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Work-related activities that may contribute to musculoskeletal symptoms among dental students: validation study

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Validity of tests; psychometrics; perception; musculoskeletal diseases

Parole chiave
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Summary
Background: *Dentists are exposed to occupational hazards, such as musculoskeletal disorders, in which symptoms can manifest early in clinical practice.* **Objectives:** *To estimate the reliability and validity of the Portuguese version of the "Questionnaire on work-related activities that may contribute to musculoskeletal symptoms" when applied to dental students.* **Methods:** *553 Brazilian students participated in the study. The one-factor structure originally proposed was tested through confirmatory factor analysis (CFA) using the indexes χ^2/df, CFI, GFI, and RMSEA. After observing an inadequate good fit (χ^2/df=7.140, CFI=0.791, GFI=0.778, RMSEA=0.129), the sample was subdivided into 3 groups and an exploratory factor analysis was conducted (EFA) (n=255). A CFA was then conducted using a subsample (n=113). To test the invariance of the obtained factorial solution, a multi-group analysis was performed using a third sample, independent from the others (n=185). The convergent (AVE) and discriminant (ρ^2) validity were assessed. The composite reliability (CR), Cronbach's alpha coefficient (α), and intra-class correlation coefficient (ρ) were calculated.* **Results:** *In the EFA, 3 factors were extracted: "Repetitiveness," "Working posture," and "External factors" (χ^2=21895.154; p<0.001; KMO=0.905; λ_1=6.683; λ_2=1.464; λ_3=1.277) that explained 62.82% of the total variance. The three-factor model presented an adequate good fit (n=113 and n=185) (χ^2/df=2.259; CFI=0.885; GFI=0.833; RMSEA=0.066). The convergent validity was compromised only for "Repetitiveness" (AVE=0.412-0.653). The discriminant validity (ρ^2=0.333-0.428), composite reliability, internal consistency, and reproducibility were adequate for all factors (CR=0.736–0.883; α=0.747–0.876; ρ=0.729-0.940).* **Conclusion:** *The questionnaire proved to be reliable and valid for the sample of dentistry students if the three-factor model is used.*

Riassunto
«***Attività lavorative che possono contribuire ai sintomi muscoloscheletrici fra studenti di odontoiatria: studio di validità***». **Introduzione:** *Gli odontoiatri sono lavoratori potenzialmente esposti a rischio di malattie muscoloscheletriche, i cui sintomi si possono manifestare in modo precoce nella pratica clinica.* **Obiettivi:** *Scopo dello studio è valutare la validità e l'attendibilità della versione portoghese del "Questionario sulle attività lavorative che possono*

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contribuire alle malattie muscoloscheletriche" mediante la sua applicazione agli studenti di odontoiatria. **Metodi:** *Hanno partecipato allo studio 553 studenti brasiliani. La struttura monofattoriale proposta originariamente è stata esaminata con analisi fattoriale confermativa (CFA) utilizzando gli indici* χ^2/df*, CFI, GFI e RMSEA. Dopo aver osservato una mancata adeguatezza (*χ^2/df*=7,140, CFI=0,791, GFI=0,778, RMSA=0,129), il campione è stato suddiviso ed è stata condotta un'analisi fattoriale esplorativa (EFA) (n=255). Una CFA è stata poi condotta su un sotto campione di soggetti (n=113). Per esaminare l'invarianza della soluzione fattoriale ottenuta è stata condotta un'analisi multi-gruppo su un terzo campione indipendente di soggetti (n=185). Sono state stimate la validità convergente (AVE) e discriminante (*ρ^2*). Sono stati calcolati la credibilità (CR), il coefficiente alfa di Cronbach (*α*) e il coefficiente di correlazione interclasse (*ρ*).* **Risultati:** *Nella EFA sono stati estratti tre fattori: "Ripetitività", "Postura di lavoro", e "Fattori esterni" (*χ^2*=21895,154; p<0,001; KMO=0,905;* λ_1*=6,683;* λ_2*=1,464;* λ_3*=1,277) che hanno spiegato il 62,82% della varianza totale. Il modello a tre fattori ha presentato un'adeguata capacità di descrivere i dati (n=113 e n=185) (*χ^2/df*=2,259; CFI=0,885; GFI=0,833; RMSEA=0,066). La validità convergente è risultata essere compromessa solo per "Ripetitività" (AVE=0,412-0,653). La validità discriminante (*ρ^2*=0,333-0,428), l'affidabilità composita, la consistenza interna e la riproducibilità sono risultate adeguate per tutti i fattori (CR=0,736-0,883;* α*=0,747-0,876;* ρ*=0,729-0,940).* **Conclusioni:** *Il questionario ha dimostrato di essere attendibile e valido per il campione degli studenti di odontoiatria se si utilizza il modello a tre fattori.*

