

Addiction Treatment as a Sociological Outcome

Christopher Carbonaro

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Drug Use in the U.S.

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- 60.2% (164.8 Million) of Americans have consumed alcohol, tobacco, or an illicit drug within the past month

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- 60.2% (164.8 Million) of Americans have consumed alcohol, tobacco, or an illicit drug within the past month
- Of these users, 31.9 million used an illicit drug within the past month

Drug Use in the U.S.

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- 60.2% (164.8 Million) of Americans have consumed alcohol, tobacco, or an illicit drug within the past month
- Of these users, 31.9 million used an illicit drug within the past month
- 20% of Americans are estimated to have used an illicit drug within the past year (SAMHSA, 2019, p. 3-8)

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Approximately “21.2 million people aged 12 or older needed substance use treatment” in 2018 (SAMHSA, p. 3).

Unfortunately, while this comprises 7.8% of the U.S. population, only 1.4 received treatment within the past year (p. 3).

This Project's Focus

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Given the disparity between the number of individuals in need of treatment and the number who receive it, we are motivated to ask:

What sociological factors best predict whether an individual will undergo substance abuse treatment?

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Current Research

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This project eschews studying addiction as a neurological phenomenon (see Venniro et al., 2017).

Instead, it builds on work which looks at sociological factors which predict addiction (Boyle, Polinsky, & Hser, 2000; Taylor, Caudy, Blasko, & Taxman, 2017; Battjes, Gordon, O'Grady, Kinlock, & Carswell, 2003).

Current Research (cont.)

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Limitations of current research:

- Small sample sizes (Boyle et. al., 2000; Battjes et. al., 2003)

Current Research (cont.)

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Limitations of current research:

- Small sample sizes (Boyle et. al., 2000; Battjes et. al., 2003)
- No use of analytic tools other than multiple regression (*Ibid.*)

Current Research (cont.)

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Limitations of current research:

- Small sample sizes (Boyle et. al., 2000; Battjes et. al., 2003)
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- Luongo et. al. (2016) conducted a Canadian study which produced results conflicting with Boyle et. al. (2000) and Battjes et. al. (2003) regarding the importance of:

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 - Severity of substance being abused

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- Luongo et. al. (2016) conducted a Canadian study which produced results conflicting with Boyle et. al. (2000) and Battjes et. al. (2003) regarding the importance of:
 - Severity of substance being abused
 - Gender

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- Luongo et. al. (2016) conducted a Canadian study which produced results conflicting with Boyle et. al. (2000) and Battjes et. al. (2003) regarding the importance of:
 - Severity of substance being abused
 - Gender
 - Ethnicity

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 - Severity of substance being abused
 - Gender
 - Ethnicity
 - Age

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 - Severity of substance being abused
 - Gender
 - Ethnicity
 - Age
 - ... and Education

Filling the Research Gap

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This project is an attempt to examine the importance of these variables (and others) on a larger scale while 1. looking for interactions between the predictors and 2. using tools other than OLS.

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Source of Data

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This project uses a survey conducted by the Substance Abuse and Mental Health Services Administration (SAMHSA), namely the 2018 National Survey on Drug Use and Health (NSDUH).

The survey consists of roughly 56,000 participants.

Predictors in the Data

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There are hundreds of variables for each respondent in the NSDUH; this study narrows the focus to roughly 40 predictors.

These include variables like age and gender, variables describing the individual's health insurance coverage, and variables describing their recency/frequency/type of drug use.

Logistic Regression

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Our first tool for examining the data is regularized regression. We use this as a baseline against which to compare our second tool.

Here, we use the elastic net to assess the importance of each variable and avoid producing an overcomplicated model.

Logistic Regression (cont.)

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$$\log \frac{\Pr(G = 2|X = x)}{\Pr(G = 1|X = x)} = \beta_0 + \beta^T x$$

Logistic Regression (cont.)

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$$\begin{aligned}\hat{\beta}^{\text{elastic net}} = \operatorname{argmin} & \frac{1}{2} \sum_{i=1}^N (y_i - \beta_0 - \sum_{j=1}^p x_{ij} \beta_j)^2 \\ & + \lambda \sum_{j=1}^p (\alpha \beta_j^2 + (1 - \alpha) |\beta_j|)\end{aligned}$$

Boosting

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One of the biggest problems with linear regression is we have a comparatively small number of positive cases (only around 5%).

This makes classifying positive cases difficult.

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Boosting is a helpful solution here, since it will raise the relative importance of misclassified observations for each subsequent tree.

