Journal of Experimental and Clinical Medicine
https://dergipark.org.tr/omujecm

Research Article

J Exp Clin Med
2022; 39(3): 620-627
doi: 10.52142/omujecm.39.3.5

Evaluation of biostatistics knowledge and skills of medical faculty students

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Received: 19.10.2021 • **Accepted/Published Online:** 18.04.2022 • **Final Version:** 30.08.2022

Abstract

Successful implementation of a scientific study and correct analysis of data obtained is possible with advanced biostatistics knowledge. The aim of this study is to find out efficacy of basic biostatistics program given to medical faculty students and to evaluate students' biostatistics knowledge, attitude and behaviour levels. Medical Faculty students in a Turkish university participated in this study. 123 of the respondents (52.6%) were male and 111 (47.4%) were female, with an average age of 20.2 ± 1.7 years. The survey used included items questioning demographic information, biostatistics knowledge, attitude and behaviours of students and 10 multiple choice questions including the subjects learned during the program. The students filled in this survey before and after training and data obtained were evaluated. Students' positive responses to having biostatistics basic knowledge were 68.0% before training and 95.7% after training. The frequency of knowing the purpose of biostatistics was 81.5% before training and 96.6% after training. While the rate of positive response was 60.9% for population and sample, 63.2% for basic principles in summarizing data, 54.7% for central tendency-location measurements, 51.5% for variability measurements before training, they were found as 95% and higher after training. Positive responses of 70.8% for hypothesis and error types, 48.7% for statistical assumptions, 36.5% for parametric hypothesis tests, 33.0% for nonparametric hypothesis tests and 27.4% for statistical package programs before training were 93.6% and higher after training. Total score obtained from responses to multiple choice questions was 2.5±1.4 before training and 7.5±2.1 after training, which was statistically significant ($p<0.001$). In this study, biostatistics knowledge, attitudes and behaviours of medical faculty students were evaluated. Biostatistics training needs changes due to latest developments in information technology. Many medical faculties currently teach basic biostatistics concepts and carry out biostatistics training studies to allow critical evaluation during the process.

Keywords: biostatistics, statistics, education, evidence-based medicine

1. Introduction

Evidence based medicine (EBM) is the application of the best medical approach for the patient as a result of combining the best evidence gathered from studies, clinical experience and patient preferences. It is the conscious, clear and reasonable use of best evidence available while making decisions about the care of the individual patient (1).

In evidence based medicine, the clinician is faced with a large number of articles that address various problems, evaluate treatment methods and investigate the predictive value of various factors on these methods (2). Physicians need to have access to original research reports and to evaluate the design, implementation, analysis and results of each study critically in order to answer a large number of clinical questions. A certain level of expertise is required on the subject for the evaluations to be made in this process (3).

Most physicians feel comfortable while reviewing parts of a research article such as abstract, introduction, methods, results and discussion. Various sources and references provide a solid basis for evaluating the quality of a research article in terms of purpose, logic and conclusion (4, 5). For this reason, it is not difficult for a knowledgeable healthcare professional to identify whether the purpose, methodology and results are compatible with the scientific methodology. However, it is more difficult to evaluate the appropriateness of statistical analysis and to interpret the results of statistical analysis (6).

Since complicated biostatistical methods are reported in medical literature, critical evaluation of original report may be difficult for many physicians. Although there are many statistical course books and articles that may help in interpreting the validity of statistics, most of the time, these references are very detailed for individuals to comprehend these statistical concepts quickly and to apply them to statistical parts of articles (7).

Many physicians have little understanding of statistical tests and therefore they have limited ability to interpret study

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results. This has been clearly shown in studies conducted on the subject (8, 9). Similar studies have shown that even physicians who are more familiar with literature and research principles have limited biostatistics knowledge. Preliminary studies conducted on evidence based medicine have shown that basic statistical concepts are poorly understood by clinicians while evaluating medical literature (10-12). The need for competence in biostatistics results from the increasing quantification of health sciences and many researchers have recommended a better statistical training in health sciences (13, 14).

Since understanding biostatistics in health sciences has a significant effect on evidence based diagnosis and treatment practices, it is indispensable in the management of clinical practice process. Carrying out a scientific study successfully, analysing the data obtained from clinical researches correctly and evaluating complex statistical results is possible with advanced biostatistics knowledge (15, 16).

