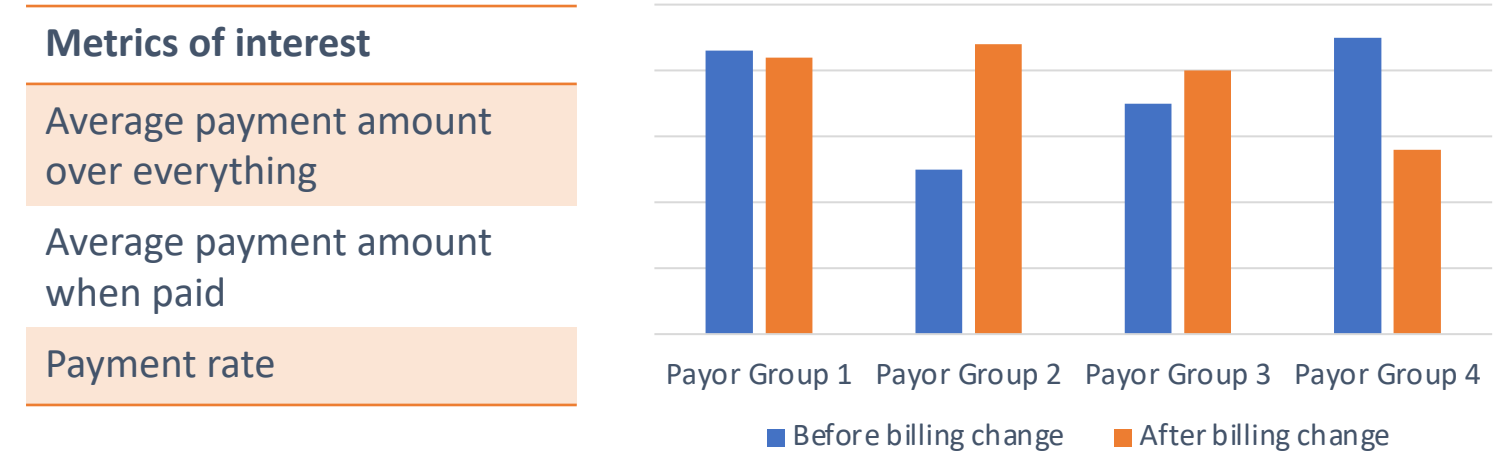
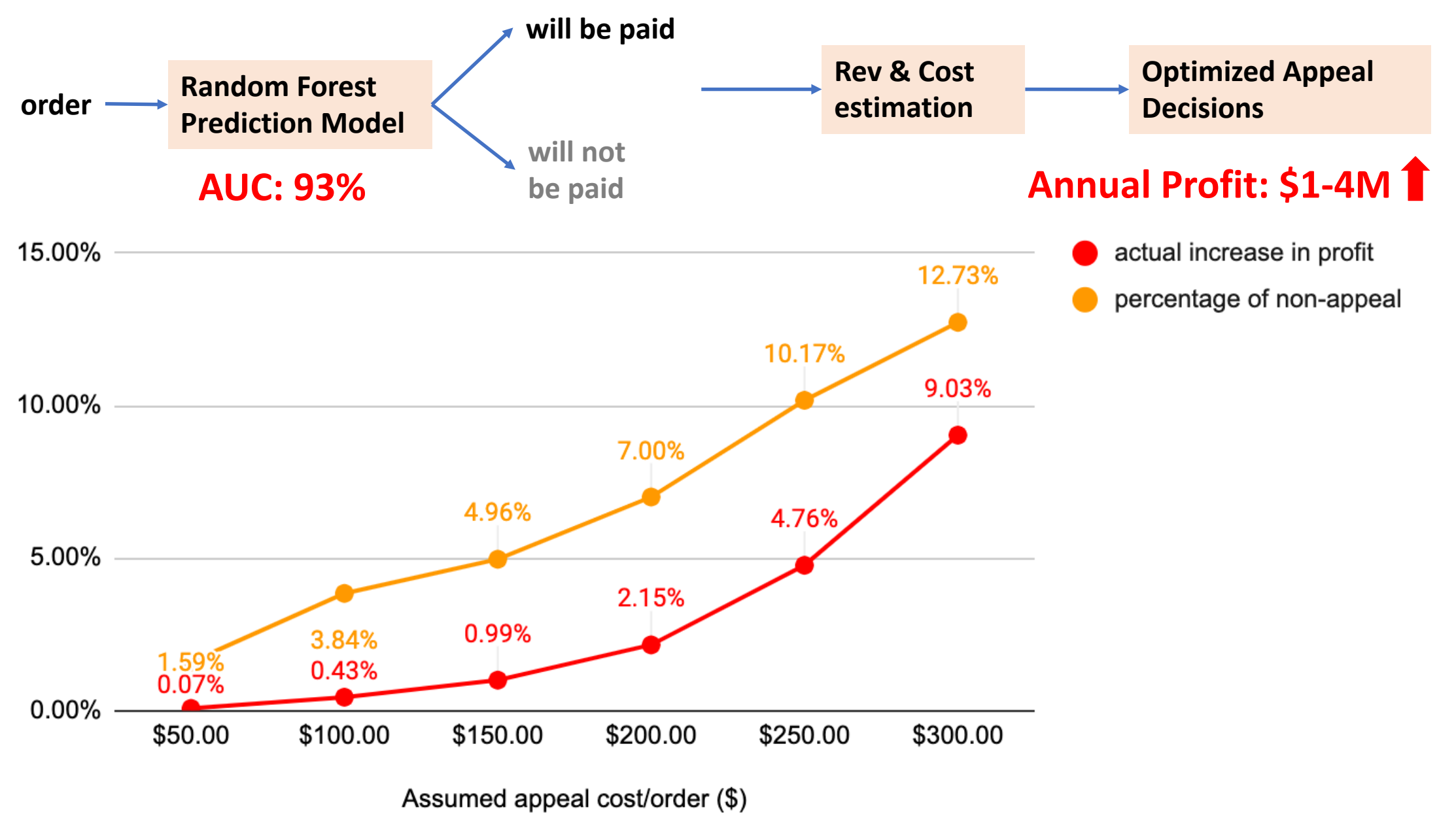## Objective 2: Claim Payout Prediction & Appeals Optimization

