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Developing A Research Question

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Overview

- The Scientific Method
- Study Designs
- The Research Question
- Formulating Testable Hypotheses
- Operationalizing The Question
- Activity

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The Scientific Method

What is science?

Is science prescriptive or descriptive?

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The Scientific Method

The Purpose of the Scientific Method

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The Scientific Method

The Purpose of the Scientific Method

“Science is descriptive, not prescriptive; it can tell us about causes but it cannot tell us about purposes. Indeed, science disavows a purpose.”

-Jonathan Sacks

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The Scientific Method

Science – and the scientific method – is not an authority figure.

Rather, it is a **method** of gaining knowledge.

(What other methods of gaining knowledge are there?)

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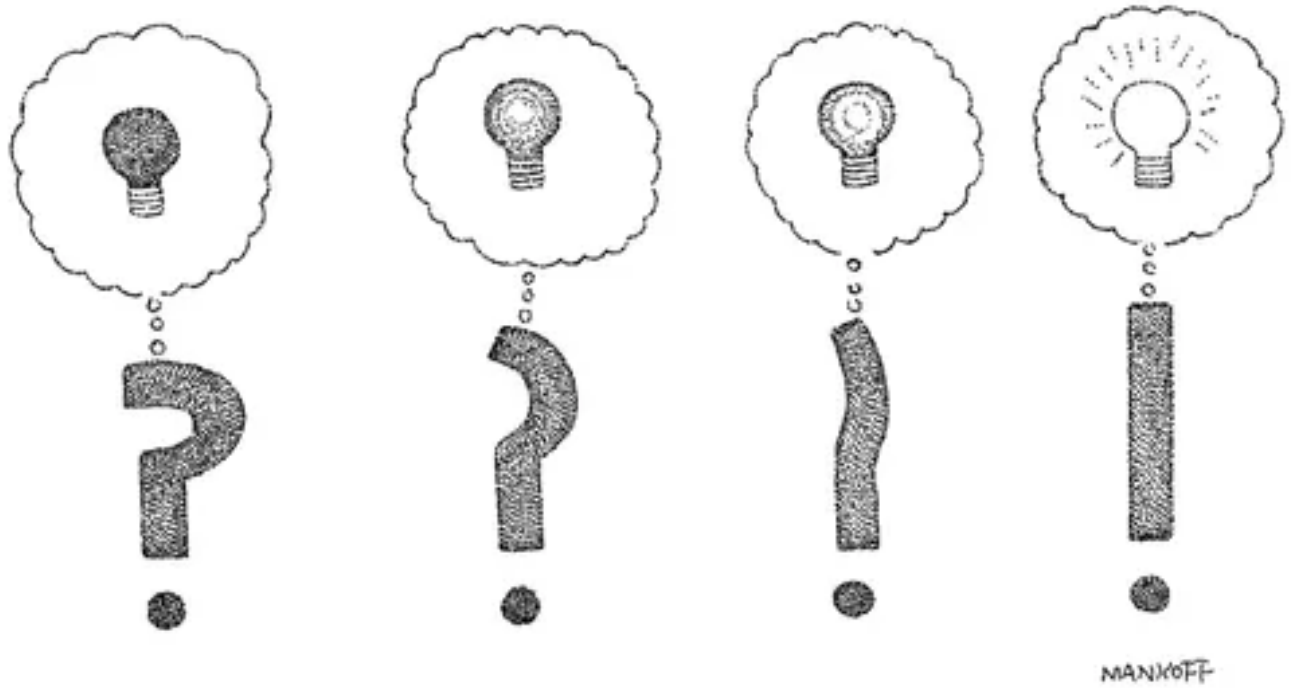
The Scientific Method

The starting point in the scientific method is **developing a research question.**

"The scientist is not a person who gives the right answers, he is one who asks the right questions."
-Claude Levi-Strauss (French philosopher)



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The Scientific Method

1. Identify a question
2. Propose an answer (research hypothesis)
3. Plan a research design (method)
4. Collect empirical data
5. Analyze data
6. Based on analyzed data, confirm or denounce hypothesis
7. Interpret results

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The Research Question

In biomedical studies, the best research questions are the ones that can be translated into statistical questions.

We can use the **FINER** and **PICOT** criteria to help us guide development of these questions (more on these later).

Some general guidelines:

- Be specific
- Be quantitative
- Consider the study designs that you can use

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The Research Question

Example

Suppose I use a 20-sided die for tabletop games. I think the die might not be rolling fairly.

What are some ways you can pose a research question with the following in mind:

- Be specific
- Be quantitative
- Consider the study designs that you can use

"A ubiquitous talisman of geekdom."

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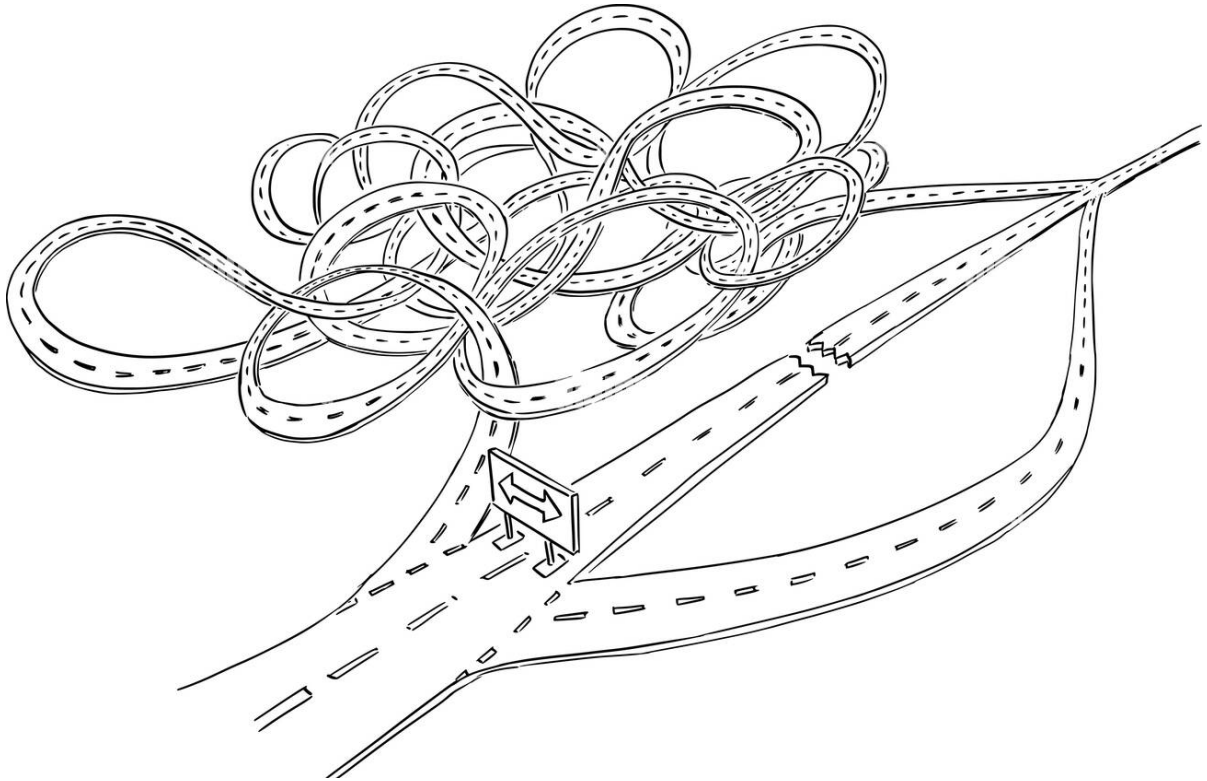
Study Designs in Medical Research

The design of your study is going to greatly impact your ability to analyze data and draw conclusions.



