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Fundamental Statistical Terminology for Library and Information Science Researchers: Key Concepts to Know

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Abstract This paper explores the crucial role of fundamental statistical terminology in guiding research within Library and Information Science (LIS). From the initial planning stages to the final analysis, statistical tools provide researchers with a systematic and quantitative framework for data analysis, enabling them to draw reliable conclusions and make informed decisions. The paper delves into essential statistical concepts, including hypotheses, variables, population, samples, sampling techniques, levels of measurement, statistical significance, validity, reliability, and data analysis. Through a detailed examination of each concept, the essay aims to equip LIS researchers with a foundational understanding of statistical terminology necessary for proficient data interpretation and manipulation. The discussion emphasizes the importance of statistical literacy in enhancing the rigour, objectivity, and credibility of research endeavours within the dynamic landscape of library and information science. Mastering these vital statistical concepts empowers researchers to contribute meaningfully to advancing knowledge in the field, fostering evidence-based decision-making and robust scientific inquiry.

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1. Introduction

Statistics refers to a branch of mathematical procedures which deals with organizing, summarizing, and interpreting information (Gravetter & Wallnau, 2013). Statistics guides research at every stage, from designing experiments to interpreting results. Statistical tools and techniques play a pivotal role in research across diverse fields by providing a systematic and quantitative data analysis and interpretation framework. Planning, organizing, collecting data, analyzing, creating an appropriate interpretation, and publishing research findings are all statistical approaches that are used in research completion (Ali & Bhaskar, 2016). These tools enable researchers to extract meaningful insights from complex datasets, identify patterns, and draw reliable conclusions. The importance of statistical methods lies in their ability to validate hypotheses, assess the significance of findings, and make informed decisions based on empirical evidence. In research, statistical tools enhance the rigour and objectivity of studies, contributing to the credibility and reproducibility of results. Whether in experimental design, data collection, or drawing inferences, applying statistical techniques adds precision to research endeavours, fostering a more robust and reliable scientific foundation.

From initial planning to final analysis, statistics is a crucial part of Library and Information Science (LIS) research at every level (Hernon & Schwartz, 2013). A simple page of raw data, devoid of organization, reveals little to no insight. Statistical methods bridge this gap, providing powerful tools for summarizing and analyzing scientific measurements. From bibliometric studies to library usability testing, librarians rely heavily on these methods to measure vital facts and draw meaningful conclusions from their research. In the dynamic field of Library and Information Science (LIS), researchers are progressively acknowledging the significance of integrating statistical methods into their endeavours. Whether it involves collection management, user needs assessment, or research activities, a foundational grasp of statistics is imperative. This article presents fundamental statistical terms for library and information science researchers to navigate and interpret data proficiently.

2. Essential Terminologies in Statistics

Before describing this in detail, we have to understand the Hypothesis, Variables, Population, Samples, Sampling, Levels of Measurement and Statistical Significance (Level of Significance).

2.1 Hypothesis

Hypotheses contribute to the systematic and structured nature of scientific inquiry, allowing researchers to make informed predictions, design experiments, and draw meaningful conclusions from their investigations. An integral part of conducting and writing research is the development of a hypothesis. Hypothesis can be defined as "untested statements that specify a relationship between two or more variables" (Nardi, 2003). Thus, it is a verifiable statement about the population characteristics (parameter) formulated with prior knowledge or based on theoretical considerations. Hypotheses are always stated as research questions in social science research.

2.1.1 Types of Hypothesis

Hypothesis is a tentative assumption, usually based upon some reasonable concept, made in order to generate interest in obtaining proof and to consider the consequences of the assumption (Van Nostrand's Scientific Encyclopedia, 2005). A scientific hypothesis is derived from a theoretical system and the results of past research (Gupta et al., 1989). In research, a hypothesis is a testable and falsifiable statement or prediction that suggests a relationship between variables or an explanation for a particular phenomenon. It is a crucial element in the scientific method and serves as the foundation for empirical investigation and analysis.
A hypothesis typically consists of two parts

Null Hypothesis (H*0*): This states that there is no significant difference or relationship between the variables being studied. It often represents the status quo or the absence of an effect.
Alternative Hypothesis (H*1* or H*a*): This posits a specific relationship or effect between the variables, suggesting that the observed data is not due to chance alone.

