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

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Joint Statistical Meetings – August 4, 2024

Problem setting

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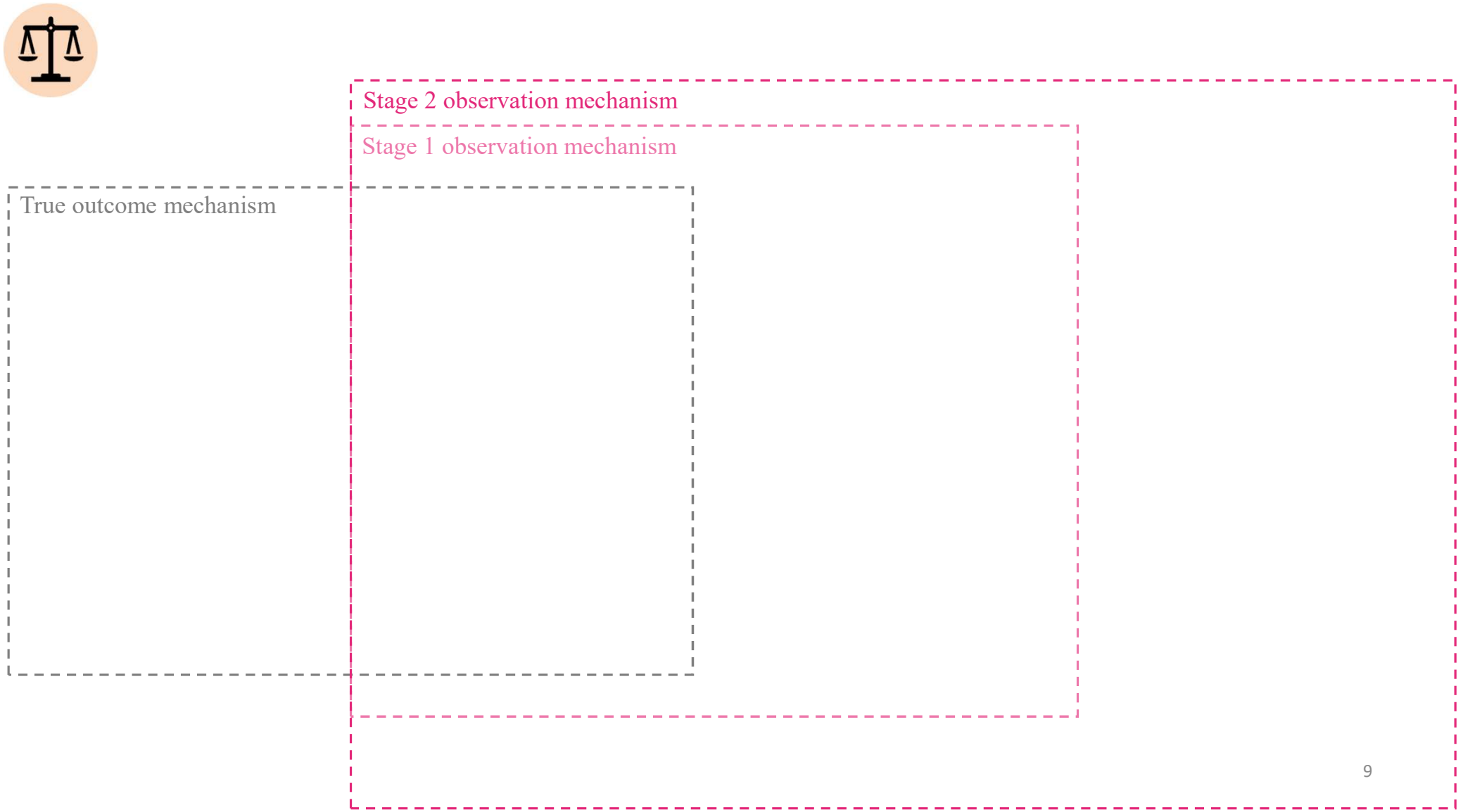
- **Method:** Develop misclassification modeling approach, incorporating the "two stage" nature of this system.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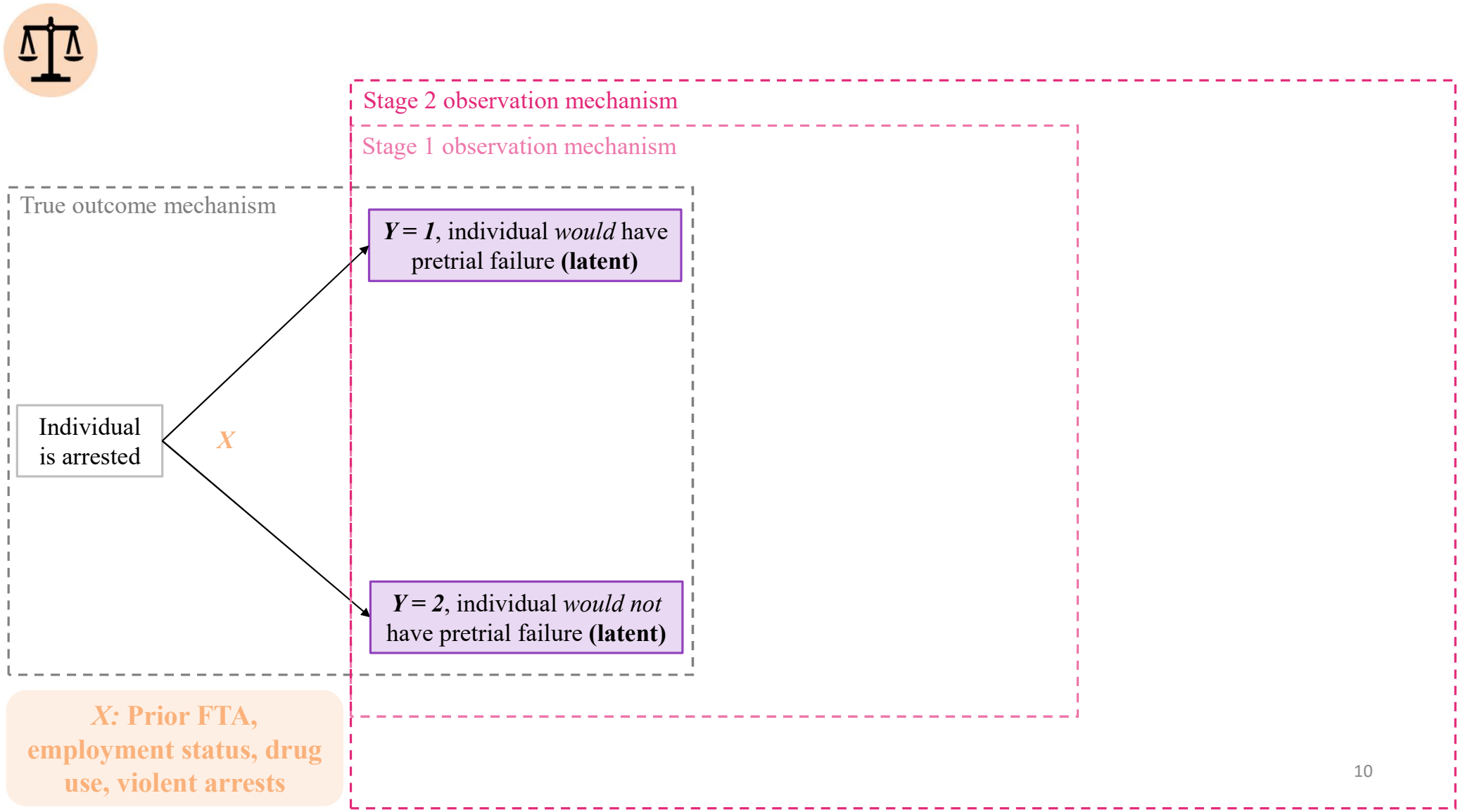
Stage 1 observation mechanism
True outcome mechanism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Individual is arrested
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X: Prior FTA, employment status, drug use, violent arrests

