ACCP Critical Care PRN: Guide for Appropriate Statistical Testing

PURPOSE

To provide a brief introduction to pharmacy residents on data classification and commonly used statistical tests.

DISCLAIMER

This document is to be used as an introductory guide and is not intended to replace a trained professional, statistician, or experienced researcher and is not intended to be the sole resource for individualized resident research projects. More complex statistical tests are not included in this guide.

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APPROPRIATE TESTING[1,2]

Prior to selecting an appropriate statistical test to analyze data, the data points (variables) should be defined with respect to the type of measurement scale used, whether or not the researcher has control over that specific variable, and the overall distribution of the data set. Four types of measurement scales exist (Table 1). Data should be classified as either an independent or dependent variable. Independent variables are those that are controlled or determined by the researcher. The result measured for is the dependent variable.

Table 1. Measurement Scales

Type of Scale	Definition	Example
Nominal	- Data represented by categories - Each observation is required to fall into one of the mutually exclusive categories	- 30-day mortality (Yes or No) - Diagnosis of diabetes (Yes or No)
Interval	- Quantitative data that can be measured - There is relative positioning with no gaps or interruptions in the continuum that <u>does not</u> include a value of zero	- Temperature (^{O}C)
Ratio	- Quantitative data that can be measured - There is relative positioning with no gaps or interruptions in the continuum that <u>does</u> include a value of zero	- Height - Weight - Blood pressure
Ordinal	- Data represented in an ascending or descending order, but the difference between units is not necessarily the same	- Modified Rankin Scale (0-6) - Visual Pain Scale (0-10)

Once data collection is completed it can be organized into a distribution, or graph of frequency of occurrence. This is a visual representation of the data to allow the researcher to begin to define and analyze data. The researcher should classify the data set as parametric or non-parametric. If the data set shape is symmetrical and bell-shaped, it is defined as parametric (normal distribution). If the data set is non-parametric (not normally distributed) it can be classified as having bimodal distribution (data has two peaks of cluster, or areas with a high frequency level in the data scale), rectangular distribution (equal

frequency of occurrence across the data scale), or skewed data (data set trails off to either the high or low end of data scale). Statistical methods are defined as being parametric or nonparametric. The type of analysis method that should be selected is dependent on the nature of the data to be analyzed. Identification of three properties of a data set can then be used to determine the appropriate statistical test to analyze a data set (Table 2).

Table 2. Selection of Statistical Tests Based on Types of Variables[1]

Independent Variable	Dependent Variable	Data Condition(s)	Statistical Test
None	Continuous	One variable	One-sample *t*-confidence interval
		Two variables - Parametric - Non parametric	 Correlation Spearman r
None	Discrete	One variable	Chi-square goodness of fit
		Two variables	Chi-square test of independence
		Two variables, small data set	Fisher's exact test
Discrete	Continuous	Independent variable (two groups) - Unpaired, parametric - Unpaired, nonparametric - Paired, parametric - Paired, nonparametric	 Two-sample *t*-test Mann-Whitney *U* Paired *t*-test Wilcoxon matched-pair test
		Independent variable (two or more groups) - Unpaired, parametric - Unpaired, nonparametric - Paired, parametric	 One-way analysis of variance Kruskal-Wallis Complete randomized block
Discrete	Discrete	Two variables - Unpaired - Unpaired, small data sets - Paired	 Chi-square test of independence Fisher's exact test McNemar test
		Risk estimates - Retrospective - Prospective	 Odds ratio Relative risk ratio
Continuous	Continuous	Two variables	Linear regression
		More than one independent variable	Multiple regression

Chi-square test vs. Fisher's exact test

- Controversy exists regarding the use of these tests
- In general, the chi-square test assumes the following:
    - No cell in contingency table should have an *expected* count <5
    - In larger tables, all cells should have *expected* counts >1 and ≤20% of expected counts should have a count <5
- The chi-square test approximates to a chi-square distribution, which is best done with a large sample size
    - Using this test in a small sample size may lead to testing inaccuracy and a reduction in power
- The Fisher's exact test computes an exact probability of the chi-square statistic and can be generally used in small sample sizes without breaking any assumptions

- Therefore, the Fisher's exact test may be "safer" to use in resident projects

REFERENCES

1. De Muth JE. Overview of biostatistics used in clinical research. Am J Health Syst Pharm. 2009;66(1):70-81.
2. Gaddis ML, Gaddis GM. Introduction to biostatistics: part 1, basic concepts. Ann Emerg Med. 1990;19:86-9.