For each research question, two hypotheses are framed. The first one is the null hypothesis, usually denoted by H*0*, which assumes no relationship between variables. In accordance with the null hypothesis, there is no relationship in the population between the predictor and outcome variables. It is a hypothesis usually formulated in a way opposite to what we wish to prove. The second one is the Alternative Hypothesis represented by H*1*. It is simply the opposite of what we stated in the null hypothesis. The alternative hypothesis is the claim that there is a relationship. Since the alternative hypothesis cannot be directly evaluated, it is assumed to be true if the null hypothesis is rejected by the statistical significance test (Johnson & Christensen, 2014). The null hypothesis is generally the one constructed for scientific research. For a study titled "Perception of Artificial Intelligence (AI): A Survey of Research Scholars in the University of Kerala". Here, we can construct two hypotheses;

H*0* = Length of Research Experience of Scholars does not affect the perception of AI Tools.
H*1* = The length of scholars' research experience affects their perception of AI tools.

2.1.2 Objectives of framing hypothesis in research

Framing a hypothesis in research serves several important objectives, providing a structured and systematic approach to scientific inquiry. Here are the key objectives of formulating a hypothesis in research

Guiding Research: Hypotheses provide a clear direction and focus for research efforts. They help researchers define the scope and purpose of their study, guiding the investigation toward specific questions or predictions.

Testability: A well-formulated hypothesis is testable, meaning it can be empirically examined through observation or experimentation. This testability ensures that research can be conducted to either support or refute the hypothesis.

Predictions: Hypotheses make predictions about the expected outcomes or relationships between variables. These predictions serve as a basis for designing experiments or collecting data to validate or invalidate the hypothesis.

Organizing Information: Hypotheses help organize information and ideas, structuring the research process by providing a framework for data collection, analysis, and interpretation. This organization enhances the efficiency and coherence of the research.

Falsifiability: A good hypothesis is falsifiable, meaning it is possible to prove it wrong. This criterion ensures that research is conducted with an open mind, allowing for the exploration of alternative explanations or unexpected findings.

Precision and Clarity: Hypotheses require precise and clear statements defining the variables and relationships under investigation. This precision facilitates effective communication among researchers and ensures the study's goals are transparent.

Foundation for Theory: Hypotheses contribute to the development of scientific theories. When multiple hypotheses are supported by empirical evidence, they can be integrated into broader theoretical frameworks that explain and predict phenomena.

Risk Management: By explicitly stating the null hypothesis, researchers acknowledge the possibility that their initial assumptions might be incorrect. This recognition of uncertainty encourages intellectual humility and helps manage the risks associated with research.

Objectivity: Hypotheses contribute to the objectivity of research by providing a structured and systematic approach. Researchers can assess evidence objectively against the predictions made by the hypothesis, minimizing bias and subjectivity.

Communication: Clearly defined hypotheses facilitate communication within the scientific community. Researchers can share their hypotheses, methods, and results, allowing others to replicate or build upon the study.

Framing a hypothesis in research is a critical step that guides the investigation, facilitates the testing of ideas, and contributes to scientific inquiry's overall rigour and objectivity.

2.2 Variables

A variable is a characteristic or attribute that can take on different values in statistics. These values, which can vary from one observation to another in a dataset, represent the different manifestations of the variable. Variables are fundamental components in statistical analysis and research, allowing researchers to measure, analyze, and understand different aspects of a phenomenon.

Understanding and correctly identifying variables are crucial in statistical analysis, as they form the basis for formulating hypotheses, designing experiments, and interpreting research findings. Variables can be classified as either categorical (qualitative) or numerical (quantitative).

a) Categorical (Qualitative) Variables: These variables represent categories or groups and can be further divided into nominal variables (categories with no inherent order) and ordinal variables (categories with a meaningful order). Nominal data, which simply means named, is the kind that shows counts in various categories when there isn't a good reason to rank the categories. Fruit varieties, eye colour, and gender are a few examples. Ordinal means that it is possible to put the data into a logical rank order. Where the data consists of counts in categories, this means that there is some logical order for the categories (McCarroll, 2017).

b) Numerical (Quantitative) Variables: These variables represent measurable quantities and can be further classified as discrete (countable) or continuous (can take any value within a range). Discrete variables are limited to distinct, discrete values. Frequently, these values are entire numbers. The number of learners in a class or the number of vehicles in a parking lot are two examples. Any value within a specified range can be assigned to a continuous variable. These numbers can include decimals and are frequently measured. Temperature, weight, and height are a few examples.

2.2.1 Dependent and Independent Variables

Variables are classified in a study as Independent Variable (IV) or Dependent Variable (DV). Independent Variable is the variable that is manipulated or controlled in an experiment. It is the presumed cause or input in a study. Changes in the independent variable are thought to influence the dependent variable.

The dependent variable is the variable that is observed or measured in response to changes in the independent variable. It is the presumed effect or outcome. The dependent variable is what researchers seek to understand, predict, or explain.