The aim of this study is to identify the biostatistics knowledge, attitude and behaviour levels of students before and after receiving basic biostatistics training provided in medical faculty, to compare these and to evaluate the efficacy of biostatistics training program.

2. Materials and Methods

2.1. Participants

The present study included medical faculty students in a Turkish university. In total, 123 of the students (52.6%) were male and 111 (47.4%) were female and the average age of the students was 20.2 ± 1.7 years. OMÜ KAEK approved the study and written informed consent was obtained from all individual participants (decision number 2019/86).

2.2. Scale and procedure

Within the scope of this study, a survey was conducted to evaluate the biostatistics training process of the students. The survey consisted of items questioning demographic information, biostatistics knowledge, attitude and behaviours of students and ten multiple choice questions including the subjects students learned during the program. The students filled in this survey before and after they received biostatistics courses and the data obtained were evaluated.

The courses on biostatistics within the four-week block in the second year of Medical Faculty are taught as 20 hours of theory and 12 hours of practice. The block also covers ethics and research techniques.

Topics including the goals of the block related with biostatistics are as follows: the definition of biostatistics and its place of use in the field of health; frequently used terms (statistics, parameter, reliability, validity, systematic error, random error, etc.); population, sample, sample and concepts of sampling error; sampling methods; grouping the data as qualitative (nominal, ordinal)- quantitative (discrete, continuous) and in four basic measurement levels (nominal, ordinal, interval and ratio); frequency table and graphical methods for qualitative and quantitative variables; measures of central tendency (arithmetic mean, median, mode, weighted mean, harmonic mean, geometric mean), measures of location (such as quartile, percentage values) and measures of variability (range of variation, mean absolute deviation, interquartile range, semi interquartile range, variance, standard deviation, standard error, variation of coefficient); the definition of hypothesis in statistics, establishing the null and alternative hypothesis, type 1 error, type 2 error, statistical significance, concepts about the power of test; normality concept in health data, distribution tables and evaluation of assumptions. One proportion-two proportions test, chi-square analyses (Pearson and continuity correction) and Fisher's exact test, parametric tests for the comparison of two independent groups (Student t and Welch tests) and non-parametric tests (Mann Whitney U, Wilcoxon RS), parametric tests for the comparison (paired groups t test) and non-parametric tests (Wilcoxon SR) of two dependent groups, one way variance analysis, Kruskal-Wallis variance analysis, multiple comparison tests, regression and correlation analyses are also other subjects taught.

Applied courses are carried out by using SPSS package program in the block. The application starts with the introduction of SPSS menu and entering a new data set to the program. Descriptive statistics, obtaining and processing graphs suitable for data, hypothesis control and hypothesis tests are carried out by using real health data. In the last part of the application, interpretation of all statistical results obtained and their presentation in a scientific article are explained to students.

2.3. Statistical analysis

Statistical analyses were performed with SPSS 21.0 for Windows (17). Data were presented as mean ± standard deviation (SD), as median (min-max) as frequence (%). The Shapiro–Wilk test was used to analyze normal distribution assumption of the quantitative outcomes. The data of two dependent groups were Wilcoxon Signed Rank test. The frequencies were compared, using the Pearson Chi-square, Continued Corrected Chi-square, Fisher Exact test and Mc-Nemar test. A p value less than 0.05 was considered as statistically significant.

3. Results

Demographic information of the students in the study was shown in Table 1. The students' grade point average for the previous year was 70.7±14.7.

Table 2 shows the pre-training biostatistics related knowledge, attitudes and perspectives of the students studying medical faculty in Turkish and English. Of the items examined, it was found that students who were studying in English answered the question "Have you been educated in Biostatistics (or Statistics) before?" with "yes" at a higher rate than the students who were studying in Turkish, statistical difference was found between the groups (p=0.002), while no statistical difference was found in terms of the other items (p>0.05).

