An assessment of racial disparities in pretrial decision-making using misclassification models

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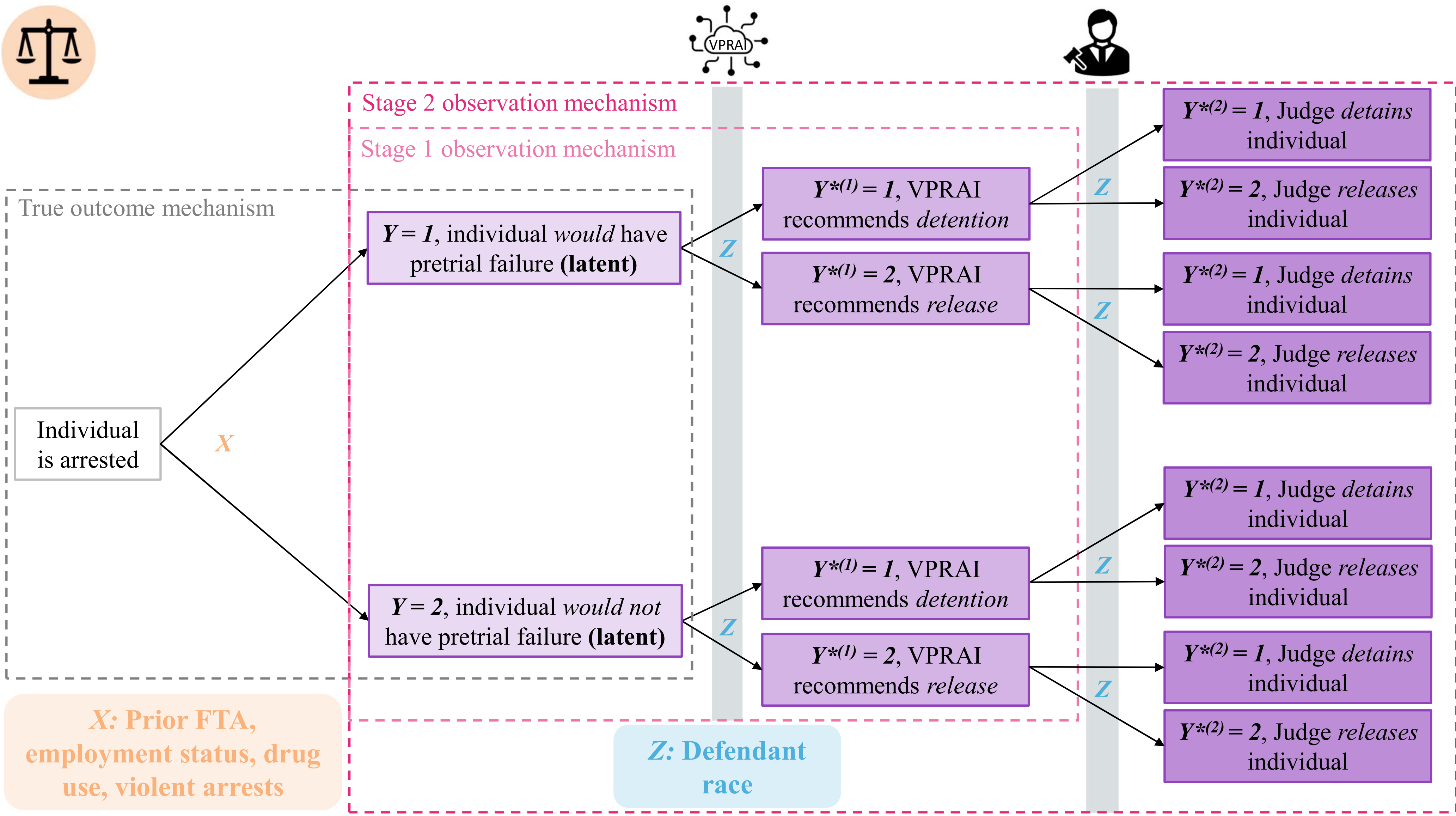
Joint Statistical Meetings – August 4, 2024

Problem setting

- **Goal:** Study **algorithmic bias** in **pretrial risk assessment**.
  - **Pretrial risk assessment algorithms** provide an evaluation of the likelihood of **"pretrial failure"**.
  - Used by judges at arraignment to determine whether to release or detain defendants pending trial.
  - What are **risk factors** for pretrial failure? Are judges and risk assessments **accurate**? Are they **biased**?

