GRADUATION PROJECT

Degree in Dentistry

HOW MANY PATIENTS ARE OFFERED A LEAD APRON TO WEAR DURING DENTAL X-RAYS?

Madrid, academic year 2024/2025

Identification number: 115

ABSTRACT

Introduction: Radiation protection is essential in dental radiography, as even low doses of ionizing radiation carry potential health risks. Despite advancements in low-radiation imaging, there is ongoing debate about the necessity of lead aprons, especially across different healthcare systems and countries; **Objectives:** This study aimed to evaluate how often patients are offered a lead apron during dental X-rays and to compare practices between Germany and Spain; **Material and Methods**: A 20-question survey was conducted, receiving responses from 272 participants: 118 from Spain, 114 from Germany, and 40 from other countries. An online form (Microsoft Forms) was used for this purpose, and it was distributed through social media; **Results:** The results revealed that 82.46% of patients in Germany were offered a lead apron during dental X-rays, compared to only 39.83% in Spain. Awareness about protective shielding was also higher in Germany (98%) than in Spain (65%). Furthermore, patients in Germany were more likely to request protection and feel at risk without it, while patients in Spain showed higher concern but less initiative. Lead apron usage varied by age and gender, with elderly individuals and children receiving less protection overall, except in Germany where older adults were more consistently protected; **Conclusions**: The findings highlight significant differences in protection practices, with Germany demonstrating higher usage of lead aprons, which highlights the need to improve and monitor standardized safety measures, reinforcing public awareness.

KEYWORDS

Dentistry, lead apron, dental X-rays, Germany, Spain

RESUMEN

Introducción: La protección radiológica es clave en la radiografía dental, ya que incluso dosis bajas de radiación ionizante conllevan riesgos. A pesar de los avances en técnicas de baja radiación, persiste el debate sobre la necesidad del delantal de plomo, especialmente entre distintos sistemas sanitarios; **Objetivos:** Evaluar la frecuencia con la que se ofrece un delantal de plomo durante radiografías dentales y comparar las prácticas entre Alemania y España; **Material y Métodos:** Se realizó una encuesta de 20 preguntas, con 272 respuestas: 118 de España, 114 de Alemania y 40 de otros países. Se utilizó un formulario en línea (Microsoft Forms), distribuido por redes sociales; **Resultados:** El 82,46% de los pacientes en Alemania recibió delantal de plomo, frente al 39,83% en España. La conciencia sobre protección fue mayor en Alemania (98%) que en España (65%). Además, los pacientes alemanes mostraron mayor iniciativa al solicitar protección y sintieron más riesgo sin ella. En España, aunque había preocupación, hubo menos acción. El uso del delantal varió por edad y género: ancianos y niños fueron los menos protegidos, salvo en Alemania, donde los mayores sí recibieron protección de forma más constante; **Conclusiones:** Los resultados reflejan diferencias claras en las prácticas de protección. Alemania presentó un mayor uso del delantal de plomo, lo que resalta la necesidad de mejorar y controlar las medidas de seguridad estandarizadas, reforzando la concienciación pública.

PALABRAS CLAVE

Odontología, delantal de plomo, radiografías dentales, Alemania, España

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1. INTRODUCTION

In dental radiography, even small amounts of radiation make it important to protect patients (1). A common protective tool is the lead apron, which helps shield patients from extra radiation. However, with new low-radiation X-ray technology, some people question whether lead aprons are still needed, especially for certain types of dental X-rays (1). This study looks at how often patients are given lead aprons during dental X-rays and compares patients in Germany and Spain, by examining how dentists educate patients about protective measures across different healthcare systems. This research aims to provide insights into current safety measures and contributes to creating consistent safety standards for dental X-rays.

Dentists and dental assistants need to complete specific courses to learn about radiation safety and understand the potential effects of radiation exposure (1).

