Predicting Emerging Adults at Risk for Disengaging from the Behavioral Health Service System

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Beacon Health Options
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Agenda

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02 Predictive Modeling Review

03 Methods

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Chapter

01

Background & Context

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Background

- Emerging adults/transition-age youth (TAY; aged 15–26) face many challenges in navigating biological, emotional, interpersonal and psychological changes

- **Behavioral Health Needs**
  - Particularly challenging for emerging adults that struggle with behavioral health issues
  - Run the risk of developing severe and persistent problems later in life if emerging adults in need of services do not receive them
  - Only about 35% of emerging adults who are in need of behavioral health services actually receive treatment
  - If emerging adults do receive services, there is a drop in service utilization as they transition from the child and adolescent to the adult behavioral health system

Connecticut Context

- **State Behavioral Health Agencies**
  - Addressing the needs of emerging adults involved with child welfare agency that are “aging out” since 1997
  - Young Adult Services (YAS) program
  - Connecticut identified as a leader within the U.S.

- **Connecticut Behavioral Health Partnership**
  - Beacon Health Options is the Administrative Service Organization (ASO) for Medicaid behavioral health since 2006
  - Fee-for-service behavioral health carve-out
  - Working in collaboration with Medicaid agency to improve outcomes for Medicaid members
  - Addressing needs of Medicaid emerging adults who are eligible for a Young Adult Service referral since 2007

Connecticut Context

- **Tampa 2018**
  - Retrospective longitudinal analysis that examined service utilization and diagnostic prevalence for Connecticut Medicaid emerging adults between their 17th and 18th year
  - Found similar results as previous research—over 38% of the sample that had a behavioral health diagnosis at 17 had no behavioral health diagnosis at 18
  - Indicated youth had no claims for services with a behavioral health diagnosis during their 18th year (Bory & Plant, 2018)

- **Current Paper**
  - Methods and results predicting which youth are most at risk for disengaging from the behavioral health service system

Chapter

02

Predictive Modeling

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Predictive Modeling Review

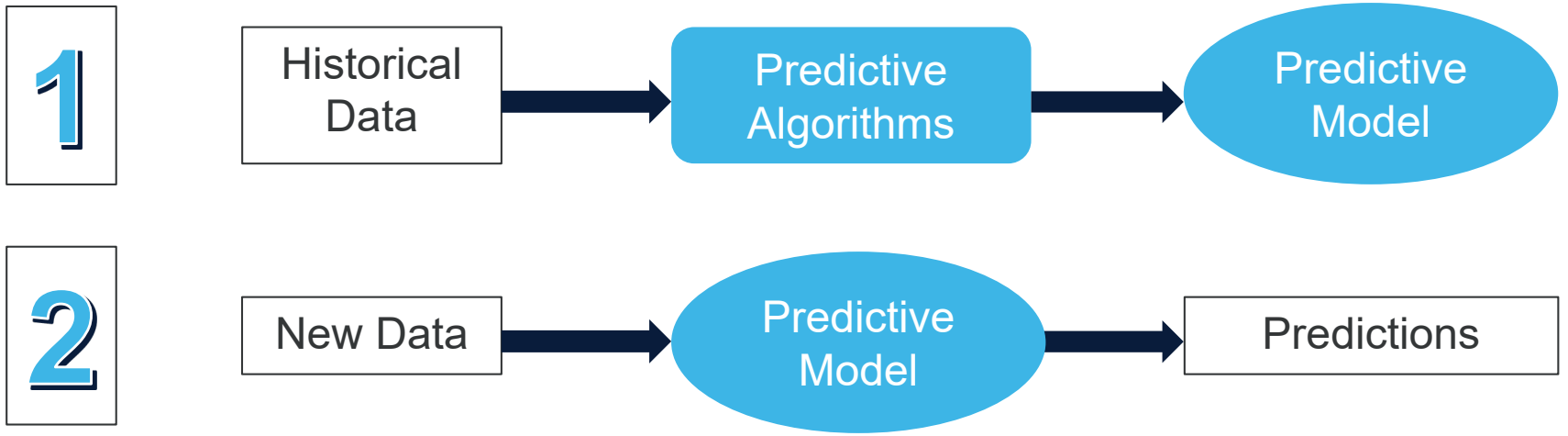
1. **Outcome of interest** (i.e., dependent variable)
   - Examples: expenditure or utilization of some type of service
   - Current analysis: utilization of behavioral health services

