A logistic regression model for analyzing the relation between dentists' attitudes, behavior, and knowledge in oral radiology

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The aim was to study the relation between risk attitude and knowledge in technical, patient-oriented, and organizationally related behavior within oral radiology. A questionnaire was mailed to 2000 randomly selected dentists listed in the register of the Swedish Dental Society, with a response rate of 69.3%. Regression analysis was used for analyzing the effects of the independent variables knowledge, risk attitude, continuing education in oral radiology, counties with specialists in oral radiology, type of practice, work experience, and sex on three categories of dependent variables: 1) technical behaviors: type of film, type of collimator, dose level, frequency of change of chemicals; 2) patient-oriented behaviors: use of patient protection barriers, strict indications for performing full-mouth X-ray examinations and bitewing radiography on new patients and recall patients; and 3) organizationally related behaviors: delegation of X-ray examinations to dental auxiliaries, influence on choice of collimator, influence on choice of film. Knowledge and education had strong direct effects for most of the dependent variables. The technical behaviors were mainly influenced by knowledge, education, and risk attitude, while organizationally related behaviors were influenced by type of practice and sex. The patient-oriented behaviors were influenced by a number of independent variables, such as education, type of practice, work experience, and sex. The present results indicate that both knowledge and the organizational context of dentists influence work. □ *Attitudes of health personnel; education, dental, continuing*

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The relations between knowledge, attitudes, and behavior are complex. For example, in a rational action model, knowledge leads to changes in attitudes that, in turn, lead to change in behavior. In a cognitive dissonance model, knowledge that does not fit into an established attitudinal structure leads rather to a more persistent attitude with no changes in behavior (1, 2).

In a study of attitudes toward risks in oral radiology, it was found that risk attitudes were strongly associated with experience in dentistry, attendance at extended courses in oral radiology, and professional behavior. For example, inexperienced dentists showed less concern for radiation hazards than more experienced ones and were also less scrupulous in their choice of radiographic procedures. Postgraduate education had a positive effect on risk consciousness (3). In an extended study it was demonstrated that the choice of dose limitation techniques was significantly associated with risk attitude, years in practice, and attendance at extended courses in oral radiology (4). Yet another study found that dentists who had attended postgraduate courses had a significantly higher level of knowledge than those who had not (5). The results of the studies suggest that education has an effect on dentists' radiologic practice, and thus support a rational action model (3). This is concordant with the suggestion that education is a method to change professional behavior (6). A similar conclusion was drawn in a study of Canadian dentists, among whom an association was found between the extent of annual continuing education and having a written office policy on radiographic selection criteria (7).

Behavioral patterns within oral radiology can be tentatively classified into three categories, distinguished by their internal covariation and external provenience. The first comprises technical behaviors related to the use of X-ray equipment, film, collimators, film development techniques, and, thus, to dose level. The second type of behaviors are primarily related to the patient, for example use of radiation protection devices and radiographic selection criteria. The third category relates to organizational factors, for example delegation to other personnel and choice of equipment.

The aim of this study was to investigate the relation between risk attitude and knowledge and these three types of behaviors. The hypothesis is that the relation is in line with a rational action model.

Materials and methods

The material, described elsewhere (3), consisted of 37 questions in a questionnaire survey of dentists in Sweden.

In all, 2000 of the 11,849 dentists listed in the register of the Swedish Dental Society were randomly selected for the study. The selected dentists worked in either the Public Dental Health Service (PDHS) or private practice (PP). In the sampling frame the following groups were excluded: dentists younger than 25 years and older than 63 years, those working at dental schools, and those not occupationally active as dentists. Of the 2000 selected dentists, 1177 (58.85%) were men and 823 (41.15%) women, and 1074 (53.7%) worked in the PDHS and 926 (46.3%) in PP. Altogether, 1386 dentists responded (69.3%). In non-response analysis, it was concluded that non-response was random (3).

Regression analysis was used for analyzing the independent direct effects of the following independent variables: years as dentist (continuous in years), sex, knowledge (measured using a 10-point scale) (5), risk attitude (very careful, careful, or less careful) (3), counties with specialists in oral radiology, continuing education in oral radiology, and type of practice (PDHS or PP).

A number of dependent variables describing dentists' behavior were chosen. The regression technique has to be adjusted to the nature of the variables; that is, logistic regression was used since the dependent variables were binary. Different dependent variables were used as indicators of the three types of behaviors.

Technical behaviors were captured in these variables: type of film (high sensitivity or not), type of collimator (round 4 cm or rectangular versus round 5 cm or 6 cm), dose level (combination of film and collimator; contrast between high-dose and low-dose equipment) (4), and frequency of changing of chemicals (regular intervals or not).