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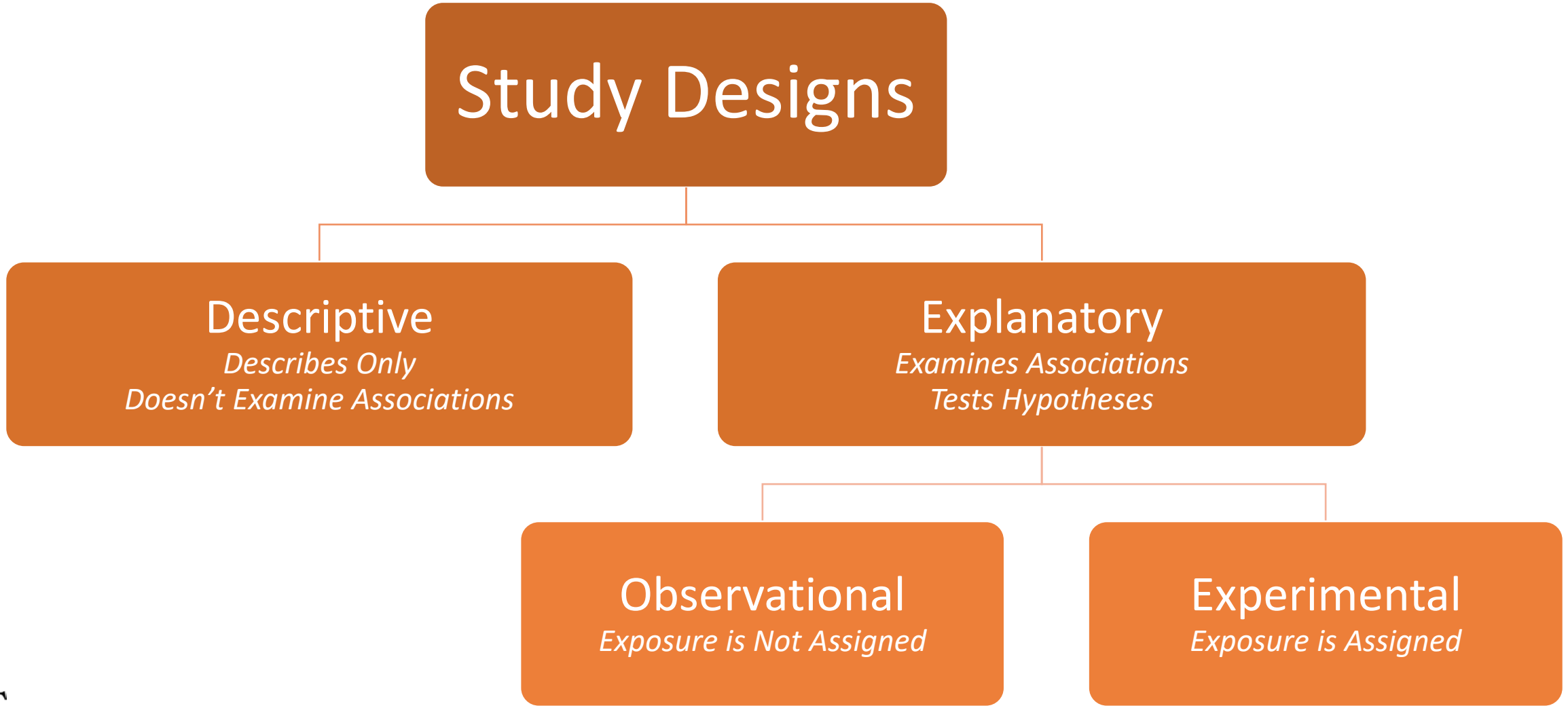
Study Designs in Medical Research



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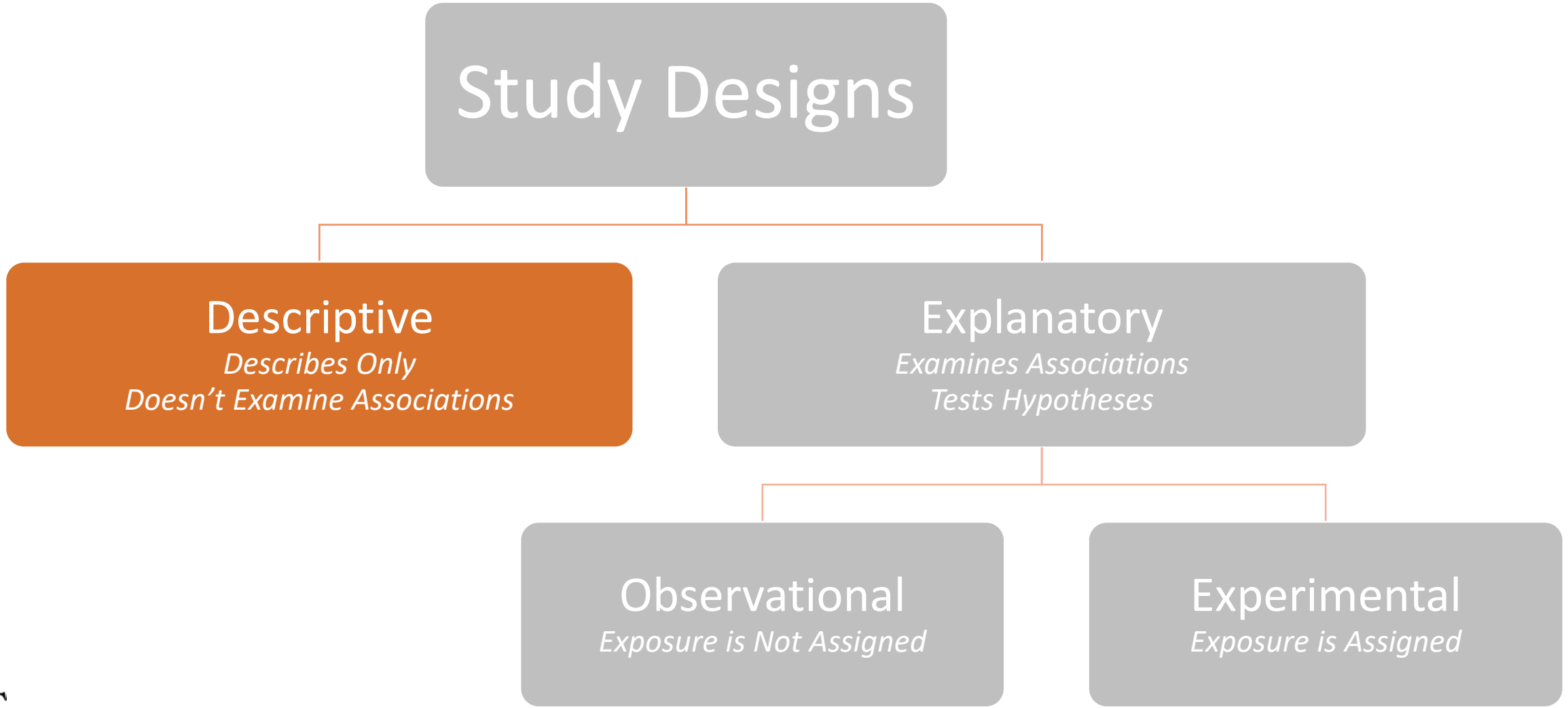
Study Designs in Medical Research



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Study Designs: Descriptive

- Case Reports
- Case Series
- Registry Summaries
- Surveys
- Anything Non-Experimental

Chicken pox complicated with necrotizing fascitis. A case report ♡

Toledo NC

PDF FULL TEXT PDF HOW TO CITE THIS ARTICLE

Language: Spanish
References: 12
Page: 72-73
PDF size: 94.22 Kb.

Key words:

Necrotizing fasciitis, chicken pox, complications.

ABSTRACT

Varicella is a common viral childhood disease that is resolved without complications; when these complications are present they can be severe and have systemic manifestations of toxicity. A case of chicken pox complicated with necrotizing fasciitis that was treated surgically with good evolution is presented. It is very important that a physician recognizes this clinical entity to refer the patient to specialized treatment.

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Study Designs: Descriptive

- Case Reports
- Case Series
- Registry Summaries
- Surveys
- Anything Non-Experimental

Perspectives on Aging and Illness by Homeless Adults Receiving Street Medicine

Alexis Coulourides Kogan PhD, Anuva Mittal, Enya Lowe MSc, Corinne Feldman MMS PA-C

https://doi.org/10.1016/j.jpainsymman.2024.02.304

Outcomes

1. Describe the street medicine model of care, how it differentiates from other models, and where it sits on the continuum of care.

2. Identify the unique challenges faced by people experiencing unsheltered homelessness as they age and manage serious illness while living outside.

