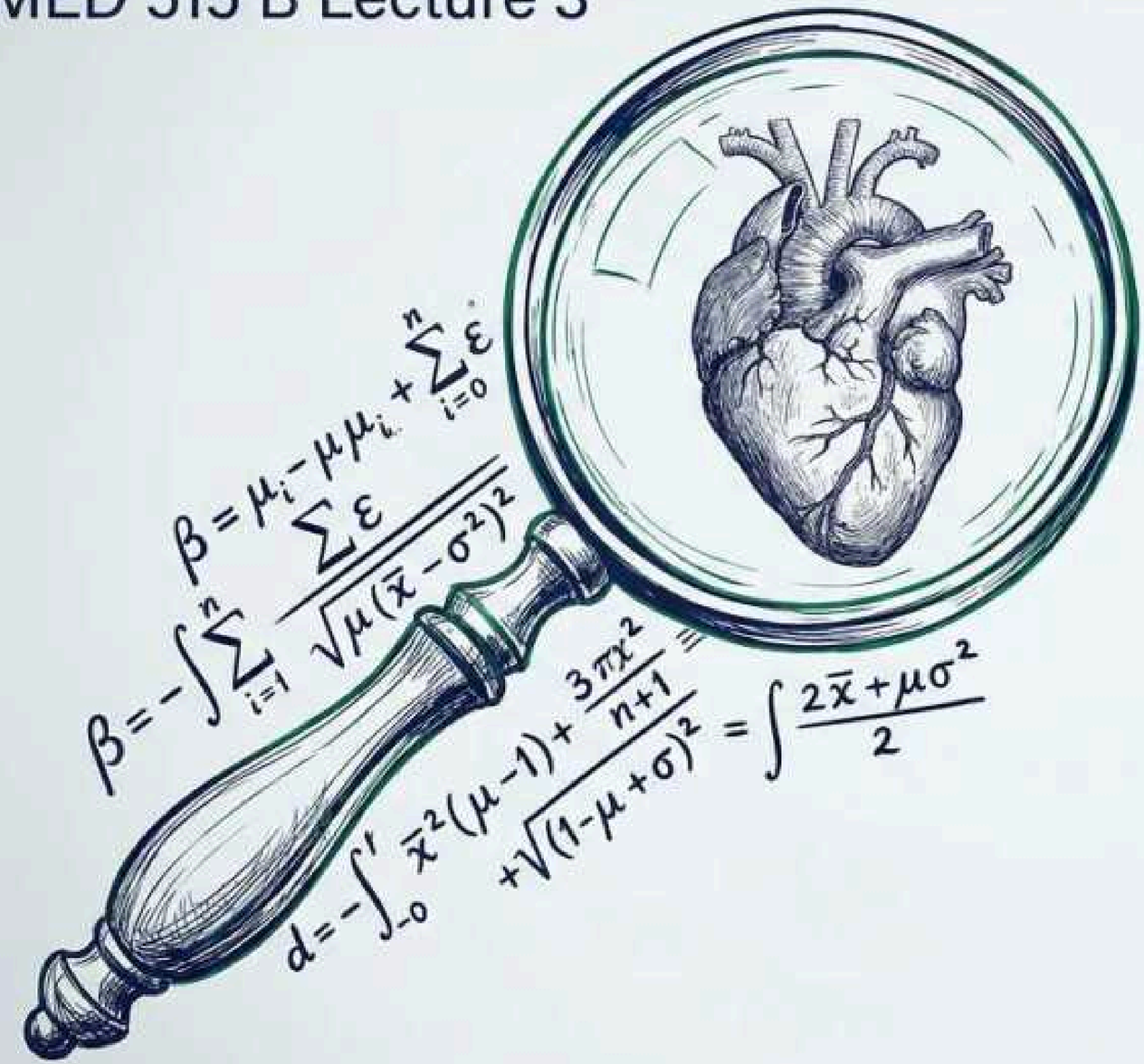
MED 515 B Lecture 3



Bias, Confounding, and Causation

The Architecture of Epidemiological Truth

¶ 3.1

Observed Association = Real Cause ∪ Chance ∪ Bias ∪ Confounding

Handled by Statistics (See MED 514 B)

Handled by good design & careful thought (Subject of this lecture)

