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Positive Impact of Clinical Research Courses on The Knowledge and Attitudes Towards Biostatistics in Clinical Residents

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1. Abstract

In biomedical research the biostatistics knowledge is fundamental to carry out the analysis of data obtained in research projects. However, health professionals usually show poor skills in this matter. This study aimed to evaluate the effectiveness of an intervention course about biostatistics in the knowledge and attitudes towards biostatistics of health residents. A quasi-experimental study was developed with an intervention consisted in a two-module course (introductory and advanced) with a participatory methodology, and practical activities with real examples of routine clinical practice and the use of computer tools to perform statistical analysis and mentoring help. To assess knowledge it was used the version translated into Spanish of the questionnaire Novack et al. and to determine attitudes it was applied the Survey of attitudes towards statistics questionnaire (SATS-28). The median in knowledge about biostatistics [11], test has significantly increased 3 points (Mann-Whitney U = 344.5; p<0.001) after completing the course. The attitude scale (SATS-28) has also increased positively by 1.64 points (Mann-Whitney U= 355, p=0.0002), highlighting the greater increase in the cognitive competence subscale with 2.67 points (U Mann-Whitney = 232.5, p<0.0001). A significant positive correlation was found between the global score of the knowledge and attitude (pre-course: p<0.001, Rho= 0.79; post-course: p-value<0.001, Rho=0.62). The use of participatory educational strategies by promoting the management of statistical programs in combination with real cases and mentoring improve the attitude and the knowledge of biostatistics in health residents.

2. Introduction

Statistics is the science in charge of expressing the knowledge in a quantitative manner, being an applicable tool in all professional fields and disciplines, both in the field of social and in health sciences [1]. When statistics is applied in the medical sciences, it is denominated as biostatistics, being their use fundamental to achieve what is known as evidence-based medicine (EBM). The goal of the EBM is to stimulate a critical, reflective mindset, developing statistical reasoning and understanding the results of biomedical research studies, for improving daily clinical practice [4,13,19]. Therefore, for all professionals engaged in biomedical research and especiallyfor medical graduates [13], it is essential to reach an adequate training in biostatistics, for being able to statistically reason the results obtained from their research studies. Thus, it is important that, at the university, during their educational period, they could acquire an adequate training in biostatistical concepts. For this reason, in some countries, like in Spain, the degree in Medicine includes some subject related to biostatistics. However, this educative program is usually poor, detecting his weaknesses during the period as a hospital resident [5]. Some studies from different countries and medical specialties have showed consensus on the lack of residents' knowledge of biostatistics, while also they recognized the importance of good statistical knowledge [1,2,8,9,18]. Although, in a recent study of the Faculty of Medicine of the University of Zaragoza (Spain) focus on physicians residents, it was described a general sufficient level of knowledge in biostatistics, being highlight that emotions and attitudes were essential, since residents with a positive attitude towards biostatistics presented the highest level of knowledge [15,16]. Thus, it seems necessary to deepen in the study of the attitudes towards the use of statistics, as a tool for the identification of the difficulties that are causing the lack of knowledge, and to create strategies to help overcome them.Attitude is defined as a personal general evaluation about objects and behaviours, with an important psychological function for individuals that influence in the personal decision making. Attitude is determined by three components, being the cognitive, affective, value, and related to behaviour sphere the most important ones [13,14]. In this sense, the existing literature has shown that the attitude plays a crucial role in the learning of statistics, changing not only students' cognitive competency but also the perceptions of their own skills [10,21]. In Spain, health specialized training consists in a system that is based on professional-centred learning with a training program that describes the objectives and competencies that residents must acquire in a period of 3 to 5 years according to the specialty chosen. One of these objectives is related to research field, including the achievement of sufficient knowledge in biostatistics. However, in these programs there is not present the single criterion specifying the content and the methodology in this regard, remaining at the discretion of each hospital training unit. For this reason, this subject still orphan of studies must be addressed. Therefore, the goal of this study is to evaluate the effectiveness of a biostatistics training strategy based on courses in the acquisition of knowledge and improvement of attitudes towards biostatistics in health residents. Also studying the factors that could influence attitudes during statistical performance.