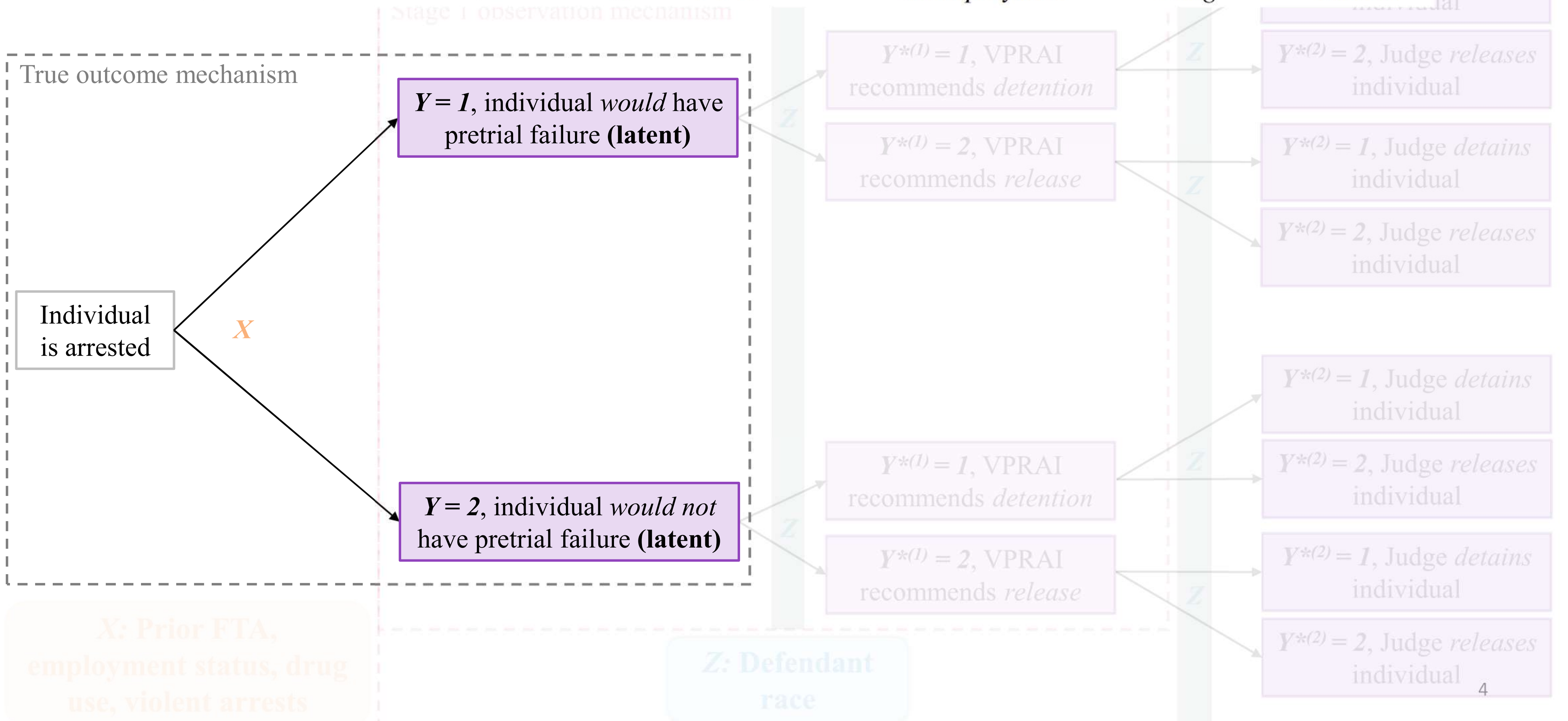
Pretrial failure: Reoffending before trial or failing to appear for trial

