# Better preanalysis plans through design declaration & diagnosis

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**Brian Nosek** @BrianNosek · Jan 16

The Journal of Politics is phasing in a requirement for all experimental research to be preregistered. I believe that this is just the second journal across the social-behavioral sciences to require preregistration.

**Pre-registration**: authors who want to submit manuscripts containing original experimental work, including laboratory, field, and survey experiments are required to submit proof of study/design pre-registration with one of the available research registries (e.g., EGAP, RCT, Open Science). Pre-registration of other types of research design is very much encouraged. The submission of unregistered laboratory, field, and survey experiments will not be accepted. This policy will be phased in: For manuscripts submitted in 2021, authors need to justify in a letter to the editor why the study was not or could not be pre-registered.

> **Journal of Politics** @The_JOP · Jan 16
>
> Dear Colleagues: before submitting to @The_JOP please have a look at the new guidelines for contributors, including pre-registration, replication, ethical considerations etc.: journals.uchicago.edu/journals/jop/i... @VETroeger

2 6 25

# What should go in a plan?

## 1. Research design declaration

Model
Inquiry
Data strategy
Answer strategy

## 2. Research design diagnosis

# What is a preanalysis plan?

**What are your hypotheses?**
**How will you test them?**

Timestamped publicly

# Why preanalysis plans?

**Clarify what you thought *before*, (*in the middle*), and *after***

**What tests are confirmatory vs. exploratory**

# Writing plans changes plans

# What goes in a plan?

**As Predicted: 9 items**

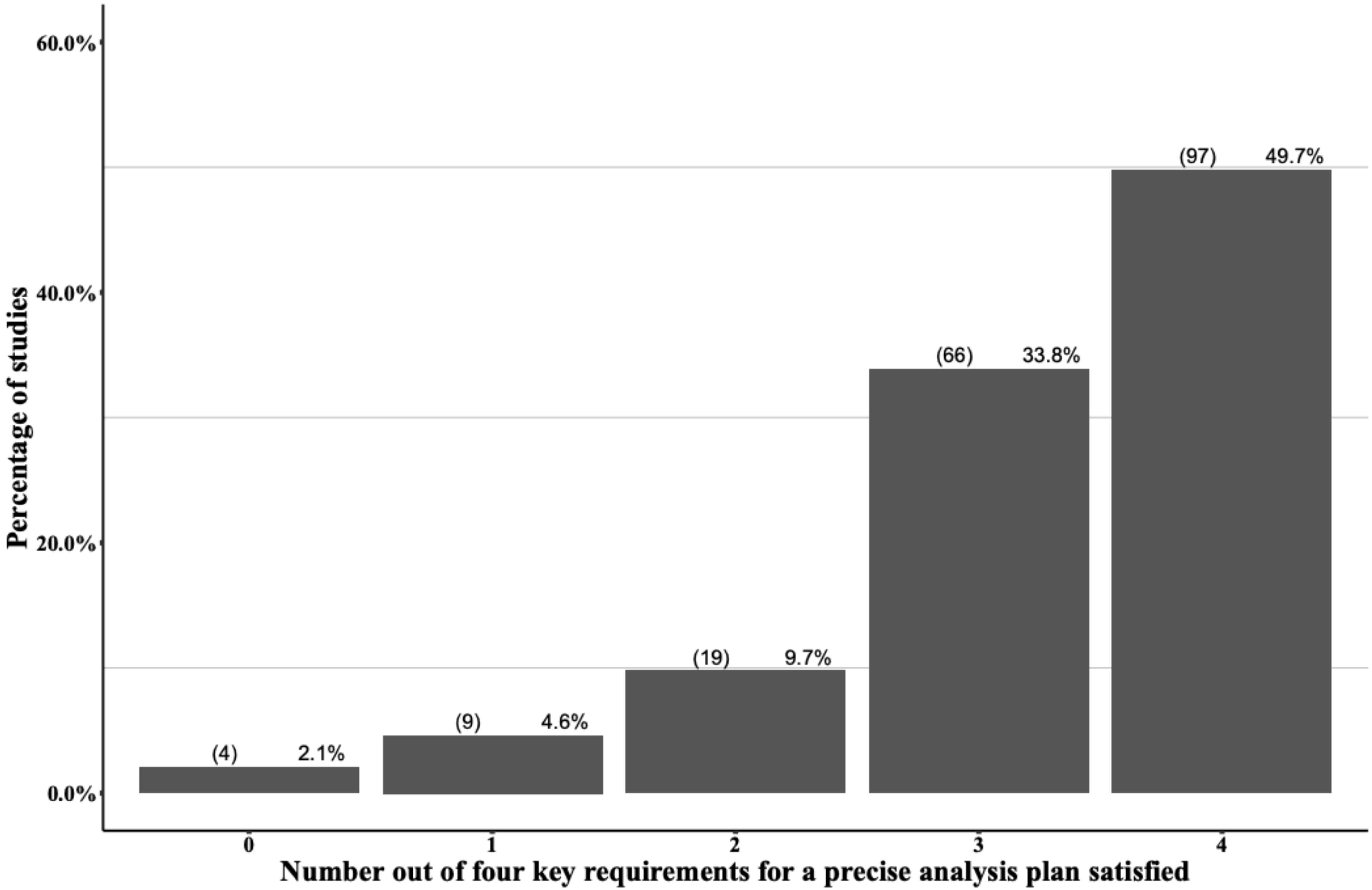