1.1 Purpose of dental radiology and the potential risk of radiation

For a good diagnosis and treatment in dentistry the radiograph is fundamental (2). In dentistry, various types of radiographs are available depending on the treatment being performed. This study focuses on fundamental radiographs commonly used in dental clinics, including intraoral radiographs (periapical, bitewing, occlusal) and extraoral radiographs (panoramic, orthopantomography), which are used during initial consultations or follow-up treatment assessments (2).

A high-quality intraoral periapical radiograph provides improved assessment of tooth morphology, periodontal structures, and periapical pathology, as well as post-treatment evaluation (3). Obtaining an intraoral radiograph can be challenging when a patient cannot withstand the placement of a periapical film due to anatomical challenges, a sensitive gag reflex, or the presence of ulcerations (3). Extraoral radiographs may be taken in these situations or when the patient has unerupted third molars. However, this may result in a lack of detail for specific dental structures, as the tooth is not viewed in isolation.

During the initial consultation, intraoral radiographs are typically used, although in specific cases, extraoral radiographs may also be employed, leading to a higher level of radiation exposure (3). Even the lowest dose of ionizing radiation poses an unavoidable risk of triggering random effects (2).

Studies have shown that radiation can lead to diseases like cancer (4) . In dental imaging, patient doses are relatively low and are generally considered to pose minimal risk (5). The ICRP, the International Commission on Radiological Protection, has established guidelines that incorporate tissue weighting factors for radiation protection and dose calculation containing those in the maxillofacial region (5).

1.2 Protective measures to minimize radiation exposure (normal patients, cancer patients, pregnant women and children)

Intraoral radiographs are the most widely performed dental X-ray exams (6). Although the risk is low, it has been proven to exist, making the use of a lead apron in dentistry essential (5). However, many patients are unaware of its importance. Children being more sensitive than adults (7). The thyroid gland is the tissue of greatest concern in dental imaging because of its radiosensitivity and anatomical location (5). Ionizing radiation exposure, particularly during childhood, is the only confirmed environmental risk factor for thyroid cancer (5).

No study has clearly proven a link between thyroid cancer and radiation from dental X-rays, but this does not mean the risk is not there (5).

Furthermore, the American Dental Association and the American Congress of Obstetricians and Gynecologists state that pregnant women can safely have internal and external dental radiographs (periapical and bitewing) at any stage of pregnancy, as long as radiation protection measures are applied to keep the dose as low as reasonably achievable (8). The risk is highest during the early stages of pregnancy (9). The American College of Obstetricians and Gynecologists (ACOG) and dental X-rays, also including panoramic radiographs, emit too little radiation to harm a fetus (10).

Shielding involves using an external material to reduce the intensity of the primary X-ray beam and any scattered radiation (5). Shielding should cover sensitive areas, like the thyroid, if they are within 5 cm of the main X-ray beam and if it does not interfere with the image quality (5). However, shielding cannot protect tissues from radiation that spreads inside the body from the X-ray beam (5). Thyroid shielding is recommended for all children under 20, and European guidelines advise it for all patients under 30, as well as for pregnant women (5,8,9) and pregnant women.

1.3 Composition of X-ray Machines and the Importance of a Collimator for Patient Protection

A dental radiograph machine consists of key components, with the collimator playing a vital role in patient protection (11). Located at the front of the X-ray tube head, it shapes and directs the X-ray beam, reducing unnecessary exposure and improving image quality (11)(12).

There are two main types: circular and rectangular collimators (6)(13). Circular collimators, produce more scatter, affecting image quality (14). In contrast, rectangular collimators reduce radiation by at least 40% and provide better protection (14). Despite these benefits, only 12.2% of private practitioners routinely use them (14).

Many clinics now adopt rectangular collimation for intraoral and extraoral radiographs, aligning with the ALARA (As Low As Reasonably Achievable) principle (6). Regulatory agencies in Australia, the UK, the US, and the EU endorse rectangular collimation for superior radiation protection (5). Studies show it lowers dose by up to 80%, making it safer than circular collimation (13).

