

Validation and Invariance of the Dental Anxiety Scale in a Brazilian sample

Fernanda Salloume Sampaio
BONAFÉ^(a)
Juliana Alvares Duarte Bonini
CAMPOS^(b)

^(a)Universidade Estadual Paulista – UNESP,
Araraquara School of Dentistry, Araraquara,
São Paulo, SP, Brazil.

^(b)Universidade Estadual Paulista – UNESP,
Araraquara School of Dentistry and
Pharmaceutical Sciences, São Paulo, SP, Brazil.

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Corresponding Author:

Juliana Alvares Duarte Bonini Campos
E-mail: jucampos@fcar.unesp.br

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Abstract: The aim of this study was to evaluate the properties of the Dental Anxiety Scale (DAS) when applied to Brazilian adults and to test its invariance across independent samples and different sociodemographic groups. Sociodemographic data, reports on previous unpleasant dental experiences and DAS responses were collected through telephone interviews. Metric properties of the one and two-factor models were evaluated using confirmatory factor analysis. The analysis included the chi-square ratio divided by degrees of freedom (χ^2/df), the comparative fit index (CFI), the goodness of fit index (GFI) and the root mean square error of approximation (RMSEA). Convergent validity was evaluated using the average variance extracted (AVE). Cronbach's alpha (α) and composite reliability (CR) were calculated. In the two-factor model, discriminant validity was evaluated. The invariance of the models was evaluated using a multigroup analysis of the independent samples ($p\Delta\chi^2_{\lambda}$, $p\Delta\chi^2_i$ and $p\Delta\chi^2_{Res} \geq 0.05$). Telephone interviews were held with 350 individuals (74.3% women). Of the participants, 135 (38.6%) had previous unpleasant dental experiences, and 117 (33.4%) knew someone who had had this type of experience. The one- and two-factor model ($\chi^2/df < 2.0$; CFI, GFI > 0.90 ; RMSEA < 0.10 ; AVE > 0.50 ; $\alpha, CR > 0.70$) were adjusted to the data. Discriminant validity was limited ($\rho^2 = 0.66$). Both models presented strong invariance across independent samples, but the invariance was weak ($p\Delta\chi^2_i < 0.05$) when samples were defined by socioeconomic variables. In conclusion, both DAS models were valid and reliable when applied to a sample of Brazilian adults. However, the weak invariance of the models suggests that sample characteristics interfered with the measurement of dental anxiety.

Keywords: Dental Anxiety; Weights and Measures; Reproducibility of Results, Psychometrics.

Introduction

Anxiety over dental treatment is an important factor that can impact individuals' oral health. Armfield and Ketting¹ affirm that decisions on whether or not to seek dental treatment are associated with the anxiety felt toward the treatment. Farhad Mollashahi² and Almoznino et al.³ report that, in addition to the negative impact on decisions, on access, and on the person's consent to receive routine dental treatment, anxiety



can also worsen overall quality of life. Furthermore, a series of factors, including negative thoughts, loss of sleep, changes in eating habits, and increased use of medication may accompany this anxiety.

The prevalence of dental anxiety in adults has been estimated in different populations, and found to vary from 5 to 40%.^{3,4,5,6} Many researchers^{1,3,5,7,8,9,10,11} have sought to better understand the psycho-social characteristics that may be linked to this anxiety and its impact on people's lives. However, for this type of protocol to be properly implemented, the use of valid and reliable measurement instruments is necessary.

Dental anxiety is frequently evaluated using psychometric instruments, in which the variable is measured indirectly. Thus, the central measurement (in this case, dental anxiety) is classified as a latent variable. Unlike directly measured variables (observed variables), latent variables require specific research protocols that include an investigation into the psychometric qualities of the measurement instrument. This investigation is a fundamental step for estimating the validity and reliability of the obtained results and should be performed for each sample. Validity and reliability are not properties of the instrument itself, but of the sample.¹² Esa et al.¹³ reported that studies frequently handle dental anxiety incorrectly, treating it as an observed variable, which leads to measurement errors that could compromise the validity and reliability of conclusions.