2. **Predictors** (i.e., independent variables)
   - Many predictive models can now handle hundreds, even thousands of predictor variables.
   - Current analysis: Initial data pull included over 290 different variables

3. **Interaction** (i.e., combination of the predictor variables)

Predictive Modeling Review

- Use historical data to predict future events
- Historical data is used to build a mathematical model that captures important trends
- Predictive model is then used on current data to predict what will happen next, or to suggest actions to take for optimal outcomes



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Chapter

03

Methods

Methods

- **Data sources**
  - Care management
  - Behavioral health authorization
  - Claims data (medical, behavioral health, pharmacy, dental)

- **Measurement period**
  - Observation Window: CY 2016
  - Prediction Window: CY 2017

Methods

- **Reduced predictors**
- **Optimized Complexity**
- **Partitioned data**
  - 40/30/30; random stratified sample on target variable
- **Selected models**
  - Decision tree, gradient boosting, logistic regression, random forest

Methods

- **Inclusion and Exclusion Criteria**
  - Overly inclusive
  - Include all Medicaid members:
    - 15 - 26 for the majority of CY 2016
    - No other inclusion or exclusion criteria for the initial data pull

Methods

- Major categories of variables include:
  - demographics, DCF involvement*, benefit package by month, eligibility days by month,
  - total medical, behavioral health, dental, and pharmacy cost by month,
  - total service utilization costs,
  - total behavioral health pharmacy category costs,
  - total primary and secondary behavioral health CCS category costs, and
  - count of both medical and behavioral health chronic conditions
  - *number of days since last behavioral health paid claim,*
  - *number of days since/until turning 18,*
  - *number of days since last behavioral health authorization, and*
  - *number of days since last behavioral health pharmacy claim.*

