University of Zambia
School of Health Sciences
Department of Biomedical Sciences

Biostatistics Epidemiology and Research Methodology (**RAD 4620**)

Hypothesis Testing, Research Question and Aims

24th January, 2020

S. M. Munsaka, BSc., MSc., PhD

Research

- Research in common parlance refers to a search for knowledge.
- One can also define research as a scientific and systematic search for pertinent information on a specific topic.
- In fact, research is an art of scientific investigation.
- The Advanced Learner's Dictionary of Current English lays down the meaning of research as "a careful investigation or inquiry specially through search for new facts in any branch of knowledge."

Aims of research

- To gain familiarity with a phenomenon or to achieve new insights into it (studies with this object in view are termed as *exploratory or formulative research studies);*

- To portray accurately the characteristics of a particular individual, situation or a group (studies with this object in view are known as *descriptive research studies);*

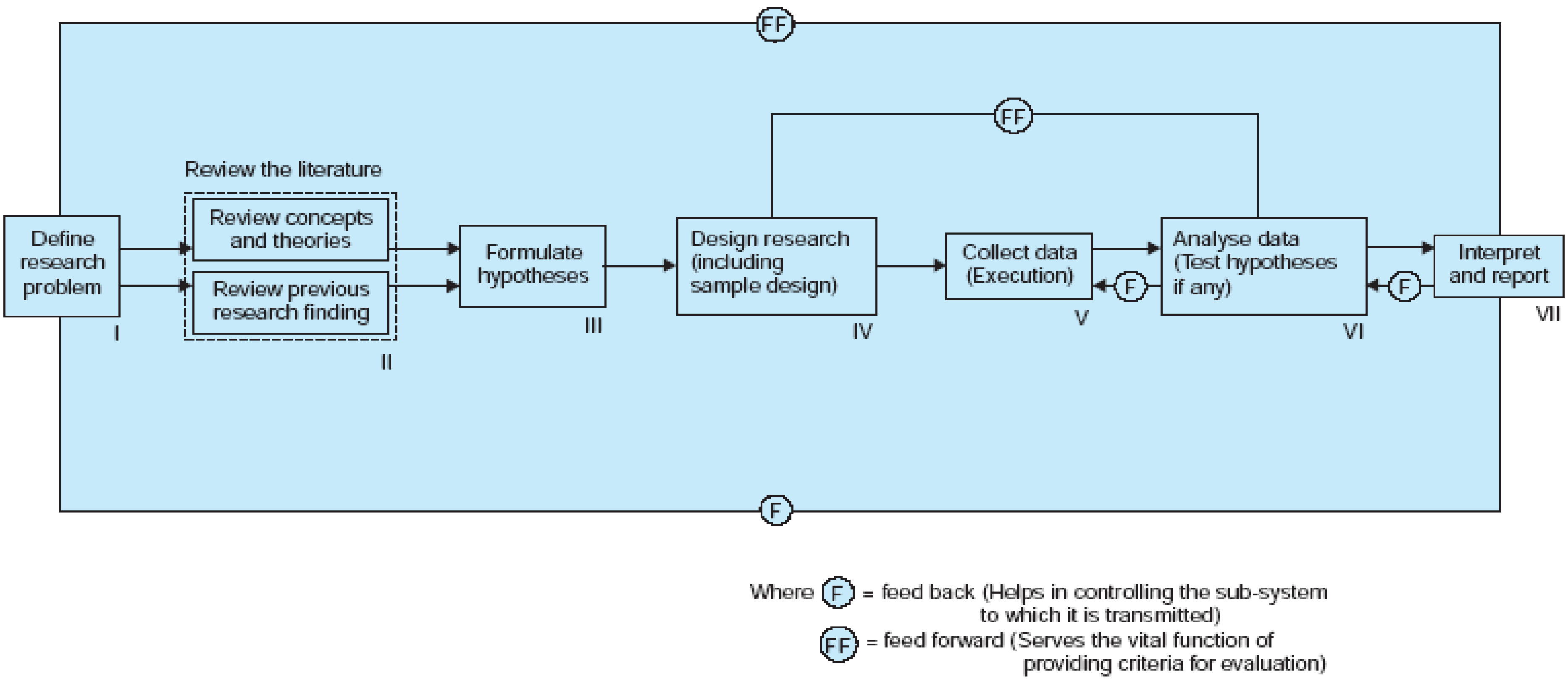
- To determine the frequency with which something occurs or with which it is associated with something else (studies with this object in view are known as *diagnostic research* studies);

- To test a hypothesis of a causal relationship between variables (such studies are known as *hypothesis-testing research studies).*

Types of research

- *Descriptive vs. Analytical:*
  - *Descriptive research includes surveys and fact-finding enquiries* of different kinds. Analytical studies identify and quantify associations, test hypotheses, identify causes and determine whether an association exists between variables, such as between an exposure and a disease.
- *Applied vs. Fundamental:*
  - *Research can either be applied (or action) research or* fundamental (to basic or pure) research.
  - *Applied research aims at finding a solution for an* immediate problem facing a society or an industrial/business organisation, whereas *fundamental research is mainly concerned with generalisations and with the formulation of a theory.*
- *Quantitative vs. Qualitative:*
  - *Quantitative research is based on the measurement of quantity* or amount. It is applicable to phenomena that can be expressed in terms of quantity.
  - Qualitative research, on the other hand, is concerned with qualitative phenomenon, i.e., phenomena relating to or involving quality or kind.

