Marginal structural models (MSM)

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Motivation: PRIMARY DIFFERENCE: MSMs model potential outcomes Y^a as opposed to observed outcomes Y.

- IPTW estimation is used for simple causal effects s.a. average causal effect (ACE)
  ↳ BUT we can also use IPTW methods to estimate causal effect params. from models

Marginal: model that is not conditional on the confounders (thus allowing use to infer population average estimates)

Structural: model for potential outcomes, NOT observed outcomes

1) Linear MSM: (continuous outcome)

params. we want to estimate

- $E[Y^a] = \psi_0 + \psi_1 a \qquad a = 0, 1$

then: $E[Y^0] = \psi_0$ and $E[Y^1] = \psi_0 + \psi_1$

thus: ψ_1 is the average causal effect $E[Y^1] - E[Y^0] = (\psi_0 + \psi_1) - (\psi_0) = \psi_1$

MSM: is a model for the mean of the potential outcomes Y^a. (i.e. $E[Y^a]$)

2) Logistic MSM: (binary outcome)

(equivalent to $P(Y^a = 1)$ b/c Y^a is binary.)

- $\text{logit}(E[Y^a]) = \psi_0 + \psi_1 a \qquad a = 0, 1$
- so $\exp(\psi_1)$ is the causal odds ratio

→ the mean of a binary outcome is a PROBABILITY of the outcome being equal to 1.

entire pop. odds ratio

$$\left\{ \frac{\dfrac{P(Y^1 = 1)}{1 - P(Y^1 = 1)} \Big\} \text{ odds that } Y^1 = 1}{\dfrac{P(Y^0 = 1)}{1 - P(Y^0 = 1)} \Big\} \text{ odds that } Y^0 = 1} \right.$$

MSM with Effect Modification (a.k.a. heterogeneity of treatment effect):

- suppose V is a variable that modifies the effect of treatment A
→ linear MSM w/ effect modifier: (e.g. $V \equiv$ diabetes, where $V(\text{diabetes} = \text{Yes}) = 1$, $V(\text{diabetes} = \text{No}) = 0$)

instead of cond. on all confounders X, only cond. on V

$$E[Y^a | V] = \psi_0 + \psi_1 a + \psi_3 V \cdot \psi_4 \cdot a \cdot V$$

main effect for interaction term $a \cdot V$

$(a = 0, 1)$

main effect for modifier V

main effect for treatment a

then $E[Y^1 | V] - E[Y^0 | V] = \psi_1 + \psi_4 V$

→ Idea of effect modifier: At different values of V, there might be different treatment effects.

- V... effect modifier

General MSM:

- $g\{E[Y^a | V]\} = h(a, V; \psi)$

$g\{\cdot\}$ ... link function

$h(\cdot)$ ... is a fct. specifying parametric form of a and V (typically additive, linear)