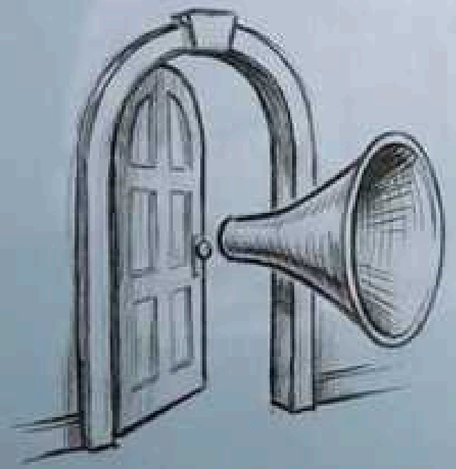
An association between an exposure and an outcome may be real—or it may be an illusion produced by external factors.

¶ 3.2

The Truth → **SYSTEMATIC ERROR (BIAS)**

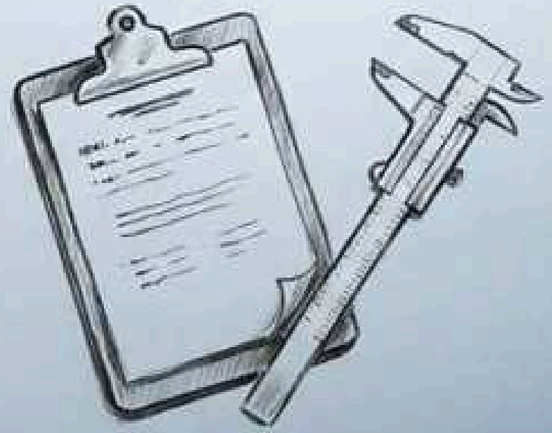
Anything in the study execution that pushes results systematically away from truth.

Selection Bias



Arises from how people *get into* a study.

Information / Measurement Bias



Arises from how data about subjects are *collected*.

Selection Bias: The Healthy Worker Effect

¶ 3.3

Factory Workers
(Employed)



Healthier on average
(very sick cannot work).

≠

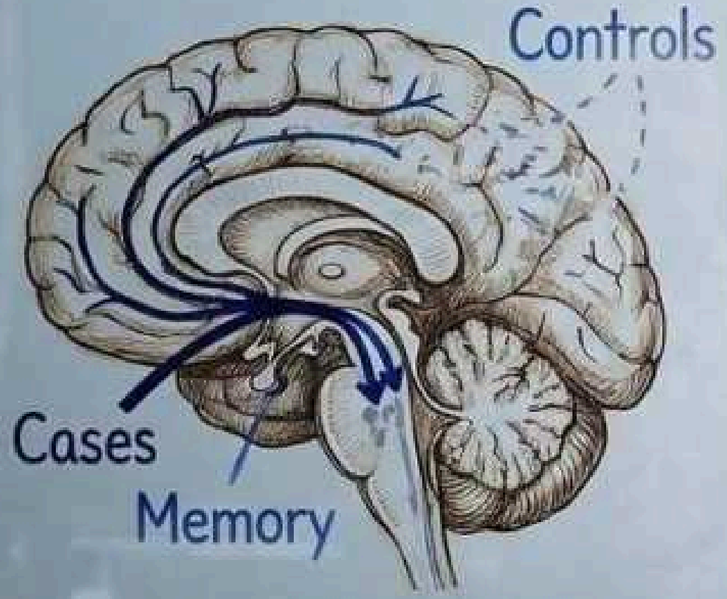
General Population
(Includes the very sick)



Comparing these two groups falsely elevates the apparent safety of the factory, masking real risks.

