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Research article

EXAMINATION OF PUBLISHED ARTICLES WITH RESPECT TO STATISTICAL ERRORS IN VETERINARY SCIENCES

ERCAN Ilker[1*], KAYA Mehmet Onur[2,6], UZABACI Ender[3,6], MANKIR Seray[4], CAN Fatma Ezgi[5,6], BASHIR ALBISHIR Musa[6]

[1]Department of Biostatistics, Uludag University Faculty of Medicine, Bursa, Turkey; [2]Department of Biostatistics, Bezmialem Vakıf University Faculty of Medicine, Istanbul, Turkey; [3]Department of Biostatistics, Uludag University Faculty of Veterinary, Bursa, Turkey; [4]Department of Statistics, Anadolu University Faculty of Sciences, Eskisehir, Turkey; [5]Department of Biostatistics, İzmir Katip Celebi University Faculty of Medicine, İzmir, Turkey; [6]Department of Biostatistics, Uludag University Institute of Health Sciences, Bursa, Turkey

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The aim of this present work was to examine statistical errors in published veterinary science articles. A total of 204 published articles (SCI or SCI-Exp) were used in this study. The articles were chosen from among those indexed in PubMed database between the years 2010 and 2014, inclusive. A total of 199 articles had at least one statistical error. The most frequently encountered statistical error among the articles published in journals indexed in SCI and in SCI-E was "errors in summarizing data". No statistical error was found in 2.45% (n=5) of 204 (SCI: 0.98% (1/102), SCI-E: 3.92% (4/102)) articles. To reduce and prevent statistical errors in publications, the researchers must have a basic knowledge of statistics and during the study process they must consult field experts. While reviewing, the reviewers have to redirect the publications to statistical editors when needed and most importantly during the process of editing, the editors have to direct the publications to a statistics reviewer.

Key words: Biostatistics; review of article; statistical error; veterinary science.

INTRODUCTION

The importance of biostatistics is well acknowledged in veterinary and medical sciences. With the advancement of tools for gaining knowledge, we have access to data with larger complexity and information. To understand the structures of the acquired knowledge, the data have to be analyzed, and this analysis can only be performed using statistical tools. Unfortunately, in the process of employing statistical methods in scientific research, inappropriate applications can be encountered. When statistical errors are made, both scientists and users of scientific findings are exposed to negative

*Corresponding author: e-mail: ercan@uludag.edu.tr

consequences [1,2]. Furthermore, statistical errors found in published articles are likely to cause the author's loss of academic credibility.

While errors can be application-related, they can also occur at different stages of the study such as planning, implementation, analysis, interpretation, and presentation, all of which are related to statistical topics [1,3,4]. Statistical errors in the study process can be categorized as the ones that occur (i) In the research process (before reporting) and (ii) in presentations or publications [1]. Some of the statistical errors in publications can be assessed, while others cannot. In publications, not all of the statistical quantities can be checked; it is only possible to check the accuracy of some of the statistics via reported descriptive values. In addition, some terminology, presentation and interpretation errors can be identified [1].

Although the authors are responsible for the errors made in publications, the journal editors are also responsible for the academic prestige of their journals. The publication of studies with statistical errors will cause the journals a loss of academic credibility. Therefore, no editor would like to publish studies that involve erroneous statistical applications in their journals. Also in order to avoid statistical errors in publications, the publications are supposed to be submitted to biostatistics reviewers in the evaluation process of the publications.

The aim of the present work was to examine the statistical errors in the published articles of veterinary sciences. Published articles in journals that are indexed in Science Citation Index (SCI) were compared to Science Citation Index-Expanded (SCI-E) journals.

MATERIALS AND METHODS

The ratio of published papers with statistical errors ranges between 0.26 (50/195) and 0.87 (48/55) (median= 0.57) [4-9]. This information was considered in this study for the calculation of sample size, which turned out to be n=204 when the significance level is α=0.05, the margin of error is d=0.07, and the ratio of articles with statistical errors is 57%. The number of articles examined for statistical errors ranged between 55 and 195 in similar studies [4-9].

