Final Project: Childhood Bullying and Subsequent Drug Use

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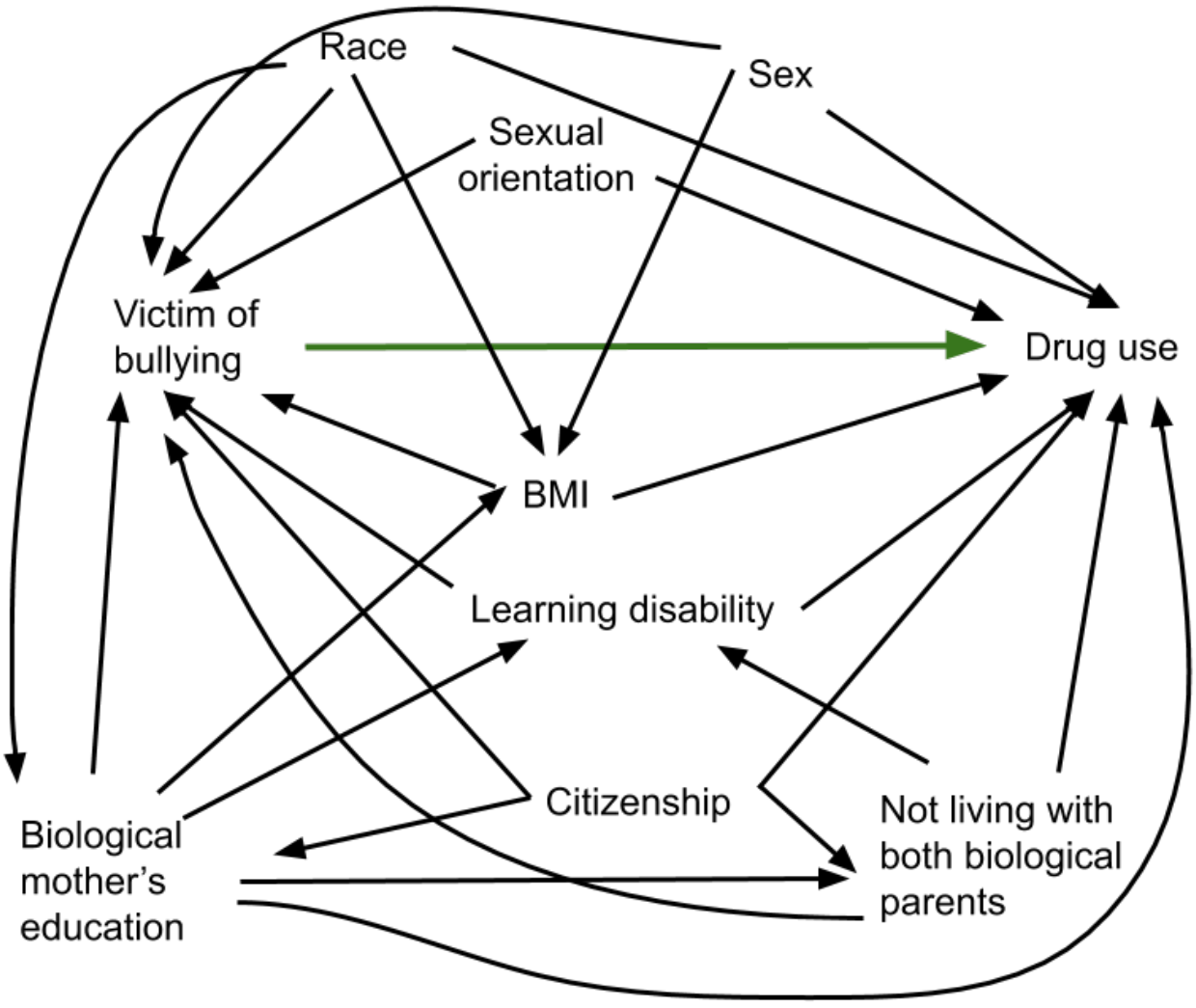
Causal Question: What is the effect of having been bullied prior to age 12 on incidence of drug use in adolescence or adulthood?

