ਜਗਤ ਗੁਰੂ ਨਾਨਕ ਦੇਵ
ਪੰਜਾਬ ਸਟੇਟ ਓਪਨ ਯੂਨੀਵਰਸਿਟੀ
ਪਟਿਆਲਾ

The Motto of Our University
**(SEWA)**
**SKILL ENHANCEMENT**
**EMPLOYABILITY**
**WISDOM**
**ACCESSIBILITY**



# JAGAT GURU NANAK DEV

# PUNJAB STATE OPEN UNIVERSITY, PATIALA

**(Established by Act No. 19 of 2019 of the Legislature of State of Punjab)**

## CERTIFICATE/ DIPLOMA IN STATISTICAL ANALYSIS AND RESEARCH METHODOLOGY

## SEMESTER I

## SARM 3: RESEARCH METHODOLOGY

**Head Quarter: C/28, The Lower Mall, Patiala-147001**
**Website: www.psou.ac.in**

The Study Material has been prepared exclusively under the guidance of Jagat Guru Nanak Dev Punjab State Open University, Patiala, as per the syllabi prepared by the Committee of experts and approved by the Academic Council.

**COURSE COORDINATOR AND EDITOR:**

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Assistant Professor

JGND PSOU, Patiala

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# PREFACE

Jagat Guru Nanak Dev Punjab State Open University, Patiala was established in December 2019 by Act 19 of the Legislature of State of Punjab. It is the first and only Open University of the State, entrusted with the responsibility of making higher education accessible to all, especially to those sections of society who do not have the means, time or opportunity to pursue regular education.

In keeping with the nature of an Open University, this University provides a flexible education system to suit every need. The time given to complete a programme is double the duration of a regular mode programme. Well-designed study material has been prepared in consultation with experts in their respective fields.

The University offers programmes which have been designed to provide relevant, skill-based and employability-enhancing education. The study material provided in this booklet is self- instructional, with self-assessment exercises, and recommendations for further readings. The syllabus has been divided in sections, and provided as units for simplification.

The University has a network of 110 Learner Support Centres/Study Centres, to enable students to make use of reading facilities, and for curriculum-based counseling and practicals. We, at the University, welcome you to be a part of this institution of knowledge.

Prof. G.S. Batra
Dean Academic Affairs

# CERTIFICATE/ DIPLOMA IN STATISTICAL ANALYSIS AND RESEARCH METHODOLOGY
## SEMESTER I
## SARM 3: RESEARCH METHODOLOGY

Max. Marks: 100
External: 70
Internal: 30
Pass: 40%
Credits: 6

**INSTRUCTIONS FOR THE PAPER SETTER/ EXAMINER:**

1. The syllabus prescribed should be strictly adhered to.
2. Question Paper will have 70 Multiple Choice questions (MCQs) and four choices of answers will be there covering the entire syllabus. Each question will carry 1 mark. All questions will be compulsory; hence candidates will attempt all the questions.
3. Paper-setters/Examiners are requested to distribute the questions from section A and Section B of the syllabus equally i.e., 35 questions from section A and 35 questions from Section B.
4. The examiner shall give clear instructions to the candidates to attempt questions.
5. The duration of each paper will be two hours.

**INSTRUCTIONS FOR THE STUDENTS**

The question paper shall consist of 70 Multiple Choice questions. All questions will be compulsory and each question will carry 1 mark. There will be no negative marking. Students are required to answer using OMR (Optimal Mark Recognition) sheets.

### SECTION-A

**Unit 1:** Introduction to Research Methodology: Characteristics, Objectives and Types, Research Design

**Unit 2:** Literature review, Research problems, Measurement and Scaling Techniques

**Unit 3:** Ethics – Definition, Moral Philosophy, Nature of Moral Judgements and Reaction, Ethics with respect to Science and Research. Intellectual Honesty and Research Integrity

**Unit 4:** Scientific Misconduct: Falsification, Fabrication and Plagiarism.Redundant Publications:

Duplicate and Overlapping Publication, Salami Slicing. Selective reporting and misrepresentation of data.

## Section B

**Unit 5:** Publication Ethics- Definition, Introduction and Importance. Best Practices/Standard Settings initiatives andguidelines: COPE, WAME etc. Conflict of Interest Software to identify predatory publications developed bySPPU

**Unit 6:** Publication Misconduct – Definition, Concept, Problems that lead to unethical behaviour and vice-versa. Violation of Publication ethics and authorship and contributor ship, Identification of Publication Misconduct, Complaints and Appeal- Examples and Fraud from India and Abroad, Predatory Publishers and Journals. Use ofPlagiarism Software like Turnitin, Urkund and other open-source software tools.

**Unit 7:** Meaning of Hypothesis, Characteristics of Hypothesis, Basic Concepts: Null Hypothesis and Alternative Hypothesis, One-tailed and Two-tailed, Type-I and Type-II errors, Level of Significance. Power of a test.

**Unit 8:** Critical Region and Acceptance Region, Hypothesis Testing Procedures (Steps), Introduction to parametric and non-parametric tests.

Note: Statistical analysis should also be taught with the help of MS Excel, SPSS or any other related software tool.

## Suggested Readings


- Anderson, D.R.; Sweeney, D.J. and Williams, T.A., "Statistics for Business and Economics", 2nd edition (2011), Thompson, New Delhi.
- Cooper, D. R., and Schindler, P.S., "Business Research Methods", 9th Edition,Tata McGraw-Hill, New Delhi.
- Kothari, C. R., "Research Methodology", 2nd Edition (2008), New Age International.
- Levine, D.M., Krehbiel T.C., and Berenson M.L., "Business Statistics", 12thEdition (2012), Pearson Education, New Delhi.
- Zacks, S. (1971): Theory of Statistical Inference, John Wiley and Sons. New York

# CERTIFICATE/ DIPLOMA IN STATISTICAL ANALYSIS AND RESEARCH METHODOLOGY

## SARM 3: RESEARCH METHODOLOGY

**EDITOR AND COURSE CO-ORDINATOR- DR. PINKY SRA**

## SECTION A

| UNIT NO. | UNIT NAME |
|---|---|
| **Unit 1** | Introduction to Research Methodology: Characteristics, Objectives and Types, Research Design |
| **Unit 2** | Literature review, Research problems, Measurement and Scaling Techniques |
| **Unit 3** | Ethics – Definition, Moral Philosophy, Nature of Moral Judgements and Reaction, Ethics with respect to Science and Research. Intellectual Honesty and Research Integrity |
| **Unit 4** | Scientific Misconduct: Falsification, Fabrication and Plagiarism.Redundant Publications |

## SECTION B

| UNIT NO. | UNIT NAME |
|---|---|
| **Unit 5** | Publication Ethics |
| **Unit 6** | Publication Misconduct |
| **Unit 7** | Meaning of Hypothesis, Characteristics of Hypothesis, Basic Concepts: Null Hypothesis and Alternative Hypothesis, One-tailed and Two-tailed, Type-I and Type-II errors, Level of Significance. Power of a test. |
| **Unit 8** | Critical Region and Acceptance Region, Hypothesis Testing Procedures (Steps), Introduction to parametric and non-parametric tests. |

**COURSE NAME: STATISTICAL ANALYSIS AND RESEARCH METHODOLOGY**

**SARM 3: RESEARCH METHODOLOGY**

**SEMESTER I**

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# UNIT 1: INTRODUCTION TO RESEARCH METHODOLOGY: CHARACTERISTICS, OBJECTIVES AND TYPES, RESEARCH DESIGN

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**STRUCTURE**



## 1.0 LEARNING OBJECTIVES

After studying the Unit, students will be able to know:

- Components of the research methodology
- Various characteristics of research
- Main objectives of research
- Different types of research
- Structure of research design
- Characteristics of research design

- Various types of research design

## 1.1 INTRODUCTION

Research methodology refers to the systematic and organized process of conducting research, which involves the collection, analysis, interpretation, and presentation of data. It provides a framework for researchers to address their research questions or objectives and to draw valid and reliable conclusions. Research methodology aims to guide researchers in selecting appropriate methods, techniques, and tools to gather and analyse data effectively. It ensures that the research is conducted in a rigorous and systematic manner, minimizing bias and maximizing the validity and reliability of the findings.

## 1.2 KEY COMPONENTS OF RESEARCH METHODOLOGY

1. **Research Design**: This involves outlining the overall plan for the research study, including the type of study (e.g., experimental, observational, qualitative, quantitative), the selection of participants or sample, data collection methods, and the overall structure of the research.
2. **Data Collection**: Researchers need to determine the most suitable methods for gathering data based on the research questions and design. Data collection methods include surveys, interviews, observations, experiments, and data analysis.
3. **Data Analysis**: Researchers need to analyse the data to draw meaningful conclusions once the data is collected. This can involve statistical analysis, qualitative analysis (such as thematic analysis or content analysis), or a combination of both.
4. **Ethical Considerations**: Research methodology requires researchers to adhere to ethical guidelines and principles to protect the rights and well-being of participants. This includes obtaining informed consent, maintaining confidentiality, and ensuring the research is conducted with integrity.
5. **Validity and Reliability**: Validity refers to the accuracy and truthfulness of research findings, while reliability refers to the consistency and stability of the results. Research methodology incorporates strategies to enhance both validity and reliability, such as using appropriate research instruments, ensuring proper sampling techniques, and addressing potential biases.
6. **Reporting and Presentation of Findings**: Researchers need to communicate their findings

effectively. This involves organizing and presenting the research results in a clear and logical manner, often through research reports, academic papers, or presentations.

Research methodology is essential across various disciplines, including social sciences, natural sciences, business, and healthcare. It provides a systematic approach to conducting research, ensuring that findings are robust, credible, and contribute to the existing body of knowledge in the field.

## 1.4 CHARACTERISTICS OF RESEARCH METHODOLOGY

Research methodology possesses several key characteristics that distinguish it from other approaches or processes. These characteristics include:

1. **Systematic Approach**: Research methodology follows a systematic and structured approach, providing a clear framework for conducting research. It involves a step-by-step process that helps researchers maintain organization and coherence throughout the study.
2. **Research Design**: Research design aims to ensure that research studies can be replicated by other researchers to verify the findings. Research activities are clearly outlined through a research design. These carefully designed procedures and analysis tools.
3. **Objective and Unbiased:** Research methodology emphasizes objectivity and minimizes bias. It requires researchers to adopt rigorous methods and techniques to collect and analyse data, ensuring that the findings are not influenced by personal opinions or preferences.
4. **Validity and Reliability**: Research methodology focuses on establishing the validity and reliability of research findings. Validity refers to the extent to which the study measures what it intends to measure, while reliability relates to the consistency and stability of the results. Researchers employ various techniques to enhance the validity and reliability of their research, such as using appropriate research instruments, employing sampling techniques, and addressing potential biases.
5. **Ethical Considerations**: Research methodology incorporates ethical considerations to protect the rights and welfare of participants. It requires researchers to obtain informed consent, maintain participant confidentiality, and adhere to ethical guidelines and principles throughout the research process.
6. **Empirical Evidence**: Research methodology emphasizes the collection and analysis of

empirical data. It relies on systematic observation or experimentation to gather data, enabling researchers to draw conclusions based on evidence rather than speculation or personal opinions.

7. **Generalizability**: Research methodology aims to produce findings that can be generalized to a larger population or applied to similar contexts. By employing appropriate sampling techniques and representative samples, researchers can make inferences about broader populations or situations.
8. **Iterative Process**: Research methodology often involves an iterative process, where researchers refine their research design, data collection methods, and analysis techniques based on initial findings or feedback. This iterative approach allows for continuous improvement and ensures that the research is responsive to emerging insights.

These characteristics collectively contribute to the reliability, validity, and credibility of research findings, enabling researchers to generate knowledge and contribute to the advancement of their respective fields.

## 1.5 OBJECTIVES OF RESEARCH METHODOLOGY

The objectives of research methodology are to provide a structured approach to conducting research and to ensure that the research process is rigorous, systematic, and capable of generating valid and reliable findings. The specific objectives of the research methodology include:

1. **To define Research Problems**: Research methodology helps researchers clearly define and articulate their research problems or questions. It assists in identifying gaps in knowledge, formulating hypotheses, and setting research objectives.
2. **Designing Research Studies**: Research methodology guides researchers in selecting appropriate research designs that align with the research objectives and address the research questions. It helps determine whether an experimental, observational, qualitative, or quantitative approach is most suitable.
3. **Selecting Data Collection Methods:** Research methodology assists in choosing appropriate data collection methods, such as surveys, interviews, observations, experiments, or existing data analysis. It ensures that the selected methods align with the research objectives and provide reliable and valid data.

4. **To Establish a causal relationship:** the objective is to find out the causal relationship between the dependent and independent variables.
5. **Developing Research Instruments:** Research methodology involves the development or selection of research instruments, such as questionnaires, interview guides, or observation protocols. These instruments should be valid and reliable to collect accurate and consistent data.
6. **Sampling Techniques:** Research methodology guides researchers in selecting appropriate sampling techniques to obtain representative samples from the target population. It ensures that the sample is suitable for making inferences and generalizations about the larger population.
7. **Data Analysis and Interpretation:** Research methodology provides guidelines for analyzing and interpreting data. It includes selecting appropriate statistical or qualitative analysis techniques, ensuring accuracy in data processing, and deriving meaningful conclusions from the findings.
8. **Ensuring Validity and Reliability**: Research methodology emphasizes strategies to enhance the validity and reliability of research findings. It includes techniques for minimizing bias, controlling variables, conducting statistical tests, and employing quality assurance measures throughout the research process.
9. **Ethical Considerations:** Research methodology incorporates ethical guidelines and principles to protect the rights and well-being of research participants. It ensures informed consent, maintains participant confidentiality, and addresses ethical issues associated with data collection, analysis, and reporting.
10. **Reporting and Dissemination:** Research methodology assists researchers in effectively communicating their findings. It guides the organization and presentation of research reports, academic papers, or presentations, ensuring that the results are clear, logical, and accessible to the intended audience.

By achieving these objectives, research methodology provides a robust and systematic approach to research, enhancing the quality and credibility of the research findings and contributing to the advancement of knowledge in various fields.

## 1.6 TYPES OF RESEARCH

There are several types of research methodologies, each with its approach and techniques. Here are some common types of research methodologies:

1. **Basic Research:** Basic research is referred to as research conducted with a view of improving knowledge. The goal of basic research is to gain an advantage against the unknowable. It is an intellectual investigation, and the findings may or may not be applicable in real-world situations. Its main goals are the creation and formulation of theories and generalizations.
2. **Quantitative Research**: Quantitative research aims to measure and quantify phenomena by collecting numerical data. It typically involves large sample sizes and statistical analysis. Surveys, experiments, and structured observations are commonly used methods in quantitative research.
3. **Qualitative Research:** Qualitative research focuses on understanding and interpreting social phenomena through non-numerical data. It involves gathering descriptive and in-depth information through methods such as interviews, focus groups, observations, and content analysis. Qualitative research aims to explore subjective experiences, meanings, and social contexts.
4. **Mixed-Methods Research:** Mixed-methods research combines both quantitative and qualitative approaches. It involves collecting and analyzing both numerical and non-numerical data to gain a comprehensive understanding of the research topic. Researchers integrate the two types of data to provide a more nuanced and comprehensive analysis.
5. **Applied Research:** Research that is applied or practical is referred to as "need-based research with high practical relevance." Expanding the scientific knowledge is the goal of applied research. Such research's primary goal is to solve issues that society, the government, or the industry are now facing. The time and cost variables are carefully planned and budgeted since it is particular, results-oriented, and driven by a clear objective. Action research is another type of applied research.
6. **Experimental Research**: Primary data is collected and the data is analyzed and subject to hypothesis testing in an experimental study. The researcher tries to manipulate the independent variables within the research design set by him and then studies its effect on the variables under

study. Experimental research involves manipulating variables to examine cause-and-effect relationships. Researchers randomly assign participants to different groups, apply interventions or treatments, and compare the outcomes. This method allows researchers to establish causal relationships between variables.

7. **Case Study Research**: Case study research involves an in-depth exploration of a specific individual, group, organization, or phenomenon. Researchers collect detailed information through various methods, such as interviews, observations, and document analysis. Case studies provide rich and contextualized insights into complex situations.
8. **Action Research**: Action research involves active collaboration between researchers and practitioners to address practical problems or improve practices in real-world settings. It focuses on generating actionable knowledge and implementing changes based on research findings. Action research often involves cycles of planning, action, observation, and reflection.
9. **Historical Research**: Historical research examines past events, contexts, and phenomena to understand their significance and implications. It involves collecting and analyzing archival documents, records, artifacts, and other historical sources. Historical research aims to provide insights into the development and evolution of phenomena over time.
10. **Descriptive Research**: Descriptive research aims to describe the characteristics, behaviors, and relationships of a specific population or phenomenon. Surveys, observations, and content analysis are commonly used in descriptive research to collect and analyze data.

These are just a few examples of research methodologies, and researchers often employ a combination of methods based on their research objectives and the nature of the research topic. The selection of the most appropriate research methodology depends on the research questions, available resources, and the desired depth and breadth of analysis.

### 1.7 RESEARCH DESIGN: MEANING

Research design refers to the plan, structure, and strategy that researchers develop to guide the process of conducting a research study. It outlines the methods, procedures, and steps that will be followed to answer the research questions or test hypotheses effectively. Research design is a crucial aspect of the research process as it helps ensure that the study is well-organized, systematic, and capable of producing reliable and valid results.

A well-designed research study typically includes the following questions:

a. Why is the study being conducted?
b. When will the study be carried out?
c. Where will the study be conducted?
d. Which kind of data is required?
e. Where is the required data available?
f. What is the technique for collecting data?
g. What is the statistical method of data analysis?
h. Which method of sampling is being used?
i. What will be the format of reporting the results?

A research design has four sub designs that are:

- Sampling design
- Observational design
- Statistical design
- Operational design

A good research design has three functions.

1. It gives a research design.
2. It limits the boundaries of research activities to make systematic investigation possible.
3. It enables a researcher to anticipate possible difficulties that he may encounter in the future.

## 1.8 STRUCTURE OF RESEARCH DESIGN

The format of a research design typically includes the following sections:

1. **Introduction:** This section provides an overview of the research problem, the research questions, and the importance of the study. It also includes a brief literature review that summarizes previous research on the topic and identifies gaps in the existing knowledge.
2. **Research Questions or Hypotheses**: This section identifies the specific research questions or hypotheses that the study will address. These questions should be clear, specific, and testable.
3. **Research Methodology**: This section describes the methods that will be used to collect and analyze data. It includes details about the study design, the sampling strategy, the data collection instruments, and the data analysis techniques.

4. **Data Collection**: This defines how the data will be collected, including the sample size, data collection procedures, and any ethical considerations.
5. **Data Analysis**: This defines how the data will be analyzed, including the statistical techniques that will be used to test the research questions or hypotheses.
6. **Results and Interpretation**: This section presents the findings of the study, including descriptive statistics and statistical tests.
7. **Conclusion**: This section summarizes the key findings of the study, interprets the results, and discusses the implications of the findings. It also includes recommendations for future research.
8. **References:** lists the sources cited or used in the research design to get an objective of the research.

## 1.9 CHARACTERISTICS OF GOOD DESIGN

A good research design possesses several key characteristics that contribute to the quality and rigor of the research study. These characteristics help ensure that the study produces reliable, valid, and meaningful results. Here are some essential characteristics of a good research design:

1. **Research Objectives**: A well-defined and specific set of research objectives or questions that guide the study and provide a clear purpose for the research. The design shows no tendency towards any side and the resultant data collected under this design would be free from biases.
2. **Validity:** The research design should be capable of measuring what it aims to measure. This includes ensuring that the operational definitions of variables accurately capture the concepts under investigation.
3. **Reliability:** The research design should yield consistent and replicable results. This implies that if the study were repeated under similar conditions, it would produce similar outcomes.
4. **Generalization:** It means that the results collected under this design, which hold for a sample must hold true for the entire population.
5. **Appropriateness:** The research design should be suitable for addressing the research questions or objectives. It should align with the type of data needed and the nature of the phenomenon being studied.

## 1.10 TYPES OF RESEARCH DESIGN

A researcher must be well experienced in different types of research design. A clear understanding of different research designs helps choose the proper technique for the research. Research design is broadly divided into quantitative and qualitative research design. We'll walk you through them in detail below.

1. **Quantitative Research Design**

Quantitative research aims to quantify relationships, patterns, and trends through numerical data analysis. It focuses on measuring variables, testing hypotheses, and making statistical inferences. This approach is often used when researchers seek to establish cause-and-effect relationships and generalize findings to larger populations

2. **Qualitative Research Design**

Qualitative research aims to understand the complexity and depth of human experiences, meanings, and social phenomena. It involves exploring perceptions, emotions, motivations, and cultural contexts. This approach is used when researchers want to gain rich insights and generate new theories or concepts.

**Further types of research designs are into the following categories:**

a) **Experimental design:** This type of research design looks at a problem scientifically by establishing a clear cause and effect of every event. It also tries to understand the impact of the independent variable on the dependable variable. Involves the manipulation of an independent variable to observe its impact on a dependent variable while controlling for extraneous variables. Typically, includes experimental and control groups. For example, testing the effect of a new drug on a medical condition by administering it to one group while providing a placebo to another group.

b) **Correlational design:** Correlation research design establishes a relationship between two related variables. The researcher observes the variables over time and then draws conclusions based on them. This type of research design requires two different groups. To examine the relationships between variables without manipulating them. It involves measuring the strength and direction of relationships between two or more variables. For example, Investigating the relationship between hours of study and exam performance among students.

**c)** A correlation coefficient determines the relationship between two variables. The value of the correlation coefficient ranges between -1 and +1. If the correlation coefficient is +1, it indicates a positive relationship between the two variables, and -1 means a negative relationship.

**d) Descriptive design:** Descriptive design is a theory-based research method describing the research's primary subject matter. This type of research design uses data collection techniques like natural observation, case studies, and surveys to derive results. Therefore, it provides an accurate description of a phenomenon or situation. It involves observing and documenting behaviors, characteristics, or conditions as they naturally occur. For example, describing the eating habits of a specific population by conducting surveys and interviews.

**e) Diagnostic design:** In diagnostic research, the design strives to explore the reason behind an issue and find solutions to solve it. This type of research design tries to solve the problems in a structured form divided into three phases- the issue's inception, diagnosis of the issue, and solution for the issue.

**f) Explanatory design:** In this research design, the researcher explores concepts and ideas on a subject to explore more theories. The main aim of the research is to explore the subjects' undiscovered aspects and answer questions like what, how, and why.

**g) Quasi-experimental research:** Quasi-experimental research design is similar to experimental research design, but it lacks one or more of the features of a true experiment. For example, there may not be a random assignment to groups or a control group. This type of research design is used when it is not feasible or ethical to conduct a true experiment. For example, Assessing the effectiveness of an educational intervention in a classroom setting without randomizing students.

**h) Case study research design:** Case study research design is used to investigate a single case or a small number of cases in depth. It involves collecting data through various methods, such as interviews, observations, and document analysis. Case study research aims to provide an in-depth understanding of a particular case or situation.

**i) Longitudinal Research Design:** Longitudinal research design is used to study changes in a particular phenomenon over time. It involves collecting data at multiple time points and analysing the changes that occur. Longitudinal research aims to provide insights into the development, growth, or decline of a particular phenomenon over time. To collect data from the same participants over an extended period. It allows researchers to observe changes and

trends over time and can reveal developmental or temporal patterns. For example, following a cohort of students from kindergarten through high school to study their academic and social development.

## 1.11 SUM UP

- Research methodology aims to guide researchers in selecting appropriate methods, techniques, and tools to gather and analyse data effectively.
- Research design refers to the plan, structure, and strategy that researchers develop to guide the process of conducting a research study.
- The structure of the research follows Introduction, Research Questions, Methodology, Data Collection, Data Analysis, Results, Conclusion, and References
- Types of research are main two types of research quantitative and qualitative**.**
- Experimental, Correlational, Descriptive, Diagnostic, Explanatory, Quasi-experimental, Case study research, Longitudinal are also the types of research design.

## 1.12 QUESTIONS FOR PRACTICE

Q1. Define Research Design. What are the characteristics of a good research design?

Q2. What are the key components of research methodology?

Q3. Explain the objectives of Research.

Q4. What are the types of Research in statistics?

Q5. What is research design? Give its structure.

Q6. Give the characteristics of Research Design.

## 1.13 SUGGESTED READINGS


- Anderson, D.R.; Sweeney, D.J. and Williams, T.A., "Statistics for Business and Economics", 2nd edition (2011), Thompson, New Delhi.
- Cooper, D. R., and Schindler, P.S., "Business Research Methods", 9th Edition,Tata McGraw-Hill, New Delhi.
- Kothari, C. R., "Research Methodology", 2nd Edition (2008), New Age International.
- Levine, D.M., Krehbiel T.C., and Berenson M.L., "Business Statistics", 12thEdition (2012), Pearson Education, New Delhi.

- Zacks, S. (1971): Theory of Statistical Inference, John Wiley and Sons. New York

**COURSE NAME: STATISTICAL ANALYSIS AND RESEARCH METHODOLOGY**

**SARM 3: RESEARCH METHODOLOGY**

**SEMESTER I**

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# UNIT 2: LITERATURE REVIEW, RESEARCH PROBLEMS, MEASUREMENT AND SCALING TECHNIQUES

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**STRUCTURE**

## 2.0 LEARNINGS OBJECTIVE

After studying this unit, you should be able to understand:

- The concept of literature Review
- Define research Problems
- Explain the concepts of sample
- Know about types/techniques of sampling
- Different levels of measurement scales
- Different scaling techniques

## 2.1 INTRODUCTION

A research problem refers to a specific question, issue, or area of concern that researchers aim to investigate, explore, and address through systematic inquiry and analysis. It serves as the focal point of a research study and guides the entire research process. The research problem sets the direction for the study, defines its scope, and helps researchers identify relevant literature, collect data, analyze findings, and draw conclusions.

## 2.2 LITERATURE REVIEW

The literature review plays a crucial role in the process of identifying and refining a research problem. It serves as the foundation for understanding the current state of knowledge in a particular field and helps researchers identify gaps, controversies, and areas where further investigation is needed.

