CareTracker

A win-win for
Tahoe Health Solutions
and its patients

Anthony Abercrombie

Find my detailed analysis on
Jupyter Notebook Viewer

Today's Presentation

1. Business Problem
2. Data Context
3. Solutions
4. Proposal
5. Next Steps

In [01]: Business Problem

- 20% of all hospitalized medicare patients are readmitted within 30 days. 34% within 90 days.
- National annual cost of hospital readmissions is **$17.4 billion.**
- Hospital Readmissions Reduction Program (HRRP) penalizes hospitals for readmissions with a fine.
- HRRP is monitoring readmissions for AMI, HF, and pneumonia. more to come....
- 18% of Tahoe Health System's (THS) medicare revenue comes from these three conditions. THS will lose **$8,000 per readmitted patient.**

In [01]: Business Problem --- Last Year's Numbers

Assumptions:

- ❖ Per-patient readmission cost of $8000.
- ❖ Patient data from the last year represents any given year (22.8% readmission rate).
- ❖ CareTracker reduces readmissions by 40%,
- ❖ ACA survives the current administration.
- ❖ HRRP expands list of conditions.

Implications:

- ❖ **$7,984,000 annual loss to HRRP fines if THS does not take action.**

In [01]: Business Problem --- The Intervention

CareTracker

Piloted by THS Seattle

Personalized Counseling

Improved education during and after visit.

At-Home Monitoring

Reduced Readmission by 40%

Costs $1,200 per patient.

- Would cost $5,258,400 if everyone got CareTracker.
- Combined cost of CareTracker for everyone + HRRP fines would be **$10,048,000**.

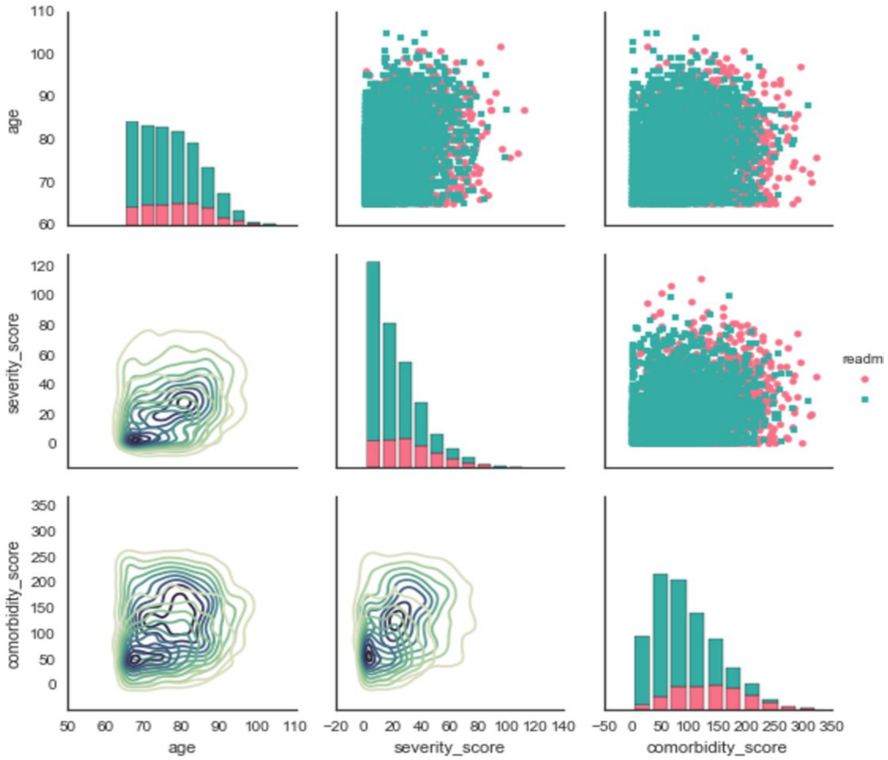
In [01]: Business Problem --- A Saner Approach

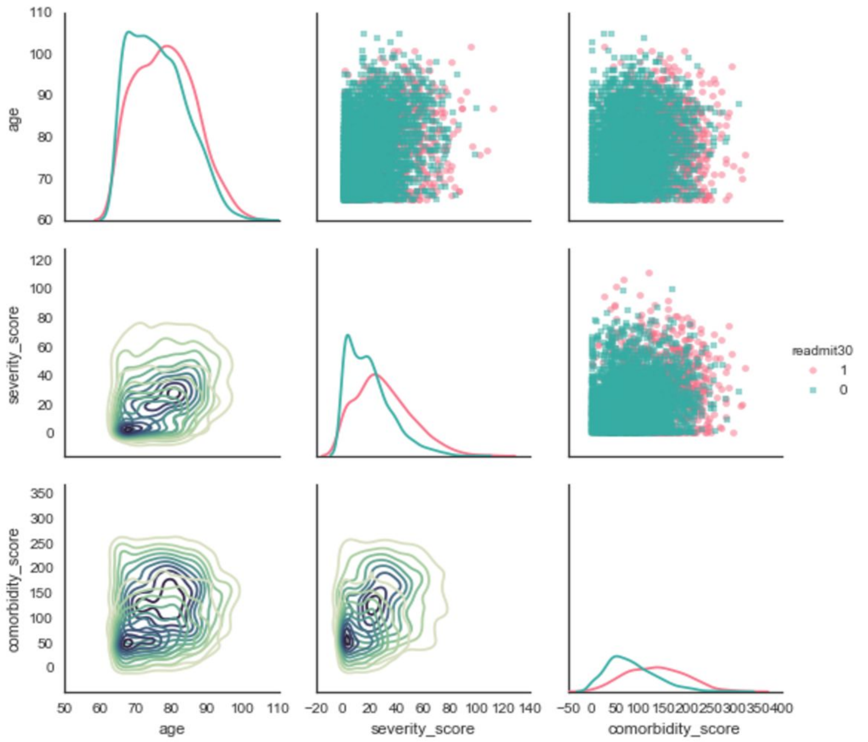
- **Extend CareTracker intervention to patients who need it.**
  - Managerial Segmentation
  - Machine Learning

Data Context

In [02]: Data Context --- State of Affairs

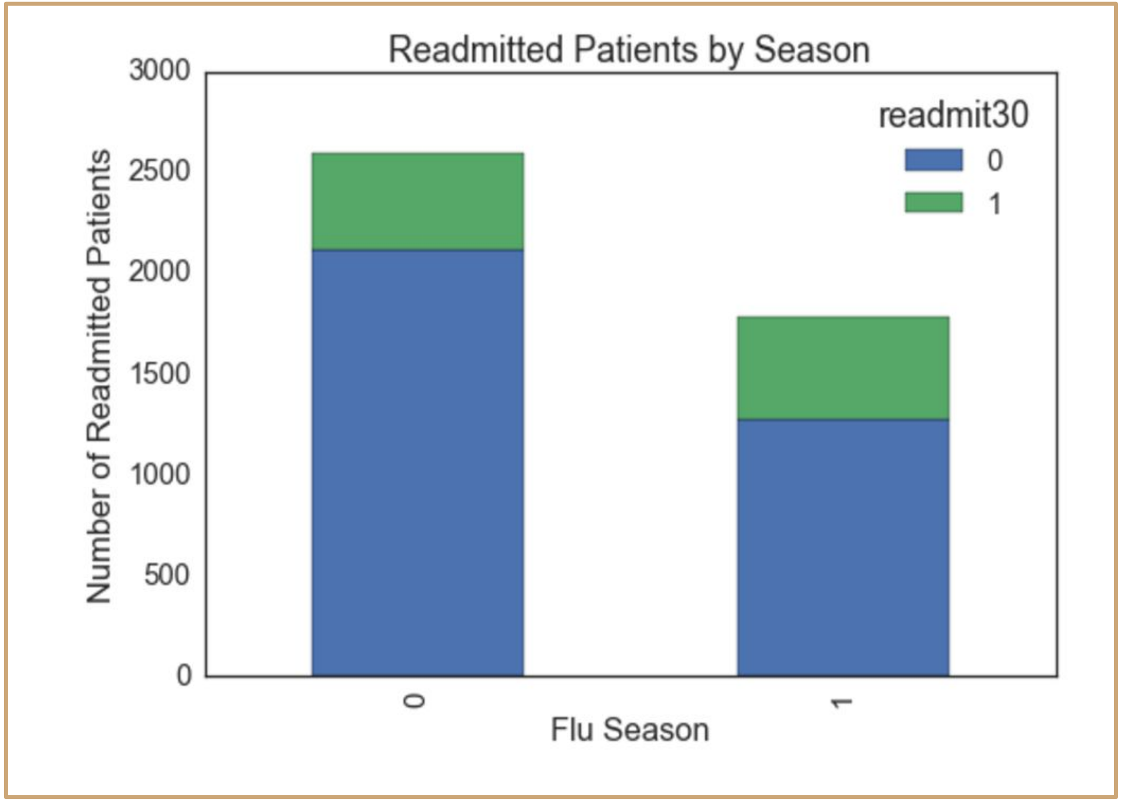
- ❖ Many patients who are readmitted have high **comorbidity** and **severity** scores.