Table 1. Demographic information of the students

	Mean±SD (Min-Max)*	n (%)
Age	20.2±1.7 (18.0-32.0)	
Average score	70.7 ±14.7 (2.6-86.0)	
Gender		
Female		111 (47.4)
Male		123 (52.6)
Nationality		
T.C		192 (82.1)
Other		42 (17.9)
Education		
Turkish		150 (64.1)
English		84 (35.9)

*Mean± Standard Deviation (Minimum-Maximum)

Table 2. Pre-training evaluation of Turkish and English class students

	Turkish Education	English Education	p
Have you been educated in Biostatistics (or Statistics) before?			0.002
No n(%)	144(96.0)	70(83.3)	
Yes n(%)	6(4.0)	14(16.7)	
Do you consider yourself proficient about biostatistics?			0.074
No n(%)	146(98.0)	78(92.9)	
Yes n(%)	3(2.0)	6(7.1)	
Do you think that you can assess an article statistically?			0.652
No n(%)	133(88.7)	72(85.7)	
Yes n(%)	17(11.3)	12(14.3)	
In which year of medical education do you think Biostatistics education should be given?			0.330
1-3.grade range	127(87.6)	76(92.7)	
4-6.grade range	18(12.4)	6(7.3)	
Do you think that biostatistics lesson will be useful for your future career?			0.133
Disagree	20(13.3)	19(22.6)	
Undecided	48(32.0)	20(23.8)	
Agree	82(54.7)	45(53.6)	
Is Biostatistics important for you?			0.200
Disagree	28(18.7)	24(28.6)	
Undecided	57(38.0)	30(35.7)	
Agree	65(43.3)	30(35.7)	
Should Statistics literacy be one of the important goals of the education in Medicine Faculty?			0.183
	21(14.1)	18(21.4)	
Undecided	49(32.9)	31(36.9)	
Agree	79(53.0)	35(41.7)	

Evaluations of the students before and after biostatistics training are given in Table 3. For all the topics examined, the frequency of "yes" after training was found to increase when compared with before training and this increase was found to be statistically significant (p<0.001).

The answers given by students to 10 multiple choice questions asked randomly from all subjects they learned during the block were compared before and after training (Table 4). The frequency of answering all the questions correctly increased after training and this increase was found to be statistically different (p<0.001).

Table 3. Students' assessments regarding biostatistics before and after training

	Before Training		After Training		p
	No n(%)	Yes n(%)	No n(%)	Yes n(%)	
I have basic information about biostatistics	74(32.0)	157(68.0)	10(4.3)	221(95.7)	<0.001
I know the intended purposes of biostatistics	43(18.5)	190(81.5)	8(3.4)	225(96.6)	<0.001
I have information about population and sample	91(39.1)	142(60.9)	10 (4.3)	223(95.7)	<0.001
I know the basic principles in the organization and summary of data	86(36.8)	148(63.2)	11(4.7)	223(95.3)	<0.001
I have information about central tendency and location measurements and their places of use	105(45.3)	127(54.7)	10(4.3)	222(95.7)	<0.001
I know about dispersion measurements and their places of use	113(48.5)	120(51.5)	12(5.2)	221(94.8)	<0.001
I have information about the definition of hypothesis and types of error	68(29.2)	165(70.8)	12(5.2)	221(94.8)	<0.001
I have information about parametric hypothesis tests	148(63.5)	85(36.5)	13(5.6)	220(94.4)	<0.001
I have information about non-parametric hypothesis tests	156(67.0)	77(33.0)	15(6.4)	218(93.6)	<0.001
I know which assumptions should be checked for hypothesis tests	120(51.3)	114(48.7)	13(5.6)	221(94.4)	<0.001
I have information about statistical package program SPSS	170(72.6)	64(27.4)	15(6.4)	219(93.6)	<0.001

Table 4. Comparison of the answers given by students to multiple choice questions before and after training

