



AN ANALYSIS OF APPLICATION OF MULTIPLE COMPARISON TESTS (POST-HOC) IN ANOVA IN RECENTLY PUBLISHED MEDICAL RESEARCH LITERATURE

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Financial Support: None declared
Conflict of interest: None declared
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How to cite this article:

Patel S, Naik V, Patel P. An Analysis of Application of Multiple Comparison Tests (post-hoc) in ANOVA in Recently Published Medical Research Literature. Natl J Community Med. 2015; 6(1):117-20.

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Date of Submission: 21-02-15

Date of Acceptance: 30-03-15

Date of Publication: 31-03-15

ABSTRACT

Background: The usage of statistical methods specially ANOVA and post hoc test are increase in medical research, however inaccurate application of ANOVA and post hoc test were observed commonly. So we reviewed application of ANOVA and post-hoc test in recent published biomedical research literature.

Method: Original articles published in bio-medical journals subscribed by the central library of our institute (SMIMER, Surat) were reviewed for statistical applications mainly ANOVA and post hoc test.

Result: Among the 1128 reviewed articles 800 (70.92%) used inferential statistical techniques. Among these 203 (25.37) articles were used ANOVA and out of that 92 (45.23%) were used post hoc test. Maximum usage of post hoc test was found in basic and paramedical research article, whereas least usage was found in the surgical articles. It has been also observed that out of the 92 original articles which applied post hoc test, in 28 (30.43%) the application was inappropriate.

Conclusion: Conceptual understanding and application of ANOVA and Post hoc test was lacking among bio-medical researcher.

Keywords: Multiple Comparison Tests, ANOVA, Medical Research Literature

INTRODUCTION

Statistical analysis is universally used in the interpretation of the results of basic biomedical research. Due to the development of computer technology, advanced and complex statistical analysis of data is easier and faster. Even computing technology significantly reduces random errors in calculations. Therefore, sources of errors are now mainly in the phase of data collec-

tion and interpretation of results; and not during the data analysis provided that researchers use correct statistical techniques. For example, for a hypothesis testing, a researcher should know and be able to justify the assumptions needed before applying and interpreting the statistics.

The Analysis of Variance (ANOVA) test has long been an important tool for researchers conducting studies on multiple experimental groups and

one or more control groups. However, ANOVA cannot provide detailed information on differences among the various study groups, or on complex combinations of study groups. To fully understand the group differences in an ANOVA, researchers must conduct tests of the differences between pairs of experimental and control groups. Tests conducted on subsets of data tested previously in ANOVA are called *post hoc* tests. A class of *post hoc* tests that provide this type of detailed information for ANOVA results are called "multiple comparison analysis" tests. Frequently used multiple comparison analytical test in medical researchers are Tukey, Newman-Keuls, Scheffee, Bonferroni, LSD, Duncan's and Dunnet's. Selection of post hoc test is depend the research group criteria.

During past several years, the application of multiple comparison tests in medical research has greatly increased, but many a time we observed inaccurate usage of post-hoc test after applying the ANOVA. This observations encourage us to review the published article which used ANOVA followed by Multiple comparison (post hoc) test. The objective of the study was to critically review the application of ANOVA and post-hoc test in recent published biomedical research literature.

METHODS

This study covered original articles published in several leading peer-reviewed journals subscribed by the central library of our institute (SMIMER, Surat) such as Basic science and Para Medical research (Anatomy, Physiology, Bio-Chemistry, Pharmacology and micro - pathology), Clinical Research (Medicine, Skin, Tb and chest, Pediatrics, Community medicine, Anesthesia, Radiology, Psychiatry, General surgery, ENT, Ophthalmology and Gynecology). All available issues of the selected journal published in the year 2013 were included in the study. List of the issues and journals included in this article are defined in Annexure- I. The application ANOVA and Post hoc test was assessed using pretested checklist.

- Assumption of ANOVA considers:
- Each sample is an independent random sample
- The distribution of the response variable follows a normal distribution
- Assumption about the equality of variance

- Use the post hoc test when ANOVA shows significance
- Test applied for the independent comparison of sample means
- Test applied for comparison of all pairs of treatment means
- Post hoc test applied for all paired wise comparison
- Test applied for comparison of control only with other experimental group's mean

RESULT

In this article 1128 original articles published in peer-reviewed journals are considered and out of them 258 (22.87%) articles are from basic and paramedical area. Among those 258 articles, 197 (76.36%) articles used statistical methods. 624 (55.31%) articles out of the original 1128 articles are from clinical non-surgical area. Among these 624 articles, 442(70.83%) articles used statistical methods. The rest 246(21.81%) articles of the total 1128 original articles are from clinical surgical area and among them 161(i.e. 65.44%) used statistical test.

