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10. A Study on Formulating and Testing Hypothesis

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Abstract:

The word hypothesis consists of two words: Hypo + thesis = Hypothesis. 'Hypo' means tentative or subject to the verification and 'Thesis' means statement about solution of a problem. The word meaning of the term hypothesis is a tentative statement about the solution of the problem. Hypothesis offers a solution of the problem that is to be verified empirically and based on some rationale.

Another meaning of the word hypothesis which is composed of two words – 'Hypo' means composition of two or more variables which is to be verified. 'Thesis' means position of these variables in the specific frame of reference. This is the operational meaning of the term hypothesis. Hypothesis is the composition of some variables which have some specific position or role of the variables i.e. to be verified empirically. It is a proposition about the factual and conceptual elements. Hypothesis is called a leap into the dark. It is a brilliant guess about the solution of a problem.

Keywords:

Formulating, Testing, Hypothesis, Hypothesis Testing.

10.1 Introduction:

A hypothesis is a tentative statement about the relationship between two or more variables. A hypothesis is a specific, testable prediction about what you expect to happen in your study. To be complete the hypothesis must include three components –

- The variables;
- The population; and
- The relationship between the variables.

Remember, a hypothesis does not have to be correct. While the hypothesis predicts what the researchers expect to see, the goal of research is to determine whether this guess is right or wrong.

10.2 What Is Hypothesis Testing?

Hypothesis testing is an act in statistics whereby an analyst tests an assumption regarding a population parameter. The methodology employed by the analyst depends on the nature of the data used and the reason for the analysis.

Hypothesis testing is used to assess the plausibility of a hypothesis by using sample data. Such data may come from a larger population, or from a data-generating process. The word "population" will be used for both of these cases in the following descriptions.[1]

10.3 Assumption, Postulate and Hypothesis:

A. Assumption: Assumption means taking things for granted so that the situation is simplified for logical procedure. Assumptions are not the very ground of our activity as the postulates are. They merely facilitate the progress of an agreement a partial simplification by introducing restrictive conditions.

B. Postulate: Postulates are the working beliefs of most scientific activity. A postulate is a statement assumed to be true without need of proof of any kind. A postulate states an assumption that we make about some relationship between objects.

C. Hypothesis: A hypothesis is different from both of these. It is the presumptive statement of a proposition which the investigator seeks to prove. It is a condensed generalization.

This generalization requires knowledge of principles of things or essential characteristics which pertain to entire class of phenomena.

The theory when stated as a testable proposition formally and clearly and subjected to empirical or experimental verification is known as hypothesis. [2, 3]

10.4 Nature of Hypothesis:

The hypothesis is a clear statement of what is intended to be investigated. It should be specified before research is conducted and openly stated in reporting the results. This allows to [4]

- the research objectives;
- the key abstract concepts involved in the research; and
- Its relationship to both the problem statement and the literature review.

The following are the main features of a hypothesis –

- Is conceptual in nature.
- Is a verbal statement in a declarative form?
- Has the empirical referent.
- Indicates the tentative relationship between two or more variables.
- Is a powerful tool of advancement of knowledge, consistent with existing knowledge and conducive to further enquiry?
- Can be tested, verifiable or falsifiable.
- Is not moral or ethical questions.
- Is neither too specific nor to general.
- Is a prediction of consequences?
- Is considered valuable even if proven false.

10.5 Functions/ Roles of Hypothesis:

A hypothesis, which is a provisional formulation, plays significant role in empirical or socio-legal research. It not only navigates research in a proper direction but also contributes in testing or suggesting theories and describing a social or legal phenomenon.

Role of hypothesis in navigating research: A hypothesis, regardless of its source, states what a researcher is looking for. It also suggests some plausible explanations about the probable relationships between the concepts or variables indicated therein. In fact, it navigates the research. Without it, no further step is possible in empirical research or non-doctrinal legal research. A hypothesis helps the researcher in drawing 'meaningful conclusions' supported by 'relevant' empirical data. A hypothesis serves as a sound guide to: (i) the kind of data that must be collected in order to answer the research problem; (ii) the way in which the data should be organized most efficiently and meaningfully, and (iii) the type of methods that can be used for making analysis of the data.

