National Human Services Data Consortium

2018 Spring Conference

Pittsburgh, PA

April 18-19, 2018

Analyzing Systemic Racial Disparities With Statistical Learning Models and HMIS Data

Clayton Aldern

Pierce County, Washington | caldern@co.pierce.wa.us

New Frontiers in Data

New Systems, Partners, and Technologies

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Alternate title:
Machine learning isn't special, but it can be useful

I. What is a statistical learning model?
II. Case study
III. Tools

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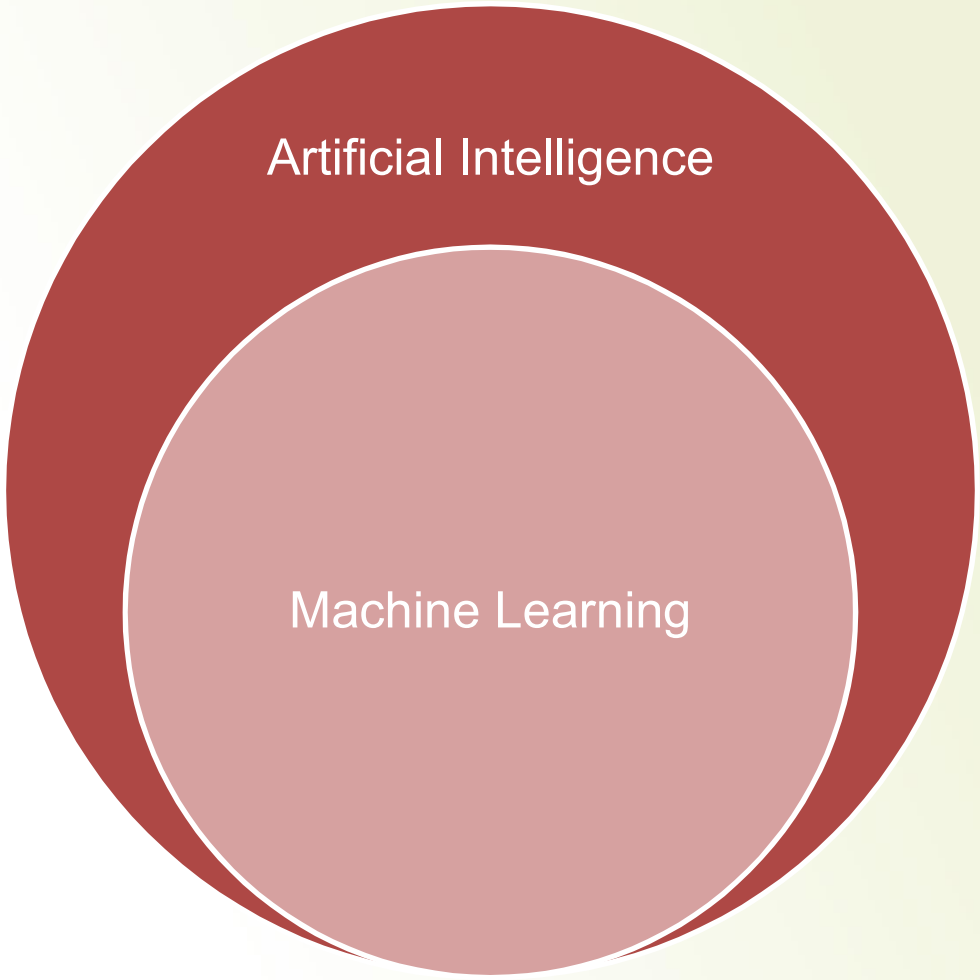

We say a machine "learns" if it improves its performance *P* on a task *T*, given some experience *E*

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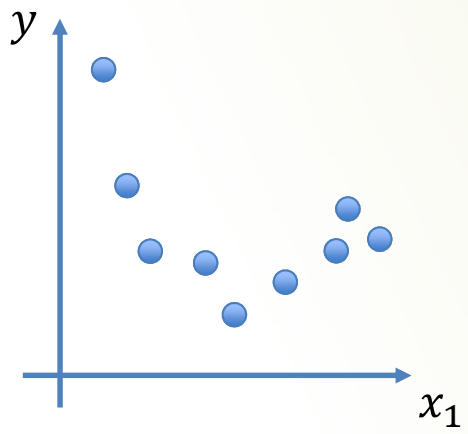

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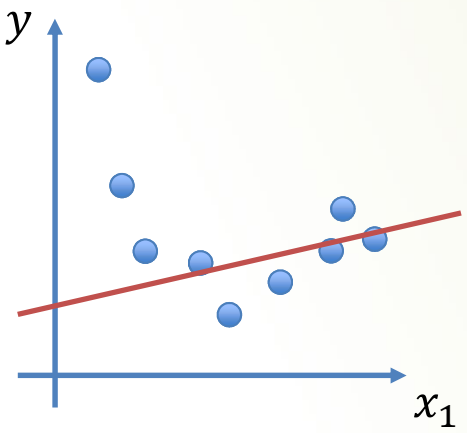