In [02]: Data Context --- State of Affairs

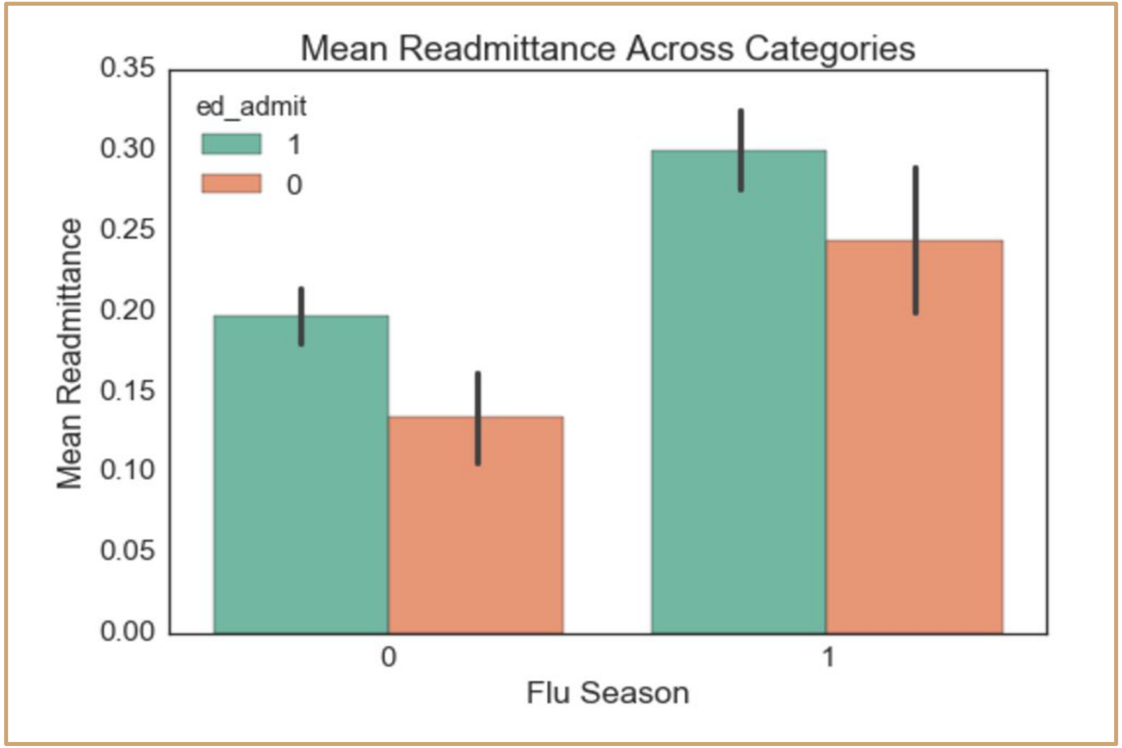
- **22.8%** of the sample size was readmitted within 30 days of the initial visit.
- **40.8%** of the sample size was admitted during flu season.



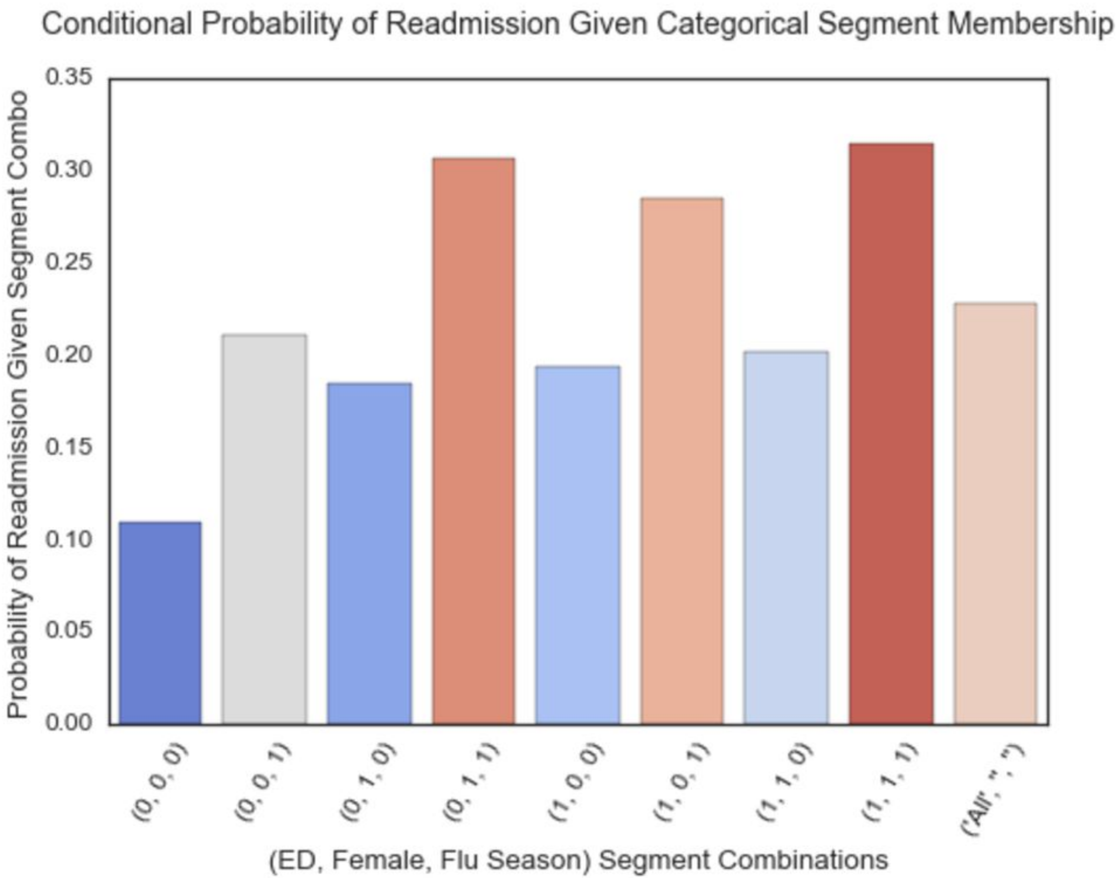
In [02]: Data Context --- State of Affairs

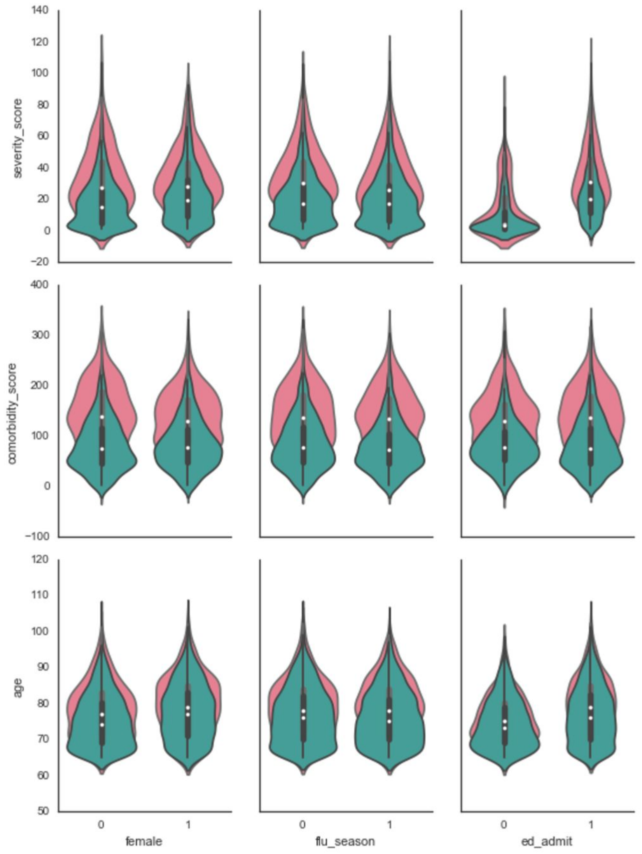
- **18.5%** of the non-flu-season visitors were readmitted within 30 days of their initial visit.

- **28.9%** of the flu-season visitors were readmitted within 30 days of their initial visit.



In [02]: Data Context --- Segmentation Opportunities





In [02]: Data Context --- The State of Affairs

Takeaways:

- Many patients who are readmitted have high comorbidity and severity scores.
- Patients who were admitted during flu season have greater readmission rates!
  - p-value = $6.81e^{-16}$
- ED admission is not a significant factor within flu season segments.
- We can use this information to target at-risk patients with CareTracker.

