

# Instruments for causal inference: an epidemiologist's reality

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## What is this all about?

A healthy skepticism that exists toward the existence of instrumental variables (IVs) and their use to identify causal effects. We aim to demonstrate that causal identification that relies on no uncontrolled confounding requires the same assumptions as IV analyses.

## Instrumental variables are required for positivity

Positivity is defined as:

$$P(A=a | L=l) > 0 \text{ for all } l$$

where A is treatment, and L is a set of confounders. This definition of positivity is in terms of a downstream result: the probability of exposure must be greater than zero in all strata of L. But positivity can be reframed in upstream terms: it implies the existence of a variable which effects treatment without having an effect on the outcome, an IV. This is because, without a variable to vary treatment within  $L=l$ , the probability of treatment cannot vary.

## Demonstration

In Figure 1 (below), no contrasts are possible when confounders are the only source of variation in A. The presence of an IV allows for one possible causal contrast.

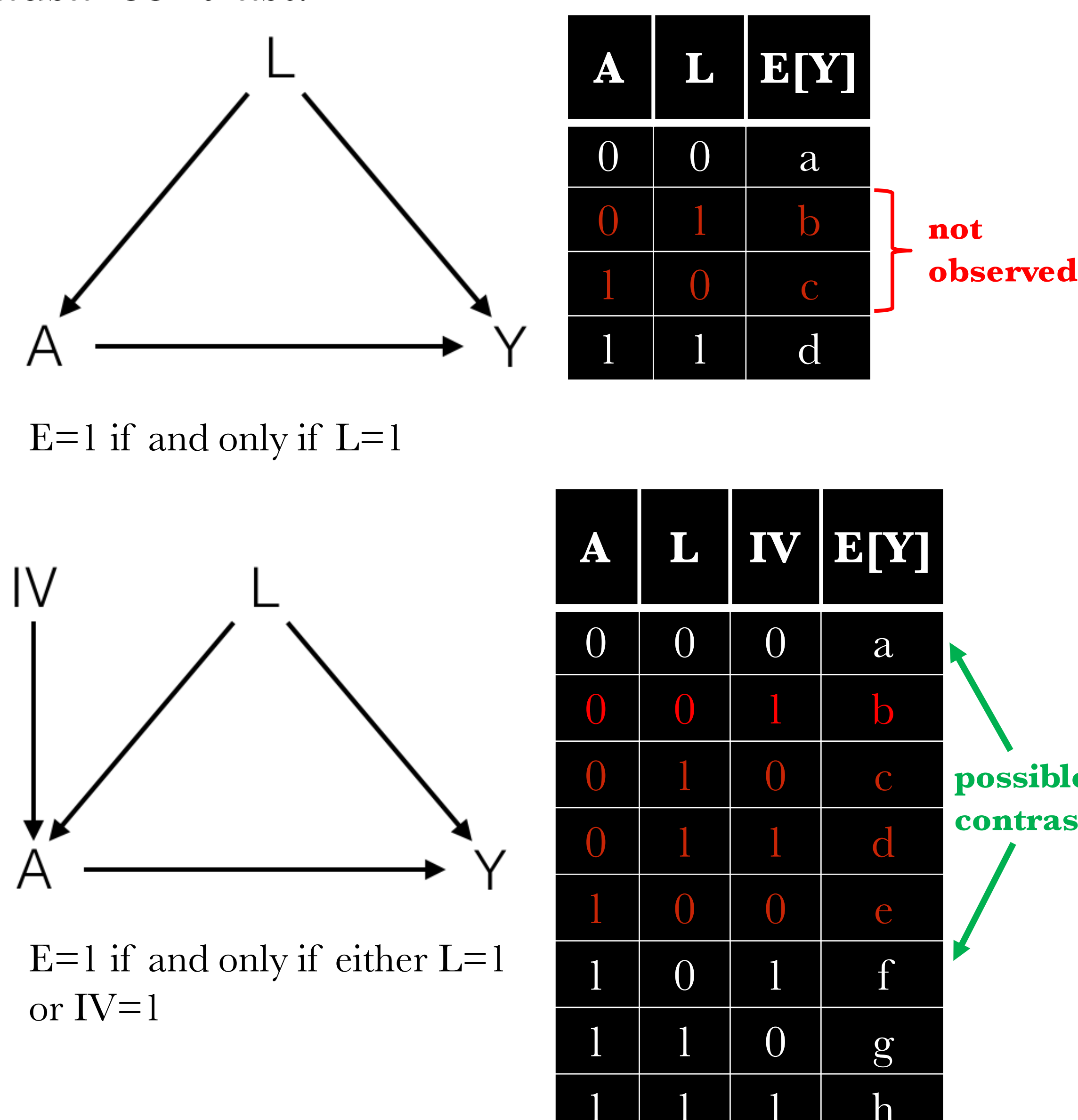


Figure 1—Causal graph and stratum specific expected values with and without an IV