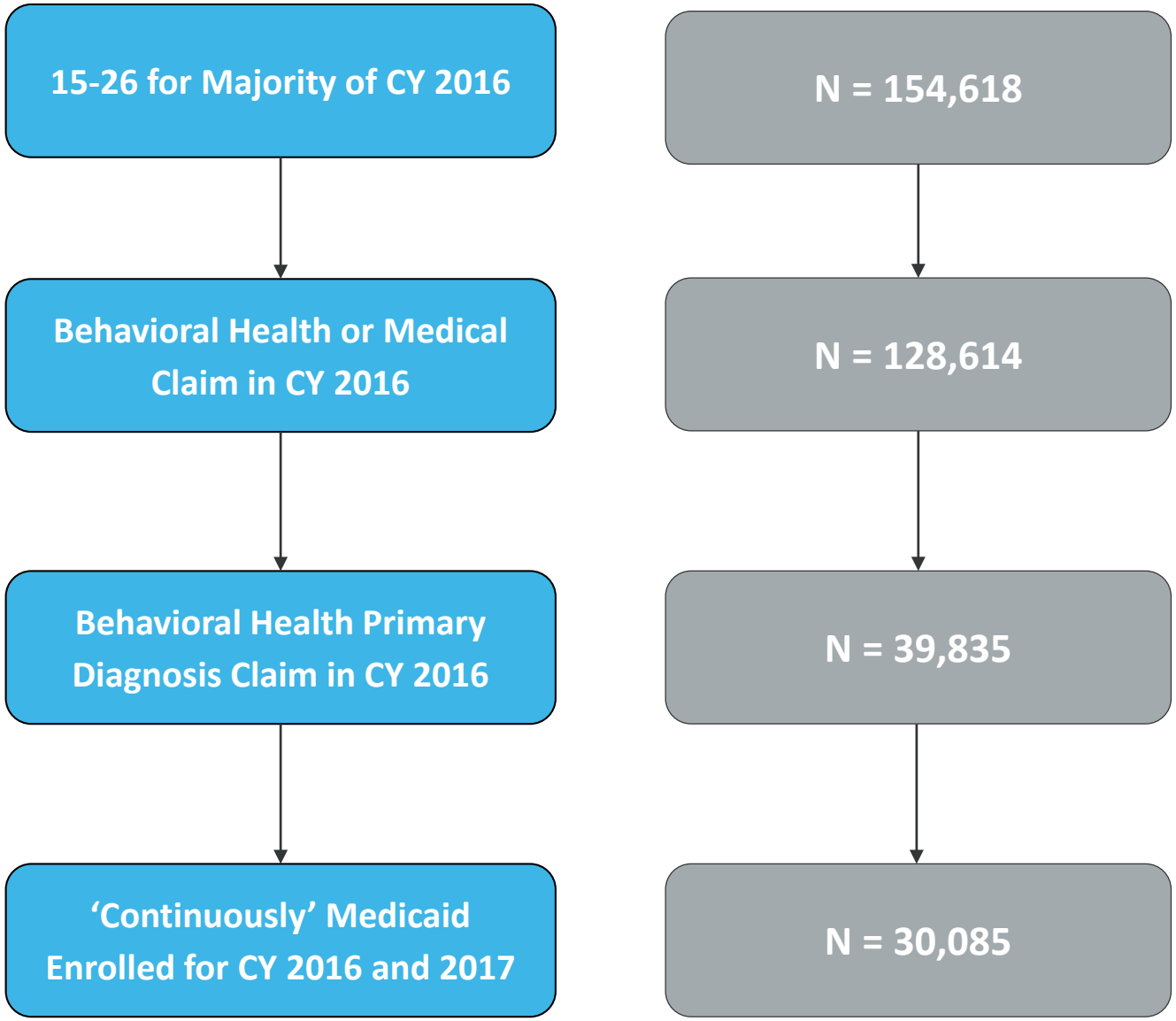
*"DCF-involvement" includes any youth who is involved with the Department of Children and Families through any of its mandates. This includes youth committed to DCF through child welfare or juvenile justice, and those dually committed. It also includes youth for whom the Department has no legal authority, but for whom DCF provides assistance through its Voluntary Services, Family with Service Needs and In-Home Child Welfare programs. In order to identify youth that are In-Home Child Welfare and Out-of-Home Committed, Beacon used a combination of the D and I/O identifier as requested by State partners.

Methods

- Defining the outcomes of interest (target)
  - **Behavioral Health Need**: paid claim with a behavioral health diagnosis in the primary position during the observation window (2016)
    - Excluded screening and history diagnostic codes
  - **Disengagement**: previously had at least one paid claim with a behavioral health diagnosis in the primary position and had no paid claims with a behavioral health diagnosis in the primary position during the prediction window (2017)

- Eligibility and enrollment
  - 76% of emerging adults with a behavioral health need were 'continuously' enrolled for both CY 2016 & 2017

Methods


15-26 for Majority of CY 2016
Behavioral Health or Medical Claim in CY 2016
Behavioral Health Primary Diagnosis Claim in CY 2016
'Continuously' Medicaid Enrolled for CY 2016 and 2017
N = 154,618
N = 128,614
N = 39,835
N = 30,085