The Dental Anxiety Scale (DAS), developed by Corah¹⁴ in 1969 is a widely used psychometric instrument. This scale was modified by Humphris et al.¹⁵ in 1995 to produce the Modified Dental Anxiety Scale, or the MDAS. These instruments are available in more than twenty languages (<http://www.st-andrews.ac.uk/dentalanxiety/scaletranslations/>), including Portuguese.¹⁶ The psychometric properties of the scale have been determined for English¹⁷ and Chinese populations¹⁸ using confirmatory factor analysis; however, only reliability has been evaluated in Brazilian populations.¹⁶

The decision on whether to use the DAS or the MDAS should be based on the objective of the study. Both scales evaluate dental anxiety one day before a dental appointment, in the waiting room, during the dentist's use of dental tools to perform scaling

procedures, and during the use of drills. The MDAS includes a question on local anesthesia, since needle fear, phobia, and anxiety is very common in the general population.¹⁹⁻²¹ However, anxiety over anesthesia may be related to the use of needles in general and not directly associated with dental treatment anxiety; needle anxiety and/or phobia has been well described in the literature.^{22,23,24,25} Thus, the inclusion of this item may interfere in the true assessment of dental anxiety, since procedures involving needles are not exclusive to dentistry and, while interesting, it may overestimate anxiety over dental treatment itself. Another aspect to consider is that not all dental procedures involve anesthesia, particularly in preventative care. Even so, individuals may experience some level of anxiety that may prevent them from seeking dental treatment, and it is very important that these individuals be identified. For this reason, we believe that the four items of the original scale (DAS) are better suited to identify dental care anxiety.

This study was developed in order to evaluate the psychometric properties of the Dental Anxiety Scale when applied to a sample of Brazilian adults, and also to test its invariance across independent samples and across specific subgroups organized by gender, socioeconomic level, and previous unpleasant dental experiences.

Methodology

Sampling and study design

A cross-sectional, non-probabilistic sampling study design was used. The minimum sample size was calculated using a sampling process for a finite population. For this calculation, an $n = 140,884$ was established (residents of the city of Araraquara in 2008 who were 18 years of age or older according to the Brazilian Institute of Geography and Statistics, or IBGE). A 40% prevalence of anxiety over dental treatment was also used for this sample population (unpublished data: $n=1,065$ residents of the city of Araraquara – study funded by São Paulo Research Foundation (FAPESP), grant #2007/04501-3). A 95% confidence interval was adopted, and a relative error margin was estimated to be 15%. Thus, the minimum sample size was 256 individuals. After considering

a possible 40% participant loss, the sample was corrected to 359 households.

Sociodemographic data

Gender, age, socioeconomic class and level of education data were collected. Socioeconomic classification was done according to the Brazilian Economic Classification Criteria (ABEP),²⁶ in which the estimated monthly household income is US\$ 931.00 and higher for Classes A/B, from US\$373.00 to US\$556.00 for Class C, and below US\$247.00 for Class D/E. The exchange rate at the time was US\$1.00 for R\$2.50.

Unpleasant dental experience data

Individuals answered yes/no questions about having a previous unpleasant dental experience and/or knowing someone who had a previous unpleasant dental experience.

Dental anxiety scale

Dental anxiety was measured with the Portuguese version¹⁶ of the Dental Anxiety Scale (DAS)¹⁴. The DAS is composed of 4 items, which explore the level of anxiety that the respondent would feel a day before a dental appointment, in the waiting room, during the use of drills and during the use of dental tools to perform scraping procedures. The answers vary on a scale of 1 (not anxious) to 5 (extremely anxious). In the original scale¹⁴ the four scores are added, with higher scores indicating higher levels of anxiety. Although the original DAS is based on a one-factor model, a two-factor model (F1: anticipatory dental anxiety and F2: treatment dental anxiety) was presented by Yuan et al.¹⁸ in a sample of Chinese adults and, in the current study, the two models were evaluated.

Procedures

Data was collected via telephone interview (sociodemographic data, unpleasant dental experience data, and DAS responses). One of the residents who was 18 years of age or older from each household, was included in the study.

The participating households were chosen at random using maps of the city's census records.

Randomly, a block, then a street from that block and finally four households from that street were chosen: the first household was the first-choice participant. If the phone was not answered or if no one accepted to participate, a second household was randomly chosen from the remaining three. This process continued until a successful call was made. If all four attempts failed to reach a respondent, the group was considered a sample loss. This occurred only nine times in the study. All interviews were performed by the same researcher. Phone calls were made during business hours, at night, and on weekends. If the phone was not answered or the person declined to participate, new phone calls were made to reach another household member. The first-choice participant was the first eligible household member to answer or come to the phone who agreed to participate.

This study was approved by the Ethics Committee on Human Research of the Araraquara School of Dentistry (Protocol No. 17/07). Consent to participate in the study was given by participants after the researcher read aloud the Informed Consent Form.