Literature review contributes to finding and defining a research problem:

a) **Identifying Existing Knowledge**: The literature review involves a comprehensive examination of existing research, theories, and findings related to the topic of interest. This step helps researchers gain a thorough understanding of what is already known about the subject.

b) **Highlighting Gaps**: As researchers review the literature, they often come across gaps or inconsistencies in the existing body of knowledge. These gaps might include unanswered

questions, contradictory findings, or areas where more research is needed to provide a complete understanding.

c) **Recognizing Contradictions**: The literature review can reveal instances where different studies present conflicting results or interpretations. These contradictions or controversies can signal areas that require further investigation to resolve discrepancies.

d) **Generating Research Questions**: By identifying gaps, controversies, and unresolved issues in the literature, researchers can generate research questions or hypotheses that target these specific areas. These questions become the starting point for formulating a research problem.

e) **Narrowing the Focus**: The literature review helps researchers refine the scope of their study. They can identify specific aspects of the topic that haven't been thoroughly explored or require deeper analysis.

f) **Contextualizing the Problem**: Understanding the context in which the research problem exists is essential. The literature review provides insights into the historical, theoretical, and practical context of the problem, helping researchers situate their study within the broader field.

g) **Avoiding Duplication**: A thorough literature review helps researchers avoid duplicating previous research efforts. It ensures that the problem they choose to investigate is unique and contributes something new to the field.

h) **Informing Methodology**: The literature review informs the choice of research methods and approaches. Researchers can learn from existing studies about the most effective methods for addressing the research problem.

i) **Justifying the Significance**: Through the literature review, researchers can demonstrate the significance of the chosen research problem. They can show how addressing this problem will fill a gap in knowledge, contribute to theory, or have practical implications.

j) **Refining the Problem**: As researchers delve deeper into the literature, they might refine their initial research problem based on new insights and information they gather. This iterative process ensures that the problem is well-defined and aligns with the current state of the field.

In summary, the literature review serves as a foundation for the identification and refinement of a research problem. It guides researchers in formulating relevant and meaningful research questions and sets the stage for designing a study that addresses a specific gap in knowledge.

## 2.3 CRITERIA OF GOOD RESEARCH PROBLEM

A well-formulated research problem typically exhibits the following characteristics:

a) **Clear and Specific**: The research problem should be well-defined and unambiguous, clearly outlining what aspect of the topic will be investigated.
b) **Feasible And Realistic**: The problem should be feasible and realistic in terms of data collection, resources, and time constraints. It should be possible to design a study to address the problem.
c) **Significance**: The problem should have relevance and importance within the field of study. It should contribute to existing knowledge, address gaps in understanding, or offer insights that can be applied to practical situations.
d) **Originality**: While the research problem doesn't need to be entirely novel, it should offer a new perspective, approach, or context to the topic.
e) **Focused**: The problem should be narrow enough to allow for in-depth analysis but broad enough to have implications beyond the specific study.
f) **Answerable**: The research problem should be formulated in a way that allows for investigation and potential resolution. It should be possible to gather data and draw conclusions that provide insights into the problem.

In the process of defining a research problem, researchers often review existing literature to identify gaps, controversies, or areas where more information is needed. This exploration helps them pinpoint a specific issue that can be explored in greater depth. Once the research problem is clearly defined, researchers develop research questions or hypotheses, design a methodology for data collection and analysis, and proceed with their study to contribute to the body of knowledge in their field.

## 2.4 TECHNIQUES INVOLVED IN RESEARCH PROBLEM

As a researcher, you must have often read that defining a problem is the first step in a research process. But, have you ever wondered what is meant by defining a problem? Well, it simply means that the researcher has to lay down certain boundaries within which he/she has to study the problem with a pre-defined objective in mind. Defining a problem is a phenomenal task, and this must be done intelligently to avoid confusions that arise in the research operation. Try to follow the below steps systematically to best define a problem:

1) **Define the problem in a Specific way**: First state the problem in general terms with respect to some practical, scientific, or intellectual interest. For this, the researcher may read the

concerned subject matter thoroughly or take the help of the subject expert. Often, the guide states the problem in general terms; it depends on the researcher if he/she wants to narrow it down to operational terms. The problem stated should also be checked for ambiguity and feasibility.

2) **Nature of the problem:** The next step is to understand the nature and origin of the problem. The researcher needs to discuss the problem with those related to the subject matter in order to clearly understand the origin of the problem, its nature, objectives, and the environment in which the problem is to be studied.
3) **Review of literature:** All available literature including relevant theories, reports, records, and other relevant literature on the problem needs to be reviewed and examined. This would help the researcher to identify the data available, the techniques that might be used, the types of difficulties that may be encountered during the study, possible analytical shortcomings, and even new methods of approach to the present problem.
4) **Go for the analysis part for evolving ideas:** The researcher may discuss the problem with his/her colleagues and others related to the subject. This helps the researcher to generate new ideas, identify different aspects of the problem, gain suggestions and advice from others, and sharpen his focus on certain aspects within the field. However, discussions should not be limited to the problem only, but should also be related to the general approach to the problem, techniques that might be used, possible solutions, etc.
5) **Rephrase the research problem into a working proposition:** Finally, the researcher must rephrase the problem into a working proposition. Rephrasing the problem means putting the problem in specific terms that is feasible and may help in the development of working hypotheses. Once the researcher has gone through the above steps systematically, it is easy to rephrase the problem into analytical and operational terms.

## 2.5 MEASUREMENT IN RESEARCH

Associating numbers or symbols with observations found during a research investigation is known as measurement. Scales like those for hours, meters, grams, etc. can be used for this. It is quite challenging to assess or quantify motivation, for instance, if one needs to. This can be accomplished by putting motivation on a scale and assigning it some numbers. The act of measuring involves keeping track of observations made as part of a research project. By certain guidelines, the observations may be recorded using numbers or other symbols to represent an

object's qualities. Characteristics of the respondents include their thoughts, feelings, and behaviors. Assigning '1' for male responses and '2' for female respondents is one example.

The respondent has the option of answering "yes" or "no" when asked whether they use the "Internet Banking" service offered by a specific bank branch. You could want to use the numbers "1" for "yes" and "2" for "no" as your response codes. For two reasons, we assign numbers to these traits. First, the numbers make it easier to conduct additional statistical analysis of the data. Second, statistics make it easier to communicate measuring guidelines and outcomes. The definition of guidelines for allocating numbers to attributes is the most crucial component of measurement. Numbering conventions ought to be standardized and implemented consistently. This cannot alter as time or things change.

## 2.6 SCALING IN RESEARCH

The process of converting a group of textual statements to numbers by a rule is known as scaling. The objects in scaling are textual assertions, typically ones that express attitude, opinion, or emotion. Consider, for instance, a scale that categorizes bank customers based on whether they "agree to the satisfactory quality of service provided by the branch." Each consumer who is surveyed has the option of responding with one of the following phrases: "strongly agree," "somewhat agree," "somewhat disagree," or "strongly disagree." We might even give a number to each response. For instance, we might rate each response as strongly agreeing at 1, agreeing at 2, disagreeing at 3, and severely disagreeing at 4. As a result, each respondent may choose from 1, 2, 3, or 4.

## 2.7 PROPERTIES OF SCALES

a) **Distinctive Classification:** A measure is considered to have this attribute if it can be used to divide objects or their properties into discrete classes or categories. This is a prerequisite for every metric. For instance, gender divides the population into two separate categories males and females.

b) **Order:** If the components of a measure can be placed in a logical order, then the measure is said to have ordered. For instance, a student's grades may be arranged in either an ascending or downward order.

c) **Equal Distance:** A measure is said to have an equal distance if there is an equal distance between any two consecutive categories of a measured property (usually referred to as values

for numeric variables). For instance, the time difference between 2 and 3 in the afternoon is the same as the time difference between 3 and 4 in the afternoon, or 1 hour.

d) **Fixed Origin:** If there is a meaningful zero or an 'absence' of the characteristic, the measurement scale for that characteristic is said to have a fixed origin. Examples include a person's income, a business's sales, etc.

## 2.8 NOMINAL SCALE

Nominal scales are qualitative scales without any sort of order. This scale only fits into one category and does not meet the other three criteria listed above. It is referred to as "nominal" because, even though one may use numbers to represent the categories, these numbers are merely "nominal" and have no intrinsic value, order, or significance. An example of a nominal measure is the color of bicycles. Which hue would you want for a bike? has a variety of potential options, including blue, black, red, etc. These hues can be numbered 1, 2, 3, or 4 in any order; this scale neither has a set order nor a value. These categorized terms are given numerical values. These codes are employed to identify people. Nominal data refers to information gathered using a scale of nominal measures. Nominal scale data is of a form that may be categorized into groups or categories and given names to describe them. Examples include a person's address, phone number, vehicle identification number, and entrance exam applicant roll number. Sometimes, instead of using numbers to categorize things, codes are used, such as STD codes for cities, bar codes for things in department shops, codes for different university disciplines, codes for books in libraries, blood type codes for people, etc.

## 2.9 ORDINAL SCALE

The identity and magnitude properties of the ordinal scale exist. Each value on the ordinal scale has a distinct meaning and is related to the other values in an ordered manner. Ordinal scales are used to assess things like attitudes and preferences as well as occupations and social classes. Ordinal scales assist in putting various elements, such as items, people, or reactions, in relative positions about a specific aspect. It is a rating scale in which items are given numbers to show the relative degree to which they contain a particular attribute. It can determine whether an object has a characteristic more or less than another object, but not by how much. For instance, if you were to imagine a competition, you could rank the winners from first to last. If someone says they placed second, you know that one competitor placed first and everyone else placed second. Ordinal

variables, however, don't provide any information regarding the exact size of the gap between first and second or between second and third. Let's look at a few instances: Rank the following characteristics in order of significance (1–5) when buying a desktop.

1. Brand Name
2. Functions
3. Price
4. After-sale services
5. Design

The respondents ranked each attribute from 1 to 5, with 5 being the least important. To rate on an ordinal scale, letters or symbols may also be used in place of numbers. Such a scale does not attempt to quantify the degree to which certain rankings are favorable. The use of an ordinal scale is once more necessary if there are four different types of pesticides and if they are ranked according to quality as Grade A, Grade B, Grade C, and Grade D. Ordinal scales enable the application of statistics like percentile, quartile, and more in addition to the counting operation allowed for data on a nominal scale. A mean cannot be utilized only a mode or median may.

## 2.10 INTERVAL SCALE

An interval scale is a measurement system whose base value is not set and whose succeeding values indicate equal amounts or values of the feature being measured. There is no genuine or fixed zero on this quantitative scale of measurement. Interval data refers to information gathered using an interval scale. Quantitative information that may be assessed on a scale of 1 to 10 is interval data. The zero point, however, does not imply that the trait being assessed is not present. Temperature, time, longitude, latitude, etc. are a few examples. The Fahrenheit temperature scale is an illustration of an interval scale. The temperature difference between 20 degrees and 40 degrees Fahrenheit is equivalent to the difference between 75 degrees and 95 degrees. There is no absolute zero with interval scales. It would not be permissible to suggest that 60 degrees is twice as hot as 30 degrees because it would be improper to express Interval level measurements as ratios. To get the average scores for each attribute across all respondents, the data from the interval scale can be used. You can also compute the Standard Deviation, which is a measure of dispersion. Common statistical measurements like range, standard deviation, and correlation are all measured using this scale. The distance between each point on the scale is the same as the researcher

continuously measures the preference, liking, or importance of a specific brand attribute. The zero point's placement is movable. The units of measurement and the zero point are both arbitrary. On interval scaled data, you can perform bivariate correlation analyses, t-tests, analysis of variance tests, and most multivariate techniques used for inference drawing.

## 2.11 RATIO SCALE

The greatest level of measurement scale is the ratio scale. This has a fixed (absolute) zero point and the characteristics of an interval scale. We can create a meaningful ratio, thanks to the absolute zero point. Scales that use ratios include those that use weights, lengths, and times. An example of a ratio scale is the volume of ATM users over the last three months for a bank. This is so that you may evaluate it in comparison to the prior three months. The researcher can compare both disparities in scores and the relative magnitude of scores using ratio scales. For instance, the time difference between 10 and 15 minutes and the time difference between 25 and 30 minutes are equal, however, the time difference between 15 and 30 minutes is twice as long. Ratio scales are commonly used in financial research that examines rupee values. However, interval scales are often the best type of assessment for most behavioral studies.

## 2.12 COMPARATIVE SCALES

The various objects are directly compared using the comparative scales. For instance, in research of customer preferences for several airlines, a consumer may be asked to rate a list of variables, such as price, punctuality, food, a flying returns program, etc., that he or she would consider when choosing a specific airline. The most favored factor must be ranked as number one, and the least preferred factor must be ranked last.

**2.12.1 Paired Comparison Scale:** A respondent is given two objects at once and asked to choose one (rate between two objects at once) based on a set of criteria in this comparative scaling technique. The collected data are ordinal. We typically have n (n - 1)/2 paired comparisons for n brands. The data recording format for paired comparisons is as follows.

The following paired comparisons on three parameters were requested as part of a research of customer preferences on two brands of Chocolate, KitKat and Five Star. Simply pick one brand out of the two.

- Which Chocolate do you prefer based on ‘TASTE’?

KitKat Five Star

- Which Glucose biscuits do you prefer based on ‘PRICE’?

  Sunfeast Parle G

- Which Glucose biscuits do you prefer based on ‘PACKAGING’?

  Parle G Tiger Biscuits

**2.12.2 Rank Order Scale:** This is a different kind of comparative scaling technique where respondents are shown multiple items at once and asked to rank them in terms of importance. This ordinal scale describes the preferred and disfavored objects but conceals the separation between them. For instance, you might use the following format to record the replies if you were interested in ranking the preferences of a few chosen brands of cold drinks. The rank order scale is likewise comparable in nature, much like paired comparison. Ordinal data are the results in rank order. When direct comparisons between the provided objects are necessary, this technique produces superior results since it is more realistic in producing the responses. The main drawback of this method is that it can only produce ordinal data.

**Example:**When choosing a new mobile service provider, rank the following services in the order of significance that you assign to them. Rankings can start at 1, move up to 2, and so forth.

| **Feature** | **Rank** |
|---|---|
| 1. Connectivity | ----- |
| 2. Minimum Call Drops | ----- |
| 3. Internet | ----- |
| 4. Value Added Services | ----- |
| 5. Roaming | ----- |
| 6. Ring tone/Caller tune | ----- |
| 7. Alerts | ----- |
| 8. Downloads | ---- |
| 9. SMS | ---- |

**2.12.3 Constant Sum Scale:** According to a criterion, respondents are asked to distribute a fixed number of units, such as points, rupees, or chips, among a group of stimuli. For instance, you might want to research how essential consumers think a detergent's price, aroma, packaging, cleaning ability, and lather are. The following structure may be used to ask respondents to indicate the

relative importance of the traits by dividing a fixed total. Cleaning ability and packaging rank second and third in importance for consumers. The two qualities that people are concerned about the least yet prefer equally are fragrance and lather. Saving time is a benefit of this method. There are two significant drawbacks, though. The use of too few attributes might result in rounding off mistakes, while using too many attributes may be excessively stressful on the respondent and lead to confusion and tiredness. Decide how much of the total of Rs. 6000 you would want to spend on the following things on your birthday (please note that the total money allocated must equal exactly 6000).

| Item | Amount |
|---|---|
| 1. Cosmetics | ----- |
| 2. Clothes | ----- |
| 3 Accessories | ----- |
| 4. Jewelry | ----- |
| 5. Dinner | ----- |
| 6. Movie | ----- |
| Total | 6000/- |

Item Amount 1. Cosmetics _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ _____ Total 5000

**2.12.4 Q-Sort Scale:** This comparison scale sorts items depending on how similar they are to some criterion using a rank order approach. The key feature of this research is that comparing responses from distinct respondents is less significant than comparing responses from different respondents' responses. As a result, rather than being an absolute rating scale, it uses a comparative approach of scaling. In this procedure, the respondent is given a huge number of statements that describe a product's features or those of numerous different brands of the same product.

## 2.13 NON-COMPARATIVE SCALES

Respondents in noncomparative scaling only need to evaluate one object. Their assessment is separate from the researcher's analysis of the other object. When utilizing a non-comparative scale, respondents use any rating criterion they see acceptable. Continuous and itemized rating scales are non-comparative methods.

**2.13.1 Continuous Rating Scales:** It is straightforward and very helpful. According to a

continuous line that extends from one extreme of the criterion variable to the other, the respondent rates the objects by placing a mark in the proper location on the line.

In the following continuum, place your answer by placing an "X" mark. In your opinion, how important is it to exhibit ethical behavior?

Very important _____ Not important

Very important ---------- Not important

10 20 30 40 50 60 70 80

**2.13.2 Itemized Rating Scales**: The scale with numbers or brief descriptions assigned to each category is known as an itemized rating scale. The respondents are asked to choose one of the few categories that best describes the product, brand, company, or product feature being scored. The categories are arranged according to scale position. In marketing research, itemized rating scales are frequently employed. In this section below we will discuss three itemized rating scales, namely (a) Likert scale, (b) Semantic Differential Scale, and (c) Stapel Scale.

**(a) Likert Scale:** Because it is so easy to use, Rensis Likert's scale has become very common in business research for evaluating attitudes. By marking how strongly they agree or disagree with carefully crafted phrases that vary from highly positive to very negative towards the attitudinal object, the respondents use the Likert scale to express their attitudes. Typically, respondents have five options to pick from: strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree. Other variations in the Likert scale are that these can be 7-point and 9-point scales too.

Following are some statements related to washing machine produced by a multinational company. Indicate your answer in terms of your agreement or disagreement on the statement by circling the concerned number as described below:

| | 1 = Strongly disagree<br>**Strongly disagree** | 2 = Disagree<br>**Disagree** | 3 = Neither agree nor disagree<br>**Neither agree nor disagree** | 4 = Agree<br>**Agree** | 5 = Strongly agree<br>**Strongly agree** |
|---|---|---|---|---|---|
| 1. Price range for the washing machine is appropriate | **1** | **2** | **3** | **4** | **5** |
| 2. Product has got innovative features. | **1** | **2** | **3** | **4** | **5** |
| 3. After sales services are poor.* | **1** | **2** | **3** | **4** | **5** |
| 4. Ad campaign is not attractive.* | **1** | **2** | **3** | **4** | **5** |
| 5. Credit policy is highly facilitative. | **1** | **2** | **3** | **4** | **5** |
| 6. Sales executives are very cooperative. | **1** | **2** | **3** | **4** | **5** |
| 7. Showroom demonstration is appropriate. | **1** | **2** | **3** | **4** | **5** |

**(b) Semantic Differential Scale:** This rating scale has seven points, and the endpoints are bipolar labels with semantic significance (such as good and poor, complex and simple, Optimistic and Pessimistic, Introvert and Extrovert etc.). There are several uses for the Semantic Differential scale. It can be used to determine whether a respondent has a favorable or unfavorable opinion of an object. It has been extensively utilized when contrasting brands, goods, and company reputations. Additionally, it has been applied in a study on new product development as well as the creation of advertising and marketing tactics.

Rate the ATM you have just used in respect of the indicated parameters. Mark × at an appropriate location that best suits your answer.

- The ATM was _____ for operations.
- Easy: ___: ___:___:___:___:___:___: Difficult
- The processing time was Slow: ___: ___:___:___:___:___:___: Fast
- The security person was Cordial: ___: ___:___:___:___:___:___: Indifferent

**(c) Staple Scale:** Staple scale is an 11-point scale where +5 and -5 are assigned above and below a factor or feature of a product etc.

| Rate the outlet on the following factors. +5 indicates that the factor is most accurate for you and – 5 indicates that the factor is most inaccurate for you. | | |
|---|---|---|
| +5 | +5 | +5 |
| +4 | +4 | +4 |

| | | |
|---|---|---|
| +3 | +3 | +3 |
| +2 | +2 | +2 |
| +1 | +1 | +1 |
| Good Ambience | Quality Products | Excellent Service |
| -1 | -1 | -1 |
| -2 | -2 | -2 |
| -3 | -3 | -3 |
| -4 | -4 | -4 |
| -5 | -5 | -5 |

## 2.14 SUM UP

Measurement is the process of relating numerical or graphical representations to the observations made during a research project. Scaling is the process of assigning items to numbers or meanings in line with a rule. Nominal, ordinal, interval, and ratio measurements are the four different types of levels. These scales make up a hierarchy, with the nominal scale of measurement having significantly fewer statistical applications than scales higher up the hierarchy. Scales possess the following four characteristics: distinct classification, order, equal distance, and fixed origin. Data on categories are provided by nominal scales, sequences are provided by ordinal scales, magnitudes between points on the scale are revealed by interval scales, and order and absolute distance between any two points on the scale are both explained by ratio scales. Two categories of measurement scales are frequently used in marketing research: comparative scales and non-comparative scales. To communicate differences between two or more businesses, brands, services, or other stimuli, respondents use comparative scales. The scales under this type are: (a) Paired Comparison, (b) Rank Order, (c) Constant Sum, and (d) Q-sort. Further, the non-comparative scales can be classified into: (a) Continuous Rating Scales and (b) Itemized Rating Scales. The Itemized Rating scales can further be classified into: (a) the Likert Scale, (b) Semantic Differential Scale, and (c) the Stapel Scale.

## 2.15 QUESTIONS FOR PRACTICE

### A. Short Answer Type Questions

Q1. What is the research problem?

Q2. Define measurement in Research.

Q3. Name four fundamental scales in Research Parlance.

Q4. What is the Staple scale?

Q5. Enumerate various Comparative Scales.

Q6. Enlist various non-comparative scales.

Q7. What is Construct validity?

**B. Long Answer Type Questions**

Q1. Criteria of Good Research Problem.

Q2. Explain in brief the concept of measurement in research.

Q3. What do you understand by "Scaling" in research?

Q4. Differentiate with the help of examples between nominal, ordinal, interval and ratio scale.

Q5. Differentiate between ranking scales and rating scales. Which one of these scales is better for measuring attitudes?

Q6. Name any four situations in commerce where you can use the Likert scale.

Q7. Point out the possible sources of error in measurement. Describe the tests of sound measurement.

Q8. Discuss the relative merits and demerits of Summated and Cumulative scales.

## 2.16 SUGGESTED READINGS


- Abebe, J. Daniels, J.W. Mckean, "Statistics and Data Analysis".
- Clarke, G.M. & Cooke, D., "A Basic Course in Statistics", Arnold.
- S.C. Gupta and V.K. Kapoor, "Fundamentals of Mathematical Statistics", SultanChand & Sons, New Delhi.
- Anderson, D.R.; Sweeney, D.J. and Williams, T.A., "Statistics for Business andEconomics", 2nd edition (2011), Thompson, New Delhi.
- Cooper, D. R., and Schindler, P.S., "Business Research Methods", 9th Edition, Tata McGraw-Hill, New Delhi.
- Kothari, C. R., "Research Methodology", 2nd Edition (2008), New Age International.
- Levine, D.M., Krehbiel T.C., and Berenson M.L., "Business Statistics", 12thEdition (2012), Pearson Education, New Delhi.

**COURSE NAME: STATISTICAL ANALYSIS AND RESEARCH METHODOLOGY**

**SARM 3: RESEARCH METHODOLOGY**

**SEMESTER I**

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# UNIT 3: ETHICS – DEFINITION, MORAL PHILOSOPHY, NATURE OF MORAL JUDGEMENTS AND REACTION, ETHICS WITH RESPECT TO SCIENCE AND RESEARCH. INTELLECTUAL HONESTY AND RESEARCH INTEGRITY

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**STRUCTURE**



## 3.0 LEARNING OBJECTIVES

After reading this unit, learners will be able to know:

- The concept of ethics
- Various aspects of moral philosophy
- Nature of Moral Judgements and Reactions
- Ethics with respect to Science and Research
- have a thorough knowledge of Intellectual Honesty

- To have complete knowhow of Research Integrity in the context of ethics

## 3.1 INTRODUCTION

The Greek word "ethos," which means character, is where the word "ethics" originates. The social science discipline of ethics examines notions like right and wrong, good, and bad, fair and unfair, just and unjust, legal and illegal, moral and immoral, and appropriate and improper in relation to human behavior. Ethics is the study of what is morally correct, objective, just, and responsible. Regardless of how significant, unusual, or original the study objective is, it must be conducted honestly. Results from fraudulent, dishonest, or unscientific research are essentially useless. Being creative and scientifically sound is insufficient if the researcher is dishonest and fails to see the value of others' work. It is known as plagiarism and is a significant breach of research integrity.

Numerous people participate in media research; therefore, maintaining their confidentiality and safeguarding their interests should be of utmost importance. Respecting others has various implications for how one should interact with them before, during, and after the research. Even if you don't use human subjects in your research, the matter of objectivity in data collection, analysis, and interpretation still needs to be addressed. False reasoning is prohibited by ethical issues for the researcher. The following two dimensions of research ethics:

- The researcher's personal principles include openness, honesty, and moral rectitude.
- The researcher's conduct towards other participants in the study, including their informed permission, confidentiality, anonymity, and decency.

Ethical ideas are simple and simple to comprehend. However, in many circumstances, their application is unclear and challenging.

Following a set of guidelines or the principle of an organization is one way to live ethically. Another way is to ponder about how to live and then act in accordance with the conclusions you come to. In contrast to the former attitude, the latter emphasizes behaving thoughtfully and introspectively. Ideals are the main topic of ethics. Ethics is therefore a normative science. Consequently, what is a normative science? The goal of normative science is to establish standards, ideals, norms, or values. The three ideals of human life—Truth, Beauty, and Goodness—are widely acknowledged. Three facets of human experience—thinking, feeling, and willingness—are reflected in them. Logic focuses on the concept of truth and works to define the broad parameters

around the search for truth. The "normative science of beauty" is aesthetics. When discussing ethics, the idea of Good is considered. Instead of only analyzing what is present or happening and trying to figure out what is right, these sciences are interested in the criteria of value.

## 3.2 DEFINITION OF ETHICS

Ethics is a highly specific, codified way of doing things that are intended to achieve certain goals and act in accordance with specific principles. "Conduct as a reality or an event in space and time, something done here and now, following from circumstances in the past and succeeded by specific effects in the future, is not the primary focus of ethics. It is focused on judging behavior, and determining if it is right or wrong. Ethics is the study of what is morally correct, objective, just, and responsible. In research as in every other area of life, ethical behavior is crucial. For responsible research-based activities, objectivity, accountability, fairness, and truth are the important components. The ideas that can be taken into consideration to define appropriate research activity should be examined because ethical principles are highly subjective and relative. Basically, there are three effective ideas that are regularly used to predict ethical behavior:

### Consequentialism

According to this theory, the ethical worth of a decision should be based on the results. Consequentiality theories exclusively focus on how an action turns out. without considering the means, or how the results came about. Therefore, before taking any action, it is best to think through all its potential outcomes. Either ethical egoism or ethical altruism can be used to evaluate the effects of a decision. While ethical altruism maintains that behaviors that benefit others and can be seen as good, ethical egoism does not reflect a cohesive social model because such actions might cause harm to others.

