RESEARCH ARTICLE

Development and validation of a questionnaire to evaluate infection control in oral radiology

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Objectives: To create and validate a questionnaire to evaluate infection control in oral radiology.

Methods: The questionnaire was developed after review of the literature, which included published articles and the biosafety protocols available from healthcare agencies. The initial version of the questionnaire was composed of 14 multiple choice questions and was divided into 3 domains on handwashing, disinfection/protection of surfaces and disinfectant used. Content validity was assessed by two expert committees, which reviewed the content and scope of the questionnaire and the relevance of each item, respectively. Reliability was evaluated using test–retest and internal consistency methods with 115 undergraduate dentistry students. Construct validity was assessed using the known-groups technique and factor analysis. The known-groups technique involved 641 undergraduate dentistry students, 20 PhD students and 15 oral radiology professors. In the factor analysis, 3 radiology technicians also participated in addition to the 641 undergraduates, 20 PhD students and 15 oral radiology professors.

Results: The content validity results were found to be satisfactory to excellent for the ordinal variables (intraclass correlation coefficient = 0.722–1.000) and good to great for the yes/no questions (kappa = 0.662–0.913) in terms of reliability and good internal consistency (Cronbach's alpha = 0.88). After a factor analysis, some questions were excluded, and the questions were grouped into new domains. Significant differences were observed between answers from different groups. The final version of the questionnaire was composed of nine domains.

Conclusions: The questionnaire created was found to exhibit good psychometric properties for assessing infection control in oral radiology.

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Introduction

Infection control in dentistry should follow the standard precautions;^{1–3} i.e. a set of guidelines aimed at preventing contamination in the clinical environment.⁴

Infection control is of fundamental importance and must also be followed in oral radiology, particularly in the case of intraoral X-ray techniques, since saliva can be a medium for transmission of pathogenic micro-organisms present in the oral cavity such as influenza, Hepatitis B and C, herpes, human immunodeficiency virus, *Micobacterium tuberculosis*, staphylococci and streptococci. Thus, the exposure of the image receptor

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to saliva can be a source of cross-contamination through direct contact between patients or indirectly through the subsequent contamination of work surfaces.¹

In addition, increased accessibility to digital systems has created a new challenge in infection control,⁵ since digital receptors allow for multiple uses (unlike films), and cannot be disinfected^{5,6} or autoclaved.^{1,3,5,6}

Thus, the receptors and surfaces of the X-ray equipment must be protected with waterproof plastic barriers as a preventive measure to avoid and reduce contamination. Alternatively, the surfaces of the equipment can be disinfected^{1,3,7,8} or handled by professionals wearing overgloves.⁸

Although all these recommendations exist, little is known about professional compliance with them. Studies on this topic are scarce,^{9–12} and the questionnaires used in these studies are outdated when compared with infection control protocols and with the digital system available today. Moreover, these studies often used questionnaires that were not evaluated psychometrically. It must be stressed that, in order to deliver scientifically sound results with clinical and academic relevance, a questionnaire must be standardized and have good psychometric qualities¹³ such as validity and reliability.^{14–18}

The extent to which one test is precise in terms of assessing what it is supposed to assess, *i.e.* its variable (or variables) of interest, is known as validity. For proper assessment and understanding, this concept is divided into content validity, construct validity and criterion validity.^{13,14,16} Content validity assesses the significance and relevance of each item and domain in the questionnaire^{13,15} and is measured after a panel of experts reviews the questionnaire using qualitative and quantitative methods.^{13,16} Normally, the questionnaire is field tested to confirm whether the study population understands the questions,^{13,14,19,20} as well as to decide whether any of the questions need to be adjusted or excluded.¹³

Alternatively, the core of criterion validity is weighing one newly developed questionnaire against a gold standard; *i.e.* a questionnaire already accepted by those familiar with one specific topic.^{15,21} If a gold standard does not exist, construct validity should be measured instead.²¹ Factor analysis and the known-groups technique may be performed to determine construct validity.^{17,21} The former validates the construct by means of a statistical model, whereby the several items designed to assess one domain within a construct are supposed to be more highly correlated with one another than with other items measuring other domains in the same questionnaire.^{15,17,18,22,23} The known-groups technique, on the other hand, tests one group in which the construct outcome is established against another group in which the outcome is not present,^{15,17,21} thus determining the discriminatory power of the questionnaire.

Reliability refers to the degree to which the results obtained from one given test or questionnaire can be consistently replicated.^{13,16,21} It provides a measure of stability, or how similarly a group answers the same

questions after a certain time interval.²¹ Internal consistency (homogeneity), equivalence and stability (test–retest reliability) are the three important aspects of reliability.^{13,15,21}

Because there is no up-to-date and psychometrically sound test questionnaire meant to assess compliance with infection control protocols in oral radiology, the purpose of this study was to create and verify the psychometric properties of a questionnaire to evaluate the infection control standards for intraoral radiographic examinations in dental schools, private clinical oral radiology clinics and public healthcare facilities.

Methods and materials

This study was approved by the Research Ethics Committee of the Piracicaba Dental School of the State University of Campinas (Protocol No. 110/2013), and consent was obtained from each subject.

The study was performed in five steps following the methodology advocated by the literature:^{4,13,17} (1) literature review; (2) generation of items and domains; (3) content validity; (4) pre-test; and (5) establishment of psychometric properties.

The data were collected from students who also provide patients with clinical care from six schools of dentistry in the state of São Paulo, Brazil (two public universities and four private institutions).

