



Empirical Articles

Attitudes Toward Statistics Among Dentistry Postgraduates

Atitudes em Relação à Estatística Entre Pós-Graduandos em Odontologia

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Abstract

Aim: To validate the Attitudes Toward Statistics Scale (EAE) and to investigate the perceptions and attitudes toward statistics among dentistry postgraduates students.

Method: A total of 115 postgraduates students (62 master's students, 80 women, age 26 ± 4 years) answered the items of the EAE and the Clinician Attitudes Toward Biostatistics (CATB). Information on academic training was collected. Confirmatory factor analysis (χ^2/df , CFI, TLI and RMSEA) was conducted to estimate the validity of the instruments to sample. The standardized mean scores of CATB and EAE factors were estimated and compared (ANOVA).

Results: The EAE two-factor fit model exhibited adequate validity for the sample ($\chi^2/df = 1.814$, CFI = 0.979, TLI = 0.976, and RMSEA = 0.086). Individuals who received their first training earlier, reported better performance in mathematics and greater knowledge of statistics, also exhibited more positive attitudes toward statistics. Individuals who reported having a research career focus, and who evaluated their supervisors' knowledge of statistics as very poor to intermediate, presented a greater awareness of the importance of statistics in research and scientific evidence.

Conclusion: The EAE was valid and reliable for the sample. Perceptions and attitudes toward biostatistics were associated with variables involving the participant's academic formation.

Keywords: statistics, validity, scales, dentistry, evidence-based practice

Resumo

Objetivo: Validar a Escala de Atitudes frente à Estatística (EAE) e verificar as percepções e atitudes frente à Estatística de pós-graduandos em Odontologia.

Métodos: Participaram 115 estudantes de pós-graduação (62 mestrandos, 80 mulheres, idade: 26 ± 4 anos) que responderam aos itens da EAE e da Clinician Attitudes Toward Biostatistics (CATB). Informações sobre atividades relacionadas à pesquisa e ao curso de pós-graduação foram coletadas. Análise fatorial confirmatória (χ^2/df , CFI, TLI and RMSEA) foi conduzida para verificar a validade dos instrumentos à amostra. Os escores médios padronizados dos fatores do CATB e da EAE foram estimados e comparados (ANOVA).

Resultados: O modelo refinado de dois fatores da EAE mostrou validade adequada para a amostra ($\chi^2/df = 1.814$, CFI = 0.979, TLI = 0.976, and RMSEA = 0.086). Indivíduos que receberam seu primeiro treinamento mais cedo, relataram melhor desempenho em matemática e maior conhecimento de estatística, também exibindo atitudes mais positivas em relação à estatística. Os indivíduos que relataram ter foco na carreira de pesquisa e que avaliaram o conhecimento de seus orientadores em estatística como muito fraca a intermediária, apresentaram uma maior conscientização sobre a importância da estatística em pesquisas e evidências científicas.

Conclusão: A EAE foi válida e confiável para a amostra. As percepções e atitudes frente à estatística estiveram associadas às variáveis que envolvem a formação acadêmica do participante.

Palavras-Chave: estatística, validação, escalas, odontologia, prática baseada em evidências

Psychology, Community & Health, 2020, Vol. 8(1), 126–138, <https://doi.org/10.5964/pch.v8i1.230>

Received: 2016-12-19. Accepted: 2019-02-01. Published (VoR): 2020-04-02.

Handling Editor: Teresa Santos, Universidade Europeia, Lisbon, Portugal; William James Research Center-WJCR/ISPA, Instituto Universitário - Lisbon, Lisbon, Portugal

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The use of statistical tools to better help clinical decision making has become imperative. Complex statistical methods are being developed for scientific advancements, and they are commonly used for providing evidence that may support clinical practice (Batra, Gupta, Dany, & Rajput, 2014). Thus, it is important that researchers, clinicians and graduate students have a sufficient knowledge of statistics, in order to correctly interpret the results presented in scientific articles and apply it to clinical practice. In general, a health science statistic can also be called biostatistics (Batanero, Estrada, Díaz, & Fortuny, 2005; Batra et al., 2014; Berwick, Fineberg, & Weinstein, 1981; Butt & Khan, 2008; Kurichi & Sonnad, 2006).

For graduate students, statistics should be recognized as a key element in decision making and they should receive solid training in statistical methods (West & Ficalora, 2007). However, researchers report that, while most graduate students recognize the importance of statistics in their careers, they have a poor understanding of even basic statistical concepts (Asif, Assim, & Awais, 2009; Astin, Jenkins, & Moore, 2002). Some consider that this limited knowledge and the difficulties that students in the health care field experience with statistics might reflect students' negative experiences in mathematics during school years (Zhang et al., 2012), and the surprise of encountering exact sciences in the medical school curriculum (Cazorla, Silva, Vendramini, & Brito, 1999; Valente, 2000). According to Cazorla et al. (1999) and to Campos, Bonafé, Dovigo, and Maroco (2013), these difficulties can lead to negative feelings that may culminate in the development of negative attitudes, expectations, and beliefs. They may also play a fundamental role in developing thoughts toward statistics and its professional application. Thus, understanding students' attitudes and their knowledge of statistical could be important for developing strategies that can both raise awareness the importance of statistics to evidence-based practice, and also increase motivation in relation to statistics, in order to facilitate the teaching-learning process and help in the application of statistical tools in graduate student routines (Batra et al., 2014; Wadhwa, Kalyan, & Kalantharakath, 2015).