Research Process



Hypothesis testing

- Hypothesis testing addresses the *statistical validity of experimental results.*

- *Research* studies are typically carried out among samples of individuals who are drawn from some larger population.

- A potential problem is that findings from a particular sample may differ substantially from the actual results in the population, due to inherent variation between samples.

- Hypothesis testing utilizes mathematical knowledge regarding the natural variability expected from sampling to describe the likelihood that a particular sample result is representative of the underlying population from which it is drawn.

The Null Hypothesis (*H_0*)

- In inferential statistics the **null hypothesis** usually refers to a general statement or default position that there is no relationship between two measured phenomena, or no difference among groups.
  - Rejecting or disproving the null hypothesis—and thus concluding that there are grounds for believing that there is a relationship or differences between two observed/measured phenomena

- The **alternate hypothesis** (H_A) states that there is a relationship between two measured phenomena or difference among groups (greater or smaller)
  - Also known as the study hypothesis

The Null Hypothesis (*H_0*)

- Suppose we are testing the efficacy of a new drug on patients with myocardial infarction (heart attack). We divide the patients into two groups—drug and no drug—according to good design procedures, and use as our criterion measure mortality in the two groups. It is our hope that the drug lowers mortality, but to test the hypothesis statistically, we have to set it up in a sort of backward way. We say our hypothesis is that the drug makes no difference, and what we hope to do is to reject the "no difference" hypothesis, based on evidence from our sample of patients. This is known as the *null hypothesis. We specify our test hypothesis as follows:*

- H_O (null hypothesis): death rate in group treated with drug A = death rate in group treated with drug B.
- This is equivalent to:
- H_O : (death rate in group A) – (death rate in group B) = 0.

Ref: Biostatistics and Epidemiology: A Primer for Health Professionals

The Null Hypothesis (H_0)

- We test this against an *alternate hypothesis, known as* H_1 *, that the* difference in death rates between the two groups *does not equal 0.* We then gather data and note the *observed difference in mortality* between group A and group B. If this observed difference is sufficiently greater than zero, we reject the null hypothesis. If we reject the null hypothesis of no difference, we accept the *alternate hypothesis, which is* that the drug does make a difference.
- When you test a hypothesis, this is the type of reasoning you use:
- (1) I will *assume the hypothesis that there is no difference is true;*
- (2) I will then collect the data and *observe the difference between* the two groups;
- (3) If the null hypothesis is true, how likely is it that *by chance alone I would get results such as these?*
- (4) If it is not likely that these results could arise by chance under the assumption than the null hypothesis is true, then I will conclude it is false, and I will “accept” the alternate hypothesis.

Hypothesis Testing

More formally:

We set up a test of one hypothesis against another

- The *null hypothesis* (H_0) is what the researcher wants to disprove; e.g., treatment has no effect
- The *alternative hypothesis* (H_A) is the one the researcher hopes to prove; e.g., treatment has some effect

In our example, our question might be:

H_0: Prob(disease) ≥ 50%

H_A: Prob(disease) < 50%

Then we try to “reject” (rule out) H_0

Hypothesis Testing

Possible Scenarios:

Our Decision \ **Truth**	H0 true: $p>0.5$	HA true: $p<0.5$
Don't reject H0 (decide $p>0.5$)	Correct	Type II Error (1-Power)
Reject H0 (decide $p<0.5$)	Type I Error (False Positive)	Correct

III: Type I and Type II Errors

- Criminal trial analogy
  - H_0: defendant did not do it (default)
  - H_A: defendant did it (must prove)
- Type 1 error: rejecting H_0 when H_0 is really true (convict defendant when defendant didn't do it)
- Type II error (acquit defendant when defendant did it)
- Our system: better to set 100 guilty people free than to convict 1 innocent person
  - Avoid type I errors!

p values

- *P-values relate the probability of observing a specific sample result, given some* pre-specified null hypothesis regarding the population.

- The definition of a *p-value is:*
  - *Given a null hypothesis regarding the population, the p-value is the probability of observing a particular sample result, or a more extreme result, due to sampling variation/chance alone.*

- For example, investigators study whether aspirin use can lower the risk of heart disease in middle-aged men. They identify a sample of 100 middle-aged men and find that aspirin use is associated with a 20% lower risk of developing heart disease; relative risk = 0.8, *p-value = 0.03.*
  - The interpretation of this *p-value would be: if there is truly no association of* aspirin use with heart disease among the entire population of middle-aged men, then the chance of finding a relative risk of 0.8 or a more extreme relative risk, in some random 100-person sample is 3%.