The DV is the one the researcher measures, while the IV is the cause, or predictor, of what is being measured. The researcher manipulates this variable during the study.

The researchers are attempting to determine whether the length of research experience of research scholars can predict the perception of AI Tools. Here the variables are;

Dependent Variable: Perception of AI Tools

Independent Variable: Length of Research Experience

2.3 Population, Samples and Sampling

Although it is possible to study an entire population (census is an example of this), in research, samples are usually drawn from the population to make experiments feasible. The results of the study are then generalized to the population.

2.3.1 Population

In statistics, the term "population" refers to the entire group that is the subject of a study or analysis. It encompasses every individual, item, or element that shares a common characteristic or set of characteristics under investigation. The population is the complete collection from which a sample is drawn for analysis. Understanding the population is crucial because it forms the basis for generalizing conclusions from a study. However, studying an entire population may be impractical or too time-consuming.

For this reason, when choosing a "sample" to represent the entire population, researchers frequently choose a subset of the population. A population's features can be varied and can include individuals, things, occasions, or anything else that is pertinent to the study. The entire student body at a university, all the books in a library, or all the people who visit a website within a given time frame could all be considered the population of a research.

For instance, all homes in a nation would be included in the population if the researcher's goal was to determine the average income of each household in that nation. However, it might be more practicable to poll a representative sample of households to determine the average income for the total population.

To conduct relevant statistical analyses and make appropriate inferences about the larger group from the sample data, a clear understanding of the population is essential.

2.3.2 Sampling

It is important to note that studying an entire population is often impractical due to time, cost, and feasibility limitations. Instead, researchers typically work with a subset of the population, known as a sample, to make inferences about the entire population. Sample is a selected subset of population chosen by some process usually with the objective of investigating particular properties of the parent population

(Everitt, 1998). Sampling is the process of selecting a subset of individuals or cases from a larger population for the purpose of conducting research (Lind, Marchal, &Wathen, 2015). There are two main types of sampling techniques. Probability sampling and non-probability sampling.

2.3.2.1 Probability Sampling

Probability sampling involves randomly selecting participants from a population so that every member of the population has an equal chance of being selected. There are several types of probability sampling, including,

(a) Simple random sampling. It is the most basic form of probability sampling. In this method, individuals are chosen randomly from the population without bias or a systematic selection process.

(b) Stratified random sampling. In this method, the population is divided into strata (subgroups) based on specific characteristics (e.g., age, gender), and individuals are randomly selected from each stratum in proportion to their representation in the population.

(c) Cluster sampling. This method divides the population into clusters (e.g., geographic areas), and clusters are randomly selected. Then, individuals within each selected cluster are randomly selected for the study.

2.3.2.2 Non- probability Sampling

Non-probability sampling involves selecting participants non-randomly, often based on convenience or judgment. There are several types of non-probability sampling, including:

(a) Convenience sampling. In this method, participants are selected based on convenience or accessibility, such as students in a class or patients in a clinic.

(b) Purposive sampling. This method selects participants based on their specific characteristics or attributes relevant to the research question. For example, a researcher may select participants with a particular medical condition.

(c) Snowball sampling. In this method, participants are initially recruited based on some predetermined criterion and then asked to refer others who meet the same criteria. This method is often used in hard-to-reach populations.

2.3.3 Sample Size

The sample size is also significant to be able to generalize to a population accurately. Generally, the bigger the sample, the better. The Central Limit Theorem states that the larger the sample, the more likely the distribution of the means will be normal, and therefore, population characteristics can more accurately be predicted.

For quantitative research, the sample size can be calculated using statistical formulas that take into account the desired level of precision, confidence level, population size, and variability of the data (Lind, Marchal, &Wathen, 2015). One common formula (based on precision rate) used for calculating the sample size is the following: n = (Z^2 * p * q) / e^2; where n is the required sample size, Z is the Z-score corresponding to the desired level of confidence (e.g., for a 95% confidence level, Z=1.96), p is the estimated proportion of the population with the characteristic of interest, q is (1-p), and e is the desired margin of error. In 1970 Krejcie & Morgan (p.608) produced a table for determining sample size based on work done by the National Education Association.

2.4 Levels of Measurement

S. S Stevens has classified the different types of measurement scales in to four categories.

- Nominal or Classificatory Scale: a scale of measurement that uses symbols, such as words or numbers, to label, classify or identify people or objects. (i.e., 1 = male; 2 = female).
- Ordinal or Ranking Scale: a rank order scale measurement. It increases and decreases at regular intervals. The best example is the Lickert Scale: 1 = very poor; 2 = poor; 3 = average; etc.
- Interval Scale: an interval scale has all the characteristics of an ordinal scale. In addition, it uses a

unit of measurement with arbitrary starting and terminating points (Celsius scale: 0 degrees to 100 degrees, Fahrenheit scale: 32 Fahrenheit to 212 Fahrenheit).

