Indian Journal of Forensic Medicine and Toxicology
Volume 16 No. 3, July-September 2022
DOI: http://dx.doi.org/xxxxx/ijfmt.xxxx.16322.58

Periodontal Research Wars: Navigating Through Minefield of Statistical Jargon

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How to cite this article: Shalini Mundra, Neetha J. Shetty, Srikant N et al. Periodontal Research Wars: Navigating Through Minefield of Statistical Jargon. Indian Journal of Forensic Medicine and Toxicology 2022;16(3):329-338.

Abstract

Statistical analysis is considered to be the backbone of research and however challenging it is to a clinician, it plays a crucial part for a researcher to comprehend the various presumptions underlying the statistical methods. In the field of periodontology, statistical analysis is routinely used for management and interpretation of data. Yet, many periodontists find it difficult to understand the various statistical methods used in periodontal researches. Thus, this paper aims to cover the basictenetsof statistical analysisin a simplified manner with the help of flowcharts, specially emphasising on understanding few crucial points beforechoosing any statistical test. Later section of the article takes an application-based approach by incorporating the already illustratedflowcharts and crucial points.

Keywords: Statistical analysis; tests of significance; periodontal research; research methodology; data; flowcharts.

Introduction

Research is a movement from known to the unknown. (Kothari CR, 2004) It is a way to fulfil one's inquisitiveness. In the era of an ongoingpandemic, people are more inclined towards research. Curiosity about the new virus, the quest to formulate a new vaccine or mere desire to be of service to society is motivating the masses to undertake research. Over recent years, the field of Periodontology per se has observed a massive leap in varied aspects of clinical, epidemiological and molecular research — from formulating new diagnostic criterias to solving various enigmas pertaining to the treatment aspects of periodontal disease. (Avula H et al., 2013) Recently, periodontal research is focused more on an evidence-based approach i.e., to find, evaluateand incorporate current evidence into dentists' decision making process.(Newman MG et at., 2006)Thus, research has become an integral part of periodontal studies.

The purpose of a research is to find out answers to questions through the implementation of scientific procedures. Scientific research starts with preparing

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a research question, followed by identifying research design and finally testing the null hypothesis. (Kothari CR, 2004).

The following flowchart (Fig 1) illustrates the steps necessary for the research process.(Kothari CR, 2004).

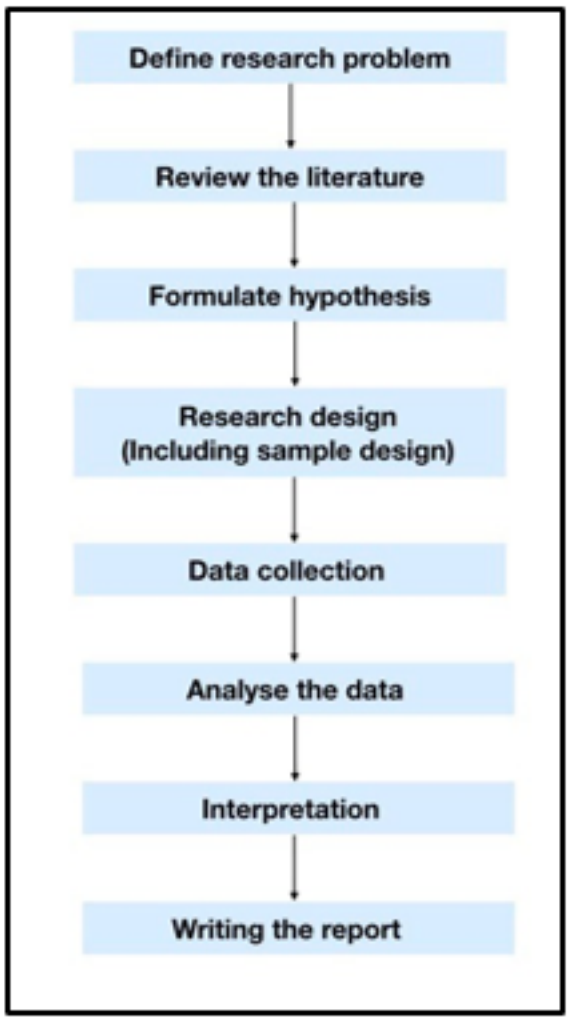

Fig 1: Flowchart of Research process

After defining research problem, formulating null hypothesis and data collection, the researchers analyse the data. (Avula H, 2013) In the process of analysis all the difference of opinions concerning original and new hypothesis are subjected to statistical methods. A periodontal researcher mostly stumbles here in decision making process of choosing the most appropriate statistical test. Therefore, the following sectiondiscussesa few crucial points to consider before applying a statistical test.

