

Original Article

Usage of statistical methods and study designs in publication of specialty of general medicine and its secular changesSwati Patel^{1*}, Vipin Naik², Rajkumar Bansal¹, Prakash Patel¹, Neeta Sharma¹¹ Department of Community Medicine, Surat Municipal Institute of Medical Education and Research, Surat, Gujarat, India² Principal of S.P.B English Medium College of Commerce, Surat, Gujarat, India

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ABSTRACT

Background & Aim: It is important that clinicians understand statistical methods into their own research and correctly apply in their research. The main objective of this study is to explore the study designs, statistical methods used and the issue of inaccuracy and inappropriate usage of statistical methods in the research publications of the specialty of general medicine as evidenced by five selected journals over a 10-year period and improvements thereof.

Methods & Materials: Originally published articles were reviewed of the journals of specialty of general medicines for the above-defined objective (list of journals: Indian Journal of Medical Research, Indian Journal of Critical Care, Indian Journal of Nephrology, Journal of the Association of Physicians of India, and New England Journal of Medicine were reviewed). Qualitative data represented by percentage, Z-test of proportion applied at 95% level of significance.

Results: The usage of some statistical methods in 2003 was 61.54% which increased to 79.26% by 2013. Only 2.19% research article had mentioned the concept of study design in 2003 which increased to 10.56% by 2013. There was a greater usage of statistical concepts and methods such as parametric and nonparametric tests, regression, survival analysis in 2013 as compared to 2003. There was a significant improvement observed in the usage of statistical software over a 10-year period. A common error observed was the usage of standard error instead of standard deviation to present the data and we found that there was a vast improvement in the use of advanced statistical methods over the decade.

Conclusion: This study highlights the increasing importance of medical statistics in the research publications pertaining to the specialty of general medicine over time so that the inferences drawn from these studies are actually representative of the population that they represent and are valid and reliable. These concepts are of paramount importance while physicians read these articles and try to adopt their recommendations.

Introduction

Statistical analysis has become an essential component of scientific publications in the field of bio-medical research, human biology, genetics,

and other branches of biology over the last decades. A great increase in the utilization of statistics has been documented in a wide range of medical journals/research articles. The results of researches have to be analyzed statistically in an adequate manner if the samples and/or measurements are obtained in more than one object, and/or more than once (1). At the present time, this requirement applies to most of the scientific investigations as it helps to arrive closer

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to the core of the problem. Results of sufficient statistical analysis might lead to new hypotheses, but on the other hand, the incorrect application may lead to erroneous results causing confusion. Many reviews have been done in different countries, predominantly in developed countries to describe the usage of statistical techniques in bio-medical journals (2, 3). Review for the bio-medical journals has also been organized in developing countries, though less frequently. Almost all the reviews showed that there was a positive trend of application of statistical techniques in medical writings. Better and more complex statistical analyses are introduced to prove the hypothesis. It is significant to know that the statistical techniques which used in medical research articles in various medical journals are correct or not and to find out what improvements should be made in the tradition of self-evaluation. This study scrutinized total 352 published original articles in selected journals of general medicine in 2003 and 2013.

It has been explored the type of study designs, utilization of statistical techniques, and the common statistical errors in the research reports in 2003 and 2013 and described its secular changes.

Methods

This study comprises the available latest volumes of indexed journals of specialty of general medicine subscribed by the central library of Surat Municipal Institute of Medical Education and Research (Surat) were taken available latest volumes of 2003 and 2013. List of the journal and issues included in the study were as: The New England Journal of Medicine Vol. 350 and 369, Indian Journal of Critical Care Vol. 7 and 17, Journal of the Association of Physicians of India Vol. 51 and 61, Indian Journal of Medical Research Vol. 118 and 13, and Indian Journal of Nephrology Vol. 13 and 23. Original research articles published in listed journal were included in the study. As very few statistics were used in editorials, letters, case reports, short communications, and other types of article, they were excluded. Categorization of statistical methods given by Emerson and

Colditz (4) and Patel et al. (5) were used in this study. Study variable includes study design, appropriateness of statistical methods mentioned, and complexity of data analysis and use of software.

Consequently, the papers containing statistical analyses which were advanced than descriptive statistics were segregated into the categories “Basic Analysis” or “Advanced Analysis” according to the complexity of applied statistical techniques. Thereby t-test, simple contingency table, correlation, and nonparametric test were considered as basic analysis. Papers containing method of advance contingency table, regression, multiple regressions, analysis of variance (ANOVA), multiple comparison test, epidemiological analysis, and confidence interval considered as advance analysis. In case more than one statistical technique were used in a study then all of them were considered separately, however, if the same statistical method applied more than once, it was singularly considered.