### Utilitarianism

The utilitarianism philosophy can be used since it thinks about how to make society better. It defines ethical behavior as that which aims to benefit the largest number of people. The utilitarian principle is reflected in Mahatma Gandhi's notion of Sarvodaya, which emphasizes the well-being of everyone. There are various justifications for opposing consequentialism and utilitarian ethical frameworks. The utilitarian way of thinking promotes moral responsibility. Although errors in

judgement are conceivable, it is advisable to take the time to carefully evaluate all the potential results of a certain course of action to assess if the overall benefits outweigh the drawbacks.

**Deontology**

Deontology focuses on a person's responsibility to choose the best course of action. Probably the most well-known advocate of this notion is Kant. He held that an action's pretension determined whether it was moral or immoral. According to Kant, there is just one virtue—goodwill—that is good without restriction. Goodwill-inspired actions are performed out of regard for morality and obligation.

## 3.3 MORAL PHILOSOPHY

The study of ethics, often known as moral philosophy, "involves systematizing, defending, and recommending concepts of right and wrong behavior,". Axiology is a subfield of philosophy that consists of the fields of ethics and aesthetics. These fields are concerned with issues of value.

There are three subfields of moral philosophy. One area of study, meta-ethics, focuses on broad issues such as "What is morality?" The question, "What is justice?" "Is there truth?" and "How can I prove that my beliefs are superior to those of others who hold contrary beliefs?"

The study of normative ethics is another area of moral philosophy. It provides an answer to the query of what is appropriate. The main goal of normative ethics is to offer a framework for determining what is right and wrong. The three most popular frameworks are utilitarianism, virtue ethics, and deontology. Applied ethics is the final branch. It discusses concrete, realistic morally significant matters like war and the death penalty. As an example, the question of whether it is morally acceptable to tell a lie to aid a friend or coworker is one that is addressed by applied ethics.

Therefore, moral philosophy can give us the skills we need to consider and live an ethical life, whether our moral focus is on broad themes, a practical framework, or applied to specific dilemmas. Human behavior as it is, rather than as it should be, is not the focus of ethics. In relation to the moral ideal, it assigns values to human activities. While the conclusions of a positive science are conclusions of fact, that is, conclusions about facts and events as they are or occur and state the laws governing them, the conclusions of a normative science, such as ethics, are conclusions of value that state whether a particular action is in accordance with moral ideals or the ideal of goodness.

Moral judgements state what we do; they are prescriptive rather than descriptive. They assess if our actions were right or incorrect.

To assess a decision's moral worth, moral standards offer instruments. Business ethics are measured by moral standards. They offer the foundation for choosing whether a particular action is right or wrong. David Fritzsche stated that "business ethics is the process of evaluating decisions, either pre or post, with respect to the moral standards of society's culture." We require a toolkit of moral norms to assess decisions. Managers will assess a decision's moral implications before making it. The moral norms of a society's culture serve as the moral yardsticks utilized to assess a decision.

Making decisions based on moral principles is a part of business ethics. Both specific and overarching moral ideas make up moral standards. Certain sorts of behaviors, such as lying, stealing, and murder, are forbidden by moral standards. Moral principles apply to circumstances where decisions must be made and offer broader rules for behavior. To assess the ethical component of choices, we will build on Integrative Social Contracts Theory. Integrative Social Contracts Theory is a normative theory of business ethics that upholds certain universal principles while allowing for moral variance among distinct cultures.

A social contract is an unofficial agreement about moral standards that emerges from the common objectives, views, and attitudes of groups of people. Businesses use their unique advantages to benefit society by ensuring that consumers are happy and that employees are motivated. This serves as the company's moral compass. The social contract can be used to assess how well-functioning organizations are performing.

## 3.4 NATURE OF MORAL JUDGEMENTS AND REACTION

An individual's capacity to distinguish between right and wrong behavior is known as moral judgment. For instance, a person with great moral judgment will be able to determine which behavior is more ethically appropriate for a certain situation when given two possible answers to a specific event—one is destructive and the other helpful. When selecting what to do in a circumstance that raises moral concerns, moral judgment is the process of determining what is right and what is wrong.

According to the utilitarian perspective, moral judgement is based on the results of our deeds: what is just is what yields the best results for the greatest number of individuals. A sincere speaker is always correct when it comes to moral judgements, according to simple subjectivism, which views moral judgements as assertions that may or may not be true. Instead, emotivism views moral judgements as either commands or sentiments and as such, it is impossible for them to be both true and wrong.

When I use the term "moral judgement," I simply refer to judgements that people hold to be moral, where a moral judgement takes precedence over other judgements. When someone does a moral assessment, they determine if another person or group of people has violated a norm that they believe above all other norms. The standard definition of a moral transgression is an activity that is still regarded immoral even after a representative of power has deemed it acceptable (for example, murdering someone for their automobile notwithstanding the Prime Minister's approval). Other rules are superseded by moral norms.

However, moral judgement is often associated with religious authority, where moral standards are revered and frequently prescribed by a higher authority (such as imams or pundits). In these situations, moral standards take precedence over other standards but are constrained by an authority person. For instance, because God forbids the consumption of these animals, eating pig in Islamic culture or beef in Hindu culture is seen as a moral sin. This norm supersedes all others and is regarded as moral rather than customary because it is deemed unlawful to eat pork or beef in Islamic or Hindu cultures, respectively.

Moral judgements can be separated from effect as well. These are moral decisions that are completely based on logic. Making the decision that stealing from independently owned markets is morally wrong because it deprives a family of its means of subsistence is an example of a moral judgement that is separated from effect. You don't need to feel angry or guilty to make this judgement; you can make it without having an emotional response to the event. Instead, you might come to this conclusion using only your reason. Such judgements are not the subject of my essay. Only moral judgements that are brought about by or accompanied by affect are the subject of this essay (i.e., moral judgements brought about by emotion and moral judgements that bring about corresponding feelings).

### 3.5 ETHICS WITH RESPECT TO SCIENCE AND RESEARCH

Rarely are ethical obligations assigned. These, however, must be taken for granted and followed as Suo motto. Below is a discussion of a few of these ethical duties that researchers must uphold.

1. **Honesty:** Honesty is crucial to enabling clear and transparent communication as well as building credibility and trust in the research's findings. No matter what field or discipline a researcher represents, this holds true for all researchers.
2. **Confidentiality:** The goal of acting morally responsibly is to avoid doing any harm or offending someone while generating and disseminating knowledge. As a result, even prior to implementation, the researcher should evaluate the suitability of the chosen research methodologies and their potential outcomes. This entails being aware of and refraining from saying anything that can damage another person's reputation, dignity, or privacy. Confidentiality and anonymity should be guaranteed when handling sensitive information.
3. **Plagiarism:** As technology has advanced, it has become easier to access and find other people's study work. Plagiarism is one example of professional or academic dishonesty that has grown out of this abundance. It refers to using someone else's research (concepts, ideas, facts, or reports) without citing the original author and passing it off as your own. This offense is serious. Serious legal offences like the breach of one's intellectual property rights (IRP) may result from it.
4. **Acknowledging others:** By just thanking the original authors, one might avoid plagiarism. By properly citing sources both in the main text and in the bibliography or reference section at the end of the work, a researcher can recognize the intellectual contributions of other scholars. It is possible to acknowledge financial and other forms of support right away.
5. **Use of appropriate language:** Language use is important. It establishes the study's tone. The use of language improperly can promote prejudice, contempt, stereotyping, prejudice, discrimination, and intolerance. Therefore, using normal language and avoiding jargon is preferred.
6. **Data collection:** The correct data gathering method ensures the capture of the necessary and pertinent information. The researcher must secure legal access if data from the secondary source are to be acquired. If the study uses primary sources, the sampling methodology used to identify the respondents is just as crucial as the method used to get the data. The respondents

must be informed of the study's objectives, the need for their opinions, the methods to be used to collect them, and how their identity and data will be handled. The responder must consent to participate in the survey before their response may be gathered. It's important to allow the respondents enough time to answer. The respondent must have the final say on what information and how much they reveal. The researcher shouldn't press the participants for information.

7. **Representation of Data:** The researcher shouldn't be forced or influenced to manipulate data to achieve the desired result. Data must be accurately portrayed and free from the researcher's bias and prejudice. Any intentional falsification should not occur. The researcher shouldn't try to manipulate, falsify, or interpret data incorrectly.

### 3.6 INTELLECTUAL HONESTY

Honesty in the collection, analysis, and dissemination of ideas is referred to as intellectual honesty. When a person speaks the truth, knowing it to be true, they are being intellectually honest. We have a moral obligation to be truthful. This obligation is especially crucial when we convey information or arguments that can influence others. Intellectual integrity blends sincerity with the main drive to discover the truth. Honesty in the collection, analysis, and dissemination of ideas is referred to as intellectual honesty. When a person speaks the truth, knowing it to be true, they are being intellectually honest. Public communications such as announcements, speeches, lectures, instructions, presentations, publications, declarations, briefings, news releases, policy statements, reports, religious instructions, social media posts, and journalism that includes not only prose and speech, but graphs, photographs, and videos are all included in this.

Intellectual honesty is a problem-solving approach that is applied. It is characterized by an objective, honest attitude that can be shown in a variety of ways, such as:

- Ensuring that adherence to preferred ideas does not obstruct the search for the truth.
- Facts are presented objectively and not distorted to give false impressions or to support one view over another.
- References, or earlier work, are acknowledged where possible.
- Plagiarism is avoided

- Relevant facts and information are not purposefully omitted even when such things may contradict one's hypothesis.

## 3.7 RESEARCH INTEGRITY

A definition of research integrity can be an active commitment to the moral standards and professional norms necessary for conducting research responsibly. By "active adherence," we mean living by the rules and tenets and not just accepting them as imposed by the authorities. Honesty, the golden rule, dependability, and high regard for the body of scientific evidence are ethical standards.

accuracy and fairness in representing contributions to research proposals and reports; honesty and fairness in proposing, carrying out, and reporting research; impartiality and competence in peer review; Disclosure of conflicts of interest; Collegiality in scientific interactions, communications, and resource sharing; Protection of human subjects during research; humane treatment of animals during study; and adherence to the shared obligations of mentors and mentees. While a strong defense of one's ideas and work is encouraged (not required) in science, maintaining research integrity ultimately entails assessing the data objectively and following the findings rather than one's own preconceptions.

Both individual researchers and the organizations where they operate are known for their integrity. It reflects a person's moral character and life experiences.1 Institutions must adopt standards of excellence, dependability, and legality that guide institutional practices to foster an environment that encourages responsible behavior.

For the individual scientist, having integrity means committing to a variety of behaviors that define ethical research conduct, intellectual honesty, and taking personal responsibility for one's actions. Intellectual honesty in the planning, carrying out, and reporting of research is one of these practices.

- Fair peer review; accuracy in representing contributions to research proposals and reports.
- Collegiality in relationships amongst scientists, including communication and resource sharing.

- Openness regarding actual or prospective conflicts of interest.
- Safeguarding research subjects who are human.
- Observance of the obligations shared by researchers and their research teams; • humane treatment of animals used in the study.

Scientists operate inside intricate organizational frameworks. The level of the individual, the level of the workgroup (for example, the research group), and the level of the research institution itself can all be impacted by factors that encourage responsible behavior. In conducting research, these various organizational levels depend on one another. Institutions must set up and regularly monitor the following structures, processes, rules, and procedures to produce an atmosphere that encourages individual scientists to behave responsibly and with integrity.

- Act as a leader in favor of ethical research practices.
- Promote respect for each individual working on a research project.
- Encourage beneficial interactions between mentees and trainees.
- Promote conformity to the regulations governing all facets of research activity, particularly those involving human beings and animals.
- Be aware of, foresee, and manage institutional and individual conflicts of interest.
- Set up prompt, in-depth inquiries and investigations into claims of scientific misconduct; and impose suitable administrative consequences.
- Provide educational opportunities related to research integrity; • monitor and assess the institutional climate supporting research integrity; and • use this knowledge for ongoing quality improvement.

Leadership demonstrated by people with strong personal integrity contributes to the creation of a climate in which researchers can freely discuss ethical research methods in the face of competing demands. All individuals involved in the research enterprise should agree that integrity is an important aspect of what it means to be a scientist, not a collection of rules that are imposed from outside.

## 3.8 SUM UP

Ethics is the study of what is morally correct, objective, just, and responsible. Results from fraudulent, dishonest, or unscientific research are essentially useless. Consequentiality theories ignore the means of activity and focus only on the result of an action. The philosophy of utilitarianism defines ethical behavior as that which is intended to produce the greatest good for the greatest number of people. The focus of deontology theory is on a person's responsibility to choose the best course of action. The study of ethics, often known as moral philosophy, "involves systematizing, defending, and recommending concepts of right and wrong behavior".

The main goal of normative ethics is to offer a framework for determining what is right and wrong. A decision's moral worth can be assessed using moral criteria, which serve as the benchmarks for corporate ethics. An individual's capacity to distinguish between right and wrong behavior is known as moral judgement. A sincere speaker is always correct when it comes to moral judgements, according to simple subjectivism, which views moral judgements as assertions that may or may not be true.

Instead, emotivism views moral judgements as either commands or sentiments, and as such, it is impossible for them to be both true and wrong. Honesty, confidentiality, plagiarism, acknowledging others, using acceptable language, gathering data, and representing data are only a few of a researcher's ethical obligations. Honesty in the collection, analysis, and dissemination of ideas is referred to as intellectual honesty. When a person speaks the truth, knowing it to be true, they are being intellectually honest. A definition of research integrity can be an active commitment to the moral standards and professional norms necessary for conducting research responsibly.

## 3.9 QUESTIONS FOR PRACTICE

Q1. Define ethics. How are these important?

Q2. What do you understand by Moral Philosophy?

Q3. Elaborate the concept of Utilitarianism.

Q4. Explain the term “Deontology.”

Q5. Explain in detail the Nature of Moral Judgements and Reaction

Q6. Investigate the different ethics concerning Science and Research

Q7. Differentiate between Intellectual Honesty and Research Integrity

Q8. What do you understand by Plagiarism?

Q9. Discuss the concept of Confidentiality in the context of ethics.

Q10. Elaborate on the significance of Consequentialism.

## 3.10 SUGGESTED READINGS


- Baron D.P. (1996), Business and its Environment, Second Edition, Prentice Hall.
- Ronald R. Sims (2003), Ethics & Corporate Social Responsibility, Praeger.
- Mary E. Guy (1990), Ethical Decision Making in Everyday Work Situations, Quorum Books.
- S.B. Rosenthal and R.A. Buchholz (2000), Rethinking Business Ethics, Oxford University Press.
- Daniel Gilbert Jr. (1996), Ethics Through Corporate Strategy, Oxford University Press.
- Grace D., Cohen S. (2005), Business Ethics, Oxford University Press.
- James M. Childs Jr. (1995), Ethics in Business: Faith at Work, Fortress Press.
- Stanwick P., Stanwick Sarah (2009), Understanding Business Ethics, Prentice Hall
- Suparna Chakraborti (2010), Values and Ethics in Business and Profession, PHI.
  Julia Driver (2007), Ethics: The Fundamentals, Oxford: Blackwell Publishing
- James Rachels (2003), The Elements of Moral Philosophy, 4th ed., Boston: McGraw-Hill.
- S.S. Iyer (2002), Managing for Value, New Age International Publishers.
- S.K. Bhatia (2002), Business Ethics and Managerial Values, Deep & Deep Publications Pvt. Ltd.
- C.S.V Murthy (2018), Business Ethics: Text and Cases, Himalaya Publishing House Pvt. Ltd.

**COURSE NAME: STATISTICAL ANALYSIS AND RESEARCH METHODOLOGY**

**SEMESTER I**

**SARM 3: RESEARCH METHODOLOGY**

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## UNIT 4: SCIENTIFIC MISCONDUCT

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**STRUCTURE**



## 4.0 LEARNING OBJECTIVES

After studying this unit, you should be able to understand:

- the concept of scientific misconduct
- various causes of scientific misconduct.
- to get acquainted with the idea of Falsification.

- the basic meaning of fabrication in the context of scientific misconduct
- a complete awareness of the classification of Plagiarism
- basic idea of Salami Slicing
- Creating an awareness of the selective reporting
- the concept of Misrepresentation of Data

## 4.1 INTRODUCTION

The proposal, performance, review, or reporting of research and creative activities that violate the norms of scholarly conduct and ethical behavior in the academic and research communities generally or in professional scientific research (research that deviates from practices generally accepted in the discipline). In other words, scientific misconduct is the deliberate falsification of data, language, hypotheses, or procedures from the published or manuscript work of another researcher.

**Causes of Scientific Misconduct**

- Personal, professional, and financial conflicts of interest Policies pertaining to using live vertebrate animals in research as well as safe laboratory procedures.
- Relationships between mentors and mentees
- Collaborative research, which may involve partnerships with businesses.
- Peer review, administration, sharing, and ownership of laboratory instruments and data collection tools.
- Research misconduct and procedures for handling misconduct
- Responsible writing and publishing
- The role of scientists in society, current moral dilemmas in biomedical research, and the effects of science on society and the environment.

## 4.2 FALSIFICATION

It involves altering or omitting study findings or data to back up assertions, theories, other facts, etc. Manipulating research tools, materials, or procedures is one type of falsification. Falsification can also be defined as the alteration of visual or verbal representations in a way that "reads too much between the lines" or distorts the data. Like other instances of misbehavior in science, fabrication differs from self-deception by scientists in that it is done with the goal of misleading.

Experiments that were never carried out can be reported as experimental data, and accurate data might be modified or misrepresented to achieve a certain goal.

### 4.3 FABRICATION

It is the creation and/or addition of information, observations, or characterizations that were not made during the data collection or experimentation phases. When "filling out" the remaining experiment runs, fabrication may take place. Claims concerning findings must be based on comprehensive data sets rather than on incomplete or presumptive results, which is considered falsification. In other terms, falsification is the process of altering or omitting data or outcomes such that the research is not accurately reflected in the research record. Falsification may also involve manipulating research materials, tools, or methods.

### 4.4 PLAGIARISM

It is when someone uses another person's creation without giving them credit and claims it as their own. Plagiarism is possible in text, figures, tables, and even in thoughts. There may be a copyright violation as well as ethical misconduct when a whole entity (such as an entire article, a figure, a table, or a dataset) is reproduced without acknowledgment or permission.

- To "plagiarize" means: according to the Merriam-Webster online dictionary.
- To use another's creation without giving due credit is to steal and pass off (their thoughts or words) as one's own.
- To present as novel and unique an idea or thing borrowed from an existing source is literary theft.

The following are all regarded as plagiarism:

- Submitting someone else's work as your own.
- Stealing someone else's thoughts or ideas without giving them their credit
- Misrepresenting the author of a quotation.
- Substituting different words for those in the original statement but failing to acknowledge the source.
- Using a source's words or ideas so frequently that it constitutes most of your own work, whether you give credit or not.

### 4.4.1 TYPES OF PLAGIARISM

a) **Complete Plagiarism:** The most severe type of plagiarism occurs when a researcher submits a paper or manuscript that was originally written by someone else under his or her own name. It is equivalent to stealing and intellectual theft.

b) **Source-based Plagiarism:** Because there are so many various kinds of sources, plagiarism might happen. An example of a misleading citation is when a researcher cites a false or nonexistent source. Another instance of plagiarism is when a researcher borrows data or information from a secondary source but merely references the original source. The quantity of reference sources increases because of both types. The number of references cited as a result rises.

c) **Direct Plagiarism:** When an author replicates another author's content verbatim, without using quote marks or giving credit, and passes it off as their own, this practice is known as direct plagiarism. In that sense, it is comparable to outright plagiarizing but only refers to portions and not the entirety of another publication. This kind of plagiarism is dishonest and will result in academic repercussions. Although it is less frequent, it is a major violation of academic ethics.

d) **Self or Auto Plagiarism:** Auto-plagiarism, sometimes referred to as self-plagiarism or duplication, occurs when an author copies substantial passages from previously published work without giving proper credit. Therefore, rather than university students, published researchers are more likely to engage in this type of plagiarism. Depending on the duplicated text, there is disagreement on the seriousness of this type of infraction. However, many academic publications have stringent requirements regarding the portion of an author's work that can be reused. Before submitting them for review, several journals check articles using plagiarism detection software.

e) **Paraphrasing Plagiarism:** It entails using someone else's writing while making a few tiny alterations to the language structure and passing it off as one's own. Plagiarism occurs even if the words are different, but the original idea is the same. There is research and writing advice accessible to lower the danger of paraphrasing plagiarism because students frequently lack a clear understanding of what constitutes plagiarism.

**f) Inaccurate Authorship:** There are two ways that inaccurate authorship or false attribution might occur: In one instance, when a person works on a document without being given credit for it. The second type is the opposite: when someone receives credit for a project without contributing to it. Any instance of this kind of plagiarism violates the standards of conduct for academic work. This type of plagiarism is also conceivable when another person edits a paper and makes significant modifications. In this instance, even if the contributors are not recognized as authors, acknowledging them at the time of publishing is advised.

**g) Mosaic Plagiarism:** Mosaic plagiarism, which incorporates words or texts from other sources inside its research, could be more challenging to spot. It is dishonest and purposeful and is also referred to as "patchwork plagiarism."

**h) Accidental Plagiarism:** There is never a justification for plagiarism, and the repercussions are frequently the same whether it was intentional or not. However, whether it happened because of carelessness, an error, or unintended paraphrasing, plagiarism may have been accidental. Universities should emphasize the value of educating students about this type of plagiarism because students are prone to committing unintended plagiarism.

## 4.5 OTHER SCIENTIFIC MISCONDUCT

Some of the other scientific misconducts are:

- Submitting the same work secretly to several journals at once.
- Submitting the same article unnoticed to two separate journals
- Sharing private information from an article you are reviewing for a journal with a coworker.
- Making unauthorized use of information, concepts, or techniques you discover while reading a document.
- Using a flawed statistical method to increase the importance of your research.
- Ignoring the peer review procedure and revealing your findings at a press conference without providing peers with enough details to evaluate your work.
- Conducting a review of the literature without recognizing the contributions of other experts in the field or pertinent earlier work.
- Not maintaining accurate research records.

- Not preserving study data for enough time.
- Making disparaging remarks and personal assaults in your evaluation of the author's submission

## 4.6 REDUNDANT PUBLICATION

When authors copy and paste content word for word from their previous writings, it is referred to as redundant publication, duplicate publication, or text recycling. It is not permissible to duplicate a published article or have a significant overlap or redundancy with another published paper. When this is discovered, we will adhere to the necessary COPE regulations and may post a notice of duplicated publication. It might not be possible to avoid a little amount of repetition or overlap. This must always be disclosed in plain language, with correct credit given and in accordance with copyright regulations.

It may be acceptable in research articles to reuse some material in the background, introduction, and methods sections. However, it is unlikely that overlap in the results and conclusions section will be accepted. Duplicate publication is one of the most common issues that editors worry about. Partitioning the material or reducing the publishable units are two examples of how to do this. Duplicate publication is the act of publishing an article that substantially resembles a previously published copy. Other words used in this context include salami-slicing, dual, divided, republication, fragmented, prior, and repeating.

Duplicate publications waste the work of editors, reviewers, scientists, and readers by adding redundant themes to the already existing texts, which has an undesirable impact on our analysis. Additionally, it breaches copyright laws and wastes the journals' sources. The term "duplicate publication of scientific articles" is not well defined. Publishing the same piece of information in many publications for the goal of profit, self-interest, or other unethical reasons while misrepresenting the output as an article is unethical in all forms. Additionally, it should be highlighted that in some instances, research misconduct could result in disciplinary sanctions.

Determining the definitions in this sector for the decision-makers is of utmost importance because making the wrong conclusion or judgment about a suspicious action or condemning the members of a scientific society could be harmful and unreasonable. At the Isfahan University of Medical Sciences, an effort has been made to define the many types of duplicate publications with respect to their underlying history and reasons in this study with the aim of changing the procedure.

## 4.7 SALAMI SLICING

The term "salami publication" or "salami slicing" refers to the practice of "slicing" research that would otherwise form one substantial paper into multiple smaller publications. Salami slicing is the process of dividing or segmenting a significant study into two or more articles, as opposed to duplicate publication, which entails reporting the exact same data in two or more journals. The term "slices" of a study is used to describe these sections. In general, this is not a good idea if the "slices" of a split-up study use the same population, methodology, and assumptions. Never publish the exact same "slice" more than once.

The rationale is that, insinuating to readers that the data presented in each salami slice (i.e., journal article), is generated from a different subject sample, the U.S. Office of Research Integrity claims that salami slicing might mislead the literature. This not only distorts the "scientific database," but it also results in duplication, which wastes the time of readers as well as editors and reviewers who must deal with each paper independently. Additionally, it unjustly boosts the author's record of citations. There are times when data from extensive clinical trials and epidemiological research cannot be published concurrently or are of a nature where they address several unrelated endpoints and diverse and distinct topics. In some situations, it is acceptable to discuss significant study results in distinct paragraphs. Each publication should, however, explicitly state its theory and be organized as a component of a much wider investigation. Most journals ask that authors disclose this information and enclose any other papers (published or unpublished) that might be a part of the work being considered for publication if they know or believe that a manuscript submitted for publication contains fragmented data.

## 4.8 SELECTIVE REPORTING

Selective reporting bias occurs when findings from scientific research are purposefully withheld or inaccurately presented to hide unfavorable or unfavorable conclusions. Because of the bias introduced during the analysis or writing processes, the findings are not repeatable. One form of prejudice that compromises the objectivity of academic research is selective reporting. It significantly contributes to the ‘reproducibility dilemma' that scientific publishing is currently experiencing.

Selective reporting bias can include a variety of additional biases, including:

- Publication bias, in which the findings of clinical trials that are unsuccessful are either under- or not reported at all.
- Outcome reporting bias, in which the outcomes of unsuccessful clinical trials are selected or manipulated to enhance the general conclusions.
- Spinning outcomes involves highlighting favorable results or downplaying negative results when discussing research findings.
- Citation bias: Studies that are positive are more likely to be mentioned than those that are negative.

Selective reporting is crucial, but many still disregard the problem. And it's one of the main reasons why we are currently experiencing a replicability issue in other types of disciplines as well as in the medicinal and social sciences. And with considerable exaggeration, this is how it might go. Positive outcomes, as we all know, are amazing. They are excellent. We cherish them. We adore them so much that very few unfavorable findings are now reported. Why is that, then? This is since they are providing us with high impact publications that are cited frequently, which is beneficial for our H-indexes and other metrics.