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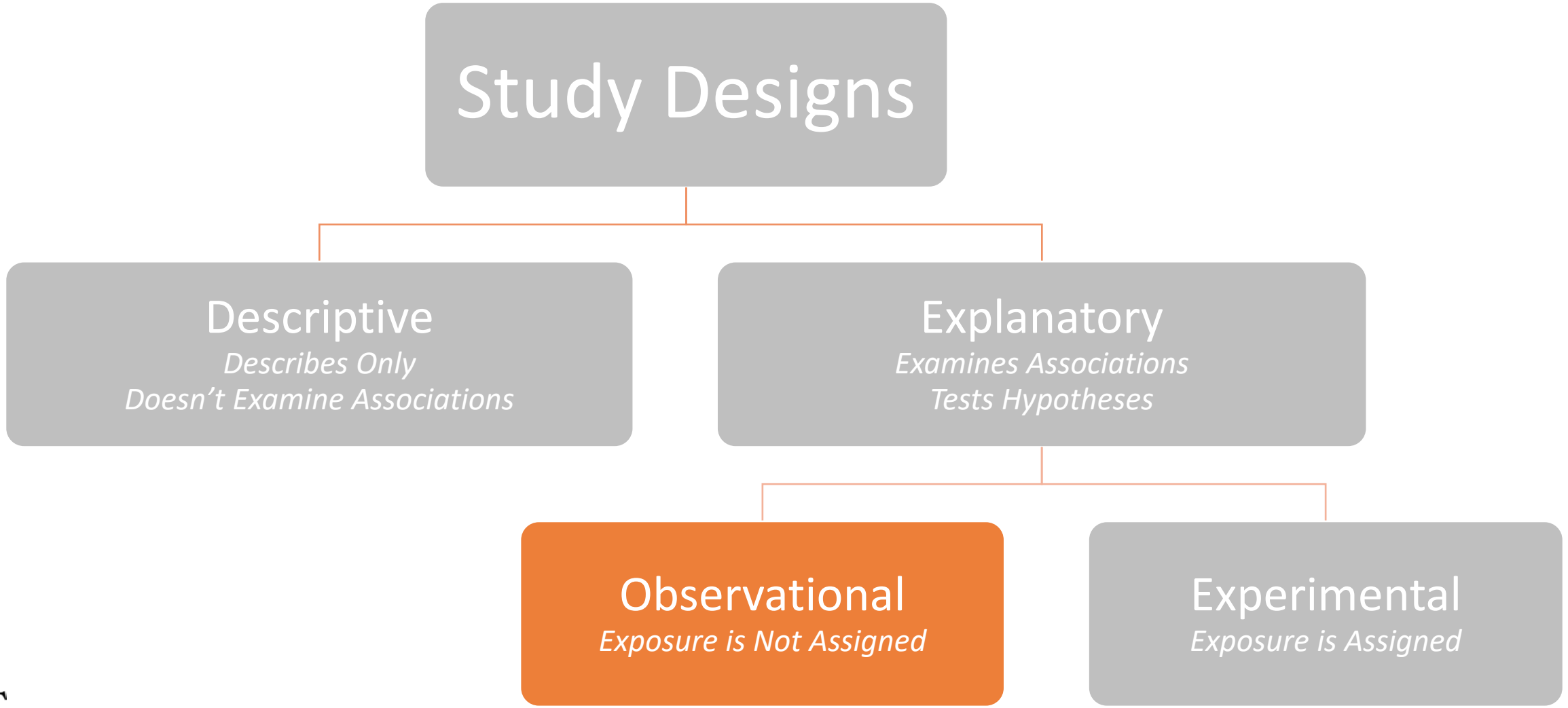
Study Designs in Medical Research



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Study Designs: Observational

A clinical study in which participants identified as belonging to study groups are assessed for biomedical or health outcomes.

Participants may receive diagnostic, therapeutic, or other types of interventions, but the investigator does not assign participants to specific interventions.

Associations between exposures and outcomes may be biased (confounded) by characteristics that differ between those that choose exposure vs. no exposure.

-clinicaltrials.gov

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Study Designs: Observational

- Ecological
- Cross-Sectional
- Case-Control (Retrospective)
- Cohort (Prospective)

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Study Designs: Observational (Ecological)

In an ecological study, the unit of observation is a population or community rather than the individual.

Community-level exposures/outcomes are compared across many different communities.

Useful for monitoring population-level health.

Study Designs: Observational (Ecological)

Example

Samet et al. (2000): Fine particulate air pollution and mortality in 20 U.S. cities, 1987 – 1994.

Question: Are city-level daily air pollution levels related to city-level mortality?

Design: Collected administrative daily, city-level data on death, air pollution, and meteorology for the 20 largest cities in the U.S.

Results: "Every 10 μg/m^3 increase in PM10 was associated with 0.68 % increase in relative rate of death from cardiovascular/respiratory causes (95% CI: 0.20, 1.16)"

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Study Designs

The design of your study is going to greatly impact your ability to analyze data and draw conclusions.

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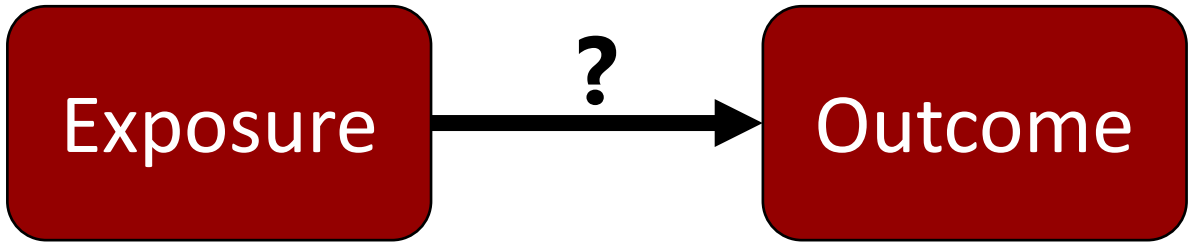
Study Designs: Observational (Cross-Sectional)

In a cross-sectional study, the exposure and outcome are determined at the same time.

Steps

1. Select or identify a population
2. Determine the outcome and exposure



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Study Designs: Observational (Cross-Sectional)

Example

Chen et al. (2015): Ambient air pollution and neurotoxicity on brain structure: Evidence from the women's health initiative memory study

Question: Does air pollution exposure impact the brains of older women?

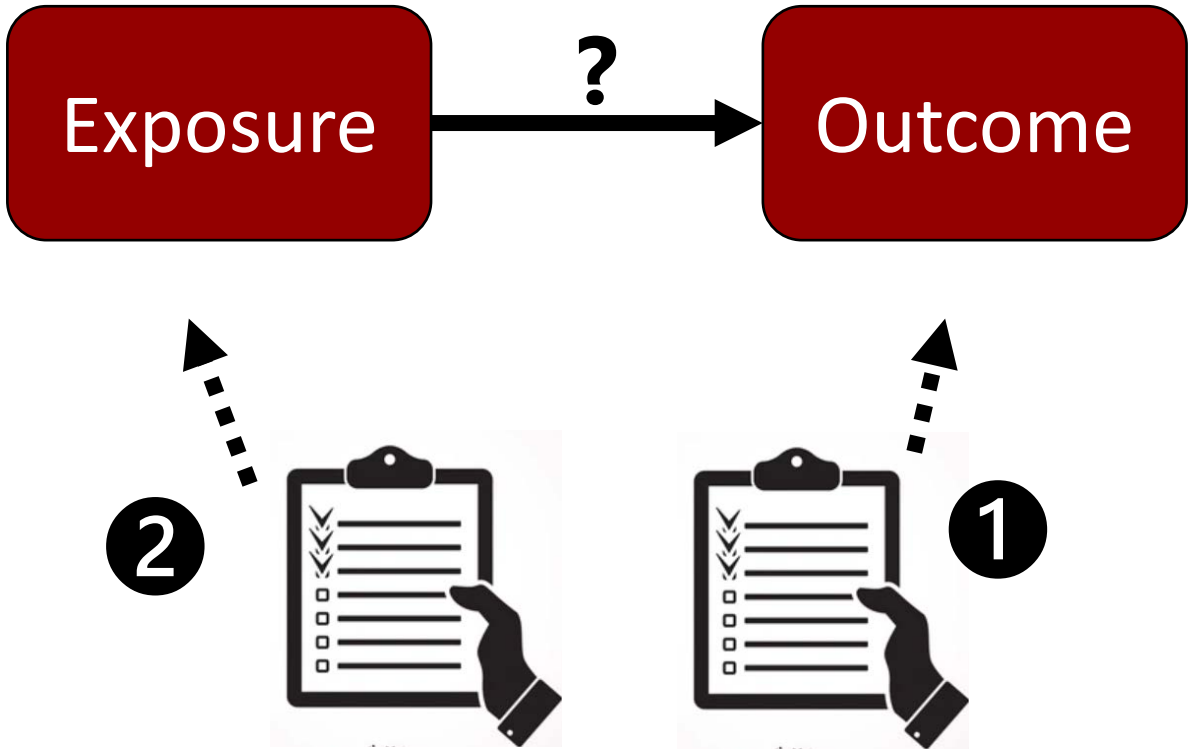
Design: Sampled 1,403 older women without dementia, took MRI scans of gray matter (GM) and white matter (WM) volume, then assessed cumulative PM2.5 exposure from 1999-2006 based on the participant's residential data.

Results: "Older women with greater PM2.5 exposures had significantly smaller WM, but not GM, volumes, independent of geographical region, demographics, socioeconomic status, lifestyles, and clinical characteristics, including cardiovascular risk factors."

Study Designs: Observational (Case-Control)

Steps

1. Select or identify a population based on some outcome
2. Determine if participants had a previous exposure



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Study Designs: Observational (Case-Control)

Example

Volk et al. (2013): Traffic-related air pollution, particulate matter, and autism

Question: Is traffic-related pollution exposure related to the development of autism?