Crucial Points

1. **Variable**: Characteristics of an observation in the population or value of something that is measured or counted in a study. The types of variables are:

   A. Dependent variable

   B. Independent variable

Dependent variable is a variable that is affected or explained by another variable andmeasures the outcome of interest or effects. Whereas, Independent variable causes effect on the dependent variable.[4]

For example – People with periodontitis are more susceptible to bone loss and tooth mobility. Here, periodontitis is causetherefore,an independent variable whereas bone loss and tooth mobility are the effectstherefore, dependent variables.

2. **Data**: Data is the basic observation or measurement collected through primary or secondary source. Data can be classified as: (Avula H, 2013)

   A. Categorical (by ordinal and nominal scale)

   B. Continuous or discrete/counts

For example– change in pocket depth from 5mm to 3mm after Scaling and Root planing (SRP) is a continuous value. On contrary, a patient's Calculus index(CI) describes either the calculus is present/ absent or it can be categorised into poor, fair & good therefore, a categorical data.

Table 1 shows various types of data in periodontology with examples.

Table 1: Types of data in periodontology

Categorical Data	Continuous Data
NOMINAL: data that is described by names • Reason for dental visit (check-up/ routine/ treatment/emergency) • Gender (male/female) • Disease(present/absent): dichotomous or binary variables.	**DISCRETE: data in form of whole numbers that can be counted** • Probing depth (3mm, 4mm, 5mm) • Bone loss in mm • Width of keratinised tissue in mm • No of teeth lost due to periodontitis

ORDINAL: data that can be arranged in an ordered manner	**CONTINUOUS: data in the form of fractions or decimals**
• Grades of tooth mobility (I, II, III), • Gingival recession / Furcation grades (I,II,III,IV) • Bleeding scores (mild, moderate, severe)	• Height (184 cm) • Weight (52.7 kg)

The raw data collected after the study is formulated in the master table and is subjected to statistical analysis to draw statistical inferences. The Flowchart of Data Presentation (Fig 2) describes the presentation of data for the distribution of different variables.

