Review Article

Deciphering the Dilemma of Parametric and Nonparametric Tests

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Abstract

The potential source of complexity while analyzing the data is to choose on whether the data collected could be analyzed properly by the application of parametric tests or nonparametric tests. This concern cannot be underrated as there are certain assumptions which should be fulfilled before analyzing the data by applying either of the two types of tests. This article describes in detail the difference between parametric and nonparametric tests, when to apply which and the advantages of using one over the other.

Key words: Homogeneity of variance, independence, level of measurements, nonparametric, normal distribution, parametric

Introduction

Statistics is a vital tool to provide the inference in medical research. Choosing an appropriate statistical test plays a vital role in analysis and interpretation of the research data. In the past four decades, it has been observed that use of diversified statistical methods has amplified to a greater extent in medical research publications; however, it is pertinent to mention here that the standards of reporting statistical tests and using them are very low as many shortcomings and pitfalls have been observed in the studies published in past in various biomedical journals. This is a serious problem, and it leads to misleading conclusions, wrong inferences, hazardous clinical consequences, and utter waste of resources.

With the wider availability of statistical software, performing statistical analysis has become very easy; however, selection of an appropriate statistical test is still lacking behind which leads to wrong study findings and misleading inference. Selection of an appropriate statistical test depends on (1) nature of the data, (2) does the data follow normal distribution or not, and (3) what is the study hypothesis. The potential source of perplexity while deciding on which statistical test to use for analyzing the data is whether the data allow for the use of parametric or nonparametric test procedures. The magnitude of this concern cannot be underrated. Before selecting the one between these two, a researcher must be aware about the underlying differences, advantages, and disadvantages of using one over the other.[1,2]

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Parametric Tests

A parametric test is one which makes assumptions about the parameters of the population distribution(s) from which the sample has been drawn. In the parametric test, assumption is made through sample population. If the information about the population from which the sample has been drawn is completely known through its parameters than the test is called the parametric tests. The common assumptions underlying parametric tests are as follows:

- The observations must be independent - independence of observation means that the data are not connected to any factor that could affect the outcome. For example, a

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person is hypertensive or not it does not depend on his/her choice of color. When we talk about the independence of observations between groups, it means that the patients in both the groups under study are separate. We do not want any patient to appear in both the groups
- The observation must be drawn from a normally distributed population
- The data must be measured on an interval or ratio scale.

Nonparametric Tests

Nonparametric tests are usually referred as distribution-free tests. A nonparametric statistical test is the one that does not necessitate any conditions to be fulfilled about the parameters of the population from which the sample was drawn. Nonparametric tests can also be used when the data are nominal or ordinal.[3,4] Nonparametric tests are also applied to the interval or ratio data which do not follow the normal distribution.

Dilemma of Using Parametric versus Nonparametric Tests

To simplify the issue, one should remember:
- Scale of measurement of the data - Figure 1 illustrates the use of parametric or nonparametric tests according to the measurement scales
- Population distribution - Figure 2 describes the use of parametric and nonparametric test according to the type of population distribution
- Homogeneity of Variances - for applying parametric tests, it must be ensured that the variances of the population are equal. On the other hand, no such assumption is required to be fulfilled for application of nonparametric tests
- Independence of samples - for parametric tests to be used the samples drawn from the population must be independent. No such assumption is required for nonparametric tests.

Limitations of Nonparametric Tests

Although nonparametric tests do not require any stringent assumptions to be fulfilled for application, yet parametric tests are preferred over them due to the following limitations of nonparametric tests:
- Parametric tests have more statistical power than nonparametric tests; therefore, they are more likely to detect a significant difference when it really exists
- Parametric tests can perform well with skewed and nonnormal data if the sample size is appropriate for performing the particular parametric tests. For example, for performing one sample *t*-test on a nonnormal data sample size should be >20, for a two sample *t*-test on nonnormal

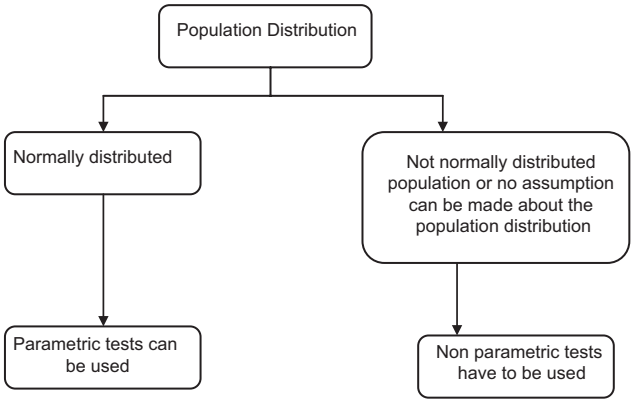

Figure 2: Use of parametric versus nonparametric tests according to population distribution.