- Ratio Scale (known as Scale, Continuous or Interval): a ratio scale has all the properties of ordinal, nominal and interval scales plus its property: the zero point of a ratio scale is fixed, which means it has a fixed starting point.

2.5 Statistical Significance (Level of Significance)

The level of significance is the probability of rejecting a true hypothesis. In LIS, it is usually set at 0.5 or 0.1, which means that the null hypothesis is rejected if the sample results are among these results that have occurred no more than 5% or 1% of the time. Common levels of significance (represented by *alpha* or *α*) are 5%, 1% and 0.1%; if *alpha* = 0.01, it is stated that there is a one in one thousand chance this happened by coincidence.

2.6 Validity and reliability

Validity and reliability are essential concepts in data collection (Drost, 2011). Validity refers to the extent to which the data collected accurately reflects the research question or topic. Reliability refers to the consistency and stability of the data collected. To ensure validity and reliability in data collection, researchers use appropriate data collection methods, establish clear and consistent procedures, and use standardized instruments and protocols.

2.6.1Validity

The degree to which a measurement tool, such a test or survey, reliably measures what it is intended to assess is referred to as validity. The accuracy and reliability of a statistical conclusion or inference drawn from the data and methods used in the study are referred to as validity. If a study or experiment measures what it is supposed to measure and is devoid of biases and errors, then it is deemed legitimate. Several forms

of validity, including as content, construct, and criterion validity, can be used to evaluate validity in quantitative research.
(i) The extent to which a measuring instrument addresses every pertinent facet of the idea being assessed is referred to as content validity. Expert opinion and a literature study are the two methods used to ensure content validity.
(ii) The degree to which a measurement instrument accurately captures the theoretical construct it is designed to capture is referred to as construct validity. Construct validity consists of two parts: divergent and convergent validity.
(iii) The degree to which a measurement instrument corresponds with an external criterion, like another measurement tool or an observable behaviour, is known as criterion validity.

2.6.2 Reliability

A measurement tool's consistency and stability across time and in many contexts are referred to as its reliability. Several forms of reliability, such as test-retest, inter-rater, and internal consistency reliability, can be used to evaluate dependability in quantitative research.
(i) Test-retest reliability refers to the degree to which a measurement tool produces the same results when administered multiple times to the same group of participants.
(ii) Inter-rater reliability refers to the degree to which different raters or observers produce consistent results when using the same measurement tool.
(iii) Internal consistency reliability refers to the degree to which different items in a measurement tool are consistent with each other. Researchers are required to measure and report the Cronbach’s alpha coefficient of their research instruments when using Likert Scale for its internal consistency reliability (Santos, 1999).

2.7 Data Analysis

Data analysis examines and interprets data collected through various methods and techniques to answer the research question (Creswell, 2012). Data analysis involves organizing, cleaning, coding, and transforming data to derive meaningful insights and conclusions (Saunders, Lewis, & Thornhill, 2007). Depending on the type of research topic and the data gathered, data analysis might use both quantitative and qualitative methodologies.

2.7.1 Descriptive Statistics

In the data analysis flow, a researcher first gets a summary (e.g., mean and variance) of the data obtained from the sample. This is known as descriptive statistics. This technique involves summarizing and describing the characteristics of a set of data, such as the mean, median, and standard deviation (Lind, Marchal, & Wathen, 2015). When the data are further analyzed (e.g., comparing the mean of two groups, analysis of variance) to conclude the population, it is known as inferential statistics. The inferential statistics are conducted after conducting descriptive statistics, and results are also presented with descriptive statistics such as percentage, mean, median, and standard deviation.

The first step of descriptive statistics is sorting the data into groups. Sometimes, sorted or grouped data are presented with figures to augment the understanding of the sample data. The next step is to summarize the data, commonly with the measures of central tendency such as mean, mode, and median and with measures of spread such as range, interquartile range and standard deviation.

2.7.1.1 Measures of Central Tendency

Measures of Central Tendency provide information about how the results are grouped. There are three measures, and which one to use depends on what level of measurement the variable is.

2.7.1.1.1 Mean

Mean (represented by M or μ) is the most commonly referred to measure of central tendency. It is the average measure, where each value is added and then the sum is divided by the number of cases. However, it should be quite clear that the mean cannot be used with nominal and ordinal variables.