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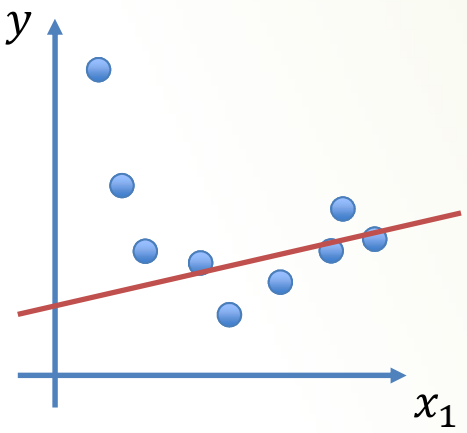

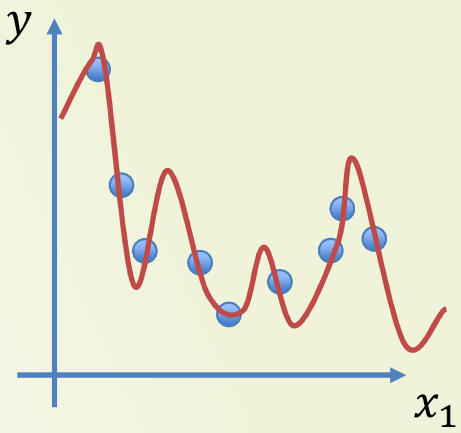

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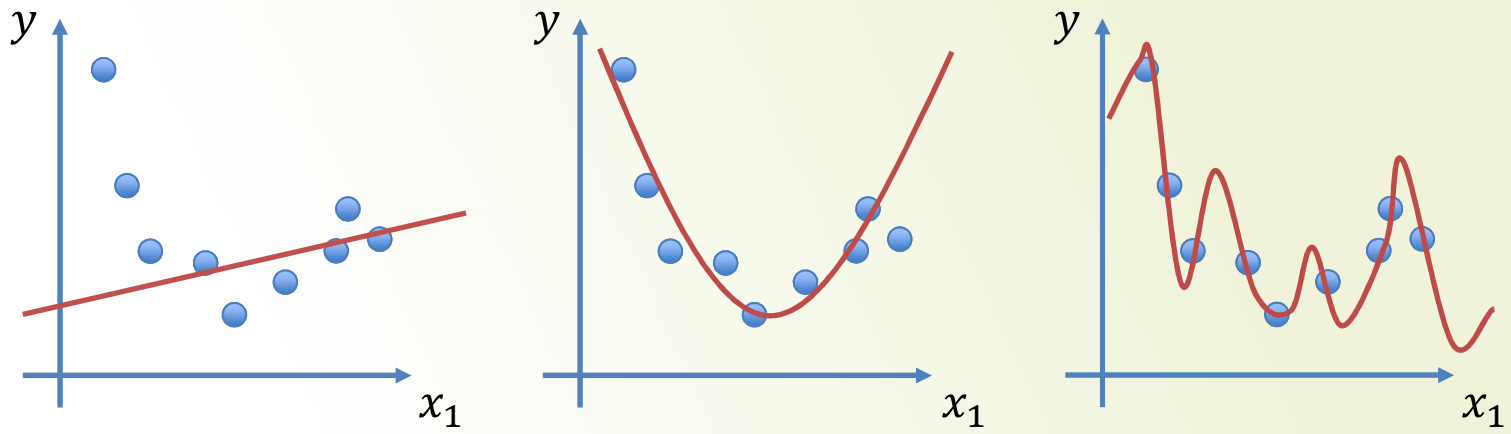

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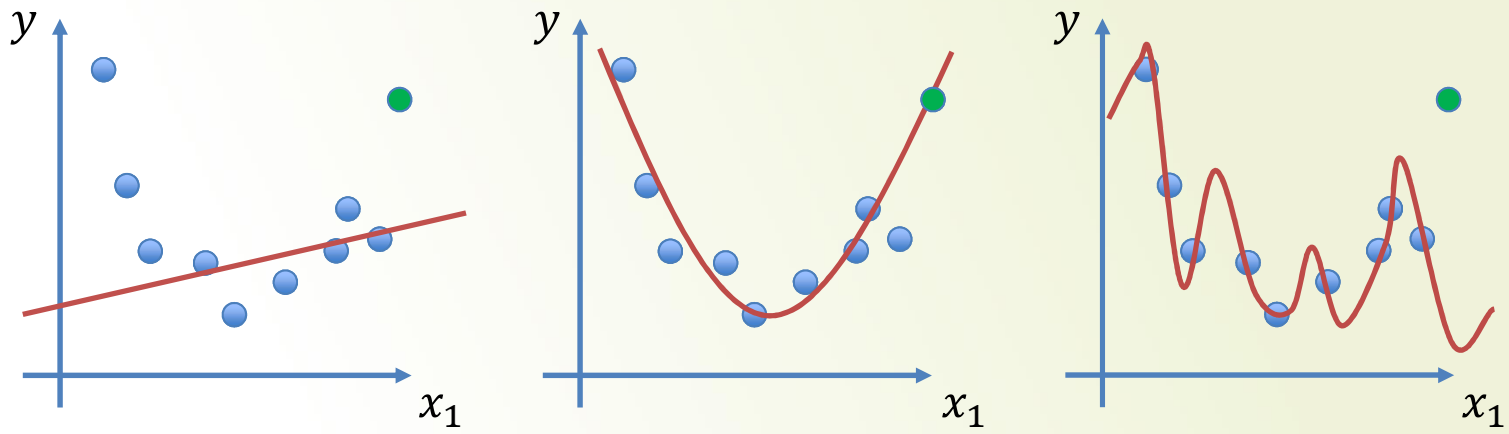