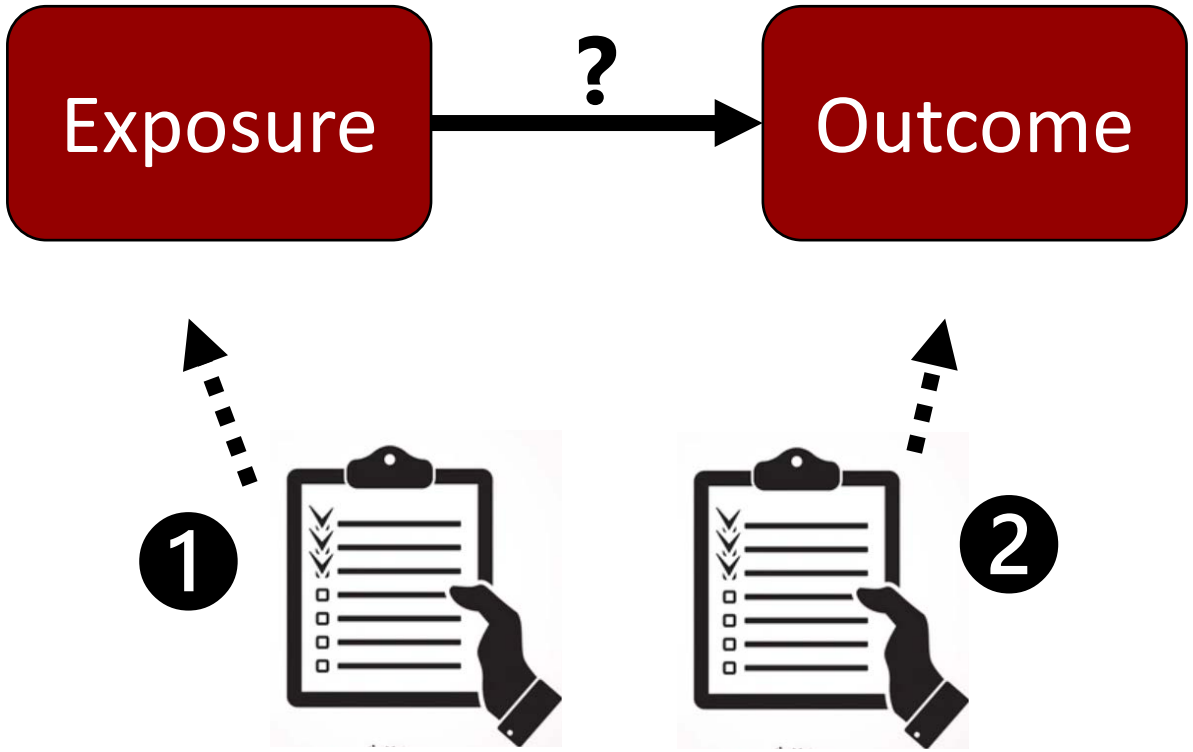
Design: Sampled 279 children with autism (from CA Department of Developmental Services) and 245 children without autism from a birth registry. The mother's address from the birth certificate was used to obtain traffic exposure data.

Results: "Children with autism were more likely to live at residences that had the highest quartile of exposure to traffic-related air pollution, during gestation (AOR, 1.98 [95% CI, 1.20-3.31]) and during the first year of life (aOR, 3.10 [95% CI, 1.76-5.57]), compared with control children"

Study Designs: Observational (Cohort)

Steps

1. Select or identify a population based on the exposure
2. Determine if participants develop an outcome later on



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Study Designs: Observational (Cohort)

Example

Cheng et al. (2019): Association between ambient air pollution and breast cancer risk: The multiethnic cohort study

Question: Is air pollution exposure associated with increased risk of breast cancer?

Design: Identified 57,589 females from the multiethnic cohort, mostly in LA County, through 2010. These individuals were followed to determine if they contracted breast cancer

Results: "Among women who lived within 500m of major roads, significantly increased risks were observed with NOx (hazard ratio [HR] = 1.35, 95% confidence interval [95% CI]: 1.02–1.79). Subgroup analyses suggested stronger associations of NOx and NO2 among African Americans and Japanese Americans."

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Comparison of Study Designs

Type of Study	Group(s) defined by	Observe	Pros	Cons
Ecological	Geography	Exposure and outcome (in a community)	• Very Inexpensive • Covers a large population • Readily available administrative data can be used	• Ecological fallacy • Outcome/disease may vary by location
Cross-sectional	Defined population	Exposure and outcome	• Quick and easy • Inexpensive • Can often use existing data • Efficient for common exposure and outcome	• Temporal ambiguity • Prevalence bias • Recall bias
Case-Control	Disease status	Exposure	• Efficient in long duration between E and O • Low time and cost • Efficient for rare outcomes	• Control selection challenging • Differential misclassification of exposure • Recall bias
Cohort	Exposure	New cases of outcome	• Efficient for rare exposure • No temporal ambiguity • Can study multiple outcomes	• Time and cost • Self-selection bias • Incomplete follow-up • Inefficient for rare outcomes

Study Designs: Which One?

Coronavirus Disease 2019 (COVID-19): A Modeling Study of Factors Driving Variation in Case Fatality Rate by Country

by **Jennifer Pan** [1,†], **Joseph Marie St. Pierre** [1,†], **Trevor A. Pickering** [1,2], **Natalie L. Demirjian** [1,3], **Brandon K.K. Fields** [1], **Bhushan Desai** [1,4] and **Ali Gholamrezanezhad** [1,4,*]

Abstract

Background: The novel Severe Acute Respiratory Syndrome Coronavirus-2 has led to a global pandemic in which case fatality rate (CFR) has varied from country to country. This study aims to identify factors that may explain the variation in CFR across countries. *Methods:* We identified 24 potential risk factors affecting CFR. For all countries with over 5000 reported COVID-19 cases, we used country-specific datasets from the WHO, the OECD, and the United Nations to quantify each of these factors. We examined univariable relationships of each variable with CFR, as well as correlations among predictors and potential interaction terms. Our final multivariable negative binomial model included univariable predictors of significance and all significant interaction terms. *Results:* Across the 39 countries under consideration, our model shows COVID-19 case fatality rate was best predicted by time to implementation of social distancing measures, hospital beds per 1000 individuals, percent population over 70 years, CT scanners per 1 million individuals, and (in countries with high population density) smoking prevalence. *Conclusion:* Our model predicted an increased CFR for countries that waited over 14 days to implement social distancing interventions after the 100th reported case. Smoking prevalence and percentage population over the age of 70 years were also associated with higher CFR. Hospital beds per 1000 and CT scanners per million were identified as possible protective factors associated with decreased CFR.

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Study Designs: Which One?

D. Walker studied the association between seeking therapy and self-efficacy to complete a degree program in college students. The data came from the Healthy Minds study, a survey distributed to over 50,000 college students across the United States.

Participants were asked whether, in the past year, they had attended at least one therapy session. They were additionally asked their confidence about being able to complete their degree program at school.

D. Walker found that attending therapy was associated with lower self-efficacy to complete the degree program.

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Study Designs: Observational (Nested Case Control)

In a nested case control study, a subgroup is identified within an ongoing cohort .

This study combines the strengths of both case-control and cohort studies:

- Information on exposures is collected before the development of disease.
- The method is cost efficient when the measurement of exposure involves expensive analysis of previously-collected specimens.

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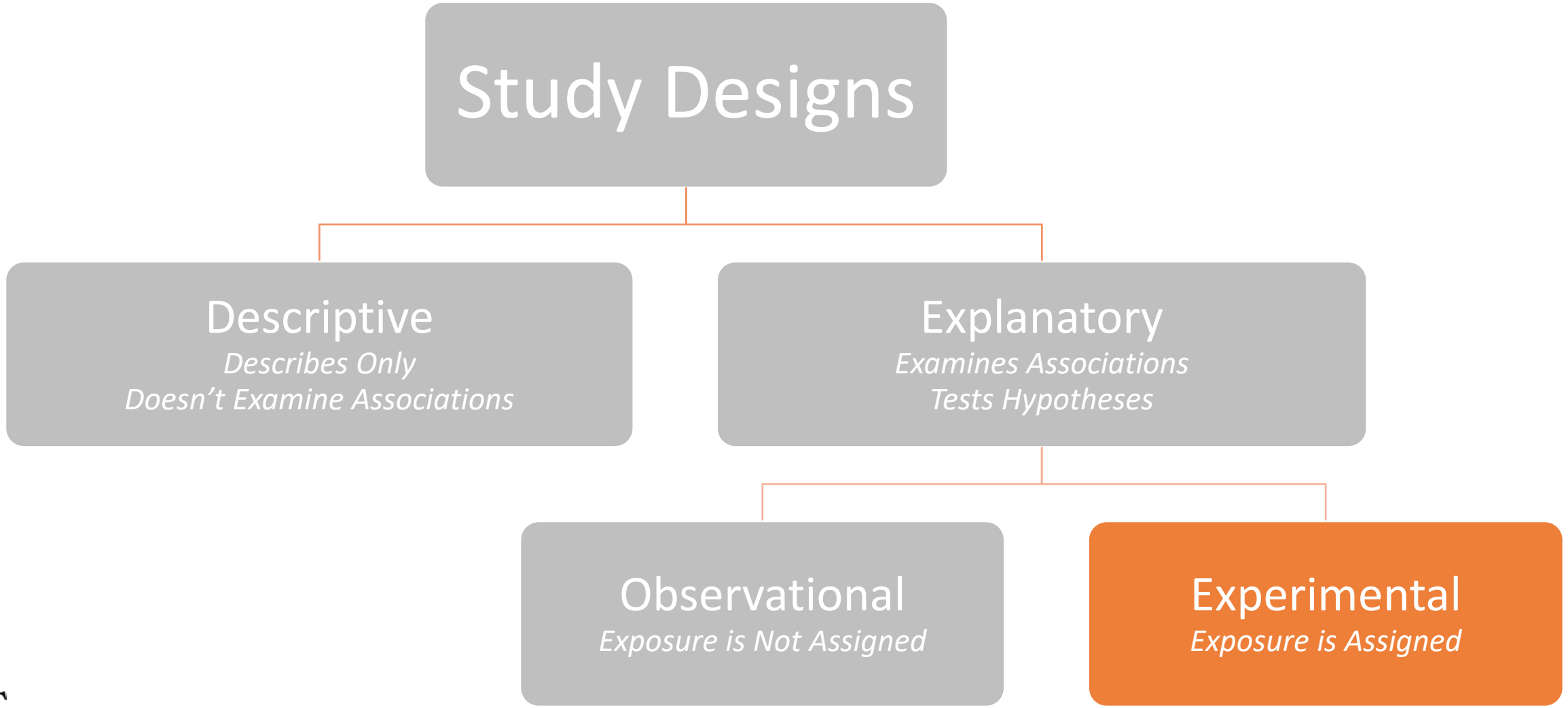
Study Designs in Medical Research