P-values

How much evidence do you have against the null hypothesis?

<u>P-value</u>

- Measures if your data “fits” with the null hypothesis
- Specifically, the probability of seeing evidence at least as extreme as observed *if* H_0 *is true*
- Often, H_0 represents nothing going on, or no effect of treatment, and p-value can be interpreted as the probability you’d see data like this by chance

Hypothesis Testing and P-values

<u>P-values continued</u>

- Since this is a *probability*, must be $0 \leq p \leq 1$
- Most useful for main question, defined before data collected
  - Small number (1 or 2) of primary questions
  - Also used for other comparisons, such as comparing groups for differences in demographics (age, sex, etc)
- The smaller the p-value, the more convincingly you ruled out chance as an explanation
- Usually, $p < 0.05$ is taken as “statistically significant” and H_0 rejected

Hypothesis Testing and P-values

In our example:

H_0: Prob(disease) ≥ 10%
H_A: Prob(disease) < 10%

observe: p-value=0.68

rule: reject H_0 if p-value <0.05

So we ***cannot reject H_0***

Conclusion:

from this data, we don't know if the probability is greater or smaller than 10%

Hypothesis Testing and P-values

In our example:

H_0: Prob(disease) ≥ 50%
H_A: Prob(disease) < 50%

observe: p-value=0.0004
rule: reject H_0 if p-value <0.05

So we can ***reject H_0*** and conclude Prob(disease) < 50%

0.05 isn't a magic number– just a convention.

- Set to control the probability of a "false positive": rejecting H_0 when it is in fact true.
  - called "Type 1 error"
- If Prob(disease)=50%, 1 in 20 chance we will (wrongly) reject it

Hypothesis vs Research question

- Depending on the write up (grant application or scientific publication) you may use a hypothesis or research question

- A research question is the question that the research project sets out to answer. In actual fact, a research study may set out to answer several questions.
- The methodology used for that study, and the tools used to conduct the research, all depend upon the research questions being asked.

- Research question
  - the research question must be accurately and clearly defined
  - Central to both qualitative and quantitative research
  - it determines where and what kind of research the writer will be looking for and
  - it identifies the specific objectives the study will address.

Hypothesis vs Research question

- Examples of research questions
  - In what ways is brain development affected by experience?
  - Are the perceived needs of the patients and users of South Bedfordshire's palliative care services being met?' 'If not, what needs to be done if these needs are to be met in the future?'
  - How are the LPA allele genetic variants related to Lp(a) and IL-6 serum levels in Zambia?
  - Do patients with high baseline Lp(a) levels before initiating on HAART have significant Lp(a) increase compared to patients with low baseline Lp(a) in the course of treatment?

Aim/goal and specific objectives

- Main aim (goal)
  - Research aim

- Specific aims (objectives or specific objectives)

Goals must be specific enough to avoid confusion. Answer what, who when, where and why when setting goals.
Goals needs benchmarks and degrees of success to be useful, including a scale of assessment is integral to a good goal.
Objectives should always be within the grasp of the individual for whom it is assigned. Unreachable goals ultimately lead to frustration.
Objectives should be relevant to the broader organizational mission, and this relevance should be communicated.
Goals should also be confined by set period of time for completion.

Research objectives/aims

- ▷ Nice if the wording of the specific aim(s)/objective(s) conveys the statistical analysis that is/will be used.
- ▷ Some examples:
  - *To describe* the distributions of risk factors among a cohort of women with breast cancer.
  - *To compare* the presentation, evaluation, diagnosis, treatment, and follow-up of. . .
  - *To estimate* the incidence of skin cancer among elderly smokers and non-smokers.
  - *To determine* whether a significant association exists between cigarette smoking and pancreatic cancer.
  - *To determine* the effect of X on Y adjusted for Z.
  - *To predict* the probability of surviving one-year post-surgery . . .

Example

- ***Specific Aim 1*: To determine the feasibility of recruiting, enrolling, treating, and following women with PCOS, who are being treated with *Gymnema s*. or placebo for 6-months.

- ***Specific Aim 2*: To compare at baseline, and months 2, 4, and 6 of intervention, parameters of menstrual cycle regularity for 6-months, between women taking *Gymnema s*. vs. placebo.

- ***Specific Aim 3***: To examine hirsutism, free testosterone, FSH/LH ratio, fasting glucose, insulin, SHBG, HgA1c, estradiol, progesterone, and cortisol, in women taking *Gymnema s*. vs. placebo for 6-months.

- ***Specific Aim 4*: To examine over 6-months, changes in quality-of-life and emotional well-being in women with PCOS taking *Gymnema s.* or placebo.