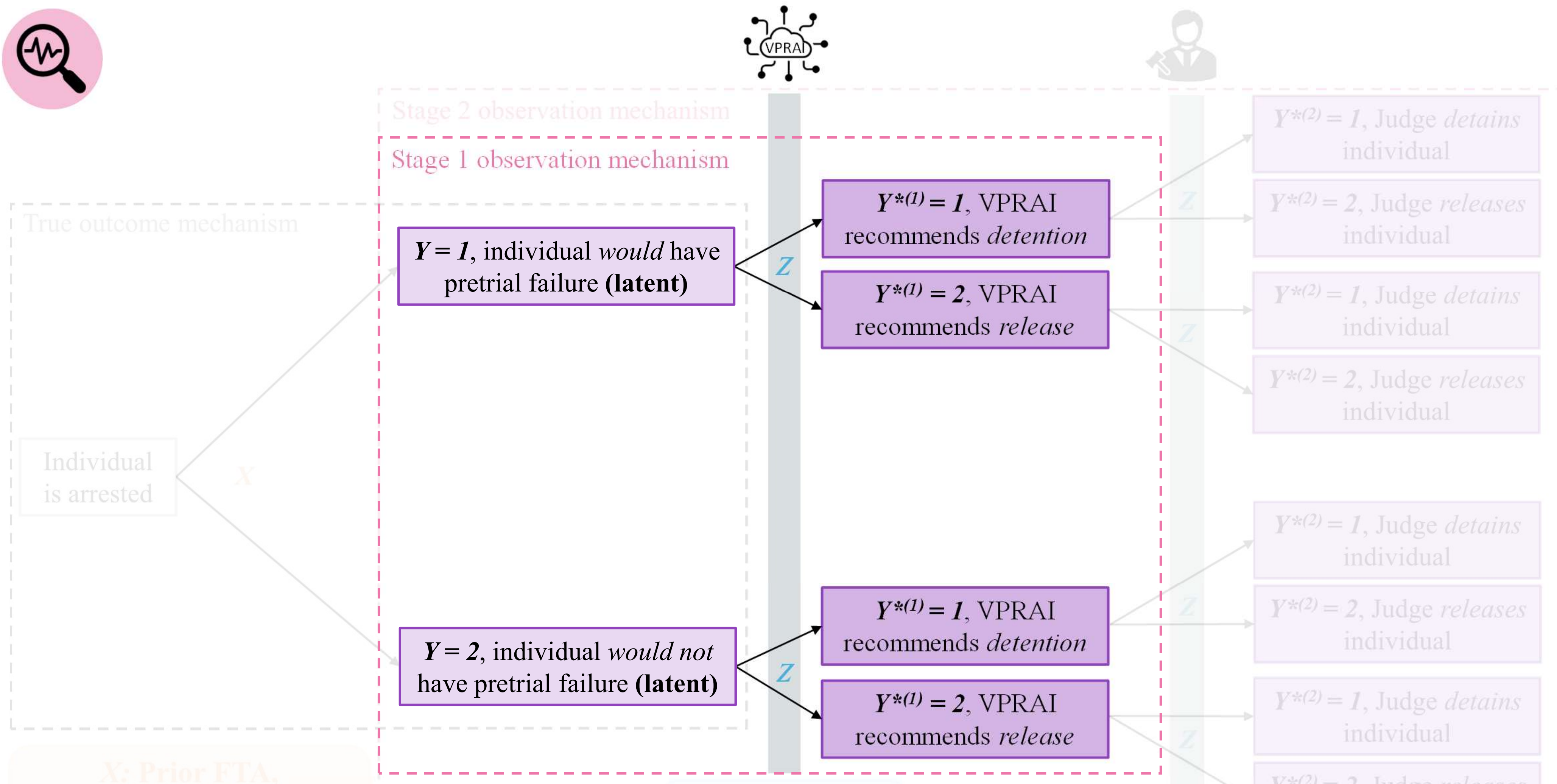
- **Method:** Develop misclassification modeling approach, incorporating the "two stage" nature of this system.



VPRAI
Stage 2 observation mechanism
Stage 1 observation mechanism
True outcome mechanism
Individual is arrested
X
Y = 1, individual would have pretrial failure (latent)
Y = 2, individual would not have pretrial failure (latent)
Z
Y*(1) = 1, VPRAI recommends detention
Y*(1) = 2, VPRAI recommends release
Y*(2) = 1, Judge detains individual
Y*(2) = 2, Judge releases individual
X: Prior FTA, employment status, drug use, violent arrests
Z: Defendant race