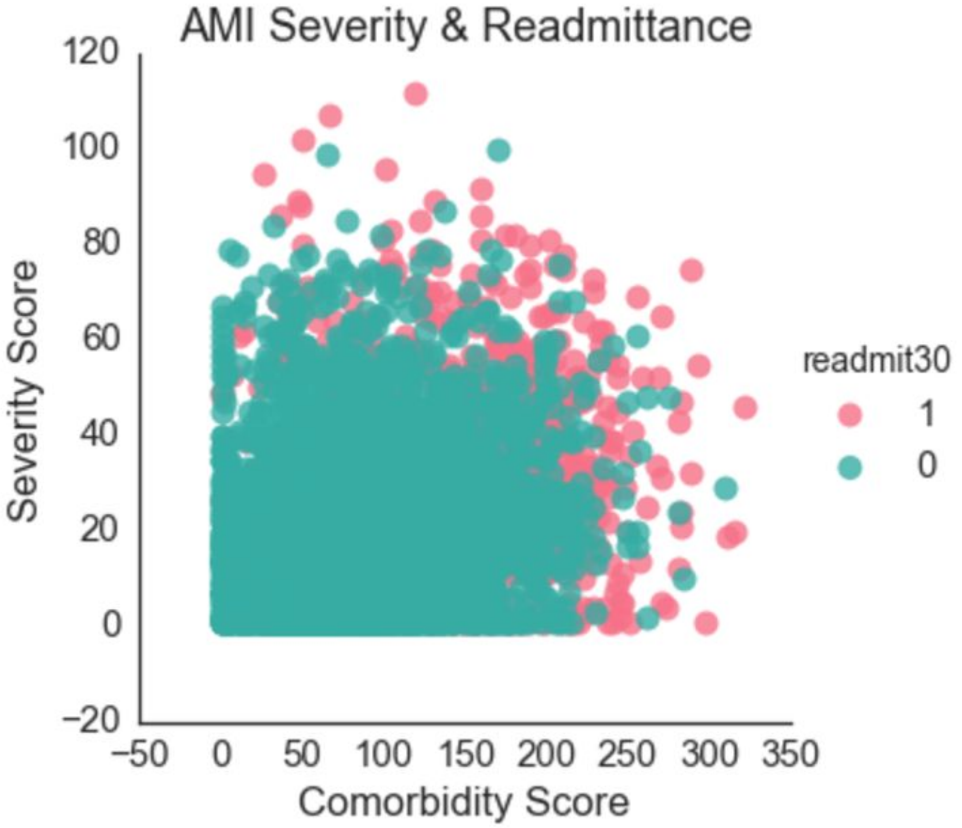
Solutions

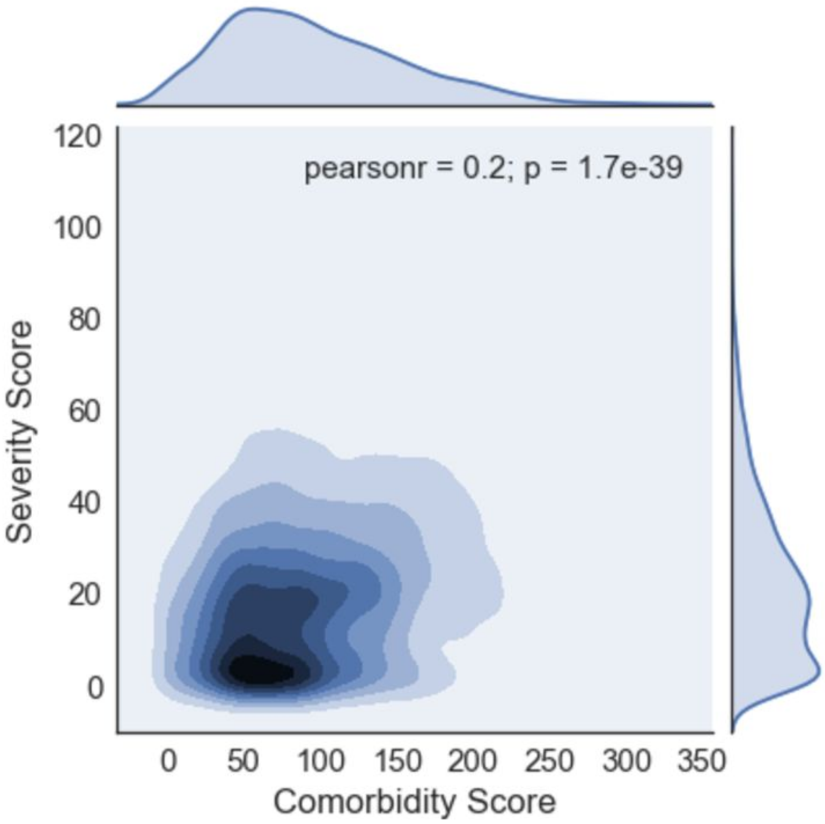
In [03]: Solutions --- Managerial Segmentation

The Concept:

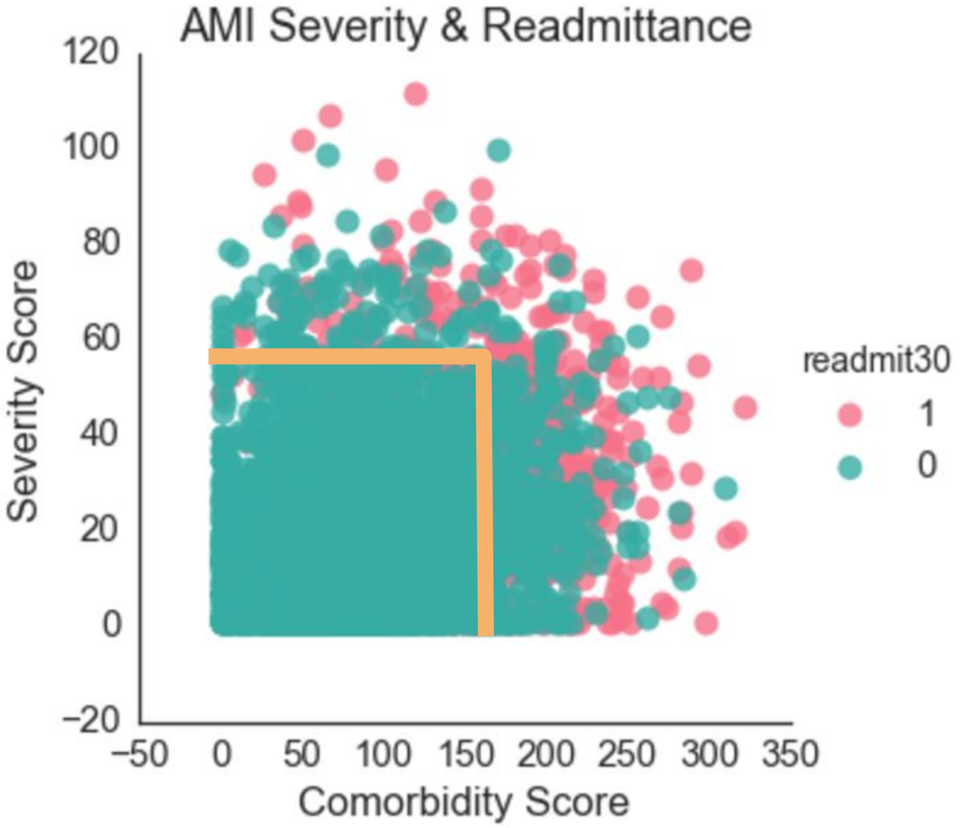
- Define thresholds for Comorbidity and Severity Scores.
- Assign CareTracker to patients who surpass either of the thresholds.
- Calculate savings.

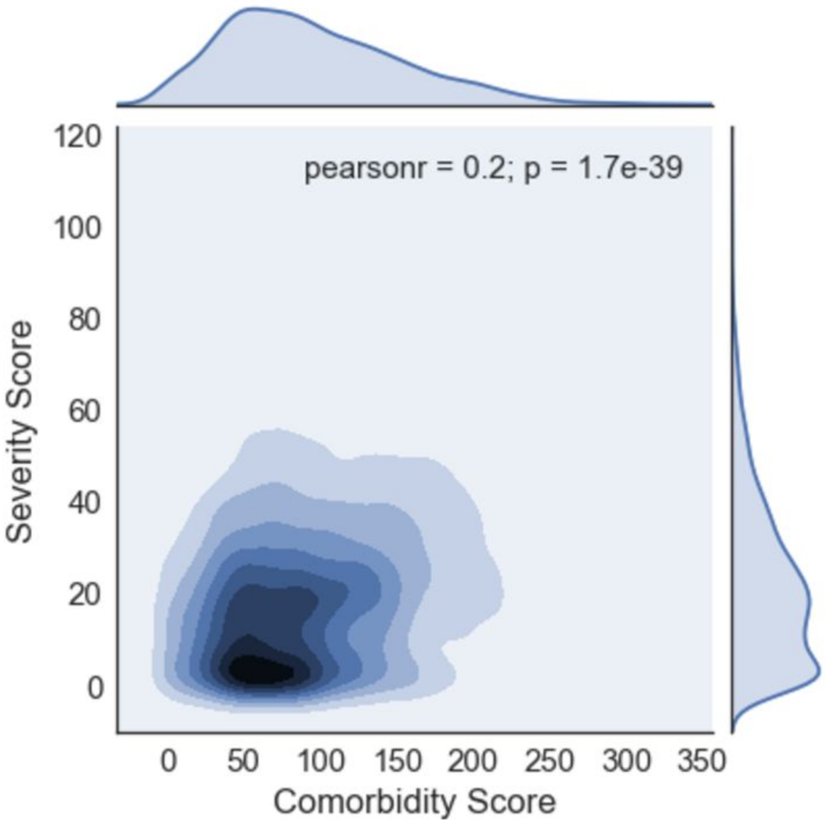
In [03]: Solutions --- Managerial Segmentation --- Drawing The Line