For patient-oriented behavior the following variables were used: use of patient protection barriers against radiation or not, using strict indications for performing full-mouth X-ray examinations (FMX) or not, using strict indications for performing bitewing radiography on new patients or not, using strict indications for performing bitewing radiography on recall patients or not.

The variables used for organizationally related behavior were delegation (dichotomized into delegation of 0%–20% or delegation of more than 60% of the X-ray examinations to dental auxiliaries; all others were deleted from the analysis), influence on choice of collimator (self or not), and influence on choice of film (self or not).

Statistics

A P value of <0.05 was considered statistically significant. In logistic regression, logit values were calculated for assessment of predictive probabilities of combinations of the independent variables. Classification plots were inspected for judgement of discriminatory ability of the models. Residual plots and Cook distances were used for judgement of goodness of fit. The -2LL statistics were calculated to assess the improvement of the models in relation to models using only a constant. The Statistical Package for the Social Sciences (SPSS) was used for the analyses (8).

Results

Table 1 shows the results of the logistic regression analyses for the technical dependent variables. Mainly three independent variables—knowledge, education, and type of practice—had an influence on the technical behavior. The choice of high-sensitivity film was influenced mainly by knowledge and risk attitude: dentists with a high level of knowledge had an odds ratio of 1.7, a statistically significant difference; and dentists with a very careful risk attitude toward radiation had an odds ratio of 1.28.

The level of knowledge was significantly correlated with type of collimator used. Dentists with a high level of knowledge had an odds ratio of 2.70 for choosing a collimator system giving a low dose.

Knowledge was also shown to have a significant effect

Table 1. Logistic regression models for technical dependent variables. Reference categories omitted. Odds ratios (OR) and significance levels (P) given

	High-sensitivity film		Low-dose collimators		Low-dose equipment		Regular change of chemicals	
Independent variables	OR	*P*	OR	*P*	OR	*P*	OR	*P*
Good knowledge	1.70	0.000	2.70	0.000	3.80	0.000	1.06	0.777
Very careful risk attitude	1.28	0.005	0.92	0.391	1.18	0.255	0.84	0.434
Careful risk attitude	1.20	0.068	0.97	0.785	1.06	0.705	0.92	0.732
Extended education	1.26	0.191	1.46	0.039	1.95	0.019	0.77	0.492
Short education	0.78	0.032	0.90	0.387	0.68	0.036	1.66	0.028
No specialist in county	0.58	0.120	1.05	0.899	0.72	0.537	0.91	0.851
PDHS practice	0.92	0.545	1.62	0.002	1.45	0.100	2.60	0.000
Years as dentist	1.00	0.771	1.01	0.167	1.01	0.448	1.00	0.784
Male dentist	1.01	0.936	1.26	0.139	1.22	0.362	0.86	0.466
Intercept	0.79	0.332	−2.64	0.002	−1.86	0.129	0.81	0.469
-2LL improvement	58.6	0.000	82.4	0.000	82.3	0.000	32.9	0.000
df	9		9		9		9	

Table 2. Logistic regression models for patient-oriented dependent variables. Reference categories omitted. Odds ratios (OR) and significance levels (*P*) given

	No use of protection		Strict indications for FMX		Strict indications for bitewing, new patients		Strict indications for bitewing bitewing, recall patients	
Independent variables	OR	*P*	OR	*P*	OR	*P*	OR	*P*
Good knowledge	1.04	0.843	0.96	0.731	1.08	0.807	0.93	0.733
Very careful risk attitude	0.78	0.205	1.23	0.018	1.14	0.476	1.13	0.381
Careful risk attitude	1.15	0.528	1.09	0.372	1.29	0.222	1.17	0.300
Extended education	0.63	0.239	0.96	0.811	3.12	0.000	1.91	0.002
Short education	0.74	0.143	0.88	0.264	0.87	0.511	0.79	0.123
No specialist in county	1.07	0.887	0.96	0.731	0.10	0.000	0.09	0.000
PDHS practice	0.88	0.480	0.86	0.266	3.01	0.001	1.61	0.031
Years as dentist	1.01	0.293	1.01	0.098	1.02	0.260	1.05	0.000
Male dentist	2.48	0.000	1.34	0.033	0.66	0.155	0.86	0.465
Intercept	−3.82	0.002	−0.97	0.220	0.29	0.823	1.79	0.093
-2LL improvement	34.3	0.000	24.4	0.004	210.9	0.000	184.6	0.000
df	9		9		9		9	

on the combined choice of film and collimator. Dentists with a high level of knowledge had an odds ratio of 3.80 with regard to choosing a combination of high-speed film and strict collimator. Extended postgraduate courses and type of practice also had effects on the choice of film and collimator.

The regularity of changing chemicals was affected by type of practice and postgraduate education. Dentists in the PDHS had an odds ratio of 2.60 for changing chemicals at regular intervals. The odds ratio for dentists having attended a continuing education course was 1.66 in this regard.