Statistical analyses

The psychometric sensitivity of the DAS items were evaluated using the summary and shape measures. Sensitivity was adequate when skewness (Sk) and kurtosis (Ku) presented absolute values below 3. The factorial validity of the DAS was evaluated using the confirmatory factor analysis (CFA) and the maximum likelihood estimate method. The fit of the model was evaluated using chi-square ratio divided by the degrees of freedom (χ^2/df), and also using the comparative fit index (CFI), the goodness of fit index (GFI), and the root mean square error of approximation (RMSEA). Values were considered adequate when $\chi^2/df < 2.0$, CFI and GFI > 0.90 , and RMSEA < 0.10 .²³ Factor weights (λ) below 0.50 were considered inadequate. Convergent validity was evaluated using the average variance extracted (AVE), which was considered adequate when ≥ 0.5 .^{27,28}

The modification indices, which were calculated using the Lagrange multiplier method (LM), were used to help determine the fit of the model.²⁷ The reliability of the scale was evaluated using

Chronbach's alpha ($\alpha > 0.70$) and composite reliability (CR > 0.70).^{28,29}

In the two-factor model, discriminant validity was also evaluated using correctional analysis, and it was established if the coefficient of determination between the factors (ρ^2) was less than the AVE of each of the factors.²⁸

The Akaike information criterion (AIC), the Bayes information criterion (BIC), and the Browne-Cudeck criterion (BCC) were calculated for each model to determine the most parsimonious model. The lower the values of these indices, the more parsimonious is the model.

The Total sample was randomly divided into a Test Sample (60% of the sample) and a Validation Sample (40% of the sample) using the SPSS Statistics software. The invariance of each of the models (one- and two-factor) was tested in independent samples as part of a multigroup analysis using the chi-square difference statistic ($\Delta\chi^2$). The factorial weights, intercepts and the variances/covariances were equalized between the groups. When the hypothesis regarding the invariance of factor weights was acceptable (metric invariance; weak measurement invariance; $\Delta\chi^2\lambda$: $p \geq 0.05$), then the invariance of the intercepts was also analyzed (scalar invariance; strong measurement invariance; $\Delta\chi^2i$: $p \geq 0.05$), as was the invariance of residual variances (strict invariance; $\Delta\chi^2Res$: $p \geq 0.05$).^{27,30}

Next, the above analyses were performed on specific participant subgroups, based on gender, age, socioeconomic level, and previous unpleasant dental experiences, which are supported by the literature as having a significant impact on dental anxiety. The literature reports that women,^{16,17,19} younger patients,¹⁷ patients at lower socioeconomic levels,^{5,19} and with previous unpleasant dental experiences¹⁸ present greater anxiety over dental treatment. These findings may reflect a pattern of response that is distinct to the items of the DAS. For this reason, scalar invariance was tested between these subgroups. Because age is a quantitative variable, the average age of each group was used.

The analyses were performed using the AMOS software, version 21.0®.

Results

A total of 350 people with an average age of 45.05 years (SD=19.23; range = 18–89 years) participated in the study. Their characteristics are detailed in Table 1.

The summary and shape measures of the answers to the DAS items are detailed in Table 2.

None of the items severely violated normality.

Figure 1 presents the original one-factor model (A) and the adjusted one-factor model (B) of the DAS.

The quality of fit indices of the original one-factor model (Model A) were not adequate for the validation sample ($\chi^2/df = 14.500$; CFI = 0.950; GFI = 0.959; RMSEA = 0.197). After the correlation between the errors of items 1 and 2 was inserted (LM = 21.29), the adjusted one-factor model (Model B) presented adequate factorial validity ($\chi^2/df = 1.506$; CFI = 0.999; GFI = 0.998; RMSEA = 0.038; AIC = 19.506; BIC = 54.227; and BCC = 19.767). The convergent validity (AVE = 0.54) and reliability ($\alpha = 0.83$; CR = 0.82) of this model were adequate.

The two-factor model (Model C) can be found in Figure 2. This model presented adequate factorial fit ($\chi^2/df = 1.506$; CFI = 0.999; GFI = 0.998; RMSEA = 0.038;

Table 1. Characteristics of the population sample.

Variable	n (%)
Gender	
Male	90 (25.7)
Female	260 (74.3)
Socioeconomic class	
A/B	195 (55.7)
C	120 (34.3)
D/E	35 (10.0)
Level of education	
Literacy	18 (5.1)
Elementary school	70 (20.0)
Middle school	50 (14.3)
High school	162 (46.3)
Higher education	50 (14.3)
Reported having previous unpleasant dental experience	
Yes	135 (38.6)
No	215 (61.4)
Reported knowing someone who had a previous unpleasant dental experience	
Yes	117 (33.4)
No	233 (66.6)

Table 2. Summary and shape measures of the Dental Anxiety Scale (DAS) item responses.