It has been observed that total 800(70.92%) articles out of the considered 1128 articles used statistical methods and among them 203(25.38%) authors used ANOVA and out of them 92 (11.5%) used post hoc test. Out of total 203 articles, 175(86.21%) used one way ANOVA, 20(9.9%) used two way ANOVA and 8(3.94%) used repeated measure of ANOVA. In total 87 (42.86%) original articles belonging to basic and paramedical research area, 91(i.e. 44.83%) articles in clinical - non surgical research area and 25(i.e. 12.32%) articles in clinical-surgical research area used one way ANOVA. In clinical -surgical research area no author used two way and repeated measure of ANOVA, where as only one article in clinical area (non surgical) and 7 (8.04%) articles in basic and paramedical research area used repeated measure of ANOVA.

Total 10 (11.49% &10.98%) articles used two way ANOVA in Basic and paramedical research and clinical (non-surgical) research area respectively. It has been also observed that in basic medical and in surgical research area (clinical) one author applied post hoc test before applied ANOVA.

Table 1 shows the details of frequency of correctly used different post- hoc test in different area of medical research. Out of the total articles maximum usage of post hoc test had found in basic and paramedical research area, where least us-

age was found in the surgical research area. Total 40 (i.e. 43.48%) original articles correctly applied the post hoc test out of the total 92 original articles which used post hoc test. And another rest was applied wrong posthoc test. And 11 (i.e. 11.96%) articles out of the 92 articles which didn't define the name of post hoc test.

Table 2 shows the list of some errors or incompleteness in usage of ANOVA and Post hoc test.

Out of the total 203 articles which used ANOVA, only 30 (14.77%) articles assumed the condition of normality. None of the article considered for equality of variance (Levnce test). In only one article it was found that the concept of spericity before applying repeated measures of ANOVA. No article had mentioned the assumption of homogeneity for selection of post hoc test.

Table:-1 frequency of correctly used post -hoc in bio medical research

Name of post hoc test.	Basic and Paramedical (n =52) (%)	Clinical Non-surgical (n= 31) (%)	Clinical surgical (n =9) (%)	Total (n =92) (%)
Test applied for the independent comparison of sample Means (LSD, Scheffe`s, Bornferoni and Newman`s)	15(28.85)	7(16.12)	2(22.22)	22(23.91)
Test applied for comparison of all pairs of treatment means,(i.e. turkey`s)	8(7.69)	5(6.45)	1(11.11)	7(7.60)
Test applied for all paired wise comparison(i.e. Ducan`s)	2(3.85)	2(3.23)	0(0)	3(3.26)
Test applied for comparison of control only with other experimental group`s mean(i.e. Dunnet`s)	4(7.69)	4(9.68)	1(11.11)	8(8.7)
Not define*	6(11.54)	4(12.90)	1(11.11)	11(11.96)

*only define that posthoc test applied but didn't mention the name of post hoc test.

Table:-2 list of some misconception in usage of ANOVA and Post hoc test.

	Basic and paramedical	Clinical non surgical	Clinical surgical
Didn't define about the Normality	77(88.50)	74(81.31)	22(88)
Didn't define about equality of variance	0(0)	0(0)	0(0)
Didn't define about spericity	1 / 7 (14.28)	0(0)	0(0)
Didn't mention the Post hoc when ANOVA showed significance.	5(5.74)	8(8.79)	2(8)
ANOVA Applied for ordinal data	2(2.3)	0(0)	0(0)
Didn't applied ANOVA Directly applied Post -hoc	2(2.3)	0(0)	1(4)
Applied Post hoc when ANOVA showed no Significance	2(2.3)	1(1.1)	1(4)
Misconception of usage of post hoc test. # \$	15(28.84)	9(29.03)	4(44.44)

Used test for the independent comparison of sample means instead of test applied for comparison of control only with other experimental group`s mean

\$ applied for comparison of control only with other experimental group`s mean instead of Test applied for the independent comparison of sample means

DISCUSSION

This study shows total 70.92% original articles used statistical techniques to analyzed data; this shows the usage of statistics increase over the period. It has been observed the usage of ANOVA has increased. To apply or perform a One-Way ANOVA test, certain assumptions (or conditions) need to exist. If any of the conditions are not satisfied, the results from the use of ANOVA techniques may be unreliable. ANOVA uses the comparison mean of more than two group comparison, but ANOVA cannot provide detailed information on differences among the various study groups, or on complex combinations of study groups, but while applying or per-

forming a One-Way ANOVA test, certain assumptions (or conditions) need to exist. If any of the conditions are not satisfied, the results from the use of ANOVA techniques may be unreliable. To fully understand group differences in an ANOVA, researchers must conduct tests of the differences between particular pairs of experimental and control groups. There are a variety of *post hoc* tests available to further explain the group differences that give to significance in an ANOVA test^(1-4, 10). Each test has specific applications, advantages and disadvantages.