Introduction

Dentists are exposed to a range of occupational risks (3, 13, 17, 26), including musculoskeletal disorders, the symptoms of which can start during initial training (14, 20). Thus, early identification of factors in the workplace that can lead to occupational risks can be a strategy to raise professionals' awareness so as to prevent or minimize risks in terms of occupational health (9-11, 27). These factors can be identified both externally (i.e., with evaluation of the workplace by a specialist in ergonomics) and internally (through the professional's awareness regarding the presence of these risk factors in the workplace), by using methods that meet the needs of the evaluation.

Internal evaluation investigates the perception of individuals, which is a psychological construct, and is therefore not directly measurable (18, 32). Thus, psychometric tools are often used to assess perception. These tools should be chosen based on psychometric properties of each investigated sample (6, 8).

One of the available tools in the literature is the "Questionnaire on work-related activities that may contribute to musculoskeletal symptoms" (29), originally developed in English. Its psychometric properties were examined on a sample of 216 employees of a U.S. industry, but the study was limited to the estimation of the reproducibility of the tool. In 2008, Coluci and Alexandre (8) culturally adapted the scale to obtain a Portuguese version; however, only the preliminary steps of validation (face and content validity) were performed. Nevertheless, it is important to complete the validation steps to assess the validity and reliability of the data obtained. This will enable safer decision-making regarding the actions required to reduce occupational risk (31).

Thus, the present study was carried out to determine the construct validity and reliability of the Portuguese version of the "Questionnaire on work-related activities that may contribute to musculoskeletal symptoms" in a sample of dentistry students.

Methods

Sampling Design

This was a validation study with non-probabilistic sampling. The population of this study consisted of undergraduate students in Dentistry, at Araraquara Dental School - UNESP, Brazil.

Variables and tools

To characterize the sample we collected information on gender and ranking in the undergraduate course. To estimate individuals' perceptions about work factors that can contribute to musculoskeletal symptoms, we used the scale proposed by Rosecrance et al., the "Questionnaire on work-related activities that may contribute to musculoskeletal symptoms" (29). In this study, we used the version adapted to Portuguese by Coluci and Alexandre (8). This tool was originally composed of 15 items arranged in a one-factor model with answers given using a Likert-type, 11-point scale (0 to 10: considering the value 0 as "no problem" and 10 as "too many problems").

Data Collection and Ethical Considerations

The questionnaire was self-completed by students, in the lecture room, in the presence of the researcher. The present study was approved by the Ethics Committee on Research with Humans of Araraquara Dental School - UNESP (Protocol 10/10). Only those who agreed to the terms of Free and Informed Consent participated in this study (n=553).

Statistical Analysis

The psychometric properties of the tool were evaluated by analyzing the factorial, convergent, and discriminant validity. Reliability was also investigated. The steps used in this process are described below.

1) First step: psychometric sensitivity was estimated using summary and shape measures. Absolute values were considered suitable when skewness (Sk) and kurtosis (Ku) were lower than 3 and 7, respectively (22).

2) Second Step: confirmatory factor analysis (CFA) was performed to assess the degree of good fit of the data to the one-factor model of the tool. The indices used were chi-square by the degrees of freedom ratio (χ^2/df), comparative fit index (CFI), good fit index (GFI) and the root mean square error of approximation (RMSEA). The good fit of the factor model to the data was considered adequate for values of χ^2/df≤2.0, CFI and GFI≥0.90, and RMSEA≤0.10 (22). Modification indices, calculated from the Lagrange multipliers (LM) method, were used to verify the existence of a correlation between the errors of the items. A correlation was considered present when LM>11.

After verifying an inadequate fit of the one-factor model, we carried out an exploratory factor analysis (EFA).

