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SCIENTIFIC ARTICLE

Design and validation of an oral health questionnaire for preoperative anaesthetic evaluation[☆]



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Abstract

Background and objectives: Dental injuries incurred during endotracheal intubation are more frequent in patients with previous oral pathology. The study objectives were to develop an oral health questionnaire for preanaesthesia evaluation, easy to apply for personnel without special dental training; and establish a cut-off value for detecting persons with poor oral health.

Methods: Validation study of a self-administered questionnaire, designed according to a literature review and an expert group's recommendations. The questionnaire was applied to a sample of patients evaluated in a preanaesthesia consultation. Rasch analysis of the questionnaire psychometric properties included viability, acceptability, content validity and reliability of the scale.

Results: The sample included 115 individuals, 50.4% of men, with a median age of 58 years (range: 38–71). The final analysis of 11 items presented a Person Separation Index of 0.861 and good adjustment of data to the Rasch model. The scale was unidimensional and its items were not biased by sex, age or nationality. The oral health linear measure presented good construct validity. The cut-off value was set at 52 points.

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PALAVRAS-CHAVE

Segurança do
paciente;
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Saúde bucal;
Higiene bucal;
Questionário

Conclusions: The questionnaire showed sufficient psychometric properties to be considered a reliable tool, valid for measuring the state of oral health in preoperative anaesthetic evaluations.

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Projeto e validação de um questionário de saúde oral para avaliação pré-anestésica no pré-operatório**Resumo**

Justificativa e objetivo: As lesões dentárias que ocorrem durante a intubação traqueal são mais frequentes em pacientes com patologia oral prévia. O objetivo do estudo foi desenvolver um questionário de saúde bucal para avaliação no período pré-anestesia, de fácil aplicação por pessoal sem formação odontológica, e estabelecer um valor de corte para detectar pessoas com má saúde bucal.

Métodos: Estudo de validação de um questionário autoadministrado, projetado de acordo com uma revisão da literatura e recomendações de um grupo de especialistas. O questionário foi aplicado a uma amostra de pacientes avaliados em uma consulta pré-anestesia. A análise Rasch das propriedades psicométricas do questionário incluiu viabilidade, aceitabilidade, validade de conteúdo e confiabilidade da escala.

Resultados: A amostra incluiu 115 indivíduos, 50,4% de homens, com idade mediana de 58 anos (variação: 38-71). A análise final dos 11 itens apresentou um índice de separação dos indivíduos de 0,861 e um bom ajuste dos dados ao modelo de Rasch. A escala foi unidimensional e seus itens não foram influenciados pelo sexo, idade ou nacionalidade. A medida linear da saúde bucal apresentou boa validade de construto. O valor de corte foi fixado em 52 pontos.

Conclusões: O questionário mostrou propriedades psicométricas suficientes para ser considerado uma ferramenta confiável, válida para medir o estado de saúde bucal nas avaliações pré-anestesia antes da operação.

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Introduction

Damage to teeth and oral tissues is one of the most frequent complications of endotracheal intubation and general anaesthesia in general.^{1,2} The incidence varies widely, with different studies reporting values between 1:4574 and 1:3 intubated patients.³⁻¹³ Previous dental pathology,^{6,8,10,11} general anaesthesia,^{9,10} laryngoscopy³ and difficult intubation^{4,6,8,11} have been commonly associated with dental injury during an anaesthetic procedure in observational studies.

Dental injuries as a complication of general anaesthesia are a frequent subject of review articles, recommendations and guidelines issued by scientific societies.¹⁴⁻¹⁷ Several authors suggested specific charts for a systematic documentation of the state of patients' dentition before the intervention in order to avoid possible litigations,^{13,14,18-20} but little has been published about effective prevention strategies.

Perioperative dental injuries seem to be more related to diseases of the oral structures themselves than to medical errors during anaesthesia,^{11,21} dental injury risk minimization should therefore start with a careful oral health evaluation during the preanaesthesia consultation. Because

correct assessment of oral health may be difficult for personnel without special dental training,⁶ and application of commonly recommended and often extensive oral health surveys may be time-consuming, we have decided to design a simple guidance tool for evaluating the oral health in a preanaesthesia clinic.

The principal objective of our study was to develop a self-administered questionnaire of oral health and oral hygiene habits for patients undergoing general anaesthesia and validate it using a Rasch analysis. The secondary objective of the study was to establish a cut-off value for detecting persons with poor oral health.

