Conditional Front-door Adjustment for Heterogeneous Treatment Assignment Effect Estimation Under Non-adherence

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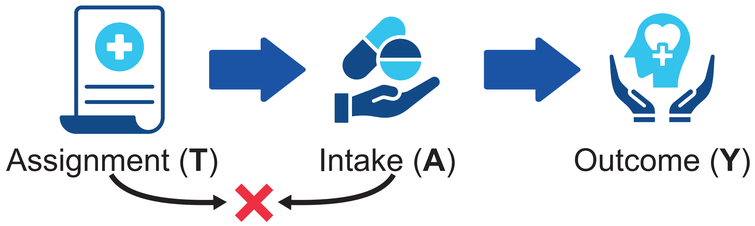
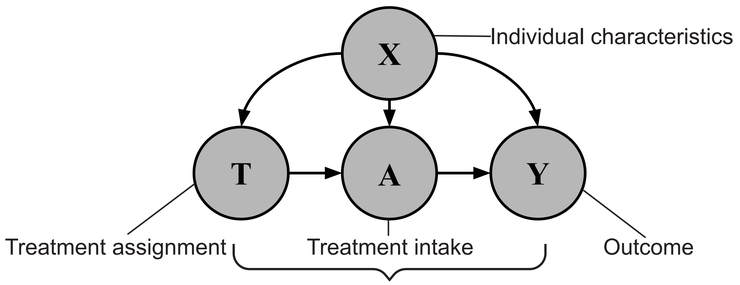
Paper Code

What is treatment non-adherence?



Non-adherence occurs when treatment intake differs from treatment assignment.

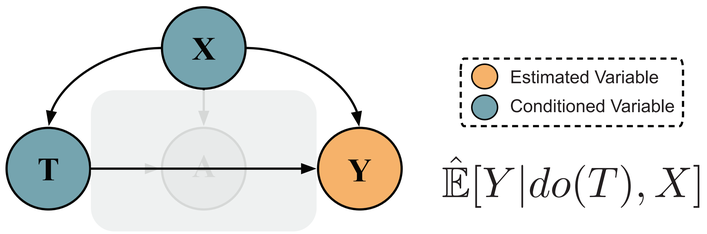
What is treatment effect estimation?



How does change in assignment affect outcome?

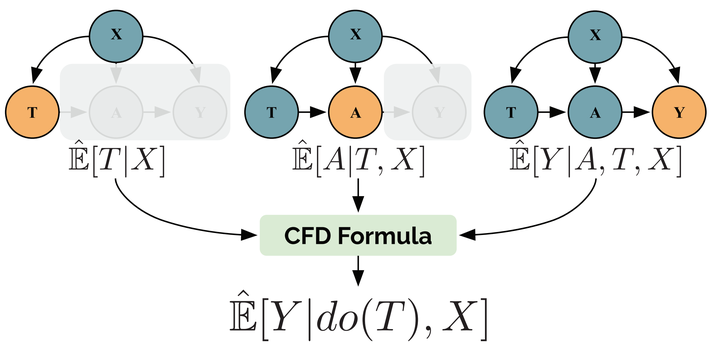
$$\Phi = \mathbb{E}[Y|do(T=1),X] - \mathbb{E}[Y|do(T=0),X]$$

Standard Backdoor adjustment (SBD) ignores intake [1]



$$\hat{\mathbb{E}}[Y|do(T),X]$$

We propose Conditional Front-door adjustment (CFD)



We develop a variance advantage bound

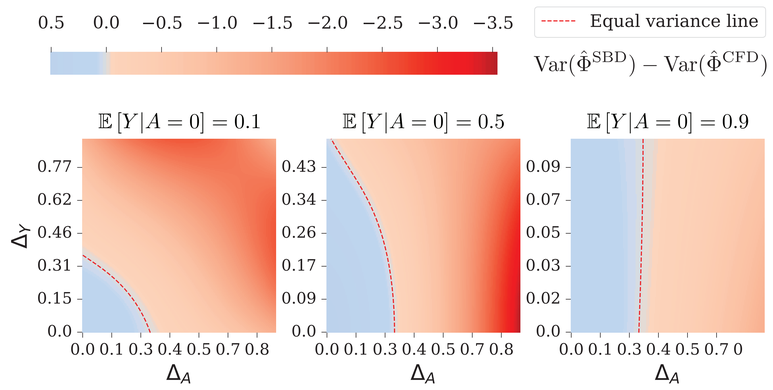
$$\lim_{n\to\infty} n\left(\mathrm{Var}\left(\hat{\Phi}^{\mathrm{SBD}}\right) - \mathrm{Var}\left(\hat{\Phi}^{\mathrm{CFD}}\right)\right) > \mathcal{O}\left(V_Y - V_Y\Delta_A^2 - V_A\Delta_Y^2\right)$$

$\hat{\Phi}^{\mathrm{SBD}}, \hat{\Phi}^{\mathrm{CFD}}$: estimates of Φ by SBD and CFD.

Δ_A, Δ_Y: $\Phi = \Delta_A\Delta_Y$ V_A, V_Y: variances of A and Y.

CFD gaurantees lower variance under small Φ.