**McKenzie (2012): 10 items**

**AEA registry: ~ 30 items**

**EGAP registry: ~ 30 items**

**Journal of Development Economics: 44 items**

**Ganimian (2018): 60 items**

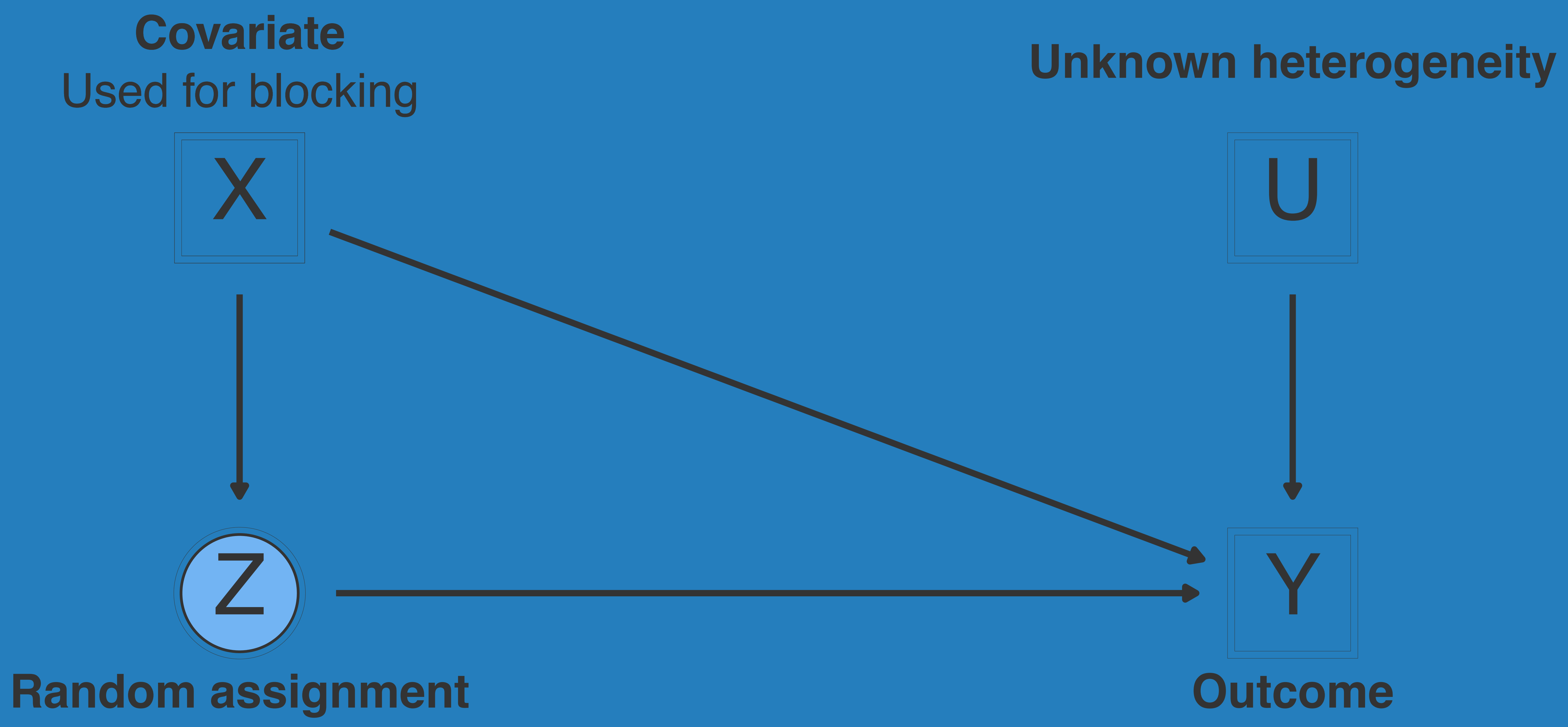


Percentage of studies
60.0%
40.0%
20.0%
0.0%
(4) 2.1%
(9) 4.6%
(19) 9.7%
(66) 33.8%
(97) 49.7%
0
1
2
3
4
Number out of four key requirements for a precise analysis plan satisfied

# We need

1. Language for research designs
2. Algorithm for choosing one

# Graphical models



# Structural models

$$Y = 0.1 * Z + X + U$$

$$X \sim \mathrm{binom}(1, 0.3)$$

$$U \sim \mu(0, 1)$$

# Design declaration

**Model**

**Inquiry**

**Data strategy**

**Answer strategy**

# Model

## Theory of the system under study

- What causes what — and how
- How variables are distributed
- Correlations between variables
- Sequence of events

- Theory if we are right, and if we are wrong

# Inquiry

## Features of the model you want to study

- Units
- Conditions
- Outcomes

- Descriptive, causal, predictive

# Data strategy

## Procedures to gather information about the world

- Sampling
- Random assignment
- Measurement

# Answer strategy

## How you summarize data from the data strategy

- Data cleaning
- Data transformation
- Estimation
- Visualization
- Interpretation

# Answer strategy

## How you summarize data from the data strategy

- Data cleaning
- Data transformation
- Estimation
- Visualization
- Interpretation
- Document selection
- Coding procedures
- Narrative

# Declaring a design in practice

## R package `DeclareDesign`

```r
design <-

  # Model
  declare_model(
    N = 100,
    X = rbinom(N, 1, 0.3),
    U = rnorm(N),
    potential_outcomes(Y ~ 0.1 * Z + X + U)
  ) +

  # Inquiry
  declare_inquiry(ATE = mean(Y_Z_1 - Y_Z_0)) +

  # Data strategy
  declare_assignment(blocks = X, block_prob = c(0.1, 0.5)) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z)) +

  # Answer strategy
  declare_estimator(Y ~ Z, model = lm, inquiry = "ATE")
```