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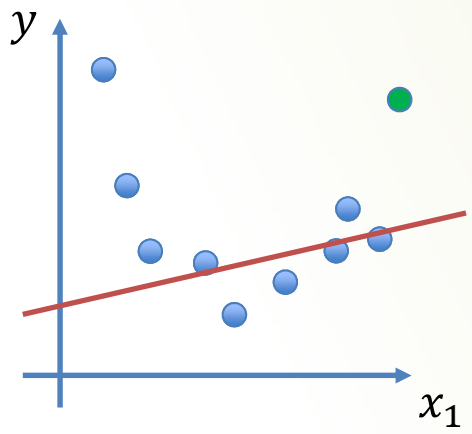

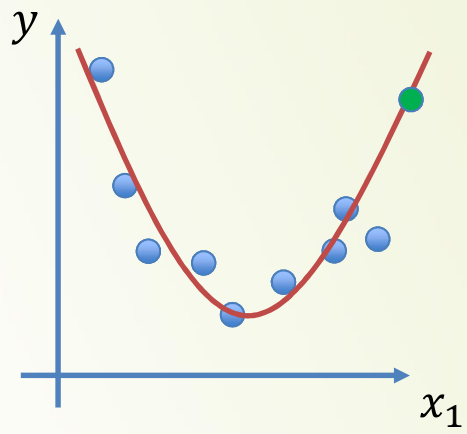

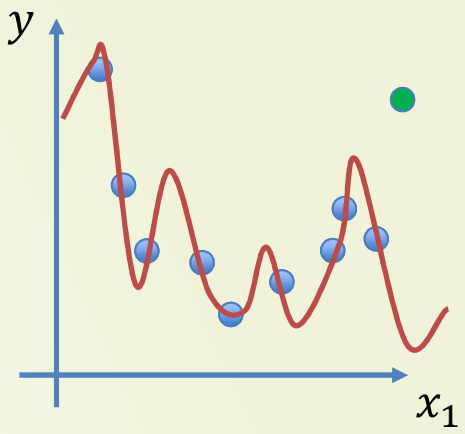

"underfitting"

"overfitting"

What are the goals of model selection?

I. Construct a good predictor. (Values of model coefficients are irrelevant.)
II. Give causal interpretations of the factors (and determine which variables are "important").

(Bickel and Li, 2006)

Motivating observations

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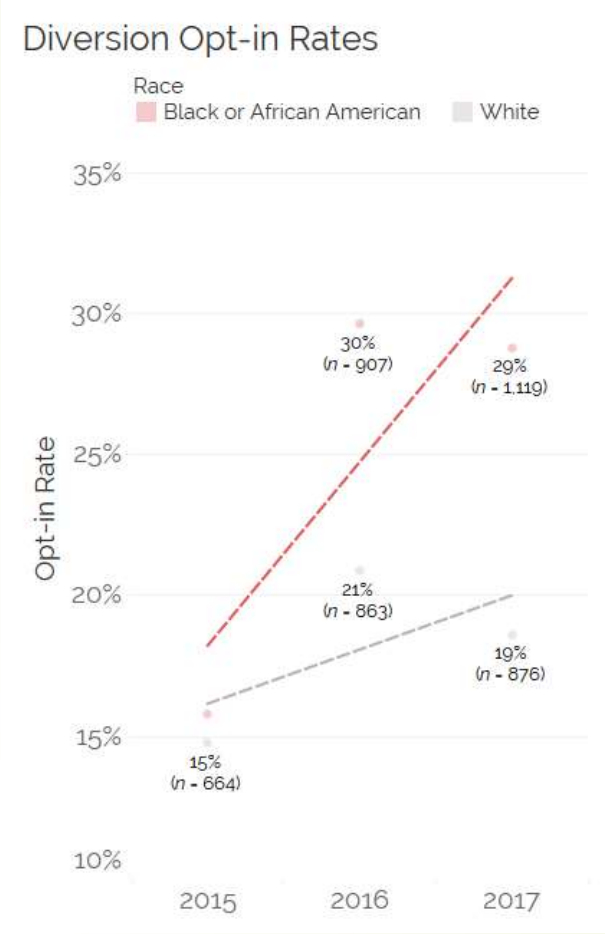