Literature suggests some instruments for the assessment of individual's attitudes and perceptions toward statistics and biostatistics, such as the Clinician Attitudes Toward Biostatistics survey (CATB; West & Ficalora, 2007) and the Attitudes Toward Statistics Scale (EAE; Cazorla et al., 1999). In a previous study, the CATB was validated for use with undergraduate students studying dentistry (Bonafé, Costa, & Campos, 2018). In what concerns to EAE, no studies were found in the literature that validated the instrument in samples of dentistry postgraduates students. However, it is known that the use of valid and reliable instruments is essential to help researchers work with more precise measures, that is, it helps to measure what is actually proposed by the instrument. And the validity and reliability are linked to the characteristics of the sample, since the validity

cannot be considered a characteristic of the instrument per se, but a characteristic of the instrument applied to a sample (Campos et al., 2013; Maroco, 2014, p. 374).

Therefore, the aims of this study were: 1) to validate the instrument EAE using a sample of dentistry postgraduate students; 2) to investigate the perceptions and attitudes towards statistics among dentistry undergraduate students with clinical experience; and, 3) to compare responses according to variables involving the participants' academic training and research experience.

Method

Study Design and Participants

This study was a cross-sectional study. Postgraduate students enrolled in Master's and PhD programs in the São Paulo State University - Araraquara School of Dentistry in 2014 and 2015 were invited to participate. It should be noted that all of these students were dentists and their programs focused on clinical and scientific education.

Sample size was estimated following the proposal by Hair, Black, Babin, Anderson, and Tatham (2005), which recommends the inclusion of 5-10 participants per instrument item. Since EAE was the instrument with most items (20 items), thus, the sample size needed to comprehend between 100 and 200 individuals. In the study, 115 students participated and the majority were women ($n = 80$) with $M_{age} = 26.28$ ($SD = 4.46$) years.

Instruments

The CATB and EAE were used; the CATB was proposed by West and Ficalora (2007) and validated using postgraduate students from a school of dentistry by Bonafé et al. (2018), and this study is the first to use the CATB on dentistry postgraduate students. It is the first presentation of the Portuguese version, and it is the first assessment the psychometric properties of the CATB using confirmatory factor analysis. The CATB model consists of 12 items, with response options ranging from 1 (strongly disagree) to 5 (strongly agree), distributed into two orthogonal factors (Perceptions of Knowledge and Training of Biostatistics and Perceptions of Biostatistics in Research and Scientific Evidence), as proposed by Bonafé et al. (2018).

The present study used the Portuguese version of the EAE, proposed by Cazorla et al. (1999) and was validated using undergraduate students by Campos et al. (2013). This instrument consists of 20 items with response options ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). The EAE model was presented in the literature as a one-factor model (Cazorla et al., 1999), but a two-factor model (Positive Attitudes and Negative Attitudes) was later proposed by Campos et al. (2013). It is important to note that the complete two-factor structure was used here, encompassing ten items in the Negative Attitudes factor and ten items in the Positive Attitudes factor.

To characterize the sample, information concerning the participants' gender, age (in years) and economic status (according to the Brazilian Economic Classification Criteria) was collected. Information regarding the academic training of the students was obtained through a questionnaire, specifically: type of postgraduate program (Master's degree or PhD.); time since graduation (years); experience in research (very extensive, extensive, moderate, limited, or very limited/none); career focus (clinical career or research); first training in

statistics (before or after completing their undergraduate degree); performance in mathematics during school years (very good, good, intermediate, poor, or very poor); scientific research carried out during undergraduate training years (yes or no); number of scientific published articles, knowledge of statistics and the participant's supervisor's knowledge of statistics (very good, good, intermediate, poor, or very poor). It should be noted that this information was self-reported by the students.

Procedures and Ethical Considerations

Instruments were completed by the students in the classroom after previously scheduled with the classes' professors. Only students who agreed to participate and who signed the informed consent form were included in this study. All answers were anonymous and collected by a researcher (an undergraduate student) with no relationship with the students. The researcher was trained to avoid embarrassment and/or coercion. This project was approved by the Ethics Committee on Human Research of the São Paulo State University (Univ. Estadual Paulista), Araraquara School of Dentistry (Registry No. 34783414.2.00005416).