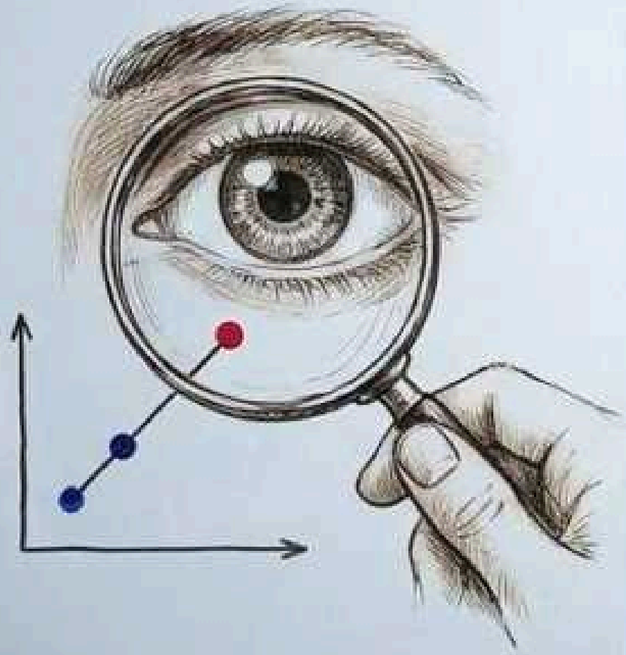
¶ 3.4

Recall Bias



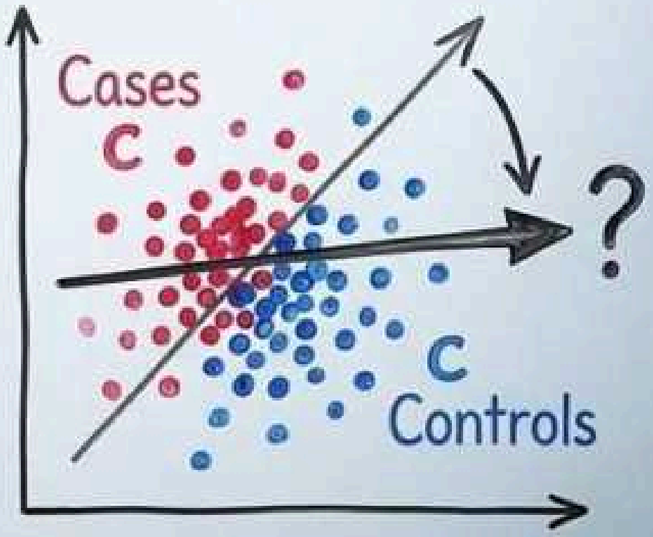
Cases remember past exposures differently than controls.