3. Method

3.1. Study Design

A quasi-experimental and longitudinal study was carried out to evaluate the effectiveness of the pedagogical methodology followed in the research courses before and after the intervention. The study was approved by the Research Ethics Committee of the Son Llàtzer University (code 22-04-2020 Inf. Eval.). The sample of participants was 55 health residents in an university hospital in the Balearic Islands. The inclusion criterion of which was to be a healthcare professional resident of the hospital and enrolled in the research course. The exclusion criterion was the refusal to participate in the study, to be residents of external rotations in this hospital, and to have completed postgraduate statistics courses. The primary end-point were the attitude towards biostatistics and the basic knowledge of biostatistics. Besides, the following variables have been analysed: age, sex, profession (e.g., physician, nurse, physiotherapist), specialty, year of residence, previous optative courses in biostatistics during the university degree excluding post-graduate courses, and management of statistics programs.

3.2. Instruments

The evaluation of the basic knowledge in biostatistics was done through the use of the questionnaire [11], which has been validated through a pilot test with 15 members of the Department of Epidemiology at Ben-Gurion University (Israel). In 2016 it was translated into Spanish by [18]. Which has been validated by the Research Directorate of the Faculty of Medical Sciences of the National University of Asunción (Paraguay) [18]. The questionnaire consists in 5 questions about basic concepts of biostatistics. Each question presents 4 or 5 possible response options (see Supplementary material Appendix A).To determine the influence of the attitude in the knowledge of statistics it was used the Survey of Attitudes Toward Statistics questionnaire (SATS-28). The questionnaire contains 28 items (written with a positive or negative meaning) and a seven-point Likert-type scale to rate each item (1: strongly disagree, 4: neutral, 7: strongly agree). The scale items are separated into 4 subscales, being the following ones: (Affect: positive and negative feeling of concern; Cognitive competence: intellectual abilities involved in statistics; Value: relevance, and value of statistics in personal and professional life; and Difficulty: attitudes towards the difficulty of statistics as a subject). The SATS-28 questionnaire has been validated in its original English version by Schau et al., and later it was translated into Spanish (see supplementary material Appendix B), being the Cronbach alpha obtained of the entire scale 0.79, and the values of the four subscales were: 0.80 for Affect, 0.76 for Cognitive Competence, 0.81 for Value and 0.79 for Difficulty [6,17]. The scores for each subscale were determined by adding the values of the subscale items and dividing them by the number of items in the subscale. Before and after the intervention, participants were asked to answer the Novack and SATS-28 questionnaires. Being answered the pre-course version of these questionnaires in the classroom before the beginning of the first class of the Research Methodology and Biostatistics course, and the post-course version of the questionnaires at the end of the courses. The questionnaires were answered completely autonomously and anonymously.

3.3. Intervention Description

The Son Llatzer University Hospital in Palma, at the Balearic Islands, in Spain, is an university hospital accredited by the Spanish Ministry of Health since 2001, where it is provided specialized training to intern physician, pharmacists, nurses and psychological residents. In 2019, it was decided to design a new training program related to clinical research focus on statistic and research methodology for residents with a more dynamic pedagogical format. This program has been designed and organized by a team of experts in research from the Research Unit, the Teaching and Health Specialized Training Unit and the Research Commission of the Hospital. The program consists in two courses about biostatistics and research methodology. Being the first course considerate and denominated as Introductory, and it is based on an introduction of basic concepts regarding methodology and biostatistics, being preferably aimed to the first and second-year of residence. The second course is considerate and denominated as Advanced, and it is focused on deepening in the concepts acquired in the first introductory course by developing more advanced concepts of methodology and biostatistics. This part of the course is preferably aimed at the third, fourth and fifth-year of residence (because some specialties have five years of residence). The pedagogical methodology used in the two courses consists in a theoretical part about epidemiology and biostatistics, accompanied by a practical part, containing problem solving and clinical case studies, in addition to the development of a research project and the accompaniment of a tutor specialized in the subject during all the educational period. The main objective of this pedagogical strategy used is to transmit a comprehensive vision of the research methodology and biostatistics. Throughout the courses, biostatistics is presented to the students as a fundamental tool that allows analysing information and reaching conclusions. The courses follow the canonical structure that characterizes the scientific projects; therefore, it starts with the bibliography search, the determination of the type of study methodology, the data collection and finally the data analysis and representation using biostatistics to reach study conclusions. Therefore, the student must learn to perform and interpret the statistical analysis to draw conclusions, developing an adequate critical spirit. During the course, it is encouraged the loss of fear regarding statistics and an attempt is made to banish myths or negative ideas regarding this subject.