Stage 2 observation mechanism

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Y* = *1, individual *would* have pretrial failure **(latent)**

Individual is arrested

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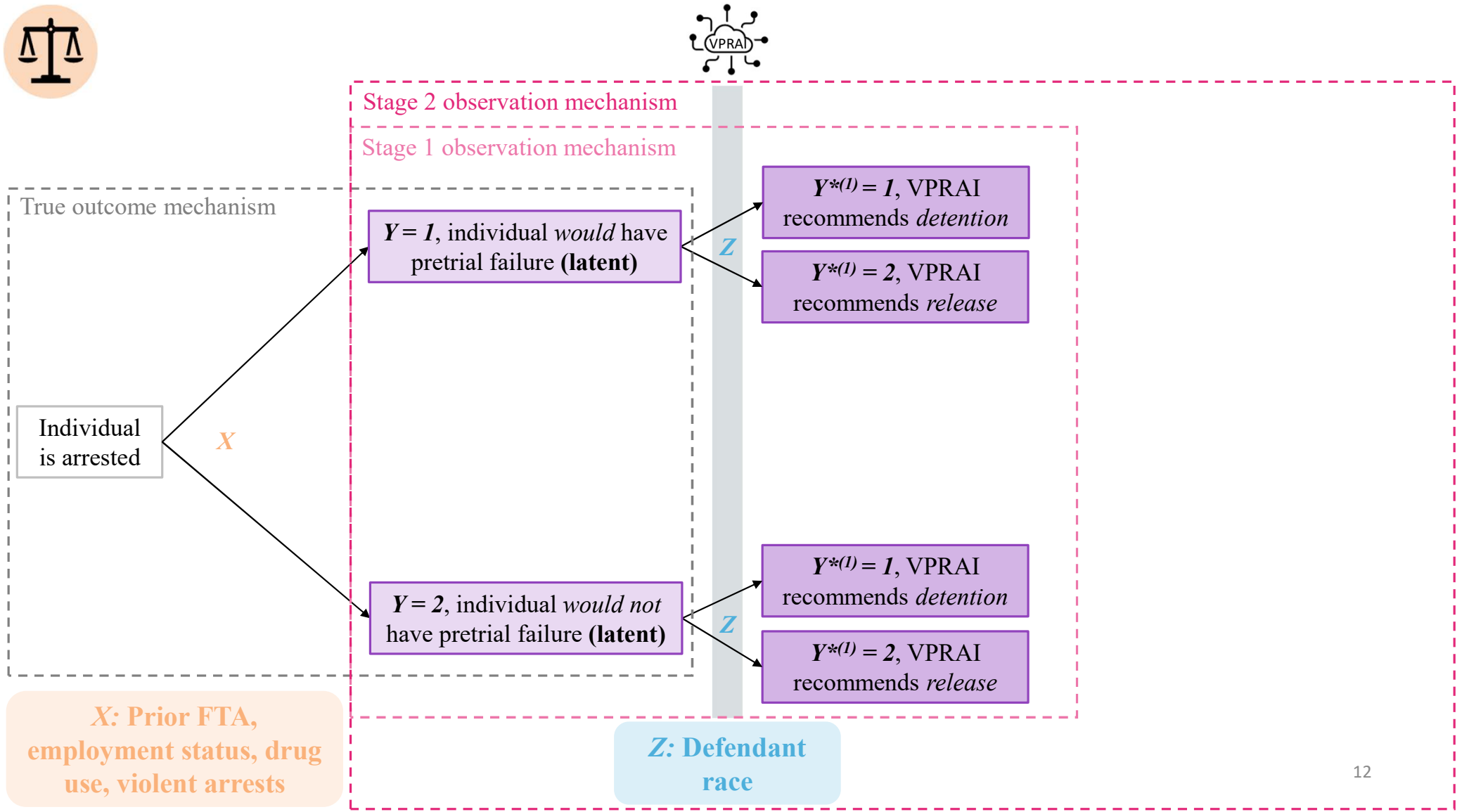
Y* = *2, individual *would not* have pretrial failure **(latent)**