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Study Designs: Experimental

A cohort study in which persons are assigned to exposure/intervention conditions and followed for ascertainment of outcomes.

A clinical trial is a study in which participants are assigned to receive one or more interventions (or no intervention) so that researchers can evaluate the effects of the interventions on biomedical or health-related outcomes. The assignments are determined by the study protocol. Participants may receive diagnostic, therapeutic, or other types of interventions.

-clinicaltrials.gov

Study Designs: Clinical Trial Designs

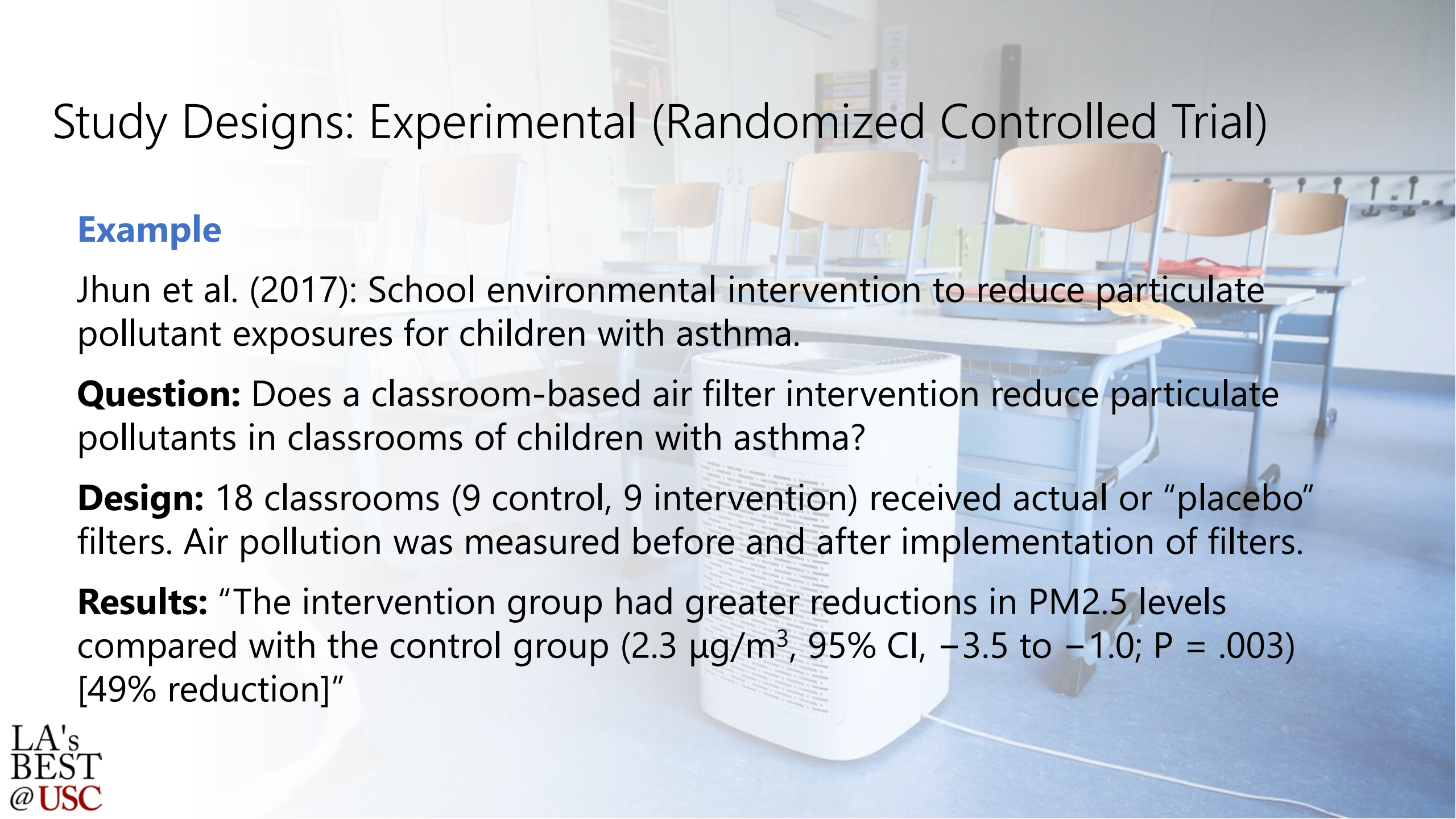
- **Parallel Group.** Each participant is assigned to one (and only one) of the trial exposures/interventions. This is the standard approach for most clinical trials.
- **Crossover.** Each participant receives both the experimental and comparator interventions, usually in a randomized order, with a washout period between interventions.

While the crossover design is preferred due to each person acting as their own control, it does increase the likelihood of dropout, it is restricted to examining diseases that are stable during the study, it is only appropriate when there is the ability to wash out, and only for short-term outcomes.

Intervention Assignment

- **Randomization.** When participants are randomized to treatment, the likelihood of systematic differences between study groups (that might taint/confound your conclusions) is greatly reduced. This is the key advantage over observational studies.
- **Crossover.** Each participant receives both the experimental and comparator interventions, usually in a randomized order, with a washout period between interventions.

Study Designs: Experimental (Randomized Controlled Trial)



Example

Jhun et al. (2017): School environmental intervention to reduce particulate pollutant exposures for children with asthma.

Question: Does a classroom-based air filter intervention reduce particulate pollutants in classrooms of children with asthma?

Design: 18 classrooms (9 control, 9 intervention) received actual or "placebo" filters. Air pollution was measured before and after implementation of filters.

Results: "The intervention group had greater reductions in PM2.5 levels compared with the control group (2.3 μg/m^3, 95% CI, −3.5 to −1.0; P = .003) [49% reduction]"

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Did the investigator(s)...

1) ...examine an association (Qx: If E, then O)?
2) ...assign E to subjects and then follow them for O?
3) ...ascertain E and O for geographic areas or groups of people rather than for individual subjects?
4) ...ascertain E and O at roughly the same time on ALL eligible subjects?
5) ...identify cases of O (& non cases) before ascertaining previous E?
6) ...identify E on subjects first before following them for onset of O?

Which study design?

1) If NO, study design is Descriptive.
2) If YES, study design is Experimental.
3) If YES, study design is Ecological.
4) If YES, study design is Cross-Sectional.
5) If YES, study design is Case-Control.
6) If YES, study design is cohort.

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Study Designs

Test Yourself

What is the key advantage of an experimental study, compared to an observational study?

A. Experimental studies are usually less expensive to conduct.
B. Experimental studies reduce systematic bias through randomization of participants to outcome.
C. Experimental studies allow researchers to look at exposures that would be unethical to assign.

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The Children's Health Study

Broad Question: Does air pollution impact health?

The Children's Health Study is a **longitudinal cohort** of children in Southern California that began in the 1990s. Children were selected from multiple communities across the region, selected to represent a wide range of air pollution needs.

While exposures were collected at baseline, the children were followed up over many years, with periodic assessments to track their respiratory health and lung function.

You will be working with the Children's Health study data A LOT during this program!

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CHS: A Cohort Study Alternative

Suppose you want to know how air pollution is related to asthma.

- Obtain air pollution levels in a group of children without asthma.
- Follow over X years to ascertain which of these children develop asthma.
- Compare asthma rates by air pollution level.