Although lead aprons remain an extra precaution, proper collimation is far more effective in minimizing radiation exposure (6)(15)(16).

1.4 Differences in Healthcare systems in Spain and Germany- laws of protection Spain, Germany and European

Spain's Sistema Nacional de Salud (SNS) provides near-universal healthcare, covering over 99% of residents, funded primarily through taxation (17). Managed at national and regional levels, healthcare services are free at the point of use, although co-payments apply to prescriptions (17). Spain also has a parallel private system for faster specialist access (17)(18).

In Germany, healthcare operates under a statutory health insurance system, or statutory health insurance (GKV), which covers about 90% of the population (19)(20).

Funded by employer-employee contributions and tax subsidies, it is managed by non-profit insurance funds (19)(20).

Public Dental coverage differs in Spain and Germany. In Spain, children under 14 (or up to 16 in some regions) receive free dental care, including check-ups, preventative treatments, and specific care. Pregnant women, individuals with disabilities, and oncology patients also have access to certain dental services (21)(22). For adults, only basic procedures like extractions are covered, while routine treatments such as cleanings, fillings, and orthodontics require private insurance or out-of-pocket payments (21)(22).

In Germany, adults receive two annual check-ups, tartar removal once per year, and periodontal screenings every two years, with coverage for basic treatments like fillings, root canals (if necessary), and partial subsidies (60%) for dentures (23)(24)(25). Children over six also get two free check-ups per year, along with preventive care. Orthodontic treatments for significant misalignments (KIG 3-5) are covered for those under 18. Fillings and periodontal therapy are included for both adults and children when medically necessary (23)(24)(25).

Both countries Germany and Spain regulate dental radiography via EU directives (26)(27)(28)(29).

Germany mandates protective gear for intraoral X-rays and strict radiation monitoring (30)(26). For intraoral dental X-rays (e.g., periapical or bitewing), a thyroid protection device is required but not mandatory, which can be either a thyroid collar or a lead apron that covers the thyroid (31)(32). For extraoral X-rays (e.g., panoramic OPG or CBCT scans), a full lead apron covering the torso and neck is mandatory, as a simple thyroid collar alone is not sufficient for protection (31)(32).

In Spain intraoral radiographs (e.g., periapical or bitewing X-rays), lead aprons are not required, but a thyroid collar is recommended if the thyroid is near the primary beam. In contrast, extraoral radiographs (e.g., panoramic or cephalometric X-rays) require a full lead apron covering the torso and neck to protect against higher scatter radiation exposure (26)(33).

2. OBJECTIVE

The primary objective of this study is to evaluate the use of lead aprons in dental clinics, specifically comparing practices between Germany and Spain.

The secondary objectives of this study are:

1. To investigate specific protective measures in place for high-risk patients.
2. To assess differences in radiation protection practices between the public and private dental sectors in Germany and Spain.
3. To identify potential improvements in protective measures against radiation exposure.

3. MATERIAL AND METHODS

For this cross-sectional research survey, a questionnaire was created for acquaintances. It included 20 questions. A total of 290 people participated in the study; however, 18 individuals were excluded for not agreeing to the informed consent, leaving 272 participants in the final study. Participants were aged between 0 and over 80 years from Spain and Germany. The study aimed to understand how many patients are offered lead aprons when taking dental X-rays. The questionnaire was made using Microsoft Forms.

The questionnaires were distributed via social media, providing participants with a link to Microsoft Forms, as well as a QR code at a German medical office. The survey was also sent by the author through WhatsApp and Instagram messages, and participants were encouraged to share it with their friends and contacts.

The survey was open for four weeks (31 days), from the 19th of January 2025 to the 19th of February 2025. The study received the approval code OD.026/2425.

4. RESULTS

The data collection included 290 participants.

4.1 Demographics

Among all participants from Spain, Germany, and other countries, 130 participants (48%) were aged 20-39, 61 participants (22%) were 40-59, 67 participants (25%) were 60-79, 7 participants (3%) were over 80, and 7 participants (3%) were 0-19 (Figure 1).

Out of all 272 individuals, 118 were from Spain, including 43 males (36%) and 75 females (64%); 114 were from Germany, including 43 males (38%) and 71 females. (62%); and 40 were from other countries (USA, Ireland, UK, Switzerland, Austria and France) including 15 males (38%) and 25 females (63%) (Figure 2).

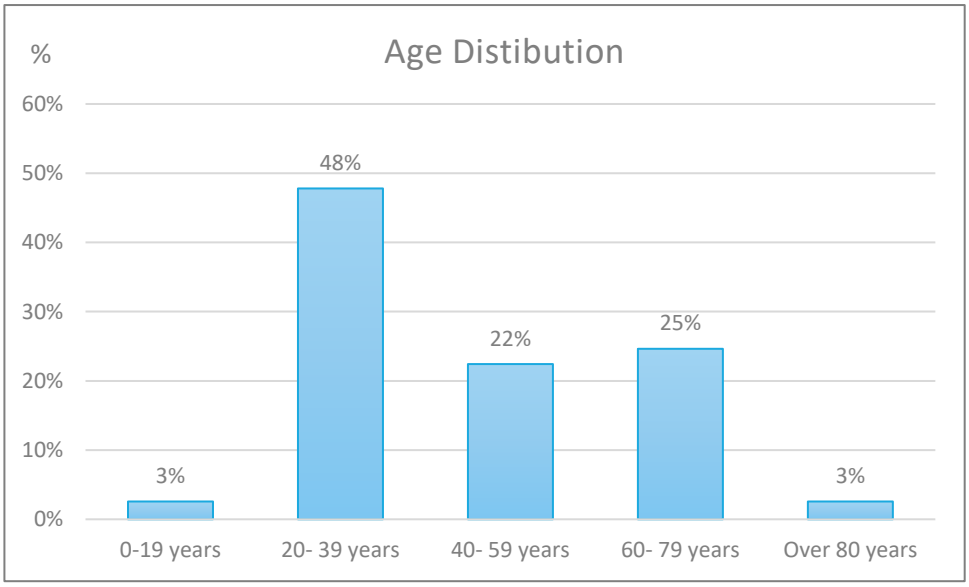

Figure 1: Age distribution

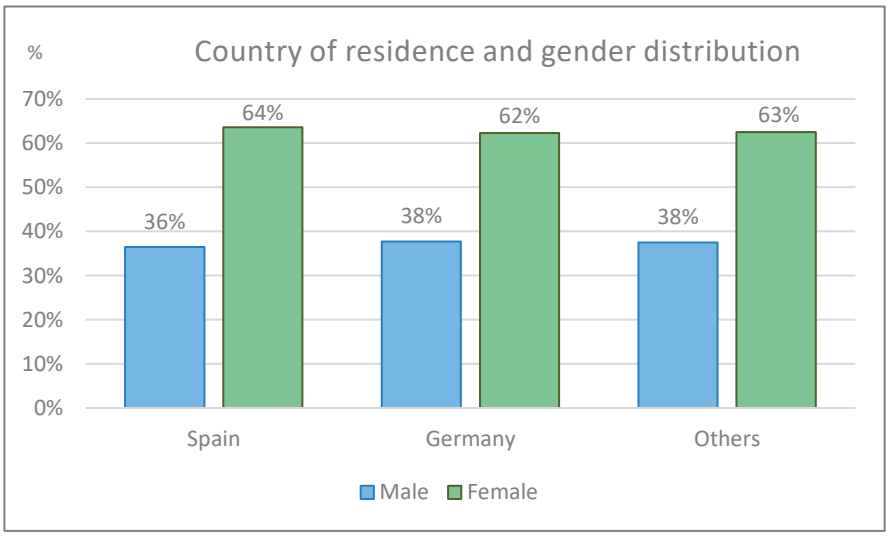

Figure 2: Country of residence and gender distribution

4.2 Dental Care Access and Xray frequency

Figure 3 presents data on the number and percentage distribution of people using different types of healthcare systems (Public, Private, or Both) in Spain, Germany, and other countries.

In Spain the vast majority (92%) rely on private healthcare. Only 3% use public healthcare, showing low dependency on the public system. 4% use both systems.
In Germany public healthcare is the most used at 46%, making it the dominant system. Private healthcare covers 39%, showing a more balanced system compared to Spain. 14% use both public and private healthcare, a significant proportion. In other Countries private healthcare dominates at 63%. Public healthcare accounts for 15%, 23% use both, the highest percentage among the three regions (Figure 3).

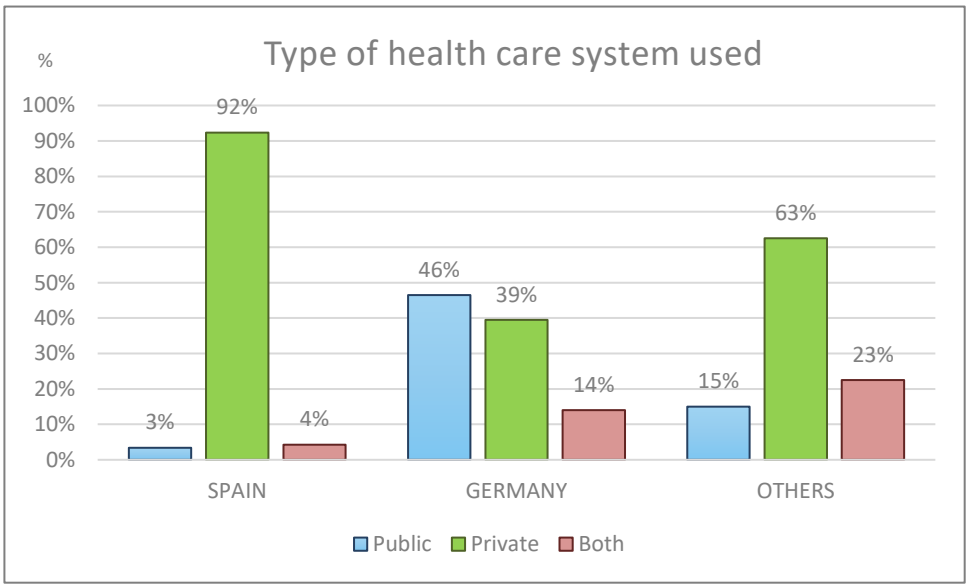

Figure 3: Types of health care system used (in numbers)

Age	1-3 times a year Spain	4-6 times a year Spain	>6 times a year Spain	1-3 times a year Germany	4-6 times a year Germany	>6 times a year Germany	1-3 times a year Other	4-6 times a year Other	>6 times a year Other
Nº of participants									
0-19 years	3	0	3	1	0	0	0	0	0
20-39 years	56	1	2	38	2	0	31	0	0
40-59 years	38	1	1	17	2	0	2	0	0
60-79 years	10	2	0	47	2	0	6	0	0
Over 80 years	1	0	0	4	1	0	1	0	0
TOTAL nº of part.	**108**	**4**	**6**	**107**	**7**	**0**	**40**	**0**	**0**

Table 1: Frequency of Dental Visits by Age Group and Country

Most dental visits in Spain occur 1-3 times a year across all age groups (Table 1, Figure 4) Frequent visits (>6 times a year) are rare, with only a few cases in younger age groups (0-19 and 20-39 years). Middle-aged and elderly groups (40-59 and 60-79 years) visit the dentist less frequently, mostly 1-3 times a year. Over 80 years have very few dental visits overall, with only 1 person visiting 1-3 times per year (Table 1, Figure 4). Dental visits in Germany are mostly limited to 1-3 times a year, especially for older age groups (60-79 years), where 47 individuals visit only 1-3 times annually. 4-6 times a year visits are uncommon, with only a few individuals in each age group.

Young individuals (0-19 years) have the lowest dental visit frequency, with only one individual visiting 1-3 times a year (Table 1, Figure 4). Most people in "Other" countries visit the dentist 1-3 times a year. No one in this category visits more than 3 times a year (no recorded cases for 4-6 or >6 visits). The 20-39 age group has the highest dental visit frequency (31 individuals visiting 1-3 times per year). Elderly people (60-79 years and over 80 years) have very few visits, like Spain and Germany (Table 1, Figure 4). Spain has more frequent dental visits (>6 times a year), especially among younger individuals, but most visits still fall within the 1-3 times a year category. Germany has the highest number of people visiting the dentist regularly (1-3 times a year), particularly in the older age groups (60-79 years). Other countries show the lowest dental visit frequency, with no one visiting more than 3 times a year. Young children (0-19 years) visit the dentist the least across all countries, except in Spain, where a few individuals have more than 6 visits per year. The elderly (over 80 years) have very few dental visits across all countries (Figure 4).

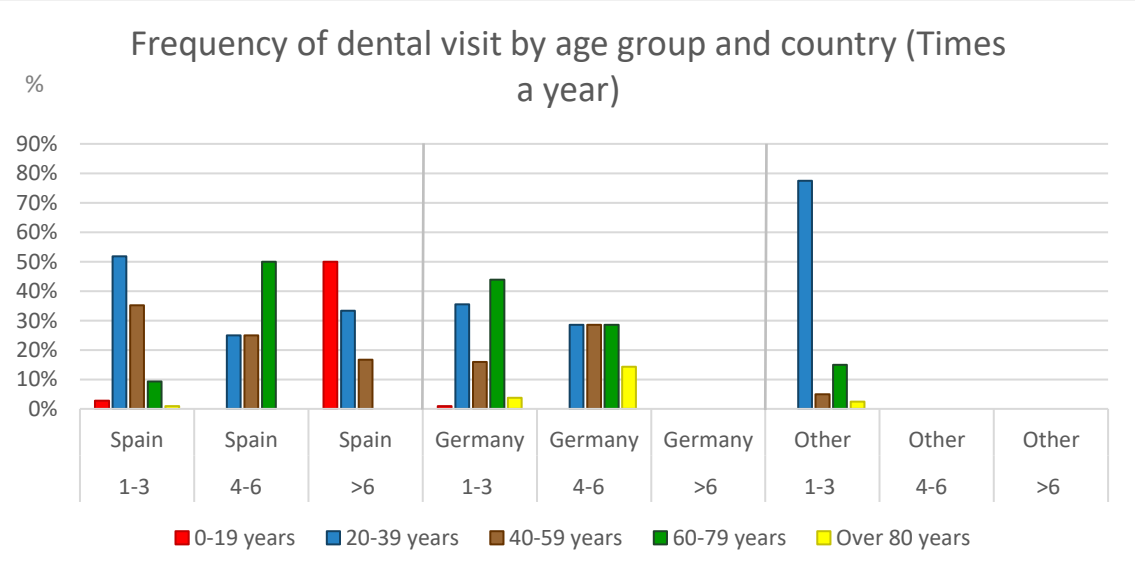

Figure 4: Frequency of Dental Visits by Age Group and Country shown in numbers

Table 2 provides data on the frequency of X-ray usage during dental visits in different health systems (Private, Public, and Both) across Spain, Germany, and other countries.

Private healthcare users in Spain show high variability: 29 people had X-rays, 27 people did not, 49 had them sometimes, making it the highest group for occasional X-rays. Public healthcare users rarely receive X-rays, with only 2 people getting them sometimes and 2 people not at all. Combined public-private users (Both) had very low X-ray usage, with a nearly equal split across all categories (Table 2).

Private healthcare users in Germany rarely receive X-rays, with only 5 people saying yes. Public healthcare has slightly higher X-ray usage (9 people got X-rays, 13 did not, 31 sometimes). Combined public-private healthcare ("Both") users follow a similar pattern with the majority in the "Sometimes" category (Table 2).

Private healthcare users in other countries have a more balanced X-ray distribution compared to Spain and Germany: 9 received X-rays, 5 did not, and 10 had them sometimes. Public healthcare users in other countries have very low X-ray usage, with 2 people receiving them and 4 sometimes. Both public-private healthcare users show a higher "sometimes" rate (6 people), with very few clear "yes" or "no" responses (Table 2).

	Xray YES	Xray NO	Sometimes	Don't remember
Private Spain	29	27	49	4
Public Spain	0	2	2	0
Both Spain	1	1	2	1
Private Germany	5	9	30	1
Public Germany	9	13	31	0
Both Germany	1	2	13	0
Private Others	9	5	10	1
Public Others	2	0	4	0
Both Others	1	1	6	1

Table 2: X-ray usage during dental visits based on private, public, or combined health systems in different countries

4.3 Awareness and Concerns About X-Ray Exposure

Figure 5 provides data on concern about X-ray exposure and awareness of protective shielding (lead apron) among respondents from Spain, Germany, and Other Countries.

Spain has the highest level of concern, with 70 people (59%) worried about X-ray exposure. Germany has less concern level about x-ray exposure, with only 32 people (28%) expressing worry, while the majority (82 people, 72%) are not concerned. Other countries show moderate concern, with 21 people (52%) worried, and 19 (48%) unconcerned. Most Germans (72%) do not consider X-ray exposure a risk (Figure 5).

Germany has the highest awareness of using a lead apron, with 112 people (98%) knowing about lead aprons. Spain has moderate awareness, with 77 people (65%) knowing about protective shielding. Other countries have the lowest awareness, with only 37 people (92%) aware, while 3 (8%) are unaware (Figure 5)