In [03]: Solutions --- Managerial Segmentation --- Drawing The Line





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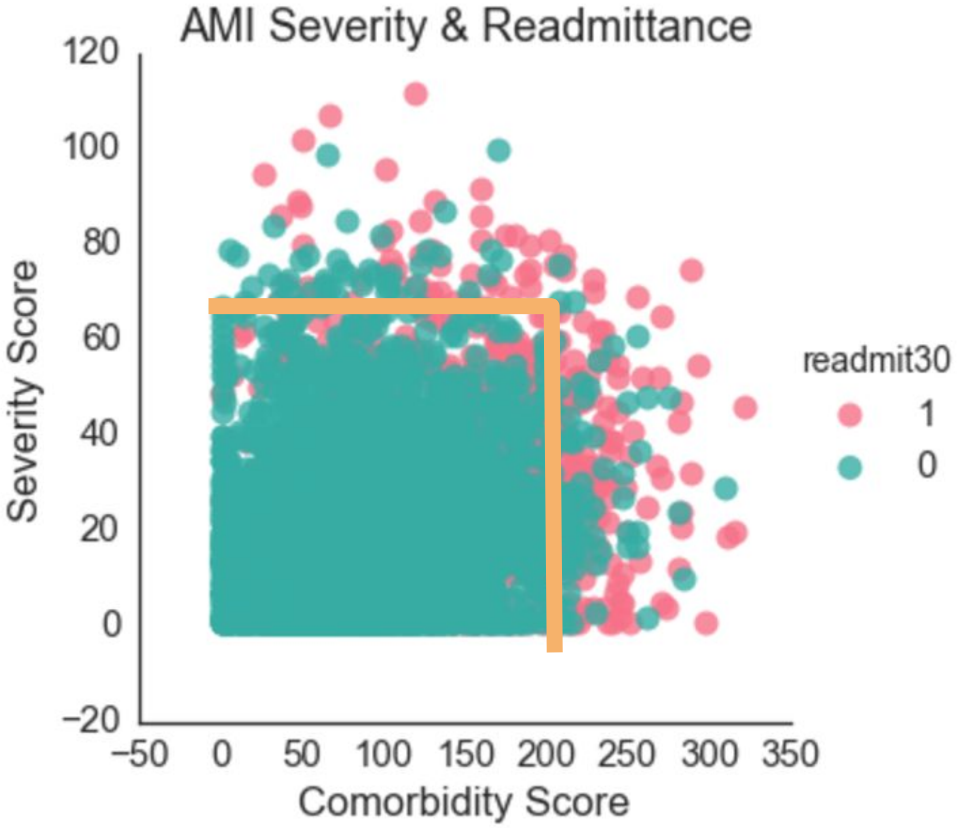

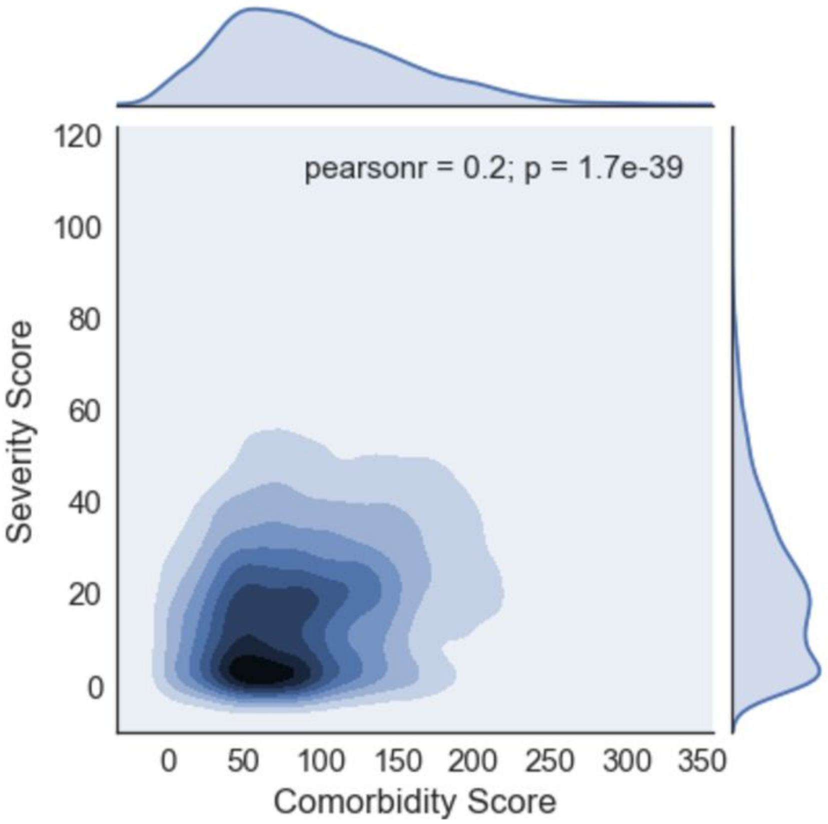

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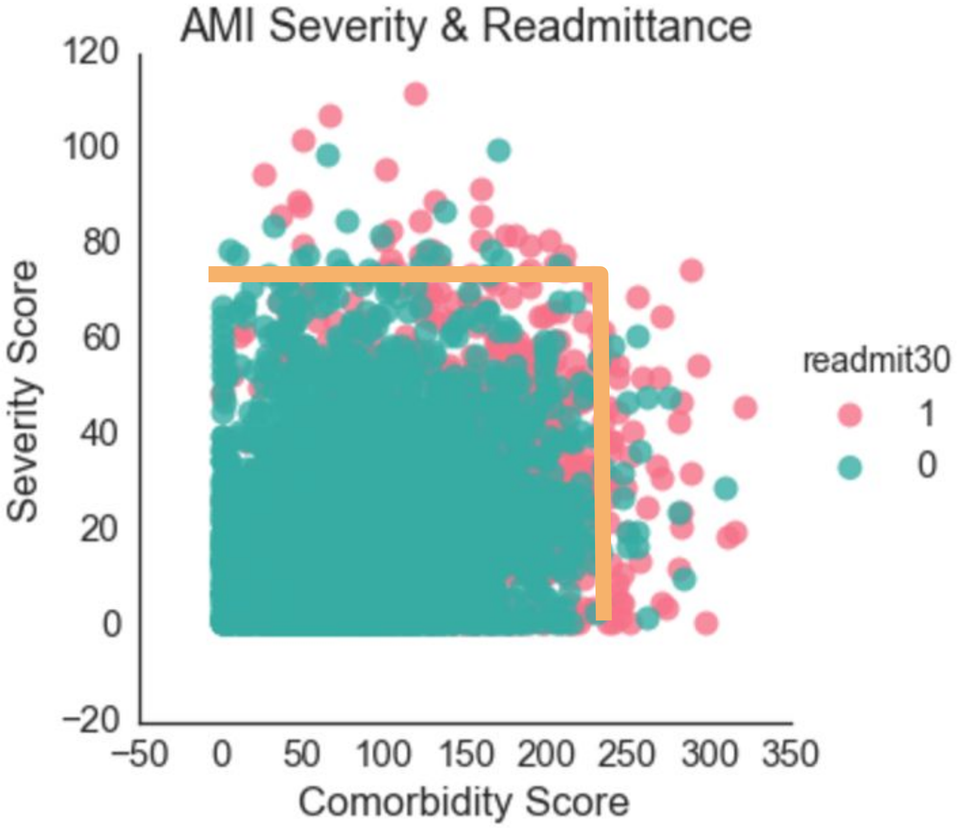
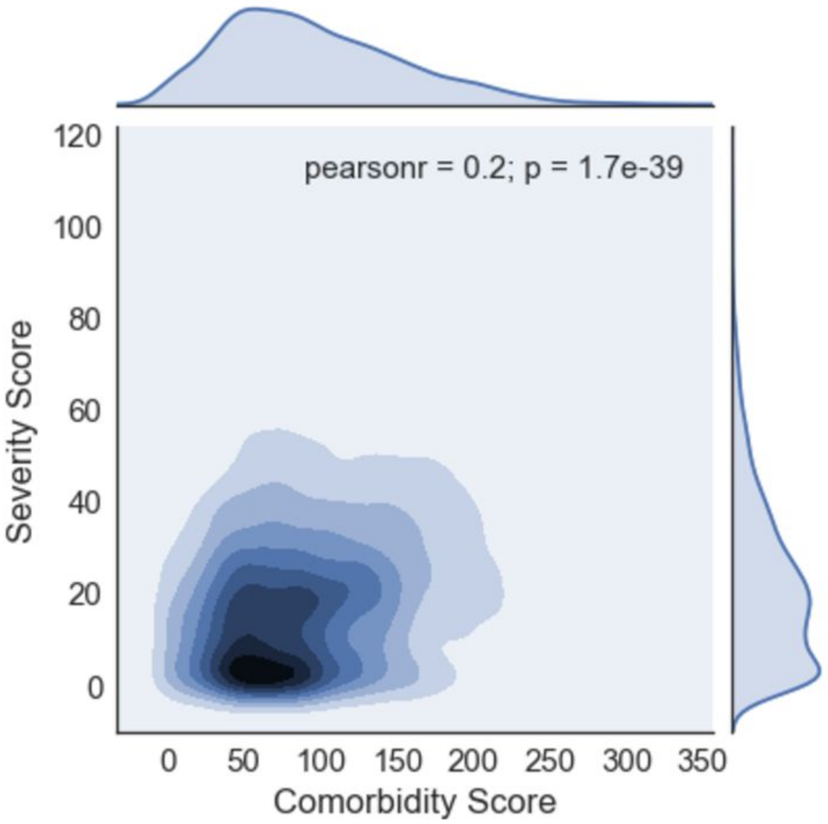




