ethap

Training in Household Air Pollution and Monitoring

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Study Design Issues on HAP assessment

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Study Designs

why now?

- Informs how, when, and how frequently measurements will be performed

- Useful to keep in mind throughout the Development process of proposals and study plans

- Extends beyond just HAP and EHS into broader issues

- No study design is perfect

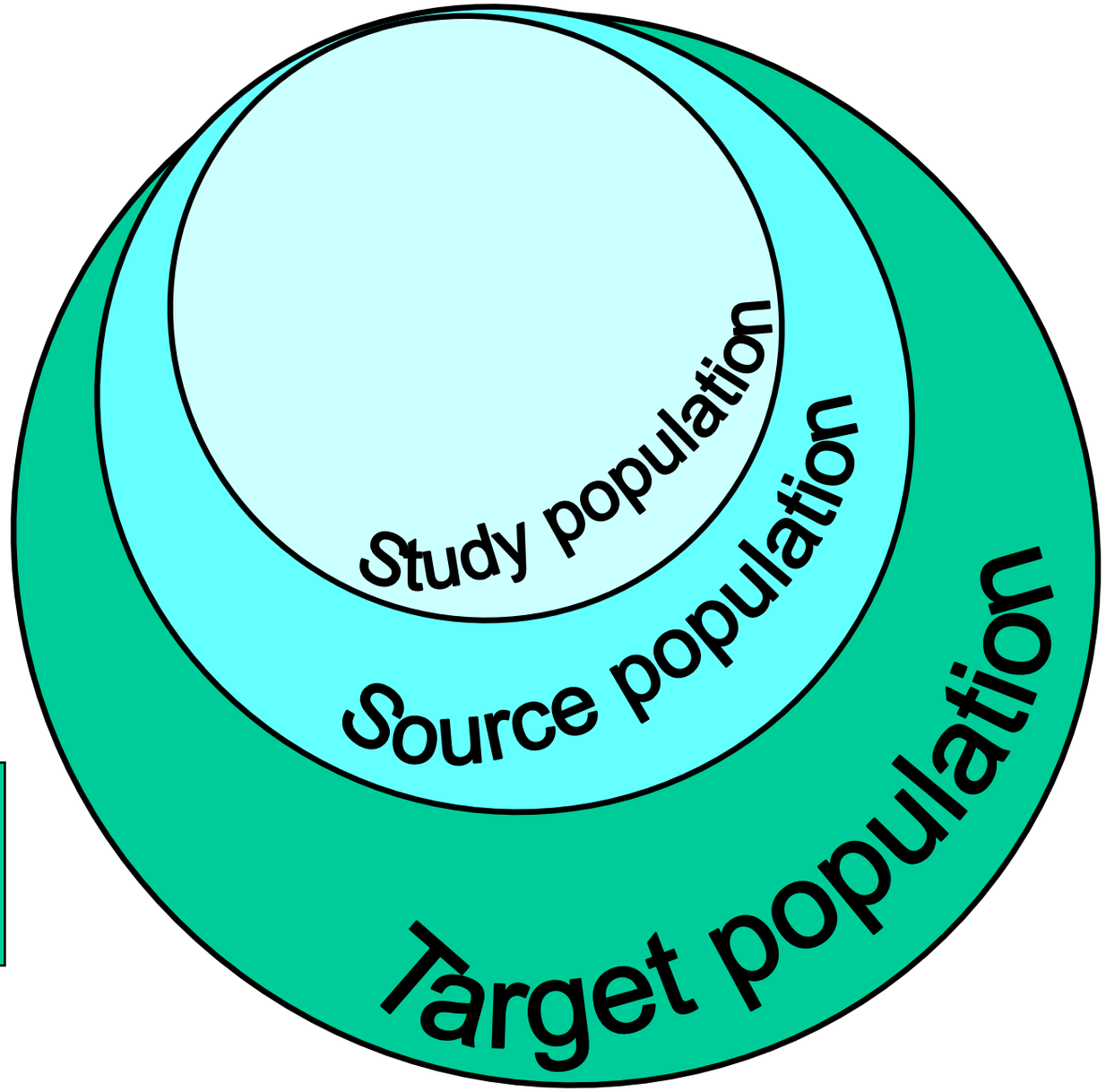
(but, early attention leads to better studies)

Study population, source population, target population

The group studied

The group from whom the study population is drawn

The group to whom inferences will be made



What makes a study useful?

- Addresses a relevant and significant research question
- Results in the study population are generalizable (external validity)
- The study population is sufficiently large to address the research question
- **The study design is appropriate**
- The study results are not (too) affected by bias (internal validity)

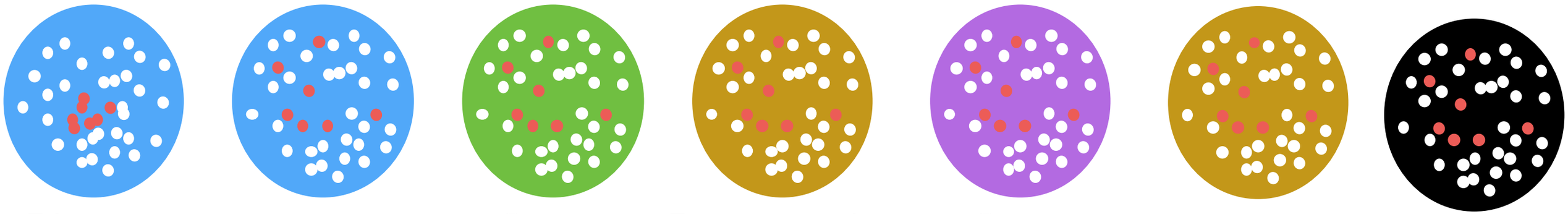
Study Design - Basics

- First: experimental or observational
  - Experimental: investigator manipulates exposure
  - Observational: investigator studies exposures as they occur
- Second: if experimental,
  - Was exposure assigned at random?
- Third: if observational,
  - What is the underlying design?

Basics of study design

- **Experimental**
  - RCT (randomization to treatment and control)
  - Other interventions
- **Observational (individual level)**
  - Cohort
  - Case-control (and other case-based sampling)
  - Cross-sectional
- **Observational (population level)**