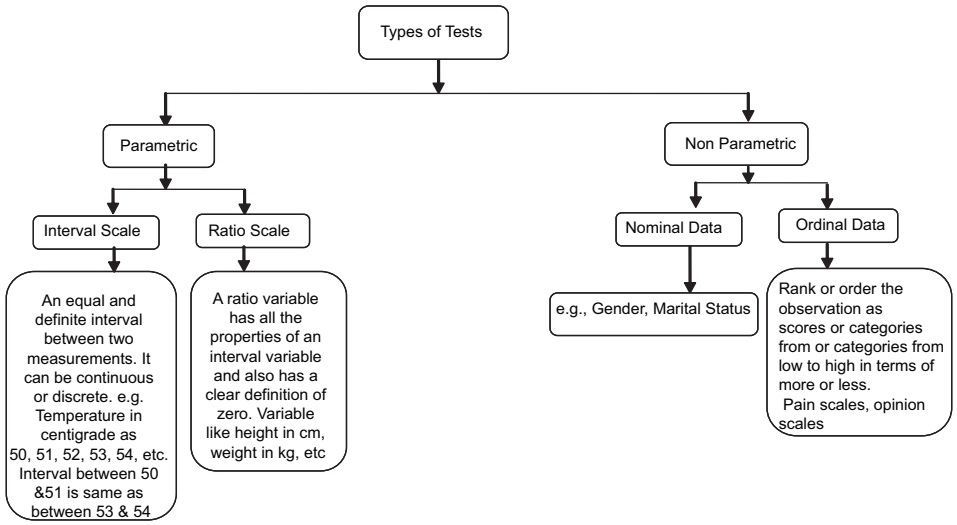

Figure 1: Use of parametric or nonparametric tests according to the scale of measurement of the data.

data each group should have more than 15 observations, and for performing a one-way analysis of variance on a nonnormal data having 2–9 groups, each group should have >15 observations
- Parametric tests can perform better when the (dispersion) of the groups is different. Although nonparametric tests do not follow stringent assumptions, yet one assumption that the dispersion of all the groups must be same is difficult to be met for running nonparametric tests. If this assumption of equal dispersion is not met, nonparametric tests may result in invalid results. Parametric tests can perform better in such situations
- Inference drawn from parametric tests is easy to interpret and more meaningful than that of nonparametric tests. Many nonparametric tests use rankings of the values in the data rather than using the actual data. Knowing that the difference in mean ranks between two groups is five does not really help our intuitive understanding of the data. On the other hand, knowing that the mean systolic blood pressure of patients taking the new drug was 5 mmHg lower than the mean systolic blood pressure of patients on the standard treatment is both intuitive and useful.

Advantages of Nonparametric Tests

The most important point while analyzing the data is to understand the fact that whether your data are better represented by mean or median. This is the key to decide whether to use a parametric or a nonparametric test. If the data are better represented by median then use a nonparametric test. For better understanding of the fact, let us explore an example. Suppose a researcher is interested in knowing the average income of the people in two groups and want to compare them. For this type of data, median will be the appropriate measure of central tendency, where 50% of the people will be having income below that and 50% will be having income above that.

If we add some highly paid people in the group than those will act as outliers and mean will differ to a greater extent, however income of a particular person will be the same. In that case, the mean values of the two samples may differ significantly but medians will not. In such cases, using nonparametric tests is better than parametric tests.

- When the sample size is small and the researcher is not sure about the normality of the data, it is better to use nonparametric tests. Because when the sample size is too small it is not possible to ascertain the normality of the data because the distribution tests will also lack sufficient power to provide meaningful results
- When we have ordinal data, nominal data, or some outliers in the data that cannot be removed then nonparametric tests must be used.

Parametric Tests and Their Nonparametric Equivalents

For all the parametric tests, there exists a parallel nonparametric equivalent. Table 1 describes in brief the type of situation under study with some examples and the relevant parametric tests and their nonparametric equivalents to be used in those situations.