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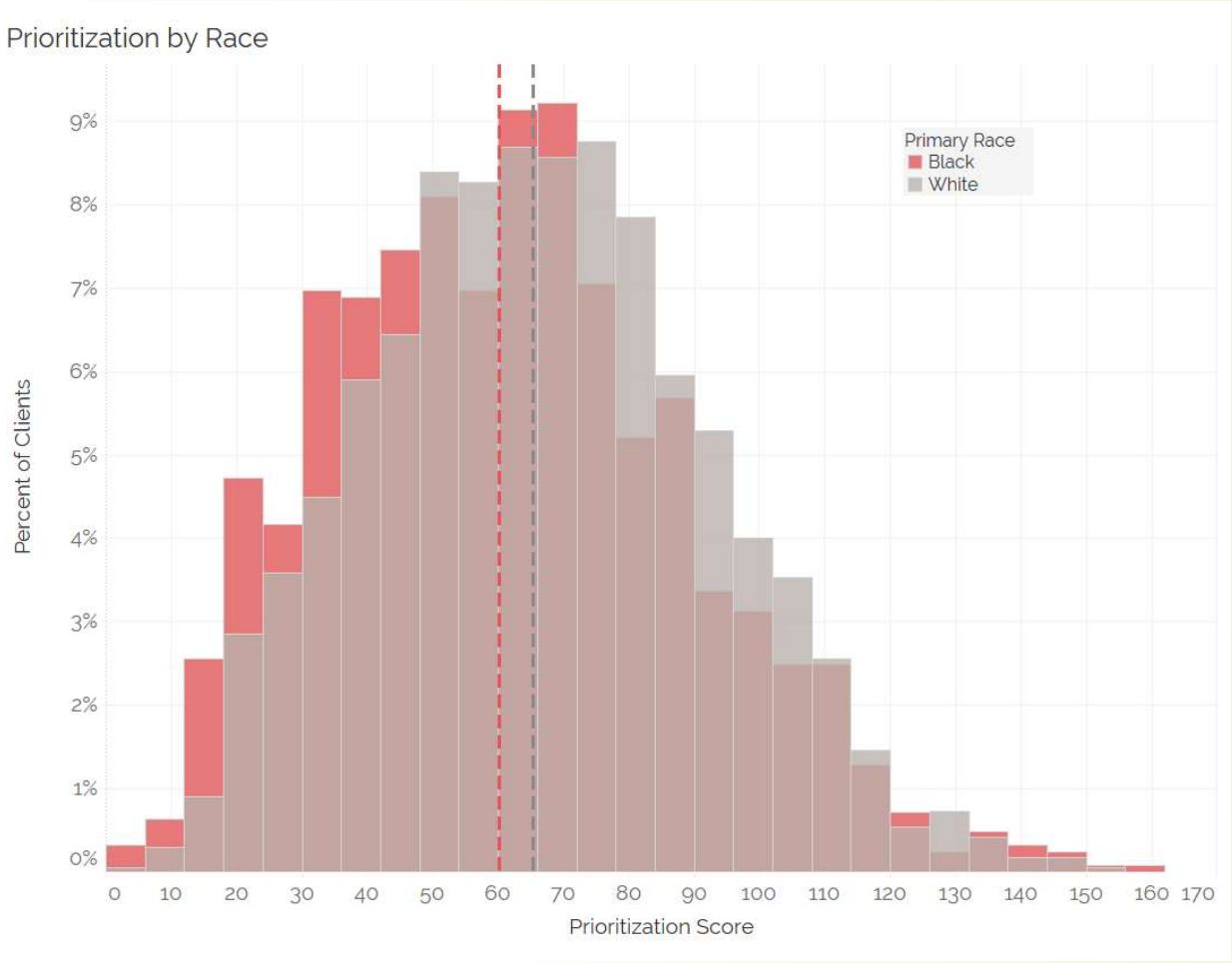

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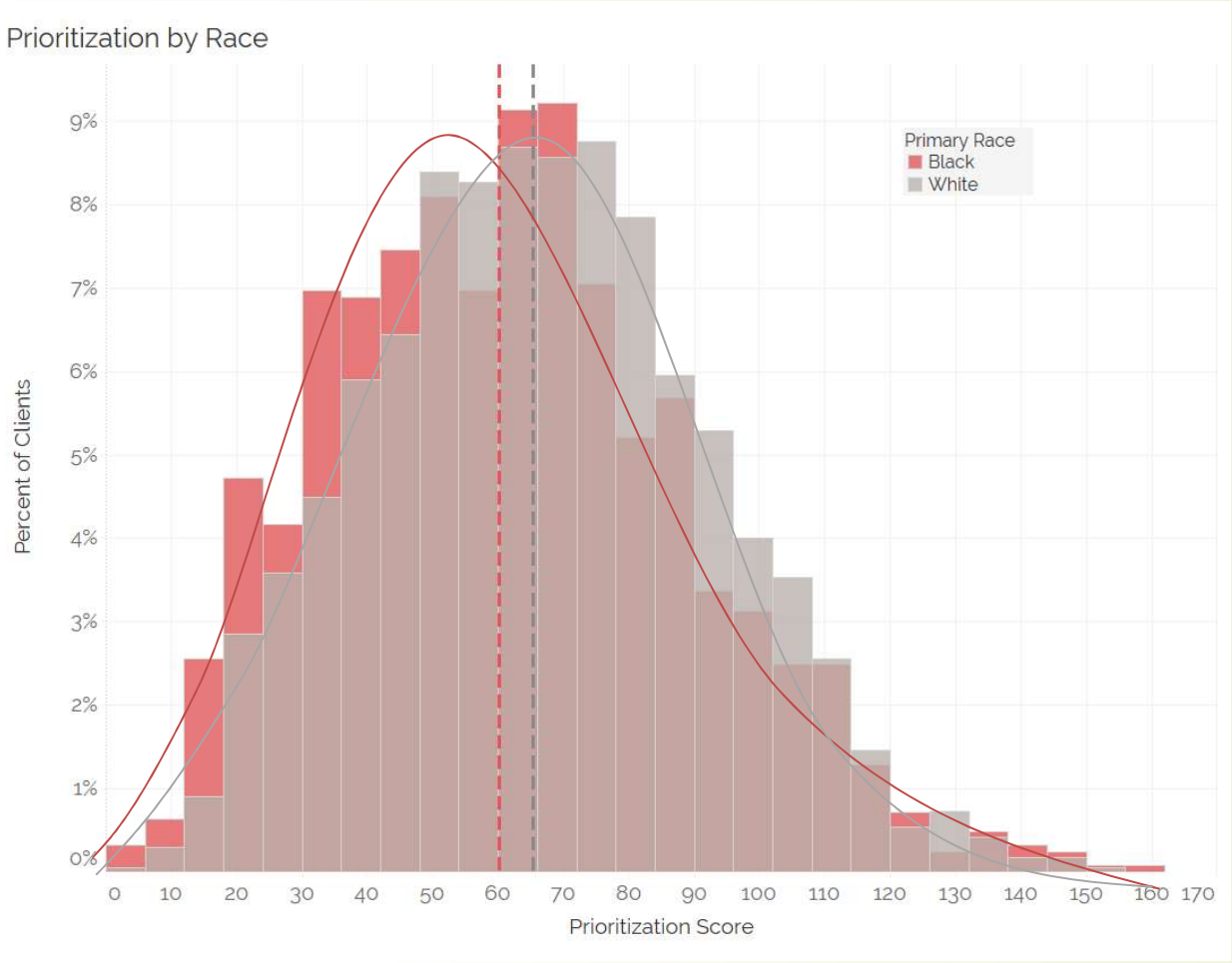