The content corresponding to biostatistics consists of two parts, the first part explains the statistical concepts with real examples of clinical practice and in the second part these concepts acquired through examples are practiced through guided exercises. For this activity there are used the analysis of databases corresponding to real research studies. Free statistical softwares are used for the analyses as for example Jamovi© for statistical analyses and Granmo© for sample size estimation. The practical sessions are carried out in 6 sessions with a duration of 2 hours in groups of 2 or 3 residents. In them, activities are carried out, some of these activities consist in carrying out a statistical analysis of a database that has been previously administered to the students in Microsoft Excel format. The instructor explains the content and the information contained in this database, then the instructor details the work they have to do with this database. Student must carry out a descriptive analysis, differentiating between quantitative variables (measures of centralization and dispersion) and qualitative variables (frequencies, percentages and 95% confidence interval). Students must also identify the independent variable and the dependent variables and to determine the type of statistical test to assess the possible statistical association between the variables studied. In the advanced course, the statistical analysis is expanded, so that the work that the residents must carry out is to establish a hypothesis and perform bivariate or multivariate analysis using parametric or non-parametric tests, previously checking the normality of the distribution of the data. There is also administered databases for carrying on survival analysis. Finally, students are required to deliver a document with a presentation of the results obtained including tables and graphs, with the interpretation, discussion and conclusion of these results. The work done during the course is registered and its delivery is necessary to obtain the certificate of completion of the course.

4. Statistical Analysis

A descriptive analysis of all the variables was carried out. Normality was assessed using the Kolmogorov Smirnov and Shapiro-Wilk tests depending on the sample size. The total score for Novack and SATS-28 questionnaires did not present a normal distribution, therefore non-parametric tests were performed to analysed them (e.g., Mann-Whitney test, Kruskal Wallis and Wilcoxon depending on the variable analysed). A Spearman rank correlation analysis was performed to examine the association between the score of the Novack questionnaire and the score (total and subscales) of the SATS-28 questionnaire. A simple and multivariate linear regression analysis was used to determine the related factors, using the score on the Novack questionnaire as Score of the questionnaire on basic knowledge in biostatistics [11].The dependent variable and the score on the SATS-28 scale and prior knowledge in biostatistics as independent variables. The determination coefficient R2 was calculated to determine the percentage of variability in the Novack questionnaire score according to the score of the attitude scale and previous knowledge in biostatistics. Differences between mean components scores at the beginning and at the end of the intervention were analysed using Mann-Whitney test. All tests were two-tailed. A value of $p < 0.05$ has been considered an indicator of a significant difference. The analyses were done by using the Statistical package for Social Sciences (SPSS, V.25) and Graphpad Prism V.8.