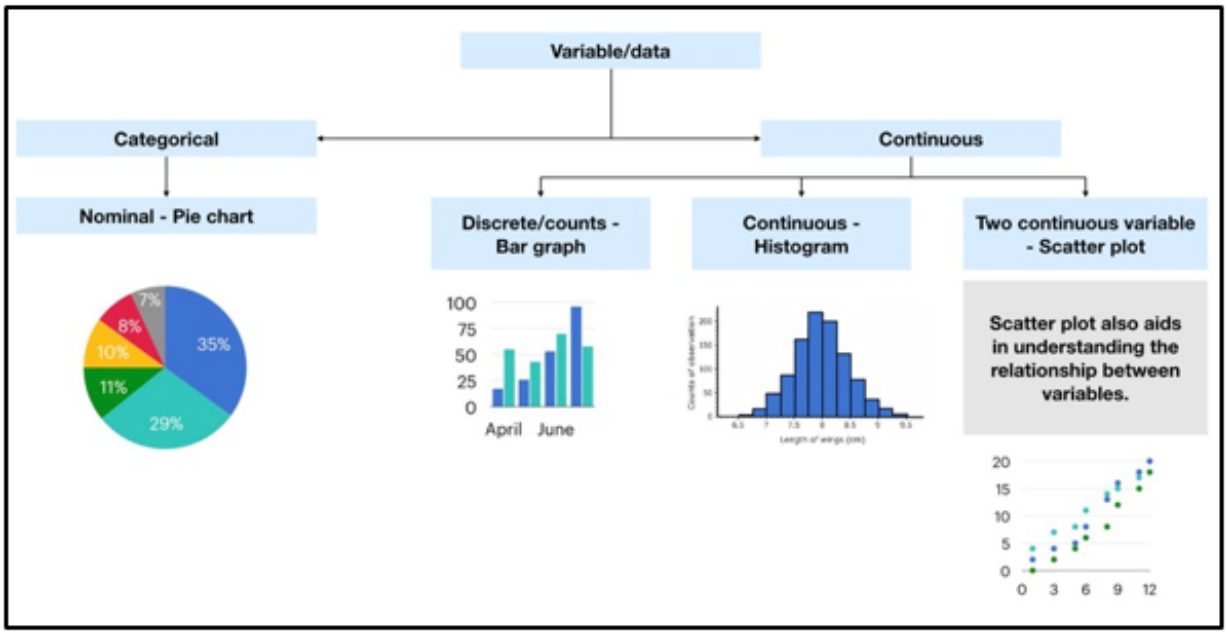

Fig. 2: Flowchart of Data Presentation

3. **Paired and Unpaired Data**: The relationship between data and population is important. (Avula H, 2013) They can be categorised into:

   A. Independent/unpaired data: Data obtained from two unrelated groups. For example– male or female, from two or three modalities of treatment.

   B. Dependent/paired data: Data obtained from same individual. For example – to determine probing depth in the same group before and after scaling and root planning(SRP), split mouth studies (data collected from left and right side is paired)

4. **Normal Distribution**: Continuous variables are defined by normal distribution. (Antonisamy B, 2017) When the data is normally distributed the mean (numerical average), median (middle value) and mode (most common value) are approximately the same. But, when the data do not follow a normal distribution, it can be skewed to either left or right side.(Fig 3)

Three important properties of distribution are: (Antonisamy B, 2017)

a. Location (described by averages — mean, median and mode)

b. Dispersion (mean and standard deviation distribution with respect to each other)

c. Skewness (asymmetry if any in a distribution)

In Figure 3

- In a normal distribution curve: mean = median = mode.

- In a negatively skewed/skewed to left curve: peak towards right and extreme values lie towards left.
- In a positively skewed/skewed to right curve: peak towards left and extreme values lie towards right.
  - **Note:** to assess the fit of distribution for continuous variable **Kolmogorov-Smirnov test** (common test for goodness of fit) is done.

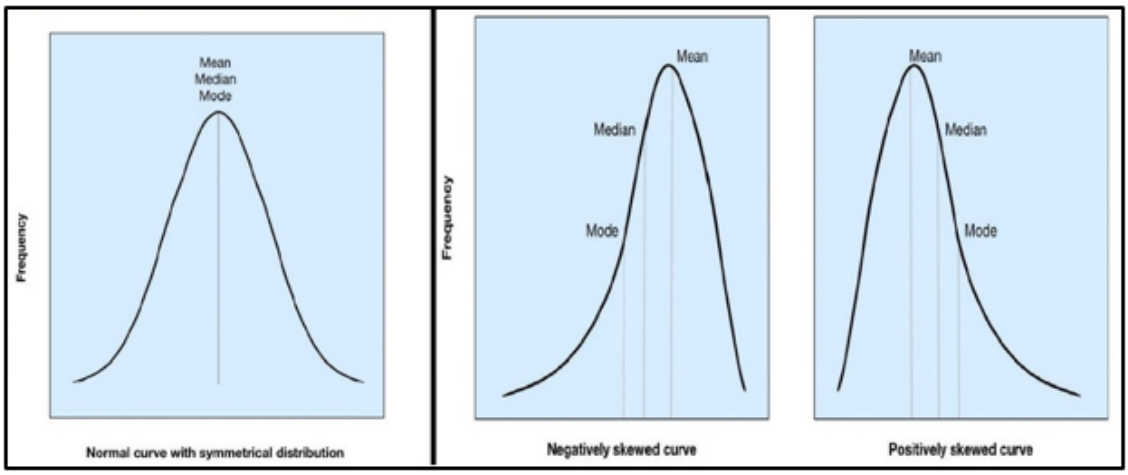

Figure 3: Data Distribution

Choosing a Statistical Test

We must be cognisant of the following questions before applying any test.

Q 1. What is your (statistical) objective?

Ifthe objective is to describe or summarise the data, descriptive statistics is used and if it requires to make a correlation/ find associations/ draw conclusions, inferential statistics is used.