## 4.9 MISREPRESENTATION OF DATA

There are several reasons why research findings may be misrepresented. It could be purposefully deceptive, unintentionally so, politically motivated, partisan, uneducated, biased, negligent, or any combination of these. Research explores uncertainty and certainty, as well as complexity and simplification. Contrary to "fabrication" and "falsification," the idea of "misrepresentation" is neither unambiguous nor without controversy. Most scientists concur that falsification involves modifying data, while fabrication involves making up data. But what does it mean to provide data inaccurately? As a basic response to this inquiry, "misrepresentation of data" can be defined as "communicating honestly reported data in a deceptive manner." But what exactly is dishonest communication?

Researchers have many chances to distort data while using statistics. To make one's results seem more significant or compelling than they are, one can employ a statistical approach like multiple regression or the analysis of variance. The outliers could also be removed (or trimmed) when 'cleaning up' the raw data. Drawing erroneous inferences from data, fabricating false graphs from

figures, and employing provocative language for rhetorical impact are further methods of misrepresenting data.

The distinction between data misrepresentation and "disagreement about research methods" is frequently hazy, though, as academics frequently argue about the right use of statistical techniques and other methods of portraying data. Many organizations have resisted classifying data misrepresentation as a type of scientific misconduct since the term "misrepresentation" is vague and difficult to define. However, if one wants to encourage objectivity in research, it is critical to draw attention to the issue of data misrepresentation because it is a major source of biases and errors in science.

When they convey truthfully reported facts in a misleading way, people may engage in research misconduct like "misrepresentation of data." Most of the time, it is done on purpose to conceal the actual results. Today, there are many statistical methods available, giving researchers various opportunities to falsify actual data. It can also be committed by manipulating the way graphs and figures are plotted, removing "insignificant data" from graphs and analyses, drawing illogical or insignificant conclusions from graphs, exaggerating some conclusions, using suggestive wording, and other methods. Before accepting a manuscript for publication, reviewers and editors pay close attention to these elements.

Other researchers may write to the journal or the organization to report "misrepresentation of data" by the author(s) if it is published in the open literature, or, in the unlikely event that it does not, it is published in the open literature. The research community views data misrepresentation as a severe offense with repercussions, whether it is deliberate, unintentional, biased, ignorant, or a mix of these.

Because there are so many ways to perceive things incorrectly, I don't believe there is a definition for misinterpretation of data. However, I can provide a well-known illustration: mistaking correlation for causation. If you say, "Observe two quantities," and it appears that a change in one causes a change in the other, it's possible that both quantities have changed in reaction to the unknown external source. Moving from general ideas to concrete instances, consider a social study that found that horseback riding increases life expectancy. It seems straightforward; however, the sample group's members' varying social statuses are not considered. Horseback riding is costly,

and if you ride a horse, you can typically afford a better lifestyle, better nutrition, and better medical care, increasing your life expectancy. Not at all related to horses.

## 4.10 CONSEQUENCES OF SCIENTIFIC MISCONDUCT

Research misconduct hurts science, but it also has negative effects on society. Before and after the OECD workshop, the general areas where negative impact occurs were recognized as follows: If false research leads to the release of a dangerous product or procedure (such as a medicine or therapy), harm to people and to society may follow. If misleading results are widely known and accepted, society could suffer. A well-established framework of national laws, rules, and organizations (such as the drug approval procedure) ensures the formal responsibility for protecting the public, which is primarily outside the research administration system.

However, it is the obligation of research administrations to ensure that the regulatory process is not hampered. By providing false leads for other scientists to pursue and/or by requiring them to expend time, effort, and money to duplicate erroneous discoveries, direct harm is done to science itself. Fortunately, because repeatability, verifiability, and consistency are hallmarks of the scientific method, the research record is essentially self-correcting. But inaccurate results sometimes linger and mislead for a long time. the deterioration of relationships between scientists, between senior scientists and undergraduates, and between scientists and agency programme managers. Damage to science is caused by the erosion of public confidence in science and the government's capacity to support and promote research effectively and responsibly. The credibility of scientific analysis and counsel on topics with significant ramifications for society could suffer as a result. Science-based laws and regulations may be required to solve these problems because they frequently have a significant scientific component (in fields like health, environment, energy, and national security, for example).

## 4.11 SUM UP

Scientific misconduct is the deliberate manipulation of the scientific process through the creation of data, text, hypotheses, or methodologies from the published work or manuscript of another researcher. Falsification is when research findings or data are altered or left out in order to support statements, theories, other data, etc. Fabrication is the creation and/or adding of facts, observations, or descriptions that were not made during the data collection or experimentation process. The act

of using someone else's work without giving them credit and passing it off as one's own is called plagiarism.

Plagiarism is possible in text, figures, tables, and even in thoughts. Complete plagiarism, source-based plagiarism, direct plagiarism, self-plagiarism, paraphrase plagiarism, inaccurate authorship, mosaic plagiarism, and accidental plagiarism are some of the several types of plagiarism. When authors copy and paste content word for word from their previous writings, it is referred to as redundant publication, duplicate publication, or text recycling. It is not permissible to duplicate a published article or have a significant overlap or redundancy with another published paper. The term "salami publication" or "salami slicing" refers to the practice of "slicing" research that would otherwise form one substantial paper into multiple smaller publications. Selective reporting bias occurs when findings from scientific research are purposefully withheld or inaccurately presented to hide unfavorable or unfavorable conclusions. Selective reporting is crucial, but many still disregard the problem. And it's one of the main reasons why we are currently experiencing a replicability issue in other types of disciplines as well as in the medicinal and social sciences. There are several reasons why research findings may be misrepresented. It could be purposefully deceptive, unintentionally so, politically motivated, partisan, uneducated, biased, negligent, or any combination of these.

## 4.12 QUESTIONS FOR PRACTICE

Q1. Explain in brief the concept of scientific misconduct.
Q2. State the differences between Falsification and Fabrication
Q3. Define the term “Plagiarism”. Explain in brief various types of Plagiarism.
Q4. Differentiate with the help of examples of Redundant publication, and duplicate publication.
Q5. Investigate in brief the concept of Salmi Slicing in the context of misconduct.
Q6. State the various consequences of Scientific Misconduct
Q7. Define “Misinterpretation of Data”. Enlist the underlying reasons for the Misinterpretation of Data
Q8. State the differences between Mosaic Plagiarism and Accidental Plagiarism
Q9. What do you understand by Inaccurate Authorship?
Q10. Discuss the concept of text recycling in the context of scientific misconduct.

## 4.13 SUGGESTED READINGS


- Baron D.P. (1996), Business and its Environment, Second Edition, Prentice Hall.
- Ronald R. Sims (2003), Ethics & Corporate Social Responsibility, Praeger.
- Mary E. Guy (1990), Ethical Decision Making in Everyday Work Situations, Quorum Books.
- S.B. Rosenthal and R.A. Buchholz (2000), Rethinking Business Ethics, Oxford University Press.
- Daniel Gilbert Jr. (1996), Ethics Through Corporate Strategy, Oxford University Press.
- Grace D., Cohen S. (2005), Business Ethics, Oxford University Press.
- James M. Childs Jr. (1995), Ethics in Business: Faith at Work, Fortress Press.
- Stanwick P., Stanwick Sarah (2009), Understanding Business Ethics, Prentice Hall
- Suparna Chakraborti (2010), Values and Ethics in Business and Profession, PHI.
  Julia Driver (2007), Ethics: The Fundamentals, Oxford: Blackwell Publishing
- James Rachels (2003), The Elements of Moral Philosophy, 4th ed., Boston: McGraw-Hill.
- S.S. Iyer (2002), Managing for Value, New Age International Publishers.
- S.K. Bhatia (2002), Business Ethics and Managerial Values, Deep & Deep Publications Pvt. Ltd.
- C.S.V Murthy (2018), Business Ethics: Text and Cases, Himalaya Publishing House Pvt. Ltd.

**CERTIFICATE/ DIPLOMA IN STATISTICAL ANALYSIS AND RESEARCH METHODOLOGY**

**SARM 3: RESEARCH METHODOLOGY**

## UNIT 5: PUBLICATION ETHICS

**STRUCTURE**



### 5.0 OBJECTIVES

After reading this unit, learners can be able to understand about:

- Publication Ethics
- Importance of Publication Ethics
- Settings Initiatives and Guidelines
- Conflict of Interest
- Guidelines to Identify Predatory Publications

## 5.1 INTRODUCTION

Although publishing by human beings started when writing was invented, the first evidence of scientific publishing was found in the 17th century. Today, publication is an essential part of any research. Scholars invest their significant time in writing a quality paper and get it published in the form of an article in journals or books. It is one of the key performance indicators to judge the work of a researcher. Publication is a tool in the hands of a scholar to demonstrate the knowledge and talent among the peer group. The publication helps in advances in the research area and fills the gaps which are not discovered yet. But there is a dark side also. Scholars use unethical practices for publication to gain and achieve their personal goals. They do not care for the quality of publication and make false claims or publish wrong results. Thus, there is a need for moral principles and guidelines for an author. These guidelines help in reducing low-standard publications and mitigating unethical practices. The focus of this chapter is understanding the publication ethics, its importance and best practices to follow to publish quality research.

## 5.2 PUBLICATION ETHICS

Ethics are the moral principles that govern the conduct of an activity. Publication ethics refers to a set of moral principles and guidelines that govern the conduct of authors, reviewers, editors, and publishers involved in the publication of scientific research and scholarly works. These principles are essential to ensure the integrity, credibility, and transparency of the academic and scientific publishing process. Publication ethics encompasses various key aspects, including:

1. **Authorship and Authorship Responsibilities:**
    - Proper attribution: Authors should be credited for their contributions to a research work accurately.
    - Authorship criteria: Authors should meet specific criteria, such as substantial contribution to the study and accountability for its content.
    - Avoidance of ghost and gift authorship: Inappropriate authorship practices like adding authors who did not contribute and omitting those who did should be avoided.
2. **Plagiarism:**
    - Authors should not present others' work, ideas, or words as their own.

- Proper citation and referencing of sources are crucial to avoid plagiarism.

3. **Data Integrity and Fabrication:**
   - Authors must ensure the accuracy and integrity of their research data.
   - Falsification or fabrication of data is a serious ethical violation.
4. **Conflicts of Interest:**
   - Authors, reviewers, and editors should disclose any financial, personal, or professional conflicts of interest that could influence their objectivity in the research or publication process.
5. **Peer Review:**
   - Reviewers and editors should conduct peer review impartially and maintain confidentiality.
   - They should provide constructive feedback to authors and avoid biased or discriminatory judgments.
6. **Transparency and Reproducibility:**
   - Authors should provide sufficient details about their methods and data to allow others to replicate their research.
   - Open access to data and materials promotes transparency.
7. **Research Misconduct:**
   - Plagiarism, data manipulation, and other forms of research misconduct should be reported and addressed.
   - Retraction of papers may be necessary in cases of proven misconduct.
8. **Ethical Treatment of Subjects:**
   - Research involving human or animal subjects should adhere to ethical guidelines and obtain necessary approvals.
   - Informed consent must be obtained from participants.
9. **Author Responsibilities:**
   - Authors should acknowledge the contributions of others, including funding sources.

- Corrections and retractions should be issued when errors are identified after publication.

**10. Editorial Independence:**

- Editors should make decisions based on the quality and validity of the research, without external influences.
- They should avoid favoritism or bias in selecting and publishing articles.

Thus, publication ethics is an umbrella term that includes various aspects as discussed in this section. It is crucial to maintain the credibility of scientific research and ensure that the findings are trustworthy. Violations of publication ethics can lead to severe consequences, including damage to reputations, retractions of published papers, and penalties for those involved in the misconduct.

## 5.3 IMPORTANCE

Publication ethics are of paramount importance in the world of academia and scientific research for several compelling reasons:

1. **Credibility and Trustworthiness:** Adhering to publication ethics ensures that the research and scholarly works published in journals and other platforms are trustworthy and credible. This trust is essential for the advancement of knowledge and the dissemination of accurate information.
2. **Integrity of the Scientific Record**: Maintaining high ethical standards helps to safeguard the integrity of the scientific record. Accurate and reliable research findings are crucial for building upon existing knowledge and making informed decisions.
3. **Preventing Research Misconduct**: Publication ethics serve as a deterrent against research misconduct, such as plagiarism, data fabrication, and falsification. Knowing that ethical violations will be identified and addressed helps maintain the integrity of the research community.
4. **Transparency**: Ethical publishing practices promote transparency in research. Authors are required to provide comprehensive information about their methods, data, and potential conflicts of interest, allowing other researchers to scrutinize and replicate their work.

5. **Fairness and Equity**: Ethical guidelines ensure fairness in the publication process. They help prevent biases in authorship, reviewer selection, and editorial decisions. This fairness contributes to a more inclusive and equitable research community.
6. **Protection of Human and Animal Subjects:** Ethical guidelines protect the rights and well-being of human and animal research subjects. These guidelines require informed consent and ethical treatment, reducing the potential harm that could be caused by unethical research practices.
7. **Peer Review Quality**: Ethical peer review practices are essential to maintaining the quality and objectivity of the peer review process. Reviewers and editors must evaluate submissions based on their merits, free from personal biases or conflicts of interest.
8. **Responsibility and Accountability**: Publication ethics hold authors, reviewers, editors, and publishers accountable for their roles in the research and publishing process. This accountability helps ensure that all parties act responsibly and with the best interests of science and scholarship in mind.
9. **Global Collaboration:** In an increasingly interconnected world of research, publication ethics help facilitate global collaboration. Researchers from different regions and backgrounds can trust that published research adheres to common ethical standards.
10. **Preventing Harm:** Ethical guidelines help prevent harm to individuals, communities, and the environment. Ensuring that research is conducted and reported ethically reduces the potential negative consequences of research endeavors.
11. **Legal and Institutional Compliance**: Many institutions, funding agencies, and legal systems require adherence to publication ethics as a condition for research funding and support. Violations of these ethics can lead to legal and institutional consequences.
12. **Maintaining Public Confidence:** Ethical publishing practices help maintain public confidence in the scientific and academic communities. When the public believes that research is conducted and disseminated with integrity, they are more likely to trust and support scientific advancements.

In summary, publication ethics are the foundation upon which the entire academic and scientific publishing ecosystem is built. They are essential for maintaining the quality, integrity, and credibility of research, ensuring that the pursuit of knowledge benefits society as a whole.

Violating publication ethics can have serious consequences, both for individual researchers and for the broader scientific community.

**Best Practices and standards**

The previous discussion highlighted the publication ethics and its importance in research and academia. So, what practices should one follow so that publication ethics should not be violated? There is no single rule or standard for observing ethics in publication. This section outlines a few of them that authors, reviewers, editors, and publishers should adhere to:

**For Authors**

1. Authorship:

- Clearly define authorship criteria based on substantial contributions to the research. All authors should have made a significant intellectual or practical contribution to the work.

- Provide a clear list of author names and affiliations.

- Ensure that all listed authors have agreed to the manuscript's submission and publication.

- Avoid ghost and gift authorship (adding or omitting authors improperly).

2. Plagiarism:

- Always attribute the work, ideas, and words of others properly through citation and referencing.

- Avoid self-plagiarism. Self-plagiarism is reusing one's work without appropriate citation.

3. Data Integrity:

- Ensure the accuracy and reliability of research data.

- Clearly document research methods and procedures.

- Retain original research data for a reasonable period in case of verification needs.

4. Conflicts of Interest:

- Disclose all financial, personal, or professional conflicts of interest that could influence research or publication decisions.

- Mitigate or manage conflicts of interest when necessary.

5. Transparency:

- Be transparent about research methods, data, and potential limitations.

- Make data, materials, and methods available to others for replication and verification.

6. Ethical Treatment of Subjects:

- Obtain informed consent from human research subjects.

- Ensure the ethical treatment of animals in research, following established guidelines.

7. Author Responsibilities:

- Acknowledge financial support, funding sources, and contributions from others appropriately.

- Address and correct errors or omissions in published work promptly.

8. Compliance with Journal Policies:

- Familiarize yourself with and adhere to the specific publication ethics guidelines and policies of the journal or publisher where you intend to submit your work.

9. Post-publication Communication:

- Be responsive to queries or concerns from readers and fellow researchers regarding your published work.

- Cooperate with journals or publishers in the event of investigations or corrections.

10. Continuous Education:

- Stay updated on evolving publication ethics standards and guidelines.

- Participate in ethics training or workshops as appropriate.

**For Publishers**

1. Peer Review:

- Conduct peer review impartially and without bias.

- Maintain confidentiality of the peer review process.

- Provide constructive and objective feedback to authors.

2. Research Misconduct:

- Report and address cases of research misconduct promptly.

- Retract or correct publications when errors or misconduct are identified.

3. Editorial Independence:

- Make publication decisions based on the quality and validity of research, not external influences.

- Avoid conflicts of interest in editorial decision-making.

4. Handling Ethical Issues:

- Establish clear and transparent processes for handling ethical issues, such as retractions, corrections, and appeals.

- Seek guidance from relevant ethics committees or organizations when facing complex ethical dilemmas.

Adherence to these best practices and standards is essential to ensure the responsible and ethical conduct of research and publication. It helps maintain the credibility of academic and scientific work, fosters transparency, and promotes trust within the research community and among the public. Journal publishers often provide specific ethical guidelines for authors, reviewers, and editors, which should be followed in addition to these general best practices.

## 5.4 SETTINGS INITIATIVES AND GUIDELINES

Few organizations are indulged in developing guidelines for ethical publications. The Committee on Publication Ethics (COPE), World Association of Medical Editors (WAME) and International Committee of Medical Journal Editors (ICMJE) are few among them. These organizations issue guidelines from time to time to curb the unethical practices of misconduct in publication among scientific communities.

**The Committee on Publication Ethics (COPE):** is an international organization that provides guidance and resources for promoting ethical and transparent practices in academic and scholarly publishing. It was founded in 1997 to address breaches of ethics in publication and research. COPE offers a set of guidelines and resources to help journals, publishers, editors, authors, and reviewers navigate ethical issues in publishing. Here are some key COPE resources/documents:

1. **Code of Conduct for Journal Editors:** COPE's Code of Conduct provides editors with a framework for ethical publishing practices. It covers issues such as handling conflicts of

interest, ensuring the integrity of peer review, and dealing with ethical violations. The document outlines the general duties of an editor and provides guidelines for the relationship of the editor with other stakeholders including editorial board members, authors, reviewers, publishers, and readers.

2. **Code of Conduct for Journal Publishers:** This document outlines the responsibilities and ethical principles that publishers should adhere to, including ensuring the quality and integrity of published content and respecting editorial independence.
3. **Ethical Guidelines for Peer Reviewers:** COPE provides guidelines to help peer reviewers conduct ethical and constructive peer reviews. It covers issues such as confidentiality, conflicts of interest, and providing clear and fair feedback. The peer review process must be transparent. Editors and reviewers must be provided training for handling the peer review process efficiently.
4. **Guidelines for Authors:** COPE offers guidance to authors on ethical publication practices, including issues related to authorship, plagiarism, data integrity, and transparency.
5. **Flowcharts for Handling Ethical Issues:** COPE provides a series of flowcharts designed to assist journals and editors in navigating common ethical issues, such as suspected plagiarism, authorship disputes, and ethical misconduct.
6. **Retraction Guidelines:** COPE's guidelines for retracting articles provide a structured approach for journals and editors when faced with the need to retract a published article due to ethical violations, errors, or other serious issues.
7. **Guidelines on Text Recycling (Self-Plagiarism):** COPE addresses the issue of text recycling or self-plagiarism, guiding how to handle this ethically complex issue.
8. **Education and Training Resources:** COPE offers a range of educational resources, including webinars, e-learning courses, and workshops, to help stakeholders in academic publishing understand and implement ethical practices.
9. **Case Discussions and Forum:** COPE maintains a forum where members and the publishing community can discuss specific cases and seek advice on ethical dilemmas they encounter in their roles as editors, authors, or reviewers.

It's important to note that COPE provides these guidelines and resources to promote ethical publishing practices, but each journal and publisher may have its specific policies and procedures based on these principles. COPE serves as a valuable resource for navigating the complex ethical

issues that can arise in academic publishing and promotes a culture of transparency, integrity, and accountability in research dissemination.

**World Association of Medical Editors (WAME):** It is an organization established in 1995 that is dedicated to promoting excellence in medical editing and publishing. WAME provides guidelines and resources to assist medical editors, authors, and reviewers in maintaining high ethical and editorial standards in medical publishing. Here are some key guidelines and resources provided by WAME:

1. **WAME Recommendations on Publication Ethics Policies for Medical Journals**: These recommendations cover various aspects of publication ethics, including authorship, peer review, conflicts of interest, ethical treatment of research subjects, and plagiarism. They serve as a comprehensive guide for medical journal editors in establishing and enforcing ethical policies.
2. **Ethical Considerations in the Conduct and Reporting of Research:** This document provides guidance to authors, reviewers, and editors on ethical considerations in the design, conduct, and reporting of medical research. It covers issues such as informed consent, human and animal research ethics, and data management.
3. **Conflict of Interest in Peer-Reviewed Medical Journals:** WAME offers guidelines for identifying and managing conflicts of interest among authors, reviewers, and editors. These guidelines help ensure transparency and unbiased decision-making in medical publishing.
4. **Authorship in Medical Journals**: WAME provides recommendations on authorship criteria and responsibilities to prevent issues such as ghost authorship and gift authorship. These guidelines emphasize the importance of clear and accountable authorship practices.
5. **Peer Review**: WAME offers guidance on the peer review process, including the selection of appropriate peer reviewers, maintaining reviewer confidentiality, and ensuring constructive and fair peer review.
6. **Editorial Independence:** These guidelines address the importance of editorial independence from sponsors, advertisers, and other external influences. They emphasize that editorial decisions should be based on the quality and validity of research.
7. **Advertising and Sponsorship**: WAME provides recommendations for journals on handling advertising and sponsorship arrangements to avoid conflicts of interest and maintain editorial integrity.

8. **Corrections, Retractions, and Expressions of Concern:** These guidelines outline how journals should handle corrections, retractions, and expressions of concern when errors or ethical issues are identified in published articles.
9. **Research Reporting Guidelines:** WAME encourages the use of standardized reporting guidelines for different study types, such as CONSORT for randomized controlled trials and STROBE for observational studies, to improve the quality and transparency of reporting.
10. **Recommendations on Chatbot/ Generative AI:** Recently, WAME has issued recommendations on using chatbot and generative AI for developing manuscripts. These recommendations state that chatbots cannot be authors. Chatbots and Generative AI can be used to develop draft text, convert text to tables check grammar etc. However, if used, the author must indicate the type and extent of the chatbot used in the manuscript.

WAME's guidelines are designed to promote ethical and transparent practices in medical publishing, ensuring the credibility and reliability of medical research. Medical journal editors, authors, reviewers, and other stakeholders can refer to these guidelines to navigate ethical challenges and uphold the highest standards of integrity in the dissemination of medical knowledge.

### 5.5 CONFLICT OF INTEREST

Conflict of interest (COI) is anything that can interfere with any activity of publishing research work. The interference can be with the objective of the article, the review process, editorial decision-making, and publication of the article. A conflict of interest can exist when any author, his/her organization or sponsors have any kind of relationship with the publisher that can influence the decision of publication. The conflict can be financial or non-financial. Financial conflicts occur when the author or his/her organization receives grants, fees, royalties, honorarium, etc. Non-financial conflicts include receipt of equipment, tools, computers, access to data repositories, holding positions in various boards, etc. Here's how COIs can manifest in publication ethics and how they are typically managed:

1. Authorship and Research Conduct:

- Authors are expected to disclose any financial or non-financial interests that could influence their research or reporting. This includes affiliations with companies, funding sources, and personal relationships.

- Failure to disclose relevant COIs can lead to doubts about the credibility of the research and potential retraction of published papers.

2. Peer Review:

- Reviewers should disclose any potential COIs that might affect their ability to provide an objective and unbiased review. These could include past collaborations with the authors or financial ties to the research.

- Editors should ensure that reviewers without significant COIs are selected for the peer review process.

3. Editorial Decision-Making:

- Editors and editorial board members should also disclose their COIs that could affect their impartiality in handling submitted manuscripts.

- Ethical journals often have policies in place to handle papers where editors have COIs, such as assigning an alternative editor to manage the review process.

4. Publication Decisions:

- Editors should base publication decisions on the quality and validity of research rather than commercial or personal interests.

- Transparency in the publication process, including clear disclosure of funding sources and any potential COIs, helps maintain public trust.

5. Conflicts with Peer Reviewers:

- Authors sometimes have the opportunity to suggest potential reviewers for their manuscript. While this can be beneficial, it can also lead to conflicts if authors select reviewers with whom they have positive relationships.

- Journals may choose to consider author suggestions but maintain editorial control over the final reviewer selection.

6. Adherence to Journal Policies:

- Authors, reviewers, and editors should adhere to the specific COI policies and guidelines of the journal in which they are involved.

- Journals may have unique policies and procedures for managing COIs, which should be followed.

7. Corrections and Retractions:

- If a COI is identified after publication and it is determined that the COI significantly affected the research or its reporting, journals may issue corrections or retractions to rectify the situation.

8. Ethics Committees and Oversight:

- Some journals have ethics committees or ombudsman who can provide guidance and oversight in managing COIs and other ethical issues.

- Regulatory bodies and organizations like COPE (Committee on Publication Ethics) also guide on handling COIs.

Managing COIs in publication ethics is essential to ensure that the research and scholarly work published in journals maintain credibility and integrity. Transparent disclosure and adherence to established policies are crucial in preventing COIs from unduly influencing research, peer review, or editorial decisions, and they help preserve the trust of the research community and the public in the academic publishing process.

## 5.6 GUIDELINES TO IDENTIFY PREDATORY PUBLICATIONS

In general, the identification of predatory publications often relies on a combination of manual assessment and the use of available resources and databases. Researchers, institutions, and publishers use various methods and tools to recognize potentially predatory journals and publishers. Here are some commonly used resources and techniques:

1. **Indexed Journals:** There are several databases available that provide indexing services for the journals. Institutions like PubMed maintain some databases while private organizations like Scopus, Web of Science, etc maintain others. Indexing of journals makes it visible to a larger audience thus helping improve readership. Before selecting a journal, the author should check its indexing. A journal indexed in a reputed database is likely to be a good journal. The main indexation services are:

a. Directory of Open Access Journals DOAJ: is an independent organization that publishes a freely available, community-curated online directory, indexing high quality, peer-reviewed gold open access (OA) journals.

b. Web of Science: is an index that provides subscription-based access to multiple databases that provide citation data for many different academic disciplines and is the home of the Impact Factor (IF).

c. Scopus is Elsevier's abstract and citation database and is home to CiteScore.

d. PubMed Central (PMC) is a full-text archive of biomedical and life sciences journals, hosted by the U.S. National Institutes of Health's National Library of Medicine (NIH/NLM).

e. MEDLINE is a bibliographic database of life sciences and biomedical articles, hosted by the U.S. National Library of Medicine (NLM).

