Causal Inference Chap 7: Confounding

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The structure of confounding

Confounding: form of lack of exchangeability between the treated and the untreated.

$\rightarrow$ Presence of confounding holds "association is not causation"

Figure 7.1

- Figure shows treatment A outcome Y and common cause L
- The path $A \leftarrow L \rightarrow Y$ is an example of a *backdoor path*.
- Presence of the common cause L creates a confounding for the effect of A on Y.
- Hence, associational risk ratio is not equal to causal risk ratio $\frac{Pr[Y=1|A=1]}{Pr[Y=1|A=0]} \neq \frac{Pr[Y^{a=1}=1]}{Pr[Y^{a=0}=1]}$

The structure of confounding

Examples of confounding in observational research

- Occupational factors: The effect of working as a firefighter A on the risk of death Y will be confounded if "being physically fit" L is a cause of both being a firefighter and having a lower mortality risk.
- Clinical decisions: The effect of drug A(aspirin) on the risk of disease Y(stroke) will be confounded if the drug is more likely to be prescribed to individuals with certain condition L(heart disease). And both L and Y are caused by atherosclerosis U, an unmeasured variable.(*confounding by indication*)

$\rightarrow$ All the cases are because of the bias with same structure.
(common cause L results in open backdoor path between A and Y)

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Confounding and exchangeability

Question: If confounding is likely, can we determine whether there exists a set of measured covariates L for which conditional exchangeability holds?

$\rightarrow$ thinking in terms of conditional exchangeability $Y^a \perp A|L$ is often not intuitive

1. the backdoor criterion applied to the causal DAG
2. the transformation of the causal DAG into a SWIG

Confounding and the backdoor criterion

Backdoor criterion

1. A set of covariates L satisfies the *backdoor criterion* if all backdoor paths between A and Y are blocked by conditioning on L
2. L contains no variables that are descendants of treatment A

$\rightarrow$ conditional exchangeability $Y^a \perp A|L$ holds iff L satisfies the backdoor criterion

Confounding and the backdoor criterion

Relation between backdoor criterion and confounding

1. If no common causes of treatment and outcome, the backdoor criterion is satisfied. This describes a marginally randomized experiment in which confounding is not expected.
2. Common causes of treatment and outcome but a subset L of measured non-descendants of A suffices to block all backdoor paths. This describes a conditionally randomized experiment in which the probability of receiving treatment is the same for all individuals with the same value of L .

Confounding and the backdoor criterion

The application of the backdoor criterion to determine whether the causal effect of A on Y is identifiable and which variables are required to ensure conditional exchangeability.

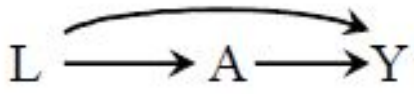

Figure 7.1

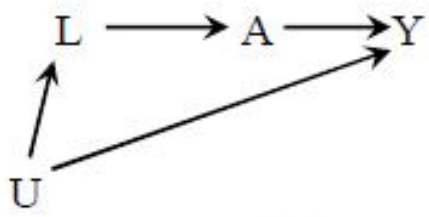

Figure 7.2

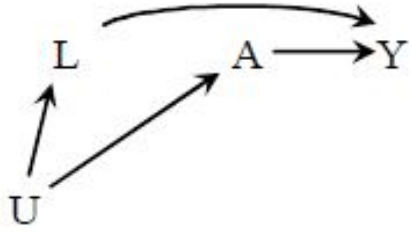

Figure 7.3

$\rightarrow$ Backdoors can be blocked by conditioning on L or U.

Confounding and the backdoor criterion

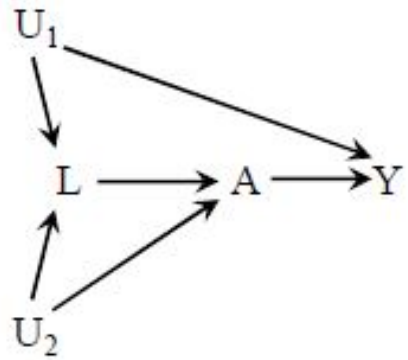

Figure 7.5

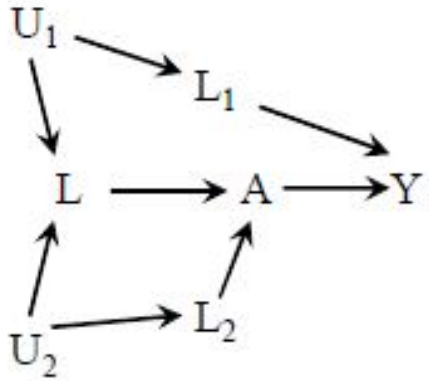

Figure 7.6

- In figure 7.5, the bias is intractable since conditioning on L would block the backdoor path($A \leftarrow L \leftarrow U_1 \rightarrow Y$) but opens another backdoor path on which L is a collider($A \leftarrow U_2 \rightarrow L \leftarrow U_1 \rightarrow Y$)
- The solution is to measure either (i) a variable L_1 between U_1 and Y (conditional exchangeability given L_1) or (ii) variable L_2 between U_2 and A (conditional exchangeability given both L and L_2)as in figure 7.6

Single-world intervention graphs

SWIG unifies the counterfactual and graphical approaches by explicitly including the counterfactual variables on the graph
$\rightarrow$ SWIG depicts the variables and causal relations in a hypothetical world in which all individuals received treatment level a.

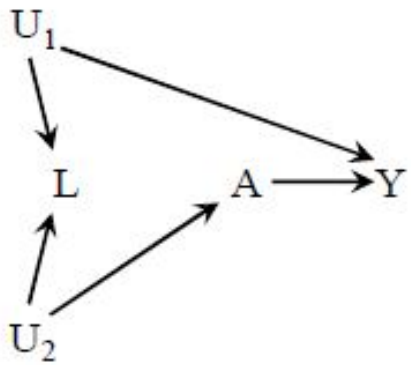

Figure 7.4

$\Longrightarrow$

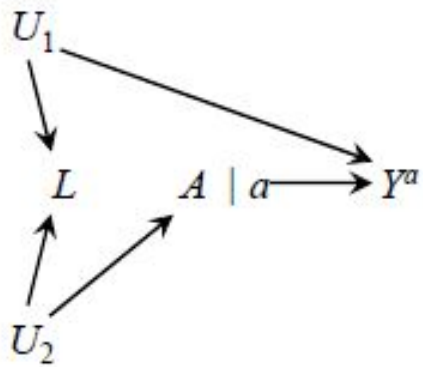

Figure 7.10

- Marginal exchangeability $Y^a \perp A$ holds because all paths between Y^a and A are blocked without conditioning on L
- Conditional exchangeability $Y^a \perp A|L$ not holds because the path is open when the collider L is conditioned on