***X*: Prior FTA, employment status, drug use, violent arrests**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True outcome mechanism
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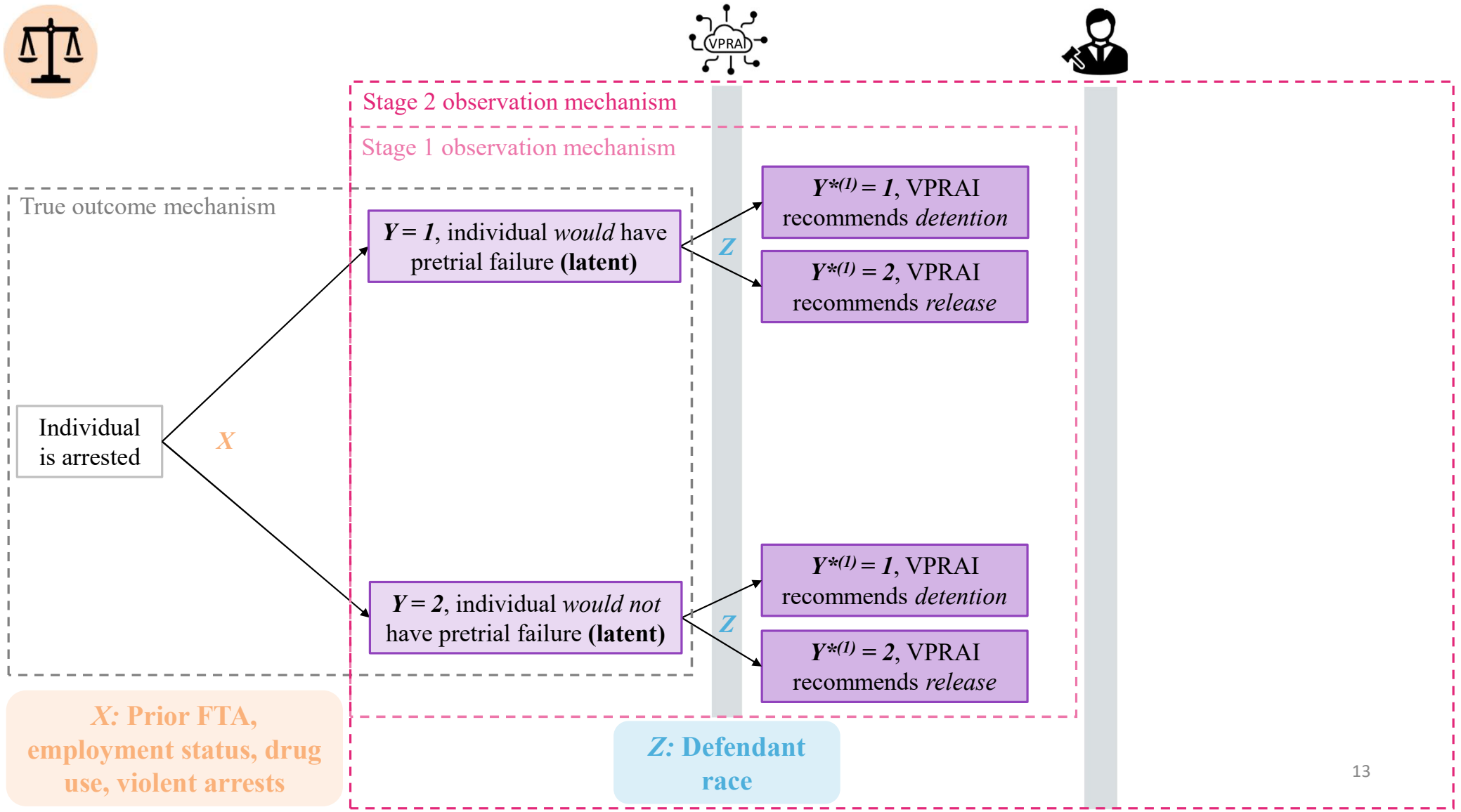
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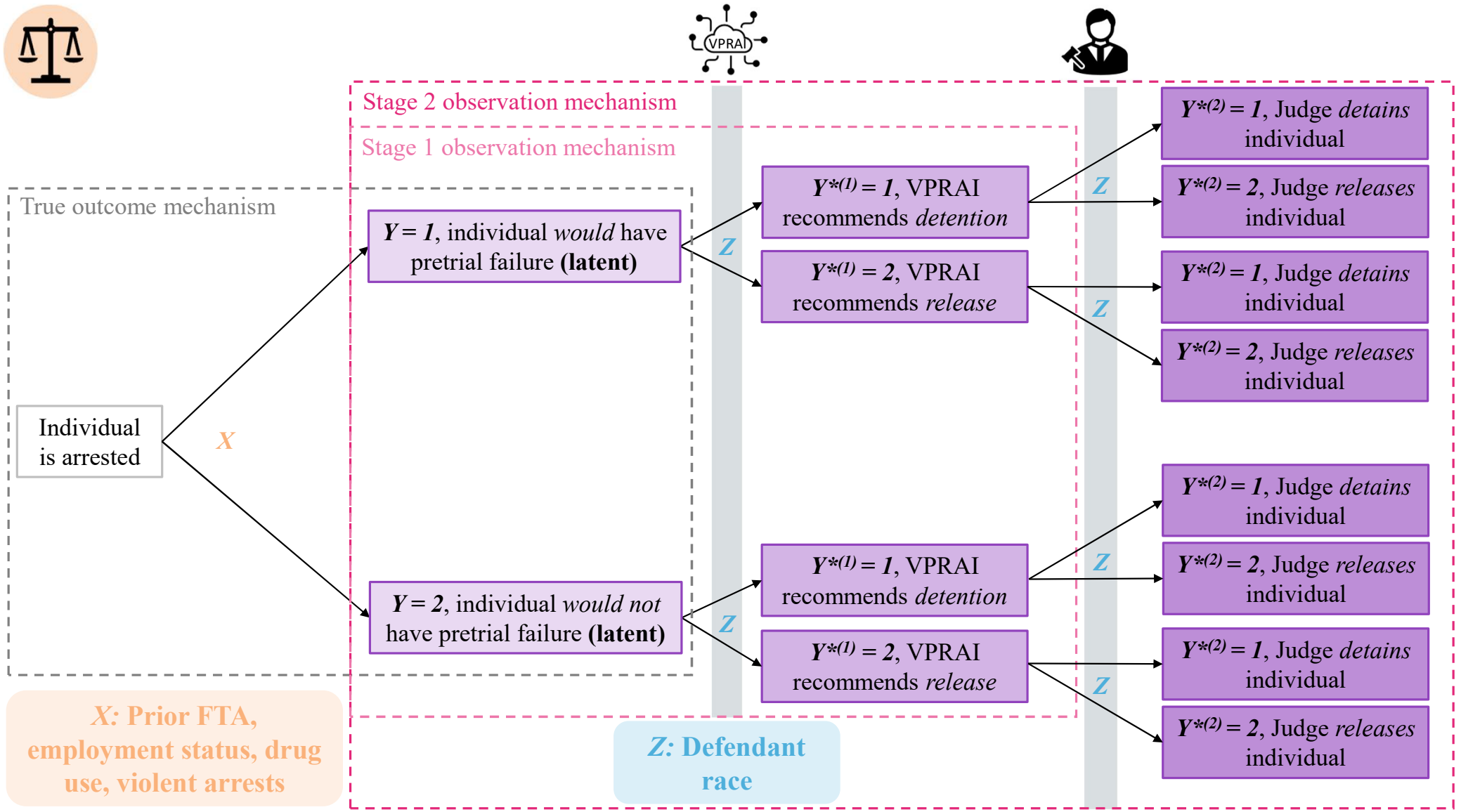