# Draw simulated data

```
draw_data(design)
```

| ID | X | U | Y_Z_0 | Y_Z_1 | Z | Z_prob | Y |
|---|---|---|---|---|---|---|---|
| 001 | 1 | 0.66 | 1.66 | 1.76 | 0 | 0.5 | 1.66 |
| 002 | 1 | -1.69 | -0.69 | -0.59 | 1 | 0.5 | -0.59 |
| 003 | 0 | -1.03 | -1.03 | -0.93 | 0 | 0.9 | -1.03 |
| 004 | 1 | -0.62 | 0.38 | 0.48 | 0 | 0.5 | 0.38 |
| 005 | 0 | 0.03 | 0.03 | 0.13 | 0 | 0.9 | 0.03 |
| 006 | 1 | 0.34 | 1.34 | 1.44 | 0 | 0.5 | 1.34 |

# Draw mock estimates

```
draw_estimates(design)
```

| est | std.err | statistic | p.value | conf.lo | conf.hi |
|---|---|---|---|---|---|
| 0.64 | 0.29 | 2.22 | 0.03 | 0.07 | 1.22 |

# Draw mock estimand

```
draw_estimands(design)
```

| estimand_label | estimand |
|---|---:|
| **ATE** | **0.1** |

# Descriptive inquiries

```
# survey targeting average policy preferences
declare_inquiry(mean_preferences = mean(Y))

# list experiment studying binary trait
declare_inquiry(proportion = mean(Y_star))
```

# Observational research designs

```
# regression discontinuity
cutoff <- 0.5
control <- function(X) {
  as.vector(poly(X, 4, raw = TRUE) %*% c(.7, -.8, .5, 1))}
treatment <- function(X) {
  as.vector(poly(X, 4, raw = TRUE) %*% c(0, -1.5, .5, .8)) + .15}

declare_model(
    N = 1000,
    U = rnorm(N, 0, 0.1),
    X = runif(N, 0, 1) + U - cutoff,
    potential_outcomes(Y ~ Z * treatment(Z) + (1 - Z) * control(X) + U),
    Z = 1 * (X > 0)
  ) +
  declare_measurement(Y = reveal_outcomes(Y ~ Z))
```

# Algorithm for selecting designs

Declare

Diagnose

Redesign

# Algorithm for selecting designs

Declare

Diagnose

Redesign

# Diagnosing a design

**What are the properties of a research design?**

1. Through analytical expressions

2. Through simulation

# Is my design powered?

$$\text{power} \approx \Phi\left( \frac{|\mu_t - \mu_c|\sqrt{N}}{2\sigma} - \Phi^{-1}\left(1 - \frac{\alpha}{2}\right)\right)$$

# Is my design powered?

$$\text{power} \approx \Phi\left(\frac{|\mu_t - \mu_c|\sqrt{N}}{2\sigma} - \Phi^{-1}\left(1 - \frac{\alpha}{2}\right)\right)$$

- **Model: normally-distributed outcome;** $\sigma_t = \sigma_c$
- **Data strategy: simple random assignment**
- **Answer strategy: equal-variance t-test with N-2 degrees of freedom**

# Is my design biased?

- Blocking with varying assignment probabilities
- Random assignment of clusters of different sizes
- Differential attrition
- Logit with fixed effects
- Posttreatment bias

How many people should I interview?
How many men and women?
How often should I interview them?
Should I assign 2 or 3 treatment arms?
Is it important in this case to use blocking?
How many items should I include in my index?
More survey items or more respondents?
Robust or cluster-robust standard errors?
Should I control for emotions in my regression?
Is it okay to drop people who didn't respond?
To where can I generalize these results?

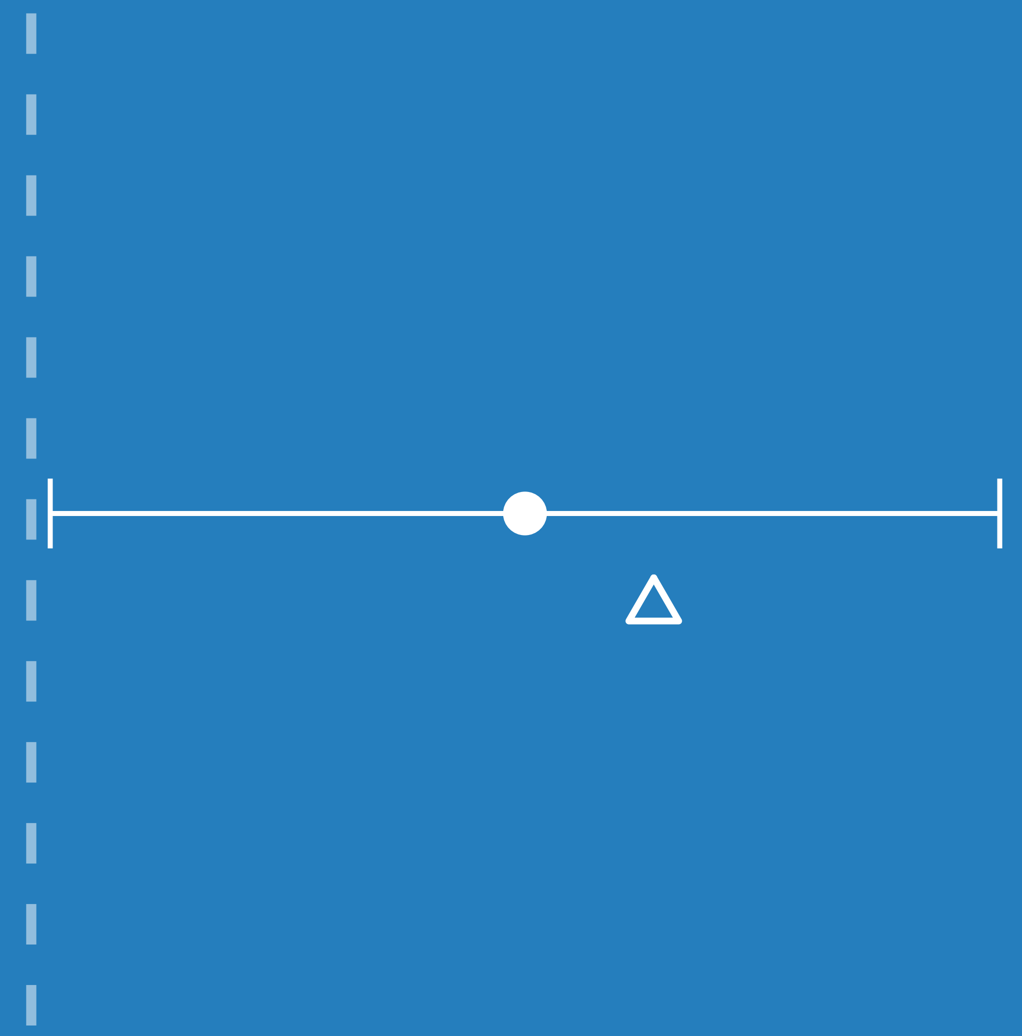
# Diagnosing a design through simulation

