Hypothesis and Rationale Building

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Outline

- Introduction
- The background work
- The Research Question
- Formulating a hypothesis
- Operationalizing
Hypothesis: Formal definition

A hypothesis is a supposition or proposed explanation made on the basis of limited evidence as a starting point for further investigation.
Hypothesis…..

“…hypothesis is perhaps the most powerful tool man has invented to achieve dependable knowledge”

–Fred Kerlinger
“The only relevant test of the validity of a hypothesis is comparison of prediction with experience.”

-Milton Friedman
“A fact is a simple statement that everyone believes. It is innocent, unless found guilty. A hypothesis is a novel suggestion that no one wants to believe. It is guilty, until found effective.”

- Edward Teller
But let’s take a step back…

- How do we get to the point where we can actually formulate a hypothesis?

- What questions should you ask yourself?
The Research Method: An hourglass

The "hourglass" notion of research

begin with broad questions
narrow down, focus in
operationalize
observe
analyze data
reach conclusions
generalize back to questions
The research structure helps us create research that is:

**Quantifiable**  **Verifiable**  **Replicable**  **Defensible**

Corollaries among the model, common sense & paper format:

**Model**
- Research Question
- Develop a Theory
- Identify Variables (if applicable)
- Identify hypotheses
- Test the hypotheses
- Evaluate the Results
- Critical Review

**Common Sense**
- Why
- Your Answer
- How
- Expectations
- Collect/Analyze data
- What it Means
- What it doesn’t Mean

**Paper Format**
- Intro
- Method
- Results
- Conclusion

Credit: Prasad, Rehani, Rao: www.public.asu.edu/~kroel/.../hypothesis.pdf
Answer these broad questions…

• What topics/fields am I really excited about?
• Do I know this area well?
• Am I willing to keep up to date with the literature in this field?
Broad questions....

- What are the currently important research areas in this field?
- Which areas need further exploration?
- Where are the gaps in knowledge?
And once you’ve honed in….

- Is this good timing for this research? “hot topic”? outdated?

- Has someone already done a similar study? How can it be modified or improved?

- Can I create a niche with this research?
And the final, most important question…

WHO CARES?

What are the future implications for answering the question you are asking?
If you can’t answer the final question to your own satisfaction…

Start over from the beginning!
The Structure for Research

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The Research Question

- The methodologic point of departure for scholarly research
- Precedes the formulation of the conceptual framework for the research
- Example: “Do children experience restorative sleep in the Pediatric ICU?”
Good Research Questions

• Focused and narrow: can translate directly into formulation of a hypothesis
  – Too broad: How do children sleep in the Pediatric ICU?
  – More focused: Do children experience slow-wave sleep and REM sleep in the Pediatric ICU?
A **hypothesis** is a supposition or proposed explanation made on the basis of limited evidence as a starting point for further investigation.
Basic building blocks of a hypothesis

- A statement, NOT a question
- Succinct
- Proposes an expected relationship between variables
- Testable
- Reflects the literature on which it is based: the educated guess
Writing your hypothesis

• Explicitly state the populations you wish to compare
• State the dependent variable and scale on which you expect to find differences
• State the direction of the treatment effect
• Should be able to write both research and null hypothesis
Q. Where have all my socks gone?

**Alternate Hypothesis**

Extra-terrestrial beings have transported themselves into my house in order to steal my socks.

**Null Hypothesis**

Aliens are not to blame. There is some other explanation for the disappearing socks.

Credit: dsm1lp.wordpress.com
Hypothesis: Research vs. Null

• Research/alternative hypothesis ($H_1$): What you predict will happen— the proposed relationship between two variables

• Null Hypothesis ($H_0$): No difference or different outcome than the one predicted by the research hypothesis
Example: Directional Research hypothesis

• We hypothesize that children who read for 15 minutes or more per day with a parent will score significantly higher on kindergarten reading assessment than children who do not read at least 15 minutes per day with a parent.
Example: The null hypothesis

- Children who read with a parent for at least fifteen minutes a day will not score significantly higher on kindergarten assessment testing than children who do not read at least fifteen minutes a day with a parent.
Once you have a hypothesis: Testing it!

Four Steps:
1. State the null and alternative hypothesis
2. Set criteria for decision
3. Collect data
4. Analyze data and decide if null hypothesis can be rejected
Setting criteria for decision: operationalizing

• Determine the primary endpoint or outcome that you will be quantifying: i.e. % change in systolic blood pressure
• Visualize the final analysis and the statistical methods you’ll be using
SAMPLE SIZE: Building blocks

Alpha-\(\alpha\) (significance level)

Beta-\(\beta\)/Power (1-\(\beta\))

Effect Size

Estimates of variability

Prevalence of event in population
Why is sample size so important?

It is how we make inferences about a population for the research question of interest.
Why is sample size so important?

• Too few cases: May not detect a clinically important difference that actually exists

• Too many cases
  – More expense
  – More risk to more subjects if intervention has potential adverse effects
Effect size

• Refers to the magnitude of the effect of one variable on another

• For every hypothesis, one must determine what effect size is
  – Clinically relevant
  – Feasible in the context of sample size
Effect size

• As a rule:
  – The smaller the effect size you want to detect, the larger the sample size that will be needed
  – Important to balance clinical relevance and feasibility
A word about errors: Type I and II

**Type I error**: Rejecting the null hypothesis when it is actually true

$\alpha = \text{probability of a Type I error}$

**Type II error**: Failing to reject the null hypothesis when it is actually false

$\beta = \text{probability of a Type II error}$
We want to minimize Type I and Type II errors!
Power = 1 - $\beta$

- The probability of rejecting the null hypothesis when the alternative hypothesis is true

- The ability of a test to detect an effect, if that effect actually exists

- $\beta$ = Probability of Type II error, or false negative rate
Power calculations

• Can be used to determine the minimal sample size needed to have a strong likelihood (i.e. 80%) of detecting a given effect size

• Can be used to determine the minimum effect size that is likely to be detected with a given sample size
Alpha (α), Type I error, and the famous p-value

• $\alpha =$ probability of rejecting null hypothesis when it is true: THE MOST IMPORTANT THING TO AVOID!

• If the p-value is at or below the set $\alpha$-level, then the null hypothesis is rejected and the result is “statistically significant”
An example