Variable	DAS			
	Item 1	Item 2	Item 3	Item 4
Mean	2.47	2.23	2.59	2.66
Median	2.00	1.00	3.00	3.00
Mode	2.00	1.00	1.00	1.00
Standard deviation	1.19	1.40	1.40	1.33
Minimum	1.00	1.00	1.00	1.00
Maximum	5.00	5.00	5.00	5.00
Skewness	1.05	0.56	0.31	0.31
Kurtosis	0.22	-1.27	-1.16	-1.02

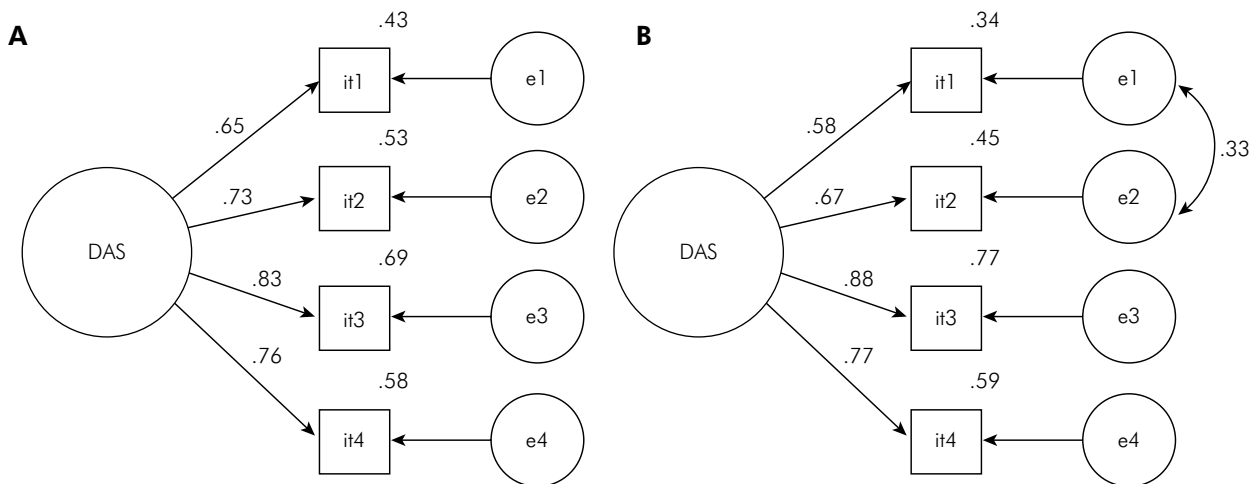


Figure 1. One-factor model (A = original; B = adjusted) of the Dental Anxiety Scale (DAS).

AIC = 19.506, BIC = 54.227, and BCC = 19.767). Convergent validity ($AVE_{F1} = 0.59$; $AVE_{F2} = 0.68$) and reliability of the model ($\alpha_{F1} = 0.73$; $\alpha_{F2} = 0.80$; $CR_{F1} = 0.74$; $CR_{F2} = 0.81$) were adequate. Discriminant validity was limited ($\rho^2 = 0.66$).

Multigroup analysis (Table 3) demonstrated that the one-factor adjusted model and the two-factor model of the DAS presented strict invariance across independent samples and metric/weak invariance between gender, age, and previous unpleasant dental experience groups.

Discussion

The original version of the DAS has been frequently used, although a thorough psychometric evaluation of the instrument has never been performed. To our

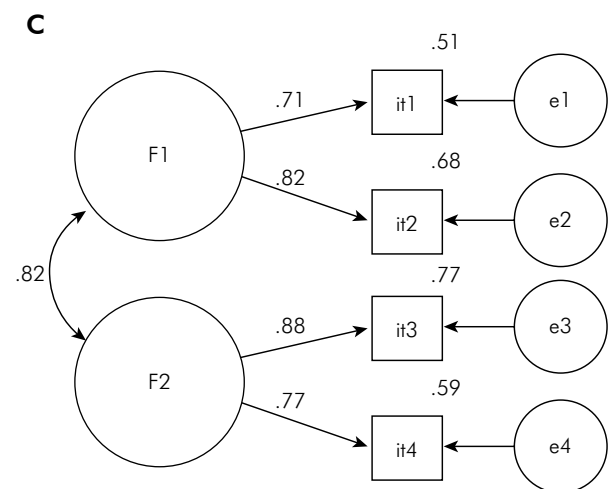


Figure 2. Two-factor model (Model C) of the Dental Anxiety Scale (DAS) (F1: anticipatory dental anxiety; F2: treatment dental anxiety).