Role of 'tested' hypothesis: A hypothesis needs to be empirically tested to draw some inferences about the initially posited relationship between the variables indicated in the hypothesis. Therefore, when it is empirically tested (or not), the initially assumed relationship between the concepts or variables, as the case may be, becomes a proved fact. Once a hypothesis is established, it ceases to be a hypothesis.

A hypothesis also performs the following significant functions:

1. Test theories: A hypothesis, when empirically proved, helps us in testing an existing theory. A theory is not a mere speculation, but it is built upon facts. It is a set of inter-related propositions or statements organized into a deductive system that offers an explanation of some phenomenon. Facts constitute a theory when they are assembled, ordered and seen in a relationship. Therefore, when a hypothesis is 'tested', it not only supports the existing theory that accounts for description of some social phenomenon but also in a way 'tests' it.
2. Suggest new theories: A hypothesis, even though related to some existing theory, may, after tested, reveal certain 'facts' that are not related to the existing theory or disclose relationships other than those stated in the theory. It does not support the existing theory but suggests a new theory.
3. Describe social phenomenon: A hypothesis also performs a descriptive function. Each time a hypothesis is tested empirically, it tells us something about the phenomenon it is associated with. If the hypothesis is empirically supported, then our information about the phenomenon increases. Even if the hypothesis is refuted, the test tells us something about the phenomenon we did not know before.
4. Suggest social policy: A hypothesis, after its testing, may highlight such 'ills' of the existing social or legislative policy. In such a situation, the tested hypothesis helps us in formulating (or reformulating) a social policy. It may also suggest or hint at probable solutions to the existing social problem(s) and their implementation.
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10.6 Importance of Hypothesis:

- Hypothesis as the Investigator's 'Eyes': By guiding the investigator in further investigation it serves as the investigator's 'Eyes' in seeking answers to tentatively adopted generalization.
- It Focuses Research: Without it, research is unfocussed research and remains like a random empirical wandering. It serves as necessary link between theory and the investigation.
- It Places Clear and Specific Goals: A well thought out set of hypothesis is that they place clear and specific goals before the research worker and provide researcher with a basis for selecting sample and research procedure to meet these goals.
- It Links Together: It serves the important function of linking together related facts and information and organizing them into wholes.
- It Prevents Blind Research: The use of hypothesis prevents a blind search and indiscriminate gathering of masses of data which may later prove irrelevant to the problem under study.
- As a Sort of Guiding Light: A hypothesis serves as a powerful beacon that lights the way for the research work.

10.7 Characteristics of a Good Hypothesis:

A good hypothesis must possess the following characteristics [8]

- Is never formulated in the form of a question.
- Should be empirically testable, whether it is right or wrong.
- Should be specific and precise.
- Should not be contradictory.
- Should specify variables between which the relationship is to be established.
- Should describe one issue only. A hypothesis can be formed either in descriptive or relational form.
- Soes not conflict with any law of nature which is known to be true.
- Guarantees that available tools and techniques will be effectively used for the purpose of verification.
- Should be stated as far as possible in most simple terms so that the same is easily understandable by all concerned.
- Must explain the facts that gave rise to the need for explanation.
- Should be amenable to testing within a reasonable time.

10.8 Types of Research Hypothesis:

Before researchers can begin working on a question that interests them, they need to formulate a research hypothesis. This is an important step in the scientific method because this determines the direction of the study. Scientists need to scrutinize previous work in the area and select an experimental design to use that helps them find data that either supports or rejects their hypothesis. [9-11] Research hypotheses are of different types: simple, complex, directional, no directional, associative, causal, inductive & deductive, null, and alternative or research.

A. Simple Hypothesis: This predicts the relationship between a single independent variable (IV) and a single dependent variable (DV). For example: Lower levels of exercise postpartum (IV) will be associated with greater weight retention (DV).