Statistical Analysis

The metric properties of EAE were evaluated. The psychometric sensitivity of the items and the validity and reliability of the instrument were estimated; psychometric sensitivity was estimated using summary statistics and the shape of the distribution (skewness $|Sk| < 3$; kurtosis $|Ku| < 7$). Factorial validity was assessed using confirmatory analysis with fit indices (χ^2/df , CFI, TLI, and RMSEA). Convergent validity was computed using the average variance extracted (AVE). Discriminant validity was estimated using correlation analysis. Internal consistency was estimated using Cronbach's alpha coefficient (α) and composite reliability (CR). Correlations between the errors of the items for fitting model were inserted using the method of Lagrange multipliers (LM). The appropriate fit values were set as $\chi^2/df \leq 2.0$, CFI and TLI ≥ 0.9 , and RMSEA < 0.10 (Maroco, 2014, p. 374). Items that exhibited factorial weights $\lambda < .50$ were removed, as were those that were deemed redundant based on the method of Lagrange multipliers (LM > 11).

Confirmatory factor analysis was performed using polychoric correlation matrices and the weighted least squares mean and variance adjusted (WLSMV) method estimation. The Mplus software, version 6.12 (Muthén & Muthén, 2010) was used.

The standardized overall scores for the EAE factors (Positive Attitudes and Negative Attitudes) and the CATB (Perceptions of Knowledge of and Training in Biostatistics and Perceptions of Biostatistics in Research and Scientific Evidence) were estimated using the regression weights matrix calculated in the confirmatory factor analysis.

These standardized global scores were compared according to characteristics of interest using analysis of variance (ANOVA). The multiple comparisons were performed using Tukey's test. A 5% significance level was used for decision making.

To examine the relationship between the attitude toward EAE factors and the CATB factors, a correlation study was performed on the standardized overall scores, using Pearson correlation coefficient.

Results

Of the 115 participants, the majority belonged to high socioeconomic classes ($n = 90$). The average time since college graduation was 4.09 ± 4.03 years. Most were enrolled in a Master's degree program ($n = 62$). On average, the students had published 3.21 ± 5.10 scientific articles.

Table 1 shows the characteristics of the sample considering academic and research related variables.

Table 1

Characteristics of the Sample Considering Academic and Research Related Variables

Variable	<i>n</i> (%)
Scientific research	
No	20 (17.39)
Yes	95 (82.61)
Scientific article published	
No	38 (33.04)
Yes	77 (66.96)
Career focus	
Clinical career	89 (78.76)
Research	24 (21.24)
First training in statistics	
Undergraduate level or earlier	92 (82.14)
Postgraduate level	20 (17.86)
Performance in mathematics	
Very poor	-
Poor	7 (6.09)
Intermediate	32 (27.83)
Good	46 (40.00)
Very good	30 (26.09)
Experience in research	
None/Very limited	7 (6.09)
Limited	32 (27.83)
Intermediate	60 (52.17)
Extensive	15 (13.04)
Very extensive	1 (0.87)
Evaluation of one's own knowledge of statistics	
Very poor	5 (4.35)
Poor	43 (37.39)
Intermediate	56 (48.70)
Good	10 (8.70)
Very good	1 (0.87)
Evaluation of supervisor's knowledge of statistics	
Very poor	1 (0.89)
Poor	6 (5.36)
Intermediate	16 (14.29)
Good	45 (40.18)
Very good	44 (39.29)

The majority of the participants considered their knowledge of statistics to be intermediate or poor (48.70% and 37.39%). Despite having many scientific articles published (66.96%), most reported a clinical career focus (78.76%). Most of the students reported that their supervisors' knowledge of statistics to be good or very good (40.18% and 39.29%, respectively).

Table 2 shows the results obtained for summary statistics and shape of the EAE items.

Table 2

Summary Statistics and Shape of the EAE Items

EAE item	Summary Measurement				Shape Measurement	
	Mean	Median	Mode	Standard-Deviation	Skewness	Kurtosis
1	3.3	2	2	0.70	0.14	-0.12
2	3.0	2	2	0.63	0.16	0.12
3	3.7	3	3	0.62	-0.46	0.63
4	3.2	2	2	0.65	0.45	0.46
5	3.5	3	3	0.62	-0.06	-0.23
6	3.3	2	2	0.74	0.18	-0.19
7	3.4	2	2	0.63	0.00	-0.22
8	3.1	2	2	0.66	0.24	0.22
9	3.7	3	3	0.66	-0.11	-0.07
10	3.2	2	2	0.76	0.36	-0.02
11	3.7	3	3	0.70	-0.14	-0.11
12	3.0	2	2	0.62	0.67	1.83
13	3.4	2	2	0.70	-0.10	-0.24
14	3.4	2	2	0.63	0.42	0.01
15	3.7	2	2	0.63	0.92	1.01
16	3.3	2	2	0.68	0.01	-0.19
17	3.0	2	2	0.63	0.59	1.39
18	2.9	2	2	0.55	0.61	3.05
19	3.3	2	2	0.63	0.45	0.29
20	3.5	2	2	0.65	0.13	-0.20

Note. EAE = Attitudes toward statistics scale.