Z-test of proportion applied to compare the proportion of two independent groups. Statistical analysis was performed by Epi tools software (Ausvet, Australia).

Results

Total 352 original articles were scrutinized out of them 14 and 42 from the New England Journal of Medicine, 8 and 25 from Indian Journal of Critical Care, 37 and 57 from Journal of the Association of Physicians of India, 32 and 82 from Indian Journal of Medical Research, and 14 and 40 from Indian Journal of Nephrology in year 2003 and 2013, respectively. The usage of statistical methods in 2003 was 61.90% which significantly increased to 79.26% by 2013 ($P = 0.0006$).

Table 1 shows the frequency of used statistical methods in 2003 and 2013. The most frequently used statistical method in 2003 was contingency table (46.15%) and in 2013 was t-test (36.92%). Commonly usage of survival analysis in the year 2003 and 2013 is 13.84%. It has been found significantly increase in usage of multiple comparison test [1.53%, 8.21%

Table 1. Frequency of used statistical methods

Statistical methods	2003	2013	P-value
Total reviewed article	105 (29.91)	246 (70.07)	< 0.0100
Use descriptive or no statistical method	40 (38.09)	51 (20.73)	0.0006
Used statistical methods	65 (61.90)	195 (79.26)	0.0006
t-test (one sample, independent and paired)	26 (40)	72 (36.92)	0.6581
Contingency table (chi-square, Fisher exact test, McNemar’s test)	30 (46.15)	79 (32.11)	0.4247
Pearson’s correlation	8 (12.30)	25 (10.16)	0.0100
Linear regression (least square method in which one predictor and other respondent)	1 (1.53)	9 (3.66)	0.4564
Logistic regression	4 (6.15)	28 (11.38)	0.1270
ANOVA (ANOVA, ANCOVA, repeated measure of ANOVA)	7 (10.77)	39 (15.85)	0.0900
Multiple comparison (procedures for handling multiple inferences on same data sets (e.g., Bonferroni techniques, Scheffe’s contrasts, Duncan’s multiple range procedures, Newmann-Keuls procedure)	1 (1.53)	16 (8.21)	0.0400
Multiple regression (linear, logistic)	3 (4.62)	18 (9.23)	0.3576
Nonparametric test (Sign test, Wilcoxon signed ranks test, Mann–Whitney test, Kendall’s tau, chi-square test for trend)	5 (7.69)	30 (15.38)	0.1155
Nonparametric correlation (Spearman’s correlation)	3 (4.62)	8 (4.10)	0.8590
Survival analysis (Kaplan–Meier survival curve, Cox regression, log rank, Cox model for comparing survival)	9 (13.84)	27 (13.84)	0.8396
Epidemiological measures (relative risk, odds ratio, log odds, measures of association, sensitivity, specificity)	5 (7.69)	24 (12.30)	0.1595
Normality	4 (6.15)	21 (10.77)	0.2274
Sample size calculated	1 (1.53)	4 (2.05)	1.000
Others (ROC, others regression analysis, principal component, cluster analysis, mathematical models)	2 (3.07)	9 (4.61)	0.8588
95% confidence interval	13 (20)	63 (32.30)	0.0600
Specify one-tail or two-tail hypothesis	2 (3.07)	10 (5.13)	0.7328
Software-used for statistical methods	14 (13.33)	99 (40.24)	< 0.0001
Do not mention version	3 (21.42)	49 (49.49)	

ROC: Receiver operating characteristic, ANOVA: Analysis of variance

($P = 0.0400$) but it was observed that in only 5 (2.56%) article author checked normality before applied the ANOVA in 2013 only, out of the total articles in only 2 author used receiver operating characteristic in both year, only 1.53% and 2.03% articles mentioned the justification of sample size in 2004 and 2013, respectively, and usage of statistical software [13.33%, 40.24% ($P < 0.0001$)] in 2003 and 2013, respectively.

Table 2 shows the details of frequency of mentioned type of study design in the article. In 2003, only 2.19% research articles had mentioned study design which increased to 10.56% by 2013 ($P = 0.0200$). Only 2% and 3.25% articles mentioned the sampling techniques in 2003 and 2013, respectively.

Furthermore, table 3 shows details of the complexity of statistical analysis. Highest usage of advanced statistical methods was found in 2013 (43%) as compared to in 2003 (31%). The proportion of articles using more than three statistical methods was significantly higher in

2013 (25%) than 2003 (12%) ($P = 0.0300$). The appropriate usage of statistical methods increased in 2013 (82%) as compared to 2003 (68%).