B. Complex Hypothesis: This predicts the relationship between two or more independent variables and two or more dependent variables. Example of a complex multiple independent variable hypothesis - low risk pregnant women (IV) who

- value health highly;
- believe that engaging in health promoting behaviours will result in positive outcomes;
- perceive fewer barriers to health promoting activities;

Are more likely than other women to attend pregnancy-related education programs (DV). Another example of a complex multiple dependent variable hypothesis - the implementation of an evidence based protocol for urinary incontinence (IV) will result in (DV)

- decreased frequency of urinary incontinence episodes;
- decreased urine loss per episode;
- Decreased avoidance of activities among women in ambulatory care settings.

C. Directional Hypothesis: This may imply that the researcher is intellectually committed to a particular outcome. They specify the expected direction of the relationship between variables i.e. the researcher predicts not only the existence of a relationship but also its nature. Scientific journal articles generally use this form of hypothesis. The investigator bases this hypothesis on the trends apparent from previous research on this topic. Considering the example, a researcher may state the hypothesis as, 'High school students who participate in extracurricular activities have a lower GPA than those who do not participate in such activities.' Such hypotheses provide a definite direction to the prediction.

D. No directional Hypothesis: This form of hypothesis is used in studies where there is no sufficient past research on which to base a prediction. Do not stipulate the direction of the relationship. Continuing with the same example, a no directional hypothesis would read, 'The academic performance of high school students is related to their participation in extracurricular activities.'

E. Associative Hypothesis: Associative hypotheses propose relationships between variables, when one variable changes, the other changes. Do not indicate cause and effect.

F. Causal Hypothesis: Causal hypotheses propose a cause and effect interaction between two or more variables. The independent variable is manipulated to cause effect on the dependent variable. The dependent variable is measured to examine the effect created by the independent variable. For the example mentioned, the causal hypothesis will state,

'High school students who participate in extracurricular activities spend less time studying which leads to a low GPA.' When verifying such hypotheses, the researcher needs to use statistical techniques to demonstrate the presence of a relationship between the cause and effect. Such hypotheses also need the researcher to rule out the possibility that the effect is a result of a cause other than what the study has examined.

G. Inductive and Deductive Hypotheses: Inductive hypotheses are formed through inductively reasoning from many specific observations to tentative explanations. Deductive hypotheses are formed through deductively reasoning implications of theory.

I. Null Hypothesis: This is a hypothesis that proposes no relationship or difference between two variables. This is the conventional approach to making a prediction. It involves a statement that says there is no relationship between two groups that the researcher compares on a certain variable. The hypothesis may also state that there is no significant difference when different groups are compared with respect to a particular variable. For example, 'There is no difference in the academic performance of high school students who participate in extracurricular activities and those who do not participate in such activities' is a null hypothesis. It asserts that there is no true difference in the sample statistic and population parameter under consideration (hence the word 'null' which means invalid, void, or a mounting to nothing) and that the difference found is accidental arising out of fluctuations of sampling. It is denoted as H0.

Table 10.1 States of Nature and Decisions on Null Hypothesis

Decision on Null Hypothesis	States of Nature	
	Null Hypothesis True	**Null Hypothesis False**
Accept	Correct Decision Probability = 1-α	Type II error Probability =β
Reject	Type I error Probability = α (α is called significance level)	Correct Decision Probability =1-β (1-β is called power of a test)

The rejection of the null hypothesis indicates that the differences have statistical significance and the acceptance of the null hypothesis indicates that the differences are due to chance.

J. Alternate or Research Hypothesis:

This hypothesis proposes a relationship between two or more variables, symbolized as H1. For example, if a researcher was interested in examining the relationship between music and emotion, s/he may believe that there is a relationship between music and emotion. H_1 (the research/alternate hypothesis): Music at a fast tempo is rated by participants as being happier than music at a slow tempo. H_0 (the null hypothesis): Music at a fast tempo and at a slow tempo is rated the same in happiness by participants. The two hypotheses we propose to test must be mutually exclusive; i.e., when one is true the other must be false. And we see that they must be exhaustive; they must include all possible occurrences.

K. Statistical Hypothesis:

Statistical hypothesis is an assumption about statistical populations that one seeks to support or refute. The null hypothesis and alternative hypothesis together are called statistical hypothesis.