In order to create the items and domains of the Questionnaire on Infection Control in Oral Radiology (QICOR), 54 articles published between 1978 and 2015 were reviewed, and biosecurity protocols from health agencies in Brazil (the National Health Surveillance Agency or ANVISA²) and the USA (Centers for Disease Control and Prevention^{1,3} and the American Dental Association⁷) were also consulted.

A questionnaire with closed questions consisting of 14 items and divided into 3 domains was created (Table 1). For the answer options, the Likert scale^{15,24} was used for Questions 1, 2, 7, 9, 10 and 11. For all other questions, the options involved the frequency of and/or procedures for infection control.

A score was assigned to each option, the highest of which reflected the best infection control behaviours. No scores were attributed to the additional options (“I perform disinfection with 70% alcohol—Questions 1 and 2; “does not apply”—Question 7; “I don’t use a radiographic film-holding device”—Question 9; “I use only digital radiographic receptors”—Questions 10 and 11), for the yes/no questions (5 and 6), for Question 8 or for the questions in the “Radiography Equipment” domain. Questions 12–14 had “other” as an option (with a blank space for the participant to write in an answer). For Question 14, the options referred to commonly used disinfectants (70% alcohol and chlorine compounds), and the scores were assigned according to the disinfection level observed in the literature.² In contrast with the current practice of avoiding initial

Table 1 Initial version of the Questionnaire on Infection Control in Dental Radiology. The scores for each answer option are in parentheses

Domain 1—handwashing

1. Before putting on gloves, do you wash your hands?
(5) Always (4) Usually (3) Sometimes (2) Rarely (1) Never (*) I perform disinfection with 70% alcohol
2. After removing gloves, do you wash your hands?
(5) Always (4) Usually (3) Sometimes (2) Rarely (1) Never (*) I perform disinfection with 70% alcohol

Domain 2—equipment

3. What kind of radiographic receptor do you use?
(*) Traditional film (*) Storage phosphor plate (*) Direct digital sensor
4. To process the radiographic films, do you use:
(*) Darkroom (*) Portable box
5. Do you use the automatic processor?
(*) Yes (*) No

Domain 3—radiographic exposure

6. Do you perform radiography examinations on your patients during clinical care?
(*) Yes (*) No
 7. During radiographic exposure, please indicate the frequency with which you use the following items: (A) Mask; (B) Procedure gloves; (C) Surgical cap; (D) Medical coat; (E) Protective goggles (F) Overgloves; (G) Protection of surfaces with plastic barriers: (G1) Film; (G2) Digital radiography receptor; (G3) Headrest; (G4) X-ray tubehead (position-indicating device); (G5) Exposure button; (G6) X-ray control panel; (G7) Computer monitor for the digital radiography system; (G8) Computer keyboard for the digital radiography system; (G9) Mouse for the digital radiography system; (G10) Printer for the digital radiography system
(5) Always (4) Usually (3) Sometimes (2) Rarely (1) Never (*) Doesn't apply
 8. In which situation(s) do you use overgloves?
(*) (A) To place patients in the chair
(*) (B) To place X-ray apron and thyroid collar on the patient
(*) (C) To handle the X-ray tubehead (position-indicating device)
(*) (D) To select the time on the control panel display
(*) (E) To press the exposure button
(*) (F) To handle radiographic film or digital radiography receptors not contaminated with saliva
(*) (G) To process the radiographic film
(*) (H) When using the computer for the digital radiography system
(*) (I) To handle the monitor, keyboard, mouse and/or printer of digital radiography system
(*) (J) I don't use overgloves
 9. How often do you sterilize the radiograph film-holding device for each patient?
(5) Always (4) Usually (3) Sometimes (2) Rarely (1) Never (*) I don't use a film-holding device
 10. How often do you use plastic barrier to pack intraoral films?
(5) Always (4) Usually (3) Sometimes (2) Rarely (1) Never (*) I use only digital radiography receptors
 11. How often do you disinfect the exposed film packets before processing?
(5) Always (4) Usually (3) Sometimes (2) Rarely (1) Never (*) I use only digital radiography receptors
 12. Indicate the infection control procedures you perform on the following devices for each new patient: (A) X-ray tubehead (position-indicating device); (B) Exposure button; (C) X-ray control panel; (D) Patient's chair
(8) Disinfection with 70% alcohol + common cleaning (water and soap) + plastic barrier/overgloves
(7) Disinfection with 70% alcohol + plastic barrier/overgloves
(6) Common cleaning (water and soap) + plastic barrier/overgloves
(5) Plastic barrier/overgloves
(4) Disinfection with 70% alcohol + common cleaning (water and soap)
(3) Disinfection with 70% alcohol
(2) Common cleaning (water and soap)
(1) I don't clean
(*) Other
 13. Indicate how often do you clean and/or disinfect the following items: (A) Patient's chair (D) X-ray Apron (C) Thyroid collar
(5) Every patient (4) Once a day (3) Once a week (2) Once a month (1) I don't know (*) Other
 14. What types of disinfectants you usually use to clean the radiography equipment [headrest, X-ray tubehead (position-indicating device), exposure button, X-ray control panel, patient's chair, X-ray apron, thyroid collar?]
(4) (A) Chlorine compounds (3) (B) 70% alcohol (2) (C) Common cleaning (water and soap) (1) (D) I don't use disinfectants (*) (E) Other
- (*) Answer options to which scores were not attributed.

fatigue among participants,¹⁹ the questions to obtain demographic data were inserted at the end of the questionnaire.^{19,25} In this section, we inserted a note informing the participants that the answers to the questions were optional, since the participants could feel embarrassed or could believe that the answers would affect their privacy.