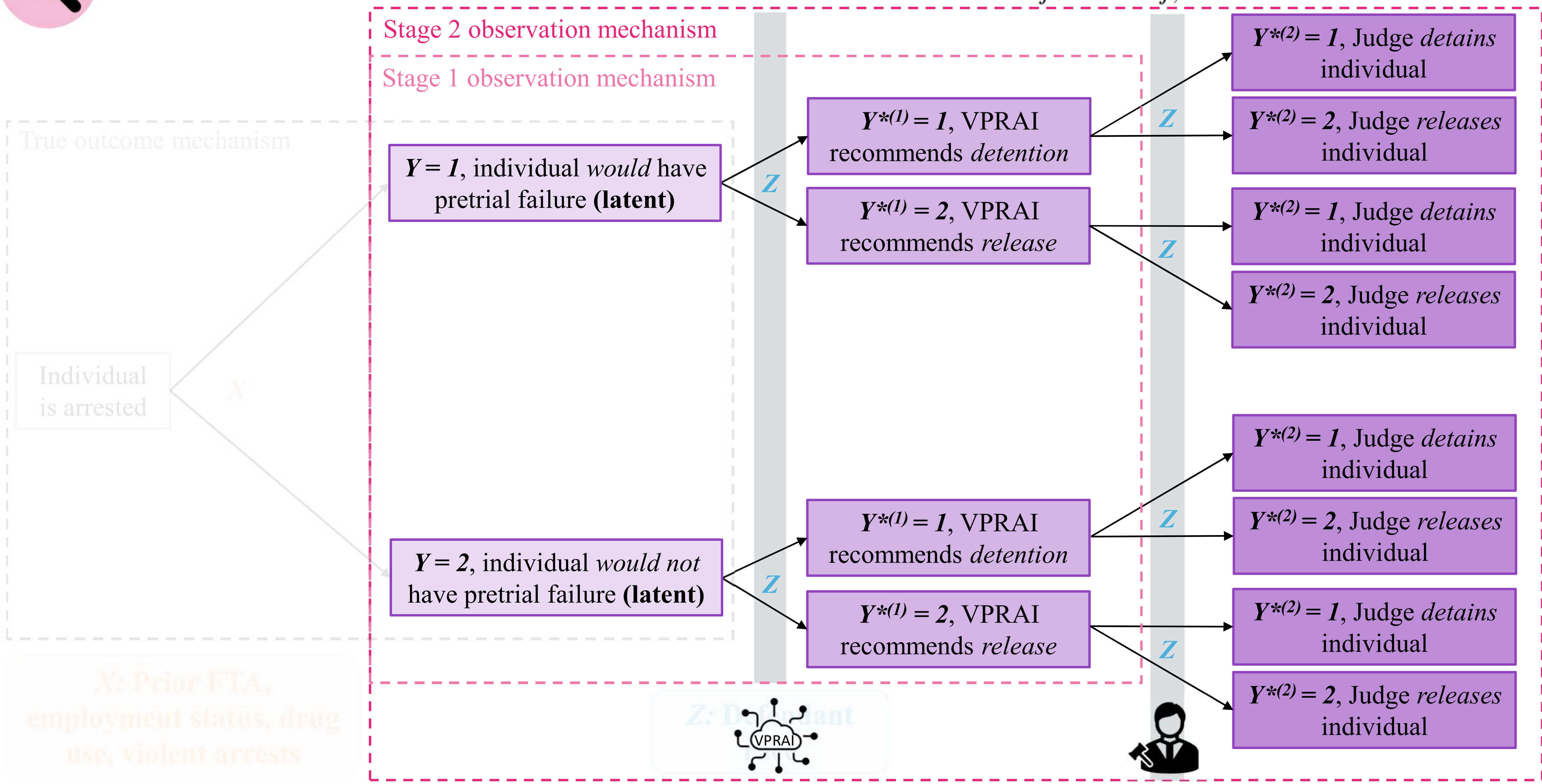
$$\text{logit}\{P(Y=1|\boldsymbol{X};\boldsymbol{\beta})\} = \beta_0 + \beta_{FTA}\text{FTA} + \beta_{unemployed}\text{E} + \beta_{drug}\text{D} + \beta_{violent}\text{V}$$





$$\text{logit}\{P(Y^{*(1)} = 1 | Y = j, \mathbf{Z}^{(1)}; \gamma)\} = \gamma_{1j0}^{(1)} + \gamma_{1j,race}^{(1)}\text{RACE}$$

$$\text{logit}\{P(Y^{*(2)} = 1 | Y^{*(1)} = k, Y = j, \boldsymbol{Z}^{(2)}; \boldsymbol{\gamma})\} = \gamma_{1kj0}^{(2)} + \gamma_{1kj,race}^{(2)}\text{RACE}$$