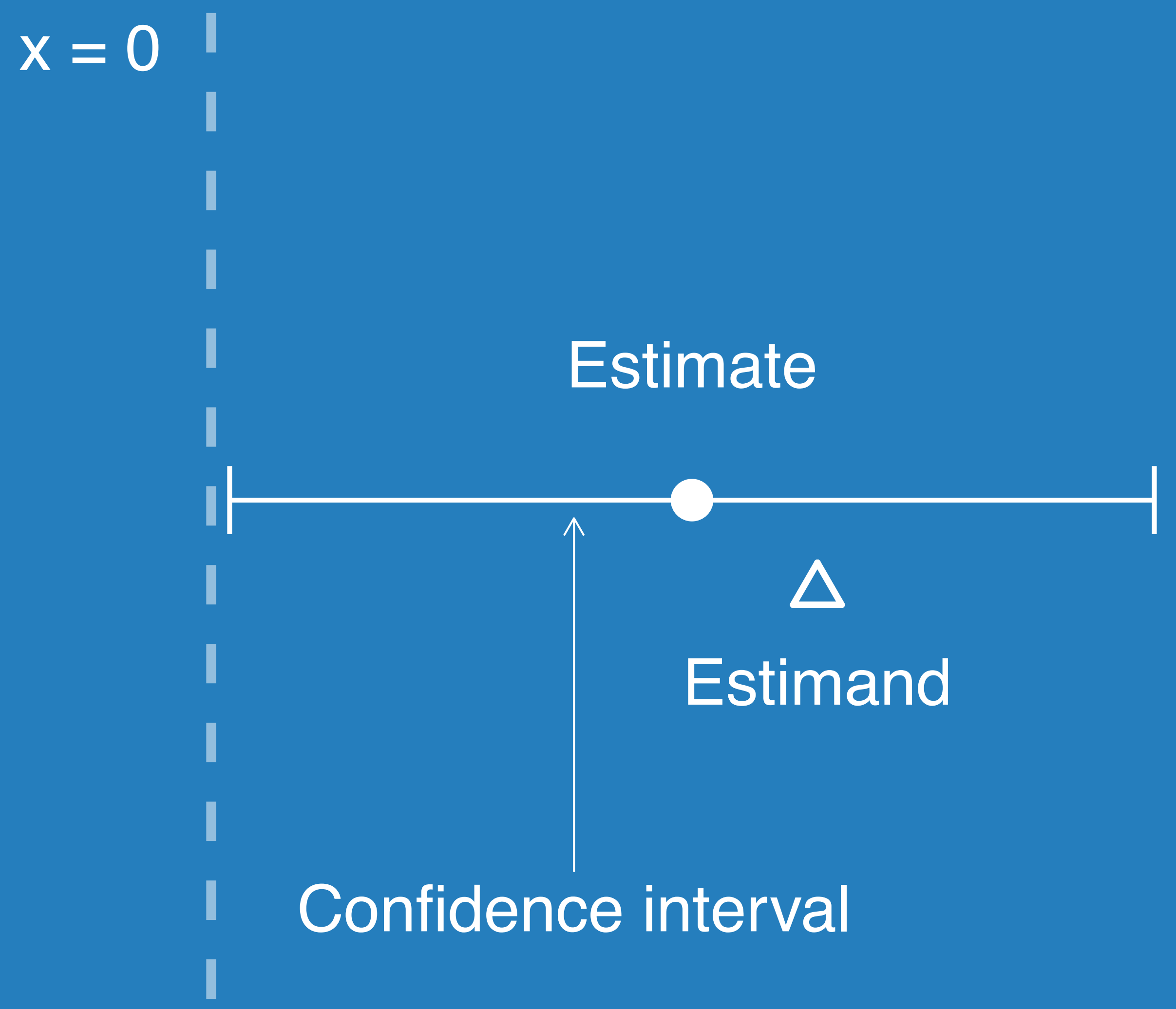
# Simulated results from the study

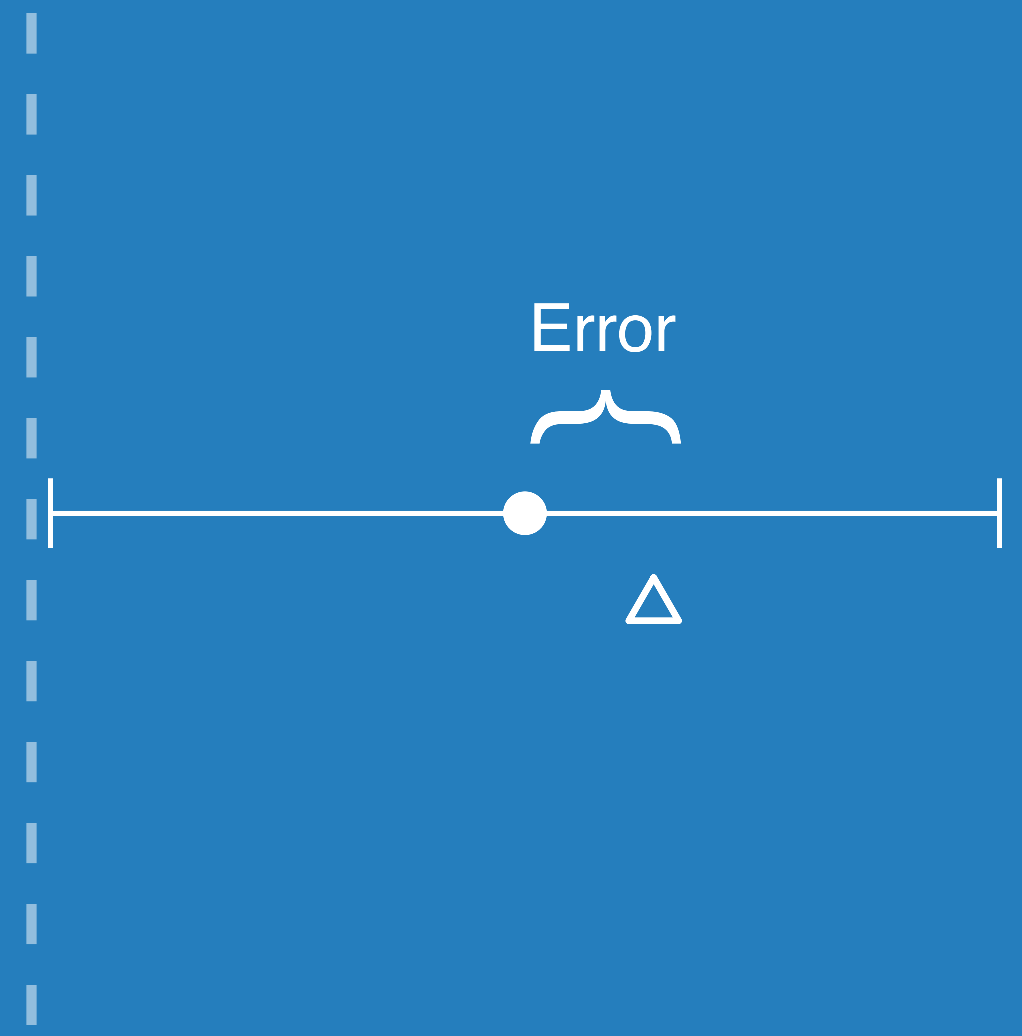
```
run_design(design)
```