To confirm whether the items of each question were appropriate and adequately representative of the content of the questionnaire, the validity of the content^{13,15} was determined in two stages.^{16,17} In the first stage, the

committee was composed of one biosafety professor, one public health professor and four oral radiology professors. This multidisciplinary committee participated in the development of the questionnaire by performing adjustments and analyzing its clarity and representativity.^{15,17,26,27}

10 students from 1 of the participating public universities and who were already in supervised clinical practice (in their third, fourth and fifth years of dental school, which is considered an undergraduate degree in Brazil) participated in the pre-test phase.

The students were asked to comment on the clarity of the questions,^{13,14,17,20} as well as on any comprehension issues.¹³ Questions with a $\geq 20\%$ level of understanding were then reviewed by the committee.²⁸

10 oral radiology professors participated in the second stage of the content validity process.^{13,29} They determined whether items of the questionnaire were to remain or be excluded, in accordance with the proposal by Lawshe.³⁰ In this stage, the committee calculated the content validity ratio (CVR) and rated each item as

“essential”, “useful, but not essential” or “not necessary”.^{28–30}

To calculate the student sample size for these stages, a minimum of 10 subjects were considered for each question.¹⁷ The scaling of the sample was based on a correlation coefficient of at least 0.3, with semi-amplitude of the 95% confidence interval of 0.1 (± 0.1), probability of Type I error (α) of 5% and 80% test power, providing a number larger than 10 times the number of questions. Thus, 115 students participated in the reliability stage, and another 641 students were

Table 2 Intraclass correlation coefficient (ICC) and corresponding confidence intervals for Questions 1–4, 7, 9 and 10–14

Questions	ICC 95%	Confidence Interval	Classification
1 Frequency of handwashing before putting on gloves	0.923	0.888–0.946	Excellent
2 Frequency of handwashing after removing gloves	0.952	0.931–0.967	Excellent
3 Radiography receptor used	1.000	–	Excellent
4 Type of radiographic film processing used	0.930	0.899–0.951	Excellent
7A Frequency of mask use during radiographic exposure	0.733	0.614–0.816	Satisfactory
7B Frequency of procedure glove use during radiographic exposure	0.854	0.789–0.899	Excellent
7C Frequency of surgical cap use during radiographic exposure	0.866	0.806–0.907	Excellent
7D Frequency of medical coat use during radiographic exposure	0.723	0.599–0.808	Satisfactory
7E Frequency of protective goggle use during radiographic exposure	0.890	0.840–0.924	Excellent
7F Frequency of overglove use during radiographic exposure	0.823	0.743–0.878	Excellent
7G1 Frequency of plastic barrier use in film during radiographic exposure	0.745	0.630–0.824	Satisfactory
7G3 Frequency of plastic barrier use on headrest during radiographic exposure	0.807	0.720–0.868	Excellent
7G4 Frequency of plastic barrier use on X-ray tubehead (position-indicating device) during radiographic exposure	0.791	0.694–0.856	Excellent
7G5 Frequency of plastic barrier use in exposure button during radiographic exposure	0.744	0.626–0.824	Satisfactory
7G6 Frequency of plastic barrier use on X-ray control panel during radiographic exposure	0.784	0.684–0.852	Excellent
9 Frequency of sterilization of the radiograph film-holding device for each patient	0.905	0.862–0.934	Excellent
10 Frequency of plastic barrier use to pack intraoral films	0.860	0.797–0.903	Excellent
11 Frequency of disinfection of the exposed film packets before processing	0.762	0.656–0.835	Excellent
12A Frequency of performance of infection control procedures on the X-ray tubehead (position-indicating device) for each new patient	0.880	0.826–0.917	Excellent
12B Frequency of performance of infection control procedures on the exposure button for each new patient	0.766	0.675–0.845	Excellent
12C Frequency of performance of infection control procedures on the X-ray control panel for each new patient	0.733	0.615–0.816	Satisfactory
12D Frequency of performance of infection control procedures on the patient chair for each new patient	0.725	0.602–0.810	Satisfactory
13A Frequency of patient chair cleaning and/or disinfecting for each new patient	0.722	0.598–0.808	Satisfactory
13B Frequency of X-ray apron cleaning and/or disinfecting for each new patient	0.783	0.685–0.850	Excellent
13C Frequency of thyroid collar cleaning and/or disinfecting for each new patient	0.803	0.714–0.864	Excellent
14 Types of disinfectants used to clean the radiography equipment	0.897	0.848–0.930	Excellent

ICC < 0.4 = poor; $0.4 \leq \text{ICC} < 0.75$ = satisfactory; $\text{ICC} \geq 0.75$ = excellent (Szklo M, Nieto FJ. *Epidemiology: beyond the basics*. 2nd edn. Sudbury, ON: Jones and Bartlett Publishers; 2007).

Questions 7G2, 7G7–7G10 on digital radiography were not evaluated, as this system was not available at the schools that participated in this study.

involved in the validation stage. All of these students were already working in supervised clinical practice (in their third, fourth and fifth years of dental school), and they came from the two public and four private schools of dentistry considered in the study.