Observer Bias

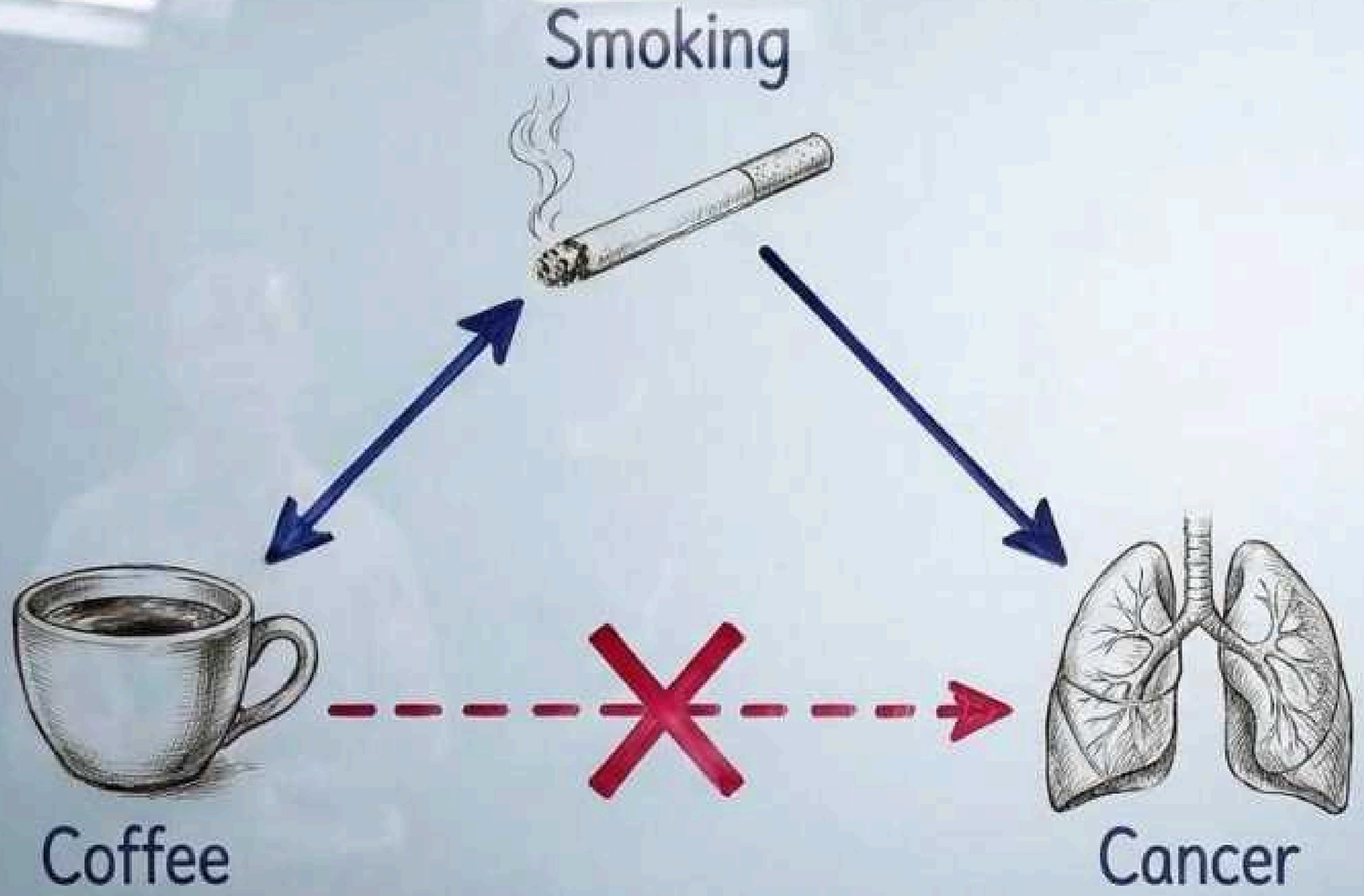


Researchers knowing exposure status look harder for the outcome.

Misclassification



Even random misclassification of exposure/disease weakens a real association, hiding existing effects.



Confounding is a mixing of effects. The confounder (Smoking) does not lie on the causal path between Coffee and Cancer, but creates a false association between them.

Controlling the Confounder

¶ 3.6

At Design Stage

Randomisation ★ Pr

The most powerful method.

Restriction

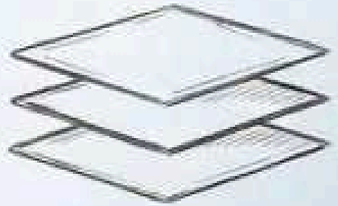
Limiting study to one group (e.g., only non-smokers).

Matching

Pairing each case with a control of identical age/sex.

