

When Standard Methods Succeed

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when correlation *is* causation

When you have no confounders and there is a linear relationship between the exposure and the outcome, that *correlation is a causal relationship*



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When you have no *confounders* and there is a linear relationship between the exposure and the outcome, that correlation is a causal relationship



randomized controlled trials

A/B testing

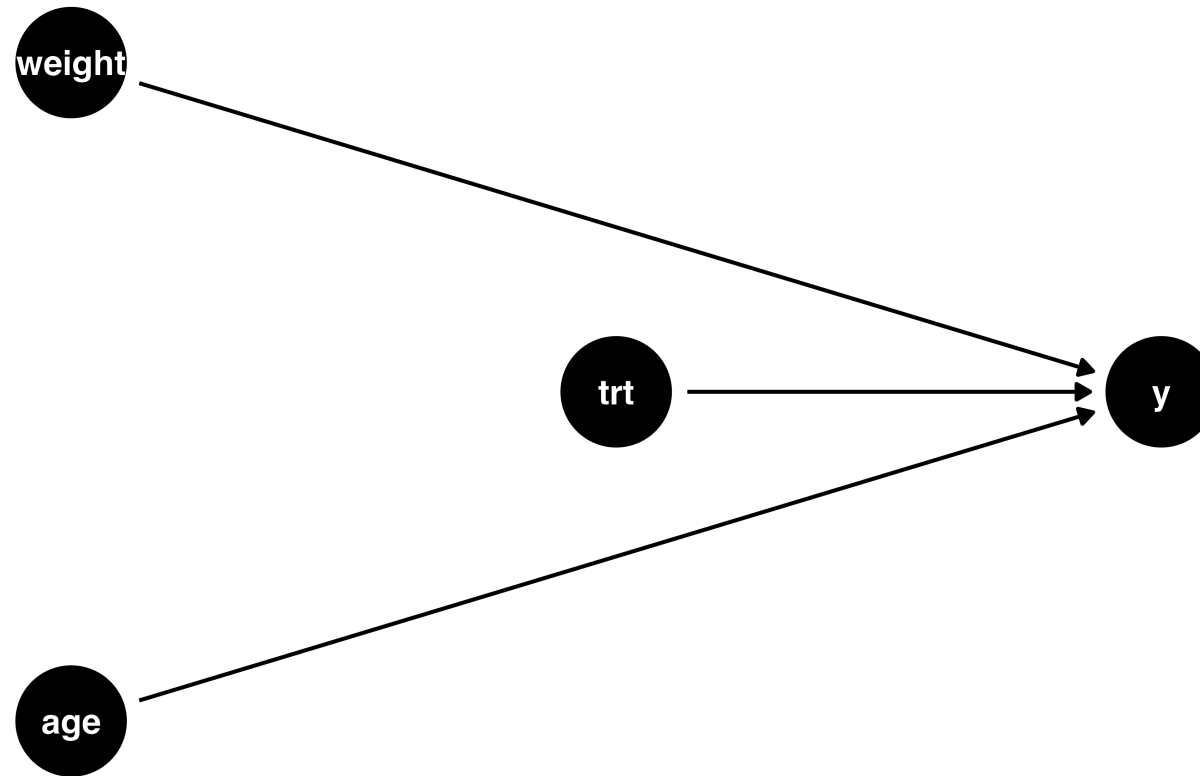
**Even in these cases, using the methods
you will learn here can help!**

- 1 Adjusting for baseline covariates can make an estimate *more efficient*
- 2 Propensity score weighting is *more efficient* than direct adjustment
- 3 Sometimes we are *more comfortable with the functional form of the propensity score* (predicting exposure) than the outcome model

Example

- simulated data (100 observations)
- Treatment is randomly assigned
- There are two baseline covariates: age and weight

Example



- True average treatment effect: 1

Unadjusted model

```
1 lm(y ~ treatment, data = data)
```

| Characteristic | Beta | SE ¹ | 95% CI ¹ | p-value |
|----------------|------|-----------------|---------------------|---------|
| treatment | 0.93 | 0.803 | -0.66, 2.5 | 0.2 |

¹ SE = Standard Error, CI = Confidence Interval

Adjusted model

```
1 lm(y ~ treatment + weight + age, data)
```

| Characteristic | Beta | SE ¹ | 95% CI ¹ | p-value |
|----------------|------|-----------------|---------------------|---------|
| treatment | 1.0 | 0.204 | 0.59, 1.4 | <0.001 |
| weight | 0.34 | 0.106 | 0.13, 0.55 | 0.002 |
| age | 0.20 | 0.005 | 0.19, 0.22 | <0.001 |

¹ SE = Standard Error, CI = Confidence Interval

Propensity score adjusted model

| Characteristic | Beta | SE | 95% CI | p-value |
|----------------|------|-------|----------|---------|
| treatment | 1 | 0.202 | 0.6, 1.4 | <0.00 |

Example

- simulated data (10,000 observations)
- Treatment is randomly assigned
- There are two baseline covariates: age and weight

Unadjusted model

```
1 lm(y ~ treatment, data = data)
```

| Characteristic | Beta | SE ¹ | 95% CI ¹ | p-value |
|----------------|------|-----------------|---------------------|---------|
| treatment | 0.96 | 0.083 | 0.80, 1.1 | <0.001 |