One hundred-two articles published in SCI journals and 102 articles published in SCI-E journals were included in this study. The articles were chosen from among those indexed in PubMed database between the years 2010 and 2014 inclusive. Not more than 25 studies were taken from each index group and publication year. Relevant articles included in the evaluation were taken from veterinary science and in SCI or SCI-E. During the investigations, the studies outside the scope of our study (with no statistical analysis and collection studies, such as case reports) were not included in the study.

The reference list of a randomly selected article was used for randomization in article selection. The first article that was ranked as first in the reference list with respect to the author name in the relevant years was selected, and then this process was repeated

for the first authors of other articles in the reference list. After the last article in the reference list was used for selection, by going back to the beginning of the reference list the second authors' name was employed as the key word for selection. The names of authors were entered into the search engines of these databases. Randomization was accomplished by repeating the process in article selection. Sample size was considered as approximately equal according to the year. The frequencies and percentages of the examined published articles by years are given in Table 1.

Table 1. Frequencies and percentages of the examined published articles by year

Years	Indexed at SCI [n (%)]	Indexed at SCI-E [n (%)]	Total [n (%)]
2014	20 (19.61)	21 (20.59)	41 (20.10)
2013	19 (18.63)	25 (24.51)	44 (21.57)
2012	23 (22.55)	16 (15.69)	39 (19.12)
2011	22 (21.57)	18 (17.65)	40 (19.61)
2010	18 (17.65)	22 (21.57)	40 (19.61)
Total	102 (100)	102 (100)	204 (100)

SCI: Science Citation Index, **SCI-E:** Science Citation Index-Expanded

In this study, the selected articles were examined by allocating articles among research team members with respect to the type of statistical errors. The examined statistical errors were classified following the description as described by Ercan et al [4,10] and Ercan and Demirtas [1]. Of note, errors assessed by each researcher were confirmed by all members of the research team. Therefore, there is no difference between researchers according to specifying the error and they are in full (100%) agreement. On this basis, there was no need to calculate inter-rater reliability.

The statistical errors were examined as: "p-values given in a closed form" (e.g., $p<0.01$, $p<0.05$, $p>0.05$), "non-reported p-values", "incorrect p-values (which are related to frequency tables)", "incorrect demonstration of p-values (e.g., $p=0.000$, $p<0.0005$ etc.)", "undefined statistical test", "incorrect name of a statistical test", "statistical technique defined but not used", "use of an incorrect test", "statistical analysis required but not performed", "errors in summarizing data" (it contains incorrect reporting regarding analyses, e.g., reporting mean and standard deviation when nonparametric tests are applied, it contains incorrect or inadequate reporting of descriptive statistics, e.g., not reporting measure of variability with arithmetic mean, errors in percentages, incorrect presentation in table format, etc.), "mathematical demonstration errors (e.g., lacking demonstration of decimals, using ":" rather than "=")", "statistical symbol errors (e.g., using π for a Chi-square value)", "incomprehensible statistical terms", "inappropriate interpretation", "errors in (statistical) terminology", and "presentation of statistical method analysis and results in the incorrect section of the manuscript" [1,4,10].

The percentage of statistical errors was calculated, taking into account the number of articles reviewed. Further, the potential difference between the statistical errors seen in articles indexed in SCI and in SCI-E journals was investigated using the Chi-square

test and Fisher's exact test. The results of the study were presented as counts and their corresponding percentage values. Data were analyzed with SPSS software 21.0.

RESULTS

In this study, 204 articles, which included 102 SCI indexed and 102 SCI-E articles were reviewed with regards respect to statistical errors. A total of 199 articles were found with at least one statistical error. The most frequently encountered statistical error was "errors in summarizing data" for articles published in journals indexed as SCI and as SCI-E. No statistical errors were found in 2.45% (n=5) of 204 (SCI: 0.98% (1/102), SCI-E: 3.92% (4/102)) articles. Table 2 gives a detailed account of the distribution of statistical errors among the articles. Also Table 3 gives a detailed account of the distribution of statistical errors in similar studies in medical sciences.

