Hypothesis Testing

Hypothesis testing in statistics is a fundamental method used to make inferences or draw conclusions about a population based on sample data. It involves formulating and testing hypotheses, which are statements about a population parameter, such as the mean or proportion.

Steps

1 Formulation of Hypotheses:

- **Null Hypothesis (H0): This is the hypothesis that there is no significant effect or difference, and it represents a statement of "no change" or "no difference". It's the hypothesis that is initially assumed to be true.**

- **Alternative Hypothesis (H1 or Ha): This is the hypothesis that indicates the presence of an effect or a significant difference that the researcher aims to prove.**

Steps

2 Choice of Test Statistic:

A test statistic is a standardized value derived from sample data, used to decide whether to reject the null hypothesis. It's calculated based on the data and the type of test being performed (e.g., t-test, chi-square test, Z-test).

Steps

3 Significance Level (α):

The significance level, often set at 0.05 (5%), is the probability of rejecting the null hypothesis when it is actually true (Type I error). It's a threshold for determining whether the observed data is sufficiently extreme to reject the null hypothesis.

Steps

4 Calculation and Decision:

- **Calculate the test statistic and compare it against a critical value determined by the chosen significance level, or calculate the p-value (probability of observing the data if the null hypothesis is true) and compare it with α.**

- **If the test statistic is more extreme than the critical value, or if the p-value is less than α, the null hypothesis is rejected in favor of the alternative hypothesis.**

Types of Hypothesis Tests:

There are several types of hypothesis tests, each suitable for different kinds of data and research questions. Here are some of the main types:

Name of Test	Use Case	Type of Data	Main Goal	Example
Z-Test	Large sample size, known population standard deviation	Quantitative	Test mean against known population mean	Comparing average test scores to national average
One-sample T-Test	Unknown population standard deviation, single group vs known mean	Quantitative	Test mean against known population mean	Testing the mean salary of a small company against the industry average
Independent two-sample T-Test	Compare means of two independent groups	Quantitative	Test difference in means	Comparing average blood pressure between two groups
Paired T-Test	Compare means of the same or paired groups	Quantitative	Test difference in means	Testing the effect of a drug before and after treatment in the same patients
Chi-Square Goodness of Fit Test	Test if sample matches a population distribution	Categorical	Test fit to expected distribution	Testing if dice are fair based on rolled numbers
Chi-Square Test for Independence	Test independence between two categorical variables	Categorical	Test for association/independence	Examining if there's a relationship between gender and voting preference
One-way ANOVA	Compare means across groups split on one variable	Quantitative	Test difference in means across multiple groups	Comparing test scores across different teaching methods
Two-way ANOVA	Compare means across groups split on two variables	Quantitative	Test difference in means across multiple groups	Examining the effect of diet and exercise on weight loss
F-Test	Compare two population variances	Quantitative	Test equality of variances	Comparing variances of test scores between schools
Mann-Whitney U Test	Compare two groups, non-normal distribution	Quantitative	Test difference in medians	Comparing reaction times of two different age groups
Wilcoxon Signed-Rank Test	Compare two related samples or repeated measurements	Quantitative	Test difference in medians	Assessing pain levels before and after treatment in the same patients
Kruskal-Wallis H Test	Compare medians of three or more groups, non-normal distribution	Quantitative	Test difference in medians across multiple groups	Comparing exam scores across different study groups with varying study habits

Consideration of Errors:

- **Type I Error (false positive): Rejecting the null hypothesis when it is actually true.**

- **Type II Error: Failing to reject the null hypothesis when it is actually false(false negative). The probability of a Type II error is denoted by β, and (1-β) is known as the power of the test.**