Methods

The study was approved by the Institutional Review Board in line with the provisions of the Declaration of Helsinki, and written informed consent was obtained from all subjects.

Study population

Adult patients (≥ 18 years old) attended in the preanaesthesia clinic of a university hospital were included in the study. All patients who are to undergo a scheduled

procedure in general anaesthesia in this hospital are evaluated in this clinic. Minors, patients with legal guardians and patients with intellectual limitations which may impede correct understanding of the questionnaire were excluded.

Questionnaire design

A short, self-administered questionnaire was designed based on a review of literature identified through a Medline search (using MeSH terms "oral health", "tooth loss/epidemiology" and "periodontal diseases") and opinions of a panel of experts consisting of four members (maxillofacial surgeon, dentist, otorhinolaryngologist and anaesthesiologist) who helped to adapt the questionnaire for its use in the preanaesthesia clinic.

The questionnaire originally consisted of 23 items identified through the bibliographic search. The response scale of the items was Likert-type, with response options based on frequency. Each response was given a score, which added up to a maximum of 100 points in total. The age was categorized into 8 groups (18–25, 26–35, 36–45, 46–55, 56–65, 66–75, 76–85, >85 years), assigning incremental values of 5–40 points to each one of them. The body mass index (BMI) was categorized into 3 groups (<25, 25–30, >30 kg/m²). Information about habits considered detrimental for oral health (smoking, alcohol consumption), medication and other diseases (diabetes, osteoporosis, liver disease, HIV, cancer or rheumatoid arthritis) was also added. The initial questionnaire was analysed independently by each one of the experts based on their knowledge and clinical experience.

The panel recommended excluding the question "how do you rate your oral health?" as it was considered to be too subjective and related more to the quality of life aspects (aesthetics and self-perception) rather than to true oral habits. Bisphosphonates were added to the list of harmful medications because of its association with osteonecrosis. BMI data replaced the question "are you obese?" as a more objective measure. The experts considered it necessary to ask about tooth mobility, gum bleeding, toothache and missing teeth, as these are unequivocal signs of poor oral health.

The final version of the questionnaire included 18 items grouped into three dimensions. The general information group consisted of five items; 13 items were related exclusively with oral health: eight of these addressed oral health and oral health habits and five items were dedicated to habits and concomitant diseases which are known to have a negative effect on oral health. Higher scores indicated worse oral health.

The questionnaire was first pilot-tested on 10 patients and then applied to the study population. The patients completed the questionnaire in the waiting room before the preanaesthesia assessment. The anaesthesiologist, previously trained in oral exploration by a dentist, evaluated the state of oral health and classified it as good, fair or poor. This oral exploration included direct observation with a dental mirror, periodontal probing, tooth mobility examination and calculation of the decayed, missing, filled teeth (DMF) index. A global rating of oral health (good, fair, poor) was provided by the anaesthesiologist and the dentist, who examined the patients independently after the anaesthesiologist.

Statistical analysis

The Rasch model was used to test the measurement properties of the oral health questionnaire.²² The Rasch analysis is the most current validation scale method which follows an additive process of joint measurement of persons and items in the same dimension or construct.²³ Information about Rasch analysis, explained in a friendly way, may be found elsewhere.²³ First, response categories of some of the items were collapsed where necessary in order to ensure that the category thresholds (point of equal probability of response between two neighbouring categories) were ordered. Items with standardized residuals above ± 2.5 were eliminated. A non-significant chi-square of the item-trait interaction, with Bonferroni correction, indicated a good fit to the Rasch model. The reliability was examined through the Person Separation Index (PSI) with the criterion of ≥ 0.7 for group comparisons and ≥ 0.85 for individual comparisons.²³ Principal component analysis of the residuals and independency *t*-test were used to ensure that all items of the scale formed a unique dimension, with significant values of <10% or the lower confidence interval limit of the binomial of <0.05.²⁴ The items should be locally independent, which means that correlations between standardized residuals should not be high (criterion fixed at 0.3). The items were free from bias by sex, age (by median: ≤ 58 , >58 years) and nationality (Spanish, other) if the *p*-value of the Bonferroni correction associated to the analysis of variance (ANOVA) of differential item functioning (DIF) was not significant. If more than one item presented DIF for a certain factor, a top-down purification analysis was performed and the impure items (with a bias) were subject to a DIF analysis, because if different items act in opposite directions, the DIF gets cancelled out.²⁵

After obtaining a fit to the Rasch model, psychometric properties (normality, acceptability and construct validity) of the linear scale were examined. The Kolmogorov–Smirnov test was used to verify the normal distribution of the linear measure. Data acceptability was analysed through the differences between mean and median (arbitrary standard of $\leq 10\%$ of the maximum score)²⁶ and floor and ceiling effects (below 15%).²⁷ The known groups validity was examined through the Student's *t*-test and ANOVA in order to examine significant differences in oral health by sex, age, obesity, nationality and level of education. Criterion validity was established by comparing the oral health linear measure with the results of dental examination (good, fair, poor), using ANOVA. The inter-observer concordance in the rating of oral health between the anaesthesiologist and the dentist was assessed through the kappa index.