When the mode (summary measurement) of the answers to the items of EAE was considered, most participants were found to disagree with all of the items that expressed some kind of negative attitude toward statistics. This same response pattern was not found in questions that addressed positive attitudes toward statistics. Furthermore, the EAE items exhibited no severe violations of normality.

Figure 1 presents the one-factor model (Figure 1A), the two-factor model (Figure 1B), and the two-factor fit model (Figure 1C) of the EAE.

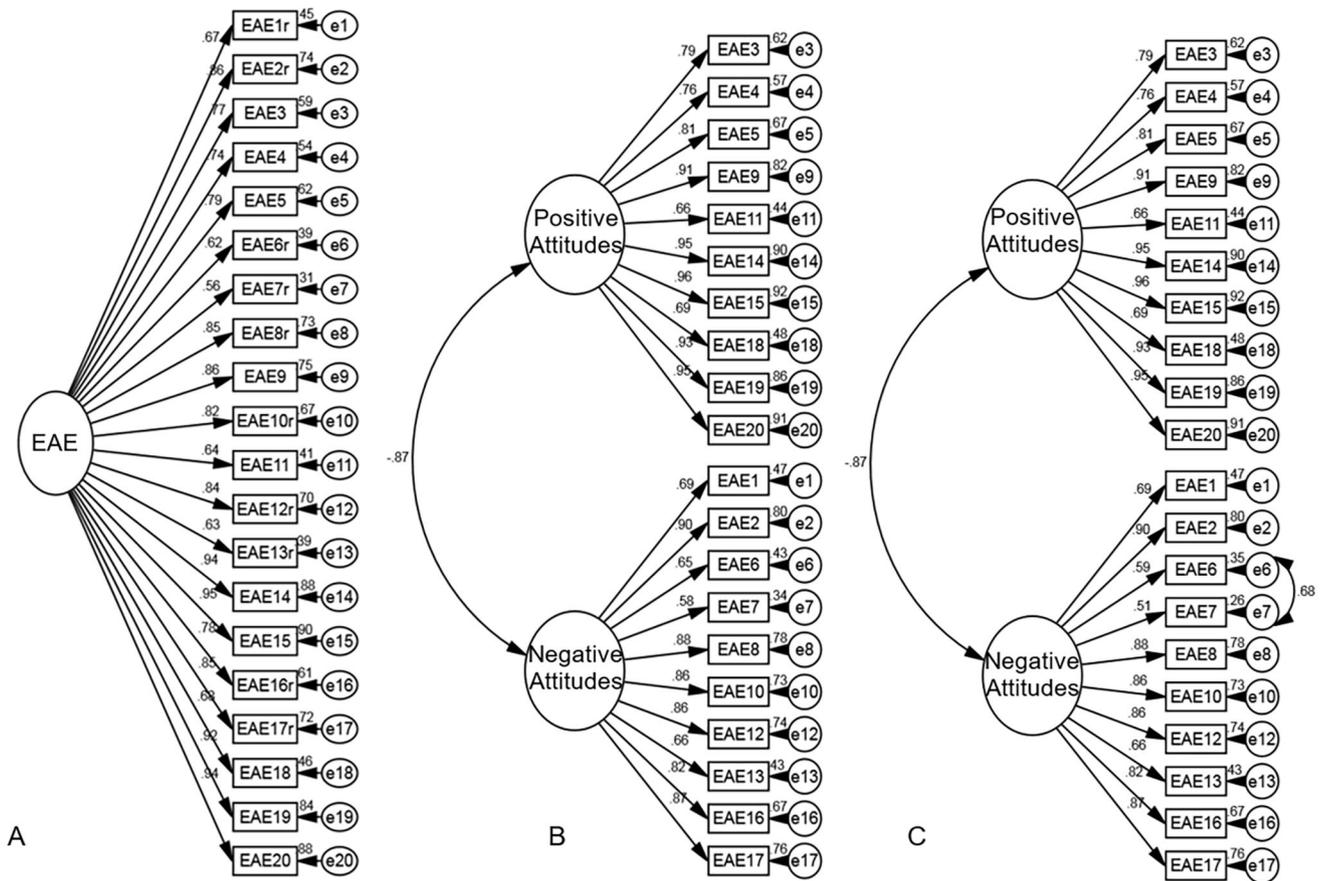


Figure 1. EAE one-factor model (Figure 1A), two-factor model (Figure 1B) and two-factor fit model (Figure 1C).

