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Spanish dental hygienist attitudes to dental radiological protection: assessment of a 1-day pilot course

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Abstract: *Objectives:* To determine hygienists' knowledge of and attitudes to X-ray equipment and film processing, and to assess both after a 1-day course. *Study population:* One-hundred and four dental hygienists from the south-east of Spain attending a 1-day course in oral radiology. *Methodology:* A questionnaire comprising different sections related with socio-demographic items, X-ray equipment and the processing of dental films was answered before and after a 1-day pilot course on radiation protection. *Results:* The response rate was 89.42% (n = 93). Of the participants 94.6% were women, with a mean age of 29.52 (SD 6.861) and 7.20 years of professional experience (SD 5.089). The level of knowledge before the course was 48.28%, which increased to 85.62% after the course ($P < 0.001$). *Conclusions:* The prescribed standard was reached by <23.65% of those attending the course at the beginning. Although attending the course led to a considerable improvement, it did not always result in a high level of knowledge of basic radiation equipment and processing.

Key words: dental hygienist; dental radiological protection; dental radiology; education dental continuing; radiology

Introduction

Following the rules of the International Commission of Radiological Safety concerning the exposure of patients and professionals to possible low radiation doses, the European Union has issued several Directives (84/466, 96/29, 97/43) which lay down the minimum that must be contained in quality assurance programmes: the clinical justification for using and optimization of

the radiological materials, quality control of the radiological equipments, procedures for evaluating the doses received by the patients in the most frequent techniques and the image quality control, by repetition of radiographs and verification of the ionizing radiation levels, all on an annual basis. These directives were implemented in Spanish legislation by Royal Decrees 1976/1999 (1) and 815/2001 (2).

The exact number of dental X-ray sets in Spain is not known, although it has been published (3) that the number of general radiodiagnostic sets is 14 411, of which 7327 have been taken with dental X-rays sets, corresponding to 50.8% of all medical radiodiagnostic equipment in the country. The annual number of dental X-ray examinations was put at 5 226 823 of the total of 30 285 445 explorations made. However, the number of radiographs is claimed to have risen with the introduction of new digital systems (4).

The dose administered to the patient, along with the quality of the image obtained in the explorations, constitute a first estimate of the global state of the radiological equipment used exploration protocols and personnel training.

Although the number of radiographs taken daily in primary dental care is excessive, the greatest risk arises when there is evidence of poor image quality or non-diagnostic images, owing to poor technical knowledge and the inadequate processing of films (5–9). It has been estimated that the elimination of non-productive examinations could lead to a 30% reduction in the collective population dose, received from medical radiology (10).

Consistent film processing, is necessary to produce good quality radiographs and reduce the need for repeat examinations (11). In Spain nearly 82% of dental clinics use manual processing (9) and only 6.2% of dental assistants have a qualification in dental hygiene (12). Dental hygienists play an important role in processing and they must assume the responsibility for poor processing practices, most of which concern not replacing processing solutions as frequently as required, overdeveloping and overfixing. As a result, many dentists tend to increase the exposure time to compensate for the improper processing, thus increasing the radiation dose to patients (13).

For eliminating unnecessary X-ray examinations, every professional who operates X-rays should be properly trained in accordance with the Ionizing Radiation Medical exposure Regulations 2000 (14).

The implantation of quality control programmes in Spain must include training courses to use X-ray equipments and it is compulsory to receive training on radiological protection prior to using any equipment. Dental hygienist must have an Official Operators License, approved by the Spanish Nuclear Safety Council, to work with ionizing radiation (1, 2).

There are few reports in the literature on the education and training in radiological protection for dental hygienists, and most of them concern with General Dental Practitioners (GDP). Studies in Sweden, Denmark, UK and Canada have found factors such as a dentist's age and attendance of postgraduate courses, which could influence radiographic practice (8, 15–17). No such studies have been made for General Dental Practitioners or dental hygienists in Spain.

The aims of this study were to determine the level of knowledge and attitudes of Spanish dental hygienists to radiological protection, and to evaluate the effectiveness of a 1-day course in radiation protection providing information on X-ray equipment, reducing radiological doses, radiation safety and other protection measures that benefit both patient and practitioner, as recommended by established international protocols and guides. A further idea was to identify the participants' strengths and weaknesses in the two oral radiology areas assessed.

Study population and methodology

One-hundred and four dental hygienists took part in an oral radiology course in Alicante province (south-east of Spain) in November 2006. At the start, the participants completed anonymously a questionnaire divided into three sections. The first section was related with socio-demographic information (age, sex and years in practice), together with two Yes/No questions concerning to previous attendance of courses in oral radiology and about the responsibility for film processing in the dental clinics where they worked.

The other two sections were categorized into subjects with binomial choice questions with no negative marking. The answers to the questions were 'true' or 'false'. The second group of statements assessed the participants' knowledge of factors affecting doses (equipment and exposure factors). The third section asked questions to assess the knowledge and attitudes to processing and storage of the image. These questions had to be answered before and immediately after the course. The whole course was given by the same specialist teacher on radiology.

Each positive answer was given one point so the overall score was the sum of the scores in each of these 19 statements. Because of the small number of items in the questionnaire, it was decided to assume a level of 63.15% or above (12 of 19 questions) as satisfactory. This mark is higher than the 62.5% adopted by other authors (18–20) in similar studies who

recommended that practitioners with an adequate grasp of the 'core of knowledge' should be able to achieve at least this score after the course.

The analysis of the results was carried out using the SPSS® version 12.00 statistical package for Microsoft Windows (SPSS®, Inc., Chicago, IL, USA). A descriptive study was made of each variable. Scores were expressed as percentages of the maximum mark obtainable. Statistical significance was accepted for $P \leq 0.05$. A 95% CI for the change in the proportion passing from pre- to post-training was calculated.

The associations between different parameters were investigated using the Student's *t*-test for quantitative variables, when the number of quantitative variables compared was not >2. One-way analysis of variance (ANOVA) was used to contrast the equality of mean values when more than two quantitative variables were compared, verifying in each case whether the variances were homogeneous. *Post hoc* analysis comprised Tukey's HSD (Honestly Significantly Different) test when a significant *F*-ratio from the ANOVA indicated a difference between groups.

Results

The project was successful in recruiting 104 dental health professionals during October 2006. The response rate to the study evaluations was high, with 93 filling in the questionnaires (89.42%). The dental hygienist covered by this study ($n = 93$) represents about 9.3% of the total number of licensed hygienists working in Spain ($n = 1000$) (21).

As most participants were woman (94.6%), it was decided not to study the correlations between the different qualitative variables and gender. Participants had a mean age of 29.52 ± 6.86 (SD) years and they had a mean of 7.20 ± 5.09 (SD) years in practice.

A total of 86% of the respondents had not attended previous courses in oral radiology (including the Official Operator License) as qualifying and most of them (90.3%) processed dental films in the clinics by themselves.

The mean (SD) pre- and post-course percentage scores in section 2 were 45.01 ± 15.75% (14.28–84.21) and 77.11 ± 18.37% (28.57–100) (Table 1). The mean improvement was 32.10% (95% CI 28.20–35.99) $t = 16.366$, with a level of significance of $P < 0.001$. The greatest changes were related with the legal/physical characteristics (voltage, amperage and diameter of collimator) that intraoral X-ray sets must fulfil (Table 2).

For section 3, the mean (SD) pre- and post-course percentage scores were 50.26 ± 21.99 (0–100) and 90.58 ± 9.99 (50–100) (Table 1). The mean improvement was 40.32% (95% CI 35.48–45.15) $t = 16.559$ ($P < 0.001$). The influence of the dose necessary to obtain the image and the type of receptor (dental radiological film) showed the biggest improvement in the second section (77.4%, 62.3% and 45.1%), followed by the characteristics of film processing (57%) and, lastly, the systems for storing radiographic film (34.4%) (Table 3).

Table 1. **Level of knowledge (in percentages) concerning all the items, sections 2 and 3 (pre- and post-training)**

Section	Pretraining (%)	Post-training (%)	Change (%)	*P*-value
Total	48.28	85.62	37.34	<0.001
X-ray equipment (section 2)	45.01	77.11	32.10	<0.001
Receptors and processing (section 3)	50.26	90.58	40.32	<0.001

Table 1 summarizes the improvements in percentage score for the two sections and the questionnaire as a whole. It shows how the level of knowledge increased significantly from the pretraining (48.28%) to post-training (85.62%), with a gain of 37.34% (95% CI 33.51–41.16).

The percentage of hygienists achieving the threshold score of 63.15% increased from 23.65% (22 of the 93 participants) before the course to 98.92% after the course, a change of 75.27% (95% CI 23.46–64.52) with a χ^2 *P*-value of 0.576 (Table 4).

The level of pretraining knowledge was influenced by years in practice. Those with 3 or less years of professional experience ($n = 29$) scored 41.96% (SD 14.31) before the course, compared with the 54.04% (SD 15.65) scored by those with 10 or more years of experience ($n = 26$); this difference was statistically significant ($P = 0.017$). The participants with 4–9 years of experience ($n = 36$) scored 50.14% (SD 17.31), which did not differ significantly from the score of those with 10 years of experience ($P = 0.610$).

Discussion

Although most dentists take radiographs themselves (22), they tend to delegate the processing of films to hygienists. In Spain nearly 82% of dental clinics use manual processing, a situation which requires dental auxiliary personnel to control the entire process and which increases the number of faults considerably (9).

One of the main objectives of radiology is to produce images of sufficient diagnostic quality while keeping the dose as low as reasonably achievable. This situation involves applying the

Table 2. **Answers (in percentages) on basic concepts of X-ray equipment (pre- and post-training)**

Questions (section 2)	Pre, *n* (%)		Post, *n* (%)	
	Correct answers	Incorrect answers	Correct answers	Incorrect answers
X-ray sets have fixed exposure settings	34 (36.6%)	59 (63.4%)	51 (54.8%)	42 (45.2%)
X-ray sets recommended by EU work at 65–70 kV and 8 mA	29 (31.2%)	64 (68.8%)	87 (93.5%)	6 (6.5%)
The filtration value of X-ray sets have to be at least 1.5 mm Al	22 (23.7%)	71 (76.3%)	59 (63.4%)	34 (36.6%)
The diameter of the collimator must be rectangular	9 (9.7%)	84 (90.4%)	71 (76.3%)	23 (23.7%)
An annual quality control inspection is compulsory according to EU directives	83 (89.2%)	10 (10.8%)	90 (96.8%)	3 (3.3%)
A visual and audible warning signal must be produced during radiation emission	85 (91.4%)	8 (8.7%)	86 (92.5%)	7 (7.6%)
The minimum operator distance from the X-ray tube is 2 m	32 (34.4%)	61 (65.6%)	59 (63.4%)	34 (36.6%)

Table 3. **Answers (in percentages) on receptors, film development techniques and storage of the image (pre- and post-training)**

Question (section 3)	Pre, *n* (%)		Post, *n* (%)	
	Correct answer	Incorrect answer	Correct answer	Incorrect answer
Ultra-speed (Kodak) intraoral dental film is the oldest film in use and the one that produces the highest radiation dose	14 (15.1%)	79 (84.9%)	86 (92.5%)	7 (7.5%)
Digital image receptors reduce radiation dose	59 (63.4%)	34 (36.6%)	90 (96.8%)	3 (3.2%)
Digital images can be modified (ethical problem)	66 (71.0%)	27 (29%)	91 (97.8%)	2 (2.2%)
Insight (kodak) dental film has the highest speed and is the most sensitive	34 (36.6%)	59 (63.4%)	92 (98.9%)	1 (1.1%)
The greater the sensitivity of film, the lower exposure times needed	48 (51.6%)	45 (48.4%)	87 (93.5%)	6 (6.5%)
Fogging may occur if films are stored inside the exposure room	37 (39.8%)	56 (60.2%)	62 (66.7%)	31 (33.4%)
By limiting the film size you limit the exposure field	42 (45.2%)	51 (54.8%)	84 (90.3%)	9 (9.7%)
Correct processing times are: 5 min developing, 30 s watering and 10 min fixing	33 (35.5%)	30 (64.5%)	86 (92.5%)	7 (7.6%)
Before storing it is necessary to introduce the film into 16–30°C water for 10 min and dry later	52 (55.9%)	41 (44.1%)	84 (90.3%)	9 (9.7%)
Chemical liquids must be changed weekly when manual processing is used	78 (83.9%)	15 (16.2%)	90 (96.8%)	3 (3.2%)
Quality Assurance methods exist for radiographic processing liquids	43 (46.2%)	50 (53.8%)	70 (75.3%)	23 (24.8%)
The use of recommended X-ray sets, rectangular collimators, sensitive films, digital systems and selection criteria, can reduce patient doses by up to 90%	58 (62.4%)	35 (37.6%)	88 (94.6%)	5 (5.4%)

Table 4. **Analysis based on proportions scoring 12 or more correct answers out of 19 (63.15%) (pre- and post-training)**

	Pass-rate (n = 93)	χ^2 (P-value)
Precourse	22/93 (23.65%)	0.313 (0.576)
Post-course	92/93 (98.92%)	
Change	75.27%	
95% CI	23.46–64.52%	

correct technique, to use highly sensitive image receptors, small irradiated volumes, optimal darkroom procedures, protective barriers and relevant selection criteria (23). There is an association between knowledge and the use of low-dose techniques and attitudes towards risks (24).

Our findings show that only 14% of the participants had attended previous courses in oral radiology (including the Official Operator License) since obtaining their qualification. In a similar study, Svenson *et al.* (23) observed that approximately 40% of dentists in the UK had not attended courses in oral radiology, decreasing to 14% when it came to annual courses (20). The Spanish syllabus of 'Técnico Superior en Higiene Bucodental' (a non-university diploma in Dental Hygiene) includes a small section on radiological protection (RD 549/1995). Only 6.2% of Spanish dental assistants are qualified hygienists (12), meaning that most of the auxiliary personnel who works in dental surgeries, has a lack of suitable knowledge on protection radiology and, in general, many dentists show little interest in educating dental nurses (25).

In Spain, it is compulsory for dentists to obtain an official certificate as 'Director of X-ray installations' and for dental hygienists who work with ionizing radiation to attend on 'Operator course'. Dentists and hygienists are well informed

about dose limitation methods but they do not seem to apply this knowledge in clinical practice (25).

The results showed that practitioners with few years in practice performed worse than their more experienced peers. In this sense, many studies show that risk attitudes towards oral radiology are strongly associated with years in practice and attendance of courses (17, 23). However, some studies with dentists (20) found the contrary to be true, those with less experience showing the greatest level of knowledge, which was explained by the experience of the newly qualified with multiple choice questionnaires and recent learning experience.

It would seem unwise to presume that dental hygienists acquire the 'core of knowledge' during their basic training, and that they will subsequently attend post-qualifying courses or otherwise. Our study shows that only 14% of hygienists, with a mean of 7.20 years in practice, had attended oral radiology courses since qualifying. The short period of time the respondents had been practicing as Dental Hygienists in Spain can be attributed to the fact that the diploma was only introduced since 1995, as a Royal Decree (26).

Although there are no parallel studies published on the situation among hygienists, dentists with 5–25 years in practice had a higher level of knowledge than those with either fewer or more years in practice (24). It has been described that dentists working in the Public Dental Health Service have a higher level of knowledge than those in private practice (24).

Similar to other studies with dentists (20, 23), our results were obtained immediately after the course and do not guarantee any knowledge and skills obtained will last a whole professional life. It would be more valid to check knowledge 3 months at least after the course. Furthermore, it is necessary to achieve long-lasting practical habits and our method is not effective for assessing long-term performance.

Many authors agree that continuing education promotes knowledge and has an effect on dental radiological practice (23, 27), which is consistent with the suggestion that education is indeed a method for changing professional behaviour (27). It has been suggested that behaviour, attitudes and knowledge in dentists concerning oral radiological protection are influenced by the availability of specialists in oral radiology in the country concerned. Svenson *et al.* (23) attributed this situation to the relationship between continuing education and specialists in oral radiology. The fact that in Spain there is no an official degree to become a specialist in Oral and Maxillofacial Radiology may explain the lack of continuous courses in oral radiology.

The results of the questionnaire showed a low level of knowledge (23.65%) of the basic concepts of X-ray equipment and film processing at the outset, using a score of 63.15% to refer to an adequate grasp of the 'core of knowledge'.

Manual processing of films demands a much greater control on the part of personnel of development times, changes of liquids and control of temperatures, not to mention the storage of the images obtained. In our study, 64.5% of those questioned did not know the manufacturers' recommended development times, while 93.9% agreed the liquids for intraoral radiography had to be changed weekly. This bears out what has been observed in dental practice, where only 24.05% of clinics had a proper control of these times and 80% renew the liquids every week (9). The mismanagement of these parameters leads to unacceptable images for diagnostic purposes, so that the patient has to undergo additional exposure in subsequent retakes.

There are many simple ways to reduce unnecessary doses, such as the implementation of quality assurance programmes in radiographic processing. These could reduce the number of unacceptable radiographs taken from 49% to 39% (5). In our study, only 46.2% of professionals were aware of these quality assurance methods at the beginning of the course. Recently a system called Vischeck® has been introduced to monitor the quality of radiographic processing in general dental practice (28).This system could be an excellent option to eliminate many problems associated with chemical processing in Spain.

Furthermore, among the advantages of digital systems over the fastest available intraoral X-ray films are a reduction (51–75%) in radiation exposure (29), convenient image acquisition, display, storage and decreased processing errors. However, in Spain, only 17% of dental surgeries have intraoral digital systems (30), which does not differ much from other European countries like Sweden (31). In our study only 63.4% of those questioned knew anything about the reduced doses administered to patients with digital methods, although there was a 33.4% improvement in this item after the course.

It should be emphasized that the course we describe was not intended to be an official dental hygiene course, but rather to demonstrate the need to prepare dental hygienists in the techniques of radiological protection as they are the people with the responsibility for film processing in Spanish dental clinics.

Conclusions

The level of knowledge concerning radiation protection was low at the outset, with those participants with longer experience showing the highest level. The results indicate that the film processing procedures used by Spanish hygienists was not

always in accordance with European recommendations and guidelines.

One of the most important areas of weakness identified concerned development times and the temperature of chemicals, observing that participants tend to choose times according to their clinical experience rather than the instructions of manufacturer.

The overall findings of this study have shown that continuous education and training programmes about radiographic techniques should be set up to improve hygienists' attitudes towards the use of ionizing radiation to meet European guidelines.

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