Finally, a Receiver Operating Characteristic (ROC) curve was calculated in order to identify a cut-off value for detecting poor oral health. The results of the oral cavity examination (poor vs. good/fair oral health) were used as the criterion variable. Sensitivity, specificity, positive and negative predictive values (PPV, NPV) and positive and negative likelihood ratios (LR+, LR–) were calculated for the selected cut-off value.

The Rasch analysis was performed with the RUMM2030 program,²⁸ and IBM SPSS Statistics version 19.0 (IBM Corp., Armonk, NY, USA) was used for the rest of the analyses.

Results

The administered version of the questionnaire included 18 items, 5 about general information and 13 concerning oral health. The estimated time for completing the 18-item questionnaire ranged between 1.5 and 2 min. The inter-observer concordance between the oral-cavity examination by the anaesthesiologist and dentist was found to be satisfactory after 3 days of training (kappa index = 0.78; standard error, SE = 0.18).

Three of the 118 patients who were approached in the preanaesthesia clinic refused to participate due to impaired vision and inability to write. All questionnaires analysed had 100% of the items completed. Of the 115 patients, 50.4% were men, with a mean age of 55.1 (standard deviation, SD = 19.1; range: 18–88) years. Ninety-three patients were Spanish (80.9%). The mean BMI was 26.8 kg/m²; 24 persons were obese (BMI >30 kg/m²; 20.9%). As for the level of education, 68 patients had less than secondary education (59.2%). Oral health was considered as good in 32 patients (28.1%); fair and poor oral health was found in 37 (32.5%) and 45 patients (39.5%), respectively (Table 1).

The first analysis of the 13 oral health items did not show good adjustment of data to the Rasch model. Two items were recoded: last visit to the dentist ("<6 months ago" and "between 6 months and 1 year ago" were combined) and gum bleeding frequency ("very often" and "always" were combined). The items concerning drinking alcohol and smoking were eliminated because they measured another construct (standardized residuals >2.5).

Table 1 Descriptive statistics of the patient sample (n = 115).

	Mean ± SD; n (%)
Age	55.1 ± 19.1
Sex	
Male	58 (50.4)
Female	57 (49.6)
BMI (kg/m ²)	26.8 ± 4.2
BMI categorized (kg/m ²)	
<25	41 (35.7)
25–30	51 (44.3)
>30	23 (20)
Nationality	
Spanish	93 (80.9)
Other	22 (19.1)
Education level	
None	31 (27.0)
Primary studies	37 (32.2)
Secondary studies	27 (23.5)
University studies	20 (17.4)
Oral health (based on an oral examination)	
Good	32 (28.1)
Fair	37 (32.5)
Poor	45 (39.5)

SD, standard deviation; BMI, body mass index.