The two-factor model of the EAE (Figure 1B) ($\lambda = .58-.96$, $\chi^2/df = 2.325$, CFI = .965, TLI = .961 and RMSEA = .110) exhibited better fit indices than the one-factor model (Figure 1A) ($\lambda = .56-.95$, $\chi^2/df = 2.768$, CFI = .956, TLI = .947 and RMSEA = .127). To determine the fit of the two-factor model (Figure 1C) ($\lambda = .51-.96$, $\chi^2/df = 1.814$, CFI = .979, TLI = .976, and RMSEA = .086, VEM = 0.602-0.720, CC = 0.936 to 0.962, $\alpha = .901$ to .919, $r^2 = .757$), a correlation between the errors of items 6 and 7 was inserted (LM = 93.139). This model exhibited adequate validity and reliability.

Table 3 and Table 4 show the standardized overall score of the Attitudes Toward Statistics scale (EAE) and the Clinician Attitudes Toward Biostatistics survey (CATB) factors, considering academic and research related variables.

Table 3

Standardized Global Score of the Factors Positive Attitudes (EAE_PA) and Negative Attitudes (EAE_NA) of Attitudes Toward Statistics Scale (EAE) Considering the Sample Characteristics or Sample-Related Variables

Variable	n	EAE_PA			EAE_NA		
		M ± SD	F	p	M ± SD	F	p
Gender							
Female	76	-0.050 ± 0.75	1.57	.212	0.690 ± 0.60	3.035	.084
Male	34	0.150 ± 0.76			-0.170 ± 0.61		
Scientific Research							
No	19	-0.190 ± 0.75	1.652	.201	0.270 ± 0.73	4.024	.047*
Yes	91	0.050 ± 0.75			-0.060 ± 0.65		
Program							
Master's degree	59	-0.180 ± 0.56	0.27	.869	0.280 ± 0.56	0.68	.794
PhD	48	0.0060 ± 0.94			-0.005 ± 0.79		
Scientific Article Published							
No	38	-0.050 ± 0.53	0.538	.465	0.090 ± 0.54	1.36	.245
Yes	72	0.050 ± 0.85			-0.060 ± 0.73		
Career Focus							
Clinical career	85	-0.050 ± 0.69	2.650	.107	0.060 ± 0.66	3.034	.084
Research	23	0.230 ± 0.97			-0.220 ± 0.72		
First Training in Statistics							
Undergraduate level or earlier	89	0.920 ± 0.74	6.896	.010*	-0.080 ± 0.66	10.251	.002*
Graduate level	18	-0.410 ± 0.72			0.450 ± 0.59		
Performance in Mathematics							
Very poor/poor	6	-0.420 ± 1.26 ^a	4.531	.018*	0.580 ± 1.02 ^a	7.587	.001*
Intermediate	29	-0.260 ± 0.47 ^a			0.270 ± 0.52 ^a		
Good/very good	75	0.160 ± 0.76 ^b			-0.160 ± 0.64 ^b		
Experience in Research							
None/Limited	37	0.080 ± 0.60	37.512	.190	0.130 ± 0.61 ^a	5.665	.005*
Intermediate	57	-0.040 ± 0.73			0.040 ± 0.63 ^a		
Extensive/very extensive	16	0.430 ± 1.03			-0.500 ± 0.77 ^b		
Evaluation of one's own Knowledge of Statistics							
Very bad/bad	46	-0.330 ± 0.58 ^a	23.408	< .001*	0.330 ± 0.54 ^a	25.641	< .001*
Intermediate	53	0.080 ± 0.65 ^b			-0.100 ± 0.56 ^b		
Good/very good	11	1.110 ± 0.75 ^c			-0.090 ± 0.63 ^c		
Evaluation of Supervisors' Knowledge of Statistics							
Very poor/poor/intermediate	22	-0.140 ± 0.77	1.225	.271	0.140 ± 0.73	1.305	.256
Good/very good	85	0.060 ± 0.75			-0.045 ± 0.66		

Note. EAE_PA = Positive Attitudes, EAE_NA = Negative Attitudes.

^{a,b,c}Equal letters indicate statistical similarity.

* $p < .05$.

Table 4

Standardized Overall Score of the Perceptions of Knowledge of and Training in Biostatistics Factor (CATB_PKT) and of the Perceptions of Biostatistics in Research and Scientific Evidence Factor (CATB_PRS) of the Clinician Attitudes Toward Biostatistics Survey Considering the Sample Characteristics or Sample-Related Variables