In Table 2 results from the logistic regression analyses for patient-oriented dependent variables are displayed. For two of the patient-oriented variables, 'no use of protection' and 'strict indications when taking an FMX', the sex of the dentist played an important role. For male dentists there was an odds ratio of 2.48 for *not* using radiation protection barriers with their patients and an odds ratio of 1.34 for applying strict indications when exposing an FMX. In connection with performing an FMX only when strictly indicated, there was an odds ratio of 1.23 for dentists with a very careful risk attitude.

As regards the use of bitewing radiographs on new and recall patients, there were mainly three explanatory variables: postgraduate education, specialist in oral radiology in the county, and type of practice. Compared with dentists in PP and those who had not attended a continuing education course, dentists in the PDHS and those having attended an extended continuing education course (1 week) were three times as likely to perform a bitewing examination on new patients only when strictly indicated. For dentists having attended an extended postgraduate course in oral radiology, there was an odds ratio of 1.91 for performing an X-ray examination on recall patients only when strictly indicated. If there was a specialist in oral radiology in the county, the probability was ten times greater that a dentist would use strict indications for exposing bitewing radiographs for new or recall patients. Work experience as a practicing dentist had little effect on the indications for performing bitewing radiography.

Table 3 shows the results from the logistic regression analyses for organizational dependent variables. There were mainly three explanatory variables—knowledge, type of practice, and sex—that exerted an influence on organizational behavior. Thus, for dentists working in the PDHS, there was an odds ratio of 1.99 for delegating the X-ray examinations to either dental nurses or dental hygienists. Compared with dentists with no postgraduate education in oral radiology, those having attended an extended continuing education course would delegate the X-ray examinations nearly three times as often. Male dentists did not delegate X-ray examinations significantly more often than female dentists.

Dentists within the PDHS felt they that they had very little influence on the choice of equipment and film. The odds ratio for no influence on the choice of collimator was 12.97, and the corresponding figure for no influence on the choice of film was 31.10. For dentists with a good level of knowledge, the odds ratios that they did not feel influential regarding the choice of collimator and film were 0.57 and 0.55, respectively. Male dentists more often felt they had an influence on the choice of collimator and film than did female dentists.

Discussion

The rapid expansion of knowledge, increasing levels of specialization, higher health care costs, and increasing patient demands require assurance of continuing competence of professionals (9, 10). This must be based on knowledge, attitudes, and skills as well as on the context in which the practice takes place (9). Continuing education deals with enhancing the knowledge of the individual, but knowledge is not the only contributor to competence, since utilizing professional skill also requires adequate resources.

Table 3. Regression models for organizational dependent variables. Reference categories omitted. Odds ratios (OR) and significance levels (*P*) given

	Delegation of X-ray examinations to nurses or dental hygienists		No influence on choice of collimation		No influence on choice of film	
Independent variables	OR	*P*	OR	*P*	OR	*P*
Good knowledge	1.11	0.553	0.57	0.001	0.55	0.004
Very careful risk attitude	0.78	0.208	1.07	0.732	1.17	0.507
Careful risk attitude	0.81	0.334	0.99	0.949	1.00	0.997
Extended education	3.37	0.000	0.74	0.399	0.93	0.856
Short education	2.04	0.001	1.03	0.890	0.72	0.180
No specialist in county	0.44	0.029	1.09	0.840	1.24	0.651
PDHS practice	1.99	0.002	12.97	0.000	31.10	0.000
Years as dentist	0.99	0.496	0.99	0.277	1.01	0.519
Male dentist	1.34	0.098	0.41	0.000	0.57	0.007
Intercept	0.58	0.530	−3.93	0.000	−7.51	0.000
-2LL improvement	58.9	0.000	234.8	0.000	150.8	0.000
df	9		9		9	

There is also a growing recognition that initial licensure does not guarantee maintenance of knowledge and skills throughout practice lifetime, and there might be a need to consider periodic rectification of competence (10).

Within oral radiology it has been shown that dentists have incomplete knowledge of guidelines and often fail to adopt recommended procedures in their practices (5, 11). On the other hand, dentists are well informed about dose limitation methods, but it has been suggested that there is little correlation between their knowledge and their behavior; dentists do not seem to apply these methods in clinical practice (11). It has been shown that the assumption that attendance at a 'Core of Knowledge' course means actually acquiring such knowledge does not necessarily hold (12).

We have, however, found evidence that continuing education does promote knowledge (5) and that it has an effect on dental radiologic practice (3), consistent with the suggestion that education is indeed a method to change professional behavior (6). A similar conclusion was drawn in a Canadian study demonstrating that dentists who took part in annual continuing education were more likely to have a written policy on radiographic selection criteria (7). Thus, there is a positive relation between knowledge about recommendations and their adoption by the dentist. This is supported by the results of the present study. Knowledge and/or continuing education had a relation to all but 2 of the 11 dependent variables. Still, 'type of practice' was the variable with the strongest effect on most dependent variables, 8 of 11. Also, the presence of a specialist in oral radiology—another organizational variable—had an effect in some cases.