Specify a Causal Model

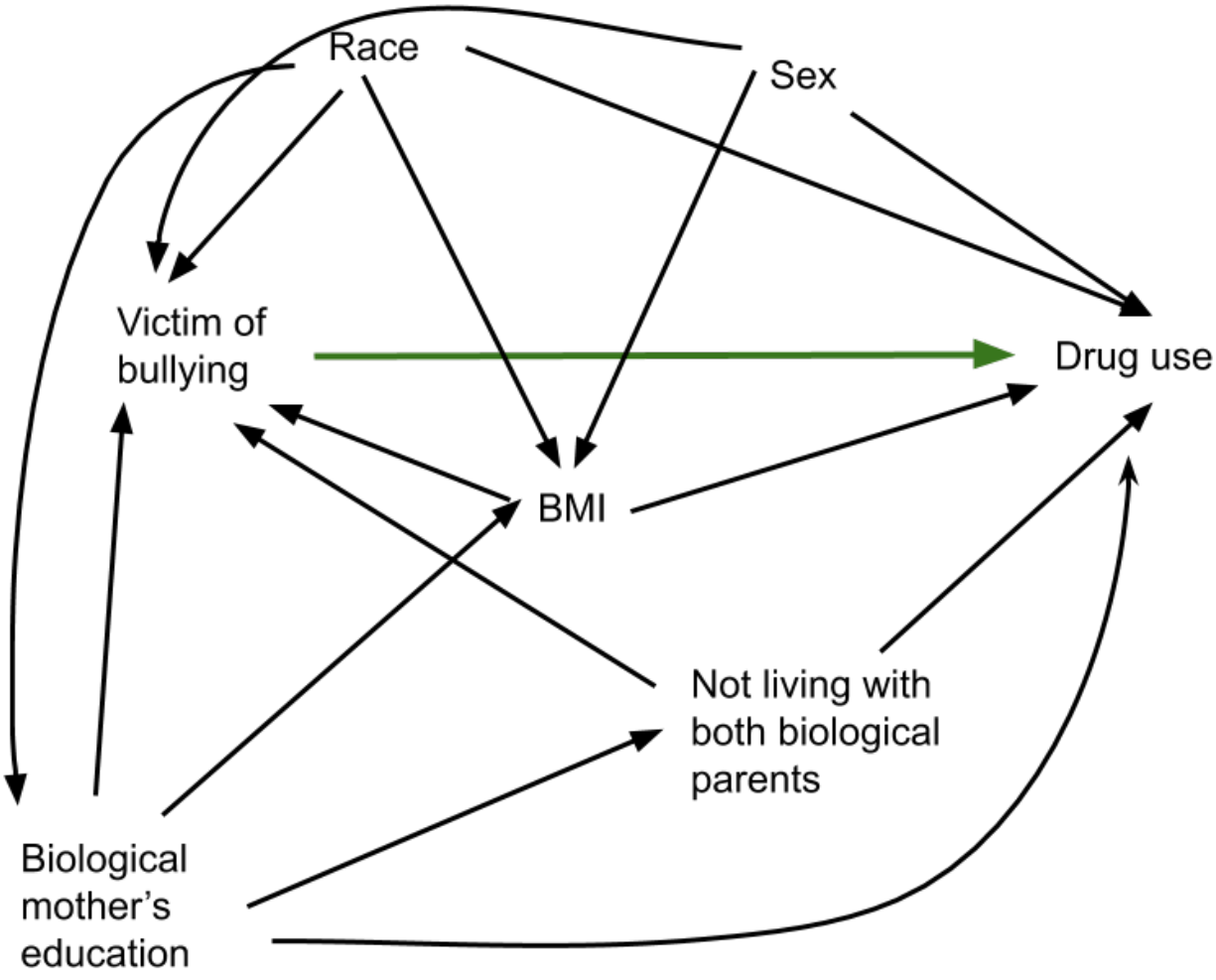
Our dataset:

- National Longitudinal Survey of Youth
- Nationally representative cohort of youth age 12-16
- Initial recruitment n = 9000 in 1997
- In our final dataset n = 7703

Original DAG



Final DAG


Race
Sex
Victim of bullying
Drug use
BMI
Not living with both biological parents
Biological mother's education

Structural Equations

Our endogenous nodes include: $X = (W, A, Y)$, where $W = (W_1, W_2, W_3, W_4, W_5)$ is the set of baseline covariates, A is victim of bullying, and Y is incident drug use.

Our background variables (exogenous nodes) include: $U = (U_W, U_A, U_Y) \sim \mathbb{P}_U$.

We place no assumptions on the distribution $\mathbb{P}_U$. We have not placed any restrictions on the functional form.

Structural Equations

Our structural equations $\mathcal{F}$ are:

$$
\begin{aligned}
W_1 &= f_{W_1}(U_{W_1}, W_3) \\
W_2 &= f_{W_2}(U_{W_2}) \\
W_3 &= f_{W_3}(U_{W_3}) \\
W_4 &= f_{W_4}(U_{W_4}, W_1) \\
W_5 &= f_{W_5}(U_{W_5}, W_1, W_2, W_3) \\
A &= f_A(U_A, W_1, W_2, W_3, W_4, W_5) \\
Y &= f_Y(U_Y, A, W_1, W_2, W_3, W_4, W_5)
\end{aligned}
$$

Where A is bullying before the age of 12 (asked in 1997); Y is incident drug use ("cocaine or other hard drugs") after 1997; W_1 = mother's education; W_2 = sex; W_3 = race/ethnicity; W_4 = not living with both biological parents; and W_5 = BMI z score.