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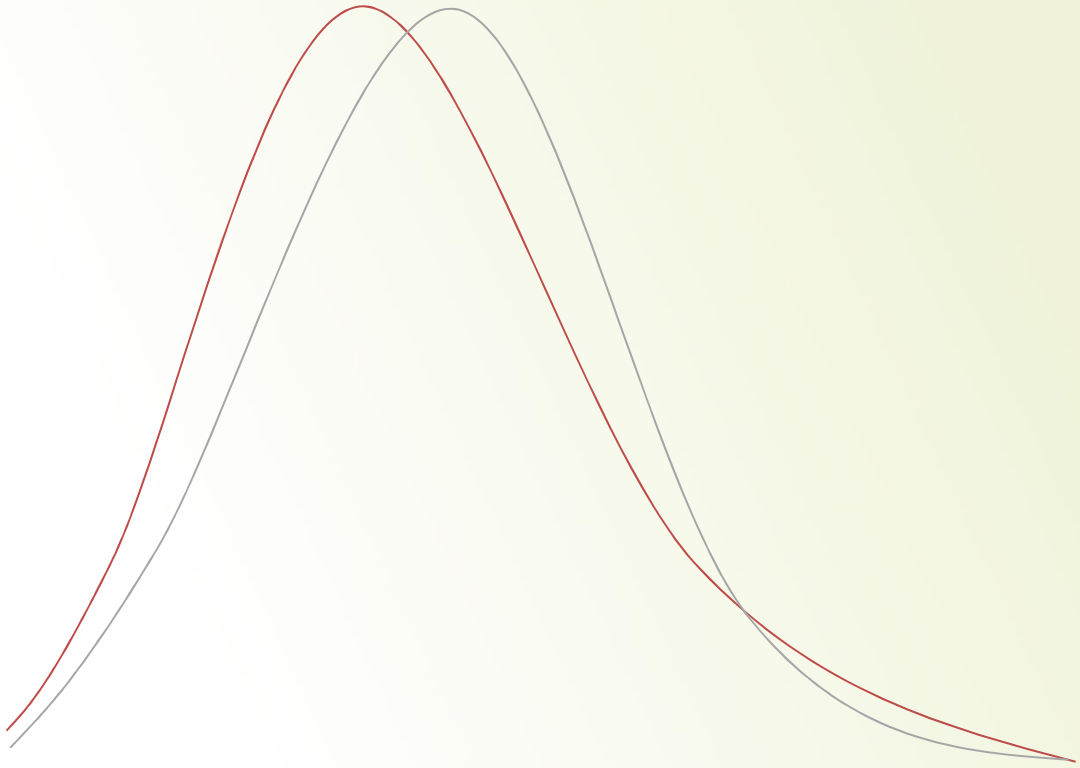

Which assessment questions and responses are significantly correlated with race?

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Which assessment questions and responses are significantly correlated with race?

Can we predict someone's race, given only their assessment responses?