Primary interest: Estimating β

Secondary interest: Estimating γ

True outcome mechanism:

$$\text{logit}\{P(Y=1|\boldsymbol{X};\boldsymbol{\beta})\} = \beta_0 + \beta_{FTA}\text{FTA} + \beta_{unemployed}\text{E} + \beta_{drug}\text{D} + \beta_{violent}\text{V}$$

Stage 1 (VPRAI) observation mechanism:

$$\text{logit}\{P(Y^{*(1)}=1|Y=j,\boldsymbol{Z}^{(\mathbf{1})};\boldsymbol{\gamma})\} = \gamma^{(1)}_{1j0} + \gamma^{(1)}_{1j,race}\text{RACE}$$

Stage 2 (Judge) observation mechanism:

$$\text{logit}\{P(Y^{*(2)}=1|Y^{*(1)}=k,Y=j,\boldsymbol{Z}^{(\mathbf{2})};\boldsymbol{\gamma})\} = \gamma^{(2)}_{1kj0} + \gamma^{(2)}_{1kj,race}\text{RACE}$$

Primary interest: Estimating β

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Estimation methods

- Proposed **EM algorithm**
- Bayesian methods (**MCMC**)

Complete data log-likelihood

- **Y (true pretrial failure status)** is a latent variable, but let's pretend we know it:

$$\ell_{complete}(\boldsymbol{\beta}, \boldsymbol{\gamma}; \boldsymbol{X}, Z^{(1)}, Z^{(2)}) = \sum_{i=1}^{N} \Big[\sum_{j=1}^{2} y_{ij} \log\{P(Y_i = j | \boldsymbol{X}_i)\}$$

True outcome mechanism

Stage 1 (VPRAI) observation mechanism

$$+ \sum_{j=1}^{2} \sum_{k=1}^{2} y_{ij} y_{ik}^{*(1)} \log\{P(Y_i^{*(1)} = k | Y_i = j, Z^{(1)})\}$$

Stage 2 (Judge) observation mechanism

$$+ \sum_{j=1}^{2} \sum_{k=1}^{2} \sum_{\ell=1}^{2} y_{ij} y_{ik}^{*(1)} y_{i\ell}^{*(2)} \log\{P(Y_i^{*(2)} = \ell | P(Y_i^{*(1)} = k, Y_i = j, Z^{(1)})\} \Big]$$

Estimation: EM algorithm

Expectation Step ⟷ **Maximization Step**

$$w_{ij} = P(Y_i = j | Y_i^{*(2)}, Y_i^{*(1)}, \boldsymbol{X}, Z^{(1)}, Z^{(2)})$$

$$\begin{aligned} Q = \sum_{i=1}^{N} \Big[& \sum_{j=1}^{2} w_{ij} \log\{P(Y_i = j | \boldsymbol{X}_i)\} \\ & + \sum_{j=1}^{2} \sum_{k=1}^{2} w_{ij} y_{ik}^{*(1)} \log\{P(Y_i^{*(1)} = k | Y_i = j, Z^{(1)})\} \\ & + \sum_{j=1}^{2} \sum_{k=1}^{2} \sum_{\ell=2}^{2} w_{ij} y_{ik}^{*(1)} y_{i\ell}^{*(2)} \log\{P(Y_i^{*(2)} = \ell | Y_i^{*(1)} = k, Y_i = j, Z^{(1)})\Big] \end{aligned}$$

“Fill in” the latent outcome:
Given the parameters and other data, compute the probability of **pretrial failure** for each subject.

Update estimates:
Replace the ***y* terms** in the likelihood with the E-step weights and then **maximize**.