Target Causal Parameter

Our target causal parameter is the difference in the counterfactual probability of drug use if all kids were bullied prior to age 12, and the counterfactual probability of drug use if all kids were not bullied prior to age 12:

$$\psi^F(P_{U,X}) = P_{U,X}(Y_1 = 1) - P_{U,X}(Y_0 = 1) = E_{U,X}(Y_1) - E_{U,X}(Y_0)$$

where Y_a denotes the counterfactual outcome under an intervention to set bullying status A = a. This target causal parameter is the average treatment effect (ATE), or causal risk difference.

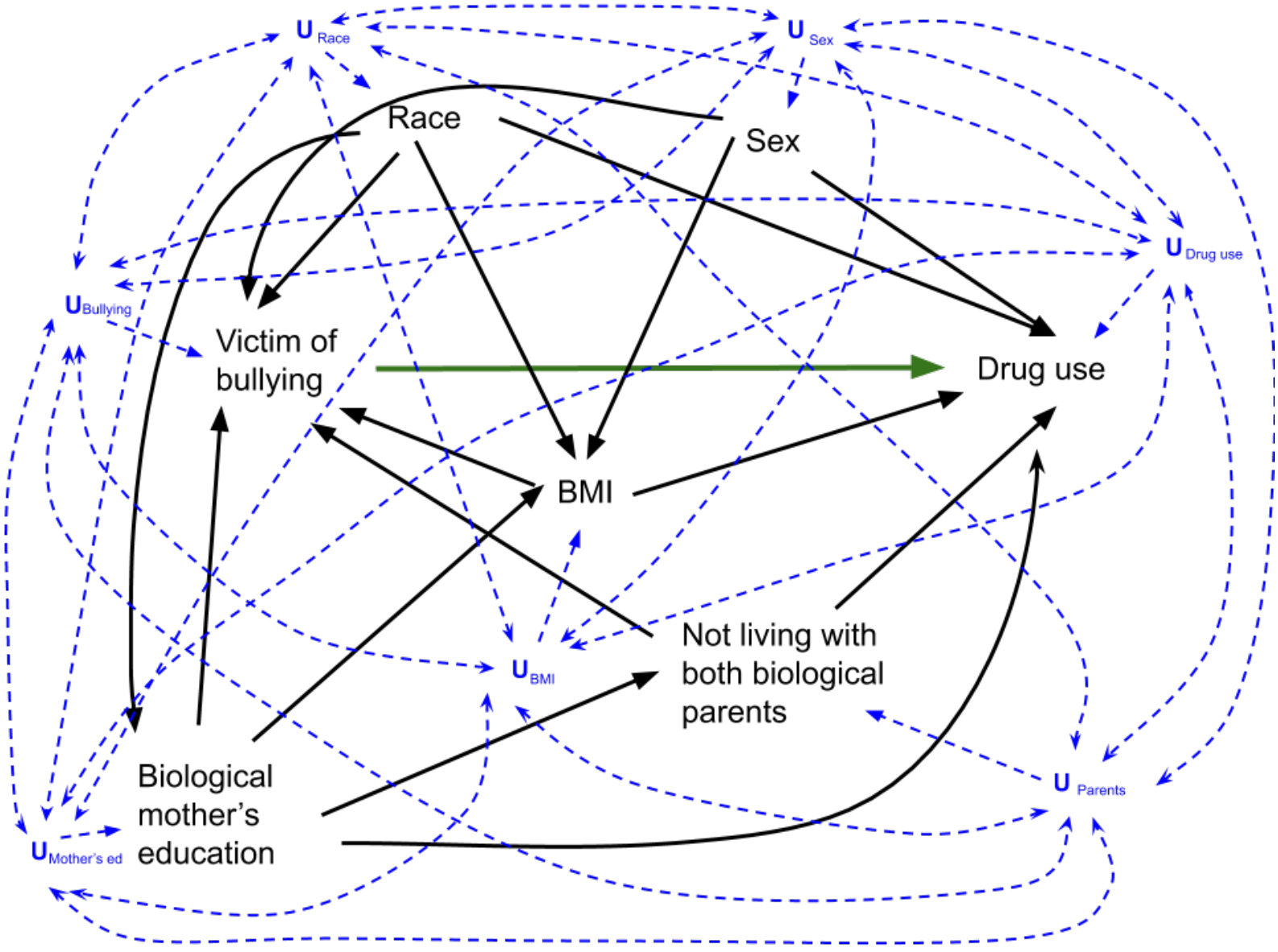
Link to the SCM

We assume that the observed data $O = (W, A, Y) \sim \mathbb{P}_0$ were generated by sampling n times from a data generating process described by the SCM. The statistical model $\mathcal{M}$ for the set of allowed distributions for the observed data is non-parametric.