Forinstance, if a researcher wants to assess the oral hygiene status in a population between 18-60 years of age in India and he/she collects thefollowing information— age, sex, occupation, number of times of brushing, dental visits per year and reason for the visits. The data obtained from this studywill becompiled together, summarised and arranged in tables/ graphs/ pie charts in order to provide a description of the population. Thus, descriptive statistics are used to describe and provide statistical information about the collected data.

On contrary,if a researcher found that brushing twice daily reduces the chances of oral health problems in a sample and he/she wants to extrapolate this finding to the population and draw conclusions about the whole population using sample, then inferential statistics is applicable.(Antonisamy B, 2017)

Kindly refer to the Flowchartof Structure of Statistical Analysis (Fig 4).

- **Descriptive Statistics:** Summarizing data

Data that is collected from a large number of subjects as individual observations is described using summary measures. The Flowchart of Summary Measures (Fig 5) presents the appropriate summary measure for each type of variable.

- **Inferential Statistics:**

The inferential statistics is mainly applied to test the tentative hypothesis postulated by the researcher. In general, null hypothesis is the hypothesis that suggests an absence of difference, association or effect, the negation of which provides evidence for presence of difference, association or effect.

Tests of significance (Fig 6) are solely based on the null hypothesis. These are used to evaluate the evidence in sample as to whether or not the null hypothesis should be rejected.

To investigate the relationship between two continuous variables correlation and regression analysis are used. Correlation analysis measures the strength of the linear relationship between two continuous variables, whereas regression expresses the relationship in form of an equation, which enables one to predict the value of one variable for the given value of the other variable.