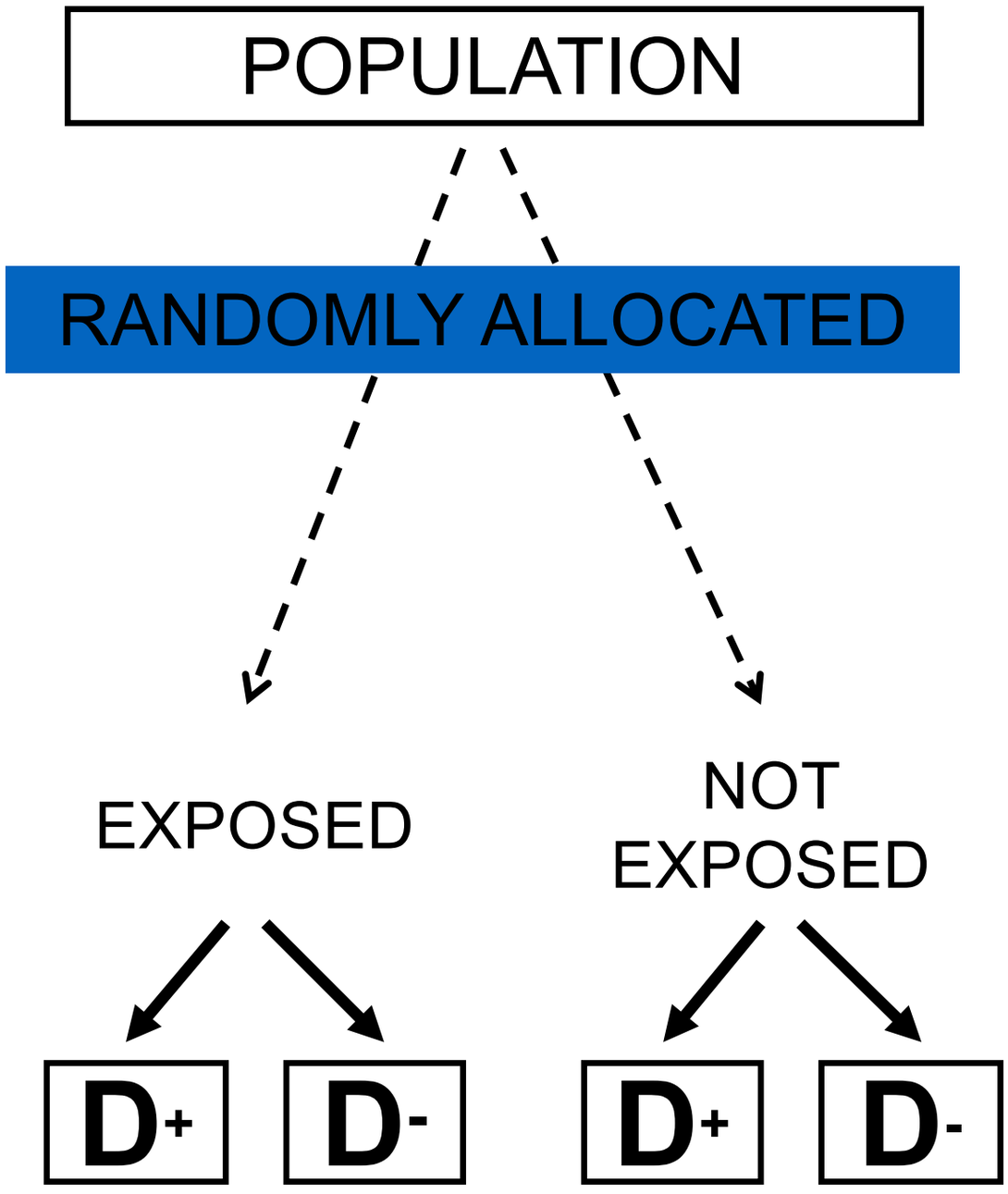
Types of Study Design



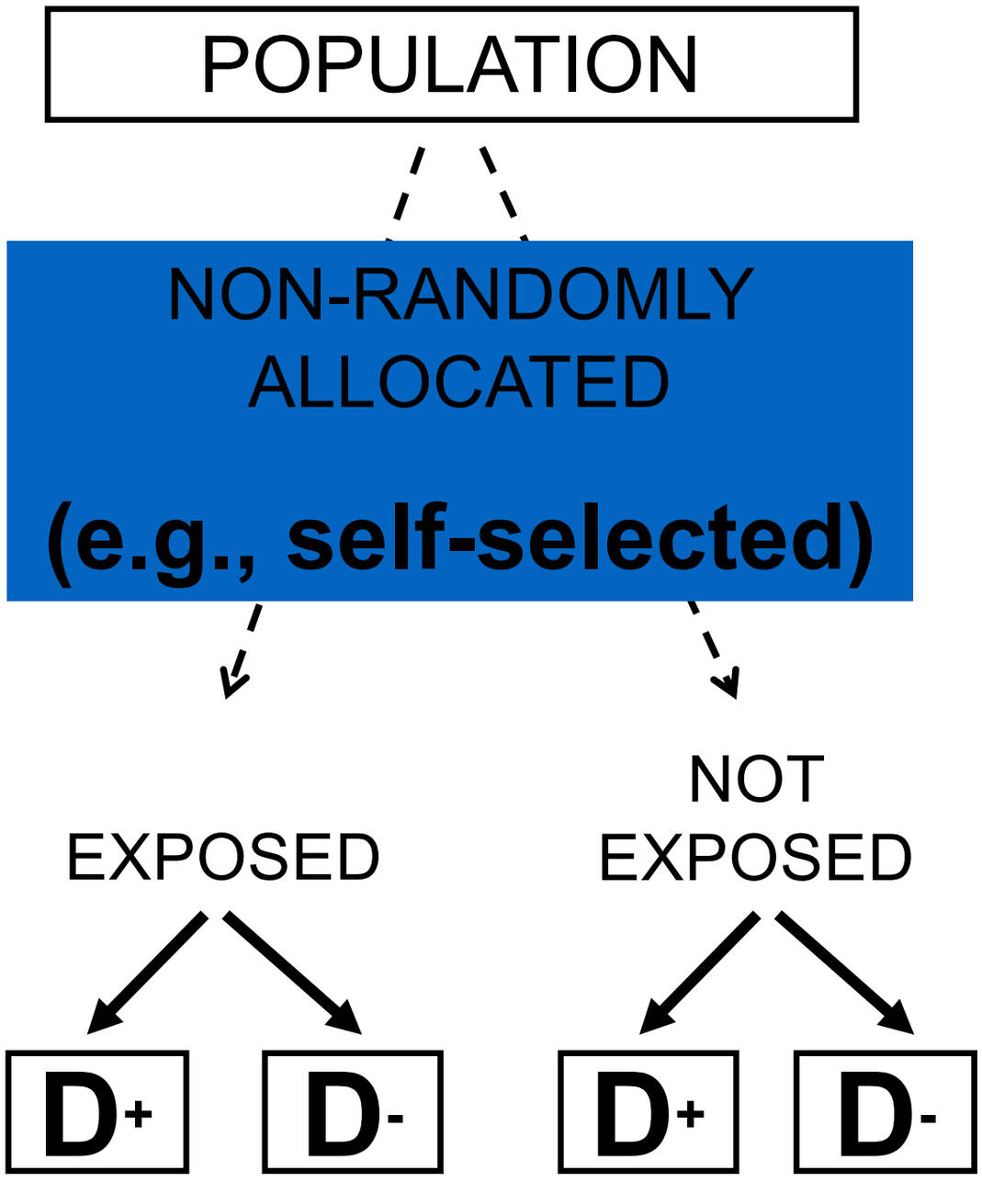
Disease Clusters | Ecological | Cross-sectional | Retrospective Cohort | Case Control | Prospective Cohort | Experimental Studies

Descriptive ⋯⋯▸ **Analytic**

EXPERIMENTAL (Randomized study)



OBSERVATIONAL (Non-Experimental Randomized) Study



Why Randomize?

- So that group assignment does not depend on participant characteristics
  - Assure comparability on potential confounding and modifying factors
  - Assure comparability on any “unknown” factors
- **Caution:** Systematic and haphazard assessment is not the same as randomization

What is your research question?

Do you have an intervention?

What are you comparing?

How long will the study take?

What type of data will you collect? How often?