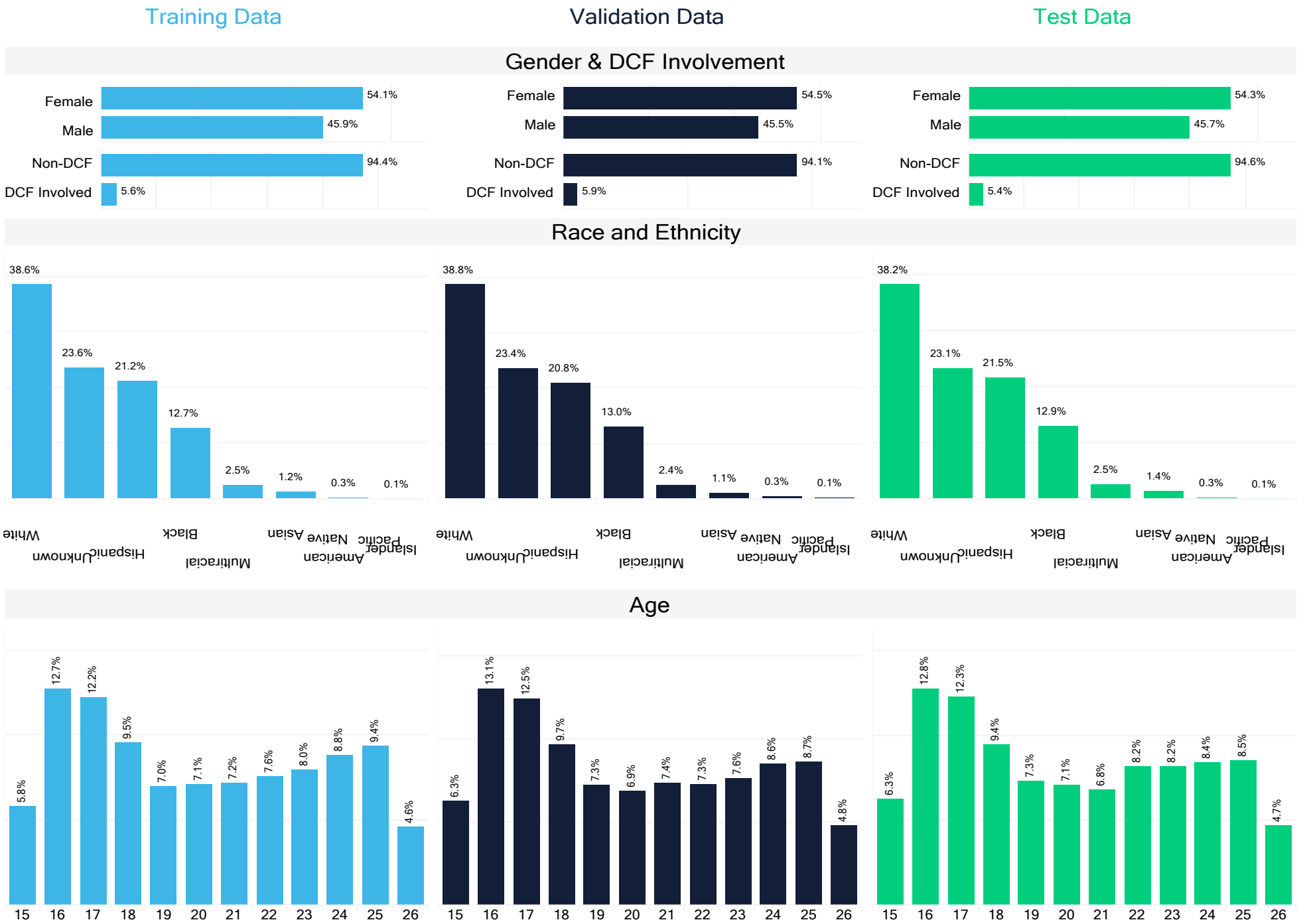
Methods

- **Model Assessment Measures**
  - Misclassification rate on validation dataset
    - Selection criterion for ‘winning’ model
  - Area Under Receiver Operating Characteristic Index Curve (AUR)