The psychometric indicators were analyzed based on reliability and validity.^{14,17,18} Reliability was determined using test–retest and internal consistency.^{13,15,17,19,24,25,31,32} In this stage, the questionnaire was applied and reapplied to the 115 students at 2 different times, with a 1-week interval between them.^{33,34} To determine intraevaluator reproducibility, the ordinal variables were analyzed using the intraclass correlation coefficient (ICC) with a cut-off value >0.70 ,^{17,18,21,31} and kappa was used for the yes/no questions with a cut-off value >0.60 .^{17,33} To determine internal consistency, Cronbach's alpha was used with a cut-off value >0.70 .^{15,18,19,24,27,32,34}

The construct validity of the questionnaire was determined using factor analysis and the known-groups technique.^{17,21} In this case, the questionnaire was also applied to professors of oral radiology and PhD students in oral radiology in addition to the 641 dentistry students, which allowed for a comparison between the scores of these group answers.^{15,17,21,27} 15 professors and 20 PhD students agreed to participate. The goal of this stage was to compare the scores attained by dentistry students, who are in the process of learning infection control protocols, with those obtained by the professional group (professors and PhD students), which included individuals who supposedly had a deeper understanding of infection control.

The factor analysis verified the need for all of the questions (items) and their grouping into domains

(factors).^{15,17,18,22–24,29} To evaluate the correlation between items and to reduce the number of questions, a varimax rotation with the formation of subgroups (dimensions) was performed. In this step, the questions that evaluated the same information were analyzed; the eigenvalues enabled for correlations between the domains (factors) to be determined.^{22,23} At this stage, 3 radiology technicians also participated in addition to the 641 students, 15 professors of oral radiology and 20 PhD students.

All statistical analyses were performed using the Statistical Analysis System software, SAS[®] v. 9.2 (SAS Institute Inc., Cary, NC), at a significance level of 5%.

Results

In the first stage of content validity, the committee members suggested the inclusion of an explanation with instructions on how to complete the questionnaire; they also suggested that the following answer options be changed in the following way:

- Questions 12 and 14: add “soap and water” after the expression “common cleaning”
- include the options “does not apply” (Question 7), “I don't use a radiographic film-holding device” (Question 9), “I use only a digital radiographic receptor” (Questions 10 and 11) and “other” (Questions 12, 13 and 14).

In the pre-test phase, no item had a level of incomprehension ≥ 0.20 ; therefore, the questionnaire did not need to be re-evaluated by the first committee.

Table 3 Kappa values (κ) and corresponding confidence intervals for Questions 5, 6 and 8

Questions (“Do you...?”)	κ	Confidence interval	Classification
5 Use the automatic processor	0.913	0.830–0.995	Excellent/almost perfect
6 Perform radiography examinations on patients during clinical care	0.688	0.552–0.823	Good
8A Use overgloves to place patients in the chair	0.676	0.509–0.842	Good
8B Use overgloves to place the X-ray apron and thyroid collar on the patient	0.826	0.722–0.929	Excellent/almost perfect
8C Use overgloves to handle the X-ray tubehead (position-indicating device)	0.788	0.674–0.901	Good
8D Use overgloves to select the time on the control panel display	0.707	0.569–0.844	Good
8E Use overgloves to press the exposure button	0.703	0.524–0.799	Good
8F Use overgloves to manipulate radiographic film or digital radiography receptors not contaminated with saliva	0.662	0.652–0.887	Good
8G User overgloves to process the radiographic film	0.770	0.500–0.911	Good
8H Use overgloves to use the computer for the digital radiography system	0.706	0.542–0.937	Good
8I Use overgloves to handle the monitor, keyboard, mouse and/or printer of the digital radiography system	0.740	0.542–0.937	Good
8J Do not use overgloves	0.773	0.631–0.914	Good

Kappa: <0.00 = poor; 0.00 – 0.20 = weak; 0.21 – 0.40 = tolerable; 0.41 – 0.60 = regular; 0.61 – 0.80 = good; 0.81 – 0.99 = excellent/almost perfect (Landis JR, Koch GG. An application of hierarchical kappa-type statistics in the assessment of majority agreement among multiple observers. *Biometrics* 1977; 33: 363–74).

Table 4 Distribution of frequency and content validity ratio (CVR) and Questionnaire on Infection Control in Oral Radiology questions/items that were accepted or rejected by the second committee of professors