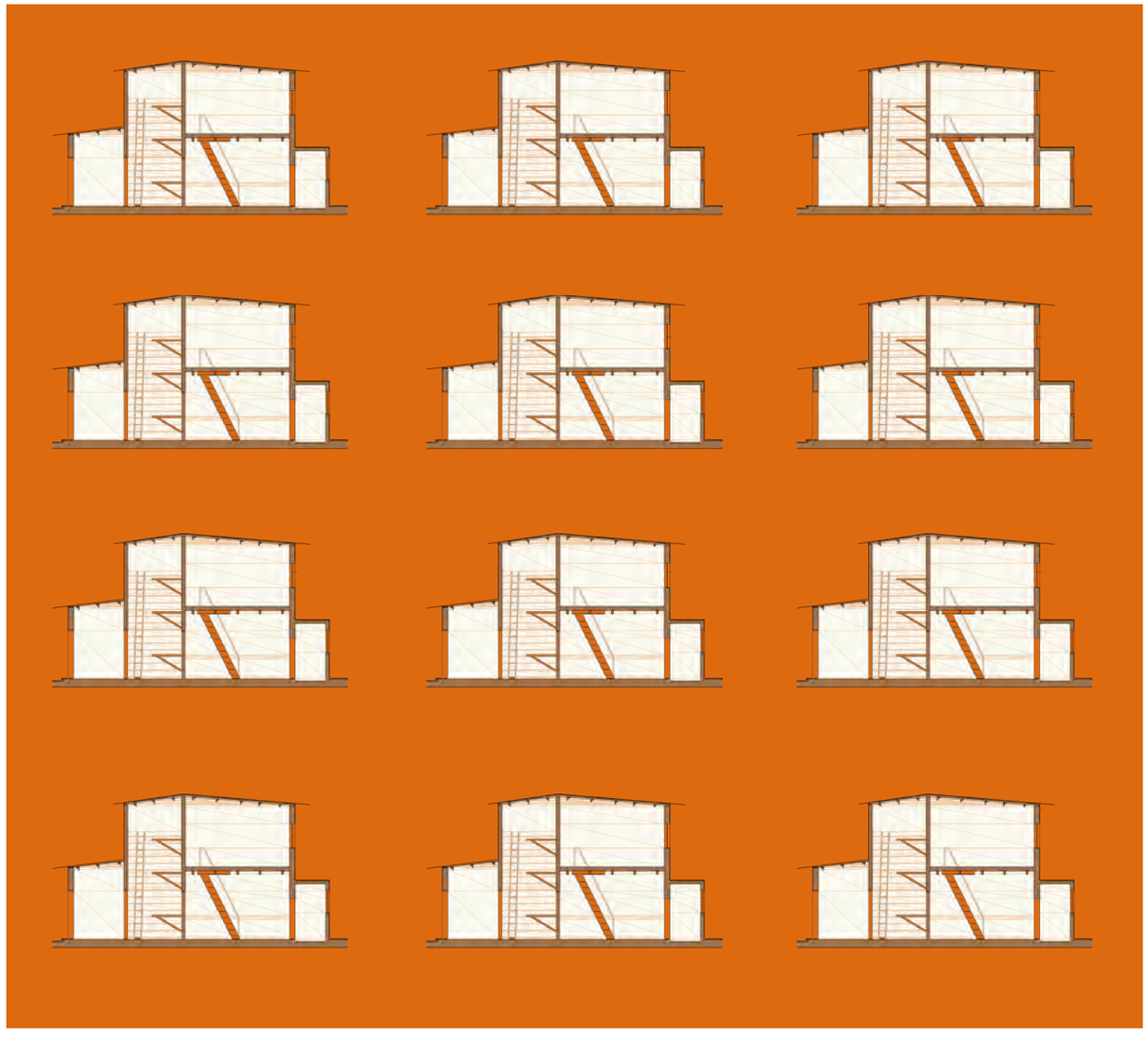
What's your budget?

The Question (Hypothesis)

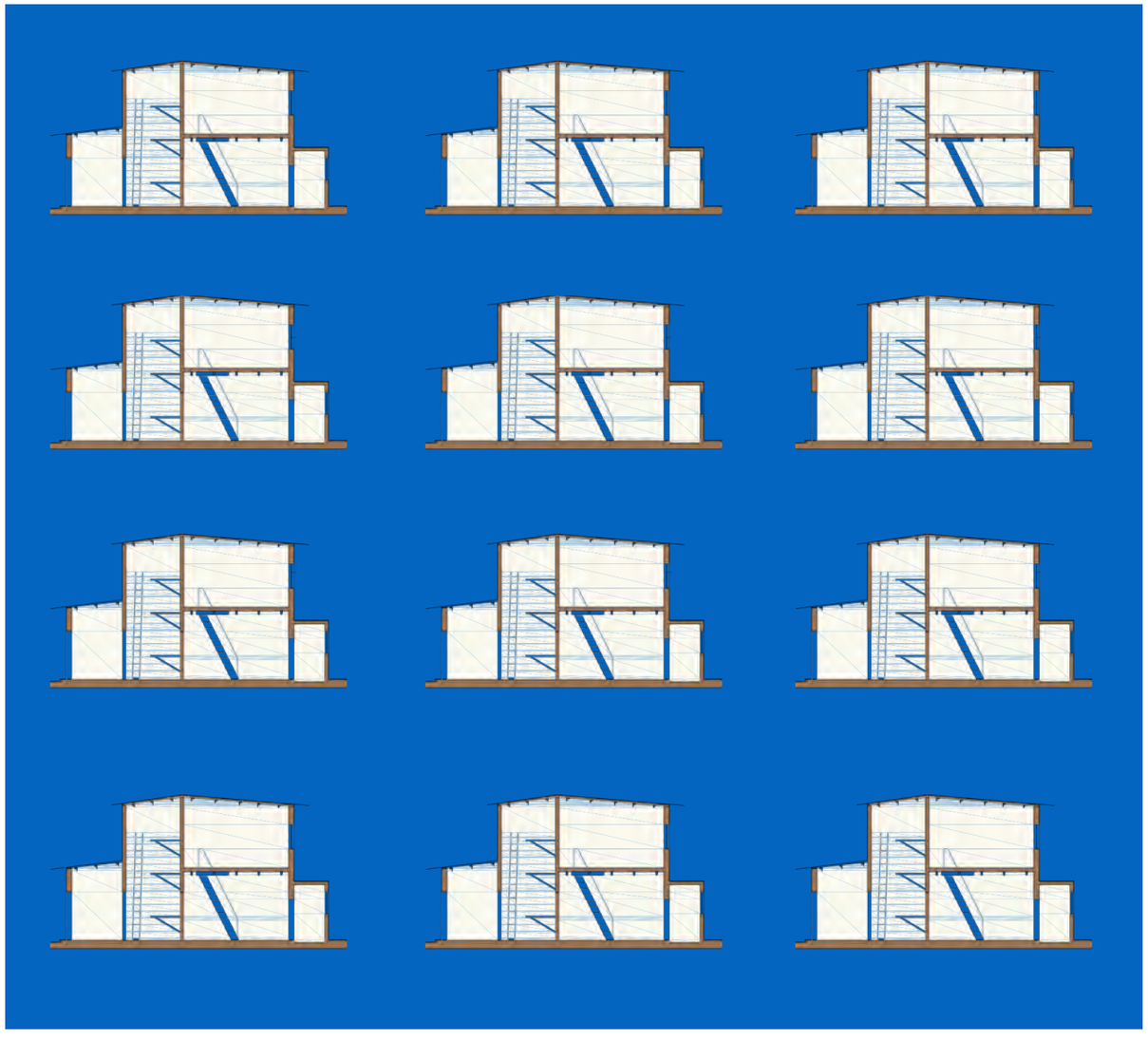
Does use of an clean (e.g., LPG) stove reduce

- The risk of chronic obstructive pulmonary disease in adult women?
- The risk of mortality in under-five children?

Cross-sectional



Group I
Traditional Stove



Group II
LPG Stove

Measurements made at the same time
May show an association • Difficult to establish causality

Cross-sectional

- Identify groups and take measurements
- Can occur quickly and relatively inexpensively
- Can study several outcomes
- Good for hypothesis generation
- Yields prevalence
- Does not establish sequence of events