How to Use the Online Calculators for Performing Mann–Whitney U-Test: A Nonparametric Test

Suppose a researcher designed a protocol to study the effectiveness of an analgesic in the patients with arthritis. He/she recruits 12 participants and randomized them into two groups to receive either the new drug or a placebo. Participants are asked to record the intensity of pain on a scale of 0–10 where 0 = no pain and 10 – severe pain. The hypothetical data are shown in Table 2.

The investigator wants to explore the difference in the intensity of pain in the participants receiving the new drug as compared to the placebo?

In this example, since the data are on an ordinal scale, hence we will use Mann–Whitney U-test to compare both the groups.

The link to the online calculator for performing Mann–Whitney U-test is http://scistatcalc.blogspot.in/2013/10/mann-whitney-u-test-calculator.html.

Step by step procedure of using this online calculator is described below:
- Step 1: For the example, explained above for comparing the

Table 1: Corresponding table for parametric tests and their nonparametric equivalents

Type of test	Level of measurement	Sample characteristics					Correlation
		One sample	Two sample		K samples (i.e., >2)		
			Independent	Dependent	Independent	Dependent	
Parametric	Interval or ratio	*Z*-test or *t*-test	Independent sample *t*-test	Paired sample *t*-test	One-way ANOVA	Repeated measure ANOVA	Pearson's test
Nonparametric	Categorical or nominal	Chi-square test	Chi-square test	Mc-Nemar test	Chi-square test	Cochran's Q	
	Rank or ordinal	Chi-square test	Mann-Whitney U-test	Wilcoxon signed rank test	Kruskal-Wallis	Friedman's ANOVA	Spearman's rho

ANOVA: Analysis of variance

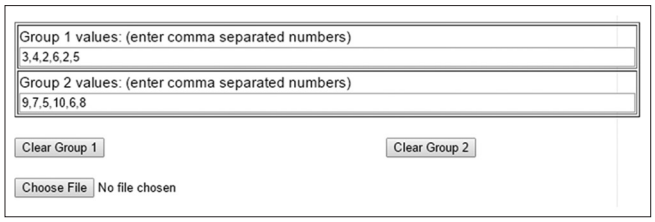

Figure 3: Data setup for a Mann–Whitney test in the online calculator.

Table 2: Number of episodes of shortness of breath in the study and placebo group

	Intensity of pain on a rating of 0-10					
New drug	3	4	2	6	2	5
Placebo	9	7	5	10	6	8

number of episodes of shortness of breath in participants treated with new drug and placebo, we have to enter the data as comma separated values for both the groups as shown in Figure 3

- Step 2: Click on perform Mann–Whitney test option and you are done. The output of the test is shown in Figure 4.

The result obtained from online calculator states that there is a significant difference between the intensity of pain in the two groups and $P = 0.0104$.

Discussion

Parametric and nonparametric are two broad classifications of the statistical tests. Parametric tests are based on the assumptions about the population from which the sample has been drawn; the most common among them is the assumption of normality. If the underlying assumptions of the parametric tests are not fulfilled using them may lead to incorrect conclusions. Utmost care should be taken while choosing between parametric and nonparametric tests and all the assumptions related to both of them must be considered while choosing one over the other.

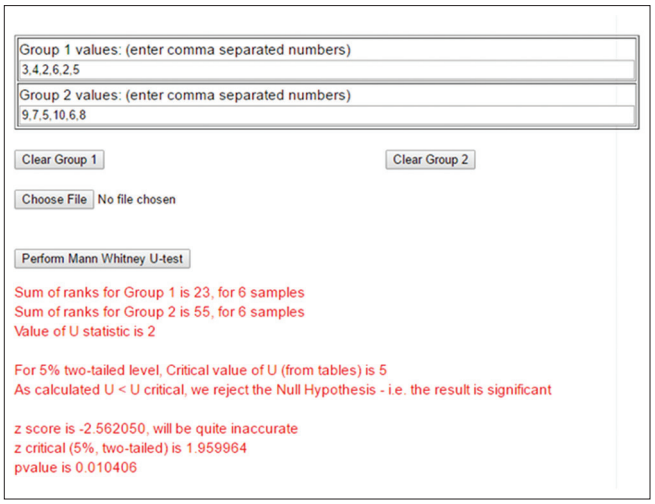

Figure 4: Output of the Mann–Whitney test from the online calculator.

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Conflicts of interest

There are no conflicts of interest.

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