5. Results

5.1. Personal and Professional Profile of The Sample

The 76.4% of the participants were women and 23.6% were men, with a mean age of 28±2.79 years. 72.7% were resident physicians and 27.3% were nurses residents, psychologists and pharmacists. 61.8% were from clinical specialties and 38.2% were from non-clinical specialties. Regarding the distribution by years of residence 38.5% of the residents were belonged to the second year of residence and 26.9% were from the fourth year of residence, the rest were from first and third year of residence (Table 1). Table 1 shows the comparison of the score of the questionnaire on basic knowledge in biostatistics [11] questionnaire with the personal and professional profile, and the previous knowledge of statistics. Regarding the relationship between the level of basic knowledge in biostatistics and the personal profile (age and gender), no significant differences were found in the global score of the [11]. questionnaire (for age rho= 0.028; p= 0.843; for sex Mann-Whitney test= 236.5; p= 0.459). At the comparison between total score of the Novack et al. questionnaire with the professional profile (profession, specialty, years of residence), no significant statistic differences were observed (for profession Mann-Whitney test= 209.5; p= 0.155; for specialty residents Mann-Whitney test= 393.5; p= 0.518; for the year of residence Kruskal Wallis test= 6.137; p= 0.189). Regarding the impact of the possible previous knowledge of statistics in the Novack et al. questionnaire score, the participants who did not followed up any course, it has been observed that they presented a lower knowledge in biostatistics, with a significant difference in the score of the [11]. questionnaire (for previous courses in biostatistics Mann-Whitney test= 549; p= 0.001; for the management of statistics programs Mann-Whitney test= 450.5; p<0.001).Correlation between the basic knowledge [11]. questionnaire) and the attitude (SATS-28 scale) towards biostatistics. A statistical positive significant correlation has been observed (rho= 0.825; p<0.001), which indicates that health professionals' residents with negative attitudes towards statistics had also a low level of knowledge in biostatistics. In addition, a positive correlation was observed between the score of each subscale of the scale of attitudes towards statistics (SATS-28) and the global score of basic knowledge of biostatistics (Novack et al. questionnaire) (Table 2). Regression models of variables associated with the basic knowledge in biostatistics [11] questionnaire).Table 3 shows the result of the simple and multiple linear regression model of the predictors of the total score of the questionnaire on basic knowledge in biostatistics [11] questionnaire). The simple linear regression model shows statistical significance for both the variable of the SATS-28 scale score (R2= 0.109; β = 0.416; p= 0.014) and for the variable of the management of statistics programs (R2= 0.110; β= 1.331, p= 0.013) with the total score of the Novack et al. questionnaire. The first indicates that for each point added to the total score of the attitude towards statistics scale, the level of knowledge in biostatistics will increase 0.42 points. The second means that if the resident manages statistics programs there is an increase of 1.33 points in the level of knowledge in biostatistics. The multivariate regression model for basic knowledge in biostatistics presents statistically significant differences only for the variable of the total score of the SATS-28 scale (R2= 0.197; β= 0.523; p= 0.025), showing that for each point that the score of the attitude towards biostatistics increases, the basic knowledge in biostatistics increases 0.52 points,considering the variables of the previous knowledge in biostatistics.

5.2. Effect of the Intervention on The Basic Knowledge and The Attitudes Towards Statistics

After the intervention the participating residents obtained a mean score of 5 out of 5 (95% CI: 2-5) with a mean of 4.23±0.186 in the Novack et al. questionnaire, showing statistical positive changes in their basic knowledge in biostatistics with a difference of 3 points (Mann-Whitney test= 344.5; p<0.0001) after completed the course respect the basal measure pre-course (total score of 2 out of 5 (95% CI: 1-4) mean 2.71±0.22)Figure 2 shows the mean scores (SATS-28 scale and subscales) before and after the course. The global score of the SATS-28 attitude scale after completing the course has increased with a significant difference of 1.64 points (Mann-Whitney test= 355, p=0.0002). In addition, the results showed that the scores of the subscales Affect (Mann-Whitney test= 357.5, p=0.0002), Cognitive Competence (Mann-Whitney test= 232.5, p<0.0001) and Difficulty (Mann-Whitney test= 365.5, p=0.0003) showed significant positive changes after the intervention, while the changes in the scores of the Value subscale were not significant (Mann-Whitney test= 584, p=0.1867). The most significant changes were identified in the Cognitive Competence subscale score with a positive difference of 2.67 points and the Affect subscale score with a positive A significant and positive correlation was observed between positive changes in Knowledge of biostatistics [11]. questionnaire) and attitudes towards statistics (subscales and SATS-28 scale) (Rho= 0.62, p-value<0.001) after completed the course, indicating that the health professionals' residents improved their knowledge in biostatistics along with the attitudes shown towards statistics after completed the course (Table 2).