2. **UGC Care List:** In 2019, The University Grants Commission New Delhi, India prepared a List of Journals known as UGC Approved Journals or UGS-CARE List. The UGC-approved List of Journals consisted of

   a. Journals Indexed in WoS (Science Citation Index, Social Science Citation Index and Arts and Humanities Citation Index);

   b. Journals Indexed in Scopus;

   c. Journals Indexed in Indian Citation Index;

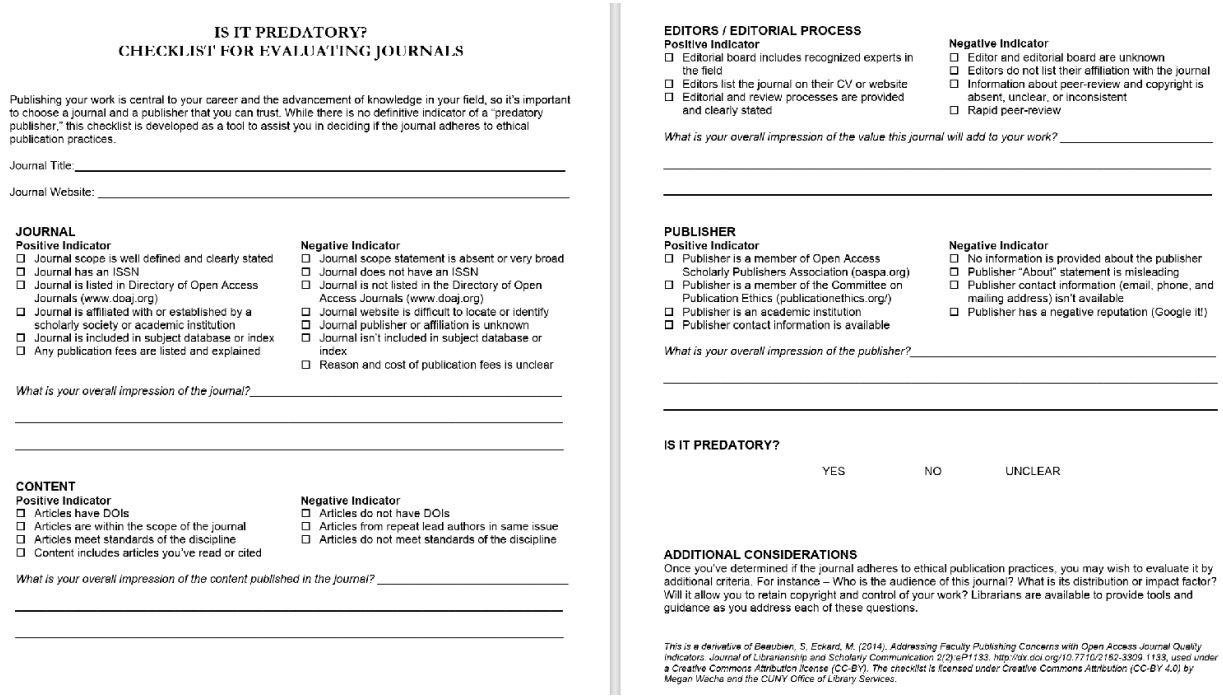
   d. Journals Recommended by the Members of the UGC Standing Committee and Language Committee(s); and

   e. Journals Recommended by the Universities (after de-duplication).

A list of UGC-approved Journals is available at the website https://ugccare.unipune.ac.in/. The list is divided into two groups: Group I and Group II. Group I contain a list of Indian journals, especially from disciplines of Arts, Humanities, Languages, Culture and Indian Knowledge Systems, and is being prepared and updated quarterly. Group II contains journals from all disciplines indexed in globally accepted databases, such as indexed in Scopus (Source list) or Web

of Science (Arts and Humanities Citation Index Source Publication, Science Citation Index Expanded Source Publication, Social Science Citation Index Source Publication).

3. **Predatory Journal Checklists:** Various checklists and criteria have been developed to help researchers and institutions identify predatory journals. These checklists often include factors like lack of transparency, spammy communication, and low editorial standards.



IS IT PREDATORY?
CHECKLIST FOR EVALUATING JOURNALS

Publishing your work is central to your career and the advancement of knowledge in your field, so it's important to choose a journal and a publisher that you can trust. While there is no definitive indicator of a "predatory publisher," this checklist is developed as a tool to assist you in deciding if the journal adheres to ethical publication practices.

Journal Title: _____

Journal Website: _____

**JOURNAL**

| Positive Indicator | Negative Indicator |
|---|---|
| ☐ Journal scope is well defined and clearly stated | ☐ Journal scope statement is absent or very broad |
| ☐ Journal has an ISSN | ☐ Journal does not have an ISSN |
| ☐ Journal is listed in Directory of Open Access Journals (www.doaj.org) | ☐ Journal is not listed in the Directory of Open Access Journals (www.doaj.org) |
| ☐ Journal is affiliated with or established by a scholarly society or academic institution | ☐ Journal website is difficult to locate or identify |
| ☐ Journal is included in subject database or index | ☐ Journal publisher or affiliation is unknown |
| ☐ Any publication fees are listed and explained | ☐ Journal isn't included in subject database or index |
| | ☐ Reason and cost of publication fees is unclear |

*What is your overall impression of the journal?*_____

**CONTENT**

| Positive Indicator | Negative Indicator |
|---|---|
| ☐ Articles have DOIs | ☐ Articles do not have DOIs |
| ☐ Articles are within the scope of the journal | ☐ Articles from repeat lead authors in same issue |
| ☐ Articles meet standards of the discipline | ☐ Articles do not meet standards of the discipline |
| ☐ Content includes articles you've read or cited | |

*What is your overall impression of the content published in the journal?* _____

**EDITORS / EDITORIAL PROCESS**

| Positive Indicator | Negative Indicator |
|---|---|
| ☐ Editorial board includes recognized experts in the field | ☐ Editor and editorial board are unknown |
| ☐ Editors list the journal on their CV or website | ☐ Editors do not list their affiliation with the journal |
| ☐ Editorial and review processes are provided and clearly stated | ☐ Information about peer-review and copyright is absent, unclear, or inconsistent |
| | ☐ Rapid peer-review |

*What is your overall impression of the value this journal will add to your work?* _____

**PUBLISHER**

| Positive Indicator | Negative Indicator |
|---|---|
| ☐ Publisher is a member of Open Access Scholarly Publishers Association (oaspa.org) | ☐ No information is provided about the publisher |
| ☐ Publisher is a member of the Committee on Publication Ethics (publicationethics.org/) | ☐ Publisher "About" statement is misleading |
| ☐ Publisher is an academic institution | ☐ Publisher contact information (email, phone, and mailing address) isn't available |
| ☐ Publisher contact information is available | ☐ Publisher has a negative reputation (Google it!) |

*What is your overall impression of the publisher?*_____

**IS IT PREDATORY?**

YES NO UNCLEAR

**ADDITIONAL CONSIDERATIONS**

Once you've determined if the journal adheres to ethical publication practices, you may wish to evaluate it by additional criteria. For instance – Who is the audience of this journal? What is its distribution or impact factor? Will it allow you to retain copyright and control of your work? Librarians are available to provide tools and guidance as you address each of these questions.

*This is a derivative of Beaubien, S, Eckard, M. (2014). Addressing Faculty Publishing Concerns with Open Access Journal Quality Indicators. Journal of Librarianship and Scholarly Communication 2(2):eP1133. http://dx.doi.org/10.7710/2162-3309.1133, used under a Creative Commons Attribution license (CC-BY). The checklist is licensed under Creative Commons Attribution (CC-BY 4.0) by Megan Wacha and the CUNY Office of Library Services.*

Fig 1: A Sample Checklist

4. **Publisher and Journal Reputation:** Researching the reputation and history of a publisher or journal can provide insights into their credibility.

5. **Consulting with Colleagues and Mentors:** Seek advice and recommendations from colleagues, mentors, and peers in your field. They may have insights into reputable journals and potential pitfalls to avoid.

6. **Institutional Support**: Many universities and research institutions have established guidelines, resources, and committees to assist researchers in identifying reputable publications and avoiding predatory ones.

It's important to note that identifying predatory publications often requires a critical and thorough evaluation of various factors, including the journal's website, peer review process, editorial board,

and publication practices. Researchers should exercise caution and due diligence when selecting journals for publication and avoid journals that exhibit predatory characteristics.

## 5.7 SUMMARY

Publishing is one of the important integral parts of every research work. Publication ethics refers to ethical principles and guidelines that govern the entire process of publishing research and scholarly works. These principles are essential for ensuring the integrity, credibility, and trustworthiness of academic and scientific publications. Authors are expected to show ethics while publishing their work. Proper citation of the work, avoiding plagiarism including self-plagiarism, ensuring data integrity and transparency are some of the key aspects that are expected from the authors. On the other hand, publishers are also required to avoid misconduct and follow proper procedures for ensuring good quality publications. Best practices and guidelines are available for all the stakeholders including authors, publishers, reviewers and editors. One should follow these practices in the interest of quality publication. A lot of publishers are running predatory journals whose purpose is to generate money out of this business. Authors are advised to be careful while selecting journals. An article published in such journals will compromise the credibility of the article as well as cause monetary loss. The authors need to check the type of the journal before sending articles.

## 5.8 Glossary

- **Ethics** are the moral principles that govern the conduct of an activity.
- **Authorship:** The process of determining and crediting individuals who have made significant contributions to a research publication.
- **Plagiarism:** The act of using someone else's work, ideas, or words without proper attribution or citation.
- **Peer Review:** The evaluation of research articles by experts in the field to ensure quality and reliability before publication.
- **Conflict of Interest:** A situation in which financial, personal, or professional interests could potentially bias research or decision-making.
- **Duplicate Publication:** The submission of the same research to multiple journals or the publication of the same work in more than one place.

- **Open Access:** A publishing model that provides unrestricted access to research articles for the public.
- **Data Integrity:** The accuracy and transparency of research data, including the availability of raw data for verification.
- **Copyright:** Legal protection of an author's intellectual property rights, which can determine how a work may be used and distributed.
- **Ethical Guidelines:** Rules and principles that define proper conduct in research, including the treatment of subjects and reporting standards.
- **Author Guidelines:** Instructions provided by journals to authors regarding manuscript preparation, submission, and ethical considerations.
- **Reviewer Confidentiality:** The expectation that peer reviewers keep the content and findings of the manuscripts they review confidential.
- **Transparency:** The clear and open reporting of research methods, results, and potential limitations.
- **Predatory Journals**: Unscrupulous publications that exploit authors and offer questionable peer review practices.
- **Academic Misconduct**: Unethical behavior in academia, such as cheating, fabrication, and falsification.
- **Ghost Authorship:** Concealing the true authors of a paper, often due to industry influence.
- **Data Fabrication:** Creating false or fictitious data to support research findings.

## 5.9 QUESTIONS FOR PRACTICE

### A. Short Answer Type Questions

Q1. What is authorship in publication ethics?
Q2. How can plagiarism be defined in academic publishing?
Q3. What is the purpose of peer review in scholarly publishing?
Q4. Why is disclosing conflicts of interest important in research publications?
Q5. Define duplicate publication in academic writing.

Q6. Why is data integrity a significant concern in publication ethics?

Q7. What are ethical guidelines, and how do they impact research conduct?

Q8. What role do author guidelines play in academic publishing?

Q9. Why is reviewer confidentiality important in the peer review process?

Q10. Define predatory journals and their ethical implications.

Q11. What does ICMJE stand for, and what are their guidelines?

Q12. What is ghost authorship, and why is it problematic in research publications?

**B. Long Answer Type Questions**

Q1. What are the key principles of authorship attribution, and how do they help maintain ethical publication practices?

Q2. Explain the different forms of plagiarism in academic publishing, and how authors can avoid them.

Q3. How does the peer review process work, and what does it play in ensuring the quality and integrity of research publications?

Q4. Why is full disclosure of conflicts of interest crucial for both authors and reviewers and how does it impact research credibility?

Q5. What is the significance of addressing duplicate publication and self-plagiarism in the academic world, and how can researchers prevent it?

Q6. What are some common ethical guidelines researchers must adhere to when conducting experiments or studies, and how do these guidelines promote research integrity?

Q7. In the context of academic publishing, how do author guidelines contribute to ethical and transparent manuscript submission and review processes?

Q8. Why is reviewer confidentiality essential, and what measures are in place to ensure that the peer review process remains unbiased and ethical?

Q9. What are the challenges posed by predatory journals and conferences, and how can authors and researchers protect themselves against unethical publishing practices?

Q10. What is the COPE, and how do their guidelines impact publication ethics?

Q11. What is the mission of the World Association of Medical Editors (WAME), and how does it contribute to the improvement of publication ethics in the medical field?

**5.10 MCQs**

**1. What does "plagiarism" refer to in publication ethics?**

a. Ethical research conduct

b. Citing sources properly

c. Using others' work without attribution

d. Peer review process

Answer: c. Using others' work without attribution

**2. Which of the following is a key principle of ethical authorship?**

a. Maximum number of authors

b. Proper credit to all contributors

c. Anonymous authorship

d. Self-plagiarism

Answer: b. Proper credit to all contributors

**3. What is the primary purpose of peer review in academic publishing?**

a. Advertising research

b. Ensuring profitability

c. Enhancing journal reputation

d. Evaluating research quality

Answer: d. Evaluating research quality

**4. Why is full disclosure of conflicts of interest important in publication ethics?**

a. To protect the publisher's interests

b. To improve article visibility

c. To ensure unbiased research and decision-making

d. To attract more funding.

Answer: c. To ensure unbiased research and decision-making

**5. In publication ethics, what is the typical consequence of research misconduct?**

a. Rapid publication

b. Article retraction

c. Increased citation count

d. Editorial promotions

Answer: b. Article Retraction

**6. What does "self-plagiarism" or "auto-plagiarism" involve?**

a. Quoting oneself accurately

b. Reusing one's work without proper citation

c. Rewriting previous work

d. Collaborating with oneself

Answer: b. Reusing one's own work without proper citation

**7. What is the primary purpose of obtaining informed consent in research involving human subjects?**

a. To ensure anonymity

b. To prevent participation

c. To protect participants' rights and safety

d. To simplify the research process

Answer: c. To protect participants' rights and safety

**8. How does open-access publishing differ from traditional publishing?**

a. It requires subscription fees for readers.

b. It restricts access to research articles.

c. It makes articles freely available to the public.

d. It doesn't involve peer review.

Answer: c. It makes articles freely available to the public.

**9. What is the purpose of issuing an "expression of concern" in publication ethics?**

a. To promote a published article

b. To alert readers to potential issues with a published article

c. To recognize exemplary research

d. To request further citations

Answer: b. To alert readers to potential issues with a published article

**10. How does copyright affect the use and distribution of a research article?**

a. It allows unrestricted use and distribution.

b. It imposes strict limitations on use.

c. It grants exclusive rights to the publisher.

d. It only applies to print publications.

Answer: c. It grants exclusive rights to the publisher.

**11. What is the primary aim of ethical guidelines in research?**

a. To limit the dissemination of research findings

b. To promote subjectivity in research

c. To provide clear standards for responsible research conduct

d. To increase author anonymity

Answer: c. To provide clear standards for responsible research conduct

**12. What role do author guidelines play in academic publishing?**

a. Ensuring rapid publication of articles

b. Guiding authors on ethical considerations and manuscript submission

c. Controlling subscription costs

d. Restricting the number of co-authors

Answer: b. Guiding authors on ethical considerations and manuscript submission

**13. Why is reviewer confidentiality important in the peer review process?**

a. To expose reviewers' identities

b. To prevent any review process

c. To encourage author influence

d. To ensure unbiased and candid assessments

Answer: d. To ensure unbiased and candid assessments

**CERTIFICATE/ DIPLOMA IN STATISTICAL ANALYSIS AND RESEARCH METHODOLOGY**

**SARM 3: RESEARCH METHODOLOGY**

## UNIT 6: PUBLICATION MISCONDUCT

**STRUCTURE**



### 6.0 LEARNING OBJECTIVES

After studying the Unit, learners will be able to understand:

- Meaning and Concept of Publication Misconduct
- various factors that lead to unethical behaviour and identify publication misconduct
- Analyse the various types of violation of publication ethics, complaints and appeal, predatory publishers and journals

- Familiarise the students with the use of plagiarism software like turnitin, urkund and other open-source software tools

## 6.1 INTRODUCTION

Academic research is an organised process involving study design, data collection, analysis, and publication, where researchers assemble information to answer specific questions and contribute to the cumulative knowledge in their field. In every part of this process, researchers must sustain ethical principles to ensure the integrity or honesty and credibility or reliability of their work. Publication is the process of making information available to the public, typically through various media channels. It includes sharing written, printed, electronic, or other forms of content with a wide audience, and sanctioning others to access and learn from the information presented. Publications can take various forms, including books, research papers, articles, journals, magazines, newspapers, blog posts, and online content.

In the academic and scientific research point of view, publication refers to the process of sharing research findings, methodologies, and conclusions in scholarly journals or other academic platforms. Publishing research permits other researchers and experts in the field to critique, review and build upon the work, promoting combinations and development in knowledge. Ethics in publication is important as it sustains the honesty and reliability of academic research. Attaching with ethical standards ensures that the information presented in publications is trustworthy, reliable, and transparent. Proper feature of authorship, avoidance of plagiarism and research misconduct, obtaining informed consent, and disclosing conflicts of interest build a root of faith between researchers, the scientific community, and the public. Ethical publication exercise promotes the responsible sharing of knowledge, prevents the diffusion of false or fallacious information, and encourages a culture of academic honesty and accountability. Faithfulness to publication ethics protects the reputation of researchers, strengthening the quality of scholarly works facilitating the improvement of science for the benefit of society as a whole.

## 6.2 CONCEPT OF PUBLICATION MISCONDUCT

Publication misconduct is the unethical or falseness activities committed by authors, reviewers, or journal editors during the procedure of publishing research. This misconduct can take different kinds, ranging from small breaches to more severe breaches of research honesty. Publication misconduct is a crucial issue at the world level concerning research ethics, stemming from a disregard for the intellectual property rights of others who are actually

working to advance academic and living standards. In simple terms, it includes unethical steps where researchers fail to give credit to the rightful owners of ideas, work, or findings, leading to unfair manipulation and misrepresentation in the academic community.

“Editors are accountable and should be responsible for everything they publish”[1]

‘‘Editor should guard the integrity of the published record by issuing corrections and retractions when needed and pursuing suspected or alleged research and publication misconduct”[1]

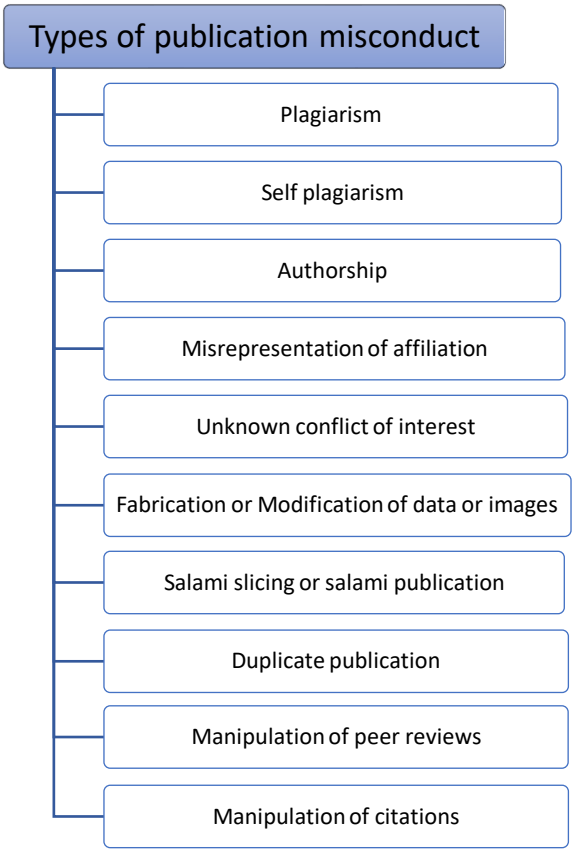
1. Guidelines for journal’s editor developed at the 2nd world conference on research integrity in Singapore, July 2010.

The US Office of Research Integrity defines misconduct quite narrowly as:

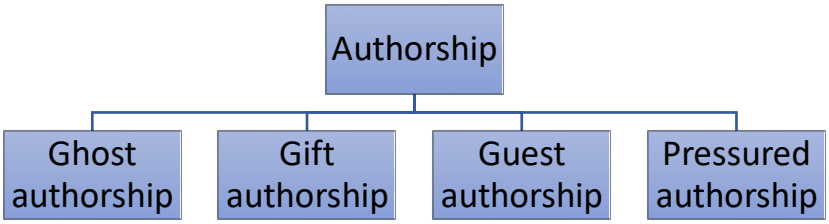
"*...fabrication, falsification, or plagiarism in proposing, performing or reviewing research, or in reporting research results"*

[Source: http://ori.hhs.gov/misconduct/definition_misconduct.shtml]

**Types of publication misconduct:-** There are various types of publication misconduct which are discussed below –



1. **Plagiarism**: Plagiarism is defined as an act of intellectual dishonesty and unethical behaviour in which an individual presents another's work, ideas, or intellectual property as their own, without providing proper credit or recognize to the original creator or source. It includes replicating or reproducing text, ideas, data, figures, research methods, or any other form of original or ingenious expression without obtaining consent or providing appropriate criteria. Plagiarism can happen in various contexts, including academic writing, research papers, essays, articles, books, and even in creative or original works like music, art, and photography. In all the forms, utilize of material, directly or indirectly, should be clearly mentioned and the source of the material should always be cited. Plagiarism can be classified into two categories which are based on the proportion of the copied content.
   **a)** The first one is Clear plagiarism, in this type of plagiarism, a large portion of the data is directly copied from another and shown as one's own, without giving any credit or acknowledgment of the original author or source. In this, the work is copied word for word from another source without using the same words.
   **b)** The second type of plagiarism is minor copying, in which the data or text is copied in small proportion or a short phrase from another source. But still, it is plagiarism because it includes someone's work or idea without mentioning proper attribution.
2. **Self-plagiarism or text-recycling**: - when a person republishes or reuses their own earlier published work or important part of it without clear citation or acknowledgment. In simple terms, self-plagiarism occurs when a person presents their own work as if it were new and original, even it has been published elsewhere before. If any case is required to include content from prior works, it should be properly mentioned and cited to ensure ethical and honest representation of the material. Different academic institutions and journals have their own guidelines or rules regarding self-plagiarism, so it is important to follow those guidelines to maintain research integrity or honesty. So, authors must be transparent by mentioning or providing citations about their prior published work.
3. **Authorship**: Authorship is the procedure of determining the name of the original owner of the research paper. The person or individual who takes responsibility for the result of the research paper is called the author. Authorship can become a significant issue in publication misconduct when the names of the individuals it is not properly assigned are actually involved in a research paper or publication. Inappropriate authorship practices can lead to serious ethical problems and reduce the honesty of the publishing process. Some common forms of authorship which are related to misconduct are: -




- **Ghost Authorship:** Ghost authorship is a practice in which someone contributes significantly to the research, writing, or creation of a work, such as a research paper, book, or article, but their role as an author is not published and are not appreciated publicly. Ghost authorship creates ethical issues in academics and other fields. When readers and reviewers do have not any information about the true author that is misleading to them also compromises the transparency and honesty of the publication.
- **Gift Authorship:** There is another common but unethical exercise known as gift authorship. This occurs when individuals who haven't contributed to a research study or work are included as authors just because they have pleased senior colleagues or maintained positive relationships. In this type, the authors have no real involvement in the project, and their contribution is often based on weak or superficial connections to the study. It misrepresents the true contributions of the authors so this practice is shown as improper. This is also compromising the credibility of the work.
- **Guest Authorship:** Some individuals have little or no actual contributions to a research work but may still be listed as authors. They are included in the authorship just to boost the chances of getting the work published. This activity is done to show the project has more authors and that leads to more reputable or credible articles just because of more authors associated with it.
- **Pressured Authorship:** This type of authorship occurs when an individual uses his/her position of authority and like being a boss or supervisor uses his power to force themselves into being listed as an author of a research paper or creative work, even if they have not really contributed much in the work.

4. **Misrepresentation of affiliation:** This is another publication misconduct that means giving fallacious information about the organization or institution that someone is associated with. This occurs when a person declares to be part of a group, institution, company, or university but in reality, they are not connected to it. This Practice might be done to get credibility, trust, benefits or access to a certain chance that they would not have any opportunity if they are not a part of these. This is considered dishonest and unethical

because it misleads readers and reviewers about someone's actual background and can lead to wrong decisions based on false information.

5. **Unknown conflict of interest**: Unknown conflict of interest refers to a situation when an individual is part of any decision-making process and in a particular bit part, he has personal, financial, or other interests included in the matter and that could influence his decision or practices, but this situation is not disclosed by the individual to the others. In other words, by individual hides the bias or interest in the matter, which affects his fairness but others are unaware of this. An unknown conflict of interest can be problematic in research, as it can undermine trust and transparency.
6. **Fabrication or Modification of data or images:** Fabrication or modification of data or images is the unethical practice in which the researcher without doing the proper research work fabricates the data or result. Fabrication can mislead readers and reviewers because this practice involves creating false information or modification of the data to show results that actually never happened. Fabrication can lead to false conclusions or results being published, a waste of resources and misleading future studies that are based on the fabricated or modified data or images.
7. **Salami slicing or salami publication:** Salami slicing is a dishonest practice in which the researcher gets data from a single research process and slices the data into smaller pieces to show the multiple separate research work and these slicing researches are submitted and published in different journals or even in same journal. In this, the reader or reviewer faces the problem of reading several papers to collect the full information about the research. It also decreases the quality of the single article. We can overcome this problem by adopting self-regulation and maintaining the integrity of research.
8. **Duplicate publication:** Duplicate publication or submission is also known as multiple submission. This practice occurs when the individual or researcher sends a single article or paper to multiple journals simultaneously to get work published in a short period in more than one journal. It is unethical to publish the same work in different journals without disclosure because it leads to time and resource wastage in the journals and violation of journal policies. So, researchers should publish their work according to the journal's guidelines and submit only to one journal.
9. **Manipulation of peer reviews:** Manipulation of peer review is a practice of obtaining positive or favorable reviews by controlling or manipulating the peer review process. It includes fake reviews under the names of reputable reviewers, selection of biased reviewers, self-review by fake identity, review rings where groups of persons agree to

positively review each other's work etc. It manipulates the fairness and objectivity of the review process.