¹ SE = Standard Error, CI = Confidence Interval

Adjusted model

```
1 lm(y ~ treatment + weight + age, data)
```

| Characteristic | Beta | SE ¹ | 95% CI ¹ | p-value |
|----------------|------|-----------------|---------------------|---------|
| treatment | 1.0 | 0.020 | 0.98, 1.1 | <0.001 |
| weight | 0.20 | 0.010 | 0.18, 0.22 | <0.001 |
| age | 0.20 | 0.000 | 0.20, 0.20 | <0.001 |

¹ SE = Standard Error, CI = Confidence Interval

Propensity score adjusted model

| Characteristic | Beta | SE | 95% CI | p-value |
|----------------|------|------|--------|---------|
| treatment | 1 | 0.02 | 1, 1.1 | <0.001 |

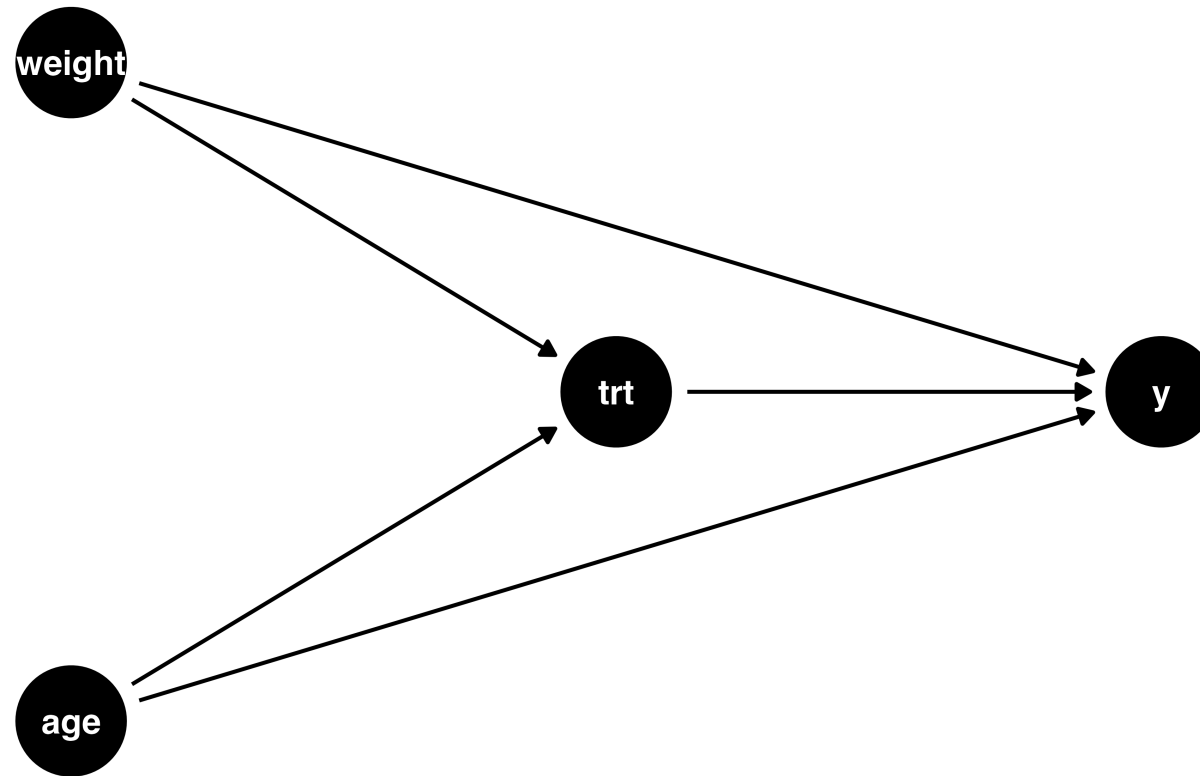
time-varying confounding

Example

Example

- simulated data (10,000 observations)
- Treatment is **not** randomly assigned
- There are **two baseline confounders**: age and weight
- The treatment effect is **homogeneous**

Example



- True average treatment effect: 1

Unadjusted model

```
1 lm(y ~ treatment, data = data)
```

| Characteristic | Beta | SE ¹ | 95% CI ¹ | p-value |
|----------------|------|-----------------|---------------------|---------|
| treatment | 1.8 | 0.085 | 1.7, 2.0 | <0.001 |

¹ SE = Standard Error, CI = Confidence Interval

Adjusted model

```
1 lm(y ~ treatment + weight + age, data)
```

| Characteristic | Beta | SE ¹ | 95% CI ¹ | p-value |
|----------------|------|-----------------|---------------------|---------|
| treatment | 0.98 | 0.021 | 0.94, 1.0 | <0.001 |
| weight | 0.20 | 0.010 | 0.18, 0.22 | <0.001 |
| age | 0.20 | 0.000 | 0.20, 0.20 | <0.001 |

¹ SE = Standard Error, CI = Confidence Interval

Propensity score adjusted model

| Characteristic | Beta | SE | 95% CI | p-value |
|----------------|------|----|--------|---------|
|----------------|------|----|--------|---------|

| | | | | |
|-----------|---|-------|--------|--------|
| treatment | 1 | 0.022 | 0.9, 1 | <0.001 |
|-----------|---|-------|--------|--------|