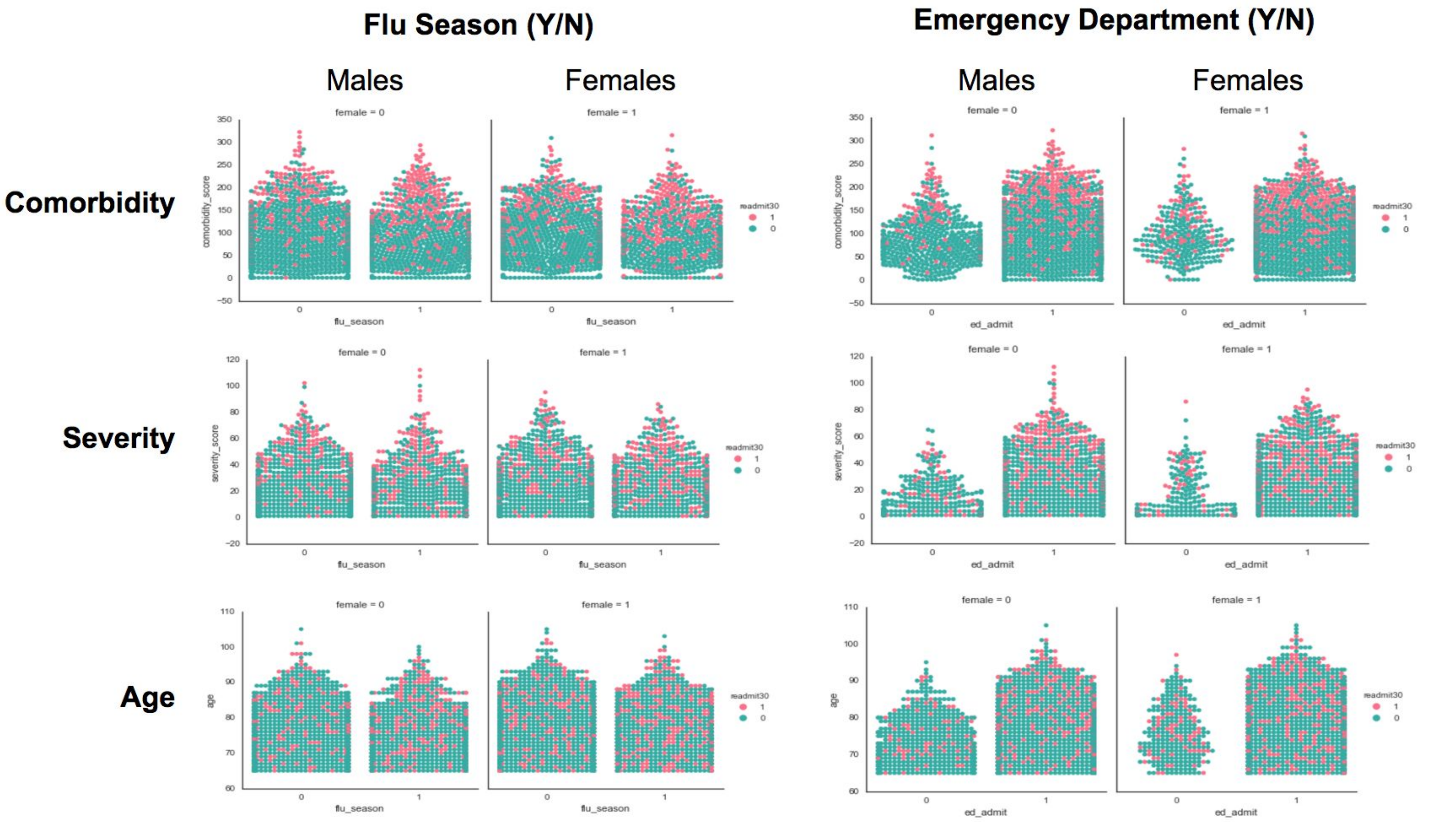
In [03]: Solutions --- Managerial Segmentation

Performance:

	Targeted	Not Targeted
Readmitted	652 (15%)	346 (8%)
Not Readmitted	858 (19%)	2526 (58%)

- Comorbidity Threshold:
  - 126.5
- Severity Threshold:
  - 43.7
- 1510 Targeted Patients (34%)
- Total Cost:
  - $ 7,709,600.0
- F1 Score:
  - 0.32
- Improvement From Base Case:
  - $ 274,400.0
  - ↑ 3%

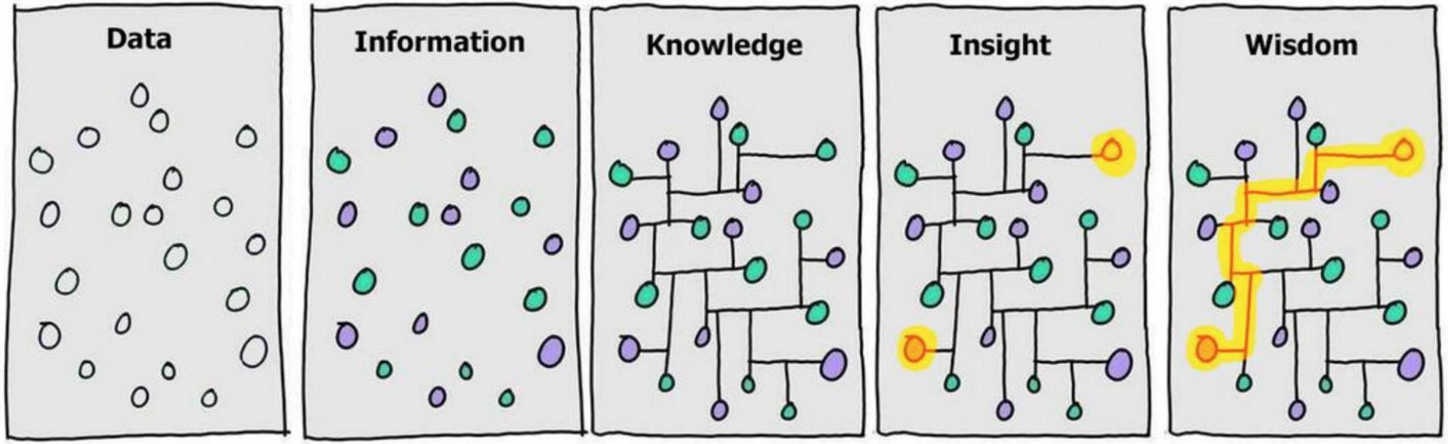
In [02]: Solutions --- Complexity at Play



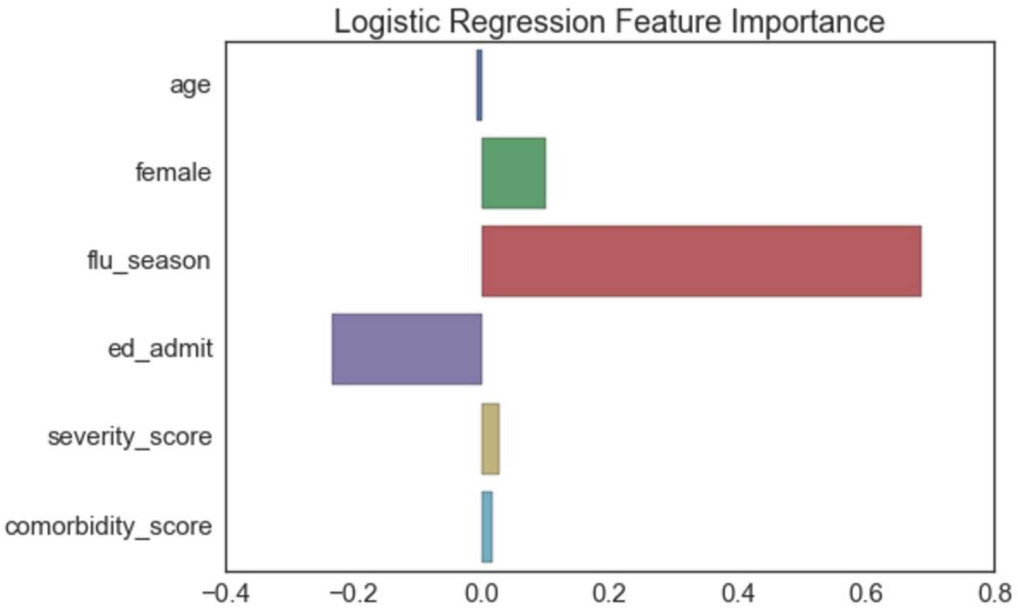
In [03]: Solutions --- Machine Learning

The Concept:

- ❖ Deploy algorithms to teach computers to learn patterns in our data.
- ❖ Train models on subsets of our data and then evaluate on a holdout test-set.
- ❖ Fit our entire dataset to the best model and predict whether patients are going to be readmitted.
- ❖ Calculate savings.



In [03]: Solutions --- Logistic Regression?