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Race	Age	Gender	…	Medical conditions in household
White	54	Male	…	4+
Black	32	Female	…	2
Black	33	Male	…	1
…	…	…	…	…
White	35	Female	…	3

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Race	Age	Gender	…	medcon 1	medcon 2	medcon 3	medcon 4+
1	54	1	…	0	0	0	1
0	32	0	…	0	1	0	0
0	33	1	…	1	0	0	0
…	…	…	…	…	…	…	…
1	35	0	…	0	0	1	0

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y	x_1	x_2	...	x_{n-3}	x_{n-2}	x_{n-1}	x_n
1	54	1	...	0	0	0	1
0	32	0	...	0	1	0	0
0	33	1	...	1	0	0	0
...	...	...	...	...	...	...	...
1	35	0	...	0	0	1	0

$$y = \beta^T x$$

(linear regression)

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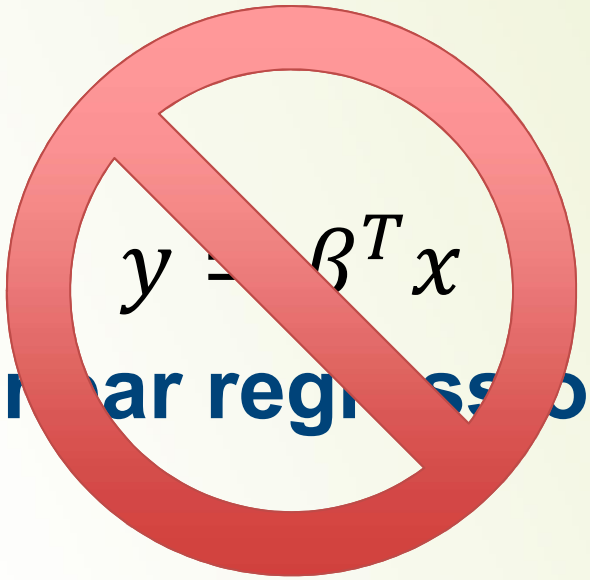

(linear regression)

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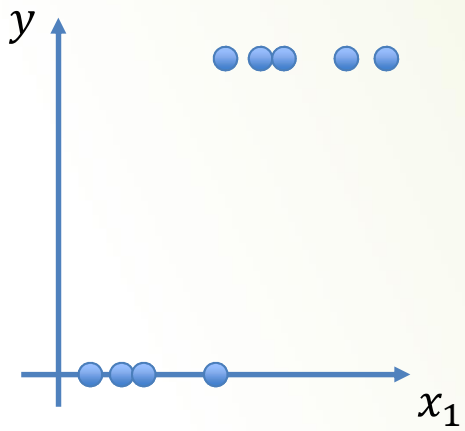

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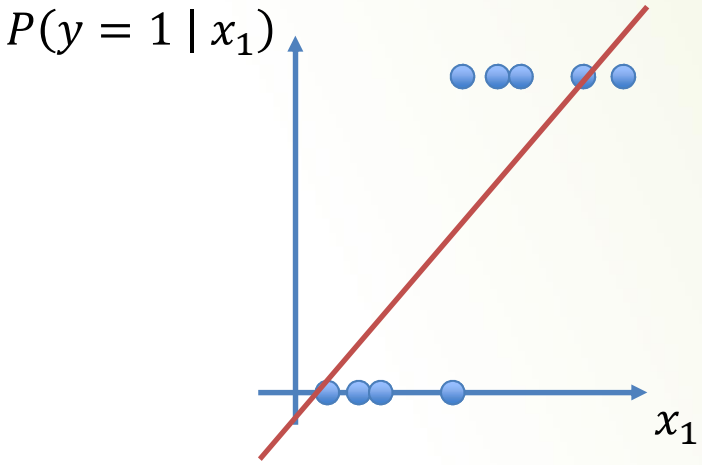

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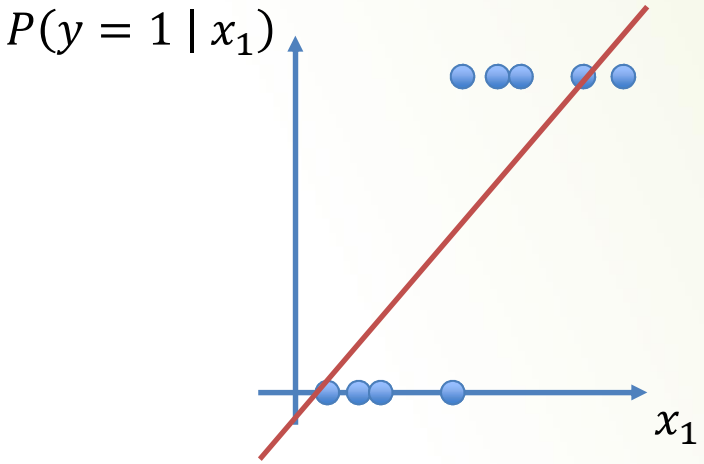