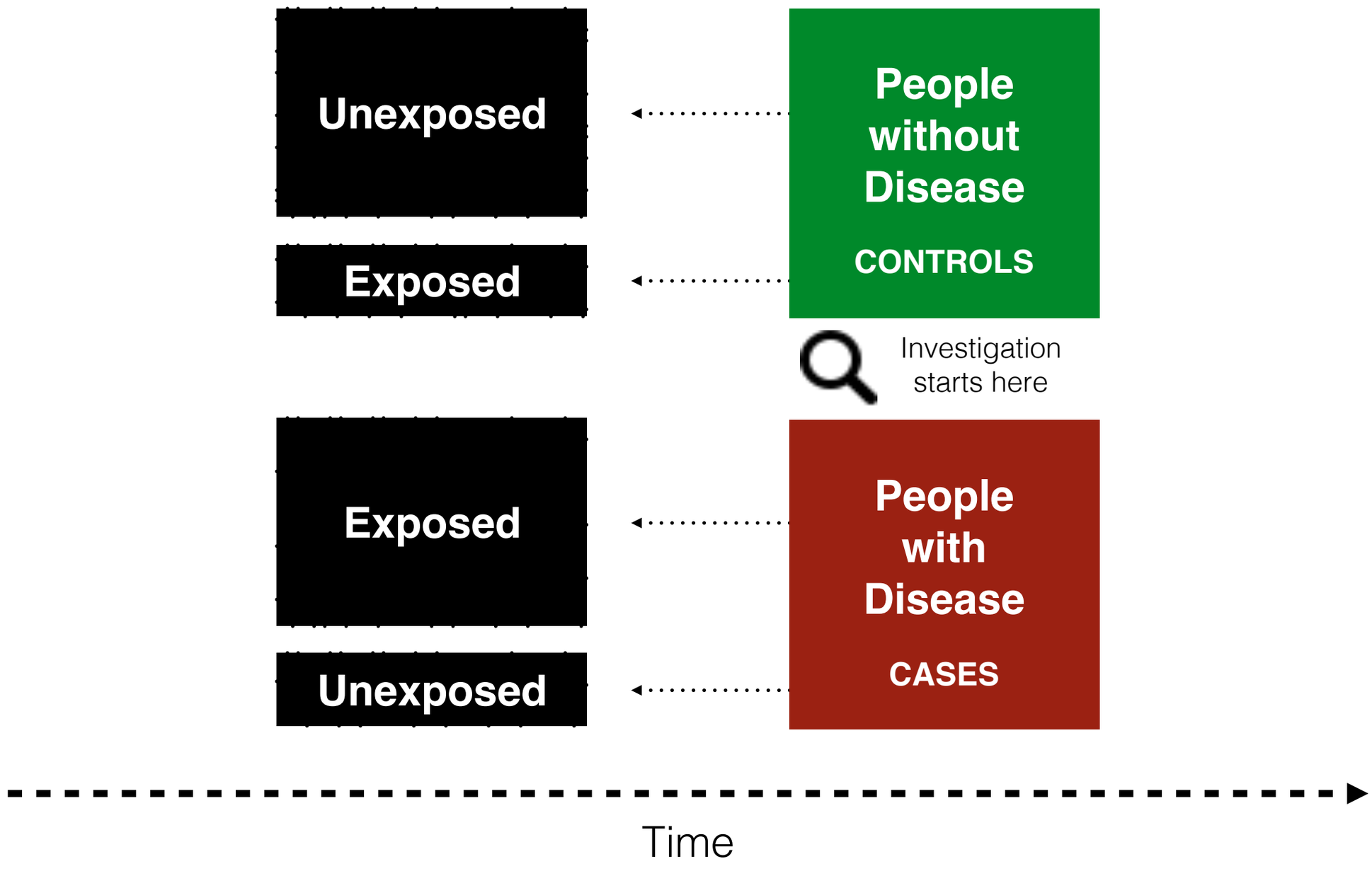
→ Issues with bias

Case Control

Compare individuals with a specific disease (cases)
to those without the disease (controls)

Useful for rare conditions

Case Control



Control Selection

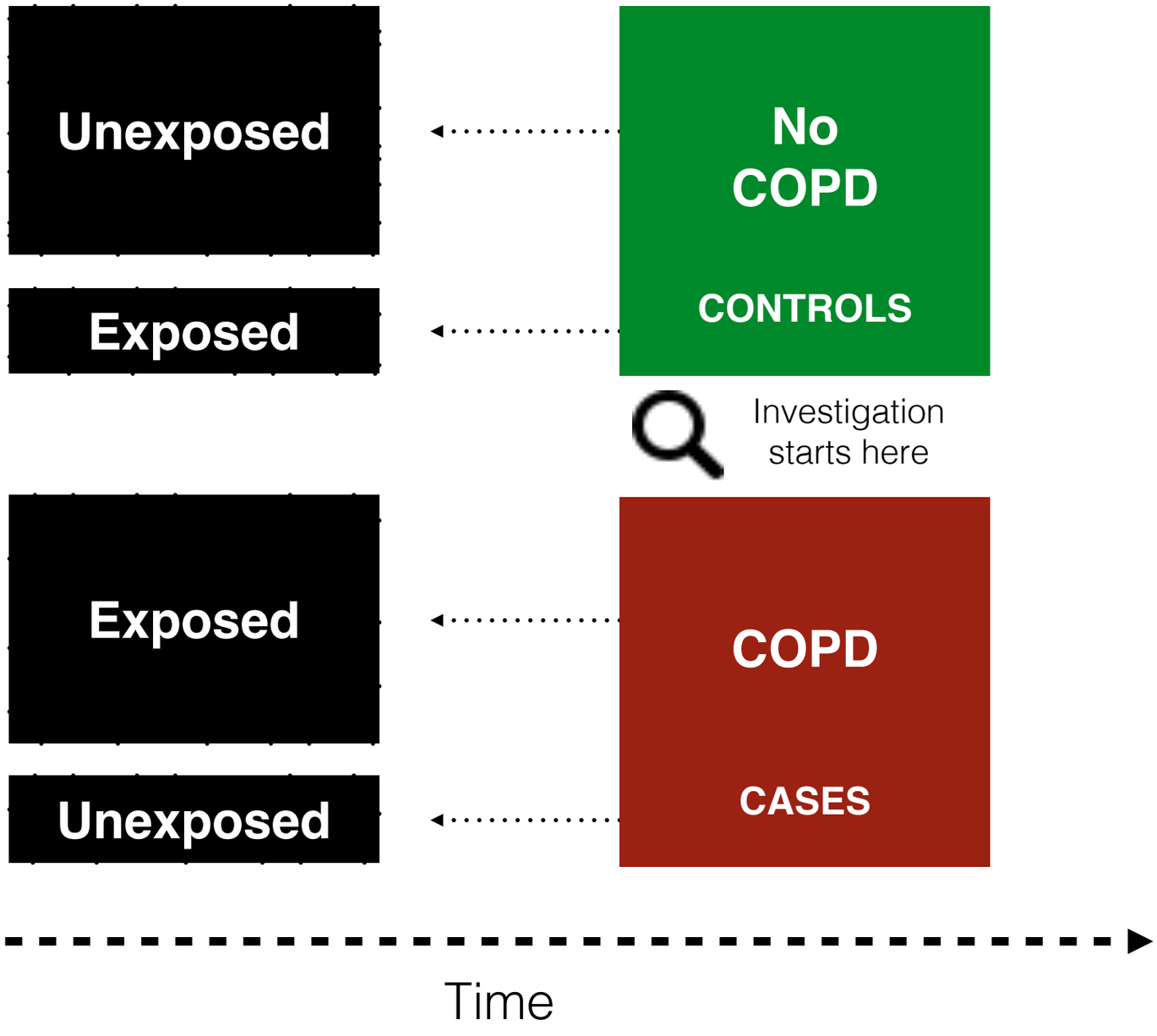
Useful to think of the "study base", i.e., the underlying population that gave rise to the cases. The assumption is that individuals in the study base are representative of the same basic experiences.

Controls should be at risk of developing the disease and represent the same underlying population which gave rise to the cases. Often match on age, sex, ethnicity, and other demographic / SES variables

Case Control

What might you look for?

Where would you want controls to come from?