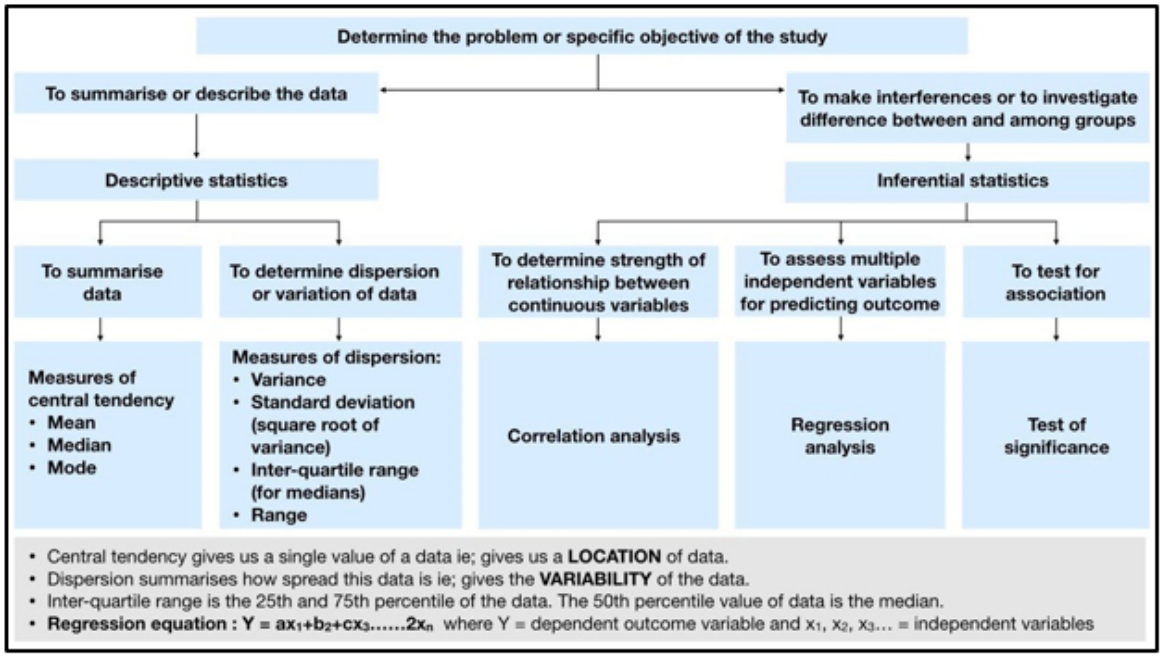

Figure 4: Flowchart of Structure of Statistical Analysis

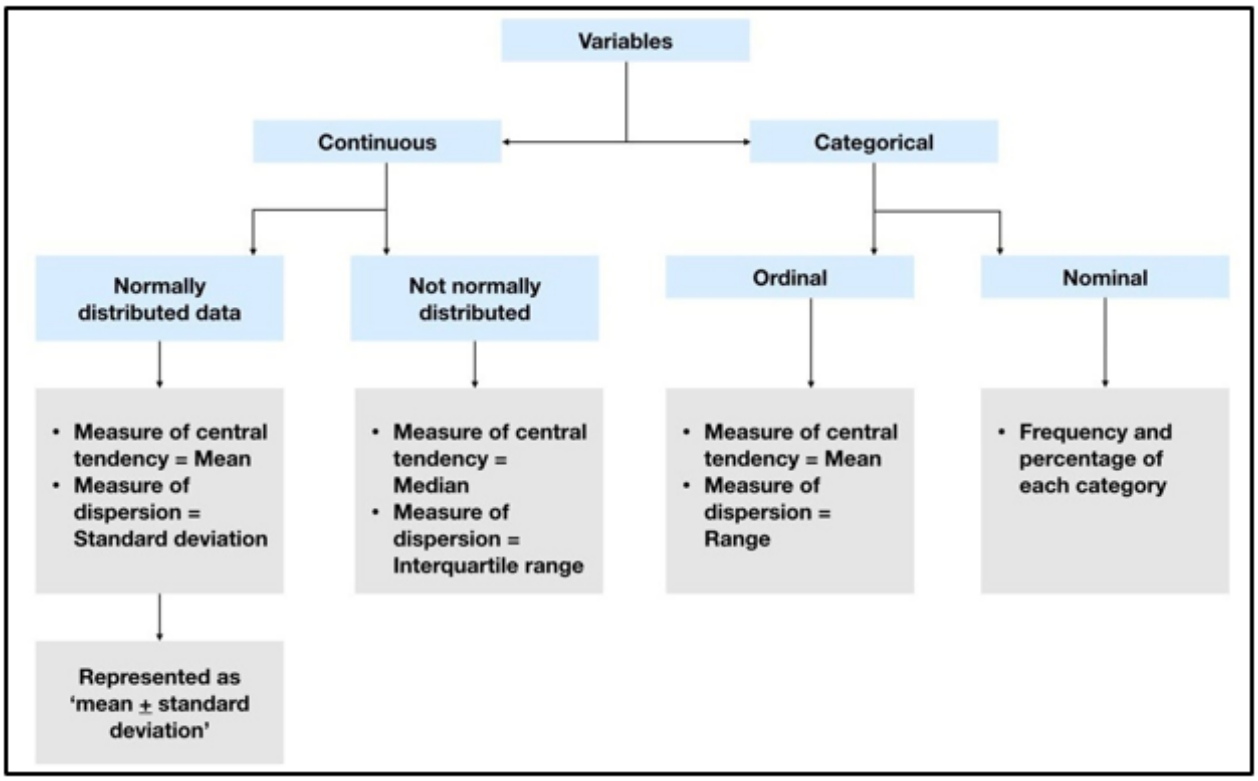

Figure 5: Flowchart of Summary Measures

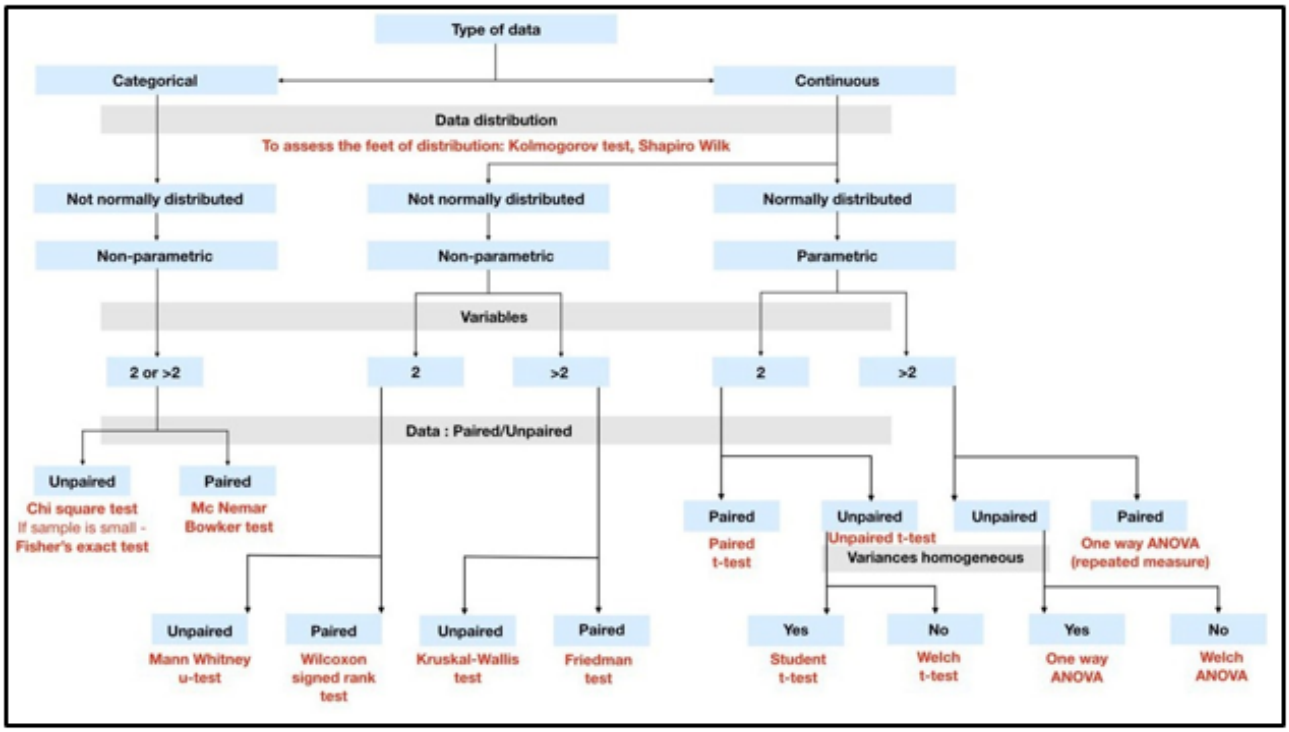

Figure 6: Flowchart of Tests of Significance

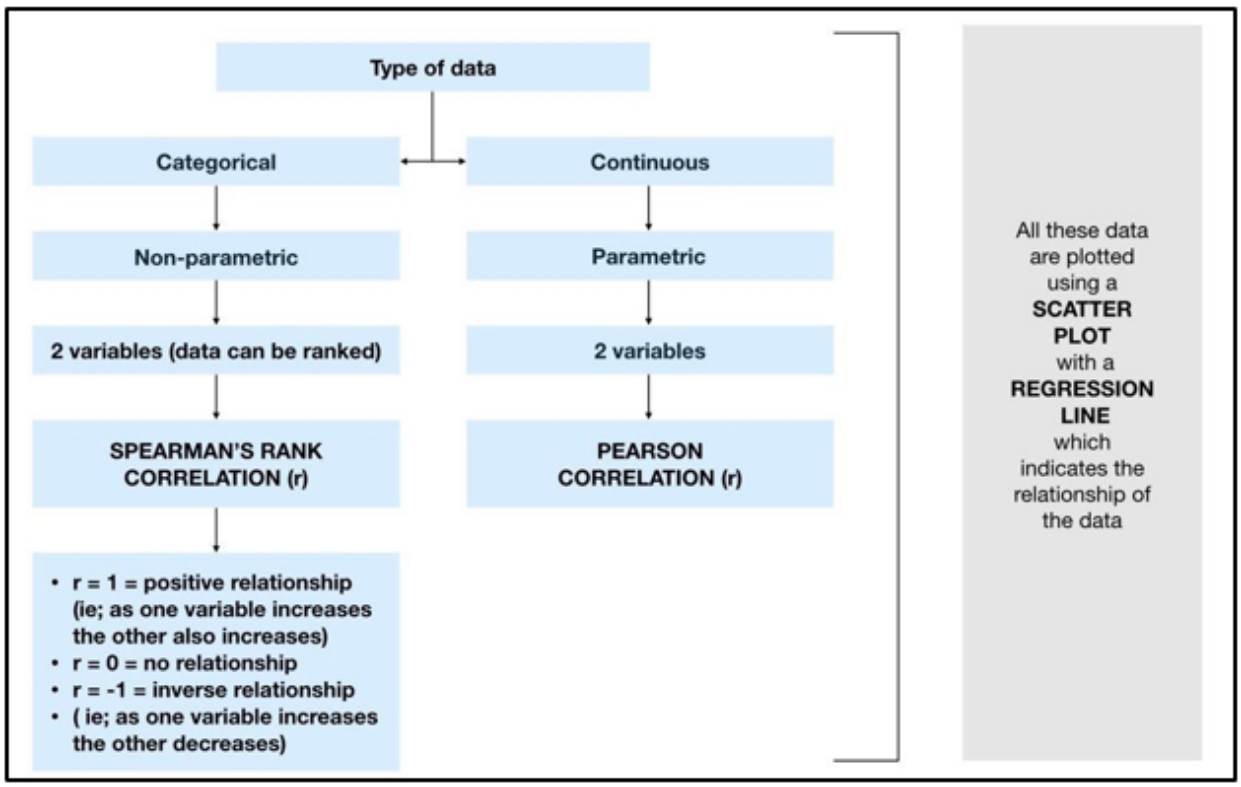

Figure 7: Flowchart of Correlation Analysis

For example, in a study on obesity and periodontitis, the relationship between the body mass index (BMI) and periodontal parameters can be examined using the two closely related techniques of correlation and regression (Fig 7). (Antonisamy B, 2017)

Q 2. What is the kind of data and how is it distributed?

The distinction between data is important because the nature of a set of data will give us the idea in choosing a particular statistical test.The categorical data is said to be non-parametric but a continuous variable has to be tested for normality.