3) Third Step: exploratory factor analysis (EFA) was performed to assess the dimensionality of the tool. Therefore, the sample was divided, randomly, into three parts, to comprise three independent samples from the same population. The first was composed of approximately 45% of cases (n=255) and was used for the EFA. The assumptions of the analysis were evaluated with Bartlett's sphericity test and the Kaiser-Meyer-Olkin (KMO) index. Factor extraction was performed through the principal components method, followed by a varimax orthogonal rotation (22).

4) Fourth Step: after the factorial structure was tested and defined, the second subsample (n=113) was used to perform the confirmatory factor analysis (CFA) to check the adjustment of the data to the structure proposed in the EFA. To verify the model's good fit, we used χ^2/df, CFI, GFI, and RMSEA with the good fit values described above.

5) Fifth Step: To verify the invariance of the obtained factor solution, a cross-validation of the model was performed. To test the invariance of the model the third subsample was used, independently from the others (n=185). Multigroup analysis was performed imposing equality constraints on the factor weights of the two groups, the test statistic of the difference between the χ^2 ($\Delta\chi^2$) of the model with fixed factorial weights (λ), and the model with different weights. When the hypothesis of invariance of factorial loadings was accepted (configurational/metric invariance; meaning that the model has weak invariance) we proceeded with the analysis of the invariance of factorial loadings and intercepts (i) (scalar invariance). Afterwards, we proceeded with the analysis of the invariance of factorial loadings, intercepts and variances/covariances of the model (residuals invariance (Res)) (invariance of the residuals, meaning that the model has strict invariance) (19, 21, 22).

6) Sixth Step: to verify the most appropriate factorial model for the data (original unifactorial model or model proposed in the EFA), indices based on information theory were calculated: Akaike Infor-

mation Criterion (AIC), Browne-Cudeck Criterion (BCC), and Bayes Information Criterion (BIC). The best model was the one that had the lowest values for one or more of these indices (22).

7) Seventh Step: For the trifactorial model, the possibility of the construction of a second-order hierarchical model (MHSO) to capture the latent concept "perception of work factors that may contribute to musculoskeletal symptoms" was assessed.

8) Eighth Step: after establishing the model with better fit to the data, the convergent validity of the tool was estimated by means of the average variance extracted (AVE). The discriminant validity was estimated by correlation analysis. Both the calculation of convergent validity and discriminant analysis were conducted following the proposal of Fornell and Larcker (12). Convergent validity was considered adequate when $AVE \geq 0.50$, and discriminant validity was considered adequate if AVE_i and $AVE_j \geq \rho_{ij}^2$ (ρ_{ij}^2: square of the correlation between the dimensions i and j) (16).

9) Ninth Step: the reliability was estimated by internal consistency and composite reliability. The internal consistency was estimated by standardized Cronbach's alpha coefficient (α), and was considered adequate if $\alpha \geq 0.70$ (28). The composite reliability (CC) was also calculated, and was deemed adequate if $CC \geq 0.70$ (12).

10) Tenth Step: to estimate the temporal stability of the tool, a test-retest study was carried out. To this end, 60 students were chosen randomly from the total sample and were asked to complete the questionnaire at two different times with a one-week interval. Reproducibility was estimated by the intra-class correlation coefficient (ρ).

Results

The mean age of students was 21.3±2.1 years and 71.4% were women. In terms of year of training, 11.9% were in their first year, 25.9% in their second, 25.0% in their third, 13.2 % in their fourth, and 24.0% in their fifth.

The measures of central tendency and shape, which allowed an evaluation to be made of the psychometric sensitivity of the items (First step), are presented in table 1.

In all samples, there were no absolute Sk and Ku values that indicated a severe violation of normality or prevented the performance of a CFA on any of the tool's items.