2.7.1.1.2 Median

Median (represented by Mdn) is the measure commonly used with ordinal data. The Median is the halfway point of the data. To calculate simply order your values from lowest to highest and see at what value half the data is below, and half is above. The Median is also an extremely valuable measure for ratio data when there are outliers (think how the average income variable would be skewed in a town with one multimillionaire). This is because the Median is not affected by how far away from the middle values are; it is just the quantity.

2.7.1.1.3 Mode

Mode is often used with nominal data (though it can also be calculated for other variable types). It is simply the most frequently occurring value in a dataset. An example of when this would be an appropriate measure is for a major. The average major makes no sense, nor does the halfway point major, but the most frequently occurring major does.

2.7.1.2 Measures of Spread

Measures of central tendency reveal much about data but not the whole story. Measures of spread will tell whether the values are clustered around the mean or more spread out. There are three main statistical methods for determining spread.

2.7.1.2.1 Range

Range is the most basic measure; it is calculated simply by subtracting the lowest score from the highest score. However, this is not the most accurate method as the range can be skewed by outlier values (a very high or very low score).

2.7.1.2.2 Interquartile Range

The interquartile range is less likely to be distorted by outliers, as it is calculated by ordering the sample from highest to lowest, then dividing the sample into four equal quarters (percentiles). The Median is then calculated for each quartile. Subtracting the median of the first quartile from the third quartile obtains the interquartile range.

2.7.1.2.3 Standard Deviation

Standard deviation (represented by SD or σ) is the most sophisticated measure of spread and a widely used statistical concept. Because standard deviation relies on calculations of the mean, it can only be used with continuous variables. A standard deviation score of 0 indicates that there is no variation in values. The higher the standard deviation, the larger the spread.

2.7.2 Inferential Statistics

Descriptive statistics is the first step to getting an insight into research data. When researchers know the central tendency and the distribution of the data, they decide on the inferential statistical analysis plan. Research data are first organized and visualized with the help of descriptive statistics. The next step is the inferential statistics. Inferential statistics are a set of techniques used to make inferences about a population based on data obtained from a sample of that population. These statistics are used to test hypotheses, estimate population parameters, and make predictions about future events (Kumar & Garg, 2018). The following are some examples of inferential statistics. The result of the inferential statistics helps to conclude the finding. Common inferential statistical tests which are applied in Library and Information Science research are the following;

- One-sample t‐test or single-sample t-test
- Independent samples t- test
- One‐way ANOVA
- Mann‐Whitney U test
- Kruskal‐Wallis test
- Friedman test
- Pearson correlation test
- Spearman correlation test
- Chi‐square

Inferential statistics is a pivotal analytical tool in research, allowing researchers to draw broader conclusions and make inferences about populations based on sample data. Unlike descriptive statistics, which summarize and organize data, inferential statistics involve making predictions, generalizations, and hypotheses testing. By utilizing various statistical tests, such as t-tests, ANOVA, and correlation analyses, researchers can explore relationships between variables, assess the significance of observed effects, and determine the reliability of their findings. Inferential statistics not only aids in uncovering patterns within datasets but also plays a crucial role in guiding decision-making processes and influencing policy recommendations. Its application extends across diverse fields, including science, social sciences, and business, facilitating a deeper understanding of the broader implications of research outcomes beyond the confines of the observed sample. Overall, inferential statistics contributes to the robustness and generalizability of research, providing a powerful tool for researchers to make informed and impactful contributions to their respective fields.

3. Conclusion

A solid understanding of fundamental statistical terminology is indispensable for Library and Information Science researchers. Researchers can improve their capacity to glean insightful information from data and adjust to the ever-changing information environment by adopting statistical literacy. The fundamental ideas discussed in this study provide the foundation for carrying out thorough and significant research in the field. These ideas serve as the foundations for solid studies, from descriptive statistics that offer a glimpse of the data distribution to inferential statistics that allow researchers to make more general conclusions.

Moreover, the exploration of measures of central tendency, variability, and correlation equips researchers with the tools necessary to uncover patterns, trends, and relationships within datasets. This knowledge is paramount for making informed decisions and recommendations in the realm of library and information science. It is impossible to exaggerate the importance of statistical literacy since it enables researchers to properly design experiments, assess the body of current literature critically, and interpret results. For academics working in this subject, being able to understand and use statistical approaches becomes increasingly important as technology develops and the amount of data available increases tremendously.

Fundamental statistical terminology mastery, in essence, improves the calibre and legitimacy of library and information science research projects. Adopting these fundamental ideas can help academics make significant contributions to the field's knowledge base and promote evidence-based decision-making in the ever-changing information management and services sector.

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