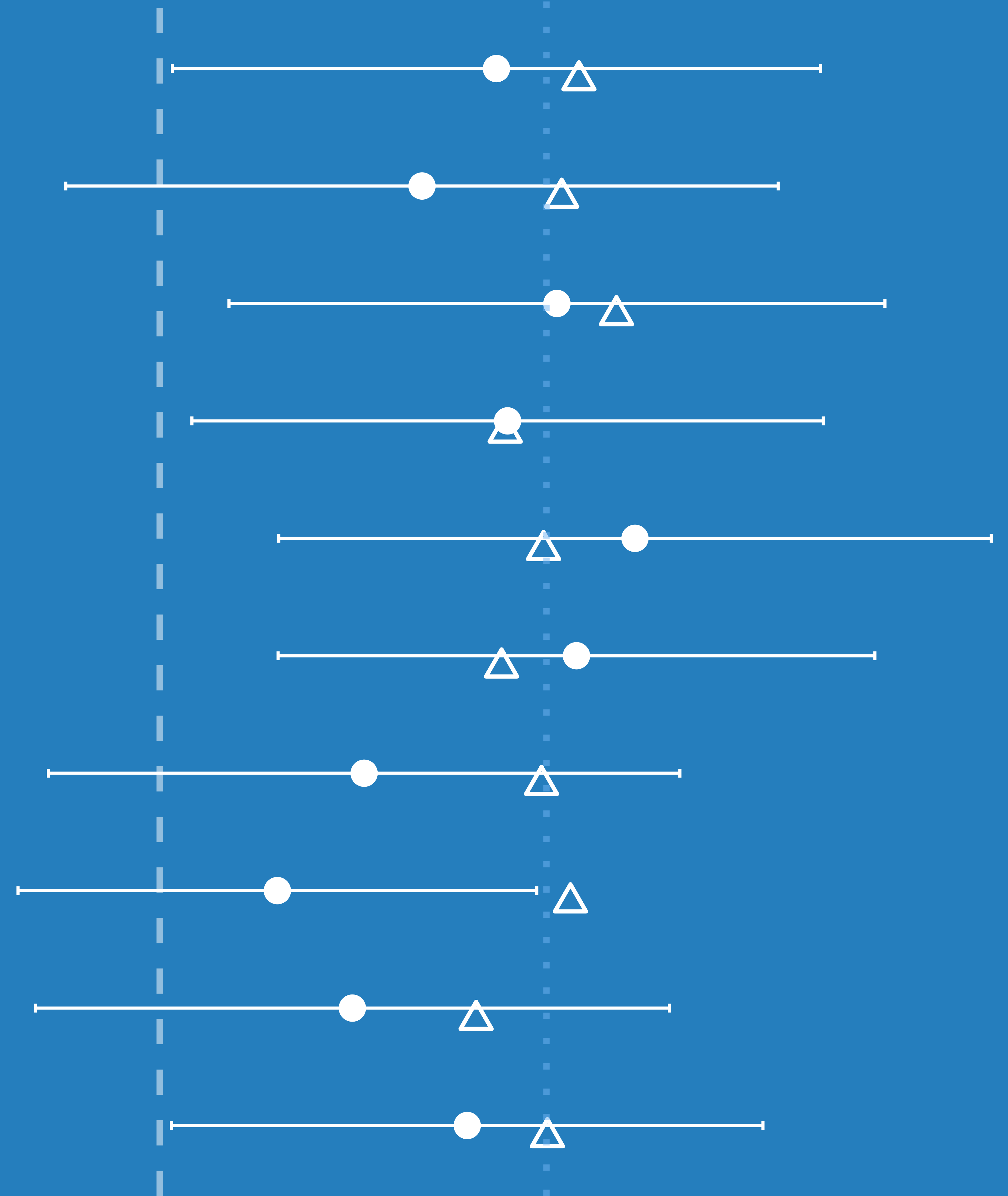
| est | std.err | statistic | p.value | conf.lo | conf.hi |
|---|---|---|---|---|---|
| 0.64 | 0.29 | 2.22 | 0.03 | 0.07 | 1.22 |