Questions	Before Training		After Training		p
	False n(%)	True n(%)	False n(%)	True n(%)	
Which of the following is not one of the basic characteristics of a sample with the ability to represent?	132(56.4)	102(43.6)	57(24.4)	177(75.6)	<0.001
Which of the following is the value obtained by dividing a health event that occurs within a defined period of time (for example 1 year) into the midyear population under risk within that period?	200(85.5)	34(14.5)	152(65.0)	82(35.0)	<0.001
Which of the following is the simplest measurement scale?	138(59.0)	96(41.0)	48(20.5)	186(79.5)	<0.001
Which of the following is not one of the criteria showing central tendency?	124(53.0)	110(47.0)	31(13.2)	203(86.8)	<0.001
Which of the following is not one of the criteria that shows variability?	157(67.1)	77(32.9)	80(34.2)	154(65.8)	<0.001
If Ho is really correct, and if the researcher rejects this correct argument according to the value he/she calculates as a result of the statistical test conducted with the evidence gathered, how can the result be interpreted?	190(81.2)	44(18.8)	32(13.7)	202(86.3)	<0.001
Which of the following is the test method to be used to compare the averages of two independent groups with data which show normal distribution?	207(88.5)	27(11.5)	26(11.1)	208(88.9)	<0.001
Which of the following is the non-parametric equivalent of paired t test?	194(82.9)	40(17.1)	57(24.4)	177(75.6)	<0.001
The researcher wants to test the association between two-category state of smoking (yes,no) and four category educational status (primary education, high school education, undergraduate education, graduate education). Which of the following is the degree of freedom of the Chi-square statistics obtained	210(89.7)	24(10.3)	51(21.8)	183(78.2)	<0.001
Which of the following (in the SPSS menu) is used to check the normal distribution assumption of a data set?	182(77.8)	52(22.2)	59(25.2)	175(74.8)	<0.001

Fig.1 shows the comparison of the scores found by adding the correct answers given by students to multiple choice questions before and after training. Total scores before and after training were found as 2.5±1.4; 2.0 (0-6.0) and 7.5±2.1; 8.0 (0-10.0), p<0.001.

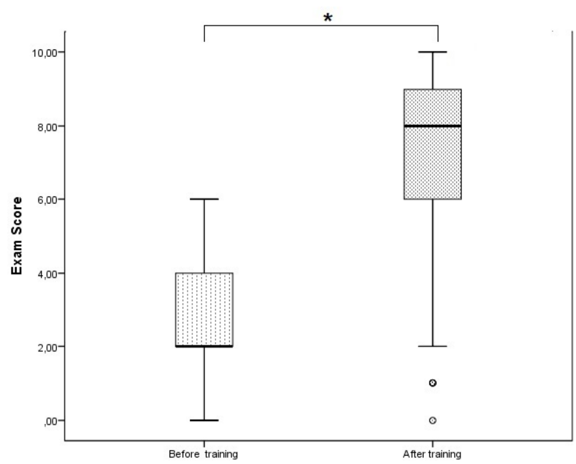

Fig. 1. Exam score comparison before and after training

4. Discussion

This study evaluated the theoretical and applied biostatistics education given to medical faculty students and examined the students' knowledge, attitude and behaviours. 47.4% of the students in the study were female and 52.6% were male; 82.1% were Turkish and 17.9% were from other nations. 64.1% of the students were studying in Turkish and 35.9% were studying in English.

Before statistics training, the students studying in Turkish and English classes were compared in terms of some subjects. 16.7% of the students studying in English and only 4% of the students studying in Turkish stated that they had received education on the subject before and this difference between the groups was statistically significant. More than 90% of the students in both groups did not consider themselves competent in biostatistics and more than 85% students stated that they would not be able to evaluate an article in terms of statistics. Most of the students in both groups preferred the training to be given in the first three years. The students in both groups responded positively to the question of whether biostatistics was important for them and for their career with a rate higher than 50% and 35%, respectively; to the question of its importance in medical faculty education with a rate higher than 40%; to the question of importance of statistical literacy with a rate higher than 80%. There were no statistical differences between the groups in terms of the topics compared.

In a study conducted on students receiving orthodontic education, 63% of the participants agreed with the statement "I would like to gain more knowledge on biostatistics", 19.9% agreed with the statement "I understand all the statistical terms seen in journal articles" and 22% agreed with the statement "I often use statistical information to formulate decisions in orthodontic treatment" (18). In a study conducted on 277 residents from different branches on residents' understanding biostatistics results in medical literature, it was found that 75% did not understand the statistics in journal articles and 95% thought that in order to be an intelligent literature reader, it was important to understand these concepts (19).

In this study, it was found that most of the students did not consider themselves competent about biostatistics before receiving biostatistics training and they thought they could not evaluate an article statistically. It was found that although the students could not comprehend the importance of biostatistics well, they thought statistical literacy was important. In studies conducted on dentistry and medicine faculty students, similarly the participants stated that they could not understand most of the statistics in articles. However, it was found that the participants believed statistical literacy was important and they wanted to have more statistical knowledge. The common characteristic in this study and other studies is the result that students did not consider themselves competent about biostatistics and they understood the importance of statistical literacy.