6. Discussion

The results obtained from this study provide an initial view of the basic knowledge and attitudes towards biostatistics among health professionals trainees in university hospitals in the Balearic Islands and evaluate the effectiveness of the new strategy used in Research Methodology and Biostatistics courses. Overall, previous the intervention students have insufficient knowledge in biostatistics. These results are in agreement with similar previous studies [2,8,11,18], demonstrating that exits important gaps of education in basic statistical knowledge, in order to then develop and integrate critical thinking in their future clinical practice and research works. The trainees who participated in our study showed a moderate level of knowledge about the most well-known statistical tests such as Chi-square and ANOVA, since the questions that referred to these statistical tests were the ones that they answered with the greatest accuracy. However, they have shown a lack of knowledge when interpreting the p-value, observing a relatively low percentage of participants who answered question 1 correctly (34.5%), which was in line with a previous study [18], this could be due to the lack of training in statistics, since more than a half (61.8%) did not take any previous biostatistics courses.In our study, gender was not significantly associated with the scores on the questionnaire on basic knowledge in biostatistics (Novack et al. questionnaire), which was also been shown in other similar studies [8,15]. No differences were found between the participated residents of the different years of residency, neither between the participated residents of clinical and non-clinical specialties, as in the case of other studies [7,16]. Likewise, the global score of the Novack et al. questionnaire was the same between residents' physicians and of another health profession (nurse, pharmacy, and psychology). This result must be considered with caution because the number of participated residents from another health profession was much lower than the number of participated residents' physicians.The low level of basic knowledge in biostatistics can be explained by the fact that the most residents revealed that they had not taken a previous biostatistics course and neither they did not handle biostatistics programs, showing

Table 1: Comparison of the score of the questionnaire on basic knowledge in biostatistics (Novack etal. [11] questionnaire) with the personal and professional profile, and the previous knowledge of statistics.

Score of the questionnaire on basic knowledge in biostatistics (Novack et al. [11])				
			Mean (95% CI)	***p-value***
Personal profile	Age in years		28± 2.79	0.843
	Gender	Male (n= 13; 23.6%)	3±1.91	0.459
		Female (n= 42; 76.4%)	2.61±1.61	
Professional profile	Profession	Physician (n= 40; 72.7%)	2.97± 1.68	0.155
		Ohers (n= 15; 27.3%)	2.28±1.54	
	Specialty	Clinical (n= 34; 61.8%)	2.58±1.67	0.518
		Non-clinical (n= 21; 38.2%)	2.9±1.7	
	Year of residence	R1 (n=7; 13.5%)	3.14±1.21	0.189
		R2 (n=20; 38.5%)	2.75±1.68	
		R3 (n=11; 21.1%)	2.55±1.69	
		R4 (n=14; 26.9%)	3±1.84	
Previous knowledge of statistics	Previous statistics courses	Yes (n=21; 38.2%)	2.86±1.74	0.001
		Non (n=34; 61.8%)	2.09±1.42	
	Management of statistics programs	Yes (n=12; 21,8%)	4.42±0.99	<0.001
		Non (n=43; 78.2%)	2.23±1.51	

Table 2: Correlation between the total score of basic knowledge in biostatistics (Novack et. al) and the total score of the SAT-28 attitude scale, and their subscales, in the studied sample before and after the pedagogic intervention.

Total score of basic knowledge in biostatistics (Novack *et. al*)						
	Pre course			**Post course**		
SAT-28 subscales	**Median score (95% CI, interquartile range)**	**Rho**	**P-value**	**Median score (95% CI, interquartile range)**	**Rho**	***P-value***
Affect subscale	2.33 (1.67-4.83)	0.66	<0.001	4.83 (3.79- 5.67)	0.40	0.038
Cognitive subscale	2.83 (2.33- 4)	0.63	<0.001	5.50 (4.67- 6.17)	0.62	<0.001
Value subscale	5.78 (5.22- 6.11)	0.53	<0.001	6 (5.53- 6.33)	0.41	0.035
Difficulty subscale	2.29 (1.71- 4.14)	0.64	<0.001	4.29 (3.11- 5.28)	0.60	0.001
Total	3.39 (2.90- 4.34)	0.82	<0.001	5.08 (4.23- 5.77)	0.62	<0.001

95% CI: 95% confidence interval.