Variable	n	CATB_PKT			CATB_PRS		
		M ± SD	F	p	M ± SD	F	p
Gender							
Female	72	-0.050 ± 0.76	1.798	.183	0.003 ± 0.59	0.202	.654
Male	33	0.150 ± 0.66			-0.050 ± 0.56		
Scientific Research							
No	20	0.080 ± 0.72	0.253	.616	-0.050 ± 0.51	0.114	.736
Yes	85	-0.008 ± 0.73			-0.005 ± 0.60		
Program							
Master's degree	56	-0.100 ± 0.71	3.367	.069	0.004 ± 0.58	0.102	.750
PhD	46	0.160 ± 0.74			-0.030 ± 0.61		
Scientific Article Published							
No	34	-0.160 ± 0.76	2.631	.108	0.040 ± 0.55	0.431	.513
Yes	71	0.080 ± 0.71			-0.04 ± 0.60		
Career Focus							
Clinical career	83	-0.040 ± 0.72	1.522	.220	-0.09 ± 0.56	8.883	.04*
Research	21	0.180 ± 0.76			0.310 ± 0.57		
First Training in Statistics							
Undergraduate level or earlier	82	0.050 ± 0.71	1.571	.213	0.006 ± 0.58	0.272	.603
Postgraduate level	20	-0.170 ± 0.86			-0.070 ± 0.61		
Performance in Mathematics							
Very poor/poor	6	-0.009 ± 0.61	1.097	.338	-0.006 ± 0.74	0.016	.984
Intermediate	30	-0.150 ± 0.76			0.0002 ± 0.59		
Good/very good	69	0.080 ± 0.73			-0.020 ± 0.57		
Experience in Research							
None/limited	36	-0.080 ± 0.69	2.634	.077	0.006 ± 0.56	0.308	.735
Intermediate	56	-0.030 ± 0.71			-0.050 ± 0.60		
Extensive/very extensive	13	0.430 ± 0.87			0.080 ± 0.58		
Evaluation of one's own Knowledge of Statistics							
Very bad/bad	46	-0.260 ± 0.61 ^a	18.425	< .001*	-0.130 ± 0.60	2.529	.085
Intermediate	49	0.050 ± 0.62 ^a			0.030 ± 0.54		
Good/very good	10	1.070 ± 0.78 ^b			0.290 ± 0.60		
Evaluation of Supervisor's Knowledge of Statistics							
Very poor/poor/intermediate	20	-0.920 ± 0.77	0.390	.533	0.220 ± 0.56	4.106	.045*
Good/very good	83	0.020 ± 0.73			-0.070 ± 0.58		

Note. CATB_PKT = Perceptions of Knowledge and Training of Biostatistics, CATB_PRS = Perceptions of Biostatistics in Research and Scientific Evidence.

^{a,b}Equal letters indicate statistical similarity.

* $p < .05$.

According to Table 3 and Table 4, the participants who received their first training in statistics before college had better performance in mathematics during school years, and the ones who reported having a greater knowledge of statistics, exhibited more positive attitudes toward statistics.

The participants who did not carry out scientific research as undergraduates; who received their first training in Statistics after college; who reported their performance in mathematics during school years to be very poor to intermediate; who reported having very limited to intermediate experience in research; and who reported having less knowledge of statistics expressed more negative attitudes toward statistics.

The participants who reported having a research career focus and who evaluated their supervisors' knowledge of statistics as very poor to intermediate presented a greater awareness of the importance of biostatistics in research and scientific evidence.

The participants who self-assessed their knowledge of statistics as good/very good had the highest scores for the Perceptions of Knowledge and Training in Biostatistics factor.

Table 5 shows the correlations obtained between the standardized total scores obtained for the CATB and the EAE factors.

Table 5

Correlations Between CATB (CATB_PKT and CATB_PRS) and EAE (EAE_PA and EAE_NA) Standardized Total Factor Scores

Factor	EAE_PA	EAE_NA	CATB_PRS	CATB_PKT
EAE_PA	1	-	-	-
EAE_NA	-.921 (< .001)	1	-	-
CATB_PRS	.251 (.012)	-.243 (.015)	1	-
CATB_PKT	.487 (< .001)	-.508 (< .001)	.109 (.267)	1

Note. Factor: EAE_PA = Positive Attitudes, EAE_NA = Negative Attitudes, CATB_PKT = Perceptions of Knowledge and Training of Biostatistics, CATB_PRS = Perceptions of Biostatistics in Research and Scientific Evidence.

Students with higher of knowledge and training in biostatistics and those who assigned greater importance to having this type knowledge and training that included research practice and scientific evidence showed more positive attitudes and fewer negative attitudes toward statistics.

Discussion

This is the first validation study of the EAE using a sample of Brazilian postgraduate students from a school of dentistry. During the validation study, all items proposed in the original survey were, the two-factor theoretical model proposed by Campos et al. (2013).