| estimand_label | estimand |
|---|---|
| ATE | 0.1 |




x = 0
Estimate
Estimand
Confidence interval


Error



# Simulations data frame

| sim_ID | estimate | std.error | conf.low | conf.high | p.value | estimand |
|---:|---:|---:|---:|---:|---:|---:|
| 1 | 0.08 | 0.04 | 0.00 | 0.16 | 0.04 | 0.10 |
| 2 | 0.03 | 0.04 | -0.05 | 0.11 | 0.45 | 0.08 |
| 3 | 0.12 | 0.04 | 0.04 | 0.20 | 0.00 | 0.11 |
| 4 | 0.10 | 0.04 | 0.02 | 0.18 | 0.01 | 0.10 |
| 5 | 0.07 | 0.04 | -0.01 | 0.15 | 0.10 | 0.10 |
| 6 | 0.05 | 0.04 | -0.03 | 0.14 | 0.21 | 0.09 |
| 7 | 0.09 | 0.04 | 0.01 | 0.17 | 0.03 | 0.11 |
| 8 | 0.03 | 0.04 | -0.05 | 0.12 | 0.44 | 0.12 |
| 9 | 0.16 | 0.04 | 0.09 | 0.24 | 0.00 | 0.09 |
| 10 | 0.04 | 0.04 | -0.04 | 0.13 | 0.33 | 0.10 |

# Diagnosands

**What are your objectives and does your design meet them?**

**Ethics:** `min(subjects_harmed)`

**Cost:** `mean(cost), max(cost)`

**Bias:** `mean(estimate - estimand)`

**Power:** `mean(p.value <= 0.05)`

**Probability of getting sign wrong:**
`mean(sign(estimate) != sign(estimand))`

# Diagnose design

```
diagnose_design(design)
```

| Bias | RMSE | Power | Pr(sign wrong) |
|---|---|---|---|
| 0.5 | 0.56 | 0.65 | 0.01 |