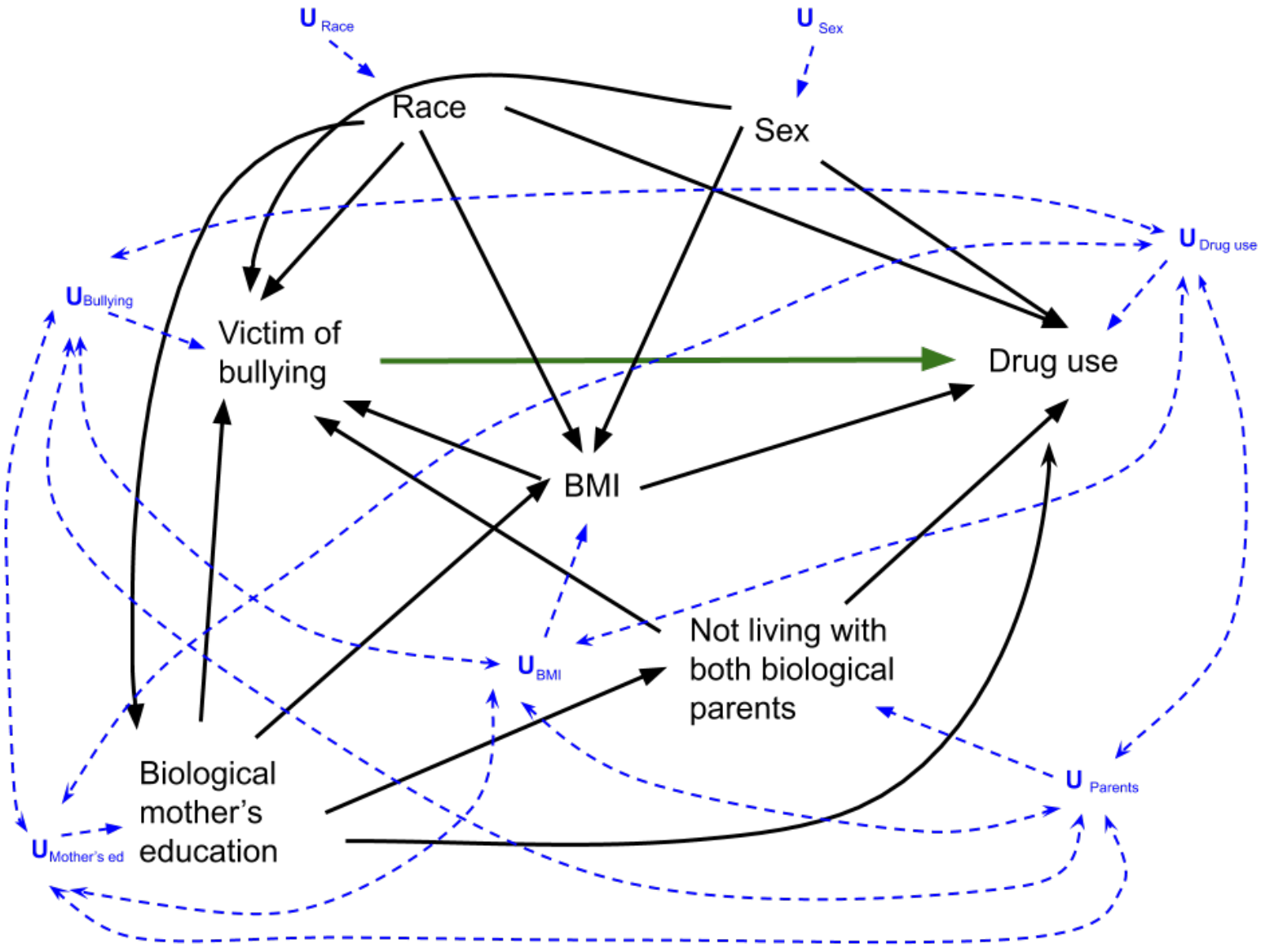
Table 1

Covariate	Drug use (%)	No drug use (%)
Drug use (Total)	1330 (17.3%)	6373 (82.7%)
Victim of bullying		
Yes	319 (4.1%)	1179 (15.3%)
No	1011 (13.1%)	5194 (67.4%)
Mother's education		
High school or less	3867 (50.2%)	732 (9.5%)
Some college or more	598 (7.8%)	2506 (32.5%)
Sex		
Female	591 (7.7%)	3218 (41.8%)
Male	739 (9.6%)	3155 (41%)
Race/ethnicity		
Black	227 (2.9%)	1788 (23.2%)
Hispanic	288 (3.7%)	1340 (17.4%)
Non-Black, Non-Hispanic	815 (10.6%)	3245 (42.1%)
Living with both biological parents		
Yes	645 (8.4%)	3176 (41.2%)
No	685 (8.9%)	3197 (41.5%)
BMI z-score	0.513 (*mean*) 1.03 (*sd*)	0.505 (*mean*) 0.98 (*sd*)