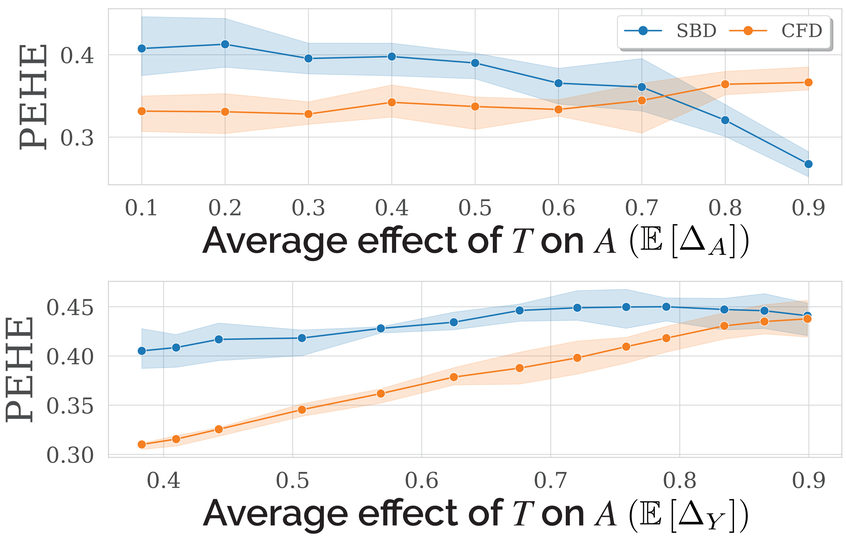
Visualization of the advantage bound



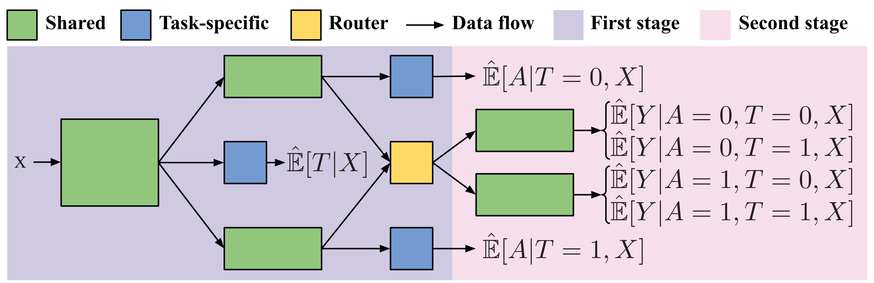
CFD's advatange increases as Δ_A or Δ_Y decreases.

Synthetic experiments validate our theory

We synthetically generate individuals' X, T, A, and Y.
Δ_A and Δ_Y are controlled via A and Y's generation.

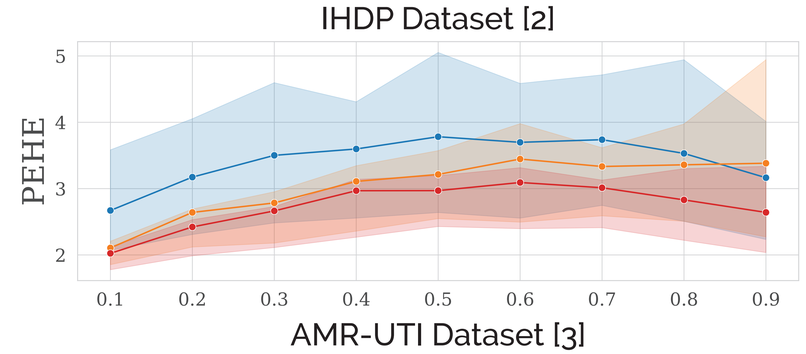


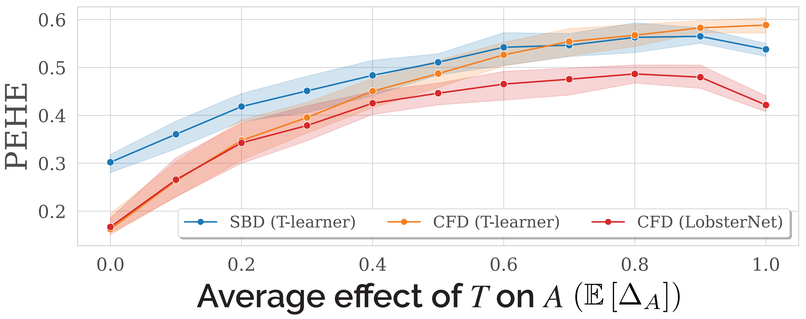
We propose LobsterNet to implement CFD



LobsterNet is a multitask neural network that jointly models all nuisance parameters required by CFD.

LobsterNet leads to further improvement





LobsterNet further improves over CFD + standard estimator (T-learner) espcially when Δ_A is large.

References

[1] Victor M Montori, et al. Intentionto-treat principle. Canadian Medical Association Journal. 2001.

[2] Jennifer L Hill. Bayesian nonparametric modeling for causal inference. Journal of Computational and Graphical Statistics. 2011.

[3] Michael Oberst, et al. AMR-UTI: Antimicrobial Resistance in Urinary Tract Infections (version 1.0.0). PhysioNet. 2020.

winstonchenn.github.io This work was supported by the Division of Information & Intelligent System of National Science Foundation (grant 2124127) chenwt@umich.edu