Shapiro Wilk test or Kolmogorov Smirnov tests can be used to identify normal distribution of data. If normally distributed, parametric tests are advised but if the continuous data are highly skewed,non-parametric test are applicable.

Alternatively, when normality assumption does not hold, appropriate transformation can be tried and then parametric test can be used. If the transformation is not yielding normality, non-parametric approach is advised.(Antonisamy B, 2017)

Parametric tests are comparison for means and Standard deviation whereas non parametric tests are comparison of medians and inter-quartile range / proportion.

Q 3. How many variables or groups are present? Is the data paired or unpaired?

It is important to know the number of groups or whether the data is paired or not as there are different tests for 2 variables/ for more than two variables and for paired/unpaired data.

Examples

1. A study aims to compare the effect of deep scaling alone v/s deep scaling with metronidazole gel in chronic periodontitis patients. Periodontal parameters assessed were probing pocket dept (PPD) and clinical attachment level (CAL) after 3 months. (Abt E, 2011)

Explanation:

1. What is the statistical objective?	• To determine the significant difference between groups and make conclusion which is effective → Inferential statistics: Tests of Significance.
2. What is the type of data	• Continuous data (PPD, CAL in mm) • Assume normally distributed → parametric test
3. How many groups are present?	• 2 groups: a. Deep scaling alone after 3 months b. Deep scaling with gel after 3 months
4. Is the data paired or unpaired?	• Unpaired as the two groups are different patients with unmatched data.
5. Which test?	• Independent Student -T Test

2. A study aimed to compare the efficiency of manual toothbrush v/s electric tooth brush in 100 periodontally healthy individuals. The full mouth oral hygiene status using Simplified oral hygiene index (OHI-S) was assessed in all the individuals who regularly visited the dental clinic.