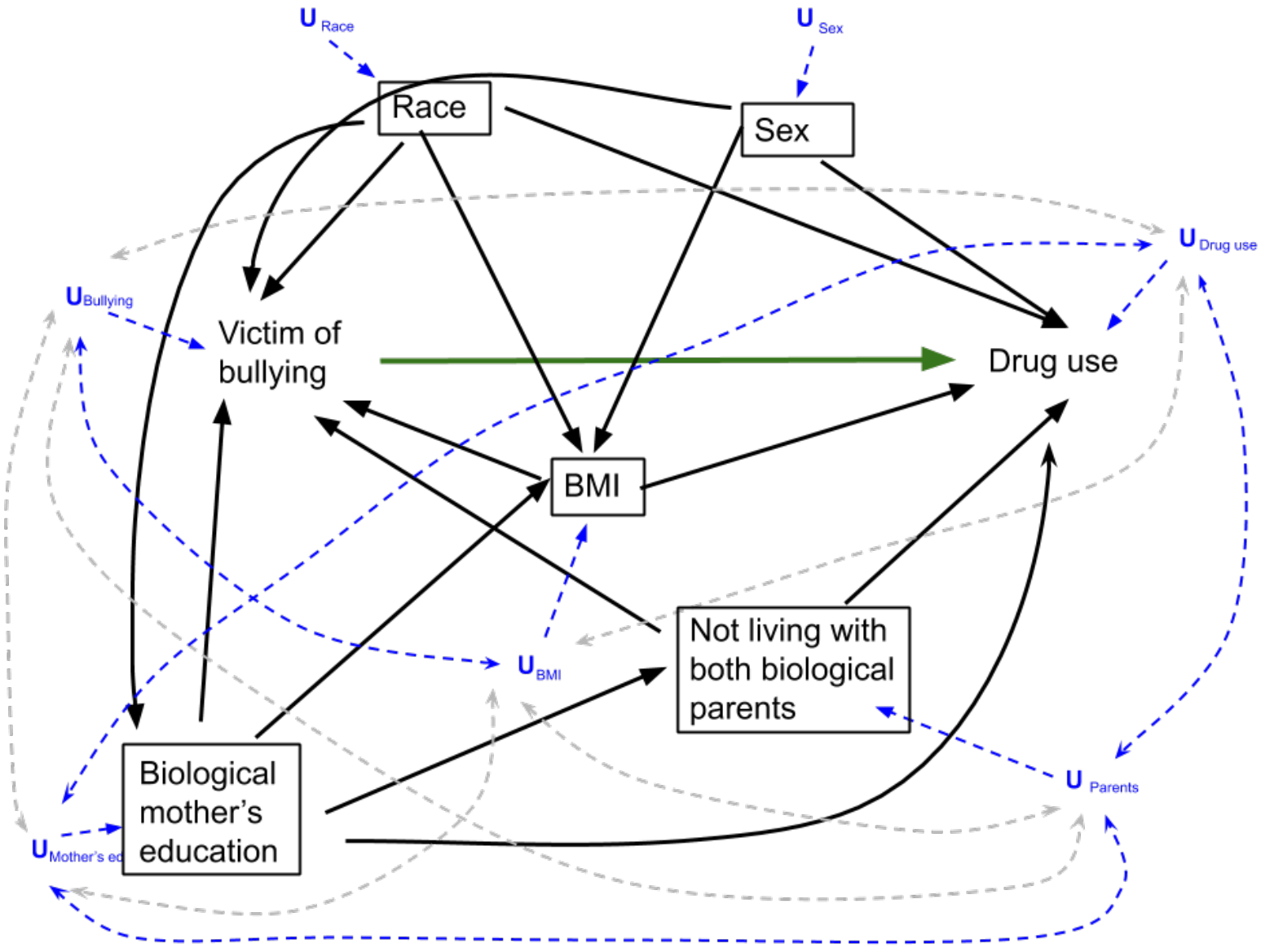
Identifiability



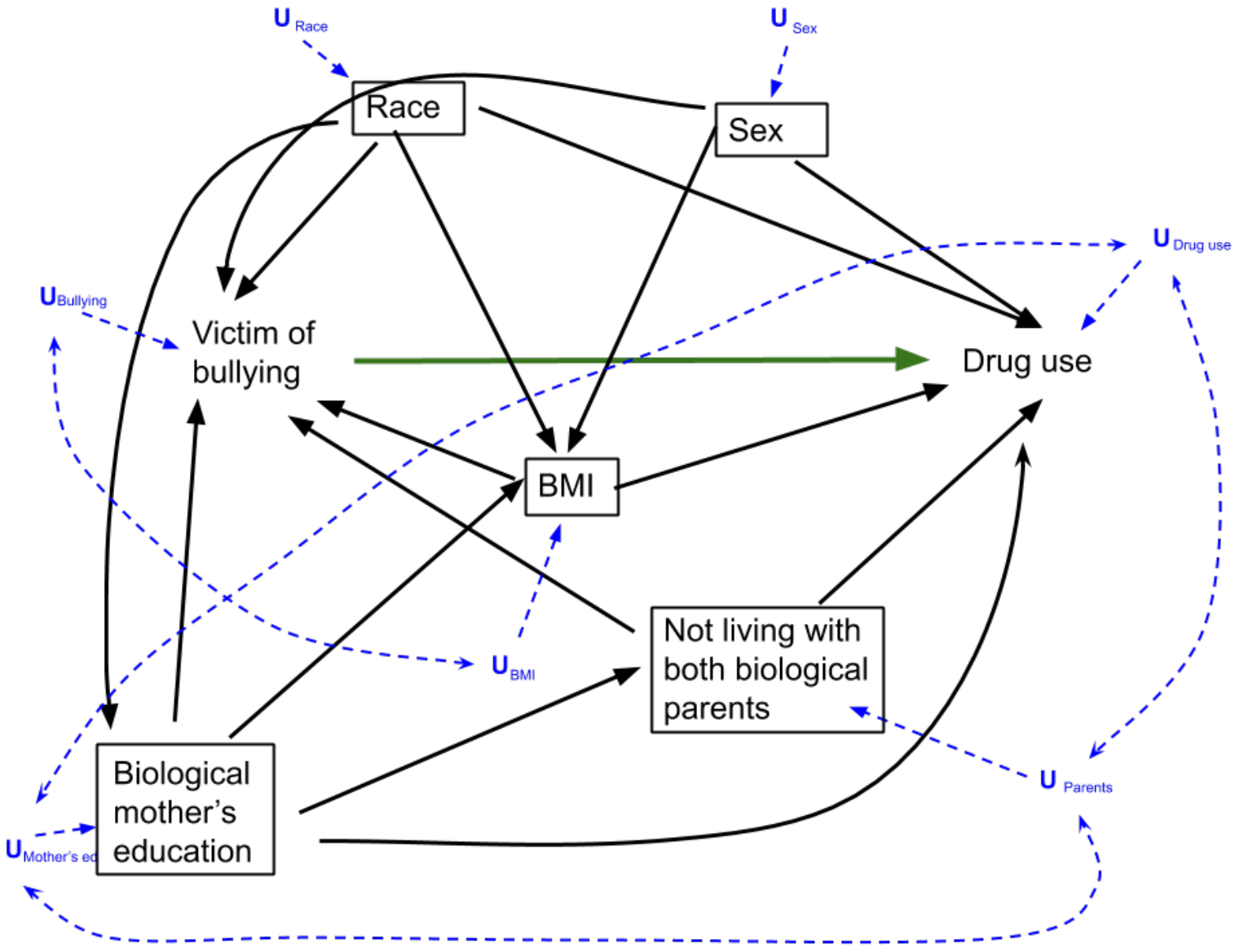
Identifiability



Identifiability



Identifiability



Estimand and Statistical Model

The target parameter of the observed data distribution (which equals the causal parameter in the augmented causal model $\mathcal{M}^{F\star}$) is the G-Computation formula:

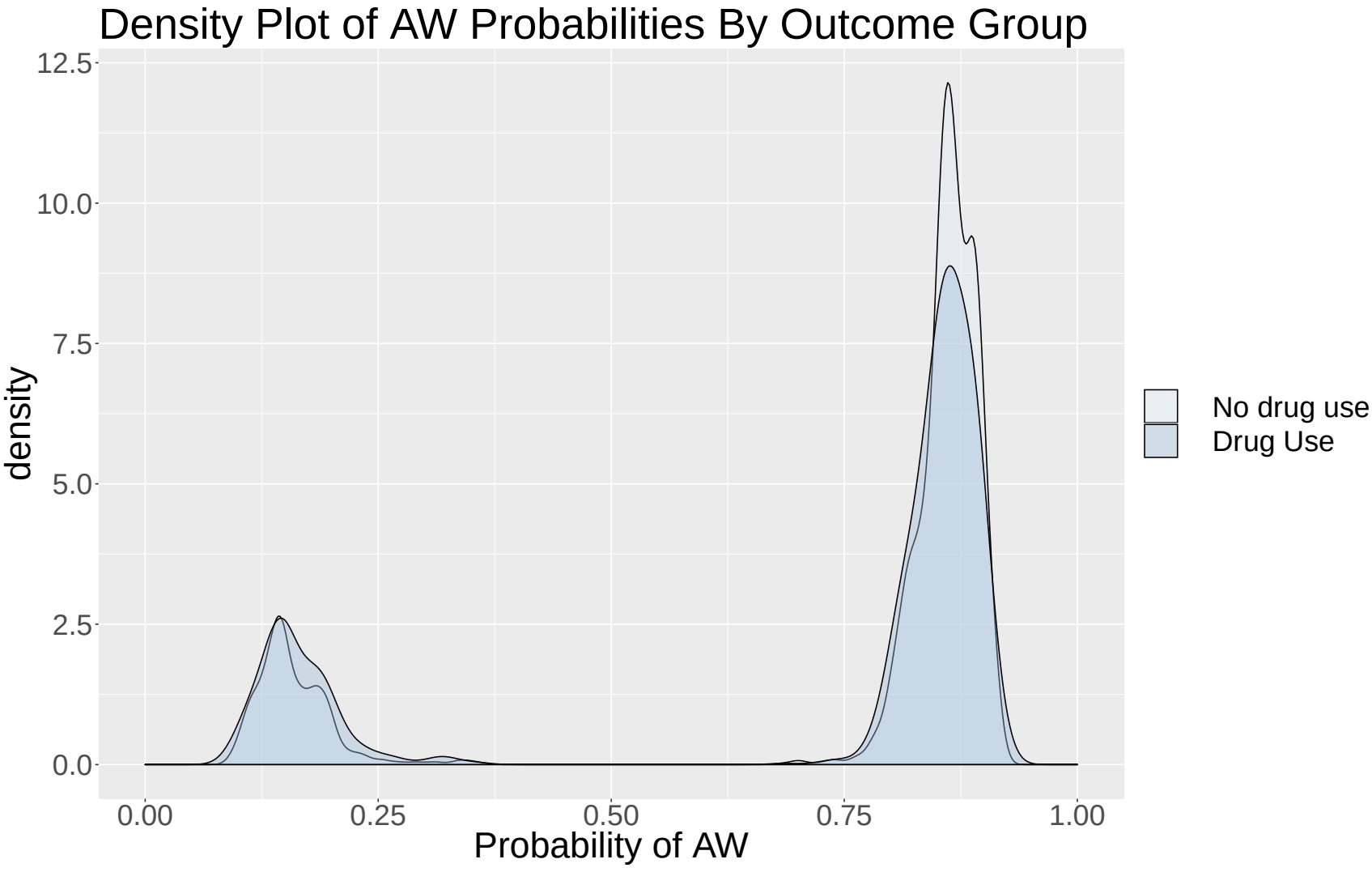
$$\psi(\mathbb{P}_0) = \mathbb{E}_0[\mathbb{E}_0(Y|A=1,W) - \mathbb{E}_0(Y|A=0,W)] =$$
$$\sum_{w1,w2,w3,w4,w5} [\bar{Q}_0(1, W1=w1, W2=w2, W3=w3, W4=w4, W5=w5) -$$
$$\bar{Q}_0(0, W1=w1, W2=w2, W3=w3, W4=w4, W5=w5)] *$$
$$\mathbb{P}_0(W1=w1, W2=w2, W3=w3, W4=w4, W5=w5)$$

This is our statistical estimand.

Checking for Practical Positivity Violations

- We tabulated exposure and outcome across all possible levels of our categorical variables
- Observations exist in every possible category of our variable set
- For our only continuous variable, BMI z-score (for age and sex), we looked at the distribution of BMI z scores in the two exposure categories