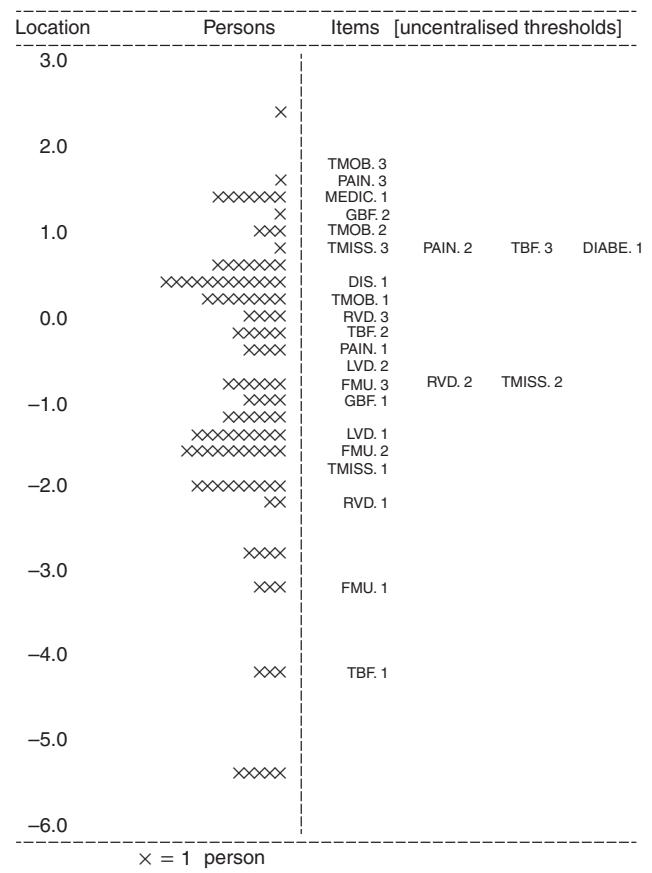


Figure 1 Person-item threshold distribution, in logits (final Rasch model).

(DIABE, Diabetes; DIS, Diseases; FMU, Frequency of mouthwash use; GBF, Gum bleeding frequency; MEDIC, Medication; LVD, Last visit to the dentist; PAIN, Pain on chewing; RVD, Reason for visiting the dentist; TBF, Tooth brushing frequency; TMISS, Number of missing teeth; TMOB, Tooth mobility).

Analysis of the remaining 11 items presented good reliability (PSI = 0.861) and good adjustment of data to the model ($\chi^2(44) = 64.168$; $p = 0.025$), with fit statistics of 0.027 (SD = 1.248) for the items and -0.196 (SD = 0.914) for person-fit. Table 2 presents the final version of the questionnaire, with a scoring example. The fit statistics for each item of the final model are summarized in Table 3.

The unidimensionality of the scale was confirmed, with 7.83% significant t -test and an acceptable confidence interval of the binomial (95% confidence interval, CI_{95%} = 0.038; 0.118). The items "tooth brushing frequency" and "pain on chewing" showed DIF by sex in opposite directions, so the DIF got cancelled out ($p = 0.740$). The item "number of missing teeth" presented DIF by age. No item showed DIF by nationality.

The third threshold of the item "tooth mobility in almost all teeth" represented the most severe oral health problem, and the first threshold of the item "tooth brushing frequency ≥ 3 times/day" represented the least severe oral health problem (Fig. 1).

Table 4 presents the transformation from raw to logit scores. The linear measure in a 0–100 scale had normal distribution (Kolmogorov–Smirnov $Z = 1.169$, $p = 0.130$) with

Table 2 Preanaesthesia oral health evaluation questionnaire with a scoring example.

Value	0	1	2	3
1. How frequently do you use mouthwash?	More than once a day	Once a day	Sometimes	<u>Never</u>
2. How often do you brush your teeth?	3 or more times a day	1–2 times a day	<u>Sometimes</u>	Never
3. When was the last time you went to the dentist?	Less than 1 year ago	1 year ago	<u>More than 2 years ago</u>	
4. What was the reason for your last visit to the dentist?	Check-up/cleaning	Fillings/root canal treatment	Tooth extraction	<u>Placement of a crown, bridge or prosthesis</u>
5. How many teeth do you have missing?	None	1–2 teeth	<u>More than 2 teeth</u>	Most teeth
6. Do you experience gum bleeding?	Never	<u>Sometimes</u>	Very often	
7. Do you experience pain on chewing?	Never	<u>Sometimes</u>	Very often	Always
8. Do you experience tooth mobility?	No	<u>Only 1 tooth</u>	2–5 teeth	Almost all teeth
9. Are you diabetic?	No	0	1	
10. Do you have any of the following diseases? Cancer, Osteoporosis, HIV, Rheumatoid arthritis, Liver disease (cirrhosis)	No	<u>Yes</u>	<u>Yes</u>	
11. Do you take any of the following medications? Corticoids, Phenytoin (antiepileptic), Bisphosphonates (Fosamax, Boniva)	<u>No</u>	Yes		
Final score^a		Column sumscore A = 5	Column sum-score B = 6	Column sumscore C = 6
				Raw score = A + B + C = 17
				Linear measure = 66.861

^a Calculation of the final score: Step 1, Sum up the score of items marked with the value 1 (A = 5); Step 2, Sum up the score of items marked with the value 2 (B = 6); Step 3, Sum up the score of items marked with the value 3 (C = 6); Step 4, Obtain the initial raw score (A + B + C = 17); Step 5, Find the linear measure associated with this raw score in the conversion table (Table 5). In our example, with a raw score of 17, the associated linear measure is of 66.861 on a 0–100 scale.

a mean of 49.01 (SD = 17.85), mean–median difference of 4.38%, and no floor or ceiling effects. Validity results are listed in Table 5: oral health was significantly worse in people over the age of 58 years and Spanish nationals, with

no significant difference by sex. When controlled for age, the difference for nationality was no longer statistically significant. ANOVA analysis showed that people without a university education and with BMI >25 kg/m² had worse oral

Table 3 Fit statistics for the items of the final Rasch model.