<i>Instructions, questions and answer options</i>	<i>Not necessary</i>	<i>Useful, but non-essential</i>	<i>Essential</i>	<i>CVR</i>	<i>Accepted/rejected</i>
Instructions for filling	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+
1 Frequency of handwashing before putting on gloves	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+
2 Frequency of handwashing after removing gloves	0 (0.0%)	1 (10.0%)	9 (90.0%)	0.80	+
3 Radiography receptor used	2 (20.0%)	5 (50.0%)	3 (30.0%)	−0.40	−
4 Type of radiographic film processing used	0 (0.0%)	7 (70.0%)	3 (30.0%)	−0.40	+
5 Use of the automatic processor	0 (0.0%)	8 (80.0%)	2 (20.0%)	−0.60	+
6 Performance of radiography examinations on patients during clinical care	1 (10.0%)	1 (10.0%)	8 (80.0%)	0.60	−
7A Frequency of mask use during radiographic exposure	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+
7B Frequency of procedure glove use during radiographic exposure	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+
7C Frequency of surgical cap use during radiographic exposure	0 (0.0%)	2 (20.0%)	8 (80.0%)	0.60	+
7D Frequency of medical coat use during radiographic exposure	0 (0.0%)	1 (10.0%)	9 (90.0%)	0.80	+
7E Frequency of protective goggle use during radiographic exposure	0 (0.0%)	5 (50.0%)	5 (50.0%)	0.00	+
7F Frequency of overglove use during radiographic exposure	0 (0.0%)	2 (20.0%)	8 (80.0%)	0.60	+
Q7G1 Frequency of plastic barrier use on film during radiographic exposure	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+
7G2 Frequency of plastic barrier use on digital radiography receptor during radiographic exposure	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+
7G3 Frequency of plastic barrier use on headrest during radiographic exposure	0 (0.0%)	4 (40.0%)	6 (60.0%)	0.20	+
7G4 Frequency of plastic barrier use on X-ray tubehead (position-indicating device) during radiographic exposure	0 (0.0%)	4 (40.0%)	6 (60.0%)	0.20	+
7G5 Frequency of plastic barrier use on exposure button during radiographic exposure	0 (0.0%)	3 (30.0%)	7 (70.0%)	0.40	+
7G6 Frequency of plastic barrier use on X-ray control panel during radiographic exposure	0 (0.0%)	4 (40.0%)	6 (60.0%)	0.20	+
7G7 Frequency of plastic barrier use on computer monitor of digital radiography system	3 (30.0%)	3 (30.0%)	4 (40.0%)	−0.20	−
7G8 Frequency of plastic barrier use on computer keyboard of digital radiography system	0 (00.0%)	4 (40.0%)	6 (60.0%)	0.20	+
7G9 Frequency of plastic barrier use on mouse of digital radiography system	0 (00.0%)	3 (30.0%)	7 (70.0%)	0.40	+
7G10 Frequency of plastic barrier use on printer of digital radiography system	4 (40.0%)	3 (30.0%)	3 (30.0%)	−0.40	−
8A Use of overgloves to place patients in the chair	2 (20.0%)	5 (50.0%)	3 (30.0%)	−0.40	−
8C Use of overgloves to handle the X-ray tubehead (position-indicating device)	2 (20.0%)	2 (20.0%)	6 (60.0%)	0.20	−
8D Use of overgloves to select the time on the control panel display	1 (10.0%)	2 (20.0%)	7 (70.0%)	0.40	−
8E Use of overgloves to press the exposure button	1 (10.0%)	1 (10.0%)	8 (80.0%)	0.60	−
8F Use of overgloves to handle radiographic film or digital radiography receptors not contaminated with saliva	2 (20.0%)	3 (30.0%)	5 (50.0%)	0.00	−
8G Use of overgloves to process the radiographic film	2 (20.0%)	1 (10.0%)	7 (70.0%)	0.40	−
8H Use of overgloves to use the computer in the digital radiography system	1 (10.0%)	2 (20.0%)	7 (70.0%)	0.40	−
8I Use of overgloves to handle the monitor, keyboard, mouse and/or printer of the digital radiography system	1 (10.0%)	3 (30.0%)	6 (60.0%)	0.20	−
8J No use of overgloves	1 (10.0%)	0 (0.0%)	9 (90.0%)	0.80	+
9 Frequency of sterilization of the radiograph film-holding device for each patient	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+

Table 4. Continued

<i>Instructions, questions and answer options</i>	<i>Not necessary</i>	<i>Useful, but non-essential</i>	<i>Essential</i>	<i>CVR</i>	<i>Accepted/rejected</i>
10 Frequency of plastic barrier use to pack intraoral films	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+
11 Frequency of disinfection of the exposed film packets before processing	0 (0.0%)	3 (30.0%)	7 (70.0%)	0.40	+
12A Frequency of performance of infection control procedures on the X-ray tubehead (position-indicating device) for each new patient	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+
12B Frequency of performance of infection control procedures on the exposure button for each new patient	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+
12C Frequency of performance of infection control procedures on the X-ray control panel for each new patient	0 (0.0%)	2 (20.0%)	8 (80.0%)	0.60	+
12D Frequency of performance of infection control procedures on the patient chair for each new patient	1 (10.0%)	2 (20.0%)	7 (70.0%)	0.40	–
13A Frequency of patient chair cleaning and/ or disinfecting for each new patient	1 (10.0%)	3 (30.0%)	6 (60.0%)	0.20	–
13B Frequency of X-ray apron cleaning and/ or disinfecting for each new patient	0 (0.0%)	1 (10.0%)	9 (90.0%)	0.80	+
13C Frequency of thyroid collar cleaning and/ or disinfecting for each new patient	0 (0.0%)	1 (10.0%)	9 (90.0%)	0.80	+
14A Use of chlorine compounds to clean the radiography equipment	0 (0.0%)	1 (10.0%)	9 (90.0%)	0.80	+
14B Use of 70% alcohol to clean the radiography equipment	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+
14C Use of common cleaning products (water and soap) to clean the radiography equipment	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+
14D No use disinfectants to clean the radiography equipment	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+
14E The use of other types of disinfectants to clean the radiography equipment	0 (0.0%)	0 (0.0%)	10 (100.0%)	0.99	+

+ Represents questions/items accepted, $CVR > 0.62$ or $CVR < 0.62$ and no cases of “not necessary”.

– Represents questions/items rejected, $CVR < 0.62$.