10.9 Testing the Hypothesis:

10.9.1 Approaches of Hypothesis Testing:

There are three approaches of hypothesis testing (Table 10.2). Each approach requires different subjective criteria and objective statistics but ends up with the same conclusion [12-15]

10.9.2 Test Statistic Approach:

The classical test statistic approach computes a test statistic from empirical data and then compares it with a critical value. If the test statistic is larger than the critical value or if the test statistic falls into the rejection region, the null hypothesis is rejected.

10.9.3 P-Value Approach:

In the p-value approach, researchers compute the p-value on the basis of a test statistic and then compare it with the significance level (test size). If the p-value is smaller than the significance level, researches reject the null hypothesis. A p-value is considered as amount of risk that researchers have to take when rejecting the null hypothesis.

10.9.4 Confidence Interval Approach:

Finally, the confidence interval approach constructs the confidence interval and examines if a hypothesized value falls into the interval.

The null hypothesis is rejected if the hypothesized value does not exist within the confidence interval.

Table 10.2 Three Approaches of Hypothesis Testing

	Test Statistic Approach	**ρ -Value Approach**	**Confidence Interval Approach**
1	State H_0 and H_1	State H_0 and H_1	State H_0 and H_1
2	Determine test size α and find the critical value	Determine test size α	Determine test size α or 1- α and a hypothesized value
3	Compute a test statistic	Compute a test statistic and its ρ-value	Construct the (1- α)100% confidence interval
4	Reject H_0 if Test Statistic > Critical Value	Reject H_0 if ρ –Value < α	Reject H_0 if a hypothesized value does not exist in Confidence Interval
5	Substantive interpretation	Substantive interpretation	Substantive interpretation

10.9.5 Procedure for/ Steps of Hypothesis Testing:

All hypothesis tests are conducted the same way. The researcher states a hypothesis to be tested, formulates an analysis plan, analyses sample data according to the plan, and accepts or rejects the null hypothesis, based on results of the analysis. [16-18]

10.9.6 Limitation of the Tests of Hypothesis:

We have some important tests (both parametric and non-parametric) often used for testing hypotheses on the basis of which important decisions may be based.

But there are several limitations of the said tests which should always be borne in mind by a researcher. [19, 20] Important limitations are as follows-

- The tests should not be used in a mechanical fashion. It should be kept in view that testing is not decision-making itself; the tests are only useful aids for decision-making. Hence, proper interpretation of statistical evidence is important to intelligent decisions.
- Test do not explain the reasons as to why do the difference exist, say between the means of the two samples. They simply indicate whether the difference is due to fluctuations of sampling or because of other reasons but the tests do not tell us as to which is/are the other reason(s) causing the difference.
- Results of significance tests are based on probabilities and as such cannot be expressed with full certainty. When a test shows that a difference is statistically significant, then it simply suggests that the difference is probably not due to chance.
- Statistical inferences based on the significance tests cannot be said to be entirely correct evidences concerning the truth of the hypotheses. This is specially so in case of small samples where the probability of drawing erring inferences happens to be generally higher. For greater reliability, the size of samples be sufficiently enlarged.

All these limitations suggest that in problems of statistical significance, the inference techniques (or the tests) must be combined with adequate knowledge of the subject-matter along with the ability of good judgement.

10.10 Conclusion:

Hypothesis testing is an important activity of evidence-based research. A well worked up hypothesis is half the answer to the research question. For this, both knowledge of the subject derived from extensive review of the literature and working knowledge of basic statistical concepts are desirable.

This paper discusses the methods of working up a good hypothesis and statistical concepts of hypothesis testing. Where Var Hypothesis testing is one of the most widely used, and some may say abused, methodologies in statistics.

Formally, the hypotheses are specified, a α-level is chosen, a test statistic is calculated, and it is reported whether H_0 or H_1 is accepted. In practice, it may happen that hypotheses are suggested by the data, the choice of α -level may be ignored, more than one test statistic is calculated, and many modifications to the formal procedure may be made.

Most of these medications cause bias and can invalidate the method. For example, a hypothesis suggested by the data is likely to be one that has `stood out' for some reason, and hence $H_1$is likely to be accepted unless the bias is corrected for (using something like Scheffe's method–see Hsu 1996). [21]

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