Goals
- **Predict** order payment results
- **Optimize** appeals decisions
- **Enhance profits & scalability** given limited resources

Target Variables	Features	Evaluation metrics
• Paid	**Feature set A (upon ordering):**	**Accuracy metrics (prediction):**
• Paid amount	• Order & Payor info	• AUC/accuracy/precision/recall
• turnaround time	**Feature set B (after claims filed):**	**Business metrics (optimization):**
	• Order, Payor & error info	• increase in profits

- **Question:** how to reduce unhelpful appeals & save costs?
- **Solution:** Prediction (identification) -> Optimization (prioritization)

- **Baseline** (current method): always appeal
- **Optimized:** only appeal when **expected revenues > costs**

order → Random Forest Prediction Model → will be paid / will not be paid → Rev & Cost estimation → Optimized Appeal Decisions

AUC: 93%

Annual Profit: $1-4M ↑

● actual increase in profit
● percentage of non-appeal

Assumed appeal cost/order ($)	actual increase	non-appeal
$50.00	0.07%	1.59%
$100.00	0.43%	3.84%
$150.00	0.99%	4.96%
$200.00	2.15%	7.00%
$250.00	4.76%	10.17%
$300.00	9.03%	12.73%

Objective 3: Patient Out-of-Pocket Estimation

Underestimate Price
Frustration and complaints after the actual price is revealed

Overestimate Price
Patient is uninclined to take the test or switch to competitors

Goal: Provide patients an out-of-pocket estimation that is as close to actual **patient responsible payment** amount as possible

Data: Primary payor group, primary commercial area, billed price, month of testing, shipping state population …

Pre-process Data
○ One-hot encode categorical variables
○ Remove highly correlated variables

Built and fine-tuned models
○ Linear regression
○ LASSO regression
○ Random forest

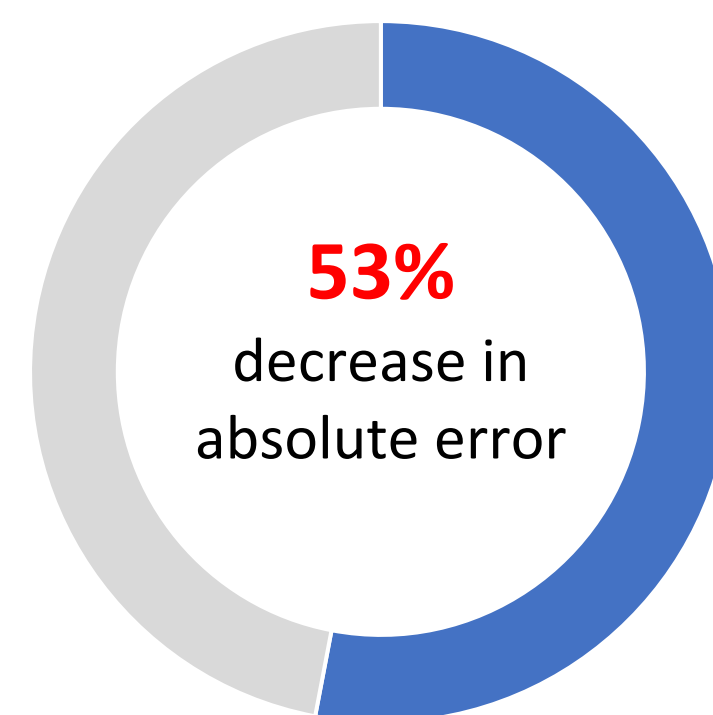**Adjust model based on previous results**
Stacked model:
○ First classify
○ Then regress

Compare model results
Compare with:
○ Current estimate
○ Baseline model (predict all to be 0)

More accurate prediction

Stacked Model vs. Current Estimation

53% decrease in absolute error

Next Steps

Further customer research

Actual price range given to customer
○ How wide should the range be?
○ Do customers prefer under- or over-estimation?

More customers paying full out-of-pocket amount

Improved efficiency from reduction in manual work

Increased customer satisfaction and retention

Impact

1 **Revenue Analysis with Change in Billing Process**
Helped the business better define future billing operation policies

2 **Claim Payout Prediction & Appeals Optimization**
Projected to increase $1-4M in profits on erroneous orders

3 **Patient Out-of-Pocket Estimation**
Provided more accurate patient out-of-pocket estimate which would improve customer retention