Table 2. Distribution of the statistical errors in the published articles in the present study

Source of Errors		Indexed at SCI Number of published articles=102 [n(%)]	Indexed at SCI-E Number of published articles=102 [n(%)]	p	Total Number of published articles=204 [n(%)]
Errors related to p-values	p-values given in closed form	49 (48.04)	51 (50.00)	0.779	100 (49.02)
	Non-reported p-values	48 (47.06)	42 (41.18)	0.398	90 (44.12)
	Incorrect p-values	9 (8.82)	9 (8.82)	1.000	18 (8.82)
	Incorrect demonstration of p-values	46 (45.10)	30 (29.41)	0.021	76 (37.25)
Errors related to tests	Undefined statistical test	11 (10.78)	21 (20.59)	0.083	32 (15.69)
	Incorrect name of the statistical test	11 (10.78)	8 (7.84)	0.630	19 (9.31)
	Statistical technique defined but not used	4 (3.92)	3 (2.94)	1.000	7 (3.43)
	Use of incorrect test	11 (10.78)	11 (10.78)	1.000	22 (10.78)
	Statistical analysis required but not performed	2 (1.96)	2 (1.96)	1.000	4 (1.96)
Mathematical demonstration errors		4 (3.92)	2 (1.96)	0.683	6 (2.94)
Statistical symbol errors		5 (4.90)	2 (1.96)	0.445	7 (3.43)
Inappropriate interpretation		17 (16.67)	13 (12.75)	0.553	30 (14.71)
Presentation of the statistical method-analysis and results in the incorrect section of the manuscript		15 (14.71)	17 (16.67)	0.847	32 (15.69)
Errors in summarizing data		56 (54.90)	62 (60.78)	0.395	118 (57.84)
Incomprehensible statistical terms		1 (0.98)	0 (0.00)	1.000	1 (0.49)
Errors in (statistical) terminology		7 (6.86)	8 (7.84)	1.000	15 (7.35)

SCI: Science Citation Index, **SCI-E:** Science Citation Index-Expanded

Table 3. Distribution of statistical errors in similar studies

Source of Errors	P.S. (%)	[10] (%)	[12] (%)
p-values given in closed form	49.02	15.21	
Non-reported p-values	44.12	22.12	
Incorrect p-values	8.82	13.36	
Incorrect demonstration of p-values	37.25	18.43	
Undefined statistical test	15.69	11.52	26.25
Incorrect name for the statistical test	9.31	3.23	12.50
Statistical technique defined but not used	3.43	2.30	21.25
Use of incorrect test	10.78	7.83	28.75
Statistical analysis required but not performed	1.96	17.51	
Errors in summarizing data	57.84	28.11 †a 17.51 †b 26.73	†a 47.50 †b 16.25
Mathematical demonstration errors	2.94	6.91	
Statistical symbol errors	3.43	3.23	
Incomprehensible statistical terms	0.49	4.15	
Inappropriate interpretation	14.71	8.76	13.75
Errors in (statistical) terminology	7.35	9.68	
Presentation of statistical method-analysis and results in the incorrect section of the manuscript	15.69	6.91	

†a=Insufficient data presented for the statistical test, **†b**=Incorrect and insufficient demonstration of descriptive statistics, **PS**=Present Study, Ercan et al. [10], Hanif and Ajmal [12].

DISCUSSION

In this study were identified statistical errors in published articles in the field of veterinary sciences. In our literature survey we observed a number of studies conducted in the field of medicine in order to identify such statistical errors, but no such studies are carried out in the field of veterinary medicine. While published scientific studies are being used as reference by scientists, the findings and decisions at the end of the studies are important for the people that will benefit from it. For this reason, the accuracy and reliability of the publications is very important. Statistics is one of the most important factors for the accuracy and reliability of a publication which starts from the first stage of the study (planning stage) and follows up to the last stage of the study (reporting stage). Therefore, statistics is the most basic element that makes a study scientific or otherwise. For this reason, in this study we examined publications in the field of veterinary science in terms of statistical errors. Errors in the application of statistical methods in publications generally can be grouped under three main categories: (i) errors related to p-value, (ii) errors related to tests and (ii) other statistical errors.