Table 1 - Summary and shape measures of the items of the "Questionnaire on work-related activities that may contribute to musculoskeletal symptoms"

	Total Sample [n=553]						Subsample 2 [n=113]						Subsample 3 [n=185]					
Item	Mean	Md	Mo	SD	Ku	Sk	Mean	Md	Mo	SD	Ku	Sk	Mean	Md	Mo	SD	Ku	Sk
1	4.70	5	5	2.76	-0.81	-0.10	5.15	5	5	2.76	-0.72	-0.05	4.45	5	5	2.86	-0.93	-0.04
2	4.38	5	5	2.87	-0.95	0.09	4.59	5	5	2.77	-0.77	0.11	4.25	4	5	2.87	-0.97	0.16
3	3.01	2	0	2.75	-0.55	0.69	3.32	3	0	2.78	-0.67	0.53	2.83	2	0	2.74	-0.04	0.92
4	5.03	5	5	3.10	-1.06	-0.12	5.00	5	5	3.31	-1.14	-0.11	5.17	5	5	3.10	-1.08	-0.11
5	7.30	8	10	2.65	0.24	-1.02	7.41	8	10	2.51	0.65	-1.01	7.28	8	10	2.86	0.17	-1.08
6	7.10	8	8	2.56	0.33	-0.97	7.17	8	8	2.41	1.36	-1.11	7.14	8	10	2.69	0.08	-0.98
7	7.36	8	10	2.62	0.60	-1.12	7.32	8	10	2.67	0.28	-0.97	7.26	8	10	2.75	0.15	-0.99
8	6.81	8	10	2.87	-0.08	-0.88	6.92	8	10	2.77	0.18	-0.89	6.72	8	10	3.03	-0.53	-0.73
9	6.20	7	8	2.85	-0.39	-0.70	6.39	7	8	2.84	0.16	-0.87	6.10	7	8	3.01	-0.73	-0.62
10	5.56	6	7	3.19	-1.05	-0.35	5.60	6	9	3.27	-1.13	-0.32	5.65	6	10	3.35	-1.17	-0.32
11	7.47	8	10	2.64	0.57	-1.15	7.63	8	10	2.41	0.13	-0.91	7.38	8	10	2.89	0.63	-1.25
12	5.48	6	8	3.18	-1.01	-0.36	5.89	6	6	3.07	-0.83	-0.39	5.44	6	8	3.29	-1.17	-0.32
13	5.06	5	5	3.08	-1.06	-0.20	5.35	5	5	3.12	-0.90	-0.31	4.85	5	5	3.14	-1.18	-0.12
14	3.54	3	0	2.77	-0.92	0.31	3.91	4	5	2.97	-0.88	0.23	3.35	3	0	2.73	-0.88	0.42
15	6.32	7	10	3.23	-0.66	-0.66	6.21	7	10	3.17	-0.66	-0.59	6.43	7	10	3.21	-0.64	-0.70

Md: median, Mo: mode, SD: standard deviation, Ku: kurtosis, Sk: skewness (according First step presented in Methods)

There was inadequate fit of the data with the factor structure originally proposed for the "Questionnaire on work factors that may contribute to musculoskeletal symptoms" (λ=0.49–0.77; χ^2/df=7.140, CFI=0.791, GFI=0.778, RMSEA=0.129, AIC=702.602; BCC=705.337, BIC=819.844) (Second step).

Thus, we decided to conduct an exploratory analysis of the factor structure. Bartlett's test of sphericity and the index of sampling adequacy KMO were acceptable (χ^2=21895.154, p<0.001; KMO=0.905) (Third step). In the distribution of the scale's items, we found three factors with eigenvalues greater than 1 (λ_1=6.683; λ_2=1.464; λ_3=1.277). The three retained factors explained 62.82% of the total variance. Table 2 presents the structural matrix with varimax orthogonal rotation of the tool's factors.

All items had factor loadings higher than 0.25. Item 9 cross-loaded on more than one factor, and thus was removed from the scale. Considering the theoretical context of the extracted factors, we named Factor 1 "Repetitiveness," Factor 2 "Working Posture," and Factor 3 "External factors."

After the insertion of the two correlations between the errors of the items (Q1–Q2 and Q5–Q8), the three-factor model presented an adequate fit with a second sample (n=113) independent from the one in which the EFA was calculated (λ=0.62–0.83; χ^2/df=1.907; CFI=0.916; GFI=0.860; RMSEA=0.090; AIC=203.288; BCC=213.494; BIC=293.291) (Fourth step). The high degree of correlation between the factors observed in the first-order model (r=0.68–0.86) could suggest the existence of a hierarchical second-order model as presented in Figure 1 (Seventh step).