All of the students were asked some questions about biostatistics before and after training. While 68.0% of the students answered the question of having basic information about statistics before training positively, this rate was found as 95.7% after training. While the frequency of knowing about the purpose of biostatistics was 81.5%, this rate was found as 96.6% after training. While the frequency of positive answers was found as 60.9% for population and sample, as 63.2% for basic principles in summarizing data, as 54.7% for central tendency-location measurements, as 51.5% for variability measurements, the rates were found as 95% and higher after training. The frequency of positive answers was found as 70.8% for hypothesis and error types, as 48.7% for statistical assumptions, as 36.5% for parametric hypothesis tests, as 33.0% for non-parametric hypothesis tests and as 27.4% for statistics package program use before training and the rates was found as 93.6% and higher after training.

In a study by Polychronopoulou et al. (18), 83.5% evaluated themselves as fairly to highly confident in interpreting p value, while 65.3% evaluated themselves as fairly to highly confident in understanding statistical methods and 78.7% evaluated themselves as fairly to highly confident in interpreting statistical analysis results in articles. In a survey study conducted on 201 clinicians in a research hospital in North Malaysia, it was found that 79.1% could interpret p value and 91.5% could interpret the statistical method used, 87.1% could identify the factors affecting the power of the study, while only 6% could evaluate the correct statistical procedure to be used in the study (20). The most regularly encountered statistical concept was inferential statistics with 63.7%, which was followed by data organization with 58.7%, correlation and dispersion with 53.7%, measures of central tendency with 45.8%, measures of dispersion with 43.3%, and measuring scales with 33.8%. In this sample, nearly 75% of the clinicians stated that they understood biostatistical results (20). In Windish's (21) study, residents rated a mean of 4.2 or greater for the curriculum helping them understand study designs, interpret p value and CI, choose a statistical test to make comparisons, interpret the results of statistical tests and assess if the correct statistical procedure was used to answer a research question. Most of the residents stated that they needed time to understand different statistical tests, 60% stated that they thought some subjects could be taught in more detail and a great majority stated that more examples would be better (21). In this study, it was found that students' levels of knowledge about the basic subjects of biostatistics increased after training and this increase was statistically significant. All these indicators show that the goals and subjects in biostatistics training program were learned and understood by students. In other studies, the rates of correct answers about topics were found to be lower or higher than the initial rates obtained in the present study. The reason for this is the fact that the participants in other studies had received biostatistics training previously. In the present study, higher correct answer rates were found after training, with the application of the survey immediately after training, the rates of remembering the outputs of the training are higher.

10 random multiple choice questions including the goals of the course program were asked to students before and after training and the students' rates of giving correct answers were compared. While the total score obtained from the answers given to multiple choice questions was 2.5±1.4 before training, it was found to increase to 7.5±2.1 after training and this increase was found to be statistically significant. With this training, the rate of correct answers to the question of sample with the ability to represent was found to increase to 75.6% from 43.6%. The frequency of correct answers to the question about basic concepts was found to increase to 35.0% from 14.5%. While the frequency of correct answers to the question about measurement level was found as 41.0% before training, it was found to increase to 79.5% after training. While the frequency of correct answers to the questions of central tendency and variability measurements were found as

47.0% and 32.9%, respectively before training; they were found as 86.8% and 65.8%, respectively after training. While the frequency of correct answers to the questions about error types, samples from parametric and non-parametric tests, Chi-square analysis and package program use were found as 18.8%, 11.5%, 17.1% and 10.3%, respectively before training; they were found as 86.3%, 88.9%, 75.6% and 78.2%, respectively after training.