When publications in the field of veterinary science were examined, errors related to p-values seem to be relatively high. This source of error is very important considering the importance of the p-value. The most common error related to p-value is giving

the p-value in a closed form. Some researchers may not be able to perceive it as an error; but not giving the p-value in the open form may look as depriving the reader from getting access to the actual information obtained from the result of the applied statistical test [11]. For example, while there is a significant difference between p=0.061 and p=0.984, when this p-value given as p>0.05 in such case it means the information is not transferred to the reader. It will also be of great importance if the p-value is given in the open form, so that during the evaluation process the reviewers can control some of the statistical tests prior to the publication of the findings. For these reasons, p-values are needed to be given in the open form and not giving them in the open form can be considered as an error. In this study the p-values of 49.02% (SCI 40.04% and SCI-E 50.00%) of the publications assessed were given in the close form. In the study conducted by Ercan et al. in medical journals between the years 2004-2010 in 217 published research SCI / SCI-E indexed or non-indexed journals the rate determined was 15.21% [10].

In this study, 44.12% of the publications (SCI 47.06% and SCI-E 41.18%) were found to have non-reported p-values, while in the study of Ercan et al. in medical journals, the rate was 22.12% [10]. Some authors gave place for statistical interpretations in their studies without giving the p-values. In this situation it cast doubt on accuracy of the statistical tests and also makes it look like the author is depriving the reader from the information of the p-value.

In the publications we reviewed, the major source of error with the quality that can affect the result directly is the wrong giving of the p-values. In this study 8.82% (SCI 8.82% and SCI-E 8.82%) of the publications examined were found to be with mispresentations of the p-value, while in the study of Ercan et al. in medical journals the rate was 13.36% [10]. Specified rate of incorrect p-values, are the rate of the result of tests reviewed with possible means of control. This rate should be considered higher because some of the statistical tests can't be controlled.

Another source of error among the errors related to p-values is the incorrect presentation of the p-value. In 37.25% (SCI 45.10% and SCI-E 29.41%) of the publications reviewed the p-value was incorrectly presented. While in the study of Ercan et al in medical journals found the rate as low as 18.43% [10]. Incorrect demonstration of the p-value is leading the reader not to understand and also to lose confidence in the study.

Another error source specified in this study is related to statistical tests. Undefined statistical test with the rate of 15.69% (SCI 10.78% and SCI-E 20.59%) is the most common error related to statistical tests in publications. In the study of Ercan et al in medical journals this rate was 11.52%, while in study of Hanif and Ajmal 80 research articles published in indexed and recognized local journals in Pakistan the rate was 26.25% [10,12]. Not defining the statistical test performed is denying the evaluation of the study in the review process.

In our study, we detected 9.31% of the publications investigated with a given incorrect name of the statistical test. In study of Ercan et al. in medical journals this rate was 3.23%, while in the study of Hanif and Ajmal this rate was 12.50% [10,12].

In this study 3.43% (SCI 3.92% and SCI-E 2.94%) of the investigated publications were found with an unused statistical technique defined. In the study of Ercan et al in medical journal this rate was 2.30%, while in the study of Hanif and Ajmal this rate was 21.25% [10,12].

One of the major errors that can affect the results of the study is the use of incorrect statistical test. In this study, 10.78% (SCI 10.78% and SCI-E 10.78%) of the investigated publications were identified with inadequate statistical tests. In the study of Ercan et al. in medical journal this rate was 7.83%, while in the study of Hanif and Ajmal this rate was 28.75% [10,12].

Sometimes the authors make a subjective interpretation without performing the necessary statistical analysis. Scientific conclusions can be reached only by performing statistical tests. If the researcher offered a subjective interpretations such as: different, much, effective etc. without performing the necessary test, it has no scientific validity and in this study this error rate was detected in 1.96% publications. Ercan et al. reported this rate to be 17.51% in medical journals [10].