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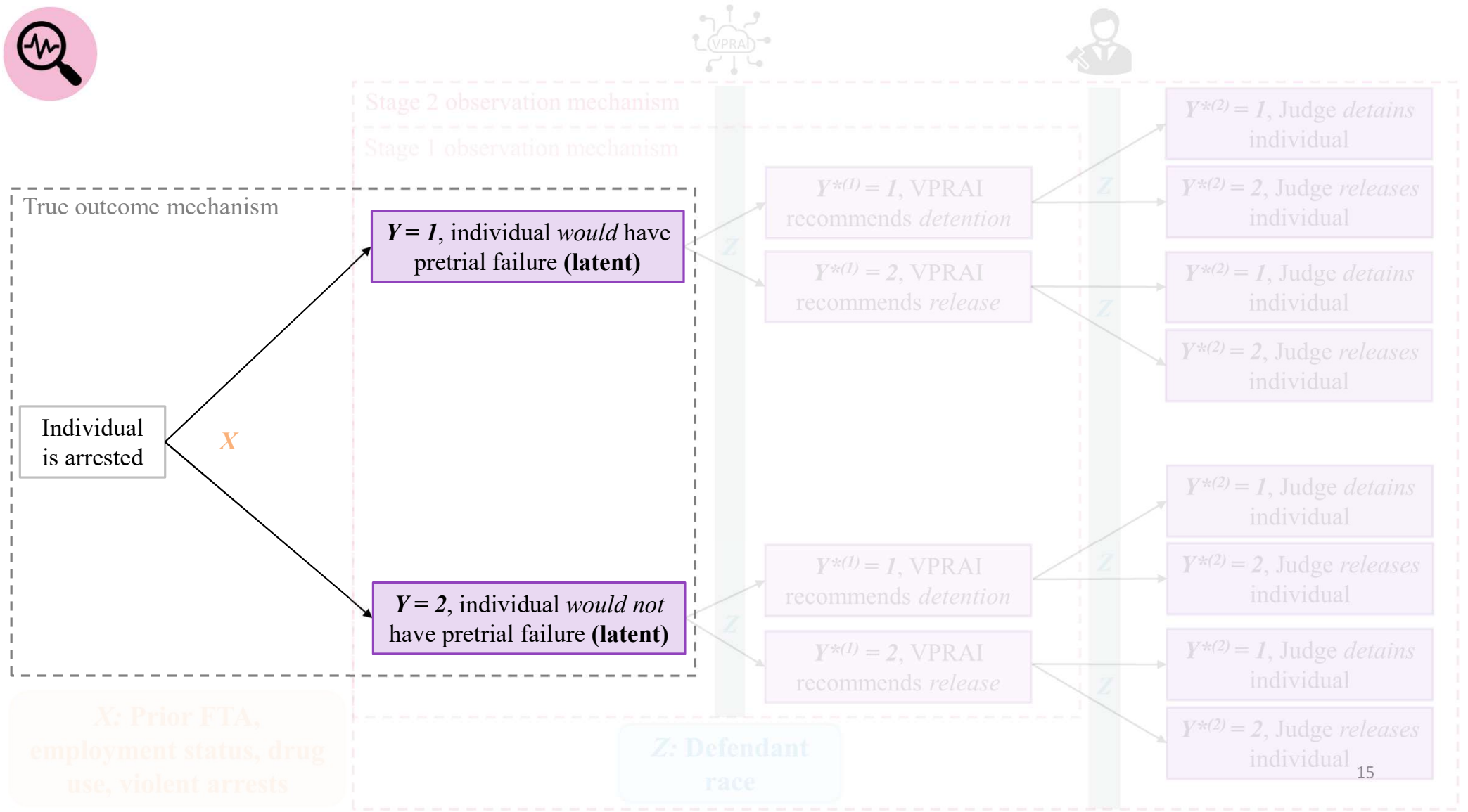
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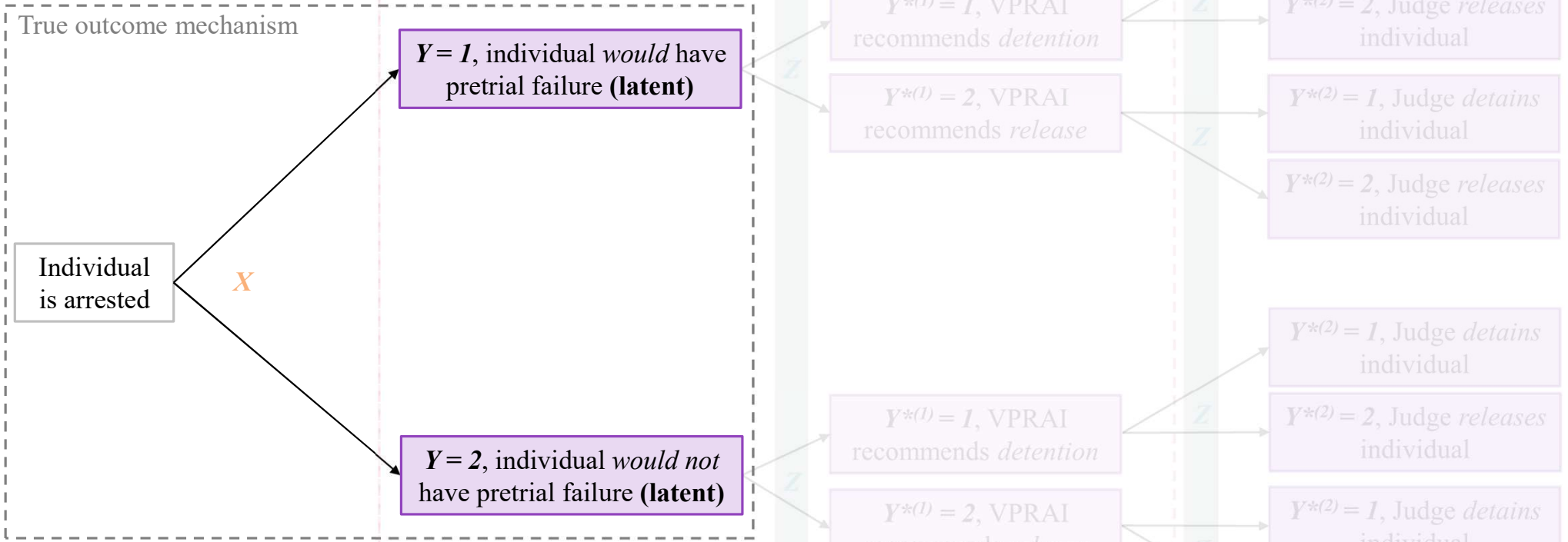
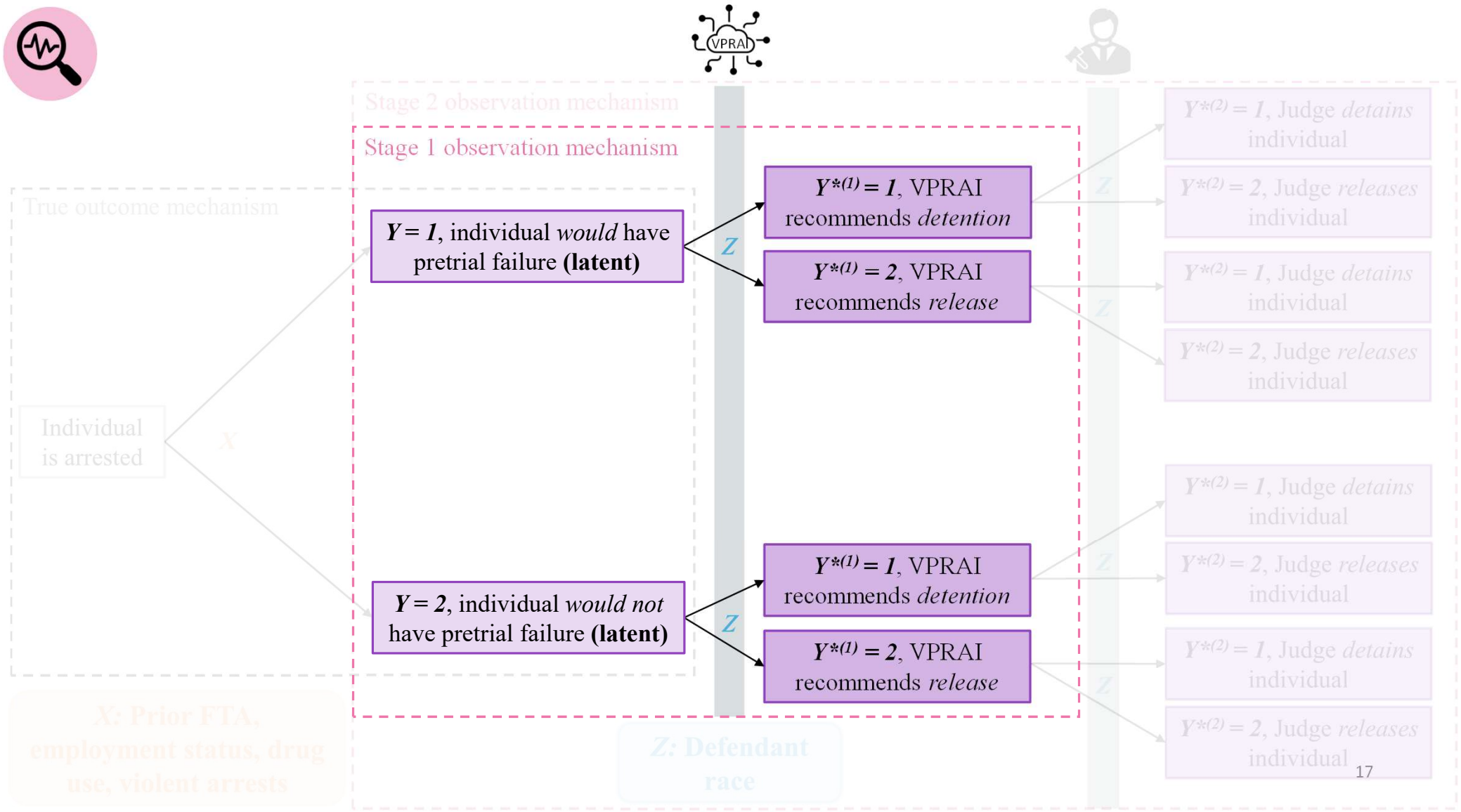
$$\text{logit}\{P(Y = 1|\boldsymbol{X};\boldsymbol{\beta})\} = \beta_0 + \beta_{FTA}\text{FTA} + \beta_{unemploymed}\text{E} + \beta_{drug}\text{D} + \beta_{violent}\text{V}$$