One can observe from the standardized regression coefficients that the first-order factors (β=0.82–1.00) are strongly related to the second-order factor ("Perceptions about work-related factors that may contribute to musculoskeletal symptoms"), and "External factors" contributed to a greater degree.

The third independent sample showed adequate fit with the three-factor model (λ=0.58–0.86; χ^2/df=2.842, CFI=0.897, GFI=0.859, RMSEA=.10). The simultaneous fit of the samples (Subsamples 2 and 3) with the three-factor model was acceptable (χ^2/gl=2.259; CFI=0.885; GFI=0.833; RMSEA=0.066) (Fifth step). Strong invariance of the three-factor model was observed when adjusted for Subsamples 2 and 3 (λ: $\Delta\chi^2$=7.844, p=0.727; i:

Table 2 - Structural matrix with varimax orthogonal rotation of the factors* of the "Questionnaire on work-related activities that may contribute to musculoskeletal symptoms".

Item	Factor 1 Repetitiveness	Factor 2 Working Posture	Factor 3 External Factors
Q1. Performing the same task over and over			0.541
Q2. Working very fast for short periods			0.741
Q3. Having to handle or grasp small objects			0.786
Q4. Insufficient breaks or pauses during the workday			0.587
Q5. Working in awkward or cramped positions	0.833		
Q6. Working in the same position for long periods	0.754		
Q7. Bending or twisting your back in an awkward way	0.831		
Q8. Working near or at your physical limits	0.711		
Q9. Reaching or working over your head or away from your body	0.549	0.574	
Q10. Hot, cold, humid, wet conditions		0.729	
Q11. Continuing to work when injured or hurt		0.503	
Q12. Carrying, lifting, or moving heavy materials or equipment		0.739	
Q13. Work scheduling		0.627	
Q14. Using tools		0.725	
Q15. Training on how to do the job		0.648	

* according to third step described in Methods.