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CHS: A Case-Control Alternative

Suppose you want to know how air pollution is related to asthma.

- Select samples of persons with asthma (cases) and without asthma (controls).
- Access historical data on air pollution levels in their hometowns.
- Compare pre-disease air pollution in cases and controls.

Back to the Research Question!

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The Research Question

In biomedical research, we frequently must be able to **translate** a research question into a statistical hypothesis that we can test.

Remember…

- Be specific
- Be quantitative
- Consider the study designs that you can use

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Hypothesis Testing

The basic steps in statistical hypothesis testing are:

- Form a **hypothesis** to be tested
- Take your data and compute a **test statistic** based on your hypothesis
- Use the test statistic to compute a **p-value** derived from a distribution based on the null hypothesis and the type of data you have
- Draw your **conclusion**

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Hypothesis Testing

Hypotheses take the form of “innocent until proven guilty”.

We assume that the hypothesis of interest is not true, and we accept it if there is overwhelming evidence.

If we make a claim, we have a burden of proof to provide evidence that the claim is true.

Hypothesis Testing

Example

Suppose I present you with a jar full of coins. It has so many coins in it that you cannot count it from the outside.

I say, “there is an even number of marbles in this jar.”

Do you have evidence to show that there is an even number of marbles in this jar?

If you don’t have evidence that there is an even or odd number of marbles, then you must logically reject my claim!

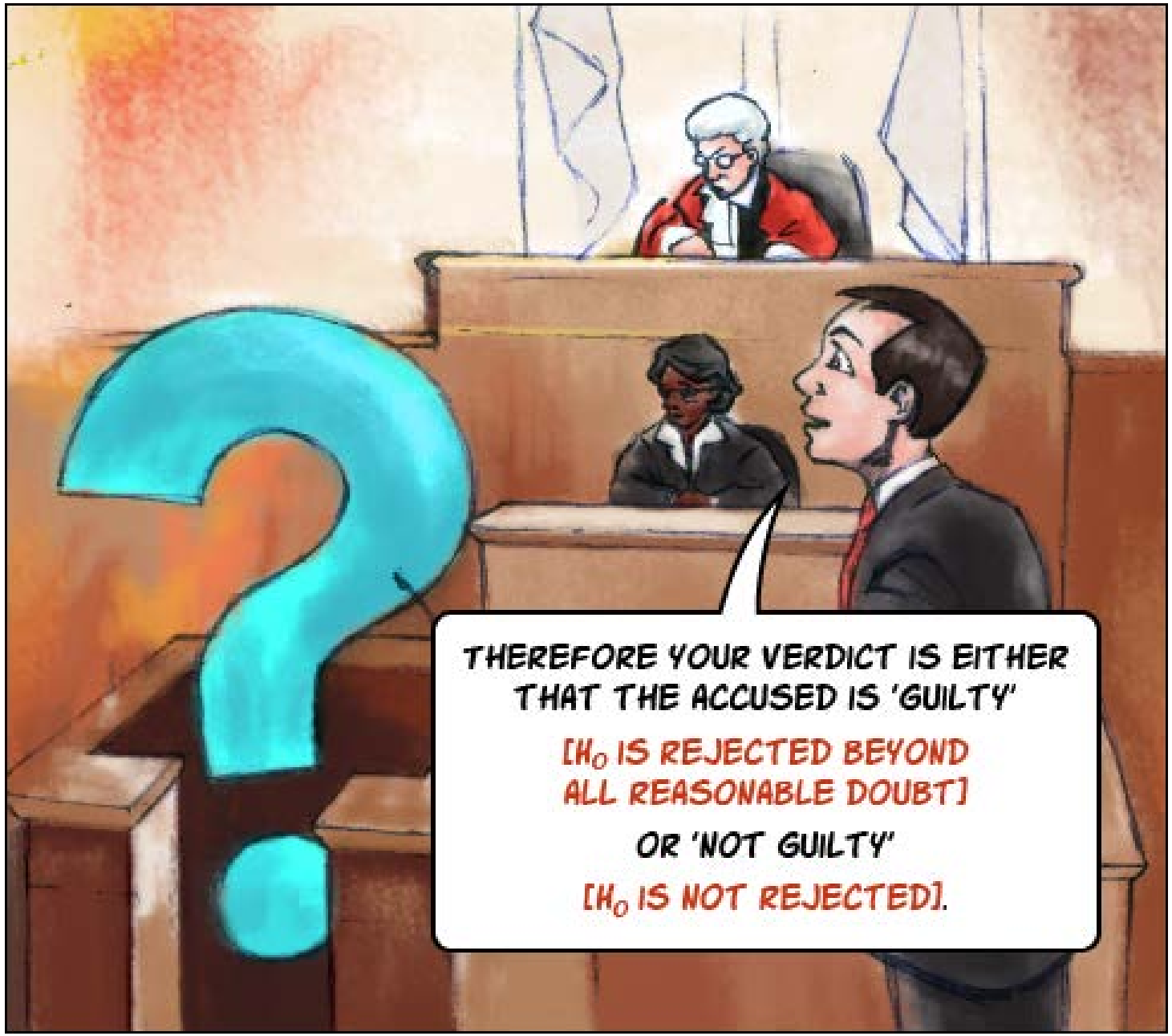
Hypothesis Testing

The **null hypothesis (H_0)** is the "status quo". It represents what should be believed if the hypothesis of interest is not demonstrated.

There is not an even number of coins in this jar.
There is no evidence that there is an even number of coins in this jar.

The **alternative hypothesis (H_1 or H_A)** is the hypothesis that we want to demonstrate is true.

There is an even number of coins in this jar.


THEREFORE YOUR VERDICT IS EITHER THAT THE ACCUSED IS 'GUILTY'
[H_0 IS REJECTED BEYOND ALL REASONABLE DOUBT]
OR 'NOT GUILTY'
[H_0 IS NOT REJECTED].

Hypothesis Testing

Hypothesis tests stem from **research questions**.

A research question is translated into a **statistical hypothesis**.

A statistical hypothesis includes a statement about a population parameter.

This statement should be **testable**.

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Hypothesis Testing

Test Yourself: Testable or Not?

- "The Beatles are the best-selling band of all-time?"
- "Scrooge McDuck is the best duck in Duckburg."
- "The reason humans sleep is because undetectable butterflies sprinkle sleep-dust on humans and it makes us tired."
- "Listening to upbeat music while cooking results in faster meal preparation times."
- "Every time somebody sneezes, a fairy gets its wings."

Hypothesis Testing

Hypotheses are not testable if (this list is not exhaustive):

- There is no clearly defined way to measure the hypothesis
- The hypothesis relates to personal opinion
- There is no way to collect data to examine the hypothesis

Hypothesis Testing

John Lennon:

I believe in everything until it is disproved. So I believe in fairies, the myths, dragons. It all exists, even if it's in your mind. Who's to say that dreams and nightmares aren't as real as the here and now? Science is just one way of understanding reality.

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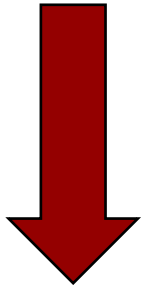
Hypothesis Testing

Research Question

- Does higher systolic blood pressure (SBP) increase dementia in the elderly?



Statistical Questions

- Among persons aged >70, do those who develop dementia have a higher proportion of those with SBP>120 than those who don't develop dementia?
- Among persons aged >70, is the incidence rate of dementia greater in those who have SBP>120 compared to those who do not?

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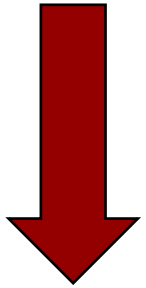
Hypothesis Testing

Research Question

- Does higher systolic blood pressure (SBP) increase dementia in the elderly?



Statistical Questions

Case Control: Compare proportions of those having SBP>120.

- Among persons aged >70, do those who develop dementia have a higher proportion of those with SBP>120 than those who don't develop dementia?
- Among persons aged >70, is the incidence rate of dementia greater in those who have SBP>120 compared to those who do not?

Cohort: Compare incidence rate of developing dementia.

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Back To The Research Question!

States a relationship between two (or more) variables, phrasing in terms of some question.

Things to consider:

- Why is this research important?
- What is the gap in our scientific understanding?
- What is the past research in this area?
- What areas need further exploration?
- Can the study help fill these gaps, or lead to greater understanding?

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Formulating Research Questions

There are a couple of different frameworks – such as PICOT and FINER – that can be used to help researchers formulate research questions.