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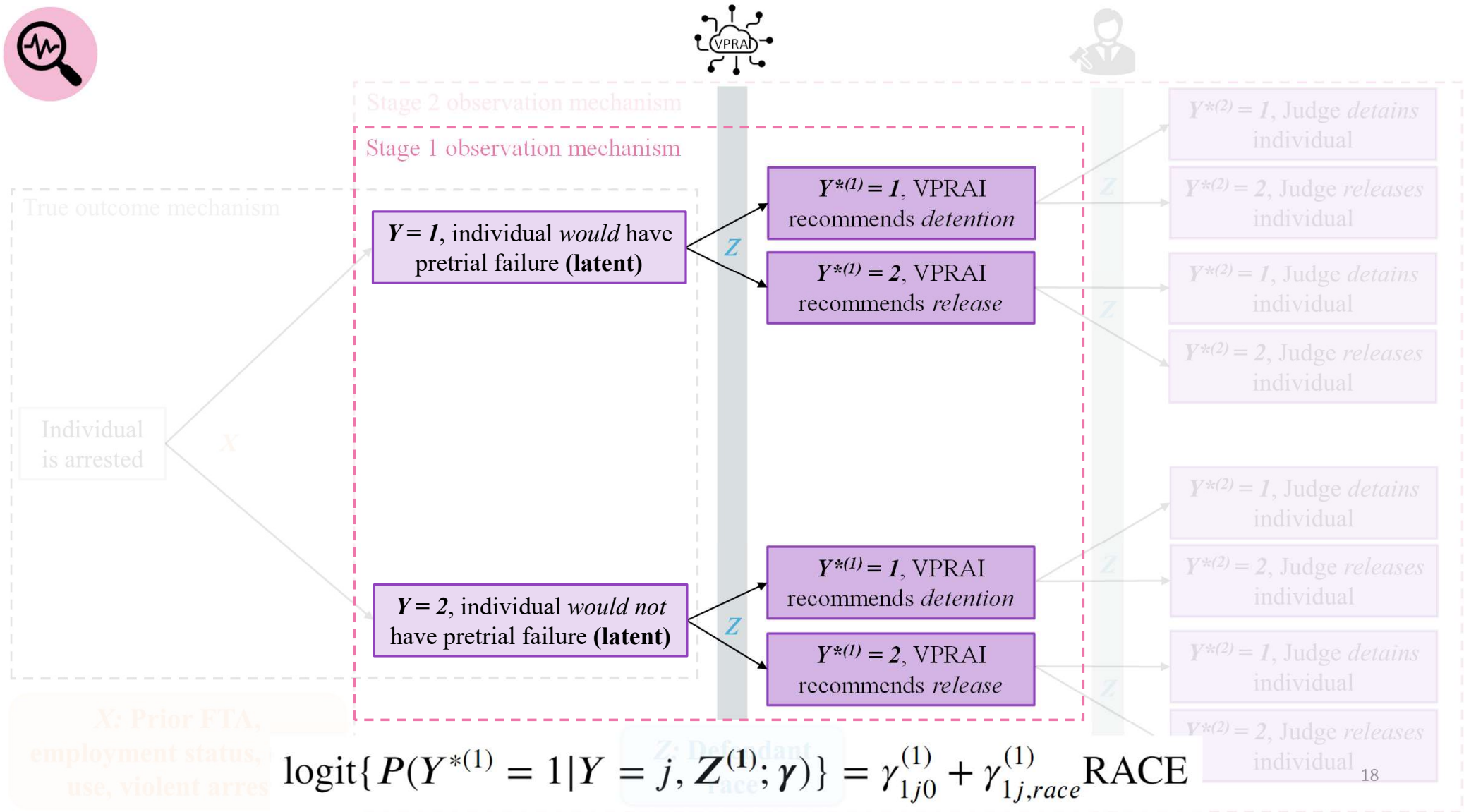
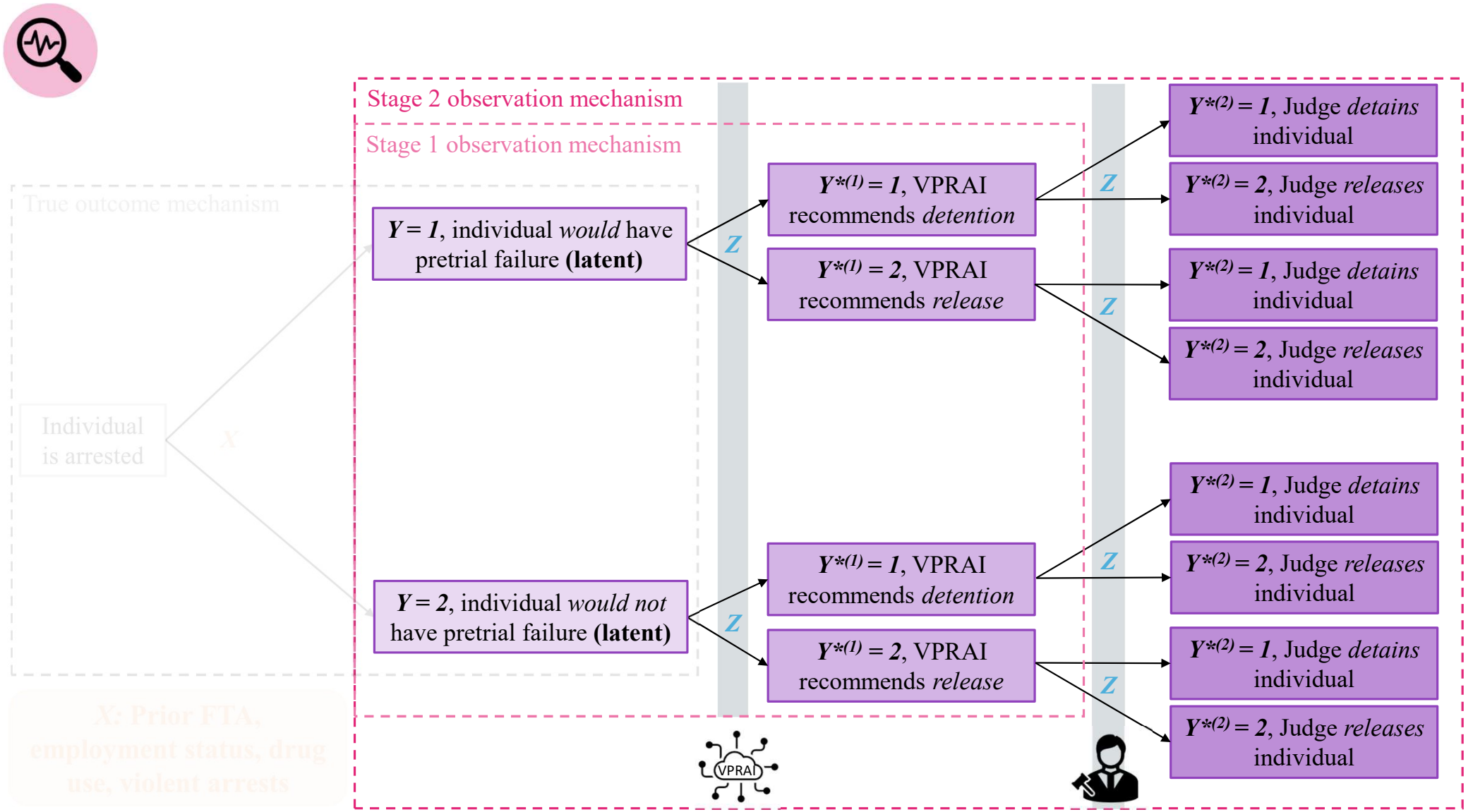