At Analysis Stage

Stratification



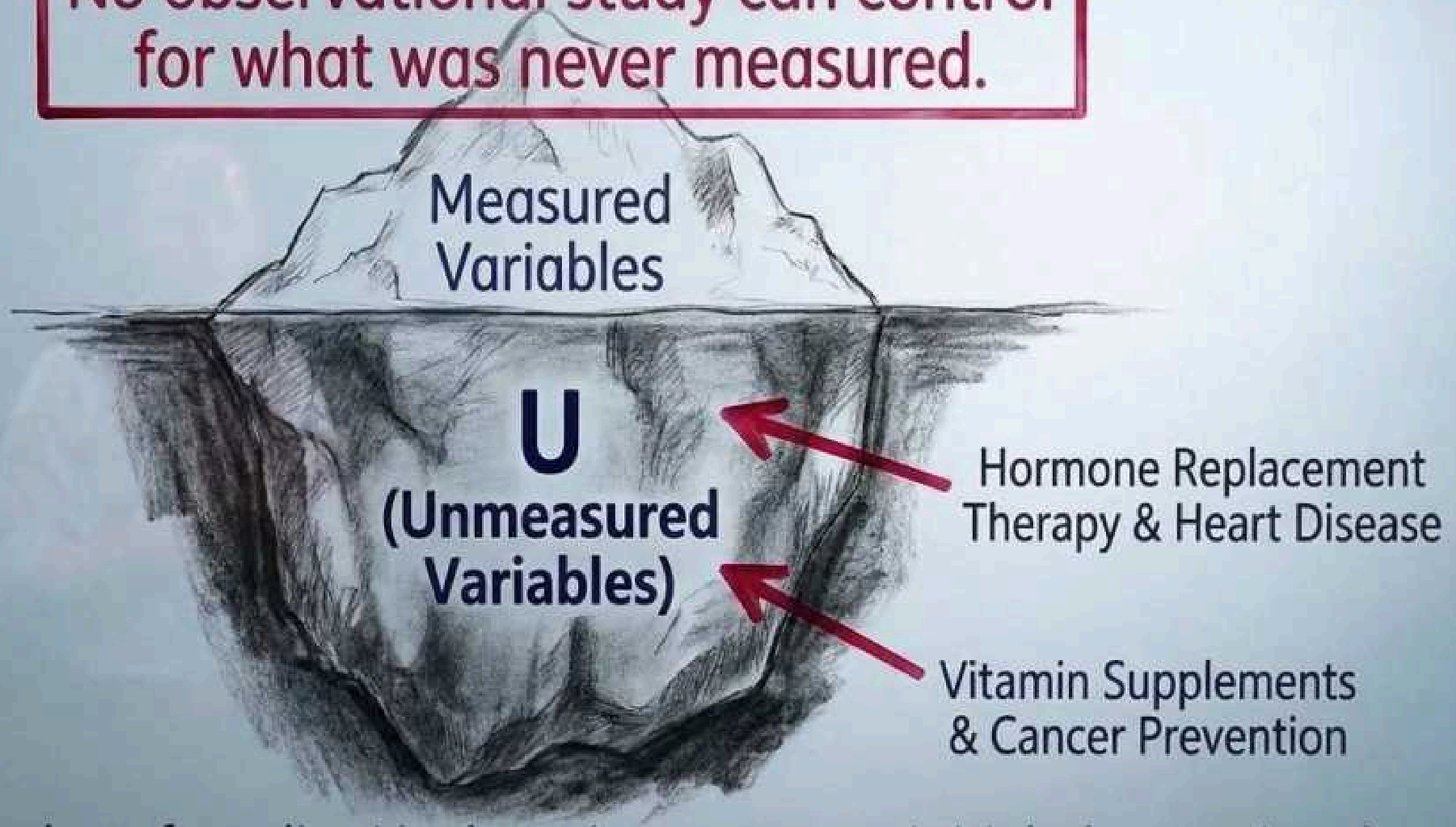
Examining results separately within levels of the confounder.

Regression $\beta_0 + \beta_1 X_1 + \dots$

Adjusting mathematically.

¶ 3.7

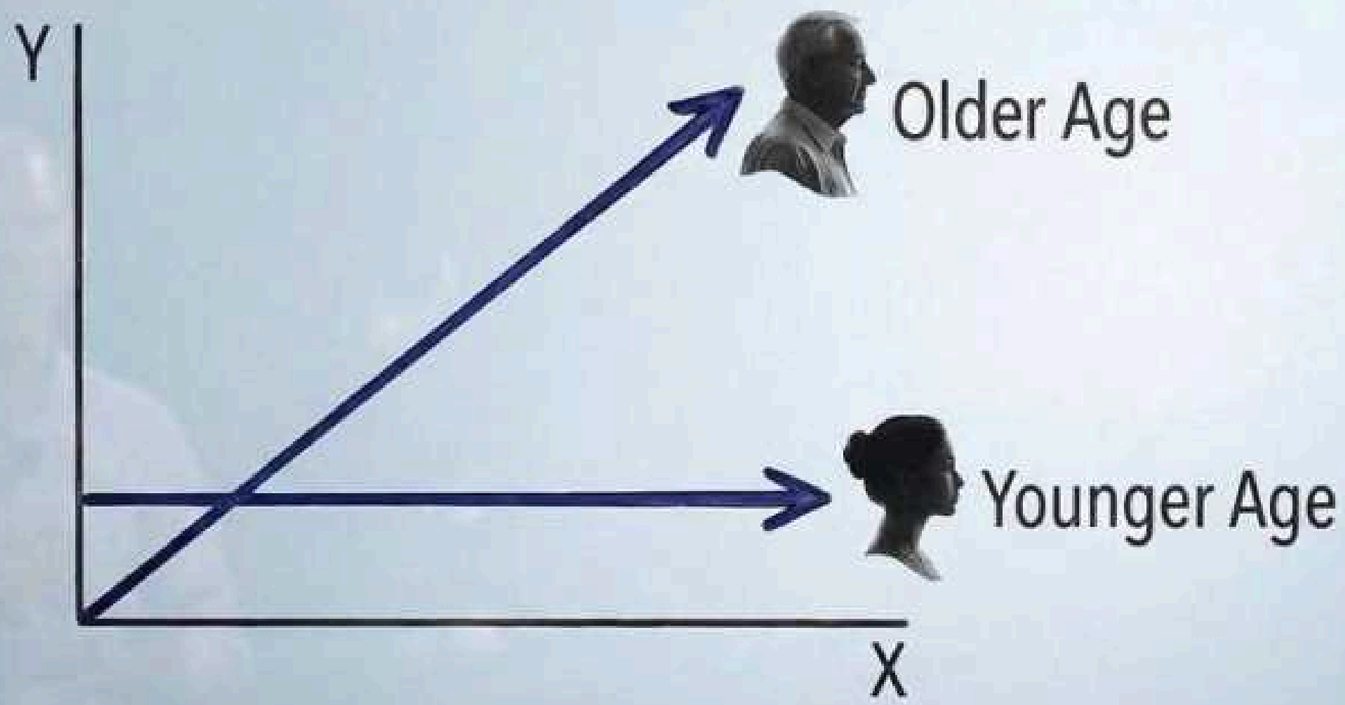
No observational study can control for what was never measured.