Logit Regression Results

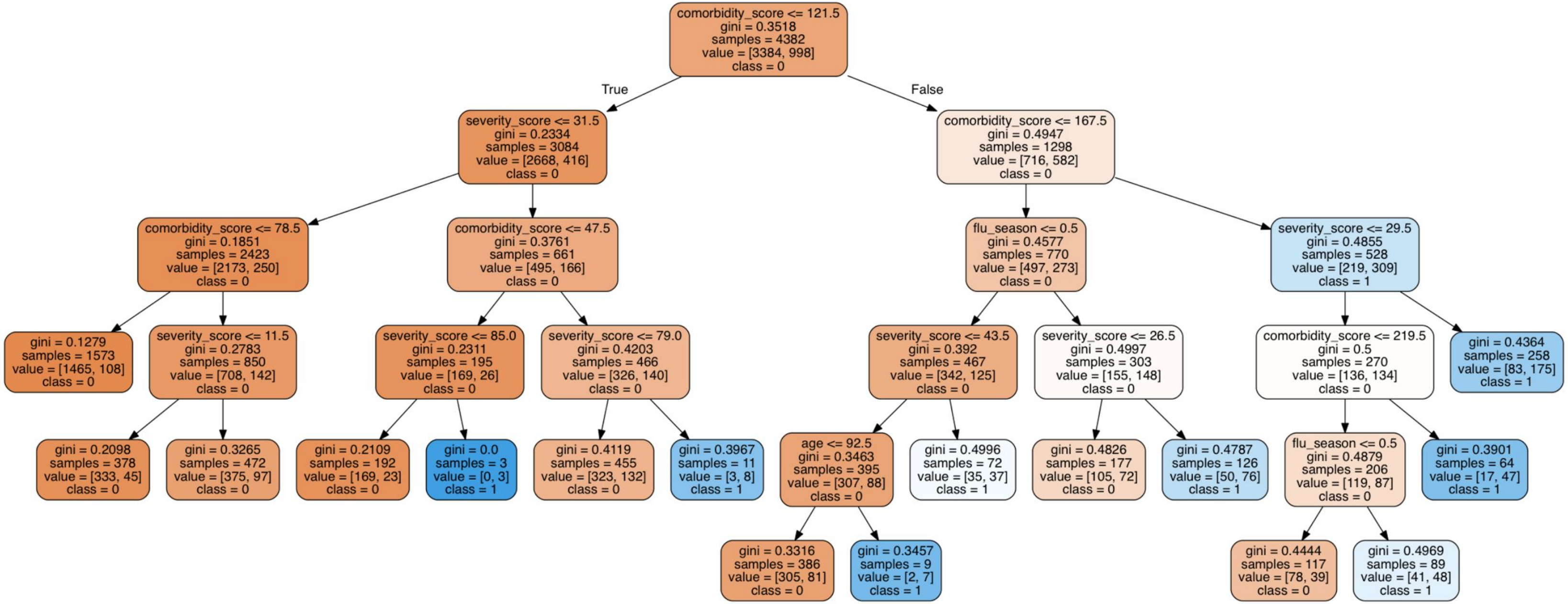
Dep. Variable:	readmit30	**No. Observations:**	4382
Model:	Logit	**Df Residuals:**	4377
Method:	MLE	**Df Model:**	4
Date:	Sat, 04 Mar 2017	**Pseudo R-squ.:**	0.1847
Time:	20:55:48	**Log-Likelihood:**	-1916.8
converged:	True	**LL-Null:**	-2351.1
		LLR p-value:	1.046e-186

	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
Intercept	-3.9849	0.128	-31.195	0.000	-4.235	-3.735
female	0.1840	0.081	2.264	0.024	0.025	0.343
flu_season	0.7439	0.082	9.081	0.000	0.583	0.904
severity_score	0.0259	0.002	11.993	0.000	0.022	0.030
comorbidity_score	0.0158	0.001	21.504	0.000	0.014	0.017

In [03]: Solutions --- Decision Tree

"One bit of advice: it is important to view knowledge as sort of a semantic tree -- make sure you understand the fundamental principles, ie the trunk and big branches, before you get into the leaves/details or there is nothing for them to hang on to."

- Elon Musk, Reddit AMA



In [03]: Solutions --- Decision Tree

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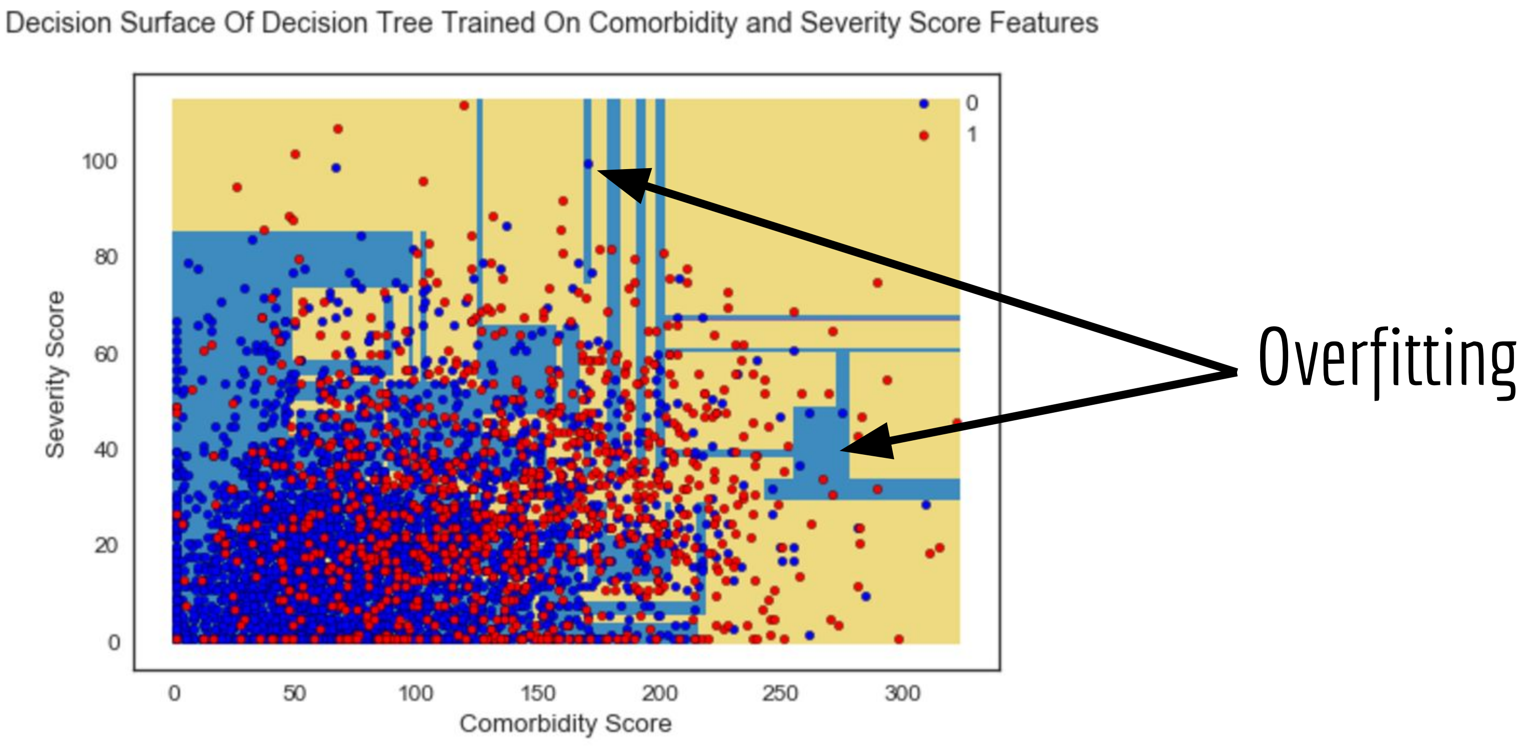
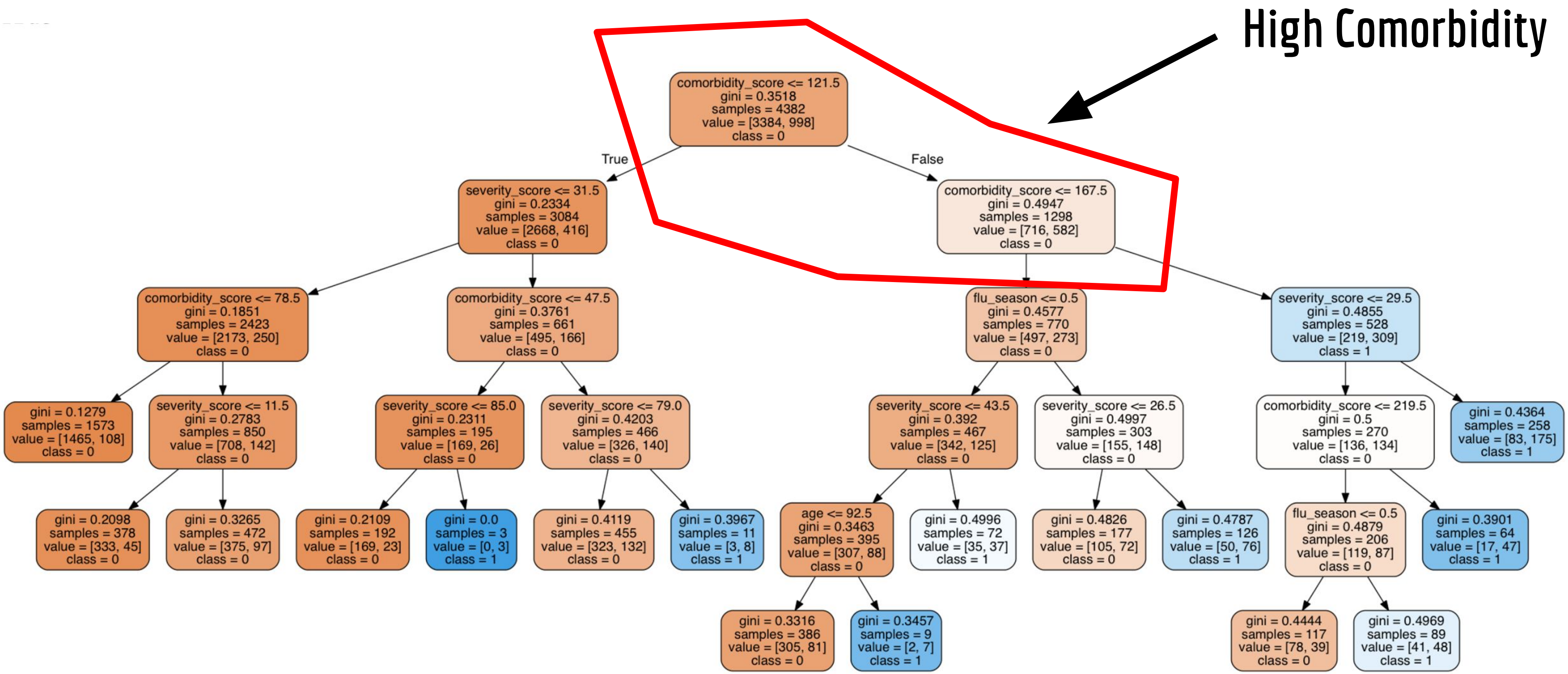
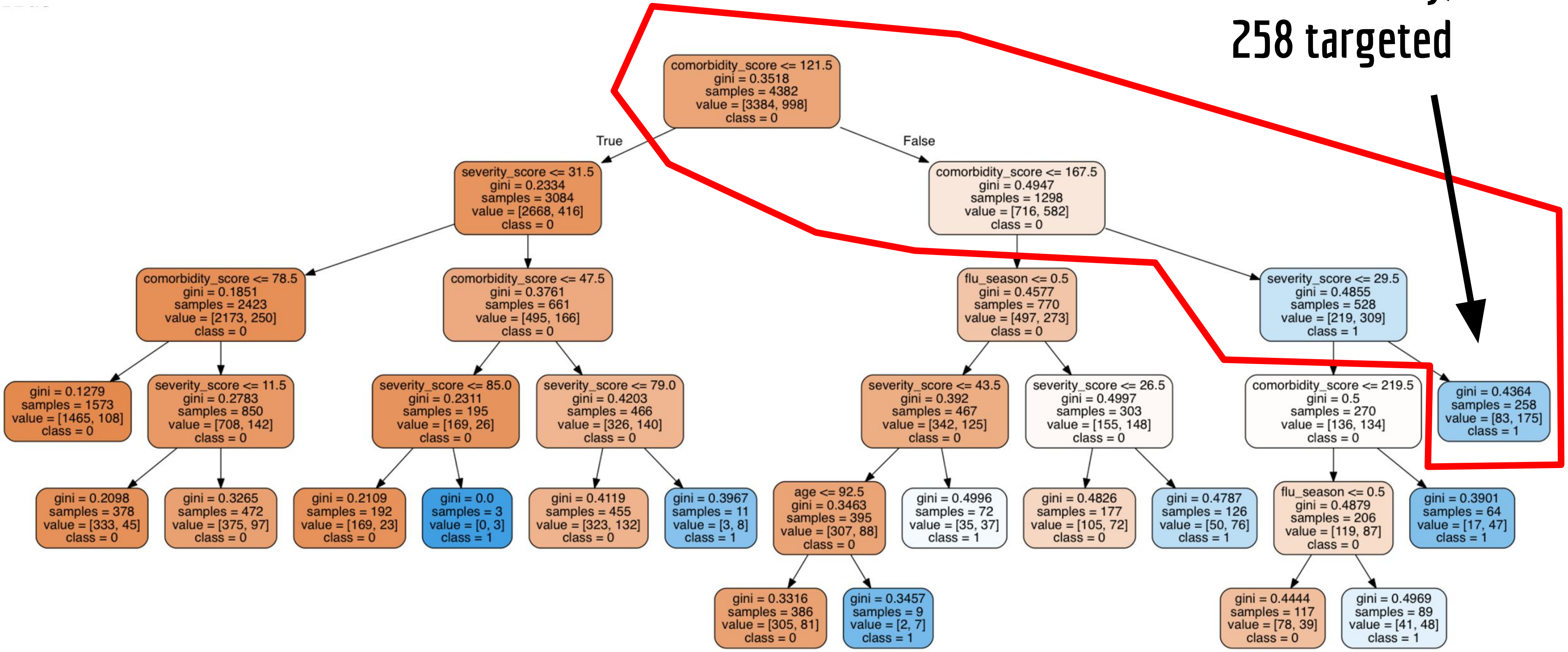