Chapter

04

Results


Training Data
Validation Data
Test Data
Gender & DCF Involvement
Female
Male
Non-DCF
DCF Involved
54.1%
45.9%
94.4%
5.6%
54.5%
45.5%
94.1%
5.9%
54.3%
45.7%
94.6%
5.4%
Race and Ethnicity
White
Hispanic/Unknown
Black
Multiracial
American Native
Asian
Islander Pacific
38.6%
23.6%
21.2%
12.7%
2.5%
1.2%
0.3%
0.1%
38.8%
23.4%
20.8%
13.0%
2.4%
1.1%
0.3%
0.1%
38.2%
23.1%
21.5%
12.9%
2.5%
1.4%
0.3%
0.1%
Age
15 16 17 18 19 20 21 22 23 24 25 26
5.8% 12.7% 12.2% 9.5% 7.0% 7.1% 7.2% 7.6% 8.0% 8.8% 9.4% 4.6%
6.3% 13.1% 12.5% 9.7% 7.3% 6.9% 7.4% 7.3% 7.6% 8.6% 8.7% 4.8%
6.3% 12.8% 12.3% 9.4% 7.3% 7.1% 6.8% 8.2% 8.2% 8.4% 8.5% 4.7%

Decision Tree Results

	Predicted Engaged	Predicted Disengaged	Total Actual Probability
Engaged	5445	900	70.3%
Disengaged	1065	1616	29.7%
Total Predicted	6510	2516	9026

Fit Statistic	Train	Validation	Test
Sum of Frequencies	12033	9026	9026
Misclassification Rate	0.20	0.22	0.22
Maximum Absolute Error	0.97	1.00	1.00
Sum of Squared Errors	3252.4	2604.85	2627.1
Average Squared Error	0.14	0.14	0.15
Root Average Squared Erroı	0.37	0.38	0.38
Divisor for ASE	24066	18052	18052
Total Degrees of Freedom	12033	.	.

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Gradient Boosting Results

	Predicted Engaged	Predicted Disengaged	Total Actual Probability
Engaged	5408	937	70.3%
Disengaged	902	1779	29.7%
Total Predicted	6310	2716	9026

Fit Statistic	Train	Validation	Test
Sum of Frequencies	12033	9026	9026
Sum of Case Weights Times Freq	24066	18052	18052
Misclassification Rate	0.19	0.20	0.21
Maximum Absolute Error	1.00	0.99	0.99
Sum of Squared Errors	3074.39	2469.61	2535.40
Average Squared Error	0.13	0.14	0.14
Root Average Squared Error	0.36	0.37	0.37
Divisor for ASE	24066	18052	18052
Total Degrees of Freedom	12033	.	.

Logistic Regression

	Predicted Engaged	Predicted Disengaged	Total Actual Probability
Engaged	6130	215	70.3%
Disengaged	2378	303	29.7%
Total Predicted	8508	518	9026

Fit Statistic	Train	Validation	Test
Average Squared Error	0.21	0.21	0.21
Average Error Function	0.62	0.63	0.63
Divisor for ASE	24066.00	18052.00	18052.00
Error Function	14872.60	11345.21	11289.99
Maximum Absolute Error	0.99	1.00	1.00
Mean Square Error	0.21	0.21	0.21
Sum of Frequencies	12033.00	9026.00	9026.00
Root Average Sum of Squares	0.46	0.46	0.46
Root Mean Squared Error	0.46	0.46	0.46
Sum of Squared Errors	5090.61	3881.07	3856.33
Sum of Case Weights Times Freq	24066	18052	18052
Misclassification Rate	0.29	0.29	0.29

Random Forest

	Predicted Engaged	Predicted Disengaged	Total Actual Probability
Engaged	5590	755	70.3%
Disengaged	1176	1505	29.7%
Total Predicted	6766	2260	9026