Case Control

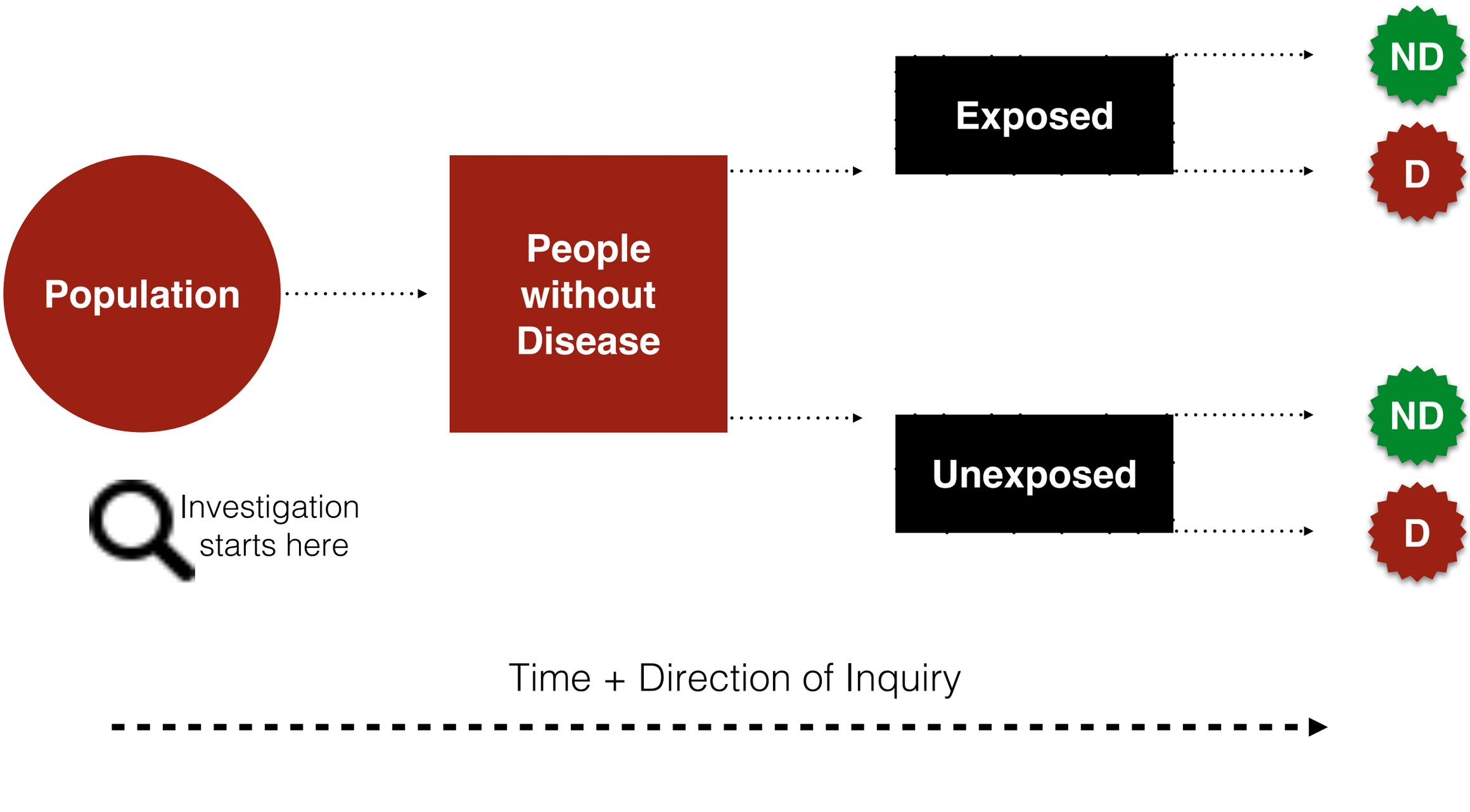
- Useful for rare diseases
- Can study multiple exposures at a time
- Relatively inexpensive, short duration
- Very difficult to "reconstruct" historical exposures
- Selecting controls can be very challenging

Cohort Studies

Define a group of people and follow them through time to observe disease occurrence in relation to exposure

"Cohort" was the Roman term for a group of soldiers that marched into battle together

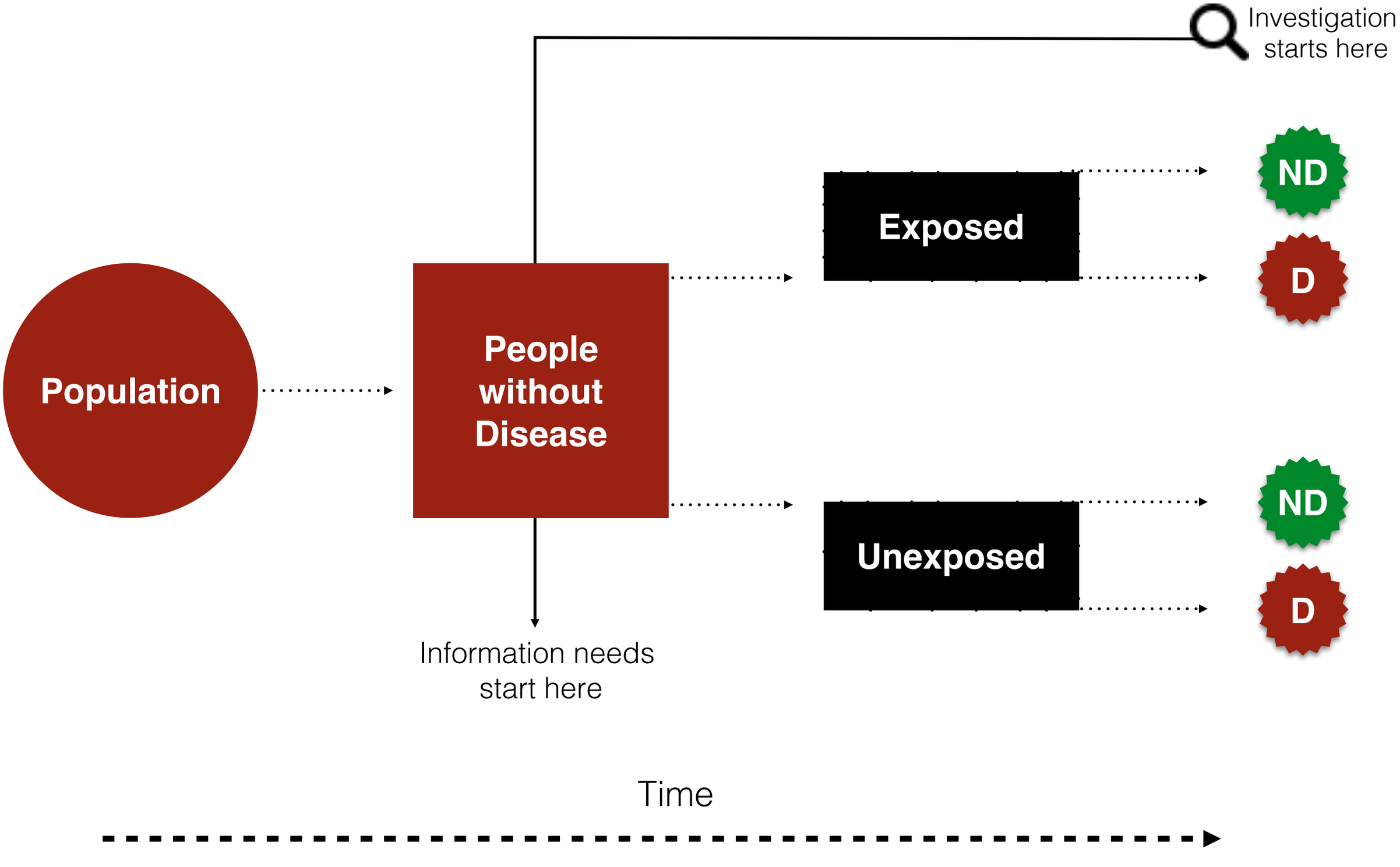
Prospective



Prospective

- Identify cohort and follow through time
- Collect data on exposures and disease
- “Gold standard” of observational studies
- Expensive, logistically intensive, and lengthy
- Difficult for rare diseases

Retrospective



Retrospective

- Define a historical cohort
- Trace mortality to present time
- Reconstruct exposure status from logs
- Quick, cheap, multi-cause, common in occupational epi
- Difficult to reconstruct historical exposures

Experimental

- Investigator controls predictor variable (an intervention)
- Controls for influence of confounding variables
- Key features: Manipulation, Control Group, and Randomization
- Considered by many as the "gold standard" of study designs

Randomized Control Trials

- Produce strongest evidence for cause + effect
- Costly in time and money
- Somewhat narrow research questions
- Customizing interventions can limit generalizability
- Ethical concerns
- Potential for observation / inclusion in a study inducing changes in behavior (known as the Hawthorne Effect)
- Placebo Effect

Hierarchy of Evidence

Table. **Validity Hierarchy**

Internal Validity

Study Design	Strengths	Weaknesses
Randomized controlled trials	• High internal validity • Reduced risk of confounding variables	• Reduced external validity • Expensive, time-consuming
Cohort studies	• Useful for sequential events • Can study multiple outcomes • *Retrospective:* less expensive	• Requires large sample size • Risk of confounding variables • Difficult to study rare outcomes • *Prospective:* Expensive
Case-control studies	• Useful for rare outcomes • Can study several exposures • Inexpensive	• Risk of confounding variables
Cross-sectional studies	• Can study multiple outcomes and exposures	• Cannot infer causality • Risk of confounding variables • Less useful for rare exposures or outcomes
Case studies	• Useful for rare outcomes • Convenient, inexpensive	• Risk of confounding variables • Lack of a comparison group • Cannot infer causality

Adapted from Ho, et al. *Circulation.* 2008;118:1675–1684.