Estimation: EM algorithm

Expectation Step

Maximization Step

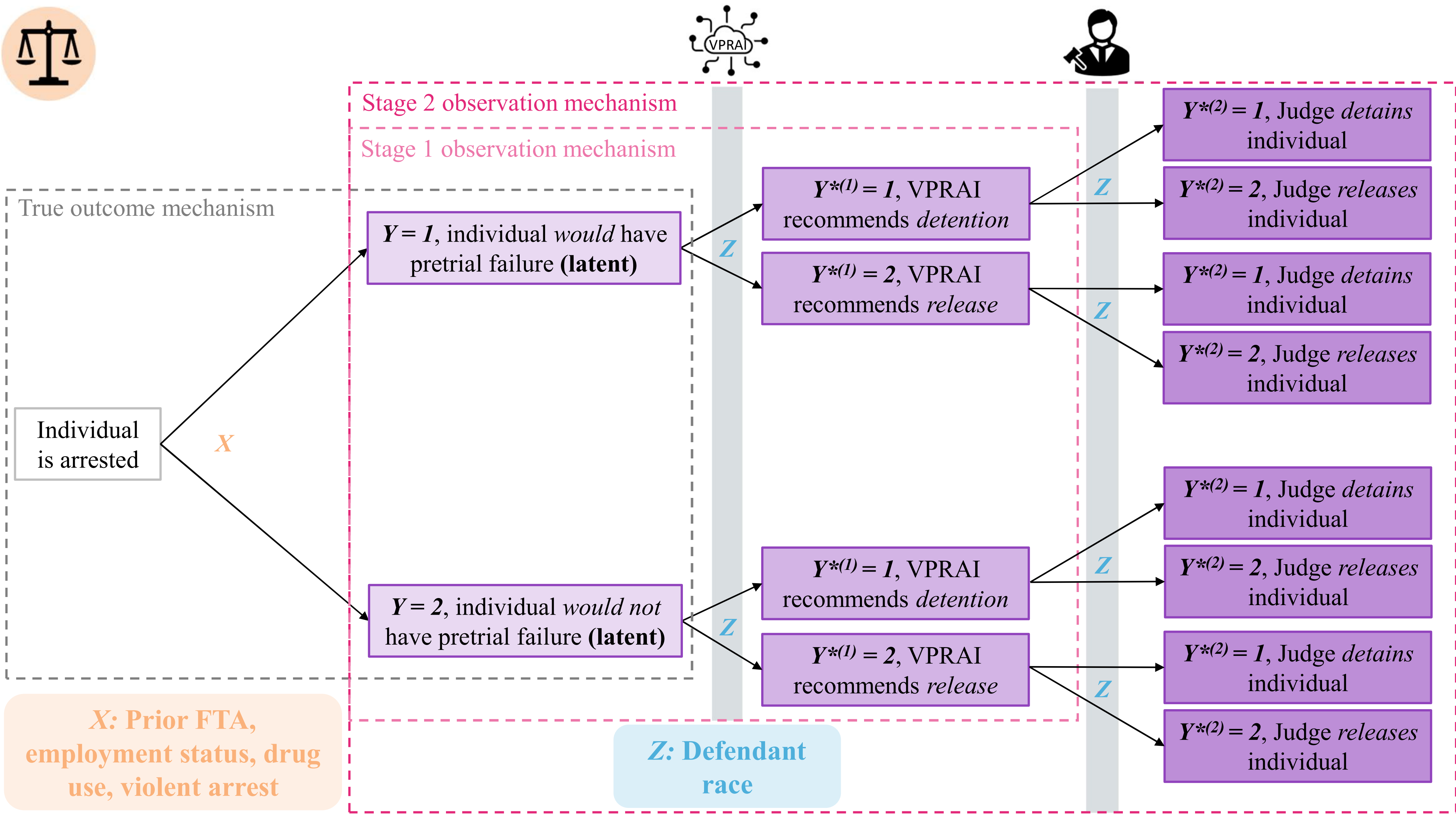
$$w_{ij} = P(Y_i = j \mid Y_i^{*(2)}, Y_i^{*(1)}, \boldsymbol{X}, Z^{(1)}, Z^{(2)})$$

$$\begin{aligned} Q = \sum_{i=1}^{N} \Big[& \sum_{j=1}^{2} w_{ij} \log\{P(Y_i = j \mid \boldsymbol{X}_i)\} \\ & + \sum_{j=1}^{2} \sum_{k=1}^{2} w_{ij} y_{ik}^{*(1)} \log\{P(Y_i^{*(1)} = k \mid Y_i = j, Z^{(1)}) \\ & + \sum_{j=1}^{2} \sum_{k=1}^{2} \sum_{\ell=2}^{2} w_{ij} y_{ik}^{*(1)} y_{i\ell}^{*(2)} \log\{P(Y_i^{*(2)} = \ell \mid Y_i^{*(1)} = k, Y_i = j, Z^{(1)}) \Big] \end{aligned}$$