When reliability was considered, the questionnaire was found to have an ICC between 0.722 and 1.00, a result which indicates satisfactory to excellent correlation³⁵ for the questions on the frequency of hand-washing, protection/disinfection of surfaces and disinfectant used (Table 2). In the yes/no questions regarding the use of overgloves, ICC values ranged between 0.662 and 0.913, with good to great correlation (Table 3).³⁶ Cronbach's alpha was 0.88. Because the reliability values were considered satisfactory, no questions or items had to be excluded. Thus, decisions to include and exclude questions and items were based primarily on the opinions of the second expert panel and the factor analysis.

10 professors participated in the second stage of the content validity process. As per Lawshe,³⁰ questions that reached a CVR of 62% were incorporated into the questionnaire. As a result of this analysis, questions with a $CVR < 62\%$ and which were not evaluated as “unnecessary” by any of the professors were also incorporated (Table 4).

The factor analysis grouped the questions into 10 factors (domains). Similar to Fraga-Maia *et al*,³⁴ the Kaiser criterion of an eigenvalue > 1 was used, which corresponded to 69.5% of the total variance (Table 5). Factor 1 was responsible for 23.8% of the total variance

and encompassed items that considered the frequency of surface protection of the X-ray equipment and the procedures for the cleaning/disinfection/protection of those surfaces. Based on the factor analysis, Question 3 (“Radiography receptor used”), Question 4 (“Type of radiographic film processing used”), Question 5 (“Use of an automatic processor”), Question 8 subitem J (“No use of overgloves”) and Question 11 (“Frequency of disinfection of the exposed film packets before processing”) were eliminated because they had low factor loading and were therefore not included in the domain formation.

After the combination of these two analyses (the second expert panel and the factor analysis), decisions were made regarding the exclusion of questions from the final version of the questionnaire. The questions rejected in both analyses were Question 3 (“Radiography receptor used”) and Question 11 (“Frequency of disinfection of the exposed film packets before processing”). Question 10 (“Frequency of plastic barrier use to pack intraoral films”) was also rejected owing to its similarity to Question 7G1.

The divergences between the two analyses were also considered. It was decided that the questions not included in the factor analysis be removed from the final version. If a question was included in the factor analysis

Table 5 Factors (domains) and associated items of the Questionnaire on Infection Control in Oral Radiology

Factor	Questions and answer options	Variance (%)
Factor 1	7G3 Frequency of plastic barrier use on headrest during radiographic exposure 7G4 Frequency of plastic barrier use on X-ray tubehead (position-indicating device) during radiographic exposure 7G5 Frequency of plastic barrier use on exposure button during radiographic exposure 7G6 Frequency of plastic barrier use on X-ray control panel during radiographic exposure 12A Frequency of performance of infection control procedures on the X-ray tubehead (position-indicating device) for each new patient 12B Frequency of performance of infection control procedures on the exposure button for each new patient 12C Frequency of performance of infection control procedures on the X-ray control panel for each new patient 12D Frequency of performance of infection control procedures on the patient chair for each new patient	23.8 ^a
Factor 2	8A Use of overgloves to place patients in the chair 8B Use of overgloves to place the X-ray apron and thyroid collar on the patient 8C Use of overgloves to handle the X-ray tubehead (position-indicating device) 8D Use of overgloves to select the time on the control panel display 8E Use of overgloves to press the exposure button 8F Use of overgloves to handle radiographic film or digital radiography receptors not contaminated with saliva 8G Use of overgloves to process the radiographic film	13.6 ^a
Factor 3	13A Frequency of patient chair cleaning and/or disinfecting for each new patient 13B Frequency of X-ray apron cleaning and/or disinfecting for each new patient 13C Frequency of thyroid collar cleaning and/or disinfecting for each new patient 14A Use of chlorine compounds to clean the radiography equipment 14B Use of 70% alcohol to clean the radiography equipment 14C Use of common cleaning products (water and soap) used to clean the radiography equipment 14D No use of disinfectants to clean the radiography equipment 14E Use of other types of disinfectants to clean the radiography equipment	6.1 ^a
Factor 4	8H Use of overgloves to use the computer for the digital radiography system 8I Use of overgloves to handle the monitor, keyboard, mouse and/or printer of the digital radiography system	5.5 ^a
Factor 5	Q7G Frequency of plastic barrier use on film during radiographic exposure	4.9 ^a
Factor 6	10 Frequency of plastic barrier use to pack intraoral films 7A Frequency of mask use during radiographic exposure 7C Frequency of surgical cap use during radiographic exposure 7D Frequency of medical coat use during radiographic exposure	3.7 ^a
Factor 7	7E Frequency of protective goggle use during radiographic exposure 9 Frequency of sterilization of the radiograph film-holding device for each patient	3.2 ^a
Factor 8	1 Frequency of handwashing before putting on gloves 2 Frequency of handwashing after removing gloves	3.1 ^a
Factor 9	7B Frequency of procedure glove use during radiographic exposure	2.9 ^a
Factor 10	6 Performance of radiography examinations on patients during clinical care	2.7 ^a
	Total variance	69.5

^aThe extent to which the factor represents the total variance of the data set.

but excluded by the expert panel, it was removed from the final version, with the exception of three questions that exhibited high factor loadings (Factor 1 represented 23.8% of total variance, Factor 3 represented 6.1% of total variance and Factor 4 represented 5.5% of total variance). Questions rejected by the expert panel but which also exhibited high factor loadings were maintained in the final version of the questionnaire. Details are included in [Table 6](#).

The new domains were renamed and reordered based on numerical order and the group of questions present in each domain ([Table 7](#)).

The questions on the digital radiography system had only their content validity evaluated, as this system was not available in the schools participating in the study. According to the second committee, items that considered the protection of the digital receptor, keyboard and mouse (7G2, 7G8 and 7G9, respectively) were kept because they were considered “essential/useful”. Thus, the item regarding the protection of the digital receptor became part of the “Radiographic Receptors” domain,

and the items that considered the protection of the keyboard and mouse were included in the “Protection/Disinfection of the Radiography Equipment” domain.

The questions concerning the use of overgloves referred to equipment used as part of digital systems (monitor, keyboard, mouse and printer) and to equipment used in non-digital dental or radiology offices. Factor analysis was applied to these questions, and the result was Factor 4 with an explained variance of 5.5%. Thus, they were arranged under the domain “Overgloves: Digital Radiography System”. Since some questions were excluded from the questionnaire, the remaining items were redistributed into the other domains, and the final version had 14 questions divided into 9 domains ([Supplementary Material](#)).

Construct validity based on the known-groups technique was found to differ significantly ($p < 0.05$) for most of the questions among the group of undergraduate students when they were compared with the group of PhD students and professors. There was no statistical difference ($p > 0.05$) in matters pertaining to

Table 6 Divergences between the expert panel and the factor analysis and reasons to accept or reject the questions and items

<i>Questions and answer options</i>	<i>Second committee</i>	<i>Factor analysis</i>	<i>Accepted/rejected</i>	<i>Reason</i>
4 Type of radiographic film processing used	+	–	–	Rejected by factor analysis, low factor loading
5 Use of the automatic processor	+	–	–	Rejected by factor analysis, low factor loading
6 Performance of radiography examinations on patients during clinical care	–	+	–	Rejected by expert panel, low factor loading
8A Use of overgloves to place patients in the chair	–	+	+	Accepted by factor analysis, high factor loading
8B Use of overgloves to place the X-ray apron and thyroid collar on the patient	–	+	+	Accepted by factor analysis, high factor loading
8C Use of overgloves to handle the X-ray tubehead (position-indicating device)	–	+	+	Accepted by factor analysis, high factor loading
8D Use of overgloves to select the time on the control panel display	–	+	+	Accepted by factor analysis, high factor loading
8E Use of overgloves to press the exposure button	–	+	+	Accepted by factor analysis, high factor loading
8F Use of overgloves to handle radiographic film or digital radiography receptors not contaminated with saliva	–	+	+	Accepted by factor analysis, high factor loading
8G Use of overgloves to process the radiographic film	–	+	+	Accepted by factor analysis, high factor loading
8H Use of overgloves to use the computer for the digital radiography system	–	+	+	Accepted by factor analysis, high factor loading
8I Use of overgloves to handle the monitor, keyboard, mouse and/or printer of the digital radiography system	–	+	+	Accepted by factor analysis, high factor loading
12D Frequency of performance of infection control procedures on the patient chair for each new patient	–	+	+	Accepted by factor analysis, high factor loading
13A Frequency of patient chair cleaning and/or disinfecting for each new patient	–	+	+	Accepted by factor analysis, high factor loading

+Represents questions/items that were accepted.

–Represents questions/items that were rejected.

the frequency of use of masks, gloves, medical coats or protective goggles.

Discussion

This study has created and validated a new questionnaire to evaluate infection control in oral radiology and has thus provided a questionnaire to determine compliance with the standard precautions in radiology practice.

The selection of the items is typically one of the biggest challenges when structuring questionnaires.²⁰ To facilitate this step, both scientific publications and the infection control protocols used in different health agencies^{1–3,7} were consulted to determine standard precautions. The protocols used in Brazil (ANVISA)² and in the USA (Centers for Disease Control and Prevention and American Dental Association)^{1,3,7} demonstrate the importance of infection control in the various specialities within the field of dentistry and guide professionals to avoid or prevent cross-contamination.

A prominent issue during the creation of this questionnaire was the care taken to create questions that were similar or which repeated important aspects of infection control in a different way in order to explore the different methods used to avoid contamination

(protection/disinfection) while also confirming the veracity of participant responses.

The analysis of the second committee determined a need to adapt the methodology from Lawshe.^{28–30} According to Pittman and Bakas,¹⁵ content validity is based on the logic and reasoning of the evaluators; so, despite the fact that this analysis can be calculated quantitatively, the professor evaluation is subjective and, in this study, dependent on their clinical experience and training in infection control. Thus, given the CVR of 62%, there was a substantial reduction in the questions which mischaracterized and compromised the final structure of the questionnaire. This event occurred because, according to Lawshe,³⁰ for an item to be incorporated into the questionnaire, it should be evaluated by a majority of professors as “essential”, to the detriment of the items evaluated as “useful, but not essential”. A review of this methodology allowed for the inclusion of items that are also of interest (“useful”) to infection control but which were not deemed “essential”.

For a questionnaire to have its validity ensured, it is necessary to evaluate whether it is reliable,^{15,29} because the amount of expected errors in its application is estimated.¹⁵ Thus, in this study, the reliability and the validity of the questionnaire were both verified. Reproducibility was also considered. The questionnaire

Table 7 Factors and domains of the final version of the Questionnaire on Infection Control in Oral Radiology

<i>Factor</i>	<i>Domain</i>	<i>Domain name</i>	<i>Questions</i>
Factor 8	1	Handwashing	1 Frequency of handwashing before putting on gloves 2 Frequency of handwashing after removing gloves
Factor 9	2	Gloves	3 Frequency of procedure glove use during radiographic exposure
Factor 6	3	Clothing	4A Frequency of mask use during radiographic exposure 4C Frequency of surgical cap use during radiographic exposure 4D Frequency of medical coat use during radiographic exposure
Factor 7	4	Accessories	5 Frequency of protective goggle use during radiographic exposure 6 Frequency of sterilization of the radiograph film-holding device for each patient
Factor 5	5	Radiographic receptors	7 Frequency of plastic barrier use on film during radiographic exposure 8 Frequency of plastic barrier use on digital radiography receptor during radiographic exposure
Factor 1	6	Protection/disinfection of radiography equipment	9A Frequency of plastic barrier use on headrest during radiographic exposure 9B Frequency of plastic barrier use on X-ray tubehead (position-indicating device) during radiographic exposure 9C Frequency of plastic barrier use on exposure button during radiographic exposure 9D Frequency of plastic barrier use on X-ray control panel during radiographic exposure 10A Frequency of performance of infection control procedures on the X-ray tubehead (position-indicating device) for each new patient 10B Frequency of performance of infection control procedures on the exposure button for each new patient 10C Frequency of performance of infection control procedures on the X-ray control panel for each new patient 10D Frequency of performance of infection control on in the patient chair for each new patient
Factor 2	7	Overgloves	11A Use of overgloves to place patients in the chair 11B Use of overgloves to place the X-ray apron and thyroid collar on the patient 11C Use of overgloves to handle the X-ray tubehead (position-indicating device) 11D Use of overgloves to select the time on the control panel display 11E Use of overgloves to press the exposure button 11F Use of overgloves to manipulate radiographic film or digital radiography receptors not contaminated with saliva 11G Use of overgloves to process the radiographic film
Factor 4	8	Overgloves: digital radiography system	12A Frequency of plastic barrier use on computer keyboard of digital radiography system 12B Frequency of plastic barrier use on mouse of digital radiography system
Factor 3	9	Cleaning and disinfecting	13A Frequency of patient chair cleaning and/or disinfecting for each new patient 13B Frequency of X-ray apron cleaning and/or disinfecting for each new patient 13C Frequency of thyroid collar cleaning and/or disinfecting for each new patient 14 Types of disinfectants usually used to clean the radiography equipment

produced stable answers when applied at different times,^{15,17,21,24,32,33} a finding which reflects the questions' high level of comprehension.¹⁹ Internal consistency was very good,^{15,18,19,24,27,32,34} a finding which indicates correlation between all of the items.^{21,31}

Owing to the lack of a questionnaire on infection control in oral radiology that could be considered the gold standard with which this new questionnaire could be compared, the validity of the criteria cannot be analyzed.^{15,21,26,27} Therefore, the questionnaire was verified using construct validity, which itself was based on a factor analysis and the known-groups technique.^{13,21}

The factor analysis confirmed the default structure of the questionnaire, and some items were excluded or

regrouped into new domains.^{15,17,18,22,23,29} Although the final version has more domains than the original version, particularly in terms of the division of the "Radiographic Exposure" domain, this division has organized and improved the questioning on the different stages of radiographic examination by grouping together questions that addressed the same topic. According to Chor *et al*,²⁰ the ordering of the questions in a coherent manner facilitates the participant recollection of events and interest in the survey. According to Coluci *et al*,¹³ a proper structure and sequencing decrease respondent physical and/or mental effort, ensuring that they stay interested long enough to answer all of the questions. Thus, the new division into the final domains

made it easier for participants to complete the questionnaire and comply with the instructions.

An interesting aspect of the factor analysis was the creation of independent domains for personal protective equipment, referred to as “Gloves” and “Clothing”. This organization suggests that, in the context of infection control in oral radiology, greater emphasis should be placed upon the use of gloves, since contaminated hands of the professional are the most common cross-contamination method in radiographic examinations. Although protective goggles are part of the set of personal protective equipment, they were also regrouped into a separate domain. Although they are a common accessory, they were placed in the same domain as the radiographic film-holding device, a radiographic accessory. This organization suggests that, unlike gloves, goggles have less of an impact on the professional protection owing to the lower risk of spills by aerosols during radiographic examinations.

The known-groups technique demonstrated the ability of the questionnaire to discriminate between the group of dentistry students and the group of PhD students and professors in terms of their infection control measures in oral radiology.^{15,17,21} Because the students are still in a learning phase, the concepts of infection control are still being incorporated into their clinical practice; so, it was expected that they would achieve lower scores on the questionnaire.

Thus, the questionnaire presented in this study exhibited good psychometric properties and may be used as an effective tool to determine in which areas of

a given practice standard precautions are not being followed and, in doing so, to establish where interventional and educational measures are needed. Moreover, the QICOR is useful for evaluating infection control protocols in oral radiology both during dentistry school and thereafter in professional settings.

It is important to note that the use of questionnaires in the health sciences is a growing trend, and it is therefore essential to understand the techniques used to develop these questionnaires.^{13,37} The methodology presented in this study may serve as an aid for future studies that involve the creation of valuable and reliable questionnaires.

Conclusions

The QICOR exhibited adequate reliability and validity; so, it may be used for evaluating infection control in centres providing oral radiology in order to identify any steps of the radiographic examination that exhibit risks of cross-contamination.

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