ELEMENTS IN THE DESIGN OF RANDOMIZED CLINICAL TRIALS

1. *Selection of subjects*

-Representativeness

-Generalizability, external validity

Evaluating an Intervention

HAP STUDY DESIGNS

Three Main Study Designs

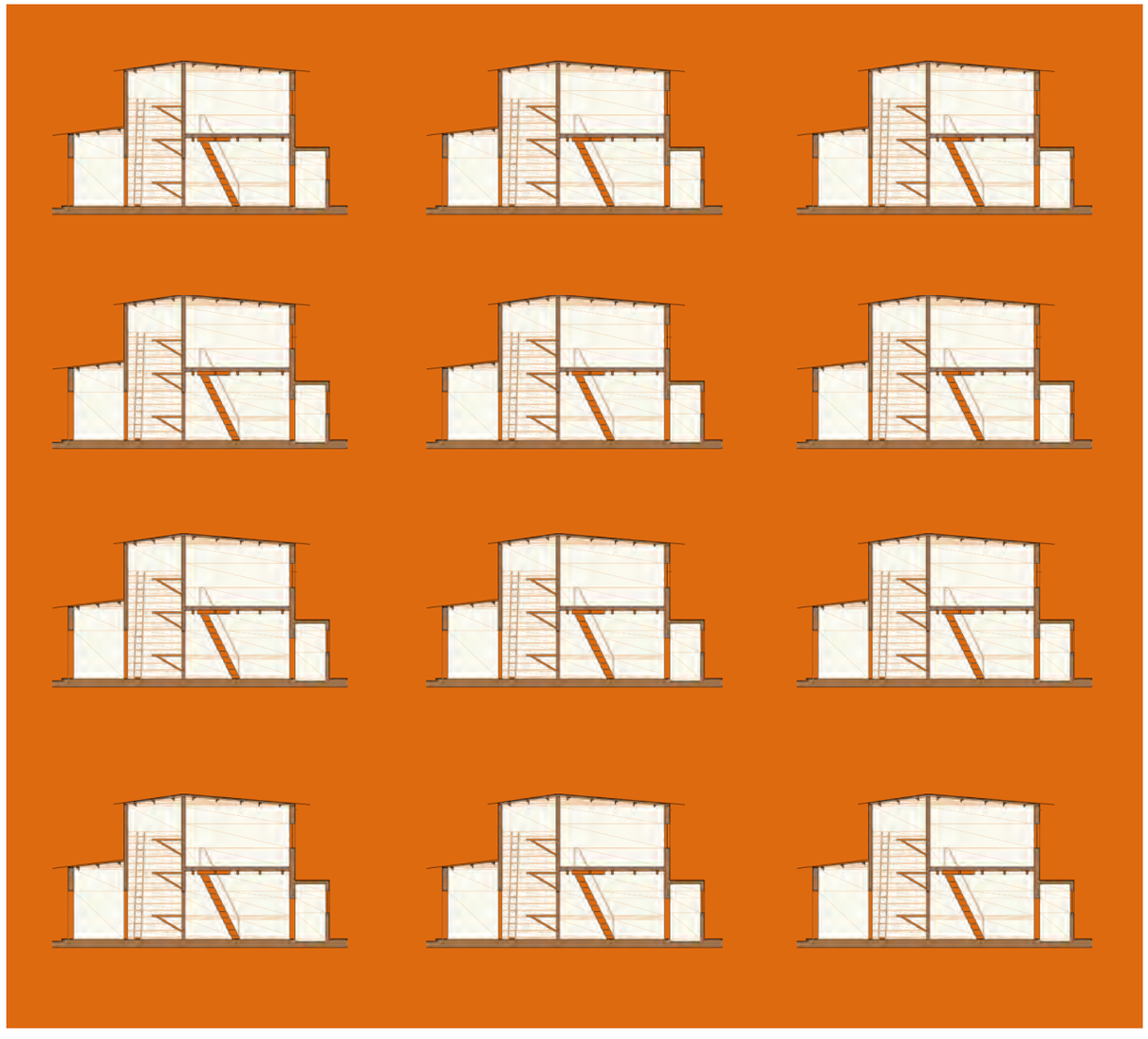
Cross Sectional

Before + After

Before + After
with control

In this case, we are evaluating the impact of an intervention on household air pollution

Cross-sectional



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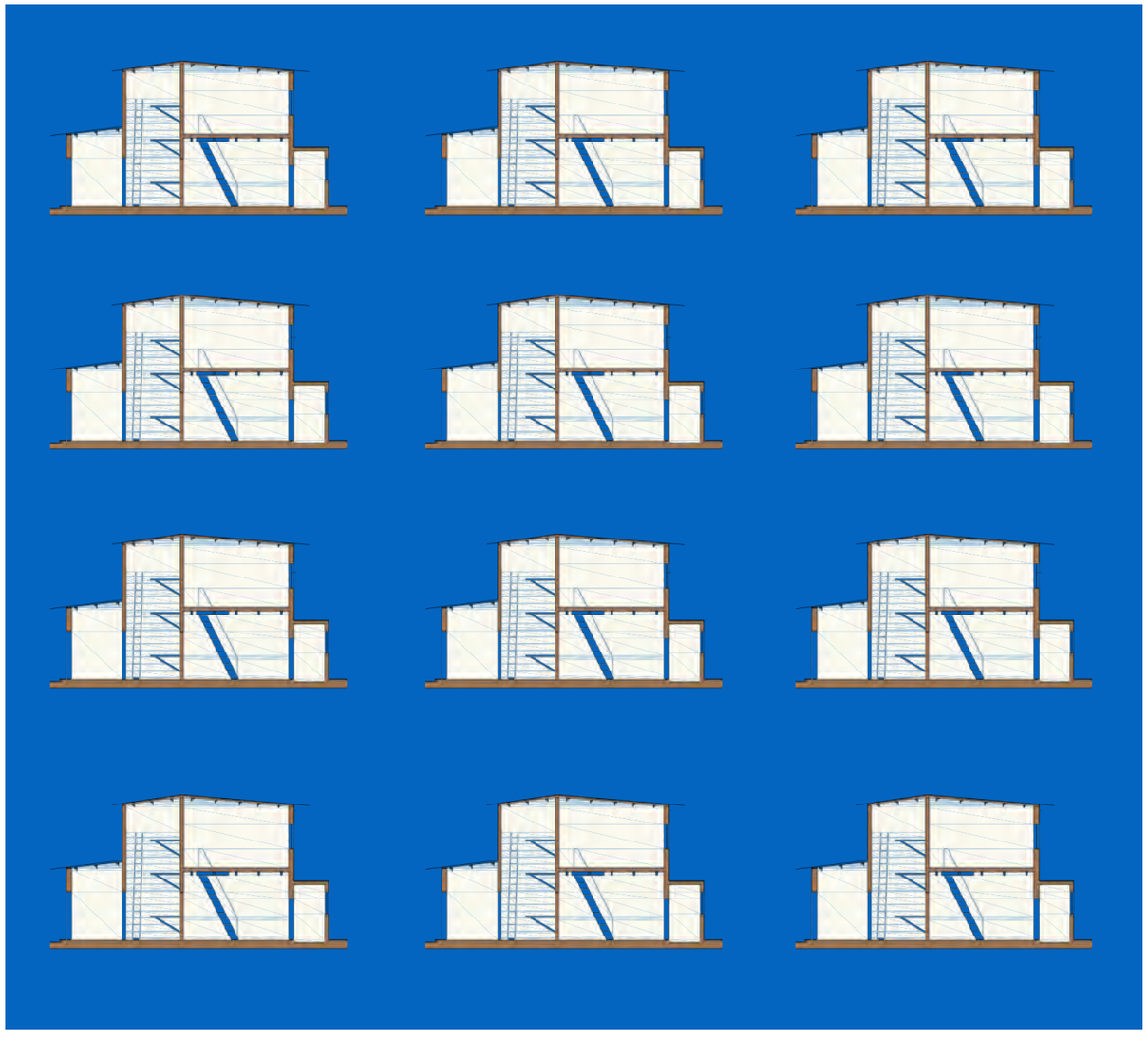