Apply the label switching correction

Estimates of β

Estimates of γ



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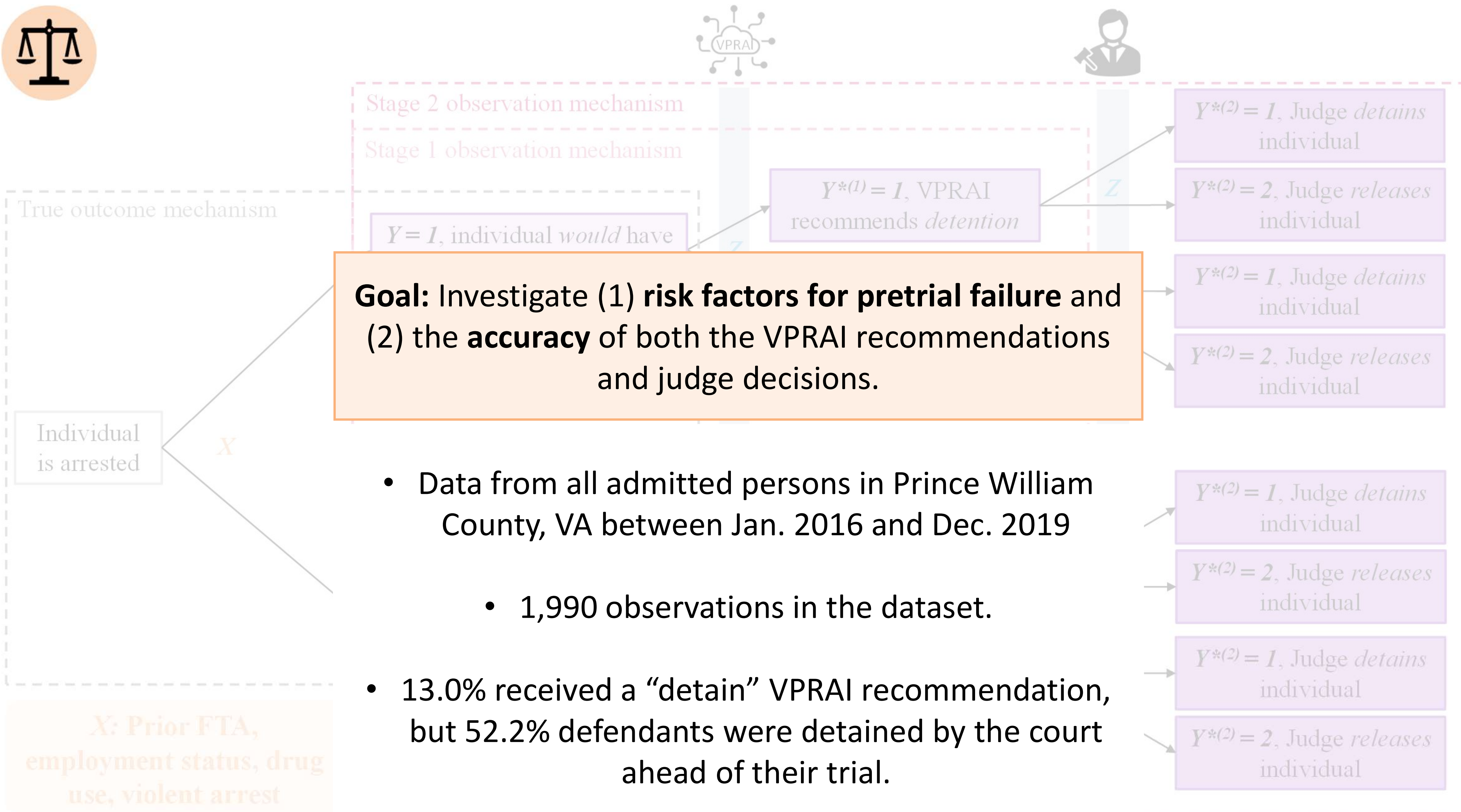


Goal: Investigate (1) **risk factors for pretrial failure** and (2) the **accuracy** of both the VPRAI recommendations and judge decisions.

- Data from all admitted persons in Prince William County, VA between Jan. 2016 and Dec. 2019
- 1,990 observations in the dataset.
- 13.0% received a “detain” VPRAI recommendation, but 52.2% defendants were detained by the court ahead of their trial.