We also compared each CATB and EAE factors standardized overall scores considering several variables, being that some results were as expected. For example, the results from EAE showed that better attitudes toward statistics were more frequently reported by postgraduate students who had a good understanding of statistics and mathematics, as well as by those who received their first training in statistics before postgraduate school. Authors such as Astin et al. (2002) claim that statistics should be administered in the early years of undergraduate education and reinforced throughout undergraduate programs, as this exposure could help to improve individuals' abilities in statistics (Windish, Huot, & Green, 2007). Gómez (2010) found that minimal

abilities in mathematics improve individuals' understanding of statistics and reduces anxiety over it. Our results are in line with these findings, since such negative attitudes were higher among the students claiming to have a poorer performance in mathematics, as well as having started statistics training in later years. The results also suggest that negative attitudes are negatively related to the student's involvement with scientific research, since the negative attitude towards statistics is greater among those who did not undertake scientific initiation and consider having less research experience.

Regarding the CATB results, this study highlights that the students who have a research-based career assign more importance to statistics in the context of research and scientific evidence. It is believed that these individuals may have closer contact with the scientific community and thus see biostatistics as a key element in decision making [West and Ficalora \(2007\)](#). [West and Ficalora \(2007\)](#), [Batra et al. \(2014\)](#), [Hannigan, Hegarty, and McGrath \(2014\)](#) and [Shetty, Al Rasheed, and Alwardi \(2015\)](#) argue that all professionals involved in health care, regardless of the approach (clinic-based or research-based), should understand basic concepts of statistics, in addition to their knowledge of biological sciences. With this foundation, these professionals should be able to develop and/or interpret information resulting from clinical and scientific research, and apply it to their daily routines.

The student's view of the importance of statistics in clinical work or research was higher when they assessed their supervisor's knowledge of statistics lower. It is suggested that students who consider their supervisor's knowledge of statistics to be worse need to conduct their own analyses and, therefore, strive to acquire the necessary knowledge to do so, consequently asserting more importance to statistics. On the other hand, those who appraised their supervisor's knowledge of statistics as good/very good do might not need to worry with statistical tools so much, because they are able to leave this responsibility to their supervisors, assigning less importance to statistics.

The correlation between the CATB factors and the EAE factors suggests that the perceptions of possessing knowledge and training in biostatistics are not correlated with the perceptions of the importance of statistics in clinical/research activities, as advocated by [Bonafé et al. \(2018\)](#). However, similarly to [Wadhwa et al. \(2015\)](#), knowledge and training in statistics was positively correlated with positive attitudes toward statistics, and negatively correlated with negative attitudes toward statistics.

The literature recommends ([Batra et al., 2014](#); [Hannigan, Hegarty, & McGrath, 2014](#); [West & Ficalora, 2007](#)) that students' connections to statistics must be strengthened as part of a reformulation of biostatistics education, through the use of integrated approaches that demonstrate how biostatistics may impact clinical decisions. In addition, [Miles et al. \(2010\)](#), in the case of postgraduates, showed that the success of teaching and learning statistics depends on the cooperation between statistics teachers and teachers from clinical fields. Together, these professionals can identify learning opportunities in the context of clinical activities, which may, in turn, result in the practical application of statistical concepts. This might contribute to making the classes more applied to the student's daily life, including, for example, statistical software and database customized according to the profession, improving the motivation for the study and the understanding of statistics.

Due to the cross-sectional nature of this study, there is a limit to the conclusions that can be extrapolated from the results, particular considering cause and effect between variables.

Concerning the metric properties of the EAE, the Attitudes Toward Statistics Scale (EAE) was found to be valid and reliable for measuring attitudes toward biostatistics among dentistry postgraduate students with clinical experience.

Competing Interests

The authors report no conflicts of interest with respect to this study.

Funding

This study was funded by the São Paulo Research Foundation.

Acknowledgments

We are also grateful for Grant No. 2014/21778-2 from the FAPESP, which provided financial support. We thank reviewers and editors for their comments and suggestions.

References

- Asif, H., Assim, B., & Awais, S. M. (2009). Importance and understanding of bio-statistics among postgraduate students at King Edward Medical University Lahore - Pakistan. *Annals*, 15(3), 107-110.
- Astin, J., Jenkins, T., & Moore, L. (2002). Medical students' perspective on the teaching of medical statistic in the undergraduate medical curriculum. *Statistics in Medicine*, 21, 1003-1006. <https://doi.org/10.1002/sim.1132>
- Batanero, C., Estrada, A., Díaz, C., & Fortuny, J. M. (2005, February). A structural study of future teachers' attitudes towards statistics - Italy. In M. Bosch (Ed.), *European research in mathematics education 4: Proceedings of the fourth congress of the European society for research in mathematics education* (pp. 508-517). Retrieved from http://www.erne.tu-dortmund.de/~erne/CERME4/CERME4_WG5.pdf
- Batra, M., Gupta, M., Dany, S. S., & Rajput, P. (2014). Perception of dental professionals towards biostatistics. *International Scholarly Research Notices*, 2014, Article 291807. <https://doi.org/10.1155/2014/291807>
- Berwick, D. M., Fineberg, H. V., & Weinstein, M. C. (1981). When doctors meet numbers. *The American Journal of Medicine*, 71(6), 991-998. [https://doi.org/10.1016/0002-9343\(81\)90325-9](https://doi.org/10.1016/0002-9343(81)90325-9)
- Bonafé, F. S. S., Costa, M. A., & Campos, J. A. D. B. (2018). Validation of the clinician attitudes toward biostatistics among Brazilian dentistry graduate students. *Revista Brasileira de Biometria*, 36(3), 588-600. <https://doi.org/10.28951/rbb.v36i3.244>
- Butt, A. K., & Khan, A. A. (2008). Teaching biostatistics and epidemiology in a postgraduate medical institution: Are we going in the right direction? *Eastern Mediterranean Health Journal*, 14(5), 1192-1197.
- Campos, J. A. D. B., Bonafé, F. S. S., Dovigo, L. N., & Maroco, J. (2013). Avaliação psicométrica da escala de atitudes em relação à estatística [Psychometric assessment of the attitude scale in relation to statistics]. *Revista Brasileira de Biometria*, 31, 327-337.
- Cazorla, I. M., Silva, C. B., Vendramini, C. M. M., & Brito, M. R. F. (1999). Adaptação e validação de uma escala de atitudes em relação à estatística [Adaptation and validation of a scale of attitudes towards statistics]. *Conferência Internacional:*