Table 3: Simple and multiple linear regression of the level of basic knowledge in biostatistics according to the attitude towards biostatistics (SATS-28 scales) and the variables of previous knowledge in biostatistics (Novack et al. questionnaire) in the study population.

	Simple Linear Regression			**Multiple linear regression**		
	Beta (95% IC)	**R^2**	***P-value***	**Beta (95% IC)**	**R^2**	***P-value***
SATS-28 scale score	0.416 (0.088 a 0.744)	0.109	**0.014**	0.523 (0.069 a 0.976)		**0.025**
Previous courses in biostatistics	0.162 (-0.777 a 1.102)	0.002	0.730	-0.799 (-1.839 a 0.241)	0.197	0.317
Management of statistics programs	1.331 (0.287 a 2.375)	0.110	**0.013**	0.634 (-0.624 a 1.892)		0.129

Beta: regression coefficient, R^2: model determination coefficient, 95% CI: 95% confidence interval. The verification of the normality of the distribution of the residuals of the model has been verified by the Kolmogorov-Smirnov test (*p-value*= 0.2).

significant differences in knowledge of biostatistics between the group of residents with prior knowledge in biostatistics and the group of residents without prior knowledge in biostatistics. This finding suggests and reinforce the idea that training and continuous use of statistics increases basic knowledge in biostatistics much more. In addition, the use of statistical programs helps to put into practice the theoretical concepts acquired, being a key point in improving the effectiveness of the training of residents. Along the same lines, there are studies that highlight the importance of continuous training in this area and learning based on practice through activities with real examples [13]. The participating residents showed a negative attitude towards statistics, presenting a low overall score on the SATS-28 scale. This result correlates significantly with the global score of the basic knowledge of biostatistics questionnaire, especially those who showed greater Difficulty in learning statistics and less Affect and Cognitive Competence for biostatistics. These attitudes changed positively throughout the courses, showing significant positive changes in Cognitive Competence, Affect and Difficulty scores, highlighting the Cognitive Competence and Affect scale scores that showed the greatest increase. The positive changes in the global score of the SATS-28 scale and the scores of the Cognitive Competence, Affect and Difficulty subscales were positively correlated with the score the Novack et al. questionnaire after completing the course. In line with the [10]. Studycognitive competence presented the strongest correlation with the level of knowledge in biostatistics after the course, indicating that those resident students who felt more skilled and competent in statistics improved their knowledge in biostatistics much more after the course. Therefore, it is important to consider residents' attitudes regarding their cognitive competence in statistics to achieve better benefits and results in learning biostatistics. Another point to highlight is the high score observed on the Value subscale of the participated residents before and after the course, without any significant change. Therefore, the residents recognize the importance and relevance of statistics in their professional life despite presenting a negative global attitude towards biostatistics before completing the course. In line with previous studies that consider important to establish innovative pedagogical strategies and the avoidance of the use of complex statistical formulas to improve students' attitudes towards statistics [2,15,16], this study aims to analyse the effectiveness of the didactic training program in the methodology of statistics, research and biostatistics within the residency curriculum at our hospital. Our program is characterized using biostatistical computer tools to carry out statistical calculations and analyses, based on a participatory methodology and collective activities of real clinical cases, typical of the residents' health field. The preliminary results obtained showed an improvement in the residents' perception of their abilities, accompanied by a better statistical performance demonstrated by the significant increase in the [11]. questionnaire score. The results obtained are in accordance with a study developed by the European University of Madrid, where they show that the use of participatory methodologies with the incorporation of technological tools in the learning of biostatistics resulted in a significant improvement in the students' perception of their learning capacity [13]. One of the limitations of this study and of similar studies published so far it the small sample size. This is due to the difficulty of to achieving a greater recruitment of residents in a single hospital. Therefore, it is necessary to provide an effective basis, even if they are preliminary, in order to promote and pave the way for other studies on the subject that would be able to establish theories based on larger sample sizes, for example, in multicentre studies, including different hospitals and with a longer period recruitment. The residents who participated in the comparative study of the level of knowledge and attitudes towards biostatistics were the participants who attended the lessons and completed all the activities of our courses, and that accept to participate in the study anonymously. For this reason, we were unable to perform a data pairing analysis because the response rate is different on the two occasions. However, the preliminary results of the effectiveness of our training program could serve as an example for other accredited health hospitals with specialized health residence. Although, it is also important to adjust the programs to the needs and resources of each hospital; in addition to considering the importance of having competent and qualified instructors to guarantee the effectivity of the pedagogical intervention. Furthermore, the importance of developing a solid program about biostatistics with a participatory methodology, allowing to apply theoretical knowledge to real cases is evident, given the current situation of the COVID-19 pandemic worldwide, which has prompt the need of the health professionals to be skilled with the main clinical research tools, being familiar with the basic concepts of biostatistics in order to be able to address several new research and decisions situations correctly and quickly.