True outcome mechanism:

$$\mathrm{logit}\{P(Y=1|\boldsymbol{X};\boldsymbol{\beta})\} = \beta_0 + \beta_{FTA}\mathrm{FTA} + \beta_{unemployed}\mathrm{E} + \beta_{drug}\mathrm{D} + \beta_{violent}\mathrm{V}$$

	EM Algorithm		**Naïve Analysis**	
	Est.	SE	Est.	SE
β_{FTA}	1.22	0.22	1.02	0.13
$\beta_{\text{unemployed}}$	0.73	0.06	0.67	0.15
β_{drug}	1.97	0.13	1.74	0.17
β_{violent}	0.28	0.02	0.26	0.03

Association between risk factors and pretrial failure is generally attenuated when misclassification in the VPRAI and judge decisions is *not* accounted for.

Stage 1 (VPRAI) observation mechanism:

$$\mathrm{logit}\{P(Y^{*(1)}=1|Y=j,\boldsymbol{Z}^{(1)};\boldsymbol{\gamma})\}=\gamma_{1j0}^{(1)}+\gamma_{1j,race}^{(1)}\mathrm{RACE}$$

	Estimated VPRAI Specificity P(Release | *Would not* have pretrial failure)	**Estimated VPRAI Sensitivity** P(Detain | *Would* have pretrial failure)
White defendant	100%	49.3%
Black defendant	99.3%	86.0%

Stage 2 (Judge) observation mechanism:

$$\text{logit}\{P(Y^{*(2)} = 1 | Y^{*(1)} = k, Y = j, \boldsymbol{Z}^{(\mathbf{2})}; \boldsymbol{\gamma})\} = \gamma^{(2)}_{1kj0} + \gamma^{(2)}_{1kj,race}\text{RACE}$$

	Estimated Judge Specificity P(Release | *Would not* have pretrial failure)	**Estimated Judge Sensitivity** P(Detain | *Would* have pretrial failure)
White defendant	60.3%	76.8%
Black defendant	48.6%	88.8%

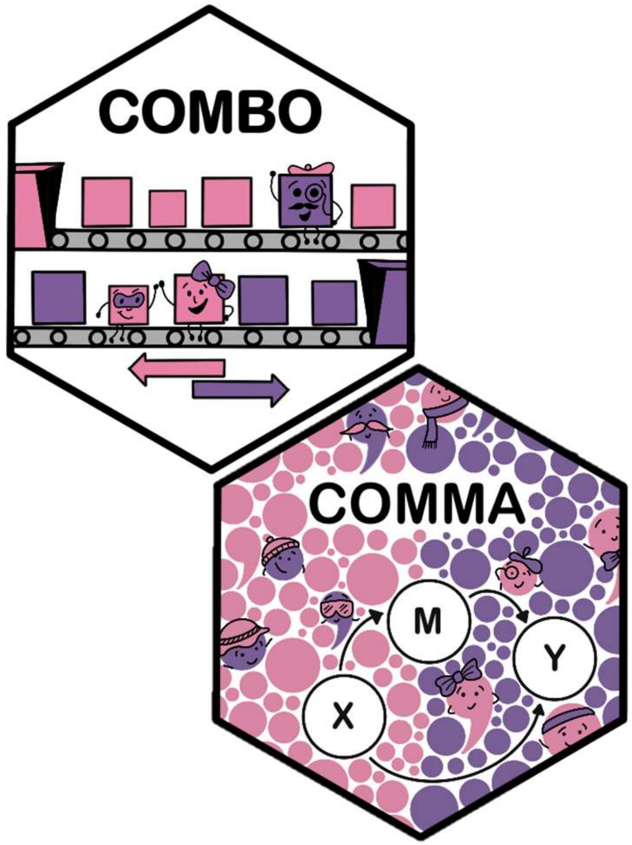
Key takeaways

- Developed new methods for handling misclassified sequential and dependent binary outcome variables.
- Used these methods to estimate misclassification rates when algorithms and judges predict pretrial failure risk.

Software

- Estimation methods for **misclassified outcomes** are available in the *COMBO* R Package on CRAN.
    - **Co**rrecting **M**isclassified **B**inary **O**utcomes

- Estimation methods for **misclassified mediators** are in the *COMMA* R Package on CRAN.
    - **Co**rrecting **M**isclassified **M**ediation **A**nalysis



Thank you!

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Cornell University Founded A.D. 1865

Cornell Bowers CIS

Statistics and Data Science

University of Pittsburgh

arXiv paper:

arxiv.org/abs/2309.08599

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