$$\text{logit}\{P(Y^{*(1)} = 1 | Y = j, \boldsymbol{Z}^{(1)}; \boldsymbol{\gamma})\} = \gamma_{1j0}^{(1)} + \gamma_{1j,race}^{(1)} \text{RACE}$$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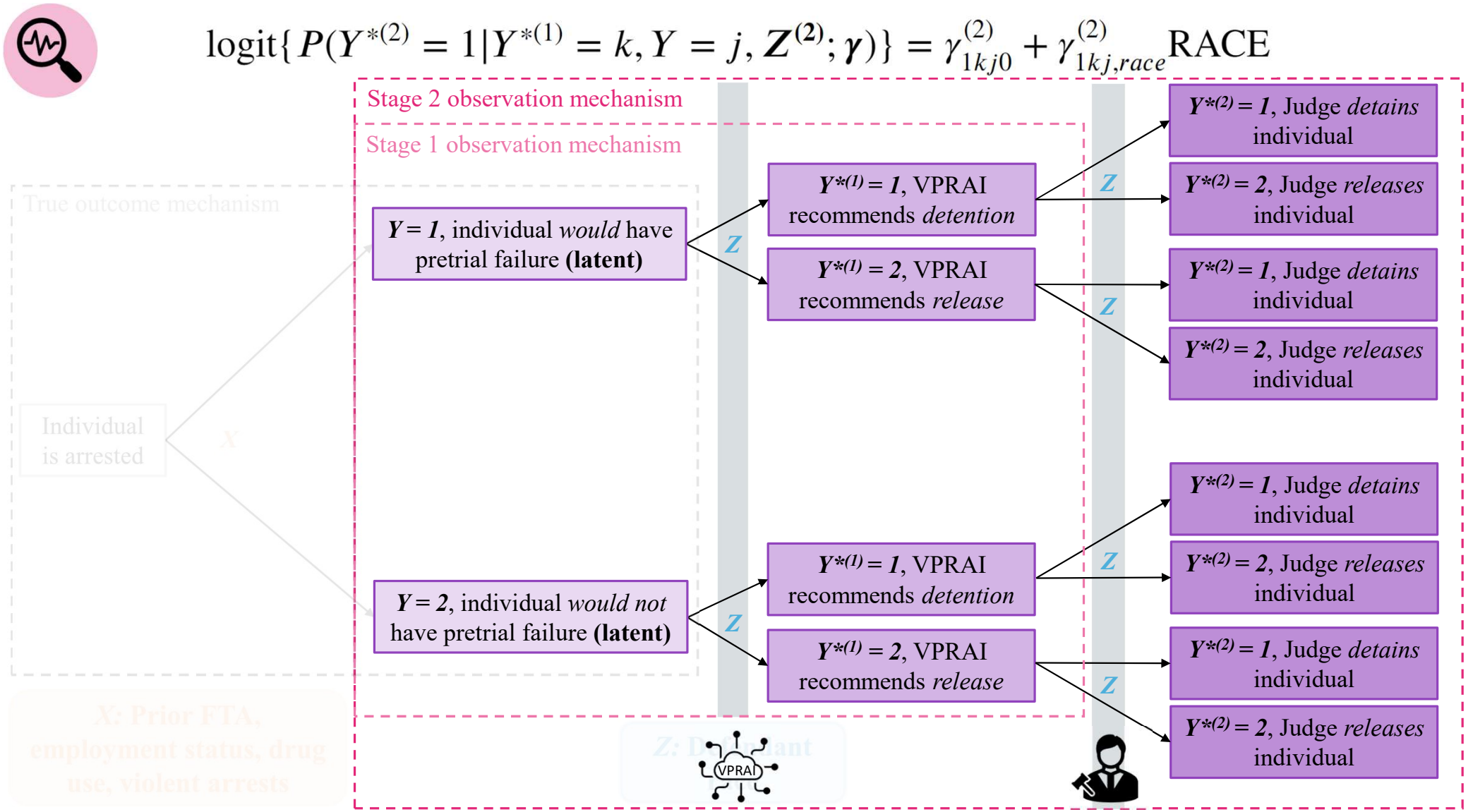
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$$\text{logit}\{P(Y^{*(1)}=1|Y=j,\boldsymbol{Z^{(1)}};\boldsymbol{\gamma})\} = \gamma^{(1)}_{1j0} + \gamma^{(1)}_{1j,race}\text{RACE}$$