Positivity: Assessing the Model Weights

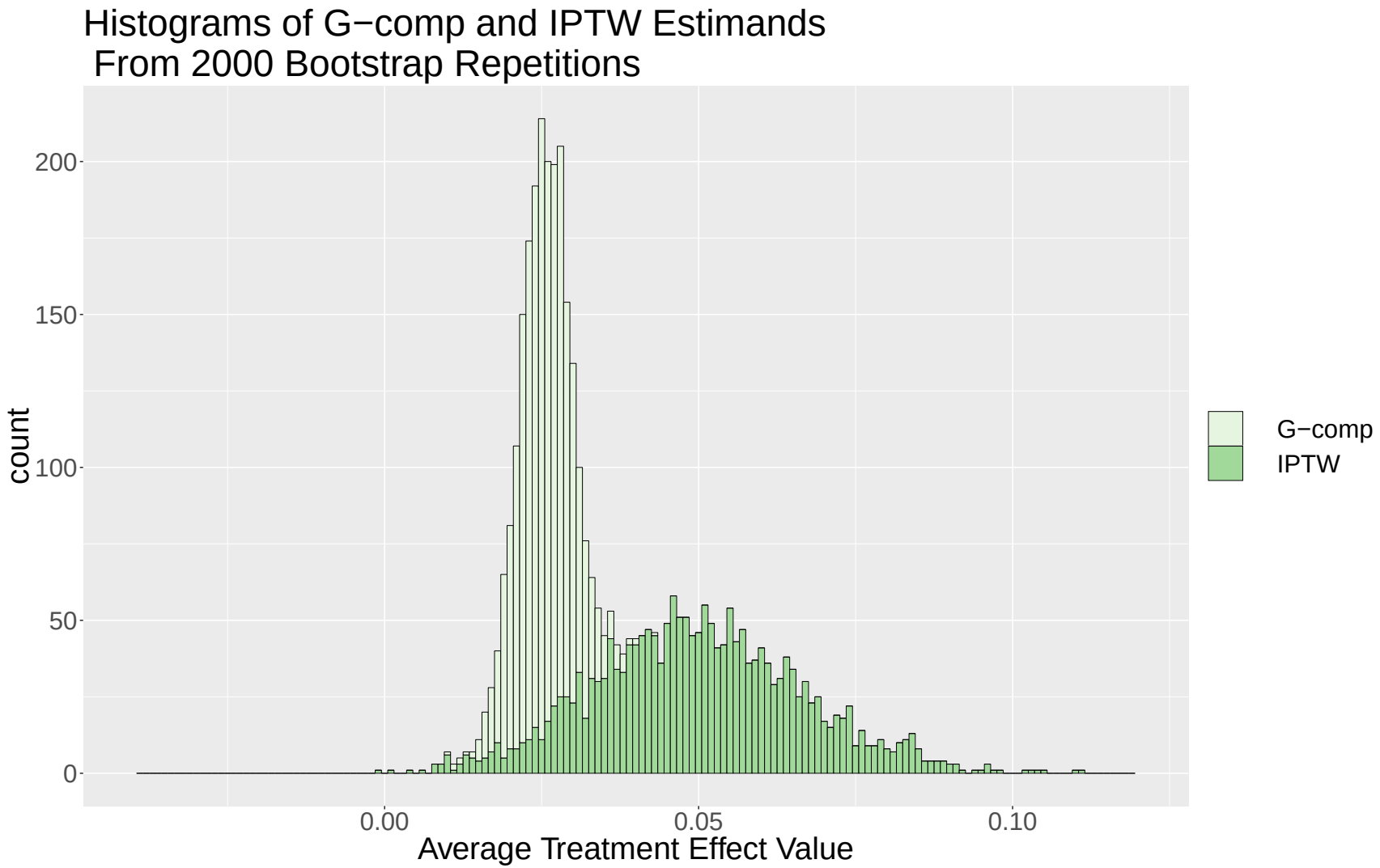


Estimation: Unadjusted ATE & SuperLearner

- The unadjusted ATE = mean(Y|A=1 - Y|A=0) = 0.05
- We use SuperLearner for prediction in all models.
- Library: SL.glm, SL.glm.interaction, SL.glmnet, SL.bayesglm, SL.randomForest, SL.step, SL.mean, SL.loglinear
- 5-fold cross-validation
- We use 3 estimators

Confidence Intervals

- For TMLE, used the robust method built in to the ltmle package
- For G-comp and IPTW we performed a bootstrap



Estimation: G-comp, IPTW, & TMLE

Estimator	ATE (95% CI)
G-computation	0.039 (0.017, 0.034)
Stabilized IPTW	0.045 (0.018, 0.084)
TMLE	0.044 (0.007, 0.08)

Estimation: SuperLearner convex combinations

Algorithm	A Risk	A Coefficient	Y Risk	Y Coefficient
glm	0.1549655	0	0.1408945	0.4628552
glm.interaction	0.155051	0.2086733	0.141501	0
glmnet	0.1549798	0	0.1409052	0
bayesglm	0.1549653	0	0.1408937	0
randomForest	0.1903391	0.4607251	0.1707125	0.2239811
step	0.1549472	0.267622	0.1408951	0.2476689
mean	0.1566939	0.0629796	0.1428772	0.0654947
loglinear	0.1549381	0	0.1409062	0

Estimation: SuperLearner performance

CV.SuperLearner

Algorithm	Avg Risk	SE
SuperLearner	0.1412062	0.0028693
Discrete SL	0.1407186	0.0027614
glm	0.1407131	0.0027616
glm.interaction	0.141278	0.0027675
glmnet	0.1407129	0.002763
bayesglm	0.1407127	0.0027616
randomForest	0.1678716	0.0041689
step	0.1407191	0.0027614
mean	0.1428802	0.0028201
loglinear	0.140726	0.0027623

Results

According to our analysis:

- the difference between the average counterfactual risk of drug use if everyone was bullied versus if no one was bullied is 0.04
- **causal interpretation**: if people are bullied, they have about a 4% increased likelihood of drug use later in life than people who are not bullied

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Limitations

1. Important exogenous variables
   - Parent drug use
   - Mental health
   - Other
2. Necessary independence assumptions

Impacts

- Identify youth who are at risk for starting to use drugs as a result of bullying
- Supports use of anti-bullying interventions in schools

Contributions of the Team Members

- Suggestion of a dataset and potential issues for exploration: Veronica
- Particular expertise that we each contributed:
  1. Shelley - Project management
  2. Stephanie - Pediatrics
  3. Veronica - Social and Substance Use Epi
  4. Lizzy - Social and Substance Use Epi
- Establishment of the causal model, delineation of the causal question and estimand of choice: Entire group
- Identifiability considerations: Entire group, with Lizzy and Shelley working on the DAG
- Creation of slides for causal question, SCM, background on our dataset: Lizzy and Shelley
- Creation of SuperLearner library: Veronica
- Coding of ATE point estimates: Veronica
- Coding of Practical Positivity Checks and Bootstrapping of Confidence Intervals: Stephanie
- Interpretation of Results: Entire Group