Explanation:

What is the statistical objective?	• Compare and determine significant differences between groups → Inferential statistics: Tests of Significance.
What is the type of data	• Categorical data (OHI-S index is assessed as excellent,good,fair and poor— ordinal data) • Assume not normally distributed →non-parametric test
How many groups are present?	• 2 groups: n = 100 a. n = 50 individual using manual tooth brushes b. n = 50 individuals using electric toothbrushes
Is the data paired or unpaired?	• Unpaired as the two groups are different patients with unmatched data.
Which test?	• CHI SQUARE Test

3. The study aimed to evaluate the efficacy of Vitamin D-3 supplements (2000 IU/Day – Group 1; 1000 IU/Day – Group 2; placebo group – Group 3) taken after Scaling and root planning in moderate or severe periodontitis patients. Clinical parameters assed were probing pocket dept (PPD); clinical attachment loss (CAL) and bleeding index (BI) after 6 months of intervention. The parameters were graded as following:

	Mild	**Moderate**	**Severe**
Probing pocket depth	4mm	4-6mm	≥6mm
Clinical attachment loss	2mm	2-3mm	≥4mm
Bleeding index	1	2	3

Explanation:

What is the statistical objective?	• To determine significant differences between groups →Inferential statistics: Tests of Significance.
What is the type of data	• Continuous converted to Categorical data (measured as mild, moderate and severe) • Assume not normally distributed → non-parametric test
How many groups are present?	• 3 groups a. 2000 IU/day V-D3 b. 1000 IU/day V-D3 c. Placebo
Is the data paired or unpaired?	• Unpaired.
Which test?	• Kruskal Wallis Test (for continuous variable) • CHI SQUARE Test (for categorical variable)

4. In a split mouth study, 20 patients exhibiting multiple maxillary miller class I &II gingival recession were treated with Modified coronally advanced flap (MCAF) on and MCAF with chorion membrane. Primary outcome variable was complete root coverage and was assessed at baseline and at 12months post operatively.

Explanation:

What is the statistical objective?	• To determine the significant difference between groups →Inferential statistics: Tests of Significance.
What is the type of data	• Categorical data (gingival recession - grade I & II) • Assume not normally distributed →non-parametric test
How many groups are present?	• 2 groups: a. MCAF alone one side of split mouth b. MCAF with chorion on other side of split mouth
Is the data paired or unpaired?	• Paired as the two groups are same patients (split mouth)
Which test?	• Wilcoxon Signed Rank Test • Mann Whitney U-Test if not split mouth i.e., if groups are unpaired.

5. In astudy 20 patients with Grade II mandibular furcation were treated with Modified Coronally Advanced Flap (MCAF) +Guided Tissue Regeneration (GTR) membrane, MCAF + Platelet Rich Fibrin (PRF) and MCAF+Emdogain. Clinical parameters measured were probing pocket depth (PPD)at mid bifurcation, clinical attachment level(CAL) and horizontal depth of furcation at baseline and at 12 months.

Explanation:

What is the statistical objective?	• To determine the significant difference between groups →Inferential statistics: Tests of Significance.
What is the type of data	• Continuous data (PPD, CAL & horizontal depth of furcation in mm) • Assume normally distributed →parametric test
How many groups are present?	• 3 groups: a. MCAF + GTR b. MCAF + PRF c. MCAF + EMDOGAIN
Is the data paired or unpaired?	• Unpaired as the two groups are different patients with unmatched data.
Which test?	• ONE – WAY ANOVA • POST HOC TUKEY TEST

Conclusion

A sound knowledge of all the intricacies pertaining to research methodology has become a pre-requisite for all the students and researcher, so asto help in understanding and critically evaluating the research studies published in their respective fields. Unfortunately, the technicalities and mathematical equations associated with statistical methods makes it very difficult for dental researchers to implement the acquired knowledge into practiceas the available materialdoes not focus on the dental practitioners' choice of interest. A sincere attempt is made in this article by simplifying the basics of data analysisin order to facilitate dental researchers'help in implementation of various statistical testsso consequently interpret the published results in

various studies and herebysuccessfully negotiating a pathway through the minefield of statistical jargon.

Ethical Clearance: Taken from Institutional Ethics Committee, Manipal College of Dental Sciences, Mangalore *(A constituent institution of MAHE, Manipal)*

Source of funding: NIL

Conflict of Interest: NIL

Abbreviations

Abbreviation	Full Form
SRP	Scaling and Root planning
CI	Calculus Index
BMI	Body Mass Index
PPD	Probing Pocket Depth
CAL	Clinical Attachment Level
OHI-S	Simplified Oral Hygiene Index
BI	Bleeding Index
MCAF	Modified Coronally Advanced Flap
GTR	Guided Tissue Regeneration
PRF	Platelet Rich Fibrin

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