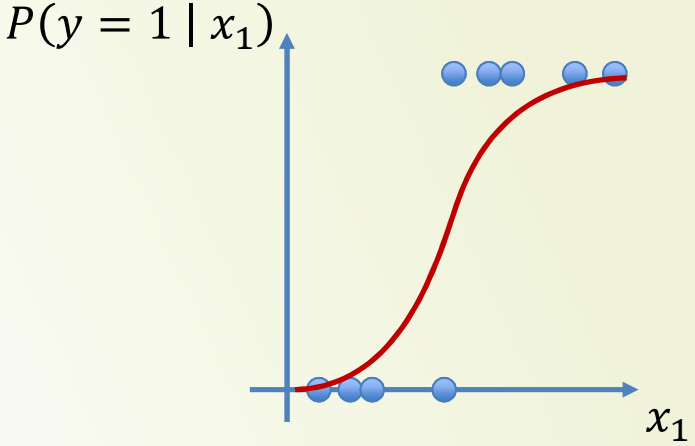

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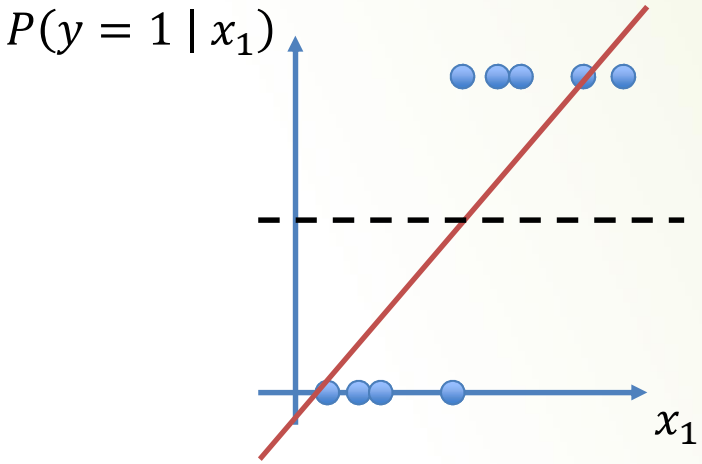

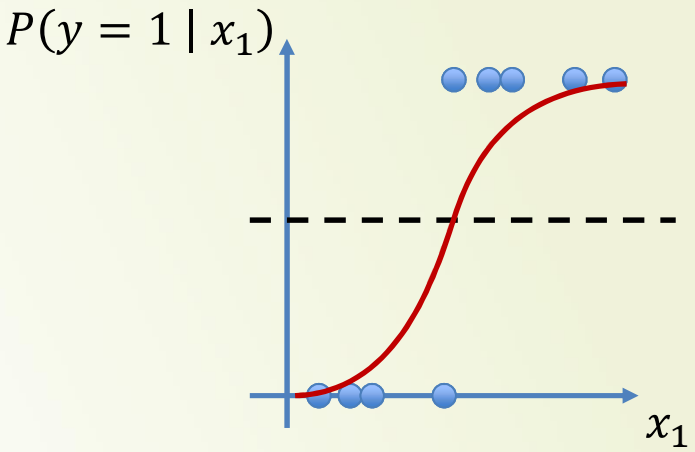

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$$P(y = 1 \mid x) = h_\beta(x) = \frac{1}{1 + e^{(-\beta^T X)}}$$

$$\log\left(\frac{P(y = 1 \mid x)}{1 - P(y = 1 \mid x)}\right) = \beta^T X$$

(logistic regression)

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$$P(y = 1 \mid x) = h_\beta(x) = \frac{1}{1 + e^{(-\beta^T X)}}$$

$$\log\left(\frac{P_{White}(x)}{P_{Black}(x)}\right) = \beta^T X$$

(logistic regression)

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$$\min_{\beta}\left\{-\frac{1}{m}\sum_{i=1}^{m}\left[y_i\log\left(h_\beta(x_i)\right)+(1-y_i)\log\left(1-h_\beta(x_i)\right)\right]+\frac{\lambda}{2m}\sum_{j=1}^{n}\left(\alpha\left|\beta_j\right|+(1-\alpha)\beta_j^2\right)\right\}$$

(logistic regression cost function with elastic net regularization)

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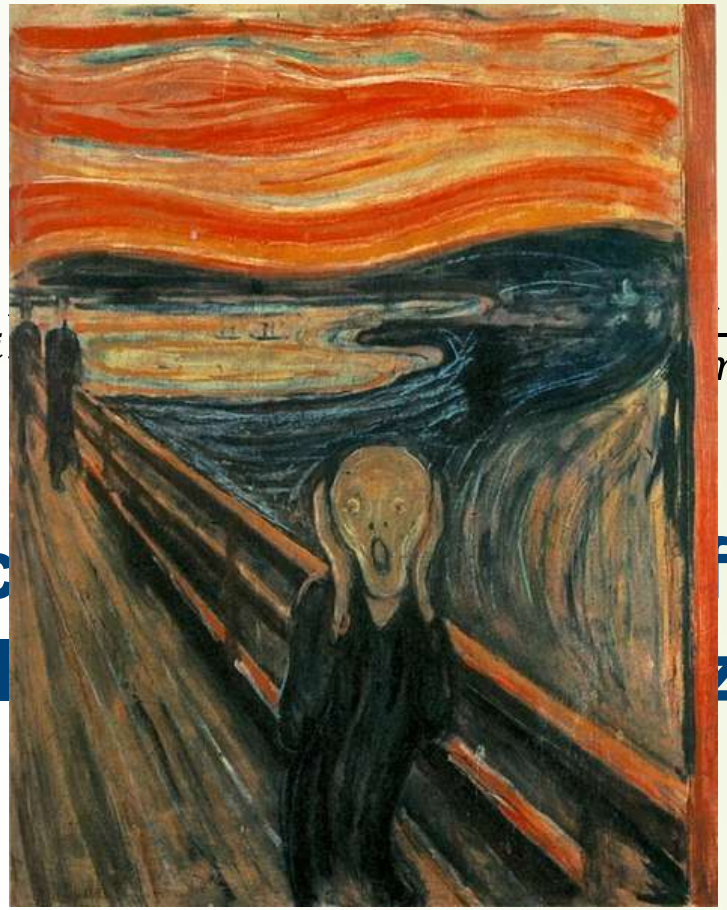
$$\min_{\beta}\left\{-\frac{1}{m}\sum_{i=1}^{m}\left[y_i \log\left(h_\beta(x_i\right)\right.\right. \qquad \frac{}{n}\sum_{j=1}^{n}\left(\alpha\left|\beta_j\right| + (1-\alpha)\beta_j^2\right)\right\}$$