Fit Statistic	Train	Validation	Test
Average Squared Error	0.13	0.14	0.14
Divisor for ASE	24066	18052	18052
Maximum Absolute Error	0.97	0.96	0.97
Sum of Frequencies	12033	9026	9026
Root Average Squared Error	0.36	0.37	0.38
Sum of Squared Errors	3154.00	2534.87	2562.77
Frequency of Classified Cases	12033	9026	9026
Misclassification Rate	0.19	0.21	0.21
Number of Wrong Classifications	2315	1931	1928

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Results

Potential Predictor Variable	Model			
	Decision Tree	Gradient Boosting[a]	Logistic Regression	Random Forest[b]
Benefit Package	X	X		X
Gender		X		
Race and Ethnicity		X	X	X
Primary Residence- County		X		
DCF Status Majority of the Year		X	X	
Total BH Pharmacy Cost	X	X	X	
Total BH Primary Diagnosis Claim Cost	X	X	X	X
Total Medical Primary Diagnosis Claim Cost		X		
Total Dental Cost		X		
Count BH Chronic Conditions-Primary		X		X
Count Medical Chronic Conditions-Primary		X		
Count BH Chronic Conditions-Secondary		X		X
Count Medical Chronic Conditions-Secondary		X		
Number of Days Since Last Authorization				X
Number of Days Since Last BH Claim	X	X	X	X
Number of Days Since Last BH Pharmacy Claim	X	X	X	X
Number of Days Until/Since 18th Birthday		X		X
Number of Group Home Days		X		
Number of Residential Treatment Center Days				X

[a] Based upon validation dataset split-based variable importance. The split-based approach uses the reduction in the sum of squares from splitting a node, summing over all nodes.

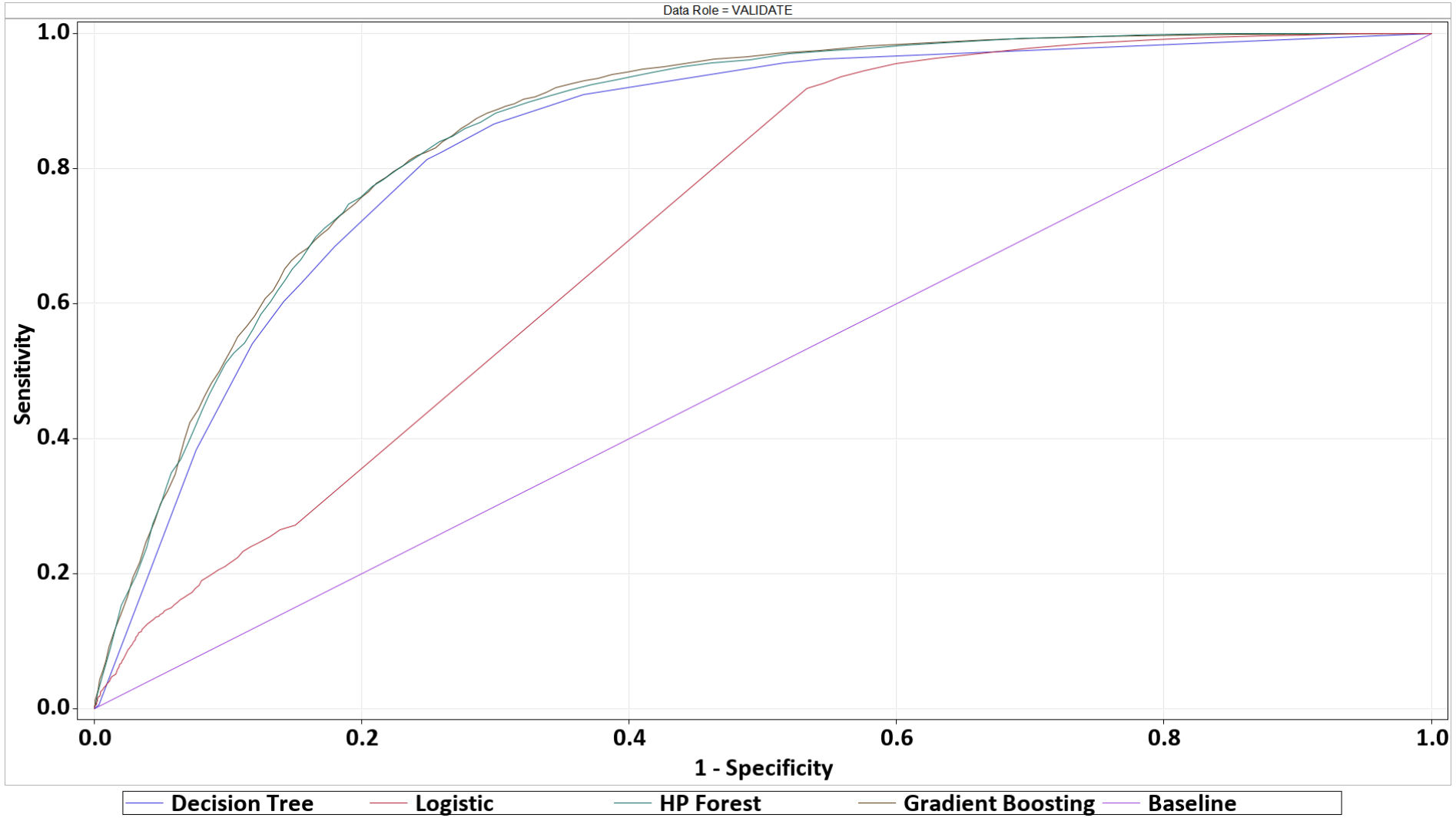
[b] Based upon validation dataset positive Gini coefficient values from the loss reduction variable importance.