In [03]: Solutions --- Decision Tree



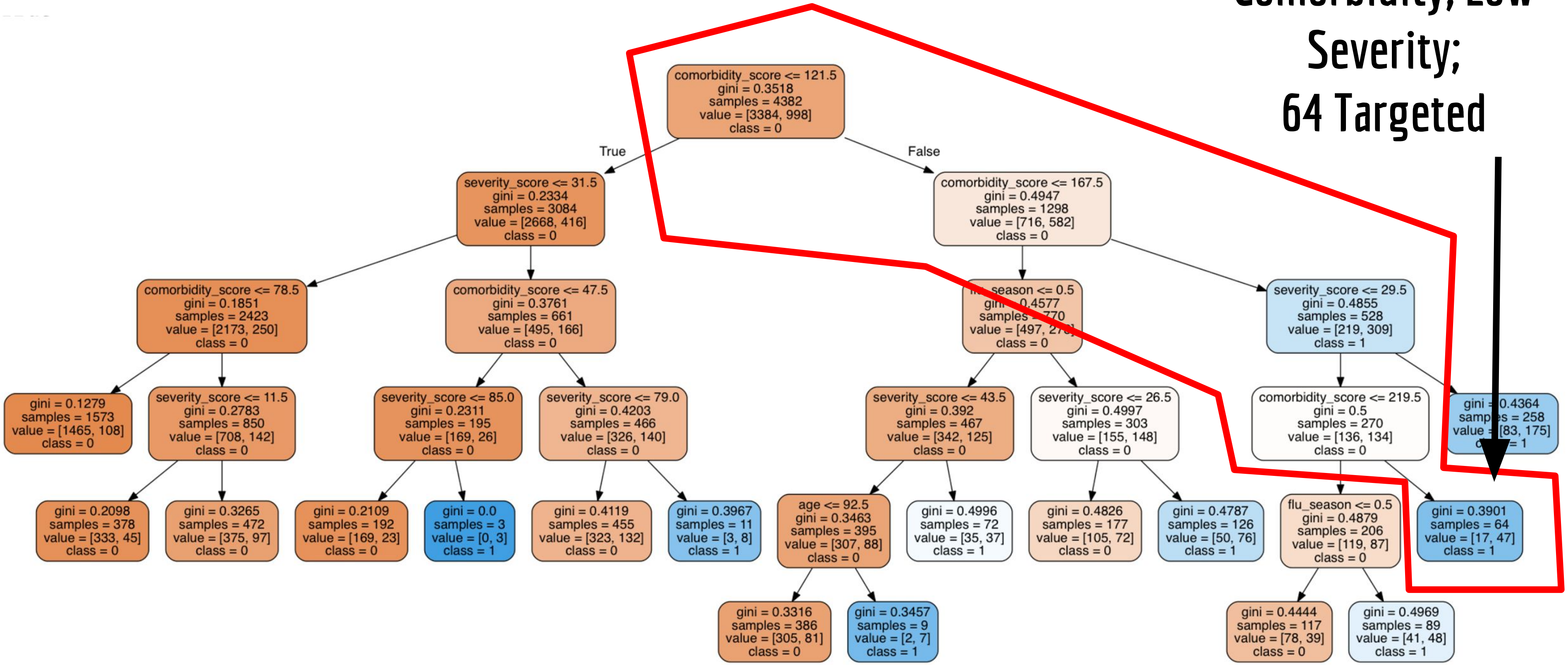
In [03]: Solutions --- Decision Tree

High Comorbidity
and Severity;
258 targeted



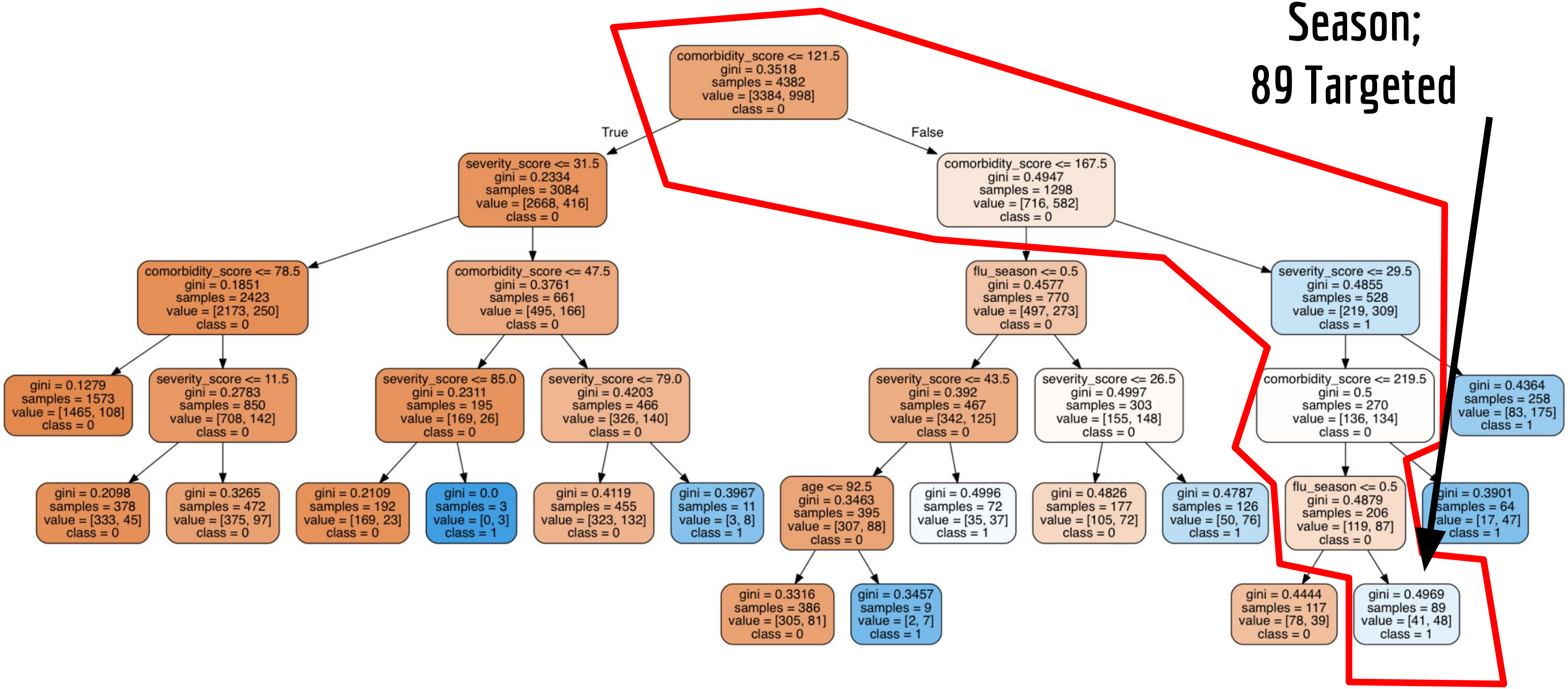
In [03]: Solutions --- Decision Tree

Really High Comorbidity, Low Severity;
64 Targeted



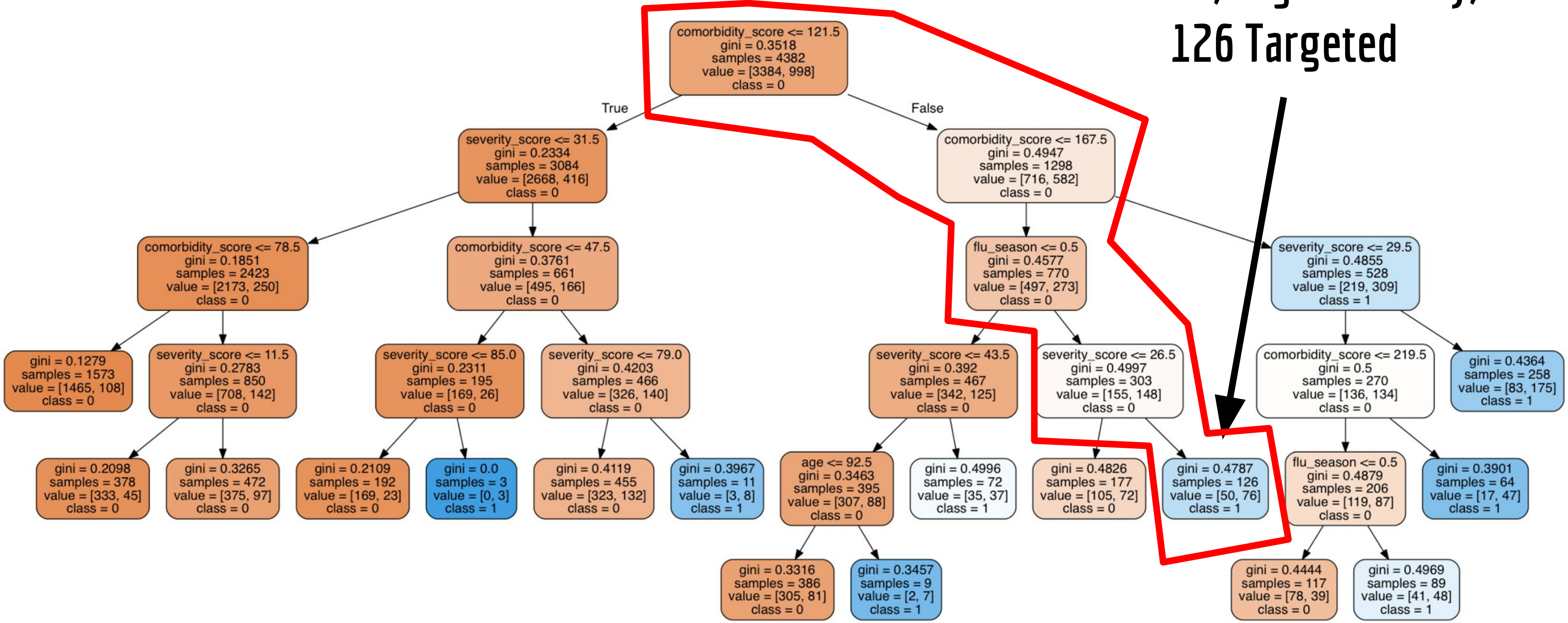
In [03]: Solutions --- Decision Tree

High Comorbidity, Low Severity, Flu Season;
89 Targeted



In [03]: Solutions --- Decision Tree

High Comorbidity, Not Flu Season, High Severity; 126 Targeted



In [03]: Solutions --- Decision Tree

Performance:

	Targeted	Not Targeted
Readmitted	470 (11%)	528 (12%)
Not Readmitted	209 (5%)	3175 (72%)

- 1510 Targeted Patients (34%)
- Total Cost:
  - $ 7,294,800
- F1 Score:
  - 0.56
- **Improvement From Base Case:**
  - **$ 689,200**
  - ↑ **9%**

Proposal

In [04]: Proposal

Policy	Cost	Savings	% Savings
Do Nothing	$ 7,984,000	$ 0	0 %
CareTracker For All	$ 10,048,800	-$2,064,800	-0.26
Managerial Segmentation	$ 7,709,600	$ 274,400	3 %
Decision Tree	**$ 7,294,800**	**$ 689,200**	**9 %**

In [04]: Proposal

Impact:

“The journey of a thousand miles begins with a single step.”

- Lao Tzu

- Saves THS **~ $689,200** a year.
- Improves patient experience and well-being.
- Improves our reputation.
- Transition to data-driven precision medicine.

Limitations:

- **CareTracker seems effective, but is not proven.**
  - Geographic context
    - Piloted in Seattle
  - Temporal context
    - No longitudinal study
    - 40% readmission reduction claim is a broad generalization.

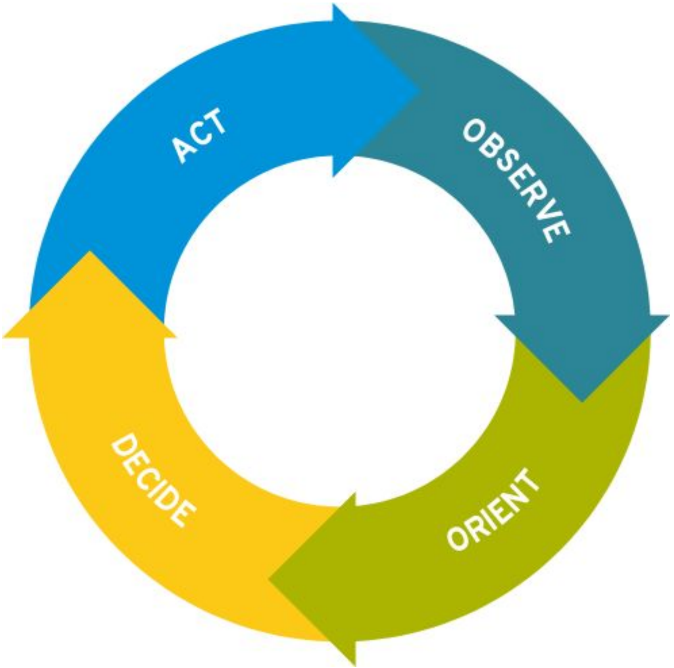
- **Model Validity**
  - Best F1 score: 0.56
  - Health care regulations will change, this model will not endure.
  - Issues of overfitting and regularization.
  - The model was trained solely on AMI cases.
    - Every medical condition has its own readmission patterns.

- **Human Element**