We can also use partial dependence plots to look for interactions between important terms.

Boosting (cont.)

From Witten, Hastie, & Tibshirani (2017, p. 323):

- 1 Set $\hat{f}(x) = 0$ and $r_i = y_i$ for all i in the training set.

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Boosting (cont.)

From Witten, Hastie, & Tibshirani (2017, p. 323):

- 1 Set $\hat{f}(x) = 0$ and $r_i = y_i$ for all i in the training set.
- 2 For $b = 1, 2, \dots, B$, repeat:

Boosting (cont.)

From Witten, Hastie, & Tibshirani (2017, p. 323):

- 1 Set $\hat{f}(x) = 0$ and $r_i = y_i$ for all i in the training set.
- 2 For $b = 1, 2, \dots, B$, repeat:
 - a. Fit a tree \hat{f}^b with d splits to the training data

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Boosting (cont.)

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- 1 Set $\hat{f}(x) = 0$ and $r_i = y_i$ for all i in the training set.
- 2 For $b = 1, 2, \dots, B$, repeat:
 - a. Fit a tree \hat{f}^b with d splits to the training data
 - b. Update \hat{f} by adding in a shrunk version of the new tree:

$$\hat{f}(x) \leftarrow \hat{f}(x) + \lambda \hat{f}^b(x)$$

Boosting (cont.)

From Witten, Hastie, & Tibshirani (2017, p. 323):

1 Set $\hat{f}(x) = 0$ and $r_i = y_i$ for all i in the training set.

2 For $b = 1, 2, \dots, B$, repeat:

a. Fit a tree \hat{f}^b with d splits to the training data

b. Update \hat{f} by adding in a shrunk version of the new tree:

$$\hat{f}(x) \leftarrow \hat{f}(x) + \lambda \hat{f}^b(x)$$

c. Update the residuals:

$$r_i \leftarrow r_i - \lambda \hat{f}^b(x_i)$$

Boosting (cont.)

From Witten, Hastie, & Tibshirani (2017, p. 323):

1 Set $\hat{f}(x) = 0$ and $r_i = y_i$ for all i in the training set.

2 For $b = 1, 2, \dots, B$, repeat:

a. Fit a tree \hat{f}^b with d splits to the training data

b. Update \hat{f} by adding in a shrunk version of the new tree:

$$\hat{f}(x) \leftarrow \hat{f}(x) + \lambda \hat{f}^b(x)$$

c. Update the residuals:

$$r_i \leftarrow r_i - \lambda \hat{f}^b(x_i)$$

3 Output the boosted model:

$$\hat{f}(x) = \sum_{b=1}^B \lambda \hat{f}^b(x)$$

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OLS Results

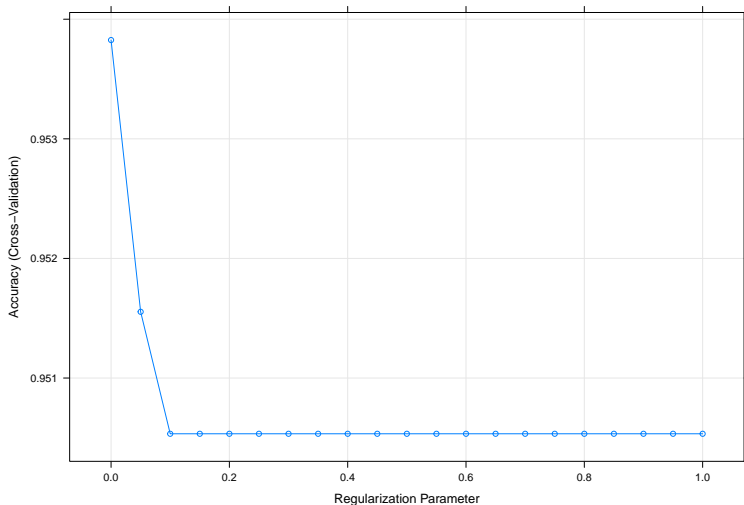
```
knitr::kable(elastic$results)
```

alpha	lambda	Accuracy	Kappa	AccuracySD	KappaSD
0.5	0.00	0.9538258	0.2739110	0.0015984	0.032127
0.5	0.05	0.9515538	0.0692769	0.0006297	0.018032
0.5	0.10	0.9505340	0.0000000	0.0000878	0.000000
0.5	0.15	0.9505340	0.0000000	0.0000878	0.000000
0.5	0.20	0.9505340	0.0000000	0.0000878	0.000000
0.5	0.25	0.9505340	0.0000000	0.0000878	0.000000
0.5	0.30	0.9505340	0.0000000	0.0000878	0.000000
0.5	0.35	0.9505340	0.0000000	0.0000878	0.000000
0.5	0.40	0.9505340	0.0000000	0.0000878	0.000000
0.5	0.45	0.9505340	0.0000000	0.0000878	0.000000
0.5	0.50	0.9505340	0.0000000	0.0000878	0.000000
0.5	0.55	0.9505340	0.0000000	0.0000878	0.000000
0.5	0.60	0.9505340	0.0000000	0.0000878	0.000000