10. **Manipulation of citations:** When the researcher increases the number of citations intentionally or artificially to boost the importance or impact of his or other's work. It is also called citation stacking. It includes grouping of mutual citation, self-citation and pressured citation, etc. such type of misrepresentation misleads the readers and reviewers and also affects the impact and importance of research. So, citations should be based on ethical standards and avoid the artificial increment of citations.

## 6.3 PROBLEMS THAT LEAD TO UNETHICAL BEHAVIOUR

A researcher might have a lot of social and professional problems as a result of publication misconduct. In this section, we've discussed several effects of wrongdoing.

1. **Damage to Reputation**: Researchers or writers proven to have engaged in publishing misconduct may experience severe harm to their careers. As a result, peers, organizations, and the general public may stop believing in them and their work.
2. **Publications that have been retracted**: If a published work has errors, the journal or publisher may do so. Retractions can harm a person's career and damage the credibility of other published work they've done.
3. **Career Reversals**: People who engage in publishing misconduct may experience career reversals, such as being passed over for promotions, research funding, or employment chances. It could also impact their capacity to work together with other researchers.
4. **Legal Repercussions**: Publication infractions may occasionally give rise to legal actions, particularly when they entail plagiarism or copyright violations.
5. **Financial Repercussions**: Institutions or funding organizations may withhold research funds and support from researchers participating in wrongdoing.
6. **Institutional Investigations**: Institutions may open Inquiries into publishing misconduct claims. Such inquiries may take a lot of time, be difficult, and be followed by disciplinary measures, including dismissal.
7. **Impact on Science**: False or misleading material may be spread due to publication misconduct, affecting future research and the use of resources. It can also compromise the integrity of the scientific literature.
8. **Loss of faith**: When cases of misbehaviour are exposed, the public's trust in academics and research may be damaged, which may impact how the scientific community is seen as a whole.

9. **Ethical Issues**: Improper conduct undermines the scientific community's credibility and casts doubt on the objectivity of academic endeavours by violating the basic moral and just standards that should guide all research.

## 6.4 VIOLATION OF PUBLICATION ETHICS AND AUTHORSHIP AND CONTRIBUTOR SHIP

Publication is the life of a researcher. A researcher needs to follow a set of rules or standards while doing study design, data collection, analysis, and interpretation and reporting results and also for the publication parts. These standards are called ethical values. Ethical norms are the basic principle in research and publication. Ethical principles build the trust of people in scientific findings, ensure high quality and also help to get projects from funded agencies. A new concept "publish or perish" is inculcated which means publication of papers is required if anyone wants to stay in the job or in that particular institution. This pressure has created D-grade papers and journals in the academic field. In the last few years or a decade, we have see numerous unethical practices happening in academics. This has taken the concerns of national and international organizations to make some guidelines for authors, reviewers, editors, publishers and others related to this field. That's how COPE (1997), WAME (1995) and ICMJE (1978) established to make these guidelines. Every reputed or peer-reviewed journal should comply with COPE guidelines to ensure high-quality scientific findings. If that's not the case, we shouldn't publish in those predatory journals. In India, every institution has its own institutional ethical committee which ensures the quality of papers written by their scholars and solves disputes if any occurs.

### VIOLATION OF PUBLICATION ETHICS

Ethical norms are prerequisites for publication. If the violation of these norms happened at any stage (pre- publication or post-publication), a complaint will be launched against the authors and if the investigation committee found it right, that paper was immediately removed from the journal and blacklisted those authors. Also in some cases, editors can inform the corresponding institutions. Violation of ethical principles not only harms the author, it also impacts their whole life such as job loss, social life, professional life, financial problems etc. There are various types of violation that can occur in academics which is given below:

1. **Fabrication:** Fabrication simply means cooking data sitting at home. The researcher doesn't get data from field studies or from secondary sources but he made data on his own. There's nothing new could be drawn from this data and one can't rely on these findings.
2. **Falsification:** Falsification is another type of data manipulation. When the results do not align with the hypotheses proposed by the researcher, then they will change some data so

that results can be drawn according to them. This is different from fabrication because falsification is manipulating the original data collected so that results can follow the hypothesis. Falsification means publishing the wrong interpretation.

3. **Plagiarism:** This is the most common mistake; we can see in the research. Plagiarism means just copying others without their acknowledgment. In plagiarism, one can copy other's ideas, data, full paper, abstract, findings, illustrations, etc. without giving credit to the original authors. Also mixing a number of papers and publishing by your name is a form of plagiarism. If any author wants to include something, they must cite properly and give credit to the original authors and it should be properly quoted. Using your own previous work in your new paper is plagiarism. If you want to use it, you must get permission from the publisher. According to UGC guidelines we can use a maximum 14 consecutive words in quotation.
4. **Redundant Publication:** Redundant publication means publishing the same paper in more than one journal. Redundant publication is the result of the "*publish or perish*" concept. For example, one author published a paper in 2019, now he published the same paper with some changes or without changes, also not giving proper references to previous work, which is called redundant publication.
5. **Multiple Submission:** Researcher submit their paper simultaneously in two or more journals which is called multiple submissions. From the fear of getting rejected the paper from the journal, one would submit the paper to a number of journals. This usually happens when the quality of the paper is very low and the author cannot comply with the journal's requirements of communication skills and command of language.
6. **Salami Slicing:** In order to publish two or three papers from one major paper that is called salami slicing. Deliberately when any author divides their own work into slices so that their list of published papers could increase. For example, one collected 1200 sample units of households and divided it into three different sets of 400 each but the objectives, data collection methods and analyses remained the same. Now author will publish three different papers with the same objectives.
7. **Conflict of interest:** Conflict of interest is the interest that can potentially influence the findings of the research study. It can be of various types such as personal interest, professional interest, financial interest, relationships, institutional interest, intellectual interest, etc. In simple terms, any type of interest that makes the outcome or results of the study biased. The issue of COIs is increasing day by day. Any type of conflict of interest found even post-publication can damage the reputation and credibility of authors. That's

why reputable journals take the declaration of COI from authors before publication. It helps readers to assess the true impact of their scientific study.

8. **Selective reporting:** Selective reporting or misleading reporting is also a violation of publication ethics. Selective reporting simply means reporting the selected findings in your paper to match up with your hypothesis and omitting some results that impact overall outcomes.
9. **Predatory Publishing:** Publishing in a low-quality journal that is not in compliance with the COPE guidelines. Predatory journals lack editorial guidelines and have a negligent peer review process.

**AUTHORSHIP &CONTRIBUTOR SHIP**

**Authorship:** Authorship as the name itself suggests to whom to give the credit of the author in the particular study to ensure academic integrity, and accountability and prevent unethical practices. There could be many authors in a paper who contributed to different parts of the paper such as study designs, data collection, analyzing or reporting the results. But sometimes credit is not given to the main authors and in some cases, the names of some authors added to the study without any significant contribution. The first author is usually the one who does most of the work regarding the design, conducting the experiment, and collecting the critical data while the last author is the investigator who has studied the work along with the first author and has conceptualized the research. The International Committee of Medical Journal Editors (ICMJE) provides widely accepted guidelines for authorship, though similar principles apply to other academic disciplines as well.

**Some of the responsibilities of authorship are:**

1. Originality
2. Good record keeping
3. Integrity and honesty
4. Transparency
5. Respect for property rights
6. Copy right agreements
7. Responsibility

According to International committee of medical journal editors (ICMJE), individuals who meet all the below given criteria are eligible as authors

1. Who helped conceptualization, design, acquisition, analysis and interpretation of data?
2. Drafting of the work

3. Who helps in final approval of the version that needs to be published?

4. Agreement for accounting for all aspects of the work

Many types of conflicts could arise in authorship which leads to unethical practices in the research field. Some of them are given below.

1. **Gift Authorship:** Gift authorship simply means gifting the credit of author to someone who didn't make any significant contribution to the study. It is an unethical practice that declines the integrity and credibility of research. It is also known as guest authorship or honorary authorship. It can take various forms such as Seniority-based authorship, Token authorship, Pressure-based authorship, Financial-based authorship, etc.
2. **Ghost Authorship:** Ghost authorship is another type of violation in academics and publication. Ghost authorship makes the main contributor of the study hidden. It simply means unlisted from the authors name in the particular study while most of the paper is written by that author. Ghost authorship could be seen in academics for many reasons such as Industry-funded research, Contract research organizations (CROs), Advisors or mentors. It is unethical practice in publication which harms the transparency and credibility of research findings.
3. **Authorship for Sale:** when real writers of the study paid to sell their authorship. In this unethical practice, those names are included as authors which doesn't make any contribution to the study. They are just paying to original writers to write for them. This may happen for many reasons such as real writers need money; fake authors wanting to increase the number of published papers in their name or for social praise etc. This practice also degrades the integrity and credibility of research.
4. **Contributor Ship:** when we get any type of help from others but we cannot include them as authors, we should acknowledge their contribution to the study. In the previous sections we studied about four main criteria of authorship, if someone doesn't fall into that category you can still mention their contribution as acknowledgment in your article or research paper. It could be classified as financial, intellectual and practical. As per ICMJE, the acknowledgment should be provided for writing, assistance, editing and proofreading.

**Resolving Authorship/Contributor Ship Issues.**

1. When researchers disagree with the list of authors, they should seek assistance from their respective institutions.
2. In case of confusion regarding authorship and contributor ship, researchers can reach out to the editorial team for clarification.
3. It is essential to carefully read and follow the provided guidelines.

4. The writer must accurately distinguish between authors and contributors when listing names in the author list.
5. Contributors should be acknowledged in the preface of the paper.

## 6.5 IDENTIFICATION OF PUBLICATION MISCONDUCT

**Plagiarism**: - Plagiarism is defined as an act of intellectual dishonesty and unethical behavior in which an individual presents another's work, ideas, or intellectual property as their own, without providing proper credit or recognition to the original creator or source. It includes replicating or reproducing text, ideas, data, figures, research methods, or any other form of original or ingenious expression without obtaining consent or providing appropriate criteria. Plagiarism can happen in various contexts, including academic writing, research papers, essays, articles, books, and even in creative or original works like music, art, and photography. In all the forms, utilize of material, directly or indirectly, should be clearly mentioned and the source of the material should always be cited**.**

**Fabrication:** Fabrication simply means cooking data sitting at home. A researcher doesn't get data from field studies or from secondary sources but he makes data on his own. There's nothing new could be drawn from this data and one can't rely on these findings.

**Falsification:** Falsification is another type of data manipulation. When the results do not align with the hypotheses proposed by the researcher, then they will change some data so that results can be drawn according to them. This is different from fabrication because falsification is manipulating the original data collected so that results can follow the hypothesis. Falsification means publishing the wrong interpretation.

## 6.6 COMPLAINTS AND APPEAL

### Complaint

When we see someone doing malpractice, we need to inform the authority or management of the research and publication committee. Here are some important steps we need to follow to complain the wrong doing in our surroundings.

- **Gather Evidence:** Compile any pertinent data of the suspected wrongdoing. Original research data, written works, published works, correspondence logs, and any other relevant material may be included in this.
- **Consult the following advice:** Review the journal's or publisher's ethical criteria for publishing and other requirements before submitting any material for consideration. Learn the precise misbehaviour categories they deal with and the processes for filing complaints.

- **Speak with the Editor or Journal:** If you think there has been wrongdoing, speak with the publisher or editor-in-chief of the journal. Email addresses or online forms are usually available in many publications for reporting ethical issues.
- **File a formal complaint:** In your complaint, describe the alleged misbehaviour and include the evidence you have acquired. Citing data manipulation, plagiarism, or any other unethical action should be done with as much specificity as possible.
- **Anonymous Reporting:** Verify that the journal or publisher supports anonymous reporting of misbehaviour if you are concerned about reprisal or would rather stay anonymous. Remember that certain journals could give information from unknown sources less weight than those from named sources.
- **Institutional Reporting:** You could also consider informing the proper research integrity officer at the institution if the alleged wrongdoing includes researchers from an institution (such as a university, research center, etc.).
- **Await Investigation:** The magazine or institution will usually start an inquiry investigating the claims. Due to the extensive review of the evidence and interaction with all pertinent parties, this procedure could take some time.
- **Confidentiality:** Remain silent about the situation while the inquiry continues to prevent obstructing or hurting anyone involved.
- **Determination and Results:** Based on the results of the inquiry, the journal or institution will decide the best course of action. Depending on the seriousness of the misbehaviour, this can lead to retractions, revisions, fines against the authors, or other steps.
- **Reporting to Authorities:** In some circumstances, especially in the case of significant violations, it could be essential to convey the misbehavior to the appropriate academic or governmental organizations in charge of monitoring research integrity.

**Appeal**

If anyone finds there is a complaint against your research work for doing malpractices and you have not done any malpractices you need to file an appeal to the management committee and provide the authentic work and clarifications. To appeal against wrongdoing complaints we need to follow some steps which are as follows:

- **Analyse the Complaint:** Carefully review the complaint's specifics and the supporting documentation. Recognize the exact charges brought out and the grounds for the protest.

- **Review-Journal Policies:** Become acquainted with the journal or publisher's ethical standards and publication rules where the complaint was lodged. Recognize the processes for processing appeals and complaints.
- **Gather Information:** Gather any pertinent information, data, and communication records to help you defend yourself against the charges. Original research data, drafts, communications with co-authors, and any other pertinent documents may be included.
- **Write a Detailed answer:** Draft a proper, well-organized response to the complaint. Address each accusation separately and defend your conduct with a concise justification supported by facts. Be transparent and honest in your response.
- **Submit the Appeal:** Email the journal editor-in-chief or the appropriate authorities managing misbehaviour matters with your answer. Make sure you submit the appeal by the deadline if one is given.
- **Emphasize Mistakes or Errors:** If you think the complaint is founded on mistakes, misunderstandings, or misinterpretations, make those points very apparent in your answer. To back up your assertions, offer verifiable proof.
- **Seek Expert Opinions:** To assist your defense, you may seek the advice of colleagues or other authorities in your area.
- **Have a Constructive Conversation:** Be ready to have a constructive conversation with the journal's or institution's investigating committee. Answer any more queries they may have and, if required, offer more proof.
- **Respect the Process:** While the appeal is pending, participate completely in the investigation and respect the procedures' fairness.
- **Await the Results:** The journal or organization will carefully analyze your appeal and reach a conclusion based on the information provided. The ruling may result in the complaint being dismissed, partially dismissed, or upheld.
- **Additional Appeal choices:** whether your initial appeal is unsuccessful and you still think the judgment is unfair, examine whether you have any more options for appealing, such as going to higher authorities or independent panels that monitor research integrity.

## 6.7 PREDATORY PUBLISHER OR JOURNAL

Predatory publishers are businesses or publishers that take advantage of writers by charging them for the right to publish their work while failing to provide the editorial and publishing services that respectable publishers, such as peer review and editing, often offer. They

frequently target academically-minded academics who employ the Open Access business model to generate a profit. Academic research's quality and integrity can be harmed by predatory publication.

## CHARACTERISTICS OF PREDATORY PUBLISHER AND JOURNAL

1. **Low or Non-existent Quality Control:** Peer reviews are frequently ineffective or non-existent at predatory publications. Almost any contribution may be accepted, regardless of how well-written or scientifically sound it is. As a result, manuscripts published in these journals might not be subjected to a thorough review, which might spread inaccurate or incorrect research.
2. **Unsolicited and spammy emails:** Researchers and academics may frequently get spammy emails from predatory publishers urging them to submit papers, serve on editorial boards, or attend conferences. Often, the writing in these emails could be more concise, general, and devoid of specifics on the recipient's job.
3. **Excessive Article Processing Charges (APCs):** Predatory journals frequently charge authors astronomical publishing fees for their work without offering significant editorial or peer review services. Instead of sharing high-quality research, these publications aim to generate money.
4. **Lack of Transparency:** Scam publishers may need to be more transparent about the members of their editorial boards, their associations, or their publication procedures. When questioned about their policies, they could also be evasive.
5. **Frequent Title and Publishing Frequency Changes:** In order to avoid being blacklisted, some predatory journals often alter their titles or publishing schedules. For scholars seeking reliable publications, this discrepancy is a warning sign.
6. **No or Little Digital Archiving:** Predatory journals might not keep up with adequate digital archiving, which could result in the loss of published articles or data in the future.
7. **Misleading Promising:** To entice naïve authors, predatory publishers frequently offer misleading claims, such as assurances of approval or quick publication.
8. **Impact factors and fake indexing:** To give their publications a false air of authority, predatory publishers may make up or falsify metrics, impact factors, and indexing services.
9. **Fake editorial boards and reviewers:** Some predatory publications list well-known scholars as editorial board members without getting their permission or knowledge. They could even make up reviewer remarks to make it seem like a real review process.

10. **Poor English and Editing:** Articles published in predatory journals may have poor language quality, a sign of improper editing and proofreading.
11. **Duplication and Plagiarism:** Predatory journals may accept manuscripts without doing adequate checks for plagiarism, resulting in the publication of plagiarized or duplicate content.

Before submitting their work, authors and researchers need to be cautious and properly assess the journals. The Directory of Open Access Journals (DOAJ) and Beall's list (which has since been taken down but was operational until 2017) are tools and resources that may be used to spot predatory publishers. Determining the reliability of a journal can also be helped by consulting knowledgeable coworkers or university librarians. To guarantee that research receives appropriate peer review and is seen by a respectable audience, publishing in reputable, well-established journals is crucial.

Researchers who publish in predatory journals risk major repercussions, including harm to their reputation, resource waste, and diminished academic careers. It is essential that authors thoroughly research journals and publishers before submitting their work to them. Researchers should pick well-known, trustworthy journals in recognized databases renowned for their ethical standards and rigorous peer review procedures.

## 6.8 USE OF PLAGIARISM SOFTWARE LIKE TURNITIN, URKUND AND OTHER OPEN-SOURCE SOFTWARE TOOLS

In the present time, a variety of plagiarism detection software program systems are available. Nowadays day human beings are extra open to the web so that plagiarism detection software programs are easily reachable.

- **Ouriginal (URKUND)@ ShodhShuddhi, INFIBNET:**

The Ministry of Education, Govt. of India has initiative a program “shodhshuddhi” on the recommendation of Sub - Committee, National Steering Committee (NSC) of e – ShodhSindhu, which provides access to all universities or institutions in India since September 2019 to Plagiarism Detection Software (PDS).in this program 1000+ institutions are identified which includes:

- Central Universities
- State Universities
- Deemed to be University Private Universities
- Centrally funded Technical Institutions (CFTIs)

- Inter-University Centre (IUCs) of UGC

This initiative was formally launched by the Former Minister of Education (formerly MHRD) on September 21, 2019.

URKUND changed its name to Ouriginal in March 2021. Students may submit directly to an academic member who has a receiver account (which needs registration as a submitter). UNICODE is the only one that supports regional languages. The file is generated in PDF format. Every source cited in the report is included in the corresponding source list. The list consists of both primary and alternative sources. A secondary source can be turned into a primary source. It's impossible to completely rule out other sources. Only first-person sources are accepted. Prior to creating similarities, an alternative source should be identified as the primary source. The use of anti-plagiarism software is increasing in universities. Anti-plagiarism software or tools only find the sources of content, but cannot stop or prevent plagiarism.

- **Turnitin:**

In 1998, The American firm Turnitin, LLC, a division of Advance Publications, operated the Turnitin online plagiarism detection tool which offers licenses to college and high schools. Students may learn how to avoid plagiarism, enhance their writing, and spot parallels with existing sources by using the results of formative assessments.

Steps for submitting a Turnitin paper:

1. Developing a login name and password
2. Sign up for Turnitin as a student or instructor.
3. Development of Classes
4. Assignment Development
5. Setting up an assignment
6. Document Upload and Author Information
7. Calculating the proportion of material that is comparable across all sources
8. Using the filter option to increase the proportion of removable least comparable items or restrict the consecutive phrases will lessen the similarity percentage.
9. Downloading several colored similarity reports in three formats, including thorough percentage-wise similarity reports, basic similarity index reports, and similarity pages.

Some other plagiarism software are as follows:

Some other plagiarism software are as follows:

- PlagScan (https://www.plagscan.com/en/)
- PlagTracker (https://www.plagtracker.com/)
- Copyleaks (https://copyleaks.com/)
- Plagiarism Checker (https://smallseotools.com/plagiarism checker /)
- Plagium (https://www.plagium.com/en/plagiarismchecker/)
- Dupli Checker (https://www.duplichecker.com/)
- Paper Rater (https://www.paperrater.com/)
- Plagirisma (http://plagiarisma.net/)

## 6.9 SUM UP

Finally, publication misconduct compromises the scientific community's integrity and the credibility of academic research. Plagiarism, fabrication, falsification, and conflicts of interest are examples of unethical behavior. The use of plagiarism detection software such as Turnitin, Urkund, and other open-source tools is critical in identifying instances of misconduct. These tools act as important safeguards, assisting in the preservation of scholarly work's authenticity and originality. By combining technology and education, we can work toward a future in which the scholarly community is built on trust, accountability, and an unwavering commitment to the pursuit of knowledge.

## 6.10 Questions for Practice

### A) Short Answer Type Questions

Q1. What is the meaning of publication misconduct?

Q2. Explain Plagiarism.

Q3. What are various types of Authorship?

Q4. What is Salami slicing?

Q5. What do you mean by Conflict of interest?

### B) Long Answer Type Questions

Q1. Explain the concept of publication misconduct and what are the various types of publication misconduct.

Q2. Give detailed explanation of Authorship and Contributor Ship?

Q3. What do you mean by Predatory Publishers and Journals? Explain the various characteristics of Predatory Publishers and Journals.

Q4.Explain about Complaints and Appeal.

Q5.Name of the various plagiarism-detected software and explain two from them.

## 6.11 MCQs

**Q1: Which of the following represents a type of publication misconduct?**

a) Correct reporting of research findings

b) Include all data, even if contradict the hypothesis.

c) Proper citation of sources.

d) Fabrication of research data

**Q2: What is the meaning of Ghost-writing in research publishing:**

a) The process of writing a research paper collectively with co-authors.

b) Include and write the names of all contributors to a research project.

c) The involvement of individuals who contributed but are not included as authors

d) Falsifying the authorship of a research paper.

**Q3: Plagiarism in research publishing refers to:**

a) Using proper citations to credit original authors.

b) Copying someone's work without giving credit to the original author.

c) Writing summaries or paraphrases with citations.

d) Association with other researchers on a project.

**Q4: Self-plagiarism occurs in research publishing when:**

a) When authors cite their own previous work.

b) When authors copy text from external sources without citation.

c) When authors reuse portions of their own previously published work.

d) When authors write a summary of the research findings

**Q5: To avoid accidental plagiarism what researcher can do:**

a) By copying someone's text without citation.

b) By using proper citation and referencing practices.

c) By paraphrasing without giving credit.

d) By submitting their work to multiple journals simultaneously.

**Q6: Which of the following is an unethical practice in peer review**?

a) Providing correct feedback to authors.

b) Deliberately delaying the review process.

c) Refusing to peer review a manuscript due to limited availability.

d) Disclosing your identity as a reviewer to the authors.

**Q7: What is the primary purpose of ethical norms in research and publication?**

a) To ensure low-quality scientific findings.

b) To build trust in scientific findings and ensure high quality.

c) To create conflicts of interest among authors.

d) To encourage multiple submission of papers.

**Q8: Which concept emphasizes the importance of publishing papers for researchers to maintain their positions in academia?**

a) Credibility principle.

b) Redundancy principle.

c) Publish or perish.

d) Predatory publishing.

**Q9: Which organization provides guidelines for ethical practices in research and publication, ensuring high-quality scientific findings?**

a) COPE.

b) WAME.

c) ICMJE.

d) All of the above.

**Q10: Which type of violation involves creating data without actual field study or reliable sources?**

a) Falsification.

b) Plagiarism.

c) Fabrication.

d) Selective reporting.

**Q11: What does "salami slicing" in publication ethics refer to?**

a) Cooking data.

b) Manipulating original data.

c) Dividing one work into multiple papers.

d) Publishing in predatory journals.

**Q12: What is the term for the unethical practice of adding authors to a paper without their significant contribution?**

a) Gift authorship.

b) Ghost authorship.

c) Authorship for sale.

d) Redundant authorship.

**Q13: According to ICMJE guidelines, which individuals are eligible as authors?**

a) Anyone who contributes ideas to the research.

b) Anyone who has read the paper.

c) Those who helped with data analysis.

d) Those who meet specific criteria such as contributing to the design, drafting, and final approval of the work.

**Q14: What is the primary reason for reporting wrongdoing in research and publication?**

a) To gain financial rewards

b) To damage reputations

c) To maintain ethical standards

d) To promote anonymous reporting

**Q15: What is the first step you should take when considering reporting malpractices?**

a) Consult colleagues for advice

b) Contact governmental organizations

c) Gather evidence of the wrongdoing

d) Write a formal complaint immediately

**Q16: What is a potential consequence of publishing in a predatory journal?**

a) Enhanced credibility among peers

b) Improved career prospects

c) Damage to academic reputation

d) Guaranteed acceptance in reputable journals

**Q17: How can authors ensure anonymity when reporting malpractices?**

a) Use pseudonyms when communicating with editors

b) Send anonymous emails to publishers

c) Utilize social media for complaints

d) Avoid reporting, to protect anonymity

**Q18: If you discover wrongdoing involving researchers from an institution, what action could you take?**

a) Keep the information confidential

b) Report directly to the institution's integrity officer

c) Ignore the situation to avoid conflict

d) Convey the issue to unrelated parties

**Q19: What is a key principle to follow while an inquiry into wrongdoing is ongoing?**

a) Speak openly about the situation

b) Gather more evidence to strengthen the case

c) Maintain silence to avoid interfering

d) Publicly share your concerns

**Q20: What could be a potential outcome after an investigation into alleged wrongdoing?**

a) Guaranteed exoneration of the accused

b) Fines imposed on the complainant

c) Retractions or revisions of published works

d) Mandatory publication of retractions

**Answer 1:** d) Fabrication of research data

**Answer 2:** c) The involvement of individuals who contributed but are not include as authors

**Answer 3:** b) Copying someone’s work without giving credit to original author.

**Answer 4:** c) When authors reuse portions of their own previously published work.

**Answer 5:** b) By using proper citation and referencing practices.

**Answer 6:** b) Deliberately delaying the review process.

**Answer 7:** b) To build trust in scientific findings and ensure high quality.

**Answer 8:** c) Publish or perish.

**Answer 9:** d) All of the above**.**

**Answer 10:** c) Fabrication.

**Answer 11:** c) Dividing one work into multiple papers.

**Answer 12:** a) Gift authorship.

**Answer 13:** d) Those who meet specific criteria such as contributing to the design, drafting, and final approval of the work.