When examining the studies in terms of other statistical errors in publications the most frequent error was identified at the rate of 57.84%, which is the error in summarizing data. In the study of Ercan et al in medical journals they categorized the error types into three groups: thus; errors in summarizing data was identified in 28.11%, insufficient data presented for the statistical test was identified in 17.51% and incorrect and insufficient demonstration of descriptive statistics also identified in 26.73% [10]. A study of Hanif and Ajmal gave this rate to two categories, as insufficient data presented for the statistical test was identified in 47.50% while as incorrect and insufficient demonstration of descriptive statistics was identified at 16.25% [12].

When examined the publications errors in terms of notation errors are considered in two groups, thus; as mathematical notation error and statistical symbol error. Due to lack of sufficient knowledge about mathematical notations as well as statistical symbols of, mathematical presentation and statistical symbol errors are seen in publications. In this study 2.94% of the investigated publications were found with mathematical notation errors and 3.43% of the publications with statistical symbol errors. In the study of Ercan et al. in medical journals the rates of mathematical notation errors and statistical symbol errors were identified in 6.91% and 3.23% respectively [10]. Specifically, statistical notation errors in the process of evaluation will mislead the reviewer of the study and affect the understanding of the reader.

In some publications, by not giving the related explanation of the statistical expressions given by the authors, incomprehensive statistical terms were found. In the investigated articles, the rate of incomprehensive statistical terms was 0.49%. In the study of Ercan et al. in medical journals this rate was 4.15% [10].

Some studies were found with conflicting interpretations of statistical analysis. In this case publications were found with contradictory interpretations of especially the significance of statistical tests. In this study 14.71% of the investigated publications were identified with inappropriate interpretations. In the study of Ercan et al. in medical journals the rate was 8.76%, while in the study of Hanif and Ajmal the rate was 13.75% [10,12].

Another type of error discovered in the publications is when the researchers lack sufficient knowledge of statistics, which lead to improper use of statistical terminology. In this study 7.35% of the investigated publications were identified with errors in statistical terminology. In the study of Ercan et al in medical journals the rate was 9.68% [10].

In some publications the statistical method-analysis and the results were presented in improper sections. In the investigated publications these types of errors were seen when the researchers presented the p-value in the discussion section of the manuscript. In this study the rate of such type of error was identified at 15.69% of the investigated publications. In the study of Ercan et al in medical journals the rate was 6.91% [10].

Statistical errors can be broadly classified as; (i) errors in the presentation and terminology, not affecting the results, (ii) errors that are directly pertinent to the results [1]. When published studies in the field of veterinary science were examined in terms of statistical errors, the rate of errors that either affected or not affected the results were found to be considerably high in number. With inadequate statistical knowledge as the leading cause statistical errors in publications, in the general scientific process these causes of statistical errors can be classified into four groups: (a) not consulting a specialist on the topic, (b) falsely assuming that it is known, (c) not having adequate knowledge, and (d) carelessness [1].

Before accepting a publication for publishing, it has to go through a serious evaluation by relevant field reviewers; however in this study, as well as other similar studies, unfortunately was seen that the statistical evaluation process was considered as insufficient or completely left out in the publications. Editors should give more consideration to the statistical aspect during the evaluation process of the manuscripts. Therefore, the editors should send the submitted studies to statistical reviewers before relevant field reviewers. Performing a statistical review before sending off the study to relevant field reviewers is more appropriate, at the same time it prolongs the review process of the manuscript, thereby providing enough time for all errors to be properly identified. If the study is sent to the statistical reviewer at the same time with the relevant field reviewer, any type of erroneous application of statistical methodology found by the statistical reviewer can bring up changes in results which also lead to changes in the discussions that can directly affect the evaluation of the field expert, in such case the field expert has to re-evaluate the study, again.

In the process of investigating the statistical error sources the researchers were not able to make one and standard classification for the statistical errors. Therefore, even

if the definitions of the errors are same, because of the differences that will arise from the classification of the researchers to the respective error classifications, a big rate of differences can occur. However, when assessing the statistical errors according to the year of publications in the same journal, the assessment of same group of researchers will be a realistic approach.

To reduce and prevent the statistical errors in publications, the researchers must have a basic statistical knowledge and during the study process, they have to get a statistical consultation from field experts. While in the review process, the reviewers have to send the studies to statistical editors when necessary and most important the editors have to redirect the publications to a statistical reviewer whenever needed.