summary(elastic\$results)

alpha	lambda	Accuracy	Ka
Min. :0.5	Min. :0.00	Min. :0.9505	Min.
1st Qu.:0.5	1st Qu.:0.25	1st Qu.:0.9505	1st Qu.
Median :0.5	Median :0.50	Median :0.9505	Median
Mean :0.5	Mean :0.50	Mean :0.9507	Mean
3rd Qu.:0.5	3rd Qu.:0.75	3rd Qu.:0.9505	3rd Qu.
Max. :0.5	Max. :1.00	Max. :0.9538	Max.
AccuracySD	KappaSD		
Min. :8.782e-05	Min. :0.000000		
1st Qu.:8.782e-05	1st Qu.:0.000000		
Median :8.782e-05	Median :0.000000		
Mean :1.856e-04	Mean :0.002389		
3rd Qu.:8.782e-05	3rd Qu.:0.000000		
Max. :1.598e-03	Max. :0.032128		

plot(elastic)



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OLS Results Discussion

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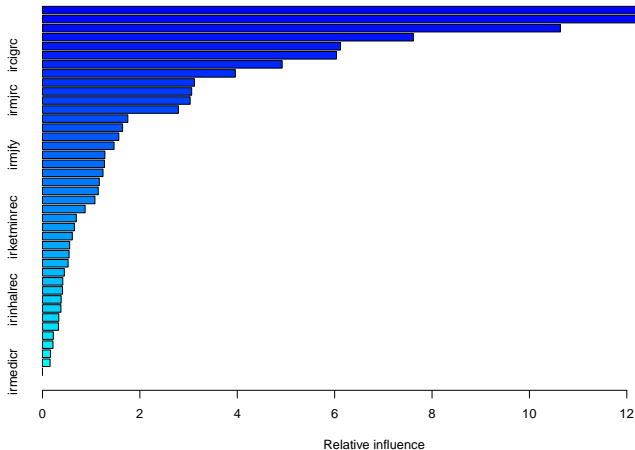
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What does this mean?

Our model is having a tough time predicting positive cases. We have a high accuracy rating, but this is because most cases are negative; our model is assuming most people are not seeking treatment, and so we are not explaining much variance.

Boosting Results

```
summary(boost$finalModel)
```



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```
summary(boost$results)
```

```
##      shrinkage      interaction.depth n.minobsinnode
## Min.      :0.010      Min.      :1.0      Min.      :10
## 1st Qu.:0.010      1st Qu.:1.0      1st Qu.:10
## Median :0.055      Median :1.5      Median :10
## Mean    :0.055      Mean    :1.5      Mean    :10
## 3rd Qu.:0.100      3rd Qu.:2.0      3rd Qu.:10
## Max.    :0.100      Max.    :2.0      Max.    :10
##      Accuracy      Kappa      AccuracySD
## Min.      :0.9505      Min.      :0.0000      Min.      :9.155e-
## 1st Qu.:0.9531      1st Qu.:0.1856      1st Qu.:1.217e-
## Median :0.9542      Median :0.2793      Median :2.122e-
## Mean    :0.9535      Mean    :0.2116      Mean    :1.610e-
## 3rd Qu.:0.9547      3rd Qu.:0.2897      3rd Qu.:2.207e-
## Max.    :0.9548      Max.    :0.3033      Max.    :2.421e-
```

Boosting Discussion

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Frequency of use is by far the best predictor of whether someone sought treatment.

Variable measuring frequency of Marijuana use and Heroin use are roughly equally important.

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- 1 Check the confusion matrix for the `glmnet` output

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- 1 Check the confusion matrix for the `glmnet` output
- 2 Recode some data to improve OLS (missing data is coded in a way which I suspect is skewing results)

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Works Cited

- 1 Check the confusion matrix for the `glmnet` output
- 2 Recode some data to improve OLS (missing data is coded in a way which I suspect is skewing results)
- 3 Get boosting to converge and examine PDPs.

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Resources (cont.)

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Resources (cont.)

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