Group II
LPG Stove

Measurements made at the same time
May show an association • Difficult to establish causality

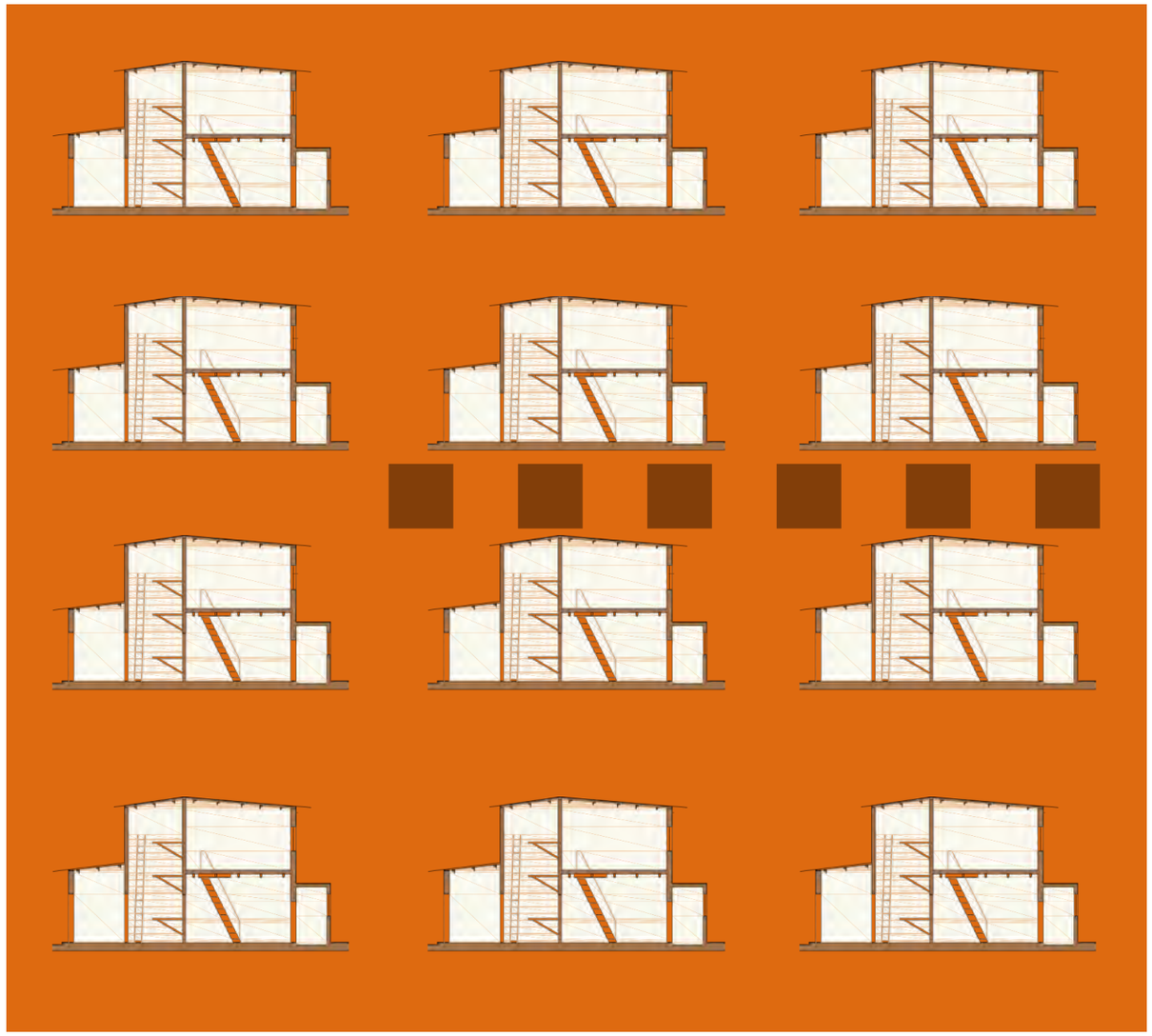
Cross-sectional

Measurements made at the same time
May show an association • Difficult to establish causality

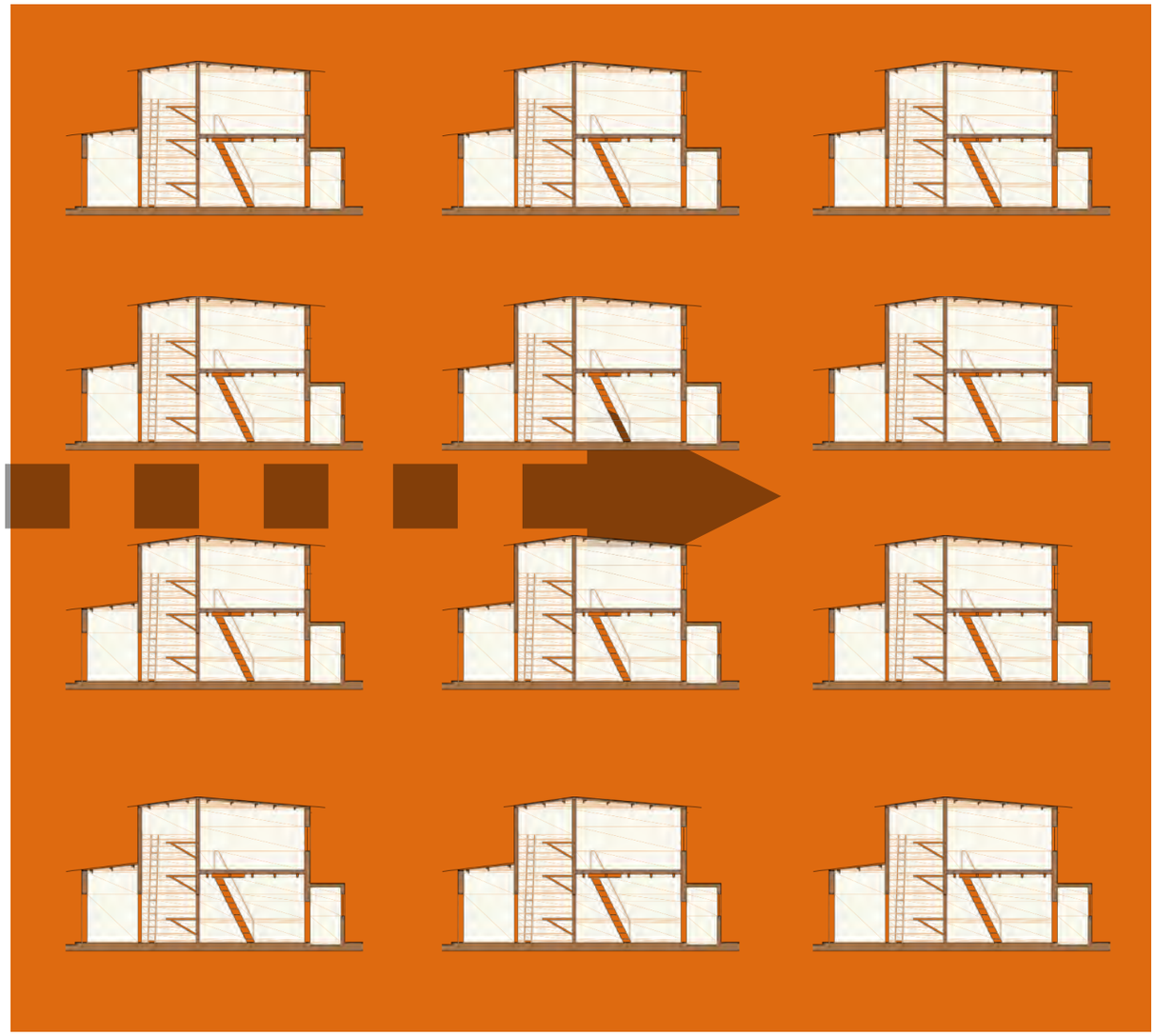
Requires least amount of planning
Requires no household-level follow-up