(logistic function
with el zation)

error complexity

$$\min_{\beta}\left\{-\frac{1}{m}\sum_{i=1}^{m}\left[y_i\log\left(h_\beta(x_i)\right)+(1-y_i)\log\left(1-h_\beta(x_i)\right)\right]+\frac{\lambda}{2m}\sum_{j=1}^{n}\left(\alpha\left|\beta_j\right|+(1-\alpha)\beta_j^2\right)\right\}$$

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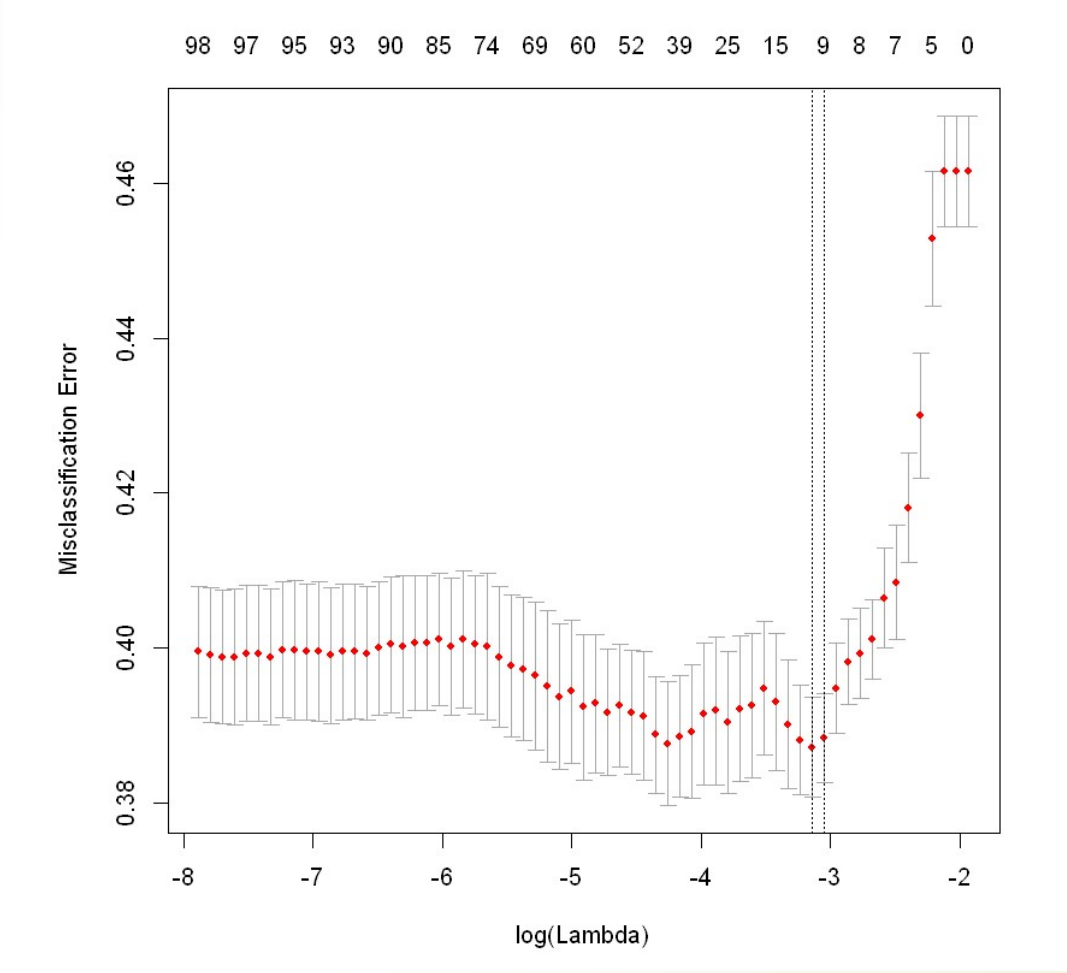

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name	*coefficient*	*odds ratio*
(Intercept)	-0.34	0.71
Age	0.01	1.01
Feelings of safety: I don't often feel safe.	-0.02	0.98
Feelings of safety: I usually feel safe.	0.12	1.13
Household AMI <10%	0.15	1.16
Household AMI 30–50%	-0.14	0.87
Disabled: No	-0.10	0.91
Disabled: Yes	0.08	1.09
Medical conditions in household: 0	-0.22	0.80
Medical conditions in household: 4+	0.28	1.32

What is the definition of vulnerability?

From p-values to predictors

- Books
  - *An Introduction to Statistical Learning with Applications in R*
  - free Machine Learning courses online (Ng)
  - *The Elements of Statistical Learning*
  - *Deep Learning* (deeplearningbook.org)
- Computing languages
  - R, Python, Octave, etc.
- Packages
  - R: glmnet; Python: scikit-learn

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a little
amount of math
a lot

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Thank you!

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