Item	Difficulty	SE	Residuals	χ^2 (df = 4)	Probability
Frequency of mouthwash use	-1.814	0.141	0.262	2.663	0.616
Tooth brushing frequency	-1.084	0.152	-1.478	6.170	0.187
Last visit to the dentist	-0.858	0.154	1.919	12.006	0.017
Reason for visiting the dentist	-0.849	0.129	0.445	4.777	0.311
Number of missing teeth	-0.495	0.132	-0.895	2.314	0.678
Gum bleeding frequency	0.200	0.169	1.104	2.425	0.658
Diseases	0.551	0.236	-0.780	7.747	0.101
Pain on chewing	0.840	0.141	1.339	5.732	0.220
Diabetes	0.999	0.252	-0.576	6.550	0.162
Tooth mobility	1.098	0.145	-1.965	6.192	0.185
Medication	1.412	0.273	0.918	7.594	0.108

SE, standard error; df, degrees of freedom.

Table 4 Conversion table from raw scores to the linear measure.

Raw score	Linear measure (logits)	Linear measure (0–100)	Raw score	Linear measure (logits)	Linear measure (0–100)
0	-5.250	0.000	13	0.015	57.908
1	-4.024	13.484	14	0.218	60.141
2	-3.190	22.657	15	0.420	62.363
3	-2.623	28.894	16	0.623	64.595
4	-2.198	33.568	17	0.829	66.861
5	-1.854	37.352	18	1.041	69.193
6	-1.559	40.596	19	1.264	71.645
7	-1.296	43.489	20	1.504	74.285
8	-1.054	46.150	21	1.771	77.222
9	-0.826	48.658	22	2.082	80.642
10	-0.607	51.067	23	2.474	84.954
11	-0.396	53.388	24	3.036	91.135
12	-0.189	55.664	25	3.842	100.000

health than the rest of the participants. The oral health linear measure increased with dental examination scores, following a significant linear trend.

A ROC curve was calculated for the linear scale, using the dental examination (poor vs. good/fair oral health) as variable criterion, with an area under curve (AUC) of 0.935 (SE = 0.018, CI_{95%} = 0.92–0.99). The cut-off value was set at 52 points (specificity = 0.96; sensibility = 0.86). The PPV, NPV, LR+ and LR– for this cut-off value were 0.811, 0.967, 6.593 and 0.052, respectively.

Discussion

The goal of the preanaesthesia evaluation is to detect patients with an increased risk of complications and design effective prevention measures. The methods used for predicting postoperative problems focus on the disease severity, surgical complexity, identification of comorbidities, and cardiac risk, among others. Nevertheless, the consequences of oral damage secondary to anaesthesia should not be underestimated as oral health is important for a good quality of life^{29,30} and for good health in general. Our objective was to design a screening tool for assessing the oral health of patients undergoing preanaesthesia evaluation.

The questionnaire is short, easy to understand, acceptable to patients and feasible to apply in the clinic as it only takes about 2 min to complete. The timing of the administration – after examination by the nurse while waiting to be seen by the anaesthesiologist – favours the response and completion rate and increases patients' awareness of this complication. The response options are similar, but not exactly the same for each question, which prevents the central tendency bias. The content validity was supported by a panel of experts.

The questionnaire is reliable, allowing for comparisons between individuals.²³ Further studies that administer the questionnaire in different occasions are needed to evaluate the test–retest reliability. The unidimensionality of the scale, representing a single construct, permits the score of all the items to be added as a linear measure. A linear measure is important for intervention studies and clinical trials as it allows applying parametric statistical tests.

Almost all items were free from bias by sex and age. However, older patients scored higher in the item "number of missing teeth", a fact previously documented.²⁹ The questionnaire displayed adequate discriminant validity and allowed a statistical differentiation according to well-known oral health risk factors: education level^{31–33} and BMI.^{34,35} The questionnaire also showed a good criterion validity when

Table 5 Descriptive analysis of data and parametric tests (Student's *t*-test and ANOVA) for the linear measure of poor oral health according to different sociodemographic variables.