Needs a large sample size

Before and After



Participating Homes
Traditional Stoves



Participating Homes
Intervention Stoves

Time 0 **3 months later**

Before and After

Small sample size

Uses same household before and after, controlling for many household-level covariates

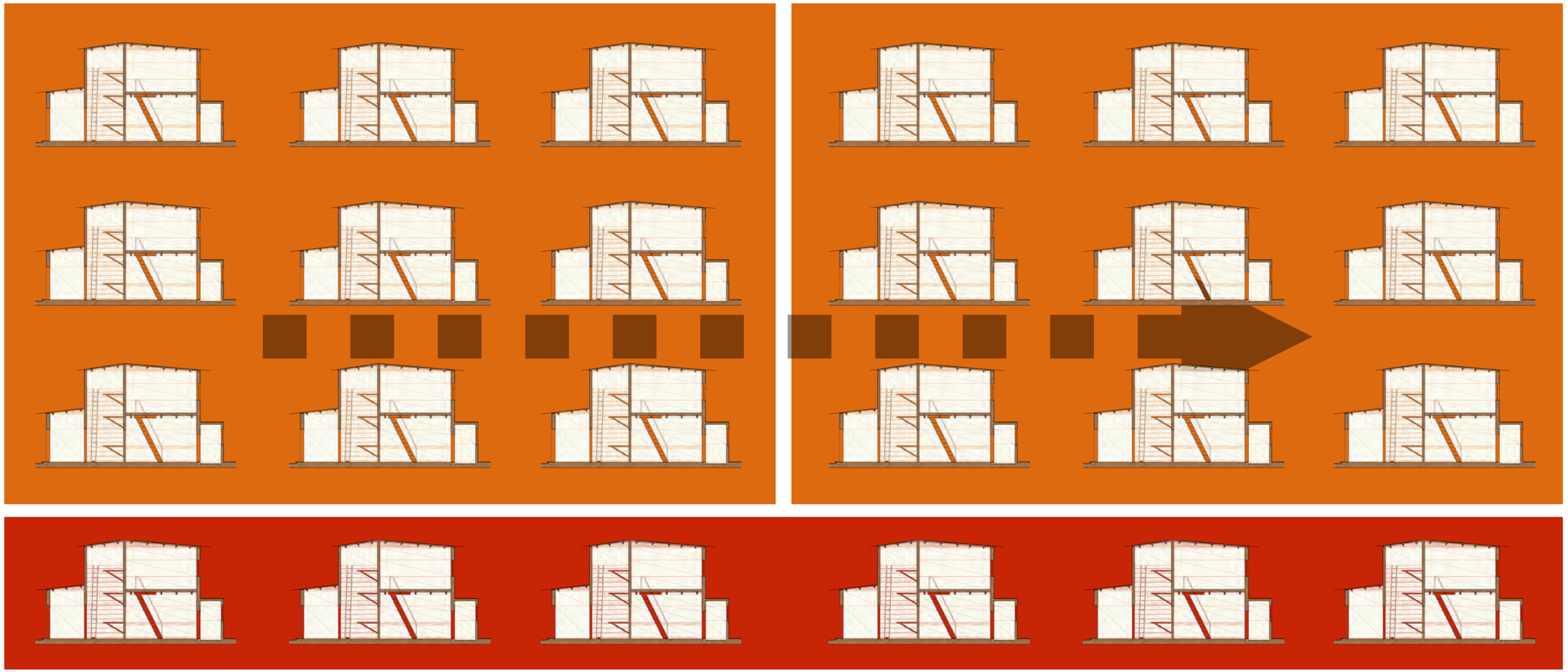
Requires several months of follow-up

Changes in air pollution may result from other factors — changes in fuel, seasonality, etc

Before and After with Control

Participating Homes
Traditional Stoves

Participating Homes
Intervention Stoves



Control Homes

Time 0 — **3 months later**

Before and After

- Separately quantifies the impact of external factors from that of the stove
- Requires a large total sample size
- Requires holding back an intervention from some households (control group), which poses ethical and political concerns
- Difficult to match controls to participants
- Controls may obtain intervention(s) independent of the study

Questions?

A primer on sample size calculations

Power

the likelihood a study will detect an effect when there is an effect to be detected. In our examples, this would be the chance of detecting a difference in household air pollution due to an intervention when there really was a difference.

p-value

fundamentally the percentage error rate of stating there is an effect when there is in fact no effect. For example, in testing interventions in a before-and-after design, where the improved stove does not really result in reduced HAP, if $p < 0.05$, there is a 5 % chance of thinking the intervention reduces HAP.

Detectable Difference

The magnitude of difference (in HAP, for our case) that will be detectable with statistical significance.

Assume 80% power and a p-value of 5%

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Cross Sectional

		COV of measurements [2]												
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3
Detectable difference in means	10%	16	63	142	251	393	565	769	1005	1272	1570	1900	2261	2653
	20%	4	16	36	63	98	142	193	251	318	393	475	565	663
	30%	2	7	16	28	44	63	86	112	142	175	211	251	295
	40%	1	4	9	16	25	36	48	63	80	98	119	142	166
	50%	1	3	6	10	16	23	31	40	51	63	76	91	106
	60%	1	2	4	7	11	16	22	28	36	44	53	63	74
	70%	1	2	3	5	8	12	16	21	26	32	39	46	54
	80%	0	1	2	4	6	9	12	16	20	25	30	36	42
	90%	0	1	2	3	5	7	10	13	16	20	24	28	33
	100%	0	1	2	3	4	6	8	10	13	16	19	23	27

Before and After

		Paired COV of measurements [2]												
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3
Detectable difference in means	10%	8	31	71	126	196	283	385	502	636	785	950	1130	1326
	20%	2	8	18	31	49	71	96	126	159	196	237	283	332
	30%	1	3	8	14	22	31	43	56	71	87	106	126	147
	40%	0	2	4	8	12	18	24	31	40	49	59	71	83
	50%	0	1	3	5	8	11	15	20	25	31	38	45	53
	60%	0	1	2	3	5	8	11	14	18	22	26	31	37
	70%	0	1	1	3	4	6	8	10	13	16	19	23	27
	80%	0	0	1	2	3	4	6	8	10	12	15	18	21
	90%	0	0	1	2	2	3	5	6	8	10	12	14	16
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Before and After

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	90%	0	0	1	2	2	3	5	6	8	10	12	14	16
	100%	0	0	1	1	2	3	4	5	6	8	9	11	13

Before and After with Control

		COV of measurements [2]												
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3
Detectable difference in means	10%	31	126	283	502	785	1130	1538	2009	2543	3140	3799	4521	5306
	20%	8	31	71	126	196	283	385	502	636	785	950	1130	1326
	30%	3	14	31	56	87	126	171	223	283	349	422	502	590
	40%	2	8	18	31	49	71	96	126	159	196	237	283	332
	50%	1	5	11	20	31	45	62	80	102	126	152	181	212
	60%	1	3	8	14	22	31	43	56	71	87	106	126	147
	70%	1	3	6	10	16	23	31	41	52	64	78	92	108
	80%	0	2	4	8	12	18	24	31	40	49	59	71	83
	90%	0	2	3	6	10	14	19	25	31	39	47	56	66
	100%	0	1	3	5	8	11	15	20	25	31	38	45	53

Choosing a CoV + Detectable Difference

The CoV is often high in these settings. Use available literature and preliminary measurements to help decide on an appropriate CoV

Altering the detectable difference can have a big impact on sample size; however, choosing a larger detectable difference may invalidate your results

Recommend oversampling by 20-30% to account for any unpredictable events in the field

Essence of Trial Design

- **Experimentation** vs. **Observation:**
  - Experimentation: “exposure” is under the control of the researcher; exposure is an intervention
  - Observation: exposure is merely observed by the researcher