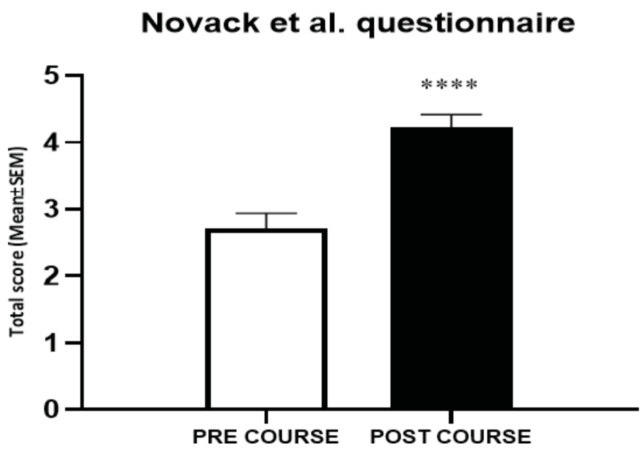

Figure 1: Results of the scores of the questionnaire on basic knowledge in biostatistics collected through the Novack et al. questionnaire (the score range is from 0 to 5). Columns represent the mean ± SEM before and after completing the course. ****p-value <0.0001 when comparing the two groups using the Mann-Whitney test.

7. Conclusions

The use of more participatory educational strategies including exercises with real clinical cases, promoting the management of statistical programs within the training of residents in their hospitals, improve their attitude and knowledge towards biostatistics. The relationship between knowledge and attitudes is clear, since residents that have good attitudes show better knowledge, and the course seems to demonstrate it through the improvement in all the cognitive skills. Our results are the beginning of an essential change towards an innovative and more structured training in biostatistics within the specialized training of health professionals' residents, heading towards the framework of an evidence-based medicine.