## Exchangeability and positivity imply the presence of an instrumental variable

- To satisfy the positivity assumption, a variable that meets the three criteria of IVs is required
- Assumption 1 (figure 2) is required to satisfy positivity
- Assumptions 2 and 3 are required to satisfy exchangeability

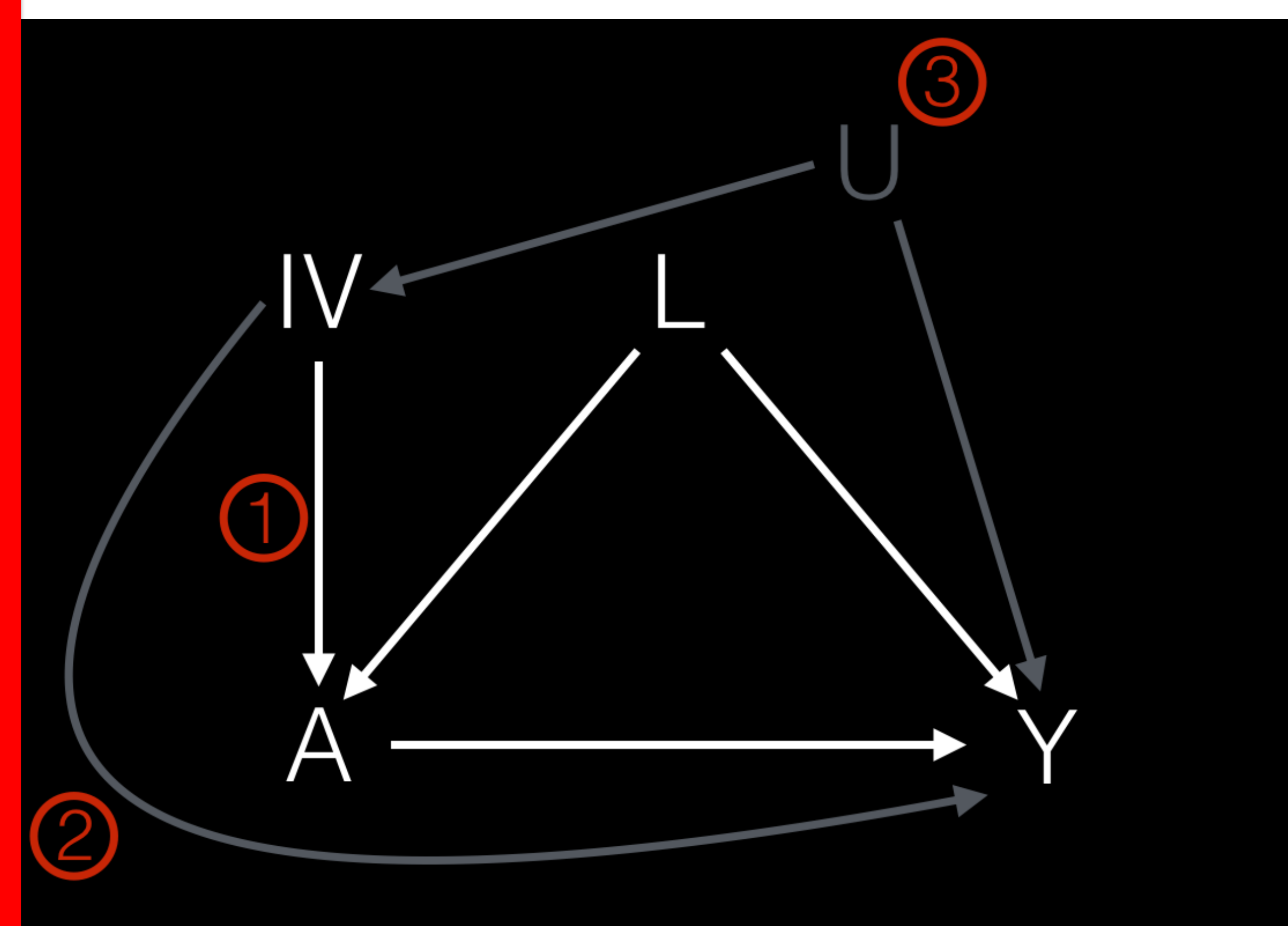


Figure 2—The three main assumptions of an IV: 1) the IV has a causal effect on A, 2) the IV does not have a direct effect on the outcome and 3) the IV does not share a common cause with the outcome.

## Comparison of IV and no uncontrolled confounding analyses

- The purpose of this poster is not to prefer one type of analysis over the other but to better understand how the assumptions made by the two are related.
- Given a causal graph where either assumption 2 or 3 is violated, the IV analysis will always be more biased. This is because, although both approaches require IV assumptions, they are not leveraged in the same way.
- Whereas in an IV analysis only one variable must meet the IV assumptions, every source of variation remaining in A after controlling for L must meet the IV assumptions in a no uncontrolled confounding analysis.
- If you think the assumptions are heroic in an IV analyses, simultaneously satisfying positivity and exchangeability simultaneously is equally heroic.