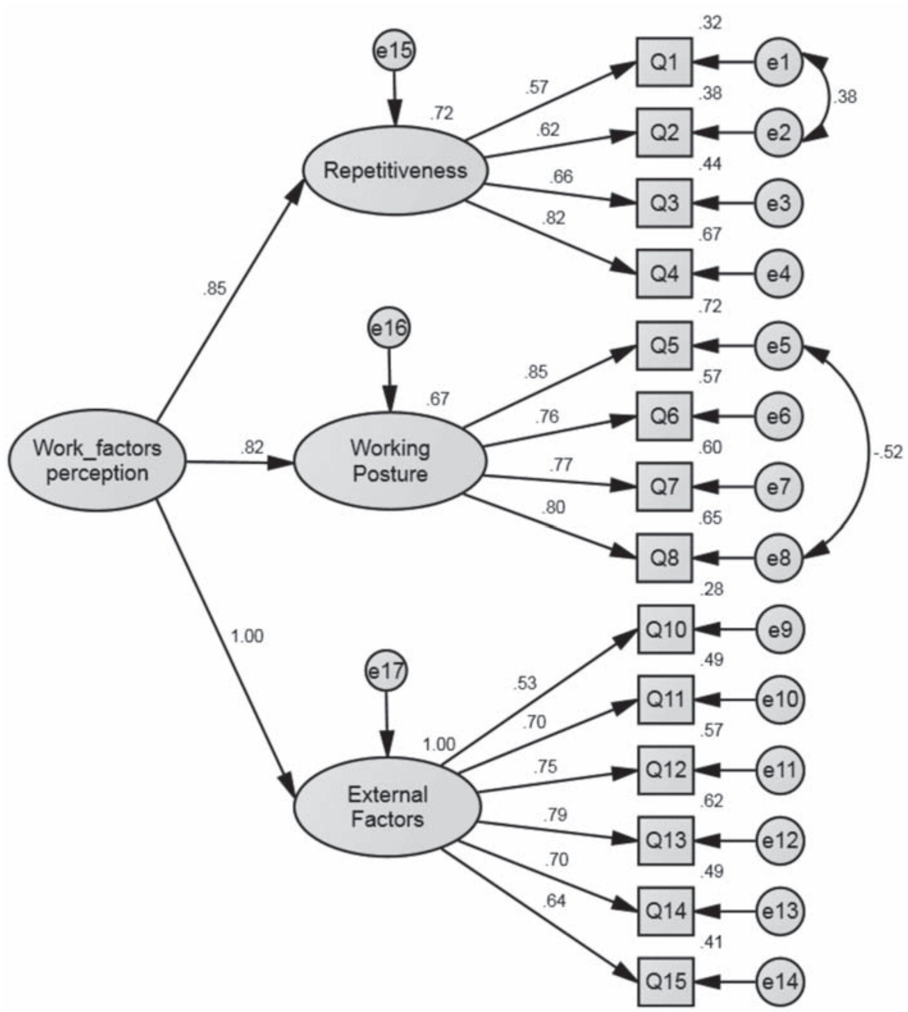

Figura 1 - Second-order hierarchical model* of the "Questionnaire on work-related activities that may contribute to musculoskeletal symptoms" [χ^2/df=1.886, CFI=0.917, GFI=0.859, RMSEA=0.089]
* according to seventh step described in Methods.

$\Delta\chi^2$=14.501, p=0.413; Res: $\Delta\chi^2$=25.872, p=0.056), indicating invariance of the factorial structure.

The convergent validity was compromised only for the "Repetitiveness" factor ($AVE_{Repetitiveness}$=0.412, $AVE_{Working\ Posture}$=0.653, and $AVE_{External\ Factors}$=0.458). The discriminant validity was adequate (ρ^2=0.333–0.428) (Eighth step).

The composite reliability, internal consistency (Ninth step), and reproducibility (Tenth step) of the tool were adequate for the three-factor model (CC: Repetitiveness=0.736, Working Posture=0.883, and External Factors=0.834; α: Repetitiveness=0.741, Working Posture=0.883, and External Factors=0.836; ρ: Repetitiveness=0.894, Working Posture=0.936, and External Factors=0.754).

Discussion

Many studies in health and social sciences involve the evaluation of attributes that cannot be measured directly and are, therefore, considered latent concepts, or abstract constructs. To measure a construct, it is necessary to use its operationalized conceptual definition to develop the most accurate measure and minimize errors (18). In this study, the construct of interest was dentistry students' perceptions regarding factors present in the work/study environment that could lead to the development of musculoskeletal symptoms. The reliability of the "Questionnaire on work-related activities that may contribute to musculoskeletal symptoms" was tested (29), and was originally designed to assess individuals' perceptions about risk factors in an American construction industry (28). However, due to use of the tool for the prevention of occupational risks, its application was extended to other occupational groups (2, 5, 8, 15, 23, 30, 31, 33). Nevertheless, implementation of the tool in other areas needed to take into account not only its theoretical aspects, but also the validity of the proposed model for the sample in question (18). Thus, to ensure the quality of the information obtained, the psychometric properties of the tool needed to be evaluated (18, 21).

This study examined the factor structure of the questionnaire applicable to dentistry students. Results showed that unlike the originally proposed questionnaire, a three-factor model was identified, including aspects related to "repetitiveness" of movements, "working posture," and "external factors" (table 2, figure 1) that are directly involved in the activities of the studied population.

For this structure to be adequate, it was necessary to remove Item 9, which cross-loaded on two factors simultaneously (table 2). This item concerns the performance of tasks above the head or far from the body, which from a theoretical point of view is not associated with the reality of dentistry work that is performed with the arms in a position below the shoulders and close to the professional's body (14).

We observed an adequate percentage of variance explained by the model. In addition, the invariance of the model was demonstrated even when applied to independent samples, which enhances its usefulness in capturing the construct ("perceived work factors that may contribute to musculoskeletal symptoms") in samples of dentistry students.

Considering that dentistry is a profession with a high risk for developing musculoskeletal disorders, and that their prevention should begin at the academic training stage of these professionals (1, 4, 7, 24, 27), it is expected that this study may contribute to the validation of a model for the "Questionnaire on work factors that may contribute to musculoskeletal symptoms" scale. This scale can be applied to dentistry students for a better detection of risk factors present in the workplace and for the maintenance of the occupational health.

The "Questionnaire on work-related activities that may contribute to musculoskeletal symptoms" using a three-factor model composed of the factors "Repetitiveness," "Working posture," and "External factors" and without item 9 was valid, invariant and reliable for the sample of dentistry students.

No potential conflict of interest relevant to this article was reported

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