This 'residual confounding' is the primary reason initial observational findings are frequently overturned by later randomized trials.

Effect Modification: A Biological Reality

¶ 3.8



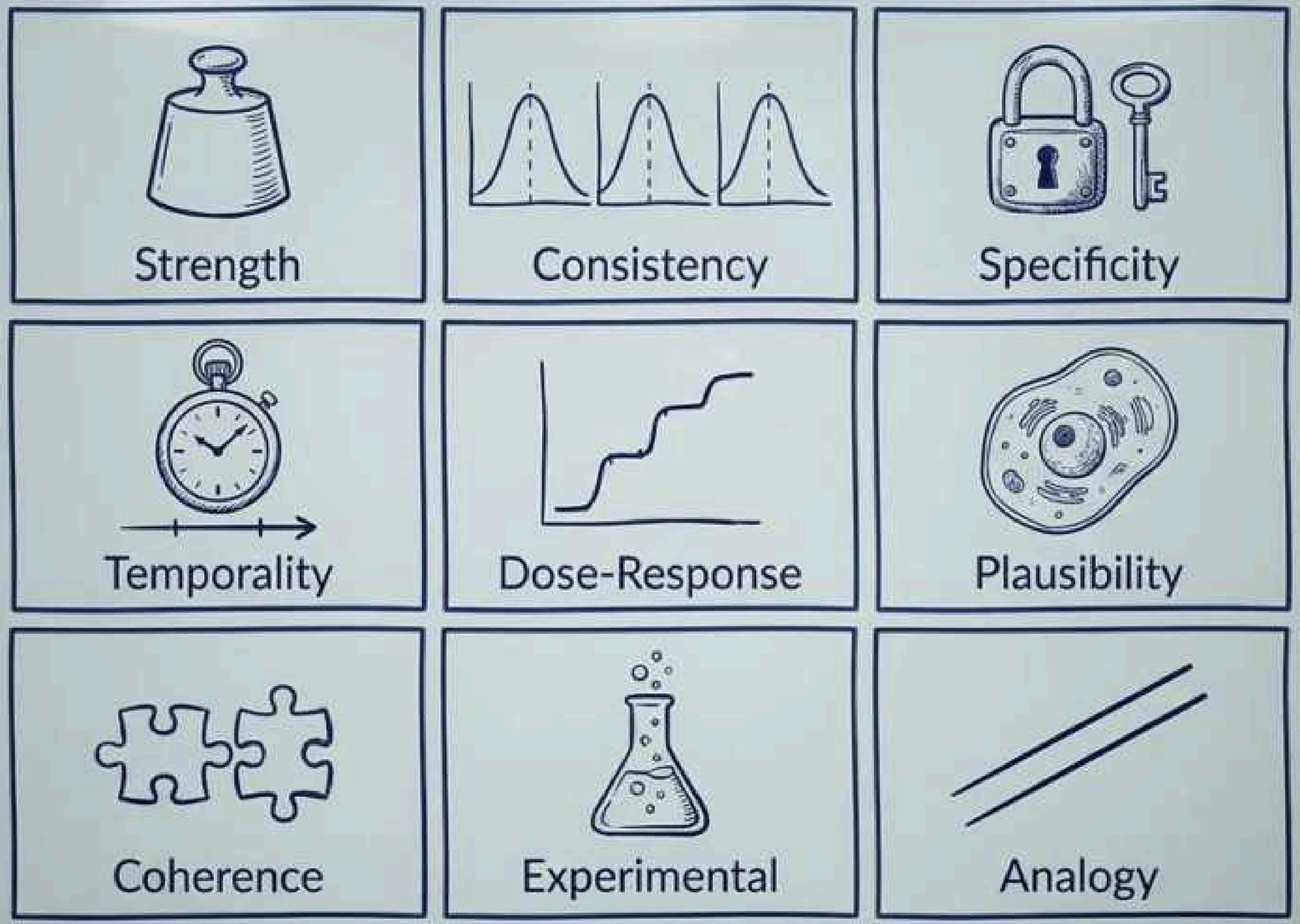
≠ BIAS
(Do not remove!)