- Experiências e perspectivas do ensino da estatística, desafios para o século XXI*, 1, 45-57. Retrieved from http://www.scielo.br/scielo.php?script=sci_nlinks&ref=000084&pid=S1413-8271200900030000500003&Ing=pt
- Gómez, E. E. (2010). Actitudes de racti de posgrado hacia la estadística aplicada a la investigación [Attitudes of graduate students towards statistics applied to research]. *Encuentro*, 85, 27-38. <https://doi.org/10.5377/encuentro.v42i85.57>
- Hair, J. F., Black, W. C., Babin, B., Anderson, R. E., & Tatham, R. L. (2005). *Multivariate data analysis* (6th ed., p. 928). Upper Saddle River, NJ, USA: Prentice Hall.
- Hannigan, A., Hegarty, A. C., & McGrath, D. (2014). Attitudes towards statistics of graduate entry medical students: The role of prior learning experiences. *BMC Medical Education*, 14, Article 70. <https://doi.org/10.1186/1472-6920-14-70>
- Kurichi, J. E., & Sonnad, S. S. (2006). Statistical methods in the surgical literature. *Journal of the American College of Surgeons*, 202(3), 476-484. <https://doi.org/10.1016/j.jamcollsurg.2005.11.018>
- Maroco, J. (2014). *Análise de equações estruturais: Fundamentos teóricos, software & aplicações* [Analysis of structural equations: Theoretical foundations, software & applications] (p. 374). Pero Pinheiro, Portugal: ReportNumber.
- Miles, S., Price, G. M., Swift, L., Shepstone, L., & Leinster, S. J. (2010). Statistics teaching in medical school: Opinions of practising doctors. *BMC Medical Education*, 10, Article 75. <https://doi.org/10.1186/1472-6920-10-75>
- Muthén, L. K., & Muthén, B. O. (2010). *Mplus: Statistical analysis with latent variables: User's Guide* (6th ed., p. 557). Los Angeles, CA, USA: Muthén & Muthén.
- Shetty, A. C., Al Rasheed, N. M., & Albwardi, S. A. (2015). Dental professionals' attitude towards biostatistics. *Journal of Dentistry and Oral Hygiene*, 7(7), 113-118. <https://doi.org/10.5897/JDOH2015.0161>
- Valente, J. P. (2000). Sobre um modo de transmissão da matemática [About a mode of transmission of mathematics]. *Cadernos de Saude Publica*, 16(2), 561-567. <https://doi.org/10.1590/S0102-311X2000000200027>
- Wadhwa, M., Kalyan, P., & Kalantharakath, T. (2015). Knowledge and attitude of medical and dental postgraduate students towards practice of biostatistics. *Journal of Postgraduate Medicine Education and Research*, 49(1), 1-4. <https://doi.org/10.5005/jp-journals-10028-1134>
- West, C. P., & Ficalora, R. D. (2007). Clinician attitudes toward biostatistics. *Mayo Clinic Proceedings*, 82(8), 939-943. <https://doi.org/10.4065/82.8.939>
- Windish, D. M., Huot, S. J., & Green, M. L. (2007). Medicine residents' understanding of the biostatistics and results in the medical literature. *Journal of the American Medical Association*, 298(9), 1010-1022. <https://doi.org/10.1001/jama.298.9.1010>
- Zhang, Y., Shang, L., Wang, R., Zhao, Q., Li, C., & Xu, Y. (2012). Attitudes toward statistics in medical postgraduates: Measuring, evaluating and monitoring. *BMC Medical Education*, 12, Article 117. <https://doi.org/10.1186/1472-6920-12-117>