Assumptions for Causal Inference

(1) Ignorability

- Able to ignore absence of counterfactual outcomes and simply use $Y(0)$ and $Y(1)$ groups to calculate ATE
- Requires groups to be equivalent

$$(Y(1), Y(0)) \perp\!\!\!\perp \text{Treatment Assignment}$$

(2) Exchangeability

- Copy paste above
- If I check treatment effects on two groups, they should be identical
- Groups should have similar characteristics

$$\boxed{E[Y(1) - Y(0)] = E[Y(1)] - E[Y(0)]}$$

(3) Identifiability

Causal effect should be expressable in the form of statistical measures and variables

$$E[Y(t)] = E[Y \mid T = t]$$

(4) Consistency

Say I have defined T, $Y(1)$ and $Y(0)$.

When I actually apply $T=1$, the observed effect should be $Y(1)$

$\Rightarrow$ Model formulation should match observed results

(5) No interference

$$\boxed{Y_i(t_1, t_2, \cdots, t_i, \cdots, t_n) = Y_i(t_i)}$$

My outcome is specified only by my treatment and not anyone else's.

Very easily violated

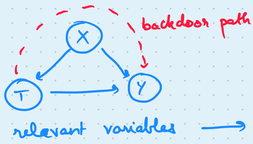
(6) SUTVA: Single Unit Test Value Assumption

Unit i's outcome is only a function of unit i's treatment

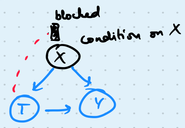
$$\boxed{\text{SUTVA} = \text{consistency} + \text{no interference}}$$

(7) Conditional exchangeability

Say exchangeability is violated due to a confounder. [unrealistic to assume all groups are exchangeable]



Conditioning on relevant variables $\longrightarrow$ subgroups obtained will be exchangeable



$$\boxed{(Y(1), Y(0)) \perp\!\!\!\perp T \mid X}$$

(8) Positivity / Overlap

For every possible combination of covariates $x \in X$, probability of both treatment & control should be non-zero.

$$\boxed{0 < P(T=1 \mid X=x) < 1}$$

If $P(T=1 \mid X=x) = 0 \rightarrow$ never be able to apply treatment $\longrightarrow$ no counterfactual exists and vice versa for $T=0$

(9) Unconfoundedness

If say X determines T and Y, there may be another covariate W that affects T and Y as well

untestable

If none $\longrightarrow$ strong unconfoundedness

Unconfoundedness vs Positivity

Strong unconfoundedness $\Rightarrow$ violation of positivity

Many many $x \in X$ in model $\longrightarrow$ All x combinations may not be present in data

$\downarrow$

Those get 0 probability of T

Relaxed unconfoundedness

Reduce x to ensure positivity $\longrightarrow$ May not capture all covariates that need to be measured.