Results

Dataset Type	Model Fit Statistics	Type of Predictive Model			
		Gradient Boosting	Random Forest	Decision Tree	Logistic Regression
Training	Misclassification Rate	0.19	0.19	0.20	0.29
	Sum of Squared Errors	3074.39	3154.00	3252.43	5090.61
	Average Squared Error	0.13	0.13	0.14	0.21
	AUR	0.88	0.88	0.86	0.72
	Gini Coefficient	0.76	0.76	0.71	0.44
Validation	**Misclassification Rate[a]**	**0.20**	**0.21**	**0.21**	**0.29**
	Sum of Squared Errors	2469.61	2534.87	2604.85	3881.07
	Average Squared Error	0.14	0.14	0.14	0.21
	AUR	**0.86**	**0.86**	**0.84**	**0.71**
	Gini Coefficient	0.72	0.72	0.68	0.42
Test	Misclassification Rate	0.21	0.21	0.22	0.29
	Sum of Squared Errors	2535.40	2562.77	2627.14	3856.33
	Average Squared Error	0.14	0.14	0.15	0.21
	AUR	0.85	0.85	0.84	0.71
	Gini Coefficient	0.71	0.70	0.67	0.41

[a]: The validation dataset misclassification rate was the selection criterion for choosing a 'winning' model.

Results


Data Role = VALIDATE
1.0
0.8
0.6
0.4
0.2
0.0
Sensitivity
0.0
0.2
0.4
0.6
0.8
1.0
1 - Specificity
Decision Tree
Logistic
HP Forest
Gradient Boosting
Baseline

Chapter

05

Conclusion & Future Directions

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Conclusion

- Gradient Boosting selected winning model
- 80% of the time correctly classify engage & disengage

- **Limitations**
  - Restrictions on claims and authorizations
  - Emerging adults may use other services not captured by claims data
  - Broader healthcare and fiscal climate - changes over time

Future Directions

- Put predictive model into production
  - Rolling monthly report
  - Identify high-risk emerging adults
  - Intervene to get them connected to services

- Develop & implement transitional assistance program to connect emerging adults to appropriate behavioral health services at risk for disengaging

Acknowledgements

- CT Beacon Quality & Clinical Departments
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- CT Department of Mental Health and Addiction Services

Thank You

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