Stage 2 (Judge) observation mechanism:

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

Primary interest: Estimating β

True outcome mechanism:

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Secondary interest: Estimating γ

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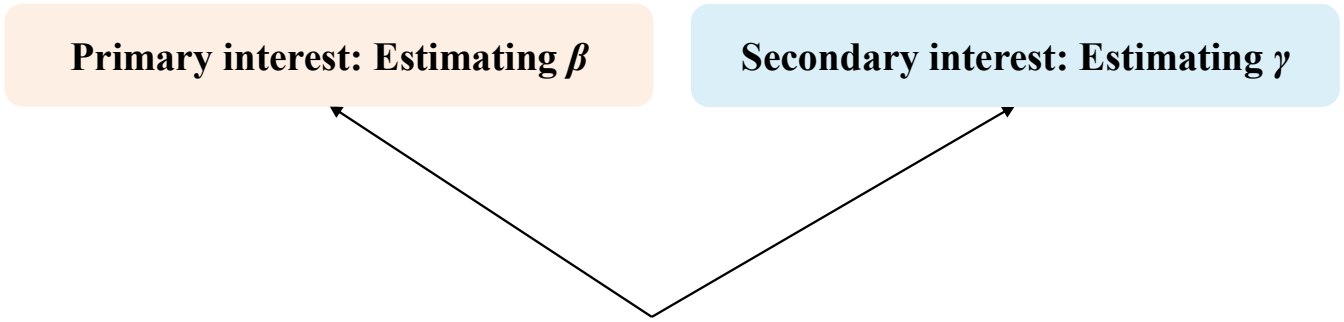

Estimation methods

- 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:

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

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**

Estimation: EM algorithm

Expectation Step ⟷ **Maximization Step**

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

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

Estimation: EM algorithm

Expectation Step ⟷ **Maximization Step**

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$$\sum_{k=1}^{2} \sum_{\ell=2}^{2} \frac{y_{ik}^{*(1)} y_{i\ell}^{*(2)} P(Y_i = j | \boldsymbol{X}_i) P(Y_i^{*(1)} = k | Y_i = j, Z^{(1)}) P(Y_i^{*(2)} = \ell | Y_i^{*(1)} = k, Y_i = j, Z^{(1)})}{\sum_{b=2}^{2} P(Y_i = b | \boldsymbol{X}_i) P(Y_i^{*(1)} = k | Y_i = b, Z^{(1)}) P(Y_i^{*(2)} = \ell | Y_i^{*(1)} = k, Y_i = b, Z^{(1)})}$$

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

Estimation: EM algorithm

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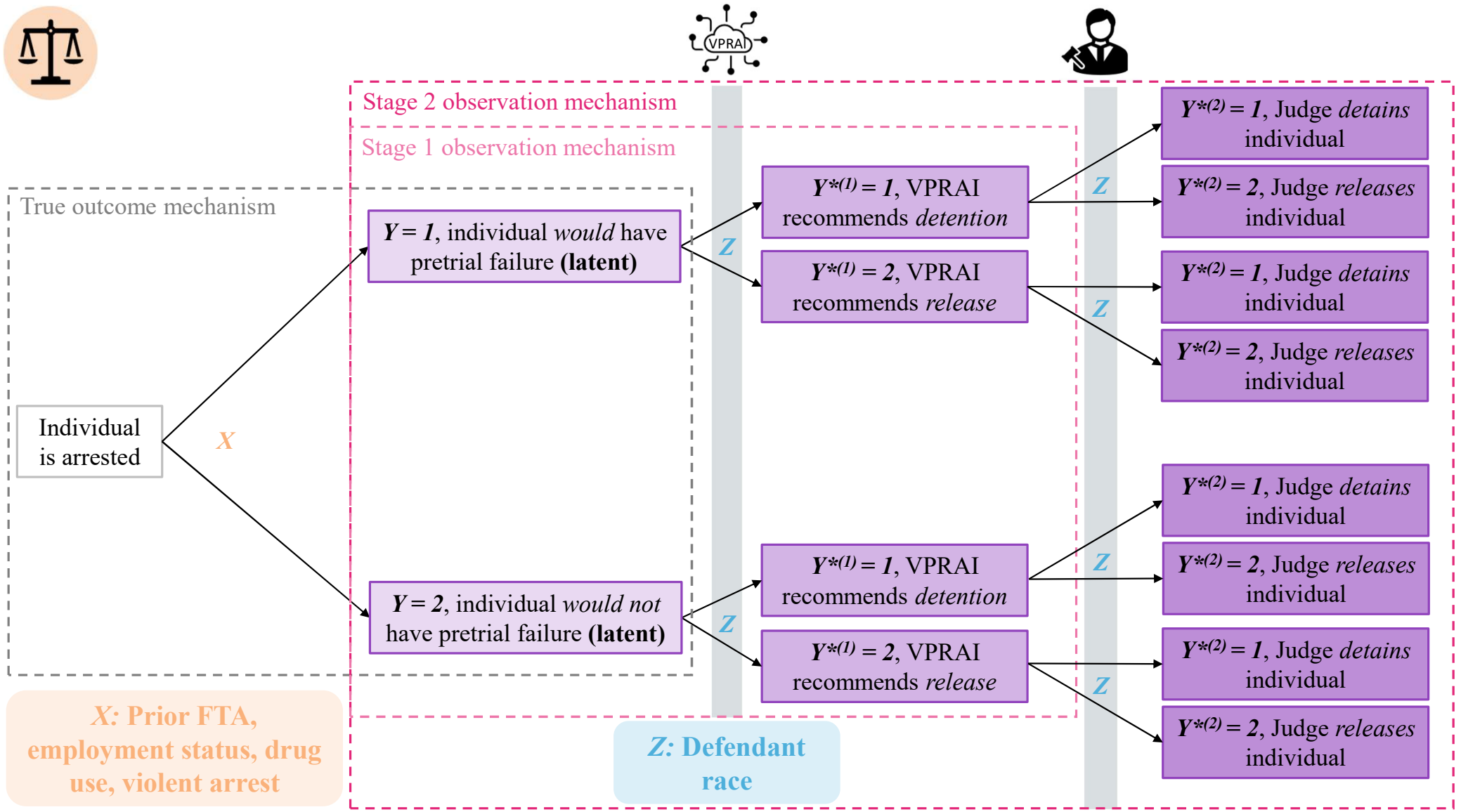
Apply the label switching correction