Table 3. Multigroup analysis to determine the invariance of the models across different subsamples.

Model	Simultaneous CFA			$\Delta\chi^2$ (p)		
	χ^2/df	CFI	RMSEA	λ	i	Res
Model B						
Test vs Validation	2.07	1.00	0.05	2.94 (0.40)	3.37 (0.50)	8.83 (0.18)
Male vs Female	2.63	0.99	0.07	5.51 (0.14)	10.06 (0.04)	-
< 45 years old vs \geq 45 years old	2.26	0.99	0.06	5.55 (0.14)	10.947 (0.03)	-
Socioeconomic Class						
A/B vs C	0.83	1.00	0.00	7.38 (0.06)	15.41 (0.01)	-
C vs D/E	0.84	1.00	0.00	1.44 (0.69)	1.61 (0.81)	6.33 (0.39)
A/B vs D/E	0.31	1.00	0.00	2.14 (0.54)	2.87 (0.58)	5.83 (0.44)
Presence vs lack of personal previous unpleasant experience	1.67	1.00	0.04	2.36 (0.50)	13.94 (0.01)	-
Presence vs lack of another person's previous unpleasant experience	1.15	1.00	0.02	4.89 (0.18)	9.87 (0.04)	-
Model C						
Test vs Validation	2.07	1.00	0.05	2.34 (0.31)	3.36 (0.50)	9.44 (0.22)
Male vs Female	4.08	0.99	0.09	0.94 (0.62)	10.86 (0.028)	-
< 45 years old vs \geq 45 years old	1.84	0.99	0.05	1.53 (0.47)	10.96 (0.03)	-
Socioeconomic Class						
A/B vs C	0.83	1.00	0.00	4.97 (0.08)	14.71 (0.01)	-
C vs D/E	0.84	1.00	0.00	1.36 (0.51)	1.62 (0.81)	6.41 (0.49)
A/B vs D/E	0.31	1.00	0.00	1.39 (0.50)	2.63 (0.62)	6.82 (0.45)
Presence vs lack of personal previous unpleasant experience	1.67	1.00	0.04	2.28 (0.32)	13.84 (0.01)	-
Presence vs lack of another person's previous unpleasant experience	1.15	1.00	0.02	4.82 (0.09)	9.78 (0.04)	-

knowledge, this is the first study to evaluate the psychometric properties of the instrument using confirmatory factor analysis, and its invariance when applied to a Brazilian sample; according to our results, the DAS presented adequate psychometric properties. Campos et al.¹² reported that the evaluation of the metric properties of a measurement instrument is essential for assuring that the researcher possesses valid and reliable data.

The originally proposed theoretical model of the DAS¹⁴ (Figure 1) and the two-factor model proposed by Yuan et al.¹⁸ (Figure 2) were found to fit adequately to this Brazilian sample, indicating that this scale can be used to investigate dental anxiety. The decision on which model to use should be based on the objective of the investigation: if the focus is anxiety over dental treatment in general, the Model B is recommended. However, if researchers wish to separately evaluate anticipatory anxiety and within-treatment anxiety, the two-factor model (Model C) is recommended. Researchers should bear in

mind, however, that this model presented limited discriminate validity.

Another aspect worth highlighting is the invariance of the DAS across independent samples. Both the one- and two-factor models presented strong invariance across independent samples ("Test sample" vs "Validation sample"), a finding which reflects adequate external validity of the results.²⁷ Nevertheless, when sociodemographic characteristics were considered, a weak invariance was often found ($p\Delta\chi^2\lambda \geq 0.05$ and $p\Delta\chi^2i < 0.05$) (Table 3). Thus, it is clear that the pattern of responses differs depending on the group or groups to which the respondent belongs. These confounding factors may certainly interfere with the final dental anxiety score and, therefore, researchers must consider these variables when planning the study. Among other effects, disregarding these factors may create biased results leading to biased conclusions.

Another important aspect for researchers and healthcare professionals interested in evaluating dental

anxiety is the need to preserve the latent nature of this construct to increase the quality (precision/accuracy) of the information obtained, and, as a consequence, improve decision-making and minimize criticisms over measurement errors.¹³

It is hoped that this study offers a reflection on the importance of evaluating the metric properties of instruments before applying them on different samples and alert professionals for the need to properly evaluate dental anxiety.

Conclusion

Both the adjusted one-factor model and the two-factor model of the Dental Anxiety Scale were

found to be valid and reliable when applied to a sample of Brazilian adults. However, the invariance of the models was weak, suggesting that certain characteristics of the sample interfered in the application of the construct (dental anxiety).

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