= REAL FINDING
(Must be reported)

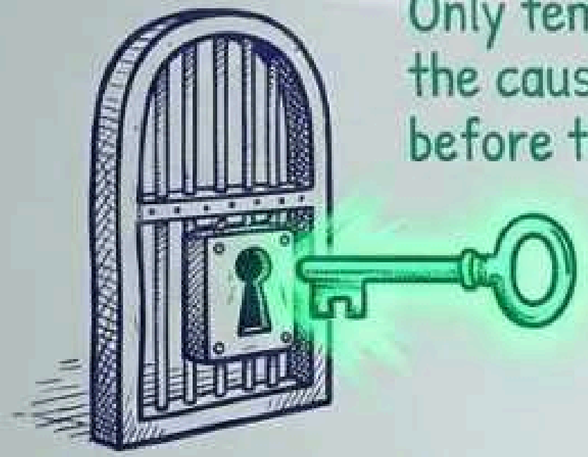
Effect modification means the exposure genuinely differs between groups (e.g., a drug works well in men, poorly in women). It is a biological reality, not a systemic error.

The Bradford Hill Considerations (1965)

¶ 3.9



A list of considerations for judging whether an association is likely to be causal.

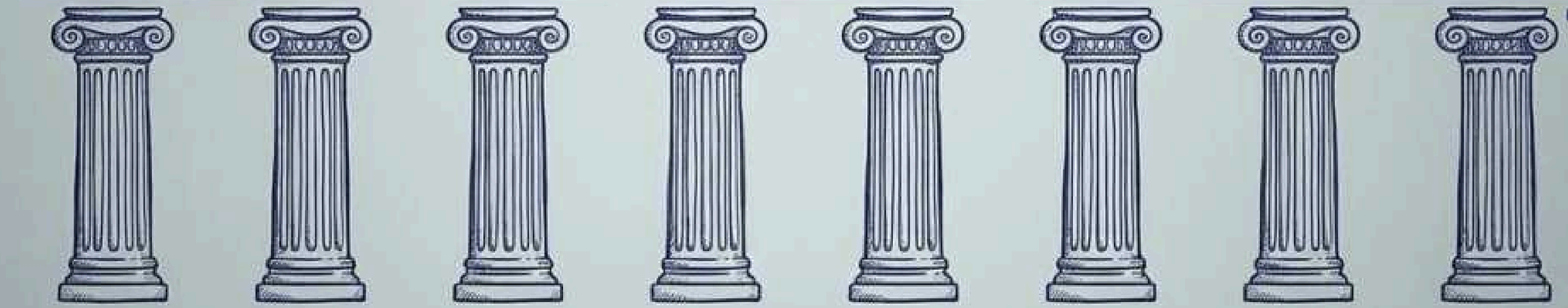


Only temporality is essential:
the cause MUST come
before the effect.

Time = $t_0 \rightarrow t_1 \rightarrow t_2$



Exposure (Smoking) Effect (Lung Cancer)



The others are aids to judgement, not strict rules. (e.g., Smoking and lung cancer satisfy almost all: strong, consistent, follows exposure, dose-response, and biologically plausible).

Step 1: Observe Association.

↓

Step 2: Rule out Chance (Stats).

↓

Step 3: Rule out Bias (Selection/Info).

↓

Step 4: Control Confounding.

↓

Step 5: Weigh Evidence (Bradford Hill).

↓

True Causal Inference.

Next Lecture →

Applying these ideas to the doctor's daily task of clinical diagnosis.