# Algorithm for selecting designs

Declare

Diagnose

Redesign

# Back to preanalysis plans

**Declare your design in MIDA**

**Present a diagnosis**

**Register it for a timestamp**

# Research lifecycle

Brainstorming

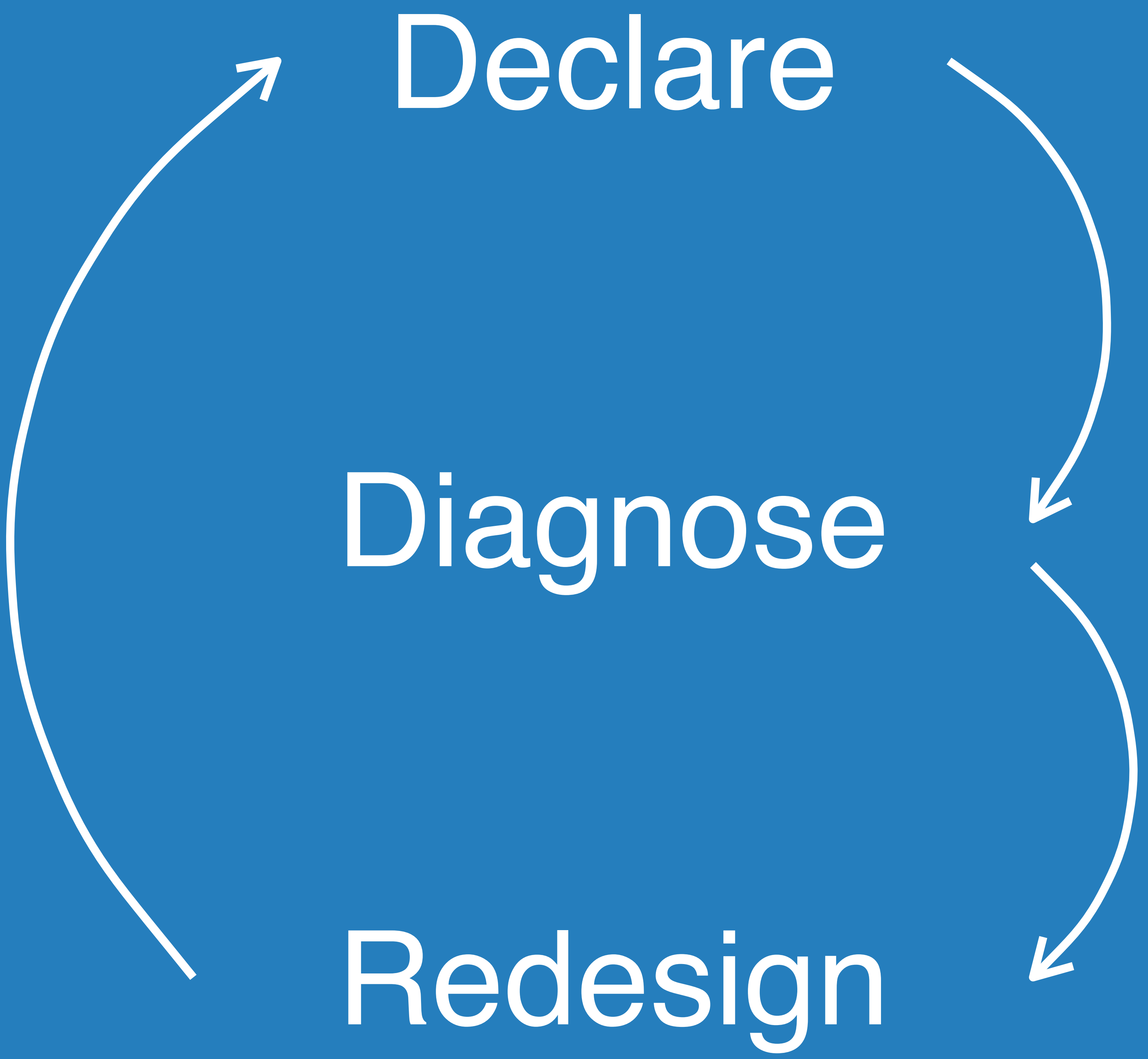
Planning

Realization

Integration

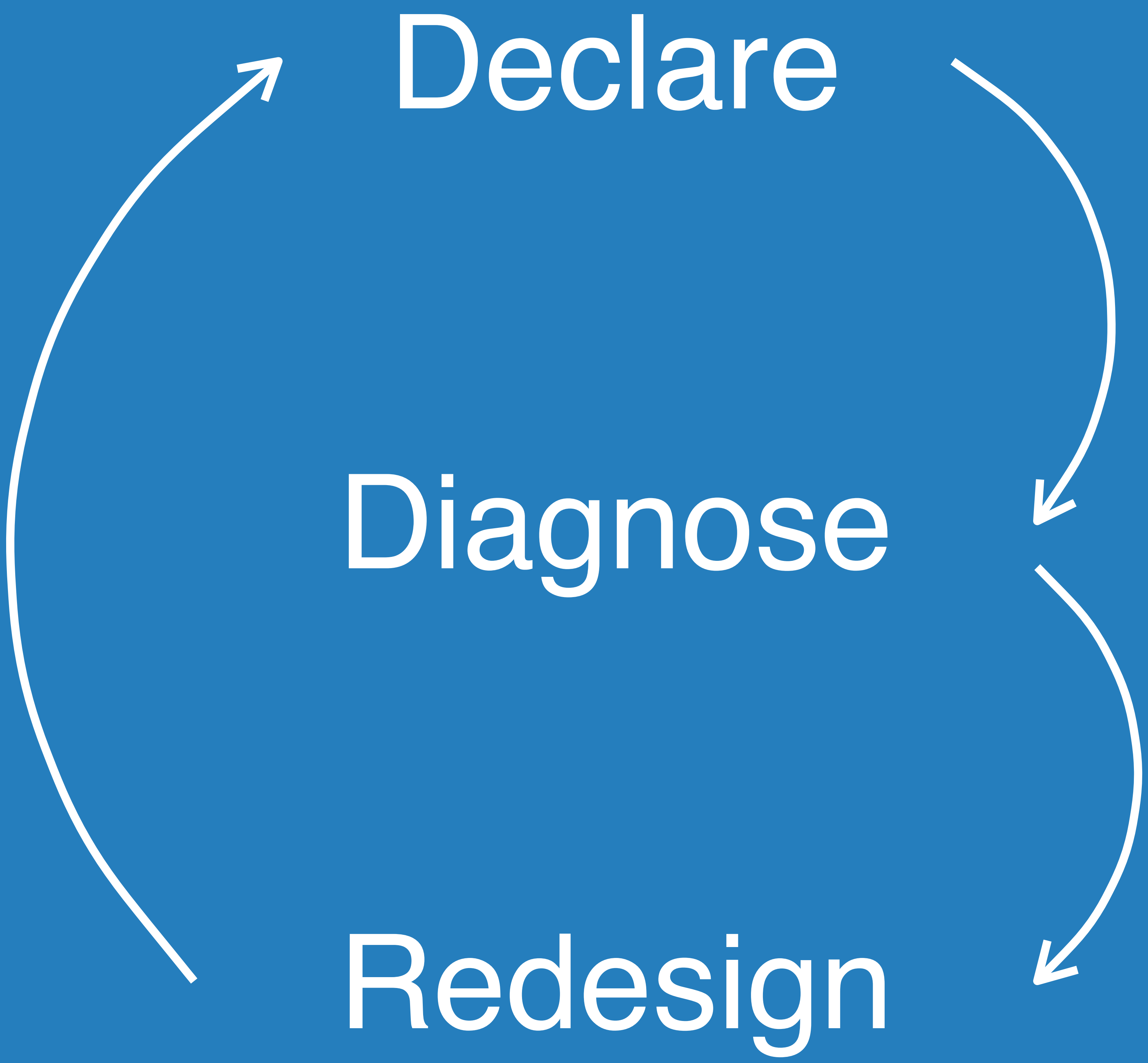
# Planning

**Ethics**
**Partners**
**Funding**
**Piloting**
**Criticism**
**Preanalysis plan**



# Realization

**Implementation**
**Pivoting**
**Populated PAP**
**Reconiliation**
**Writing**
**Publication**



# Integration

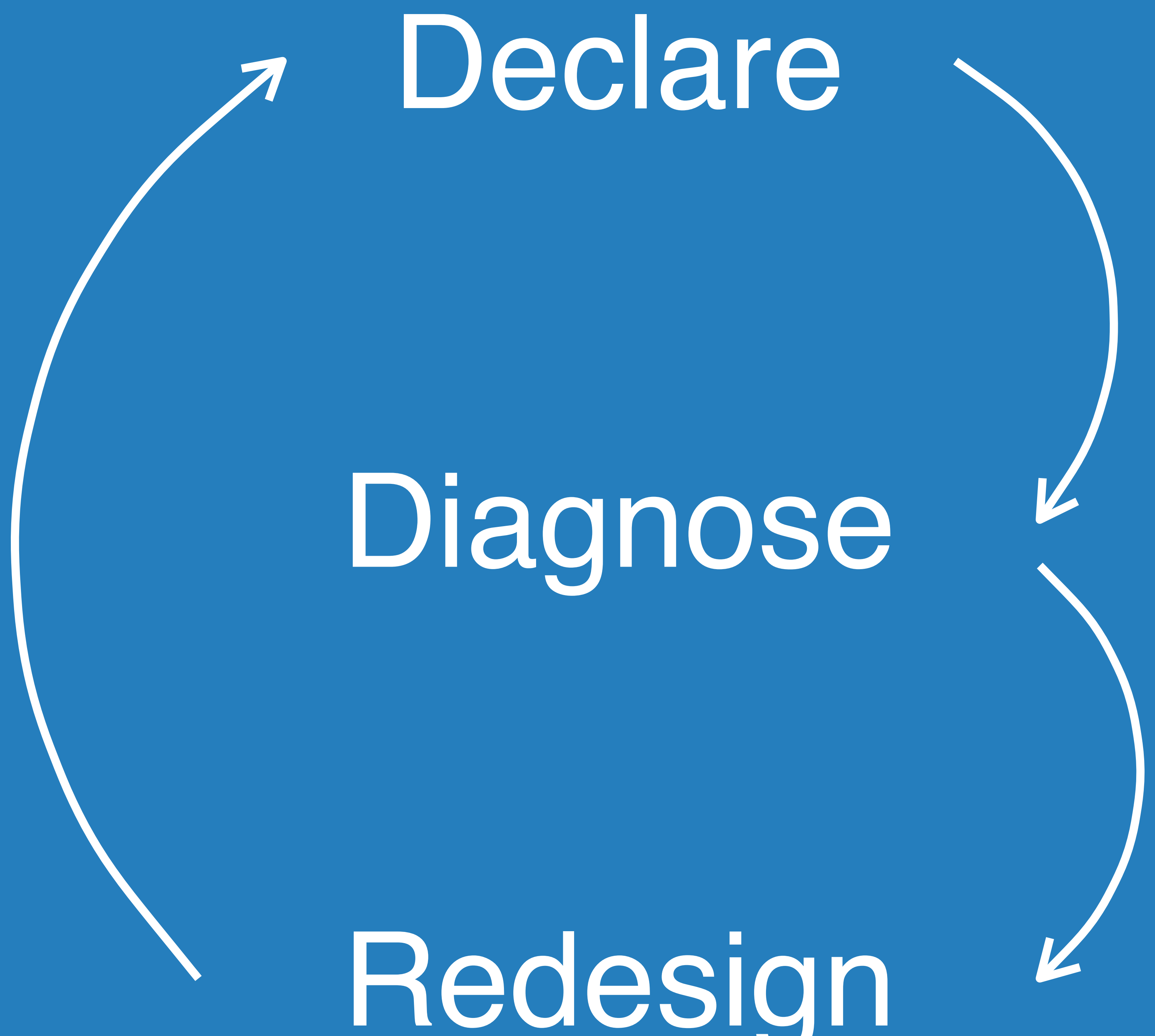
**Archiving**
**Reanalysis**
**Replication**
**Disputes**
**Synthesis**

Declare

Diagnose

Redesign

**We're caught between higher research standards and lack of ideas for how to assess and communicate about designs**



# Take aways

**Minimum:**
**Write a plan to change your plan**

**Medium: Register your plan**

**Maximum:**
**Declare in code, diagnose**

# Thank you

**More at declaredesign.org**

Big team effort: Clara Bicalho, Jasper Cooper, Neal Fultz, Sisi Huang, Markus Konrad, Lily Medina, Aaron Rudkin, Luke Sonnet, and John Ternovski

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