## Thinking about sources of variation in the exposure

- Given the importance of positivity to causal inference, more attention should be paid to the source of positivity and whether it can plausibly satisfy the IV assumptions.
- Equal thought should be given to potential confounders and IVs that can satisfy the positivity assumption.
- If the positivity assumption is satisfied in the absence of an IV then, under faithfulness, this logically implies that the causal estimated must be biased.
- Recognizing the importance of IVs in causal inference reemphasizes the fact that adjusting for an IV can reduce precision, reduce positivity and introduce amplification bias.

## Example

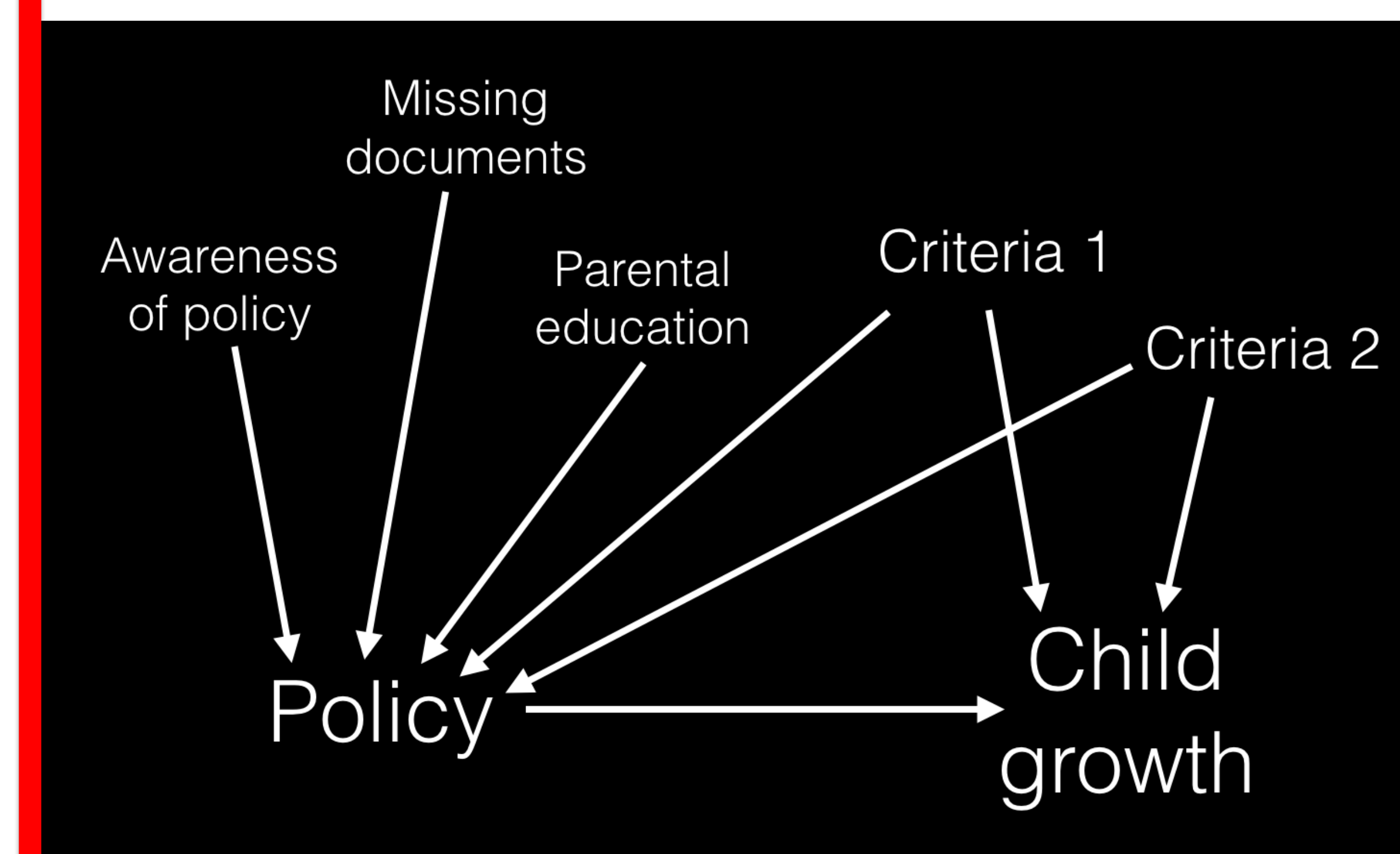


Figure 3—Causal graph of the effect of a policy on child growth

- If adherence to the policy is perfect and there are no criteria for policy participation unrelated to the outcome, positivity will not be satisfied.
- If participation is not perfect, if one aims to estimate causal effects, a plausible source of variation in the exposure that is not related to the outcome must exist.
- In the example given above, do any of the proposed IVs seem plausible?

This work was made possible by the following: