# The use of protection measures in dento-maxillofacial radiology in Europe: a survey among experts

Accepted for publication September 12, 2022

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**Keywords**: radiology, dose protection, shielding, collimation

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## Abstract

Patient contact shielding to reduce radiation exposure to radiosensitive organs of patients is known to be used inconsistently in the field of dento-maxillofacial radiology (DMFR). There is an ongoing discussion if its use is still justified with regard to recent technical enhancements in the field. Thus, the aim of this study was to investigate the recommended and applied safety standards regarding dose protection measures in dental radiology within European countries. With an online questionnaire the use of safety measures, especially lead protection and collimation, in different patient groups (adults, children, pregnant women) was interrogated including leading experts in the field of DMFR. Among the 24 participants from 13 different countries, there was a tendency towards lead protection for intraoral radiography and towards collimation for extraoral radiography. Participants based their decision mainly on law and societal guidelines. Overall, the application of radiation protection measures varies within Europe. It seems safe to say that lead protection as a measure of radiation dose limitation is still recommendable even though collimation and technical advancements have led to great dose reductions. Collimation should be used more broadly and a standardization of protection measures and an update of radiation protection guidelines in Europe is desirable.

## Introduction

Radiographs are essential tools for diagnostics, treatment planning, follow-up and monitoring in dental medicine. In 2018, more than 5 million dental x-rays have been taken in Switzerland, comprising of 4.2 million intraoral x-rays, 800,000 panoramic views and 400,000 cone-beam computed tomography (CBCT) scans. Dental x-rays constitute 48.39% (including dental CBCT) of all medical radiographs taken in Switzerland (VIRY ET AL. 2021).

Ionizing radiation has biological side effects, which may lead to the development of cancerogenic and genetic damage (PASLER 2017). Stochastic biological effects, according to the linear non-threshold model, can occur independently of the applied dose. On the other hand, deterministic effects, which appear only above a certain threshold are not reached by routine dental x-rays (LITTLE ET AL. 2009). Stochastic effects can be initiated in tissues which are either affected by the direct beam or which are exposed to scattered radiation. To minimize unnecessary exposure of sensitive tissues (e.g., thyroid, salivary glands), radiation dose protection is a necessary and mandatory measure.

Radiation dose protection is based on the 3 principles of justification, optimization and dose limitation. For member states of the European Atomic Energy Community (Euratom), these principles are made binding by the Council Directive 2013/59/Euratom (EUROPEAN ATOMIC ENERGY COMMUNITY 2013). The directive was complemented by the guidelines on radiation protection 136 (about 2-dimensional radiographs) and 172 (about CBCT) (RADIATION PROTECTION 136 (2004) and 172 (2012)). Besides dose reducing equipment factors such as kilovoltage settings, filtration and image receptors, patient contact shielding and collimation were discussed in the literature (HORNER 1994). Collimation uses blinds

(collimators) in different shapes to reduce the beam ray to the necessary minimum. For periapical radiographs or bitewings a rectangular collimator can reduce the round beam ray to the rectangular shape of the film  or image receiver.

The guidelines 136 and 172 stated that routine use of abdominal (gonadal) lead protection was not justified for dento-maxillofacial radiology (DMFR). Lead shielding of the thyroid gland should be used if the thyroid gland is in line of, or (very) close to the primary beam. According to the guideline 136 there was no need to alter the normal selection criteria for dental x-rays in pregnant patients.

Rectangular collimation was considered as a highly effective means of dose reduction for intraoral x-rays, and should be used in combination with film holders incorporating beam aiming devices. Also for extraoral 2D radiography, limitation/collimation of field size to the area required for diagnosis should be used, if available. For CBCT scans, examinations should use the smallest field of view compatible to the clinical question to provide less radiation dose to the patient (RADIATION PROTECTION 136 (2004) and 172 (2012)).
The application of lead protection is known to be used inconsistently in Switzerland, and it could be shown recently in a study in Turkey that the knowledge of dentists in radiation protection was insufficient (YURT ET AL. 2022).  Furthermore, regulations and recommendations in many countries do not explicitly specify how and also what protective tools shall be used (CANDELA-JUAN ET AL. 2021). Thus, the aim of this study was to investigate what kind of radiation protection measures are applied in the different European countries and to assess differences between countries.

## Materials and Methods

### Data collection

An online questionnaire focusing on radiation protection measures was designed. A link to this questionnaire was sent to the central board members and associated specialists of the European Association of Dentomaxillofacial Radiology (EADMFR) in 17 countries. Answers were collected during a period of three months ranging from April 2021 to June 2021. The questionnaire contained a total of 13 questions, and the average time required to answer was about 4 min.

### Questionnaire

The questionnaire comprised two parts. Personal data was requested in the first part including country, type of practice (private dental clinic, government, university, other) and board membership of the local DMFR society (yes/no).

The second part addressed personal preferences regarding protection measures (thyroid protection, lead apron, collimation measures, other, not specified or do not know) for routine modalities in DMFR (intraoral x-rays, extraoral 2D including panoramic and lateral cephalometric imaging, and 3D (CBCT)). The application of the preferred protection measures in all modalities was asked for 3 different population groups (adults, children, and pregnant women). The participants were also asked to define on what basis their choice was founded (law, societal guidelines, personal opinion, or other) for each patient group. For all questions in the second part, multiple answers and comments for further explanations were possible.

## Analysis

Only completely filled-in questionnaires were taken into account for further analysis.

The type of protection measure (shielding, collimation or combination), the type of shielding (thyroid protection, lead apron) and the basis of choice (law, societal guidelines, personal opinion, or other) were analyzed descriptively for the different patient groups. Comments by individual participants were evaluated separately.

## Results

### Study participants

The questionnaire was sent to 38 members of the central board in 17 countries and answered by 30 participants from 15 different European countries. Out of these, 6 participants did not finish the questionnaire after filling-in the first page (personal data). These incomplete questionnaires were excluded from the further evaluation process. The other 24 participants from 13 countries completed the entire questionnaire. The response rate was 63.2%.

Out of these 24 study participants, 4/24 (16.6%) declared working in a private clinic, 18/24 (75.0%) at a university clinic, one person for a government clinic and one person in another institution. Membership of national DMFR-societies were stated in 10/24 (41.6%). Five countries were represented by more than one participant (5 complete questionnaires from France and Norway, 2 each from the Netherlands, Sweden and Belgium).

### Radiation dose protection measures with regard to intraoral x-rays

For adults, 62.5% of the participants used a combination of lead protection and collimation, 20.8% used “lead protection only”, and 16.7% used “collimation only” when taking intraoral radiographs. For children, less participants used a combination (54.1%), and more “lead protection only” (29.2%), while 16.7% used “collimation only”. The percentage distribution for protection measures in pregnant women was similar to that for children (Figure 1).

For lead shielding, 75.0% used “thyroid protection only” for adults, 10.0% “lead apron only”, and 15.0% a combination of both. For children, less participants used “thyroid protection only” (65.0%), no participant used “lead apron only”, and most dentists

used a combination of both (35.0%) compared to adults. For pregnant women, “thyroid protection only” (47.6%) and a combination of thyroid protection and lead apron (47.6%) was used in equal shares and “lead apron only” in 4.8% (Figure 2).

**Radiation dose protection measures with regard to extraoral 2D radiographs**

For adults, 16.7% of the participants used a combination of lead protection and collimation, 25.0% used “lead protection only”, 45.8% used “collimation only”, and 12.5% answered “not specified” with regard to extraoral 2D radiographs. In children, compared to adults, more participants used “lead protection only“ (29.2%) or “collimation only" (54.1%), and a smaller fraction (12.5%) a combination of both. For pregnant women, compared to adults, more participants (30.4%) used a combination of lead shielding and collimation. The percentages for children and pregnant women can be seen in Figure 1.

A majority of participants (90.0%) preferred “lead apron only” over “thyroid protection only“ (10.0%). No participant used a combination of both for adults. For children and pregnant women, less participants used “lead apron only” (70.0 resp. 76.9%), while more participants used a combination of lead protection and collimation (20.0 resp. 15.4%), compared to adults (Figure 2).

**Radiation dose protection measures with regard to 3D radiographs (CBCT)**

For CBCT scans, 45.8% used “collimation only”, 25.0% “lead protection only”, and 16.7% used a combination of both in adult patients. The percentage distribution of applied protection measures for children and pregnant women was similar to adults with a small shift toward “lead protection only” and combined protection measures (Figure 1).

The feedback for applied lead protection measures in all patient groups was almost identical to that reported for 2D extraoral radiographs.

**Basis for application of dose protection measures and general findings**

The basis of use for certain protection measures in adults was most frequently answered with “law” (75.0%), which was often combined with “societal guidelines” (58.3%) and “personal opinion” (33.3%). The distribution in all patient groups was very similar (Figure 3).

The use of lead protection was very common. Only 3 participants did not use any lead protection (1x Denmark, 1x Netherlands, 1x Spain), and one participant (France) indicated to use lead protection only with children and pregnant women. In Nordic countries, a tendency towards more frequent use of collimation could be observed.

## Discussion

Radiation dose protection in Switzerland is based on the national RADIATION PROTECTION ACT, the RADIATION PROTECTION ORDINANCE and the RADIATION REGULATION as well as directions of the Federal Office of Public Health (FEDREAL OFFICE OF PUBLIC HEALTH (2018)). They are based on the general principles of justification, optimization and dose limitation and set (next to other dose reducing measures) minimal equipment requirements for protection measures in dental radiology. They stipulate the application of adequate protection gear as follows: thyroid shield or lead apron for intraoral x-rays and a lead apron for all extraoral dental radiographs. Lead aprons need to cover from the base of the neck until beneath the gonads with a lead equivalent of 0.25 mm lead, or for intraoral x-rays protection shields need to have a lead equivalent of 0.25 mm lead (RADIATION REGULATION). According to article 15 of the Radiation Protection Act, there are no dose limits for diagnostic or therapeutic purposes, and exposure of the patient is the decision of the treating clinician based on clear indications. Furthermore, in Switzerland radiation protection measures are defined by law, but can be adapted by the radiation authorization holder in a dental clinic or dental private practice to assure appropriate self-responsible and case-based use of protection measures.

**For intraoral x-rays**, most participants reported to use thyroid protection, which was, especially for the more vulnerable patient groups, sometimes combined with a lead apron. The Euratom guideline 136 (RADIATION PROTECTION 136 (2004)), which recommended thyroid shielding, when the thyroid is in or very close to the primary beam, and recommends collimation for intraoral radiographs otherwise, is in line here with the Swiss legislation.

A review from almost three decades ago by Horner reported that rectangular collimation could offer a similar level of protection for the thyroid as thyroid shielding (HORNER 1994). This study was one of the sources, which lead to the recommendation of Euratom guideline 136 (RADIATION PROTECTION 136 (2004)). According to HORNER (1994) lead aprons did not protect against scattered internal radiation, and did not have a significant effect on the extremely low gonadal dose. Thus, according to Horner, neither thyroid shielding nor lead aprons are indicated for intraoral x-rays. Later RUSH & THOMPSON (2007) found that thyroid shielding did have an additional advantage to rectangular collimation when using the paralleling technique for intraoral radiographs. HOOGEVEEN ET AL. (2016) found that thyroid shielding lead to an additional dose reduction for the thyroid of 8% (compared to bitewing with rectangular collimation) to 75% (compared to apical x-ray of an upper incisor with round collimation). Therefore, according to them, a lead shield should be used at least for imaging of the upper anterior teeth.

**For extraoral x-rays**, lead shielding was less often applied, but its use is still reported by at least 41.7% (adults and children) of the participants. Most participants used a lead apron, and a small fraction used also thyroid protection for extraoral radiographs.

*With panoramic x-rays* a thyroid shield may interfere with the primary beam and cause artefacts, which may cover relevant anatomical structures (RADIATION PROTECTION 136 (2004)). According to ROTTKE ET AL. (2013), a lead apron was not able to statistically lower the dose of the torso or protect against internal body scatter. Therefore, lead shields are not to be recommended for panoramic views. This finding is contradicted by a study from SCHULZE ET AL. (2017) presenting that the skin entrance dose in the breast region during panoramic radiography was 112-fold higher without lead apron than when using a lead apron. For the thyroid, the

dose difference was minimal (1.02-fold) as the apron did not cover this specific region, as it would interfere with the primary beam. These differences may be explained by dosimeters of much higher sensitivity (highly sensitive solid-state-dosimeter) used in the study of SCHULZE ET AL. (2017) than those used by ROTTKE ET AL. (2013) (thermoluminescence dosimeter). Furthermore, the numbers cannot be compared directly, as one study measured absorbed doses (ROTTKE ET AL. 2013) and the other (SCHULZE ET AL. 2017) skin entrance doses (due to the bigger size of the dosimeter).

*For cephalometric x-rays***,** the thyroid should be excluded from the primary beam whenever possible. Only if this is not possible, a thyroid collar can be justified (CRANE & ABBOTT 2016). It was reported that the use of a thyroid collar in cephalometric x-rays could reduce the overall effective dose by 34% (PATCAS ET AL. 2013). A lead apron without thyroid collar is of no use, because the torso is not in the primary beam. Classical rectangular collimation exposes a lot of structures, which are not needed for orthodontic diagnostics (e.g., skull). Therefore research has focused on a more anatomical collimation (BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS AND THE BRITISH SOCIETY OF DENTAL AND MAXILLOFACIAL RADIOLOGY 1985, ALCARAZ ET AL. 2009, LEE ET AL. 2012)). An alternative to classical collimation and thyroid protection could be a cephalographic thyroid protector (CTP), which is clamped onto the neck of the patient in combination with an anatomical cranial collimation, which is fixed on the positioning device and covers parts of the skull that are not needed for orthodontic diagnostics. Used in combination, a reduction of almost 60% of effective dose could be achieved, and with the CTP alone a reduction by 85% of thyroid dose, which was almost as much as with a thyroid collar (89% reduction) but without the risk of coverage of any relevant anatomical structures (HOOGEVEEN ET AL. 2015). This

method was also specifically mentioned by one participant of the present questionnaire. But it remains unclear if this method was used by more participants who mark it simply as “thyroid protection” in 2D radiographs.

*For CBCT scans*, the use of a thyroid collar tightly fitted under the chin can be recommended, but should not be used when visualization of tissues at the level or slightly above the shield is needed (PAUWELS ET AL. 2019). The recommendation for thyroid shielding when using large fields of view is especially given for children as many CBCT devices are not optimized for paediatric patients. Thus, thyroid gland doses are generally found to be higher with children than with adult patients (HIDALGO ET AL. 2015). Some authors recommended lead glasses as additional protective measure of the eyes (TSAPAKI 2017, GOREN ET AL. 2013). Another study concluded no significant change in effective dose for CBCT scans with lead aprons (ROTTKE ET AL. 2017). As collimation dose protection measure, an appropriate field size should be chosen. To help with selection of the ideal field of view, scout images and real time tube current modulation can be used, if available (PAUWELS ET AL. 2019).

Recently, benefits and risks of lead shielding were also discussed in the medical field: due to new projection technologies as well as the risk of automated exposure control and risks of unacceptable image quality (artefacts of lead shielding), lead shielding was not recommended anymore. Exceptions in the dental field were mentioned due to the proximity of the thyroid gland for many dental indications, and the high percentage of paediatric patients examined. In contrast, gonad shielding was not recommended for dental purposes anymore (HILES ET AL. 2021). The recently published recommendation of the Swiss Commission for Radiation protection, which proposed to renounce the usage of lead protection in all

conventional x-rays, cannot be applied on a 1:1 for dentistry (FEDERAL COMMISSION ON RADIOLOGICAL PROTECTION 2021).

In the present study lead protection was reported as a frequently used measure to protect patients from unnecessary radiation. A majority of participants used thyroid protection for intraoral x-rays and a lead apron for extraoral x-rays. The use of collimation was not reported as frequently as lead protection. Nordic countries reported more frequently the use of collimation than other countries of Europe. A broader use of collimation would be desirable as every reduction of the primary beam does automatically reduce dose from scattered radiation, and therefore is a more efficient way of dose reduction than shielding of scattered radiation alone. In addition, patient contact shielding of the thyroid is useful when the primary beam is affecting the thyroid or is close to it, as well as in young adults (LUBIN EL AL. 2017, WALL ET AL. 2011).

Most participants justified their choice of radiation protection measures with “law” often combined with “societal guidelines”, and sometimes also cited “personal opinion”. As laws and societal guidelines should in general be based on science it could be assumed that their choice is adopted to current knowledge on radiation protection and should be homogenous. Nevertheless there was a great variability and lack of specificity in legislative documents and recommendations about lead shielding in Europe (CANDELA-JUAN ET AL. 2021), which could be seen in the differing answers of the participants even within one country.

One drawback of the present study was the restricted number of countries in Europe, which could be contacted via EADMFR. The answers of different participants from one country were often similar, but especially for the more vulnerable patient groups, there was often disagreement. A greater number of participants would have allowed for a better and more in-depth analysis, for example comparison of tendencies

between geographical regions (e.g., Nordic, Baltic, German-speaking countries) and to identify outliers. Another drawback was that panoramic and cephalometric x-rays were summarized as extraoral 2D x-rays. A separate evaluation would have been desirable as these two modalities have very different beam paths. Furthermore, the type of lead shielding could have been defined more precisely, e.g., thyroid shield vs. thyroid collar, round vs. rectangular collimation.

**Conclusions:** The application of radiation protection measures varies within Europe. Lead protection as a measure of dose limitation is still recommendable even though collimation and technical advancements have led to great dose reductions. The use of collimation in intra- and extraoral radiographs is recommendable.

## Zusammenfassung

*Einleitung:*

Röntgenaufnahmen sind in der Zahnmedizin in der Diagnostik, der Behandlungsplanung und zur Verlaufskontrolle unverzichtbar, können jedoch biologische Nebeneffekte haben, welche auf ein Minimum reduziert werden sollten. Es ist bekannt, dass die Verwendung von Strahlenschutzmitteln, selbst innerhalb der Schweiz, unterschiedlich gehandhabt wird. Die vorliegende Studie sollte die Anwendung von Strahlenschutzmitteln in der Zahnmedizin innerhalb sowie zwischen den Ländern Europas untersuchen.

*Material und Methoden:*

Eine online-Umfrage bestehend aus zwei Teilen wurde per Mail an Vorstandsmitglieder sowie an weitere Spezialisten der European Association for Dentomaxillofacial Radiology gesendet. Der erste Teil enthielt allgemeine Fragen zum Herkunftsland, Institutionstyp und Mitgliedschaft in der regionalen Gesellschaft für dentomaxillofaziale Radiologie. Im zweiten Teil wurde nach den präferierten Röntgenschutzmitteln für die verschiedenen Röntgenmodalitäten (intraoral, extraoral 2D, extraoral 3D) in den drei Patientengruppen Erwachsene, Kinder und Schwangere, sowie nach der Begründung für ihre Entscheidung gefragt (Gesetze, Richtlinien der Röntgen-Gesellschaft, persönliche Meinung, andere). Die Umfrage war anonym, sofern die Teilnehmer am Schluss ihre E-Mailadresse zur Information über die Studienergebnisse nicht angegeben haben.

*Resultate:*

Von initial 30 Teilnehmern mussten 6 Beantwortungen aufgrund Unvollständigkeit ausgeschlossen werden. Somit blieben 24 Fragebögen aus 13 Ländern. Hiervon arbeiteten 75% der Befragten an einer Universitätsklinik, 16.6% in einer Privatpraxis

und eine Person in einer staatlichen Klinik. 41.6% der Teilnehmer waren Mitglied ihrer nationalen Fachgesellschaft für dentomaxillofaziale Radiologie.
Die Verwendung von Schutzmitteln in Form von Bleischutz und/oder Kollimation war weit verbreitet. Bei intraoralen Röntgenaufnahmen wurden Bleischutzmassnahmen häufiger angewendet, als bei extraoralen. Hierbei wurde zumeist ein Schilddrüsenschutz angewandt, welcher bei Kindern und Schwangeren häufig mit einer Bleischürze kombiniert wurde. Bei extraoralen Aufnahmen wurde häufiger eine Bleischürze angewandt. Als Begründung für die Wahl des Schutzmittels wurde zumeist das Gesetz angegeben, oftmals kombiniert mit Richtlinien der Röntgen-Gesellschaft oder der persönlichen Meinung.

*Diskussion:*

Trotz technologischen Weiterentwicklungen ist der Einsatz von Bleischutzmitteln noch immer weit verbreitet. Der Nutzen von Bleischutzmitteln ist nach wie vor gegeben, wenngleich er in Kombination mit Kollimation einen kleineren Stellenwert einnimmt. Kollimation sollte intra- und extraoral vermehrt genutzt werden. Prinzipiell ist auch eine Vereinheitlichung der Strahlenschutzmassnamen in der dentomaxillofazialen Radiologie in Europa wünschenswert.

## Résumé

*Introduction:*

En médecine dentaire les radiographies sont indispensables pour le diagnostic, la planification du traitement et le suivit du développement des lésions. Malgré leurs avantages elles peuvent créer des effets secondaires biologiques, qui doivent être réduits à un minimum. Il est connu que même en Suisse l'utilisation de moyens de radioprotection est inhomogène. La présente étude cherchait à analyser l'application de moyens de radioprotection en médecine dentaire en Europe.

*Matériels et méthodes:*

Un sondage en ligne constitué de deux parties a été envoyé par e-mail aux membres et associés de l'European Association for Dentomaxillofacial Radiology.

La première partie du sondage consistait en des questions générales comme des informations sur le pays, le type de clinique et l'appartenance à la société de radiologie dentomaxillofaciale locale. La deuxième partie consistait en des questions sur les moyens de radioprotection préférés pour les différentes modalités (intraoral, extraoral 2D, extraoral 3D) dans les groupes des adultes, des enfants et des femmes enceintes et demandait la justification pour le choix de moyen de protection (loi, directives de la société de radioprotection, avis personnel ou autres). Le sondage était anonyme excepté si les participants mentionnaient leur adresse e-mail à la fin du sondage dans le but d'être informés sur les résultats de l'étude.

*Résultats:*

Des 30 participants, 6 participants ont dû être exclus à cause de réponses incomplètes, ce qui menait à 24 participants dans 13 pays. 75% des participants exerçaient dans une clinique universitaire, 16.6% dans un cabinet privé et une personne dans une clinique public de l'état. 41.6% des participants étaient membres de la société de radiologie dentomaxillofaciale locale. L'application des moyens de

radioprotection en forme de protecteurs en plomb ou collimation était largement répandue. Les protecteurs en plomb étaient plus souvent utilisés dans les radiographies intraorales que extraorales. Pour les radiographies intraorales il s'agissait dans la plupart des cas d'un protecteur pour la glande thyroïde, qui était dans les cas des enfants et femmes enceintes souvent combiné avec un tablier en plomb. Pour les radiographies extraorales la plupart des participants utilisaient un tablier en plomb.

Comme justification pour le choix de moyen de protection la loi était mentionnée le plus souvent et était souvent combinée avec les recommandations de la société de radioprotection locale ou l'opinion personnel.

*Discussion:*

Malgré des avancements technologiques l'utilisation de moyens de radioprotection est toujours très répandue. L'avantage de l'utilisation de protecteurs en plomb est toujours donné, bien qu'ils prennent moins d'importance en combinaison avec la collimation. La collimation devrait être utilisée plus globalement pour les radiographies intra- et extraorales et une uniformisation des mesures de protection en radiologie dentomaxillofaciale est souhaitable.

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## Legends

### Figures (submitted separately)

Figure 1: Use of protection measures for the different modalities in the different patient groups assessed in the present questionnaire

Figure 2: Use of lead protection measures for the different modalities in the different patient groups

Figure 3: Basis for application of dose protection measures for the different patient groups as reported by the study participants, multiple answers possible

### Tables

## Tables

| Country | Number of participants |
|---|---|
| Albania | 1 |
| Austria | 1 |
| Belgium | 2 |
| Denmark | 1 |
| France | 5 |
| Germany | 1 |
| Netherlands | 2 |
| Norway | 5 |
| Poland | 1 |
| Portugal | 1 |
| Spain | 1 |
| Sweden | 2 |
| Turkey | 1 |

Table 1

| | | lead protection only | combination | collimation only | not specified |
|---|---|---|---|---|---|
| **Albania** | intraoral | 1 | 0 | 0 | 0 |
| | extraoral 2D | 1 | 0 | 0 | 0 |
| | extraoral 3D | 1 | 0 | 0 | 0 |
| **Austria** | intraoral | 0 | 1 | 0 | 0 |
| | extraoral 2D | 0 | 1 | 0 | 0 |
| | extraoral 3D | 0 | 1 | 0 | 0 |
| **Belgium** | intraoral | 0 | 2 | 0 | 0 |
| | extraoral 2D | 0 | 0 | 2 | 0 |
| | extraoral 3D | 0 | 0 | 2 | 0 |
| **Denmark** | intraoral | 0 | 0 | 1 | 0 |
| | extraoral 2D | 0 | 0 | 1 | 0 |
| | extraoral 3D | 0 | 0 | 1 | 0 |
| **France** | intraoral | 2 | 2 | 1 | 0 |
| | extraoral 2D | 1 | 3 | 1 | 0 |
| | extraoral 3D | 1 | 3 | 1 | 0 |
| **Germany** | intraoral | 1 | 0 | 0 | 0 |
| | extraoral 2D | 1 | 0 | 0 | 0 |
| | extraoral 3D | 1 | 0 | 0 | 0 |
| **Netherlands** | intraoral | 0 | 1 | 1 | 0 |
| | extraoral 2D | 0 | 0 | 2 | 0 |
| | extraoral 3D | 0 | 0 | 2 | 0 |
| **Norway** | intraoral | 1 | 4 | 0 | 0 |
| | extraoral 2D | 0 | 0 | 3 | 2 |
| | extraoral 3D | 0 | 0 | 3 | 2 |
| **Poland** | intraoral | 0 | 1 | 0 | 0 |
| | extraoral 2D | 1 | 0 | 0 | 0 |
| | extraoral 3D | 1 | 0 | 0 | 0 |
| **Portugal** | intraoral | 0 | 1 | 0 | 0 |
| | extraoral 2D | 1 | 0 | 0 | 0 |
| | extraoral 3D | 1 | 0 | 0 | 0 |
| **Spain** | intraoral | 0 | 0 | 1 | 0 |
| | extraoral 2D | 0 | 0 | 0 | 1 |
| | extraoral 3D | 0 | 0 | 1 | 0 |
| **Sweden** | intraoral | 0 | 2 | 0 | 0 |
| | extraoral 2D | 0 | 0 | 2 | 0 |
| | extraoral 3D | 0 | 0 | 1 | 1 |
| **Turkey** | intraoral | 0 | 1 | 0 | 0 |
| | extraoral 2D | 1 | 0 | 0 | 0 |
| | extraoral 3D | 1 | 0 | 0 | 0 |

Table 2

| | | thyroid protection only | combination | lead apron only |
|---|---|---|---|---|
| **Albania** | Intraoral | 1 | 0 | 0 |
| | extraoral 2D | 1 | 0 | 0 |
| | extraoral 3D | 1 | 0 | 0 |
| **Austria** | Intraoral | 0 | 0 | 1 |
| | extraoral 2D | 0 | 0 | 1 |
| | extraoral 3D | 0 | 0 | 1 |
| **Belgium** | Intraoral | 2 | 0 | 0 |
| | extraoral 2D | 0 | 0 | 0 |
| | extraoral 3D | 0 | 0 | 0 |
| **Denmark** | Intraoral | 0 | 0 | 0 |
| | extraoral 2D | 0 | 0 | 0 |
| | extraoral 3D | 0 | 0 | 0 |
| **France** | Intraoral | 1 | 2 | 1 |
| | extraoral 2D | 0 | 0 | 4 |
| | extraoral 3D | 0 | 1 | 3 |
| **Germany** | Intraoral | 1 | 0 | 0 |
| | extraoral 2D | 0 | 0 | 1 |
| | extraoral 3D | 0 | 0 | 1 |
| **Netherlands** | Intraoral | 1 | 0 | 0 |
| | extraoral 2D | 0 | 0 | 0 |
| | extraoral 3D | 0 | 0 | 0 |
| **Norway** | Intraoral | 5 | 0 | 0 |
| | extraoral 2D | 0 | 0 | 0 |
| | extraoral 3D | 0 | 0 | 0 |
| **Poland** | Intraoral | 1 | 0 | 0 |
| | extraoral 2D | 0 | 0 | 1 |
| | extraoral 3D | 0 | 0 | 1 |
| **Portugal** | Intraoral | 1 | 0 | 0 |
| | extraoral 2D | 0 | 0 | 1 |
| | extraoral 3D | 0 | 0 | 1 |
| **Spain** | intraoral | 0 | 0 | 0 |
| | extraoral 2D | 0 | 0 | 0 |
| | extraoral 3D | 0 | 0 | 0 |
| **Sweden** | intraoral | 1 | 1 | 0 |
| | extraoral 2D | 0 | 0 | 0 |
| | extraoral 3D | 0 | 0 | 0 |
| **Turkey** | intraoral | 1 | 0 | 0 |
| | extraoral 2D | 0 | 0 | 1 |
| | extraoral 3D | 0 | 0 | 1 |

Table 3

## Figures

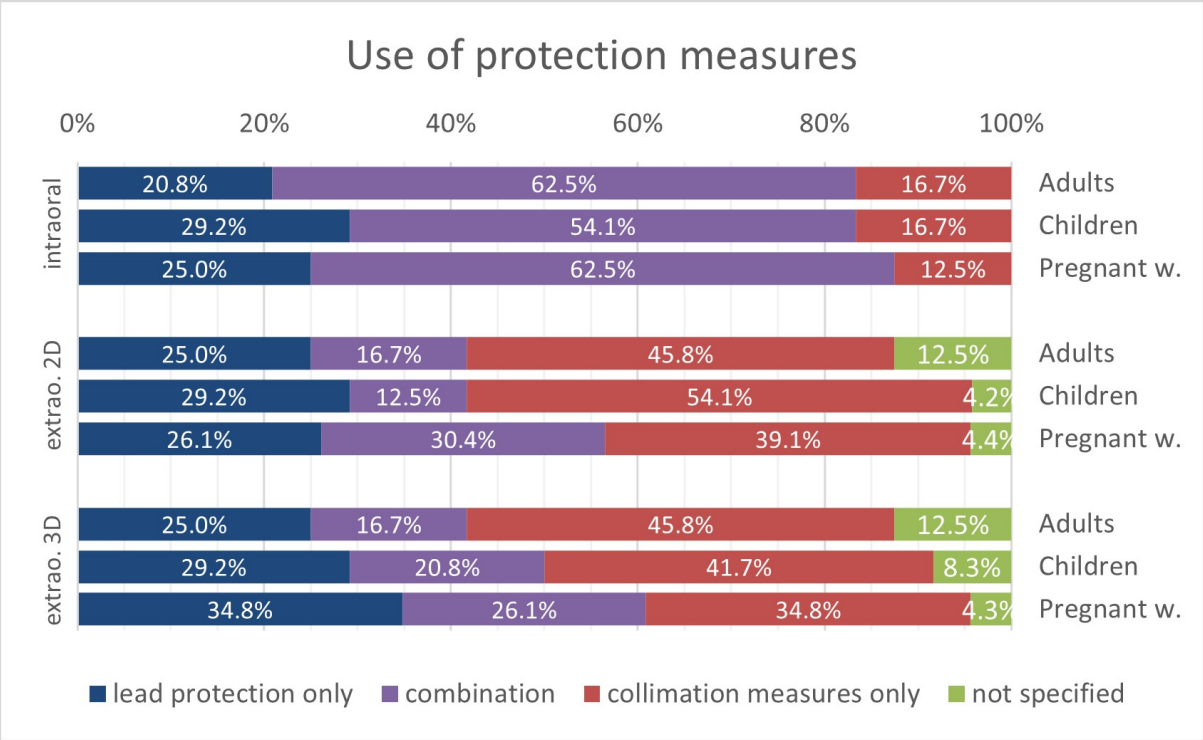


Figure 1

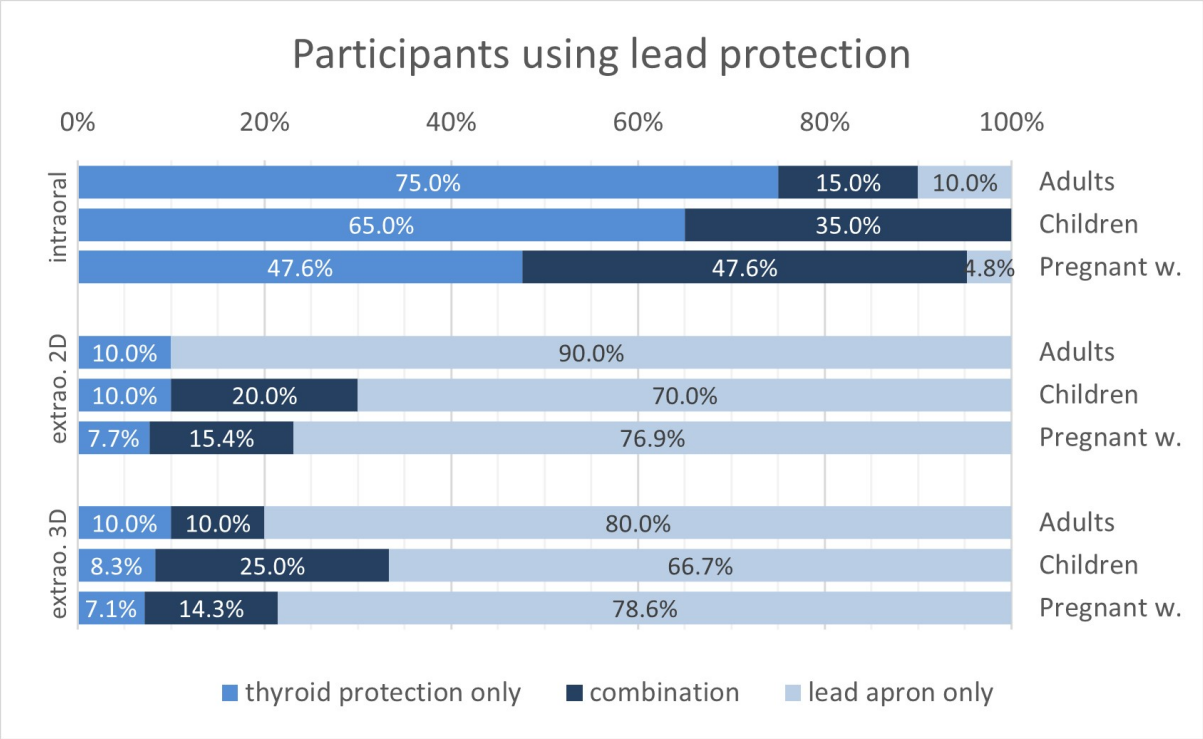


Figure 2

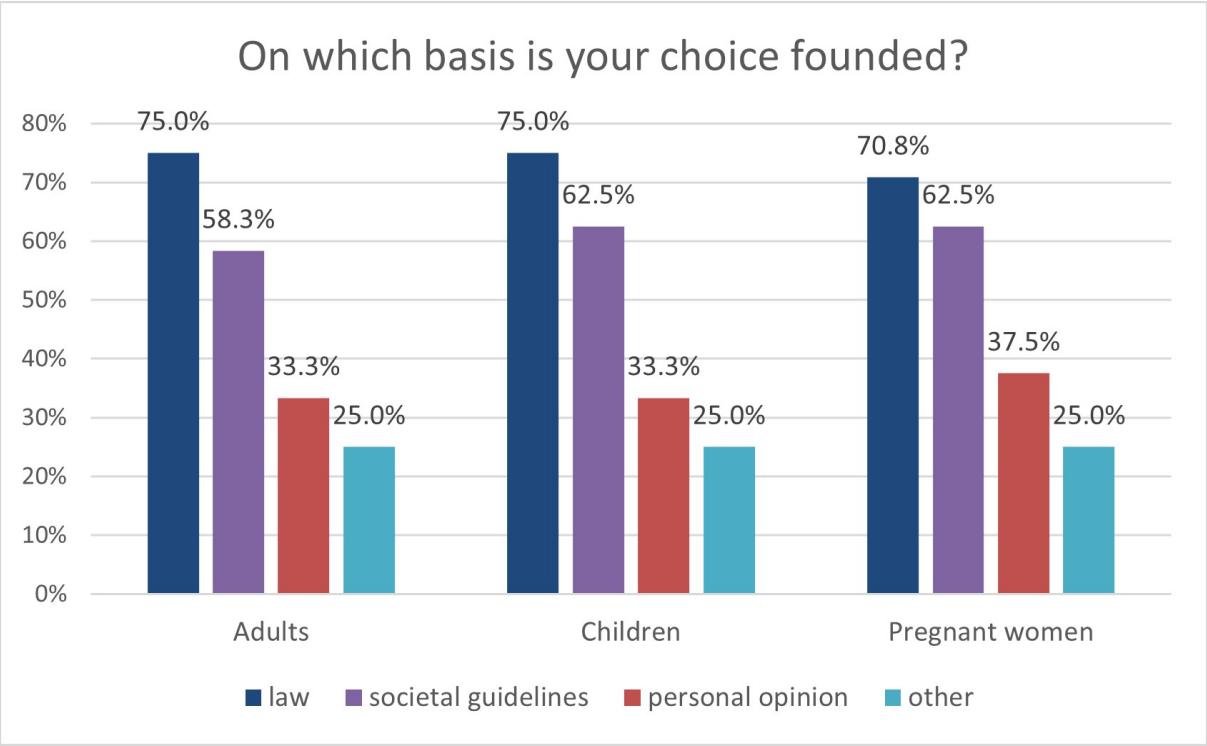
On which basis is your choice founded?
80%
70%
60%
50%
40%
30%
20%
10%
0%
75.0%
58.3%
33.3%
25.0%
75.0%
62.5%
33.3%
25.0%
70.8%
62.5%
37.5%
25.0%
Adults
Children
Pregnant women
law
societal guidelines
personal opinion
other

Figure 3