Authors' contributions

EI participated in the design of the study and performed the statistical analysis. All authors conceived of the study, and participated in its design, coordination and helped to draft the manuscript and read and approved the final manuscript.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

1. Ercan I, Demirtas H: Statistical Errors in Medical Publication. Biom Biostat Int J 2015, 2: 00021.
2. Ercan I, Yazici B, Yang Y, Ozkaya G, Cangur S, Ediz B, Kan I: Misusage of Statistics in Medical Research. Eur J Gen Med 2007, 4: 128-134.
3. Ercan I, Ocakoglu G, Ozkaya G, Sigirli D, Cangur S, Gunel Karadeniz P: An International Survey of Physicians' Knowledge of Biostatistics. Turkiye Klinikleri J Med Sci 2013, 33: 401-409.
4. Ercan I, Ocakoglu G, Sigirli D, Ozkaya G: Assessment of Submitted Manuscripts in Medical Sciences According to Statistical Errors. Turkiye Klinikleri J Med Sci 2012, 32: 1381- 1387.
5. Glantz SA: Biostatistics: How to Detect, Correct and Prevent Errors in the Medical Literature. Circulation 1980, 61: 1-7.
6. Lukiæ IK, Marusiæ M: Appointment of Statistical Editor and Quality of Statistics in a Small Medical Journal. Croat Med J 2001, 42: 500-503.
7. McGuigan S: The Use of Statistics in the British Journal of Psychiatry. Brit J Psychiat 1995, 167: 683-688.
8. Simundic AM, Nikolac N: Statistical Errors in Manuscripts Submitted to Biochemia Medica Journal. Biochem Med 2009, 19: 294-300.
9. Welch II GE, Gabbe SG: Statistics Usage in the American Journal of Obstetrics and Gynecology: Has Anything Changed? Am J Obstet Gynecol 2002, 186: 584-586.

10. Ercan I, Karadeniz PG, Cangur S, Ozkaya G, Demirtas H: Examining of Published Articles with Respect to Statistical Errors in Medical Sciences. International Journal of Hematology and Oncology. 2015, (2) 25: 130-138.
11. Ercan I: Letter to the Editor: p-degeri acik mi kapali mi yazilmali? [Should P-Values Be Written in the Open or Closed Form?]. J Pediatr Inf 2010, 4: 47.
12. Hanif A, Ajmal T: Statistical Errors in Medical Journals (a Critical Appraisal). Annals of KEMU 2011, 17: 178-182.

ANALIZA GREŠAKA U STATISTIČKOJ OBRADI PODATAKA U NAUČNIM RADOVIMA OBJAVLJENIM IZ OBLASTI VETERINARSKE MEDICINE

ERCAN Ilker, KAYA Mehmet Onur, UZABACI Ender, MANKIR Seray, CAN Fatma Ezgi, BASHIR ALBISHIR Musa

Cilj ove analize je bio da se ispita prisustvo grešaka u statističkoj obradi podataka u objavljenim naučnim radovima na polju veterinarske medicine. Ukupno je analizirano 204 objavljena rada (SCI ili SCI-Exp). Izbor radova je uključivao one koji su indeksirani u PubMed bazi podataka za period od 2010. do 2014. godine uključujući i 2014. godinu. Najmanje jedna statistička greška je ustanovljena u 199 radova. Najčešće greške u časopisima SCI i SCI-E, bile su"greške prilikom sumiranja podataka". U 2,45% radova (n = 5) od ukupno 204 rada, samo u 5 objavljenih radova i to (0,98% odnosno 1 od 101 sa SCI liste i 3,92% ili 4 od 102 sa SCI-E liste), nije uočena nijedna greška. Da bi se smanjio procenat kao i broj statističkih grešaka prilikom objavljivanja radova, istraživači treba da raspolažu osnovnim znanjem iz statistike. Istovremeno, tokom izrade rada kao i prilikom obavljanja recenzije, potrebno je da rad pregledaju i eksperti iz polja statistike. To je ujedno i najznačajnije za eliminisanje grešaka tokom procesa pregleda i objavljivanja naučnih radova.