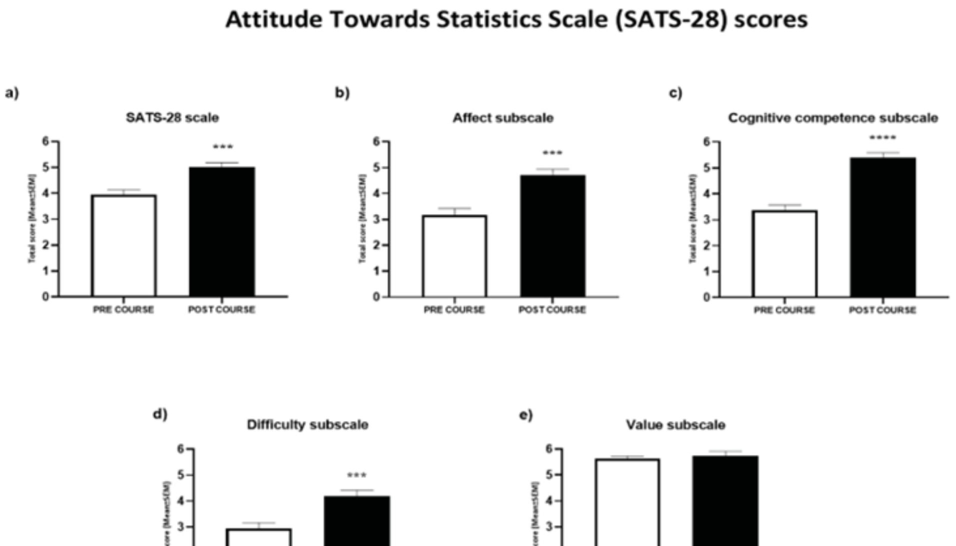

Figure 2: Results of the scores of the subscales and the scale of attitudes towards biostatistics collected through the SATS-28 questionnaire (the scale score range is from 1 to 7). Columns represent the mean ± SEM before and after completing the course. ***p-value <0.001. ****p-value <0.0001 when comparing the two groups using the Mann-Whitney test.

Appendix A: Assessment of basic knowledge of biostatistics (Novack et al. 11)

Mark with X the correct answers to the following statistical questions.

1. Treatment A was found to have a significant effect with a value of p = 0.05 and the effect of treatment B was found to be significant with a value of p = 0.002. We can conclude that:
a. The effect of treatment A is greater than that of treatment B
b. The effect of treatment B is greater than that of treatment A
c. It is impossible to compare the size of the effects
d. Both treatments have significant effects and, therefore, are equally effective.
2. In a clinical study, a number of patients are treated with a new drug to study whether, in a period after the administration of that drug, the level of bilirubin has decreased. It is accepted that the distribution of bilirubin is normal for this design. What is the statistical test of choice?:
a. Student's T for paired data
b. Student's T for independent data
c. Chi square
d. Mann-Whitney
e. Fisher's exact test
3. To study the possible association between maternal rubella and congenital cataracts, a sample of 20 children with this disease and 25 children with a similar history and age who do not have it is selected. An interview with each child's mother determines whether or not she had rubella during pregnancy. Which statistical test is the most appropriate to perform this study?:
a. Student's t of independent data
b. Student's T forpaired data
c. Chi square
d. Correlation
e. ANOVA (analysis of variance)
4. Which test should be used for the comparison of blood pressure values between subjects belonging to three levels of smoker?
a. Student t
b. Student's T for related samples
c. Correlation
d. ANOVA (analysis of variance)
5. In a statistical hypothesis contrast, if the null hypothesis were true and is rejected:
a. A type II error is made
b. A correct decision is made
c. Statistical power increases
d. A type I error is made
e. The most conservative decision is made

Appendix B: Survey of Attitudes Toward Statistics SATS-28 (Schau et al. [17]).

Rate with X the following information on a scale of 1 through 7, where 7 "strongly agrees" and 1 is "strongly disagrees".

	1	2	3	4	5	6	7
1. I like the statistic							
2. I feel insecure when I do statistics problems							
3. I don't understand statistics much because of my way of thinking							
4. Statistical formulas are easy to understand							
5. Statistics are useless							
6. Statistics is a complicated subject							
7. Statistics is a requirement in my training as a professional							
8. My statistical skills will facilitate my access to the world of work							
9. I have no idea what the statistic is about							
10. Statistics are not useful for the common professional							
11. I get frustrated when doing statistical tests							
12. Statistical concepts do not apply outside of work							
13. I use statistics in everyday life							

14. In statistics classes I am in tension							
15. I enjoy statistics class							
16. Statistical conclusions rarely occur in life							
17. Most people learn statistics quickly							
18. Learning statistics requires a lot of discipline							
19. In my profession I will not use statistics							
20. I make a lot of math mistakes when I do statistics							
21. I'm afraid of statistics							
22. Statistics involve a lot of calculation							
23. I can learn statistics							
24. I understand statistical formulas							
25. Statistics are not important in my life							
26. Statistics are very technical							
27. I find it difficult to understand statistical concepts							
28. Most people must change their thinking to make statistics							

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