**Answer 14**:c) To maintain ethical standards

**Answer 15**:c) Gather evidence of the wrongdoing

**Answer 16**:c) Damage to academic reputation

**Answer 17**:a) Use pseudonyms when communicating with editors

**Answer 18**:b) Report directly to the institution's integrity officer

**Answer 19**:c) Maintain silence to avoid interfering

**Answer 20**:c) Retractions or revisions of published works

**References: -**


- Tandon, V. R., Mahajan, A., Sharma, S., & Gupta, S. K. (2006). Unethical publication practices. *JK Science*, *8*(3), 123-124.
- Mondal, A. 6. Publication Misconduct: Concept, Types, Reasons and Consequence. *RESEARCH & PUBLICATION ETHICS*, 34.
- Jaleel, S., Joseph, S., Shanavas, K. E., & Cleetus, A. Publishing Misconduct: A Need of Understanding and Reduction.
- Trjvedi, G.& Sharma, R.M. (2023). *Fundamental of Research and Publication Ethics*. 41-80
- Yadav, S.K. (2022). *Research and Publication Ethics*. 136-148.

**STATISTICAL ANALYSIS AND RESEARCH METHODOLOGY**

**SEMESTER I**

**SARM 3: RESEARCH METHODOLOGY**

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# UNIT 7: MEANING OF HYPOTHESIS, CHARACTERISTICS OF HYPOTHESIS, BASIC CONCEPTS

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**STRUCTURE**

## 7.0 LEARNING OBJECTIVES

After Reading this unit, Learners can able to know about the:

- Meaning of Testing of Hypothesis
- Types of hypotheses
- Types of tails used in testing
- Types of errors in the testing of hypothesis
- Level of significance
- Power of a test

## 7.1 INTRODUCTION/ MEANING OF HYPOTHESIS

Testing of hypotheses is a fundamental concept in statistics and scientific research that plays a crucial role in decision-making and conclusions based on data. It involves a systematic and structured approach to evaluate and validate assumptions or claims about a population. The terms "hypo" and "thesis" combine to form the word "hypothesis." Hypo implies a subject to verification, while the thesis is a statement on how to solve a problem. Therefore, the definition of the word hypothesis is an assumption regarding how a problem might be solved. A hypothesis presents a solution to the issue that must be tested empirically and is supported by some logic.

A hypothesis is an unproven assertion of the association between two or more variables. A hypothesis is a clear, verifiable forecast of what will occur in your investigation. The population, the variables, and the relationships between the variables are necessary for the hypothesis to be complete.

Remember, a hypothesis does not have to be correct. While the hypothesis forecasts what the researchers expect to see, the goal of research is to determine whether this guess is right or wrong. When experimenting, researchers might explore several different factors to determine which ones might contribute to the outcome. In many cases, researchers may find that the results of an experiment do not support the original hypothesis. When writing up these results, the researchers might suggest other options that should be explored in future studies.

## 7.2 CHARACTERISTICS OF HYPOTHESIS

A good hypothesis must possess the following characteristics are as follows:

- are never formulated as questions.
- can be tested experimentally, whether true or false.
- must not be contradictory.
- must identify the variables between which a relationship must be established.
- should describe a problem. A hypothesis can be formulated in descriptive or relational form.
- does not conflict with any law of nature considered to be true.
- ensure that available tools and techniques are used effectively for verification.
- should be presented as specifically as possible in the simplest terms so that all concerned can easily understand it.
- must explain the facts that give rise to the need for explanation.
- It can be tested within a reasonable time frame. A 'workable' or 'usable' hypothesis would satisfy many of the following criteria.

**a. conceptually clear:** The concepts used in the hypothesis should be clearly defined, not only formally but also, if possible, operationally. The formal definition of the concepts will clarify what a particular concept stands for, while the operational definition will leave no ambiguity about what would constitute the empirical evidence or indicator of the concept on the plane of reality.

**b. should be specific**: No vague or value-judgmental terms should be used in the formulation of a hypothesis. It should specifically state the posited relationship between the variables. It should include a clear statement of all the predictions and operations indicated therein and they should be precisely spelled out.

**c. should be empirically testable**: It should have empirical referents so that it will be possible to deduce certain logical deductions and inferences about it. Therefore, a researcher should take utmost care that his/her hypothesis embodies concepts or variables that have clear empirical correspondence and not concepts or variables that are loaded with moral judgments or values. Such statements as 'criminals are no worse than businessmen' and 'capitalists exploit their workers', in other words, a researcher should avoid using terms loaded with values or beliefs or words having moral or attitudinal connotations in his hypothesis.

**d. related to available techniques**: The researcher may be ignorant of the available techniques, which makes him/her weak in formulating a workable hypothesis. A hypothesis, therefore,

needs to be formulated only after due thought has been given to the methods and techniques that can be used for measuring the concepts or variables incorporated in the hypothesis.

e. **related to a body of theory or some theoretical orientation**: A hypothesis, if tested, helps to qualify, support, correct or refute an existing theory, only if it is related to some theory or has some theoretical orientation. A hypothesis imaginatively formulated does not only elaborate and improve existing theory but may also suggest important links between it and some other theories. Thus, the exercise of deriving a hypothesis from a body of theory may also be an occasion for a scientific leap into newer areas of knowledge.

## 7.3 BASIC CONCEPTS OF HYPOTHESIS

The hypothesis is a fundamental concept in the scientific method and research process. It serves as a starting point for investigations and experiments, guiding researchers in their pursuit of knowledge. Here are some basic concepts related to hypotheses.

### 7.3.1 Null Hypothesis

The null hypothesis is a general statement that states that there is no relationship between two phenomena under consideration or that there is no association between two groups. This hypothesis is either rejected or not rejected based on the viability of the given population or sample.

In other words, the null hypothesis is a hypothesis in which the sample observations result from the chance. It is said to be a statement in which the evaluators want to examine the data. It is denoted by $H_0$. In statistics, the null hypothesis is usually denoted by the letter H with subscript '0' (zero), such that $H_0$ (pronounced as H-null or H-zero or H-nought). At the same time, the alternative hypothesis expresses the observations determined by the non-random cause. It is represented by $H_1$ or Ha. The main purpose of a null hypothesis is to verify/ disprove the proposed statistical assumptions.

An example of the hypothesis is as, If the hypothesis is that, "If random test scores are collected from men and women, does the score of one group differ from the other?" a possible null hypothesis will be that the mean test score of men is the same as that of the women.

$H_0$: $\mu_1 = \mu_2$

$H_0$= null hypothesis

$\mu_1$= mean score of men

$\mu_2$= mean score of women

Sometimes the null hypothesis is rejected too. If this hypothesis is rejected means, that research could be invalid. Many researchers will neglect this hypothesis as it is merely opposite to the alternate hypothesis. It is a better practice to create a hypothesis and test it. The goal of researchers is not to reject the hypothesis. However, a perfect statistical model is always associated with the failure to reject the null hypothesis.

### 7.3.2 Alternative Hypothesis

An alternative hypothesis is a statement that describes that there is a relationship between two selected variables in a study.

- An alternative hypothesis is usually used to state that a new theory is preferable to the old one (null hypothesis).
- This hypothesis can be simply termed as an alternative to the null hypothesis.
- The alternative hypothesis is the hypothesis that is to be proved that indicates that the results of a study are significant and that the sample observation does not result just from chance but from some non-random cause.
- If a study is to compare method A with method B about their relationship and we assume that method A is superior or method B is inferior, then such a statement is termed an alternative hypothesis.

The symbol of the alternative hypothesis is either $H_1$ or $H_a$ while using less than, greater than, or not equal signs.

The following are some examples of alternative hypothesis:

If a researcher is assuming that the bearing capacity of a bridge is more than 10 tons, then the hypothesis under this study will be:

Null hypothesis $H_0$: $\mu$= 10 tons

Alternative hypothesis $H_a$: $\mu$>10 tons

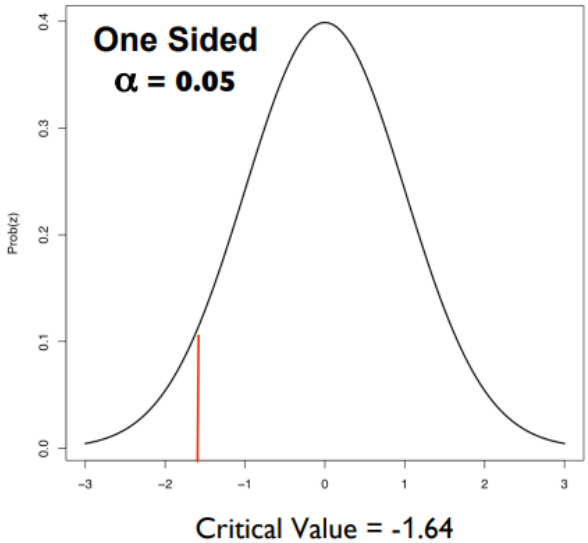
#### 7.3.2.1 One-tailed & Two-tailed

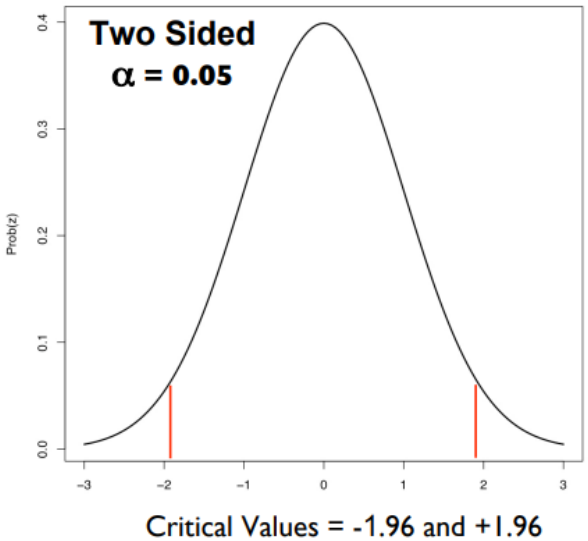
A test of testing the null hypothesis is said to be a two-tailed test if the alternative hypothesis is two-tailed whereas if the alternative hypothesis is one-tailed then a test of testing the null hypothesis is said to be a one-tailed test. For example, if our null and alternative hypothesis is $H_0$: $\mu = \mu_0$ and $H_1$: $\mu \neq \mu_0$ then the test for testing the null hypothesis is two-tailed because the alternative hypothesis is two-tailed which means, the parameter $\mu$ can take value greater than $\mu_0$ or less than $\mu_0$. If the null and alternative hypotheses are $H_0$: $\mu = \mu_0$ $H_1$: $\mu > \mu_0$ then the test for testing the null hypothesis is right-tailed because the alternative hypothesis is right-tailed. Similarly, if the null and alternative hypotheses are $H_0$: $\mu = \mu_0$ $H_1$: $\mu < \mu_0$ then the test for testing the null hypothesis is left-tailed because the alternative hypothesis is left-tailed. The above discussion can be summarised in the Table below:

Table: Null and Alternative Hypothesis (Right and Left tailed test)

| Null Hypothesis | Alternative Hypothesis | Types of Critical Region |
|---|---|---|
| $H_0$: $\mu = \mu_0$ | $H_1$: $\mu \neq \mu_0$ | Two-tailed test having critical regions under both tails |
| $H_0$: $\mu = \mu_0$ | $H_1$: $\mu > \mu_0$ | Right-tailed test having critical region under right tail only |
| $H_0$: $\mu = \mu_0$ | $H_1$: $\mu > \mu_0$ | Left-tailed test having critical region under left tail only |

Let us do one example based on the type of tests.




Example 3: A company has replaced its original technology of producing electric bulbs with CFL

technology. The company manager wants to compare the average life of bulbs manufactured by original technology and new technology CFL. Write appropriate null and alternate hypotheses. Also, say about one-tailed and two-tailed tests.

Solution: Suppose the average lives of original and CFL technology bulbs are denoted by: $\mu_1$ and $\mu_2$ respectively. If the company manager is interested just in knowing whether any significant difference exists in the average time of two types of bulbs then null and alternative hypotheses will be:

H0: $\mu_1 = \mu_2$ [average lives of two types of bulbs are same]

H1: $\mu_1 \neq \mu_2$ [average lives of two types of bulbs are different]

Since the alternative hypothesis is two-tailed therefore corresponding test will be two-tailed.

If company manager is interested just to know whether the average life of CFL is greater than original technology bulbs then our null and alternative hypotheses will be

H0: $\mu_1 \geq \mu_2$

H1: $\mu_1 < \mu_2$

Here, average life of CFL technology bulbs is greater than the average life of original technology,

Since alternative hypothesis is left-tailed therefore corresponding test will be a left-tailed test.

**Difference between Null Hypothesis and Alternative Hypothesis**

Now, let us discuss the difference between the null hypothesis and the alternative hypothesis.

| **Null Hypothesis** | **Alternative Hypothesis** |
|---|---|
| 1. Denoted by $H_0$ | Denoted by $H_1$ |
| 2. The null hypothesis is a statement. There exists no relation between the two variables | An alternative hypothesis is a statement, that there exists some relationship between two measured phenomena |
| 3. It is the hypothesis that the researcher tries to disprove. | It is a hypothesis that the researcher tries to prove. |
| 4. The mathematical formulation of the null | The mathematical formulation alternative |

| | |
|---|---|
| hypothesis is an equal sign | hypothesis is an inequality sign such as greater than, less than, etc. |
| 5. The result of the null hypothesis indicates no changes in opinions or actions. | The result of an alternative hypothesis causes changes in opinions and actions. |
| 6. The observations of this hypothesis are the result of chance | The observations of this hypothesis are the result of real effect |
| 7. If the null hypothesis is accepted, the results of the study become insignificant. | If an alternative hypothesis is accepted, the results of the study become significant. |
| 8. If the p-value is greater than the level of significance, the null hypothesis is accepted. | If the p-value is greater than the level of significance, the null hypothesis is accepted. |

### 7.3.3 ERRORS IN HYPOTHESIS

If the value of test statistic falls in rejection (critical) region then we reject the null hypothesis and if it falls in the non-rejection region then we do not reject the null hypothesis. A test statistic is calculated based on observed sample observations. But a sample is a small part of the population about which decision is to be taken. A random sample may or may not be a good representative of the population. A faulty sample misleads the inference (or conclusion) relating to the null hypothesis. For example, an engineer infers that a packet of screws is sub-standard when it is not. It is an error caused by to poor or inappropriate (faulty) sample. Similarly, a packet of screws may infer good when it is sub-standard. So, we can commit two kinds of errors while testing a hypothesis which are summarised in Table 9.1 which is given below:

**Table: Types of Error**

| **Decision** | **$H_0$ True** | **$H_1$ True** |
|---|---|---|
| **Reject $H_0$** | Type I Error ($\alpha$) | Correct decision |
| **Do not Reject $H_0$** | Correct Decision | Type II Error<br>(Power of test) $\beta$ |

Let us take a situation where a patient suffering from high fever reaches a doctor. Suppose the doctor formulates the null and alternative hypotheses as

$H_0$: The patient has a Stomach Infection

$H_1$: The patient has not a Stomach Infection

The following cases arise:

Case I: Suppose that hypothesis $H_0$ is true, that is, the patient is a Stomach Infection and after observation, pathological and clinical examination, the doctor rejects $H_0$, that is, he/she declares him/her a non-Stomach Infection patient. It is not a correct decision and he/she commits an error in a decision known as a type-I error.

Case II: Suppose that hypothesis $H_0$ is false, that is, the patient is a non-Stomach Infection patient and after observation, the doctor rejects $H_0$, that is, he/she declares him/her a non-Stomach Infection patient. It is a correct decision.

Case III: Suppose that hypothesis $H_0$ is true, that is, the patient is a Stomach Infection patient and after observation, the doctor does not reject $H_0$, that is, he/she declares him/her a Stomach Infection patient. It is a correct decision.

Case IV: Suppose that hypothesis $H_0$ is false, that is, the patient is a non-Stomach Infection patient and after observation, the doctor does not reject $H_0$, that is, he/she declares him/her a Stomach Infection patient. It is not a correct decision and he/she commits an error in a decision known as a type-II error.

### 7.3.4 LEVEL OF SIGNIFICANCE

The level of significance is the probability of rejecting a true null hypothesis that is the probability of "Type I error" and is denoted by α. The frequently used values of α are 0.05 (i.e., 5 %); 0.01(i.e., 1 %); 0.1(i.e., 10 %), etc. When $\alpha = 0.05$ it means that the level of significance is 5%. $\alpha = 0.01$ which means 1% level of significance. $\alpha = 0.01$ which means 10% level of significance. In fact, α specifies the critical region. If the calculated value of the test statistic lies in the rejection (critical) region, then we reject the null hypothesis and if it lies in the non-rejection region, then we do not reject the null hypothesis. Also, we note that when $H_0$ is rejected then automatically the alternative hypothesis $H_1$ is accepted. Now, one point of our discussion is how to decide critical value(s) or cut-off value(s) for a known test statistic. Suppose the distribution of test statistics could be expressed into some well-known distributions like Z, $\chi 2$, t, F test etc. Then our problem will be solved and using the probability distribution of test statistics, we can find the cut-off value(s) that provides us critical area equal to 5% (or 1%). 16 Testing of

Hypothesis Another viewpoint about the level of significance relates to the trueness of the conclusion. If $H_0$ does not reject at level, say, $\alpha = 0.05$ (5% level) then a person will be confident that "concluding statement about $H_0$" is true with 95% assurance. But even then, it may be false with 5%a chance. There is no percent assurance about the trueness of the statement made for $H_0$. As an example, if among 100 scientists, each draws a random sample and uses the same test statistic to test the same hypothesis $H_0$ conducting sathe me experiment, then 95 of them will reach the same conclusion about $H_0$. But still, 5 of them may differ (i.e., against the earlier conclusion). A similar argument can be made for, say, $\alpha = 0.01$ (=1%). It is like when $H_0$ is rejected at $\alpha = 0.01$ by a scientist, then out of 100 similar researchers who work together at the same time for the same problem, but with different random samples, 99 of them would reach the same conclusion however, one may differ.

### 7.3.5 Confidence Interval

Confidence interval is the interval marked by limits within which the population value lies by chance and the hypothesis is considered to be acceptable. If an observed value falls in the confidence interval $H_0$ is accepted.

### 7.3.6 Degree of Freedom

Degree of freedom refers to the number of values that are free to vary after we have given the number of restrictions imposed upon the data. It is commonly abbreviated by df. In statistics, it is the number of values in a study that are free to vary. The statistical formula to find out how many degrees of freedom are there is quite simple. It implies that degrees of freedom are equivalent to the number of values in a data set minus 1, and appears like this:

$df=N-1$

Where N represents the number of values in the data set (sample size).

That being said, let's have a look at the sample calculation.

If there is a data set of 6, (N=6).

Call the data set X and make a list with the values for each data.

For this example, data, set X of the sample size includes: 10, 30, 15, 25, 45, and 55

This data set has a mean, or average of 30. Find out the mean by adding the values and dividing by N:

(10 + 30 + 15 + 25 + 45 + 55)/6= 30

Using the formula, the degrees of freedom will be computed as df = N-1:

In this example, it appears, df = 6-1 = 5

This further implies that, in this data set (sample size), five numbers contain the freedom to vary as long as the mean remains 30.

### 7.3.7 Power of Test

Nowadays use of p-value is becoming more and more popular because of the following two reasons:

- most the statistical software provides a p-value rather than a critical value.
- p-value provides more information compared to critical value as far as rejection or not rejection of $H_0$

Moving in this direction, we note that in scientific applications one is not only interested in rejecting or not rejecting the null hypothesis but he/she is also interested in assessing how strong the data has the evidence to reject $H_0$.

This smallest level of significance (α) is known as the "p-value". The p-value is the smallest value of the level of significance(α) at which a null hypothesis can be rejected using the obtained value of the test statistic. The p-value is the probability of obtaining a test statistic equal to or more extreme (in the direction of sporting $H_1$) than the actual value obtained when null hypothesis is true.

The p-value for various tests can be obtained with the help of the tables. But unless we are dealing with the standard normal distribution, the exact p-value is not obtained with the tables as mentioned above. But if we test our hypothesis with the help of computer packages or software such as SPSS, SAS, MINITAB, STATA, EXCEL, etc. These types of computer packages or software present the p-value as part of the output for each hypothesis testing procedure. Therefore, in this block, we will also describe the procedure to decide on the null hypothesis based on critical value as well as p-value concepts.

## 7.4 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.

Research hypotheses are of different types: simple, complex, directional, nondirectional, associative, causal, inductive & deductive, null, and alternative research.

1. **Simple Hypothesis**: if a hypothesis specifies only one value or exact value of the population parameter then it is known as a simple hypothesis. This predicts the relationship between a single independent variable (IV) and a single dependent variable (DV). e.g., a motorcycle company claims that a certain model gives an average mileage of 100 km per Liter, this is a case of a simple hypothesis.
2. **Complex Hypothesis:** if a hypothesis specifies not just one value but a range of values that the population parameter may assume is called a composite hypothesis. This predicts the relationship between two or more independent variables and two or more dependent variables. The average age of students in a class is greater than 20. This statement is a composite hypothesis.
3. **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.
4. **Nondirectional 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 nondirectional hypothesis would read, ‘The academic performance of high school students is related to their participation in extracurricular activities.’ Associative Hypothesis: Associative hypotheses propose relationships between variables, when one variable changes, the other changes. Do not indicate cause and effect.

5. **Causal Hypothesis:** Causal hypotheses propose a cause-and-effect interaction between two or more variables. The independent variable is manipulated to cause an effect on the dependent variable. The dependent variable is measured to examine the effect created by the independent variable. 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.
6. **Inductive and deductive Hypotheses**: Inductive hypotheses are formed through inductive reasoning from many specific observations to tentative explanations. Deductive hypotheses are formed through deductively reasoning the implications of the theory.
7. **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 concerning 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 is denoted as $H_0$.

## 7.5 SUM UP

Hypothesis testing is a fundamental statistical method used to make inferences about population parameters based on sample data. Here is a summary of the key concepts and steps involved in hypothesis testing are as:

- Formulate Hypotheses: Null Hypothesis ($H_0$): This is the default hypothesis that there is no effect or no difference in the population. It represents the status quo.
- Alternative Hypothesis (Ha or $H_1$): This is the hypothesis you want to test, suggesting there is an effect or difference in the population.
- Select Significance Level ($\alpha$): The significance level, often denoted as $\alpha$, represents the probability of making a Type I error (rejecting a true null hypothesis). Common values for $\alpha$ include 0.05 or 0.01.
- Determine the P-value: The p-value is the probability of obtaining a test statistic as extreme as, or more extreme than, the one calculated from the sample data, assuming the null hypothesis is true. A smaller p-value indicates stronger evidence against the null hypothesis.

- Make a Decision: If the p-value is less than α, you reject the null hypothesis and If the p-value is greater than α, you fail to reject the null hypothesis.
- Draw a Conclusion: If you reject the null hypothesis, you conclude that there is evidence to support the alternative hypothesis.
- If you fail to reject the null hypothesis, you do not have enough evidence to support the alternative hypothesis.

## 7.6 QUESTIONS FOR PRACTICE

**Define the below-mentioned terms:**

a) Null Hypothesis
b) Alternative Hypothesis and its Types
c) Type I Error
d) Type II Error
e) Level of Significance
f) Degree of Freedom
g) Power of a Test

## 7.7 MCQs

Q1.A statement made about a population for testing purposes is called?

a. Statistic
b. Hypothesis
c. Level of Significance
d. Test-Statistic

**Answer b**

Q2.The rejection probability of the Null Hypothesis when it is true is called as?

a. Level of Confidence
b. Level of Significance
c. Level of Margin
d. Level of Rejection

**Answer: b**

3. Consider a hypothesis H, where against H, where o,> 5. The test is?

a. Right-tailed
b. Left-tailed
c. Middle-tailed
d. Cross tailed

**Answer: a**

Q4. The choice of one-tailed test and two-tailed test depends upon

a. Null hypothesis
b. Alternative hypothesis
c. None of these
d. Composite hypothesis

**Answer: b**

Q5. Consider a hypothesis where $H_0$ where $X_1 = X_2$ against H1 where $X_1 < X_2$. The test is?

a. Right-tailed
b. Left-tailed
c. Center-tailed
d. Cross tailed

**Answer: b**

Q6. In hypothesis testing, what is the p-value?

a. The probability of making a Type I error
b. The probability of making a Type II error
c. The level of significance
d. The probability of obtaining the observed results, or more extreme results, under the null hypothesis

**Answer: d.**

Q7. Which of the following best describes the significance level (α) in hypothesis testing?

a. The probability of making a Type I error
b. The probability of making a Type II error
c. The confidence interval
d. The power of the test

**Answer: a.**

Q8. Type 1 error occurs when?

a. We reject $H_0$ if it is True
b. We reject $H_0$ if it is False
c. We accept $H_0$ if it is True
d. We accept $H_0$ if it is False

**Answer: a**

Q9. Type II error in hypothesis testing is also known as:

a. False positive
b. False negative
c. Alpha error
d. Beta error

**Answer: b.**

Q10. Consider a hypothesis where H, where X= 23 against H, where, X> 23. The test is?

a. Right-tailed
b. Left-tailed
c. Center-tailed
d. Cross tailed

**Answer: a**

Q11. If we do not reject the null hypothesis, we conclude that:

a. there is enough statistical evidence to infer that the alternative hypothesis is true
b. there is not enough statistical evidence to infer that the alternative hypothesis is true
c. there is enough statistical evidence to infer that the null hypothesis is true
d. the test is statistically insignificant at whatever level of significance the test was conducted at

**Answer: b**

Q12. If we do not reject the null hypothesis, we conclude that:

a. there is enough statistical evidence to infer that the alternative hypothesis is true

b. there is not enough statistical evidence to infer that the alternative hypothesis is true
c. there is enough statistical evidence to infer that the null hypothesis is true
d. the test is statistically insignificant at whatever level of significance the test was conducted at

**Answer: d**

Q13. Type 1 error occurs when?

a. We reject Ho if it is True
b. We reject Ho if it is False
c. We accept H if it is True
d. We accept Ho if it is False

**Answer: a**

Q14. An Alternative Hypothesis is also called as?

a. Composite hypothesis
b. Research Hypothesis
c. Simple Hypothesis
d. Null Hypothesis

**Answer (b)**

## 7.8 SUGGESTED READINGS


- Anderson, D.R.; Sweeney, D.J. and Williams, T.A., "Statistics for Business and Economics", 2nd edition (2011), Thompson, New Delhi.
- Gupta SC: Fundamental of statistics, S. Chand & Company. New Delhi
- Gupta, SP: Statistical Methods, S. Chand & Company. New Delhi
- Kothari, C. R., "Research Methodology", 2nd Edition (2008), New Age International.
- Meyer, P.L. (1990): Introductory Probability and Statistical Applications, Oxford & IBH Pub.
- Monga, GS: Mathematics and Statistics for Economics, Vikas Publishing House, New Delhi.
- Rohatgi, V. K. and Saleh, A.K.M.E. (2010): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

**STATISTICAL ANALYSIS AND RESEARCH METHODOLOGY**

**SEMESTER I**

**SARM 3: RESEARCH METHODOLOGY**

# UNIT 8: CRITICAL REGION AND ACCEPTANCE REGION, HYPOTHESIS TESTING PROCEDURES (STEPS), INTRODUCTION TO PARAMETRIC AND NON-PARAMETRIC TESTS

**STRUCTURE**



## 8.0 LEARNING OBJECTIVES

After reading this unit, learners can understand about:

- Critical Region
- Acceptance Region
- Steps involved in testing the hypothesis
- Parametric Test
- Non-Parametric Test

## 8.1 INTRODUCTION

In statistics, we use hypothesis tests to determine whether some claim about a population parameter is true or not. Whenever we perform a hypothesis test, we always write a null hypothesis and an alternative hypothesis, which take the following forms:

$H_0$ (Null Hypothesis): Population parameter = ≤, ≥ some value

$H_1$ (Alternative Hypothesis): Population parameter <, >, ≠ some value

There are two types of hypothesis tests:

Alternative hypothesis contains either < or > sign (One-tailed test)

alternative hypothesis contains the ≠ sign (Two-tailed test)

In a two-tailed test, the alternative hypothesis always contains the not equal (≠) sign. This indicates that we're testing whether or not some effect exists, regardless of whether it's a positive or negative effect.