Variable	Frequency (n)	Mean	SD	p
<i>Age (years)</i>				<0.001
≤58	58	38.7	16.7	
>58	57	59.5	11.9	
<i>Sex</i>				0.209
Male	58	51.1	13.2	
Female	57	46.9	21.5	
<i>Nationality</i>				0.017 ^a
Spanish	93	50.9	17.7	
Other	22	40.9	16.5	
<i>Education level</i>				<0.001
None	31	63.4	11.1	
Primary studies	37	53.1	9.7	
Secondary studies	27	45.4	10.6	
University studies	20	24.0	18.4	
<i>BMI (kg/m²)</i>				<0.001
<25	41	40.0	22.0	
25–30	51	51.2	12.9	
>30	23	60.2	9.8	
<i>Oral health</i>				<0.001
Good	32	30.7	17.1	
Fair	37	45.8	11.4	
Poor	45	64.1	7.6	

SD, standard deviation; BMI, body mass index.

^a Non-significant when adjusted by age.

compared to the dental examination, but further studies are needed to examine the predictive validity of the questionnaire by comparing the scores obtained with the intubation outcome. One study reported that 80% of the injuries were classified as "unavoidable", which raises the question of the usefulness of predicting this event. Several authors have found that it is difficult to predict dental damage, however, they have looked at predicting a difficult intubation^{8,13,19,36} rather than the risk of dental injury itself.

Dental injury has not been demonstrated to be more frequent in emergency surgeries^{8,10,12,13,19,36} or to be associated with the level of experience of the anaesthesiologist.^{7,12,19} Several major studies have emphasized that dental injury was up to 50 times more likely to occur in patients with previous dental pathologies,^{8,10} which suggests that the personal predisposition is more important than the actions of the anaesthesiologist. The design of the questionnaire was based on this premise. At the same time, it is the biggest limitation of our study: there is no evidence up to date that being aware of the oral health conditions of the patients decreases the risk of dental injury during an anaesthetic procedure. A cohort study of patients evaluated through our questionnaire and followed-up for the incidence of dental injury after the anaesthetic procedure would be necessary to estimate its utility in reducing dental damage. Still, a careful examination of the oral cavity is considered an integral part of the preanaesthesia evaluation. One study noted that while pre-existing dental pathology was present in

two-thirds of the cases, it was noticed by the anaesthesiologist in only one-fifth of the patients prior to intubation.⁶ Therefore, our questionnaire for detecting patients with poor oral health may serve as a guidance to the anaesthesiologist assessing the risk of dental injury. In addition, it offers a cut-off value for detecting poor oral health.

Other limitations of our study include a relatively small sample size³⁷ and the fact that the data were collected from a single centre. Despite the small number of participants, we have achieved a good fit to the Rasch model.

It is not clear which preventive measures to take when a patient is considered at an increased risk of dental injury. The use of protective devices such as mouthguards is controversial: while some authors argue that they decrease the already limited amount of space available,^{6,12} others concluded that the difference in time needed for intubating a patient with or without a mouthguard was not clinically relevant.³⁸ Custom-made mouthguards may be less bulky than other methods such as using an impression putty,²⁰ but they are more costly and require time to manufacture. If the risk of dental injury is considered to be high, previous dental assessment is recommended. Alternative anaesthesia and intubation techniques may also be considered whenever possible in such cases. One group proposed a special technique for protecting very loose teeth,³⁹ but preservation of severely compromised teeth at any price may be questionable; such teeth are a persistent source of infection and may be dangerous to a patient undergoing a surgical procedure.

Summary

Our goal was to develop and validate a questionnaire of oral health and oral habits suitable for a preanaesthesia clinic. This questionnaire has demonstrated sufficient psychometric properties to be considered a reliable and valid tool for measuring the state of oral health, and also takes into account sociodemographic factors known to be associated with oral health and general health state of the patient.

Some of the benefits of our questionnaire may be classifying patients according to the dental injury risk, alerting the anaesthesiologist about complicated patients where additional precautions would be necessary during intubation, informing patients with higher scores about their increased risk, raising patients' awareness about the importance of good oral health, suggesting dental treatment before surgery in order to prevent an injury, and decreasing the compensation claims which would result in savings.

Conflicts of interest

The authors declare no conflicts of interest.

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