  - Patients may react adversely to being "Targeted."
  - Demands on practitioners and infrastructure.
  - Ethical issues around patient confidentiality.

Next Steps

In [05]: Next Steps

- ❖ Begin "online" targeting of at-risk patients for CareTracker.
  - ➢ Retrain readmission model iteratively by comparing predictions with outcomes.
- ❖ Implement CareTracker in hospitals with high readmission rates.
  - ➢ Monitor readmission reduction rates over time.
  - ➢ Bayesian A/B testing
- ❖ Develop and implement models for all major conditions.
- ❖ Collect more patient data and engineer better features for each condition.
  - ➢ Hospital locations
  - ➢ Admission and readmission dates
  - ➢ Medical history



In [06]:

```
C:\Users\Scott\Anaconda2\lib\site-packages\scipy\signal\filter_design.py in <module>()
     12 from numpy import mintypecode
     13 import numpy as np
---> 14 from scipy import special, optimize
     15 from scipy.special import comb
     16

C:\Users\Scott\Anaconda2\lib\site-packages\scipy\optimize\__init__.py in <module>()
    220
    221 from .optimize import *
--> 222 from ._minimize import *
    223 from ._root import *
    224 from .minpack import *

C:\Users\Scott\Anaconda2\lib\site-packages\scipy\optimize\_minimize.py in <module>()
     29 # constrained minimization
     30 from .lbfgsb import _minimize_lbfgsb
---> 31 from .tnc import _minimize_tnc
     32 from .cobyla import _minimize_cobyla
     33 from .slsqp import _minimize_slsqp

C:\Users\Scott\Anaconda2\lib\site-packages\scipy\optimize\tnc.py in <module>()
     35 from __future__ import division, print_function, absolute_import
     36
---> 37 from scipy.optimize import moduleTNC, approx_fprime
     38 from .optim                         izeResult, _check_unknown_options
     39 from numpy import inf, array, zeros, asfarray

ImportError: cannot import name moduleTNC
```

Questions?