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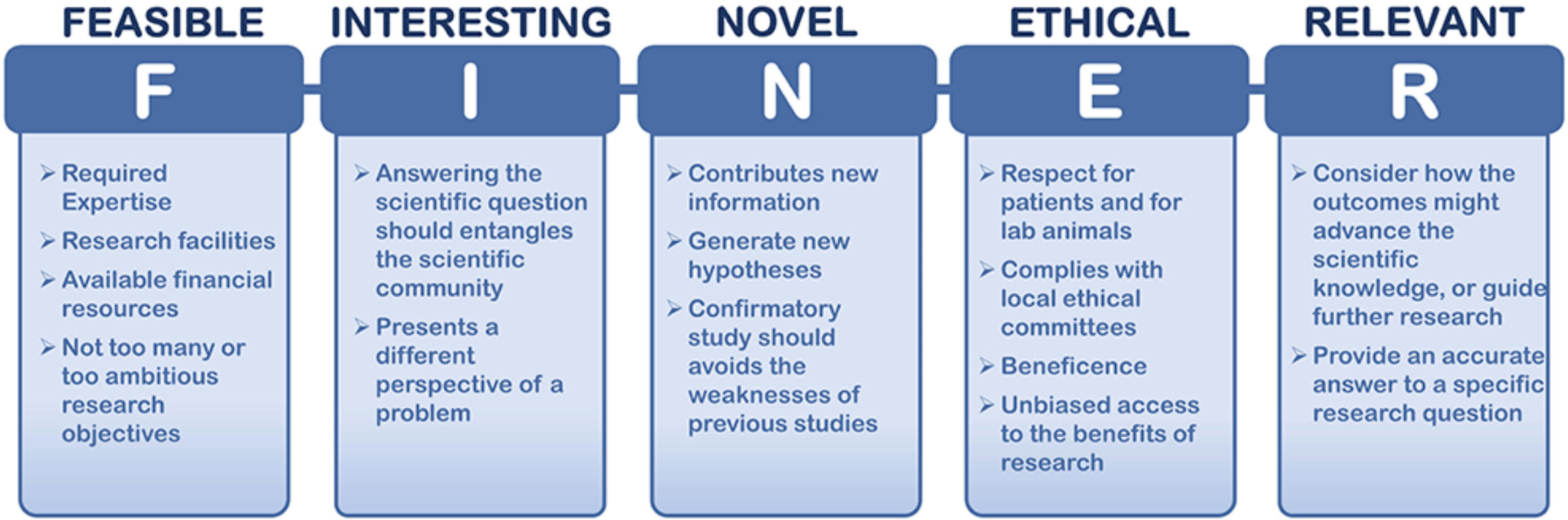
FINER Criteria



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Acharya S, Preda MB, Papatheodorou I *et al.*. The science behind soft skills: Do's and Don'ts for early career researchers and beyond. A review paper from the EU-CardioRNA COST Action CA17129 [version 1]. *Open Res Europe* 2023, **3**:55 (doi: 10.12688/openreseurope.15746.1)

FINER Criteria

This criteria can be used to decide on the merit of a research question.

- **Feasible –** There is an adequate number of subjects, the team contains the required expertise, the study is affordable and manageable.
- **Interesting –** To the scientific community.
- **Novel –** Confirms, refutes, or extends previous findings.
- **Ethical –** Patient perspective is considered.
- **Relevant –** To scientific knowledge, clinical/health policy, and future research.

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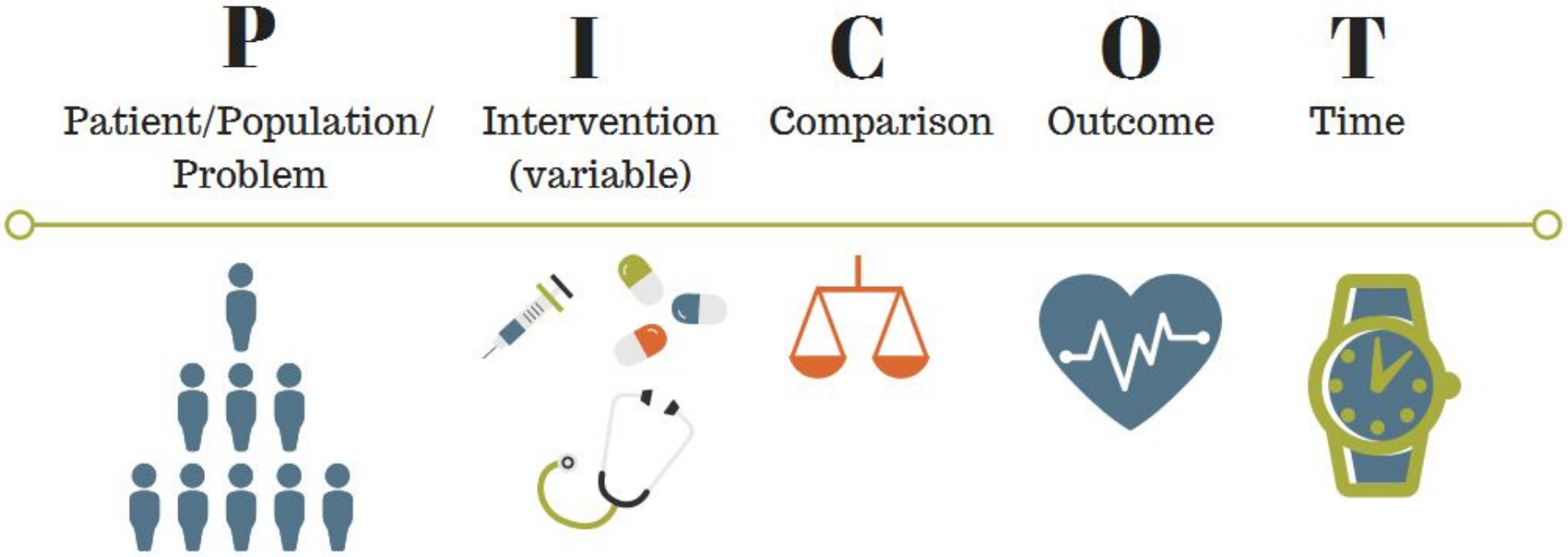
PICOT Criteria



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Sackett D, Richardson WS, Rosenburg W, Haynes RB. How to practice and teach evidence-based medicine. 2nd ed. Churchill Livingstone; 1997.

PICOT Criteria

This criteria can be used to develop research questions that can be translated to a statistical hypothesis.

- **Population –** What specific group of people will you use?
- **Intervention –** What is the exposure to be investigated?
- **Comparison –** What is the comparator group by which to judge the effect of the intervention?
- **Outcome –** What will you measure, improve, affect?
- **Time –** Over what time period will the outcome be assessed?

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Population & Sample

The people you sample for your study will determine the population that your results are generalizable to.

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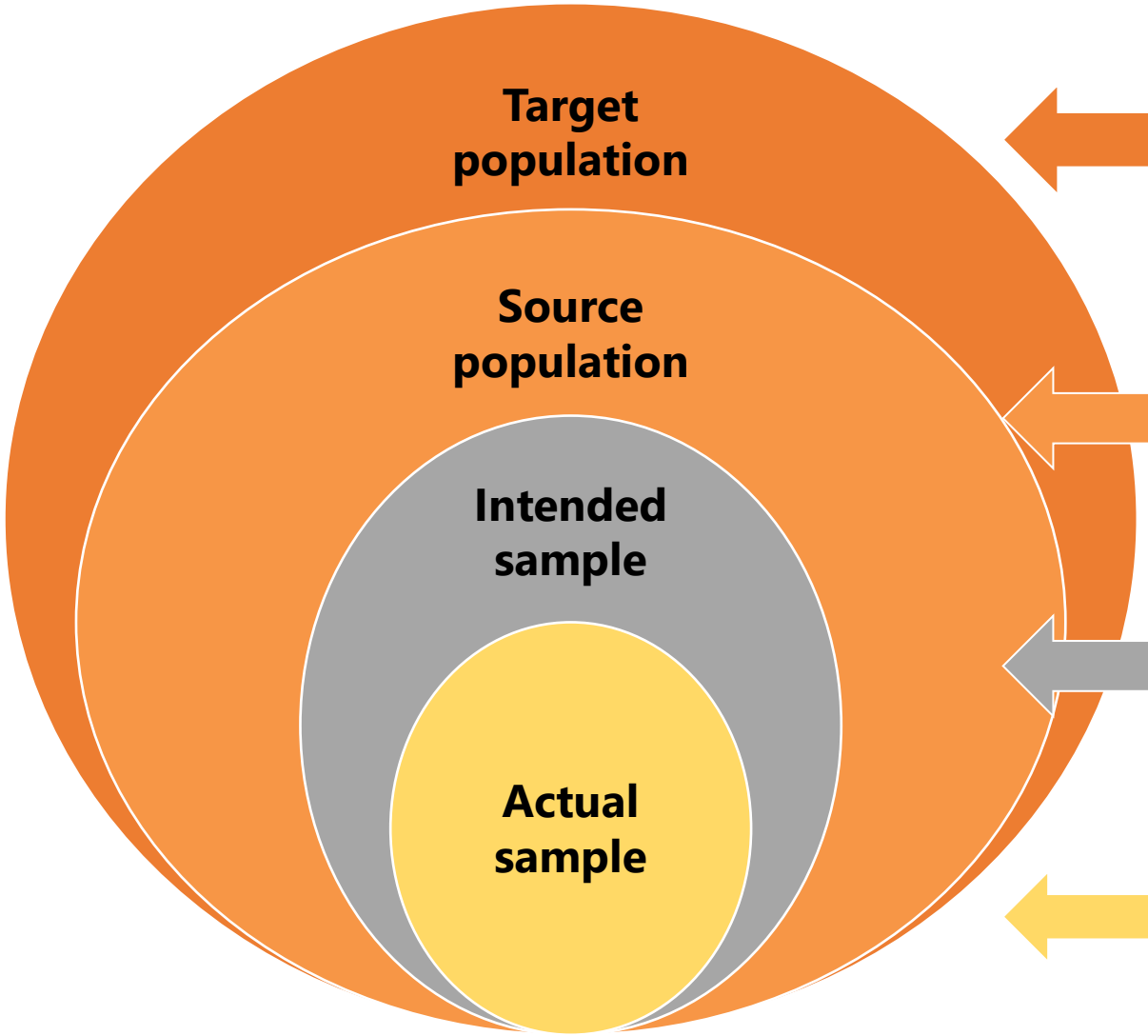