In a study evaluating the biostatistics knowledge levels of postgraduate orthodontic students, the correct answer rate of the participants was found as 43.8% (18). Correct answer rates for topics were found as 44.8%, 44.0%, 37.8%, 70.0%, 62.2%, 33.0%, 42.5%, 11.8% and 40.1%, respectively for a continuous variable, a nominal variable, standard deviation, null hypothesis, parametric methods, p value, analysis of variance, chi-square test and t-test. It was found that the students' biostatistics knowledge was affected by the related trainings they received previously (18). The rates of correct answers given to multiple choice questions in a study conducted on residents in Connecticut were found as 33-44%, 50%, 30%, 59%, 57%, 58%, 26% and 47 %, respectively for variable types, standard deviation, the relationship between test power-sample size and significance level, interpretation of p value, choosing the appropriate statistical test, t test, Chi-square test and ANOVA (19). Additional advanced degrees, prior biostatistics training and enrolment in a university-based training program were factors associated with higher scores in residents. In this study, most of the residents did not have the required biostatistical knowledge to interpret many results in published clinical research. In order to successfully prepare residents for this important lifelong learning skill, the curricula of residency programs should include more effective biostatistics training şeklindeydi (19). The rate of correct answers for 20 multiple choice questions after statistical training received by 52 residents in Yale Primary Care Internal Medicine Residency Program was found as 58±16. The program included hypothesis test process, sample size, test power, p value, confidence interval, statistical significance, variable types measurement level, statistical methods and Kaplan Meiyer (21). When the answers given to questions were examined, it was found that variable types were answered correctly with a rate of over 71%, variance analysis was answered correctly with a rate of 54%, Chi-square was answered correctly with a rate of 38%, student t test was answered correctly with a rate of 71%, interpretation of p value was answered correctly with a rate of 75%, power, sample size and statistical significance was answered correctly with a rate of 40% (21). In Belgrade University Public Health postgraduate program, it was evaluated whether blended learning was a more effective method than traditional method in students' gaining biostatistical competence (22). Course program for blended learning included statistical definition, parameter, probability, normal distribution, sample and methods, statistical power, point and range estimation, confidence limit, statistical significance and statistical test, parametric and nonparametric statistics, t test, Chi-square test, correlation, regression and linear regression. The program was evaluated according to final score. Both the final statistics score (89.65 ±6.93 vs. 78.21±13.26; $p<0.001$) and knowledge test score (35.89±3.66 vs. 22.56±7.12;$p<0.001$) of the blended learning group were higher than for the on-site group (22). The mean of correct answers given to 10 multiple choice questions in the survey study conducted to evaluate pharmacists' understanding and assessing statistical information in literature was 2.8±2.0 (23). The rate of correct answers given to the questions in the survey which included the most common statistical terms and tests was 77.7% for definition of assumptions related with statistical techniques, 62.5% for statistical test characteristics, 50.8% for statistical and clinical significance, 50.8% for statistical and clinical significance, 22.9% for confidence limit, 18.2% for hypotheses, 13% for p value, 10% for student t test, 17.8% for test power, 5.1% for Chi-square and 2% for ANOVA (23). A six-stage training program was implemented on endodontic first year residents to develop an initiative curriculum in post-graduate health education (24). At the end of the curriculum, all residents were found to show competency. 36.9% pre-test correct answer rate increased to 79.8% in the post-test (24).

In this study, all of the questions had higher correct answer rates after training when compared with before training and the difference was found to be statistically significant; this result shows that training was sufficient to provide knowledge and behaviors to students in basic topics. In other studies conducted on the subject, it was found that basic biostatistics questions had different response rates. Similarly, the rate of answering the questions increased before and after biostatistics training and this was found to be statistically significant. It was also found that having received biostatistics training previously had an effect on the score.

A large number of medical faculties currently teach basic biostatistics concepts and studies are carried on biostatistics training that will allow critical evaluation during the process in medical faculty. Accreditation boards also provide practices to improve education and services to teach biostatistics better (25, 26). It is also important to know the knowledge levels of students to solve the problems that occur during biostatistics training and to plan curriculum for both undergraduate and postgraduate education (27).

As a conclusion, the basic biostatistics training program given in medical faculty was evaluated in addition to biostatistics knowledge, attitude and behaviors of students for this study. It was found that the biostatistical knowledge of students, which was limited before training, increased after training. At the same time, the importance of statistical literacy within the framework of evidence based medicine and analysis of statistical literature were shown. Biostatistics, which is widely used in clinical education for evidence based medicine, is important to ensure the understanding of biostatistics teaching, to interpret clinical data and to evaluate research evidence. The continuity of evidence based medicine depends on clinicians' commitment to keep the latest clinical information up-to-date.

Conflict of interest
The authors declare no conflict of interest.

Funding
None.

Acknowledgments
None to declare.

Authors' contributions
Concept: LT., Design: LT., HC., Data Collection or Processing: LT., HC., Analysis or Interpretation: LT., Literature Search: LT., Writing: LT.

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