Table 2. Frequency table of mentioned study design in research article

Study design	2003	2013
Double-blind study	0 (0)	1 (0.41)
RCT	0 (0)	3 (1.22)
Cross sectional	0 (0)	8 (3.25)
Case control	0 (0)	2 (0.81)
Cohort	0 (0)	1 (0.41)
Comparative	0 (0)	2 (0.81)
Longitudinal	0 (0)	1 (0.41)
Observational	0 (0)	3 (1.22)
Prospective	3 (2.86)	2 (0.81)
Retrospective	0 (0)	4 (1.63)
Total	3 (2.86)	27 (10.98)

RCT: Randomized controlled trial

Table 4 shows the inappropriate usage of statistical method in 2003 and 2013. Yet in 18% of articles found with inappropriate usage statistical methods as of 2013.

Table 3. Complexity of statistical analysis

Complexity of statistical analysis	2003	2013
No statistics or descriptive statistics	40 (61.54)	51 (20.73)
Basic statistics*	32 (38.10)	90 (36.59)
Advance statistics**	33 (30.48)	105 (42.68)
Only one statistical method used	37 (56.92)	91 (46.67)
2 or 3 statistical method used	24 (36.92)	86 (44.10)
4 or 5 statistical method used	4 (6.15)	18 (9.23)

t-test (one sample, independent t-test, paired t-test), contingency table (chi-square, fisher), correlation (Pearson, spearman), nonparametric test (Wilcoxon sign ranked, Mann-Whitney), **Contingency table (kappa), regression (linear, logistic), multiple regression, ANOVA, multiple comparison test (post-hoc), epidemiological analysis, confidence interval. ANOVA: Analysis of variance

It has been found that usage of statistical software increased in 2013 (40%) as compared to 2003 (13%). Still, approximately, 50% of the research paper did not mention the version of software.

Discussion

An increase of 17% usage of statistical methods over the 10-year period was observable indicating the increased importance of statistics in medical research (3, 6-8). This study observed a significant improvement in the use of statistical methods over a period alike others (4, 5, 9). Among the all the original articles, t-test and contingency table were frequently used as compared to the complicated statistical methods alike other observations (8). These observations collectively lead us to a conclusion that statistics usage has continuously shown an

improvement over the last three decades. It is also important to note that very few articles had mentioned about study design, sample size, and sampling techniques properly. In general, the conceptual understanding of methodology was lacking (1). In 18% of articles, there was inappropriate usage of inappropriate statistical methods as of 2013 like others (3, 4). The mainly observed problems in the study were omitting description of statistical methods and giving "P" values without mentioning the statistical method (9-11). This study has been also observed author applied wrong test (i.e., usage of independent t-test instead of paired t-test) also found in the other studies (9, 12). The most common error found in this was ambiguity regarding the test used, for example, studies had mentioned that they used chi-square/Fisher exact test without specifying the test actually used.

Table 4. Appropriateness of statistical methods in 2003 and 2013

In descriptive statistics	2003	2013	P-value
Inappropriate used of descriptive statistics	10 (15.38)	7 (3.59)	0.0008
Wrong presentation of measurement (SE instead of SD)	6 (9.23)	7 (3.59)	0.0700
Misconception of use of sign (i.e., +)	2 (3.08)	0 (0)	0.0600
Confusing regarding use of presentation of data (i.e., SD/SE)	2 (3.08)	0 (0)	0.0600
In statistical methods			
Inappropriate used of statistical methods	21 (32.30)	35 (17.95)	0.0100
Confusion regarding application of statistical method (i.e., chi-square or Fisher, independent t-test or Mann-Whitney)	4 (6.15)	12 (6.15)	1.0000
Did not define the name of statistical method	2 (3.07)	6 (3.07)	1.0000
Did not mention the P-value	2 (3.07)	1 (0.51)	0.1550*
Wrong test applied (i.e., chi-square instead of Yates or Fisher, t-test instead of ANOVA)	4 (6.15)	3 (1.54)	0.0600*
Used linear regression but did not follow the criteria of it (normality, linearity, and correlation)	1 (1.54)	3 (1.54)	1.0000
For qualitative paired observation applied chi square test	0 (0)	1 (0.51)	0.5600
No exact P-value mention	8 (12.30)	9 (4.61)	0.0400

SD: Standard deviation, SE: Standard error, ANOVA: Analysis of variance

Conclusion

The quality of used statistical methods in specialty of general medicine is improving and its frequency is comparable globally. Although inappropriate usage of statistics remains a problem. This study shows that many studies published in general medicine research journals did not follow "General Principles for Reporting Statistical Methods." This study observed that many of the author's preferred descriptive statistics to advanced statistics even where latter was required and would have given superior results. Increasing awareness among medical professionals regarding the benefits of advance medical statistics in obtaining better results will certainly lead to its increased use.

Conflict of Interests

Authors have no conflict of interests.

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