Who you want to generalize to

Which populations are relevant to the question?
Adults age >65 years
Clinical characteristics?

Who you have access to

Which populations with these characteristics are available to you?
Adults age >65 years in Los Angeles County from 1/1/2020 to 12/31/2020

Who you plan to sample

Which population will you attempt to recruit?
Adults age >65 years in Los Angeles County from 1/1/2020 to 12/31/2020 who visited Keck hospital for an annual physical

Analysis sample

Who did you actually recruit?
230 adults age >65 years in Los Angeles County from 1/1/2020 to 12/31/2020 who visited Keck hospital for an annual physical

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Operationalizing Concepts

Remember, a key part of the research question is to be specific!

Part of this is operationalizing the concepts from your research question.

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Operationalizing Concepts

Research Question

Does higher systolic blood pressure (SBP) increase dementia in the elderly?

- **Population.** Elderly persons (those aged >70 years at baseline, without dementia).
- **Intervention.** Those with elevated SBP, as measured by an average SBP>120 in the prior year.
- **Comparison.** Those without elevated SBP, as measured by an average SBP<120 in the prior year.
- **Outcome.** Dementia, as operationalized by new diagnosis of dementia.
- **Time.** Over 5 years of follow-up time.

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Activity Time!

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John Doerr, the venture capitalist who invested in tech companies such as Slack, Google and Amazon, on the Stanford campus. Carolyn Fong for The New York Times

By David Gelles
David Gelles writes about climate change and business, and has interviewed hundreds of C.E.O.s in recent years.

May 4, 2022 Updated 11:50 a.m. ET

John Doerr, one of the most successful venture capitalists in the history of Silicon Valley, is giving $1.1 billion to Stanford University to fund a school focused on climate change and sustainability.

"Climate and sustainability is going to be the new computer science," Mr. Doerr, who made his estimated $11.3 billion fortune investing in technology companies such as Slack, Google and Amazon, said in an interview. "This is what the young people want to work on with their lives, for all the right reasons."

"Climate and sustainability is going to be the new computer science."

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https://www.nytimes.com/2022/05/04/climate/john-doerr-stanford-climate.html

“Tackling climate change could be the greatest global health opportunity of the 21st century”

“Many mitigation and adaptation responses to climate change are “no-regret” options, which lead to direct reductions in the burden of ill-health, enhance community resilience, alleviate poverty, and address global inequity. Benefits are realised by ensuring that countries are unconstrained by climate change, enabling them to achieve better health and wellbeing for their populations. These strategies will also reduce pressures on national health budgets, delivering potentially large cost savings, and enable investments in stronger, more resilient health systems.”

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Watts N, Adger WN, Agnolucci P, Blackstock J, Byass P, Cai W, Chaytor S, Colbourn T, Collins M, Cooper A, Cox PM. Health and climate change: policy responses to protect public health. The Lancet. 2015 Nov 7;386(10006):1861-914.

Background:

- SoCal has the 2 busiest container ports in the US
- 2006: emissions reduction plan (ERPPGM) for goods movements
- While air quality improved, health impacts have not been directly studied

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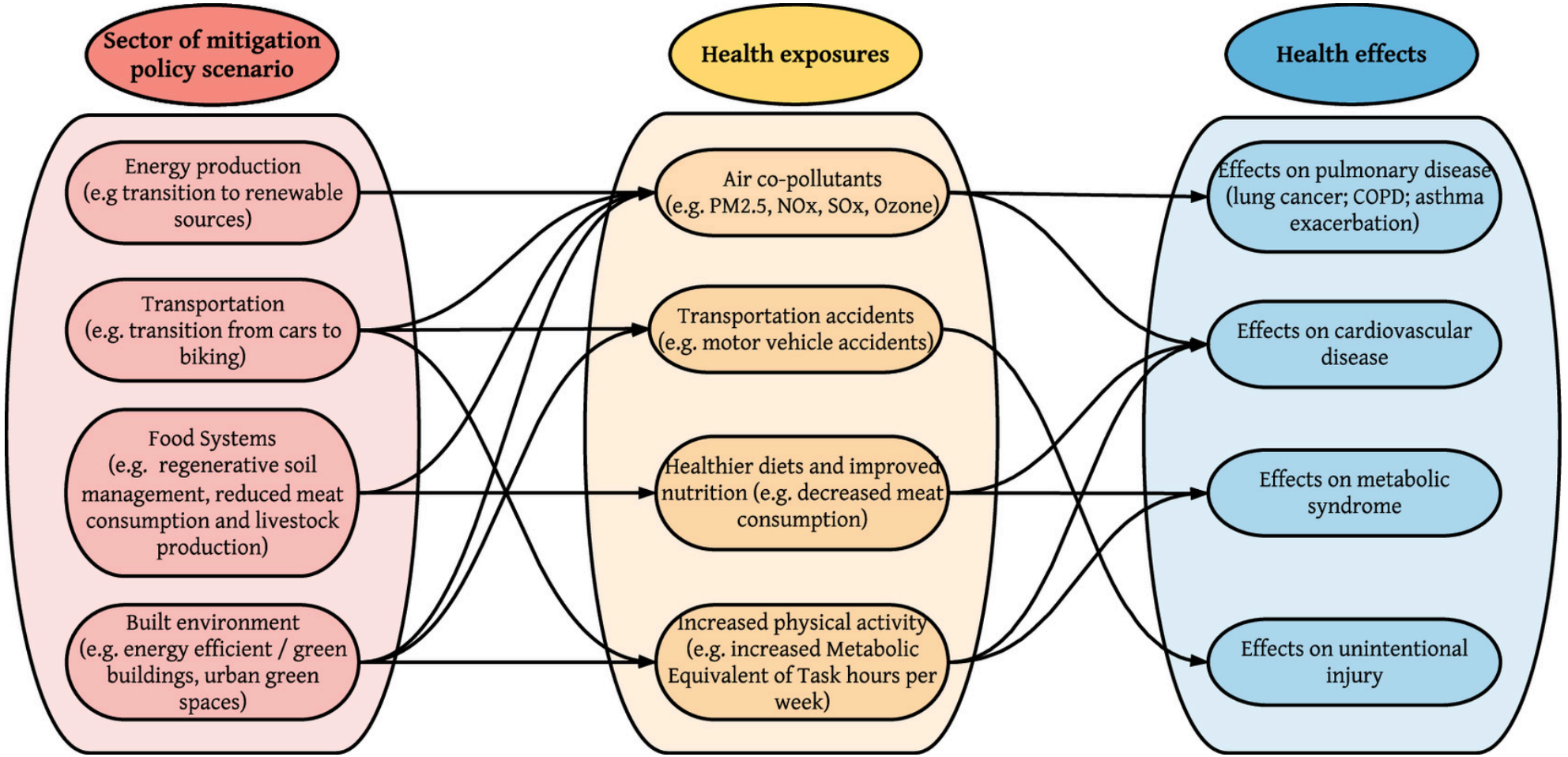
Meng YY, Yue D, Molitor J, Chen X, Su JG, Jerrett M. Reductions in NO2 and emergency room visits associated with California's goods movement policies: A quasi-experimental study. Environmental Research. 2022 Jun 3:113600. https://pubmed.ncbi.nlm.nih.gov/35660569/

Today's Activity

Design a study that describes the health co-benefits of climate change mitigation efforts.



https://ehp.niehs.nih.gov/doi/10.1289/EHP6745

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Today's Activity

1. Develop a research question on the health co-benefits of climate change mitigation efforts.
2. Describe how you would test this research question using a specific study design.
    1. Randomized Controlled Trial
    2. Cohort
    3. Cross-Sectional
    4. Case-Control
    5. Ecological

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