LSD, Bornferroni, Scheffe and newman all this test use for all independent comparison of sample means, where as Dunnet`s test compares

only control to other experimental groups, Duncan's procedure for all paired comparison and turkey's procedure for all pairs of treatment.^(3,10)

It is therefore important to select the test that best matches the data, the kinds of information about group comparisons, and the necessary power of the analysis^(3, 10). It is also important to select a test that fits the research situation in terms of theory generation versus theory testing. The consequences of poor test selection are typically related to Type 1 errors, but may also involve failure to discover important differences among groups^(3, 10). Multiple comparison analysis tests are extremely important because while the ANOVA provides much information, it does not provide detailed information about differences between specific study groups, nor can it provide information on complex comparisons. The secondary analysis with these post hoc tests may provide the researcher with the most important findings of the study.

CONCLUSION

Based on this study we conclude that statistics methods are used widely in different area of bio medical research. As far as the ANOVA and post-hoc test are concerned conceptual understanding is lacking among biomedical researcher which can be evidence from popover assumptions and inappropriate selection of post hoc test. So, researcher should include the statistician before applying the statistical test in research.

Annexure-1: List of journals included in the study

Journal of Cytology, volume -30 ,
 Indian Journal of Physiology and Pharmacology volume 57,
 Journal of applied Physiology ,volume 114
 Indian Journal of Clinical Biochemistry ,volume 28
 Indian Journal of Pathology and Microbiology ,Volume 56
 Indian Journal of Medical Microbiology, Volume 31
 Indian journal of Pharmacology Volume 45
 Journal of Pharmacology and Pharmacotherapeutic Volume 4
 Indian Journal of Public Health, Volume 57
 Indian Journal of Community Medicine, Vol. 38
 The New England journal of Medicine Vol .369
 Indian Journal Critical Care Med Vol.17
 JAPI vol.,61
 Indian J Medical Research Vol.137
 Indian Journal of Nephrology Vol .23
 Indian Pediatric Vol.50
 Indian Journal of Medical and Paediatric Oncology Vol .34
 Journal of Indian Association of pediatric surgeons Vol.18

REFERENCES

1. Keselman HJ, Keselman JC, Games PA. Maximum familywise Type I error rate: The least significant difference, Newman-Keuls, and other multiple comparison procedures. *Psychol Bull* 1991;110:155-62
2. Savitz, D. and F. Olshan (1995). "Multiple Comparisons and Related Issues in the Interpretation of Epidemiologic Data." *American Journal of Epidemiology*, 142(9), 904-908.
3. Shaffer JP. Multiple Hypothesis Testing. *Annu Rev Psychol* 1995;46:561-84.
4. Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. *J R Stat Soc Series B Stat Methodol* 1995;57:289-300.
5. Benjamini, Y. and D. Yekutieli (2001). "The Control of the False Discovery Rate in Multiple Testing Under Dependency." *The Annals of Statistics*, 29(4), 1165-1188
6. McHugh MM. Standard error: meaning and interpretation. *Biochem Med* 2008;18:7-13.
7. Ilakovac V. Statistical hypothesis testing and some pitfalls. *Biochem Med* 2009;19:10-6.
8. Marusteri M, Bacarea V. Comparing groups for statistical differences: How to choose the right statistical test. *Biochem Med* 2010;20:15-32
9. Cue RI. Multiple Comparisons. Department of Animal Science, McGill University, 2003. Available at: <http://animsci.agrenv.mcgill.ca/servers/anbreed/statisticsII/mcomp/index....> Accessed September 3, 2011
10. Mary L.McHUGH.Multiple comparison analysis testing in ANOVA.*Biochemia Medica* 2011;203-9. <http://dx.doi.org/10.11613/BM.2011.029>

Journal of Minimal Access Surgery Vol. 9
 Indian journal of surgery Vol .75
 Indian Journal of Urology Vol. 29
Clinical and Experimental Otorhinolaryngology vol. 6
 Indian Journal of Orthopaedics Vol. 47
 Indian Journal of Psychiatry Vol. 55
 Indian Journal of Radiology and Imaging Vol .23
 Indian J Dermatology, Venereology, and Leprology volL. 79
 Indian Journal of Dermatology vol .58
 Lung Indian vol.30
 The Indian J of Chest Diseases & Allied Sciences Vol. 55
 Indian journal of tuberculosis Vol.60
 The Indian Journal of Chest Diseases & Allied Sciences Vol.57
 Journal of Anesthesiology Clinical Pharmacology , Vol .29
 Indian journal of Anesthesia , Vol .56
 Infect Dis Obstet Gynecol 2013 ,vol 2013
 The journal of obstetrics and gynecology of India vol.63.