Estimates of β

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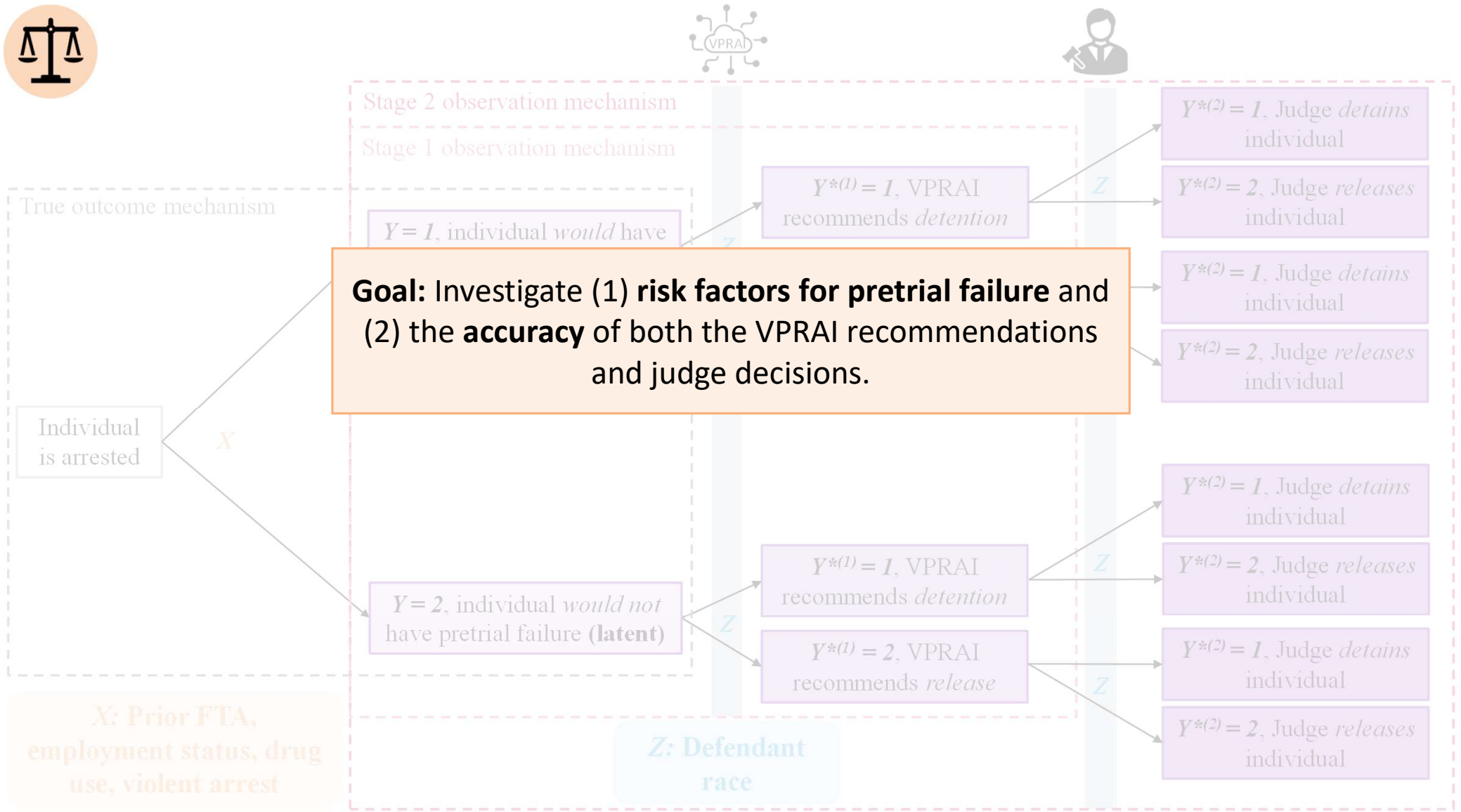
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Goal: Investigate (1) risk factors for pretrial failure and (2) the accuracy of both the VPRAI recommendations and judge decisions.

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- Data from all admitted persons in Prince William County, VA between Jan. 2016 and Dec. 2019

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- 1,990 observations in the dataset.

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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:

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

	EM Algorithm		**Naïve Analysis**	
	Est.	SE	Est.	SE
β_{FTA}				
$\beta_{unemployed}$				
β_{drug}				
$\beta_{violent}$				

True outcome mechanism:

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

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

	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:

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

	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

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- Developed new methods for handling misclassified sequential and dependent binary outcome variables.

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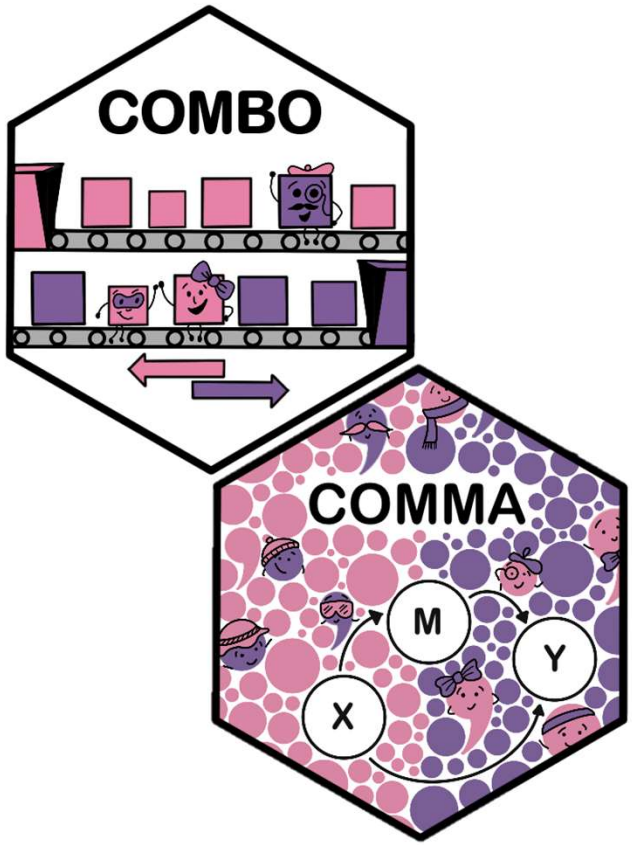
- Developed new methods for handling misclassified sequential and dependent binary outcome variables.
- Used these methods to estimate misclassification rates when algorithms and judges predict pretrial failure risk.

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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arXiv paper:

arxiv.org/abs/2309.08599