A general result was that risk attitude had little relative importance for individual characteristics. Sex had some importance, but not work experience. In the latter case it should be kept in mind that the regression models assess the independent effects of each variable, holding the other variables constant. This means that work experience had no effect on its own when, for example, knowledge was held constant. In the following, we will discuss the results in more detail for each group of dependent variables.

The technical radiologic behavior was mainly influenced by knowledge and education, although type of practice also had relevance. The use of a knowledge measure is one way of describing dentists' competence. It does not, however, warrant the assumption that knowledge will be applied. Relatively few dentists used a low-dose method, although most of them knew that this significantly decreases the radiation doses (4, 5).

The type of practice was also shown to exert influence on the technical behavior and on adoption of the regulatory requirements set by the Swedish Radiation Protection Institute. Thus, dentists in the PDHS more often used rectangular collimation and a lower dose level, and they changed the developing chemicals more regularly than dentists in PP. This is to some extent consistent with the finding of Platin & Ludlow (11), who pointed out that type of practice exerted a major effect on the adoption of regulations.

A surprising finding was that there was a non-significant relation between years in dentistry and the technical dependent variables; that is, younger dentists did not use high-sensitivity film or rectangular collimators more often than older colleagues did. An explanation may be that, even though dental schools serve as models for later professional use of low-dose methods, there might be a modification of the approach to their use because, for example, dentists in the PDHS might have little influence on the choice of what equipment and materials to use.

We found that variables significantly influencing patient-oriented behavior were different from those affecting technical behavior. Knowledge, for example, showed no significant influence on the former variables, while education, the presence of an oral radiology specialist in the county, and type of practice did. In counties where specialists in oral radiology were available, they seemed to exert a significant influence on dentists' behavior as regards the use of bitewing radiographs on new and recall patients. This observation may be related to ongoing continuing education in counties with specialists in oral radiology, which may influence not only the level of knowledge (5) but also attitudes toward different aspects of oral radiology.

Demands from patients and parents of children and adolescents, as well as an overall greater awareness of radiation hazards among dentists today, may explain the use of strict indications when performing X-ray examinations. Dentists within the PDHS more often applied a strict model for their X-ray examinations. This might be explained by the fact that dentists in the PDHS have a patient mix largely made up of children and adolescents.

One of the objectives of radiology is to produce images of sufficient diagnostic quality while keeping the dose as low as reasonably achievable. This can readily be achieved by applying technical, patient-oriented, and organizational measures, that is, the use of high-sensitivity image receptors, small irradiated volumes, optimal darkroom procedures, protective barriers, and relevant selection criteria.

In industrialized countries the average number of X-ray examinations per year is one per individual if oral radiology is included (13). For oral radiology alone it was calculated that in Sweden, the USA, and Norway there was more than one radiograph per person every year (14). Another study showed that 75% of patients from age 9 to age 18 were subjected to at least one bitewing examination every year (15).

In Sweden many counties have oral radiologists working either in hospitals or in specialist clinics affiliated to the PDHS. In counties with one or more oral radiologists, there was a significantly higher level of knowledge of oral radiology, indicating their role in continuing education (5). It could be noted that continuing education had a significant effect on delegation and that, in counties with access to an oral radiologist, dentists delegated more X-ray examinations to their nurses or dental hygienists. Delegation of X-ray examinations may have the effect of a raised standard in oral radiology. Access to an oral radiologist may be important for the attainment of high radiologic quality in dental practice.

Both education and knowledge have a major effect on the behavior of dentists, but the interest of dentists to adapt to new regulations could be improved. It was shown that only 40% of the dentists had attended a continuing education course since graduation. Therefore, dentists should be offered a regular continuing education program to increase their level of knowledge and to influence their behavior and attitudes.

In sum, the overall result of this study does not support a rational action model as it stands in its simplest form, that is, as a direct relation between knowledge on the one hand and attitudes and behavior on the other. Rather, it gives the impression that there are two different and interacting sources of influence on dentists' behavior: knowledge and the organizational context of their work. Knowledge and education had strong direct effects, not mediated via attitudes, on most of the dependent variables. Organizational factors, primarily the difference between privately and publicly employed dentists, had independent effects. It does not seem an unreasonable assumption that organization also may have an indirect effect via possible influence on the settings of the acquiring of knowledge. This would confirm the results of our previous study in which knowledge was set as a dependent variable (5). The associations found for counties having specialists in oral radiology suggest that this could be correct.

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