## 8.2 CRITICAL REGION

Results from statistical tests will fall into one of two regions: the rejection region, which will lead you to reject the null hypothesis, or the acceptance region, where you provisionally accept the null hypothesis. The acceptance region is basically the complement of the rejection region; If your result does not fall into the rejection region, it must fall into the acceptance region.

Critical values are values separating the values that support or reject the null hypothesis and are calculated on the basis of alpha. We will see more examples later on and it will be clear how we choose α. Based on the alternative hypothesis, three cases of critical region arise:

**Case A) Two-tailed test:**

In this hypothesis testing method, the critical region lies on both sides of the sampling

distribution. It is also known as a non - non-directional hypothesis testing method. The two-tailed test is used when it needs to be determined if the population parameter is assumed to be different than some value. The hypothesis can be set up as follows:

$H_0$: the population parameter = some value

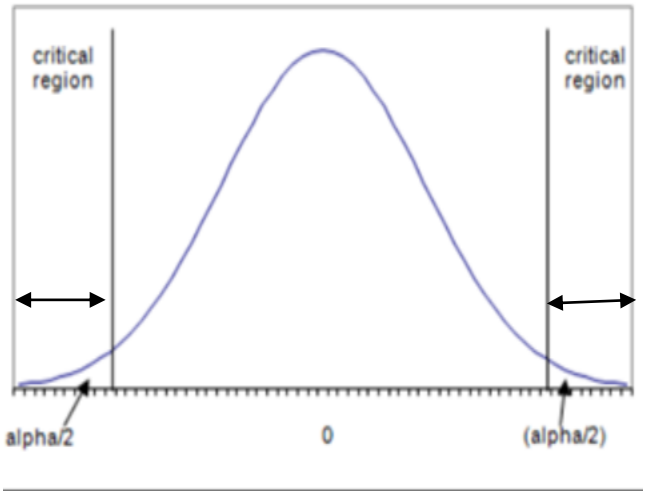
$H_1$: the population parameter ≠ some value

The null hypothesis is rejected if the test statistic has a value that is not equal to the critical value.

Therefore, $H_0$: $\mu = \mu_0$

$H_1$: $\mu \neq \mu_0$

Figure1: Two-tailed hypothesis testing




**Case B) Left-tailed test:**

The left tail test is also known as the lower tail test. It is used to check whether the population parameter is less than some value. The hypotheses for this hypothesis testing can be written as follows:

$H_0$: The population parameter is ≥ some value

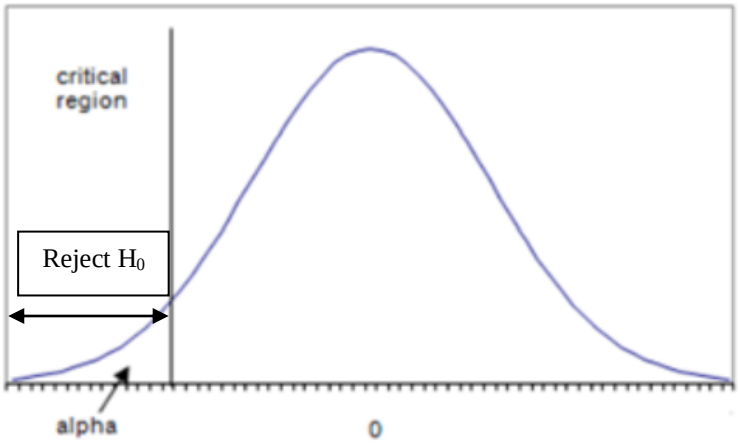
$H_1$: The population parameter is < some value.

The null hypothesis is rejected if the test statistic has a value lesser than the critical value.

Therefore, $H_0$: $\mu = \mu_0$

$H_1$: $\mu < \mu_0$

Figure 2: Left-tailed hypothesis testing




**Case C) Right-tailed test:**

The right tail test is also known as the upper tail test. This test is used to check whether the population parameter is greater than some value. The null and alternative hypotheses for this test are given as follows:

$H_0$: The population parameter is ≤ some value

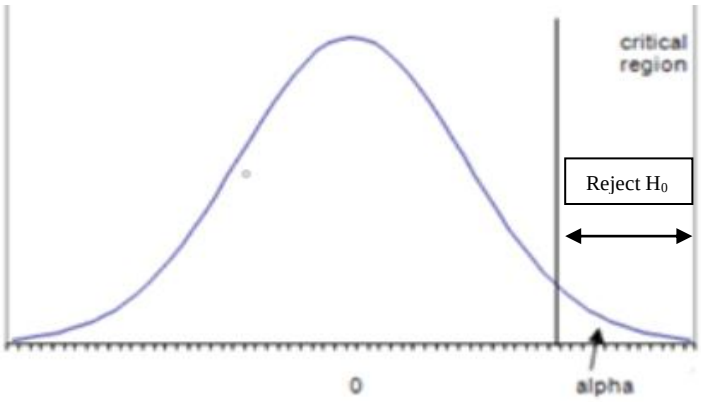
$H_1$: The population parameter is > some value.

If the test statistic has a greater value than the critical value then the null hypothesis is rejected.

Therefore, $H_0$: $\mu = \mu_0$

$H_1$: $\mu > \mu_0$

Figure 3: Right-tailed hypothesis testing



## 8.3 ACCEPTANCE REGION

The acceptance region is "the interval within the sampling distribution of the test statistic that is consistent with the null hypothesis $H_0$ from hypothesis testing." In more simple terms, let's say you run a hypothesis test like a z-test. The results of the test come in the form of a z-value, which has a large range of possible values. Within that range of values, some will fall into an interval that suggests the null hypothesis is correct. That interval is the acceptance region. As shown in figure 4 shows a two-tailed having 95 % acceptance region i.e., 2.5 % from the left side and 2.5 % from the right side.

Figure 4: Two-tailed hypothesis testing

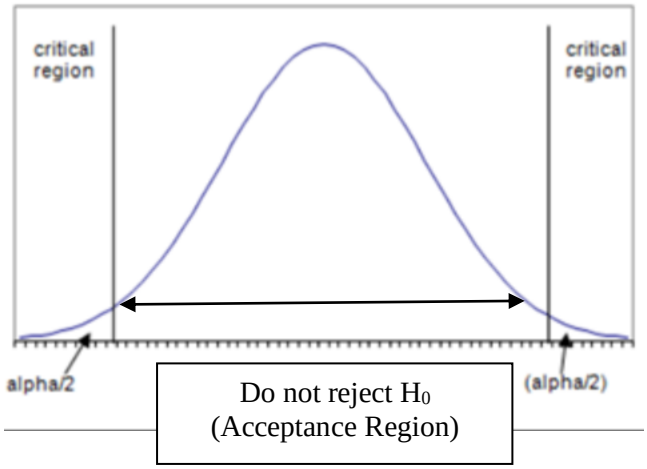
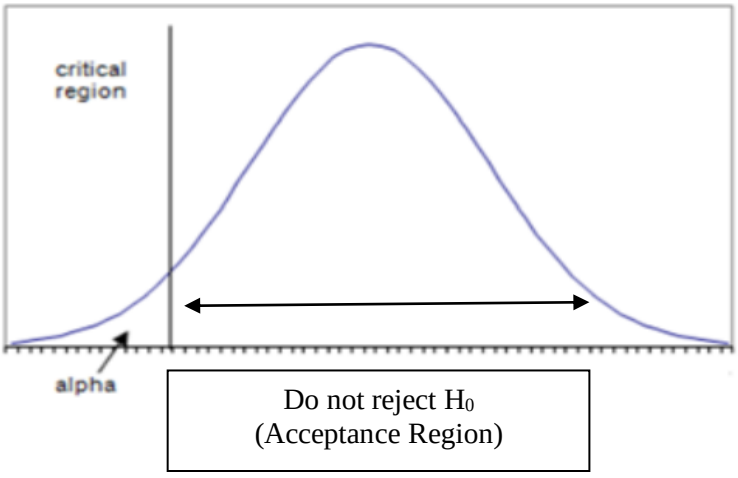


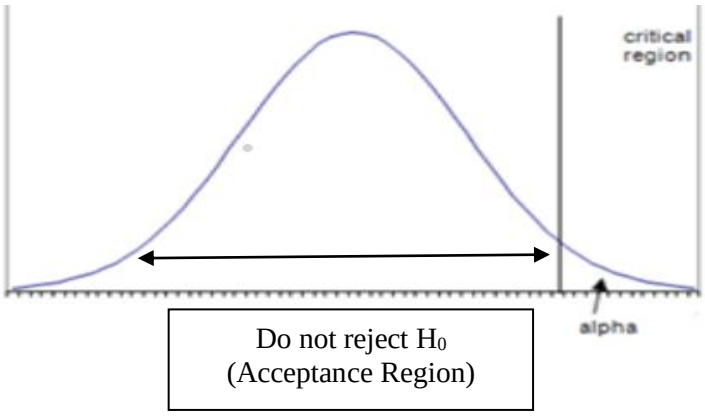

Figure 5, shows that 95 % of the right region is an acceptance region.

Figure 5: Left-tailed hypothesis testing




However, figure 6, shows 95 % of the left region as an acceptance region.

Figure 6: Right-tailed hypothesis testing




## 8.4 HYPOTHESIS TESTING PROCEDURE

Testing of hypothesis is a huge demanded statistical tool by many disciplines and professionals. It is a step-by-step procedure as you will see in the next three units through a large number of examples. The following steps are involved in hypothesis testing:

**Step I:** First of all, we have to set up null hypothesis $H_0$ and alternative hypothesis $H_1$. Suppose, we want to test the hypothetical / claimed / Testing of Hypothesis assumed value $\mu_0$ of parameter $\mu$.

So, we can take the null and alternative hypotheses as $H_0$: $\mu = \mu_0$

$H_1$: $\mu \neq \mu_0$ (for the two-tailed test)

While one- tail test as:

$H_0$: $\mu = \mu_0$ and $H_1$: $\mu > \mu_0$

$H_0$: $\mu = \mu_0$ and $H_1$: $\mu < \mu_0$

In case of comparing the same parameter of two populations of interest, say, $\mu_1$ and $\mu_2$, then our null and alternative hypotheses would be

$H_0$: and $\mu_1 = \mu_2$ and H1: $\mu_1 \neq \mu_2$ (for two-tailed test)

While one- tail test as:

$H_0$: $\mu_1 \leq \mu_2$ and $H_1$: $\mu_1 > \mu_2$

$H_0$: $\mu_1 \geq \mu_2$ and $H_1$: $\mu_1 < \mu_2$

**Step II:** After setting the null and alternative hypotheses, we establish a criteria for rejection or non-rejection of null hypothesis, that is, decide the level of significance ($\alpha$), at which we want to test our hypothesis. The most common value of $\alpha$ is 0.05 or 5%. Other popular choices are 0.01 (1%) and 0.1 (10%).

**Step III:** The third step is to choose an appropriate test statistics form like Z (standard normal), $\chi 2$, t, F or any other well-known in literature.

**Step IV:** Obtain the critical value(s) in the sampling distribution of the test statistic and construct the rejection (critical) region of size $\alpha$. Generally, critical values for various levels of significance are putted in the form of a table for various standard sampling distributions of test statistics such as Z-table, $\chi$ 2 -table, t-table, etc.

**Step V**: After that, compare the calculated value of test statistic obtained from Step IV, with the critical value(s) obtained in Step V and locate the position of the calculated test statistic, that is, it lies in the rejection region or non-rejection region.

**Step VI:** ultimately testing the hypothesis, we have to conclude.

It is done as explained below:

(i) If the calculated test statistic value lies in the rejection region at the significance level, then we reject the null hypothesis. It means that the sample data provide us sufficient evidence against the null hypothesis and there is a significant difference between hypothesized value and observed value of the parameter.

(ii) If the calculated test statistic value lies in the non-rejection region at the significance level, then we do not reject the null hypothesis. It means that the sample data fails to provide sufficient evidence against the null hypothesis and the difference between hypothesized value and observed value of the parameter due to sample fluctuation.

Nowadays the decision about the null hypothesis is taken with the help of p-value. The concept of p-value is very important because computer packages and statistical software such as SPSS, STATA, MINITAB, EXCEL, etc., all provide p-value.

**Example 2:** Mean average weight of men is greater than 100 kgs with a standard deviation of

15kgs. 30 men are chosen with an average weight of 112.5 Kg. Using hypothesis testing, check if there is enough evidence to support the researcher's claim. Check the significance at 5 % level.

**Step 1**: This is an example of a right-tailed test. Set up the null hypothesis and alternative hypothesis as

$H_0$: $\mu = 100$.

The alternative hypothesis is given by

$H_1$: $\mu > 100$.

**Step 2**: Level of Significance:

As this is a one-tailed test,

$\alpha = 5\%$. This can be used to determine the critical value.

$1 - \alpha = 1 - 0.05 = 0.95$

0.95 gives the required area under the curve. Now using a normal distribution table, the area 0.95 is at z = 1.645. A similar process can be followed for a t-test. The only additional requirement is to calculate the degrees of freedom given by n - 1.

**Step 3**: Select the statistic

Here, we must use the z statistic to test the null hypothesis since the variance is known.

**Step 4:** Find the critical region:

The z-value obtained from the statistical Table for z is 1.645. Hence, the critical region for a one-tailed test is: z > 1.645.

**Step 5:** Calculate the z-test statistic. This is because the sample size is 30. Furthermore, the sample and population means are known along with the standard deviation.

$$Z = \frac{\bar{X} - \mu}{\frac{\sigma}{\sqrt{n}}}$$

$\mu = 100$, $\bar{X} = 112.5$, n=30, $\sigma = 15$

$$Z = \frac{12.5 - 100}{\frac{15}{\sqrt{30}}} = 4.56$$

**Step 6:** Conclusion. As Cal Z > tab Z

i.e., 4.56 > 1.645 thus, the null hypothesis can be rejected.

**Example 3 of left-tail:** The average score of a class is 90. However, a teacher believes that the average score might be lower. The scores of 6 students were randomly measured. The mean was 82 with a standard deviation of 18. With a 0.05 significance level use hypothesis testing to check if this claim is true.

**Solution. Step 1**: Set up the null and alternative hypotheses as

H0: $\mu = 90$,

Alternative hypothesis

H1: $\mu < 90$ (Left-tailed)

$x = 110$, $\mu = 90$, $n = 6$, $s = 18$

**Step 2:** level of significance:

As this is a one-tailed test,

$\alpha = 5\%$. This can be used to determine the critical value.

$1 - \alpha = 1 - 0.05 = 0.95$, df= N-1= 6-1=5

**Step 3:** It is a small sample test; therefore t-test is to be determined as

$$t = \frac{\bar{X} - \mu}{\frac{s}{\sqrt{n}}}$$

**Step 4:** Determine the critical value

The critical value from the t table is -2.015

**Step 5:** Test Statistics

$$t = \frac{\bar{X} - \mu}{\frac{s}{\sqrt{n}}}$$

$$t = \frac{82 - 90}{\frac{18}{\sqrt{6}}} \qquad t = -1.088$$

**Step 6:** Conclusion

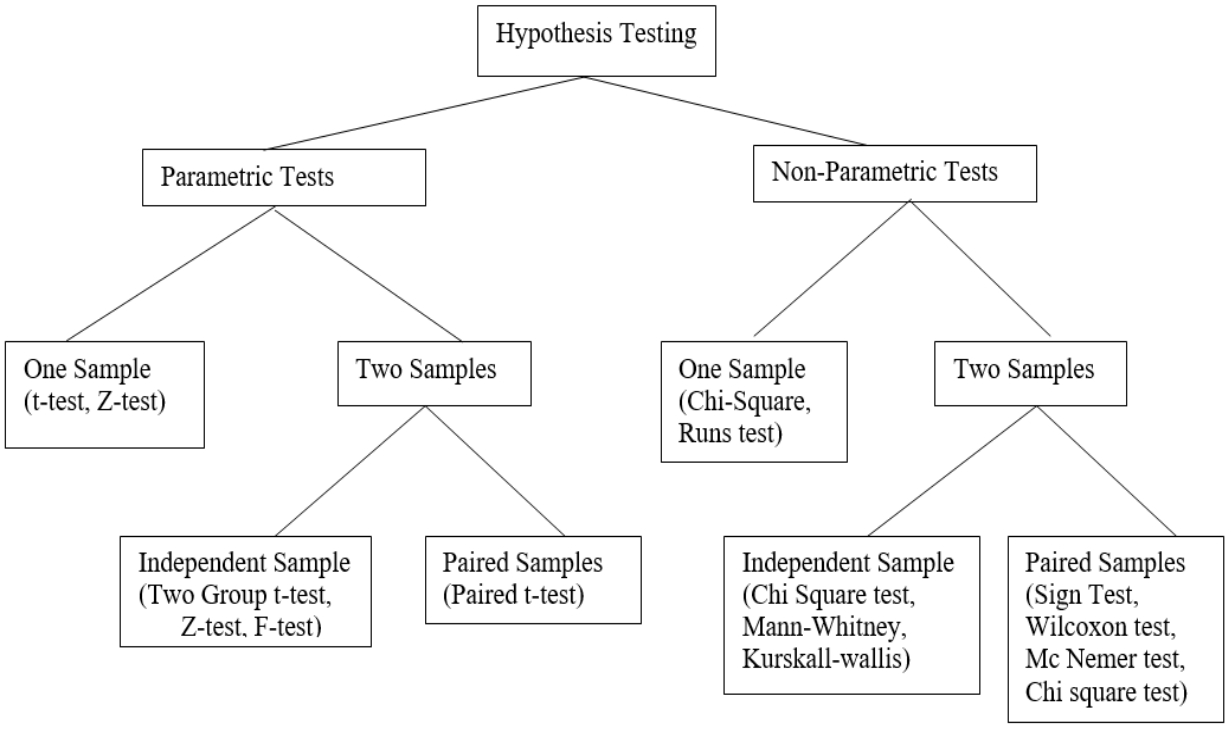
As -1.088 > -2.015, we fail to reject the null hypothesis. There is not enough evidence to support

the claim.

## 8.5 TYPES OF HYPOTHESIS TESTING

Hypothesis testing is a fundamental statistical technique used to make inferences about populations based on sample data. Several types of hypothesis tests are designed for different scenarios and research questions.

- Parametric Tests: These tests assume that the data follows a specific probability distribution, typically the normal distribution. Common parametric tests include t-tests, analysis of variance (ANOVA), and linear regression.
- Non-Parametric Tests: These tests make fewer assumptions about the data distribution. They are used when the data is not normally distributed or when you have ordinal or categorical data. Examples include the Wilcoxon signed-rank test and the Kruskal-Wallis test.




## 8.6 PARAMETRIC TEST

These tests are based on several assumptions about the parent population from which the sample was taken. The assumptions may relate to sample size, distribution type, or population characteristics like mean, standard deviation, etc. The most widely used parametric tests are the Z-test, t-test, and $\chi 2$ test (although x is considered a nonparametric test when used as a test of

independence or good of fit). Since they use interval and ratio data, parametric tests are more potent than nonparametric tests. The parametric tests are based on certain assumptions.

The observations being tested should be independent so that the inclusion of one set of observations does not affect the subsequent observations,

- normality of distribution
- It requires interval or ratio measurement scales so that arithmetic operations can be applied to them

The "Z" test is used for t-distribution and binomial or Poisson distribution also when the sample size is very large on the presumption that such a distribution tends to approximate normal distribution as the sample size becomes larger. This Z value is compared with the calculated Z-statistic for judging the significance of the measure concerned. The 't' test is a univariate test that uses t-distribution for testing sample mean and proportion when the size of sample is small (i.e., less than 30). The t-distribution is a symmetrical bell-shaped curve. The variance of t-distribution approaches the variance of the standard normal distribution as the sample size increases. Hence the widely practiced rule of thumb is that $n > 30$ is considered large and for such sample size normal distribution is used and for $n < 30$ t-distribution is used. 'F'-test is based on F-distribution. It is generally used to compare the variance of two sets of observations. F-distribution is a frequency distribution that uses two sets of degrees of freedom i.e., one in numerator and one in denominator. ANOVA is a case of using F-test to compare variance. Chi-square considered as a parametric test is used to compare a sample variance to some theoretical population variance. It is based on chi-square distribution.

## 8.7 NON-PARAMETRIC TEST

Non-parametric tests, also known as distribution-free tests, are a category of statistical tests that do not make strong assumptions about the underlying distribution of the data. These tests are used when the data do not meet the assumptions of parametric tests, which assume that the data follow a specific distribution, such as a normal distribution. Non-parametric tests are often used when dealing with ordinal or nominal data, small sample sizes, or data that are not normally distributed.

Here are some common non-parametric tests:

**Mann-Whitney U Test (Wilcoxon Rank-Sum Test):** This test is used to compare two independent groups to determine if there is a significant difference between them. It is used as a non-parametric alternative to the independent samples t-test.

**Wilcoxon Signed-Rank Test:** This test is used to compare two related (paired) groups when the data is not normally distributed. It is an alternative to the paired samples t-test.

**Kruskal-Wallis Test:** This is a non-parametric alternative to the one-way ANOVA test. It is used to compare three or more independent groups to determine if there are significant differences between them.

**Friedman Test**: This is the non-parametric counterpart of the repeated measures ANOVA. It is used to test for differences between multiple related groups when the data are not normally distributed.

**Chi-Square Test:** The chi-square test is used to analyze the association between categorical variables. It can be used for tests of independence (chi-square test of independence) or tests of goodness-of-fit (chi-square goodness-of-fit test).

**Mann-Whitney-Wilcoxon Test (MWW):** This is an extension of the Mann-Whitney U test for comparing more than two independent groups.

**Sign Test**: A non-parametric test for comparing paired data. It tests whether the median of the differences between paired observations is significantly different from zero.

**Runs Test**: This test is used to determine whether a sequence of data points is randomly ordered or exhibits some systematic pattern.

Non-parametric tests are valuable tools in statistics when assumptions of normality or other parametric assumptions are not met. They are robust and provide a way to perform statistical analysis when the data does not conform to the assumptions of parametric tests. However, they are generally less powerful than their parametric counterparts when the assumptions of parametric tests are met, so it's important to choose the appropriate test based on the nature of your data and research questions.

## 8.8 DIFFERENCES BETWEEN PARAMETRIC TEST AND NON-PARAMETRIC

| **Properties** | **Parametric Test** | **Non-Parametric** |
|---|---|---|

| | | |
|---|---|---|
| **1. Assumptions** | Here assumptions are made | No assumptions are not made |
| **2. Correlation** | Pearson Correlation | Spearman Correlation |
| **3. Probabilistic** | Distribution Normal probabilistic distribution | Arbitrary probabilistic distribution |
| **4. Use** | Used for finding interval data | Used for finding nominal data |
| **5. Application** | Applicable to variables | Applicable to variables and attributes |
| **6. Population** | Knowledge Population knowledge is required | Population knowledge is not required |
| **7. Examples** | T-test, z-test | Mann-Whitney, Kruskal-Wallis |

## 8.9 SUM UP

Testing of hypotheses means to test the assumption validity through null hypothesis. Results from statistical tests will fall into one of two regions: the rejection region and the acceptance region, rejection region leads you to reject the null hypothesis, or the acceptance region, where you provisionally accept the null hypothesis. The acceptance region is "the interval within the sampling distribution of the test statistic that is consistent with the null hypothesis $H_0$ from hypothesis testing. Parametric Tests assume that the data follows a specific probability distribution, typically the normal distribution. Common parametric tests include t-tests, analysis of variance (ANOVA), and linear regression. Whereas, Non-Parametric tests make fewer assumptions about the data distribution. They are used when the data is not normally distributed or when you have ordinal or categorical data-for example, the Wilcoxon signed-rank test and the Kruskal-Wallis test.

## 8.10 QUESTIONS FOR PRACTICE

Define the following:

a. Acceptance region
b. Rejection region
c. Steps for testing of hypotheses
d. Parametric test

e. Non-parametric test

## 8.11 SUGGESTED READINGS


- Gupta SC: Fundamental of statistics, S. Chand & Company. New Delhi
- Gupta, SP: Statistical Methods, S. Chand & Company. New Delhi
- Kothari, C. R., "Research Methodology", 2nd Edition (2008), New Age International.
- Meyer, P.L. (1990): Introductory Probability and Statistical Applications, Oxford & IBH Pub.
- Monga, GS: Mathematics and Statistics for Economics, Vikas Publishing House, New Delhi.
- Rohatgi, V. K. and Saleh, A.K.M.E. (2010): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.