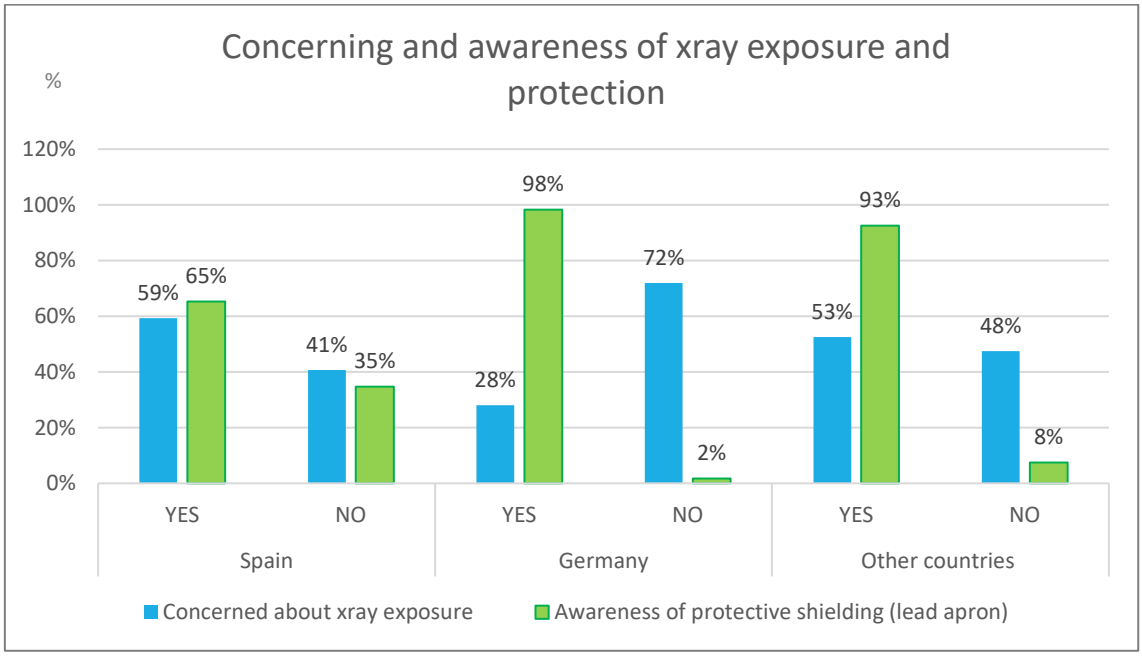

Figure 5: Concerning and awareness of Xray exposure and protection

4.4 Use of lead apron in dental office

In Spain, only 71 patients (40%) were offered a lead apron, while 107 patients (61%) were not. In Germany, 94 patients (82%) received a lead apron, whereas 20 patients (18%) did not. In other countries, 14 patients (35%) were provided with a lead apron, while 26 patients (65%) were not (Figure 6).

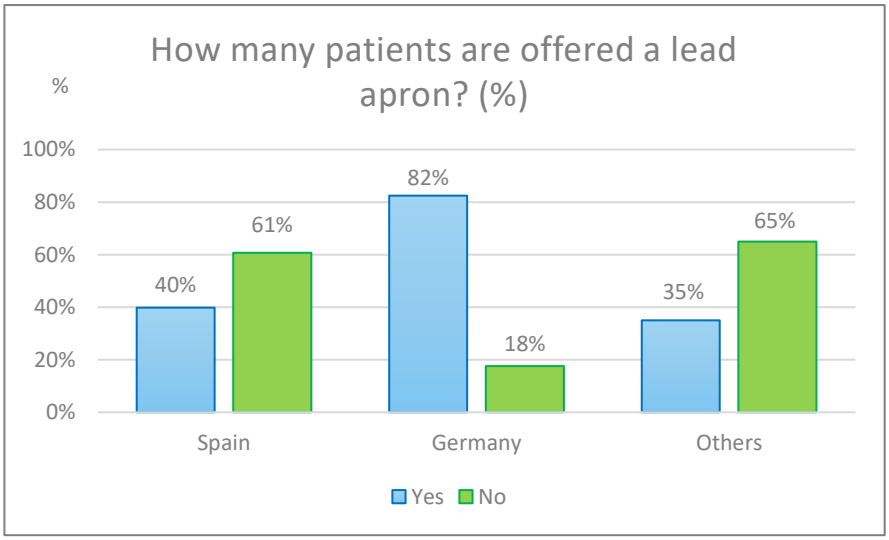

Figure 6: How many patients are offered a lead apron

Figure 7 categorize the data by country (Spain, Germany, Others), gender (Female, Male), and age groups (0-19, 20-39, 40-59, 60-79, Over 80 years). Females are more likely to be offered a lead apron than males in all countries.

In Spain, 27 females (57%) vs. 20 males (43%) were given a lead apron. In Germany, 60 females (64%) vs. 34 males (36%). In Other Countries, both genders have an equal number (7 each (50%). Germany has the highest number of people receiving a lead apron, especially for females (60 women (64%) received it compared to 34 men (36%)) (Figure 7).

Young people (0-19 years) are the least likely to receive a lead apron. Only 2 children (4%) in Spain received one, while in Germany and other Countries, no one in this age group was offered a lead apron. The highest number of lead aprons is given to the 20-39 age group, especially in, Spain (27 people (57%)) and Germany (37 people (39%)), other Countries (9 people (64%)) (Figure 7).

Germany offers lead aprons more frequently to older age groups. 36 people (38%) aged 60-79 in Germany received a lead apron, while only 3 (6%) in Spain and 4 (29%) in other Countries. Germany has the highest number of people receiving a lead apron (188), almost double the number in Spain (94).

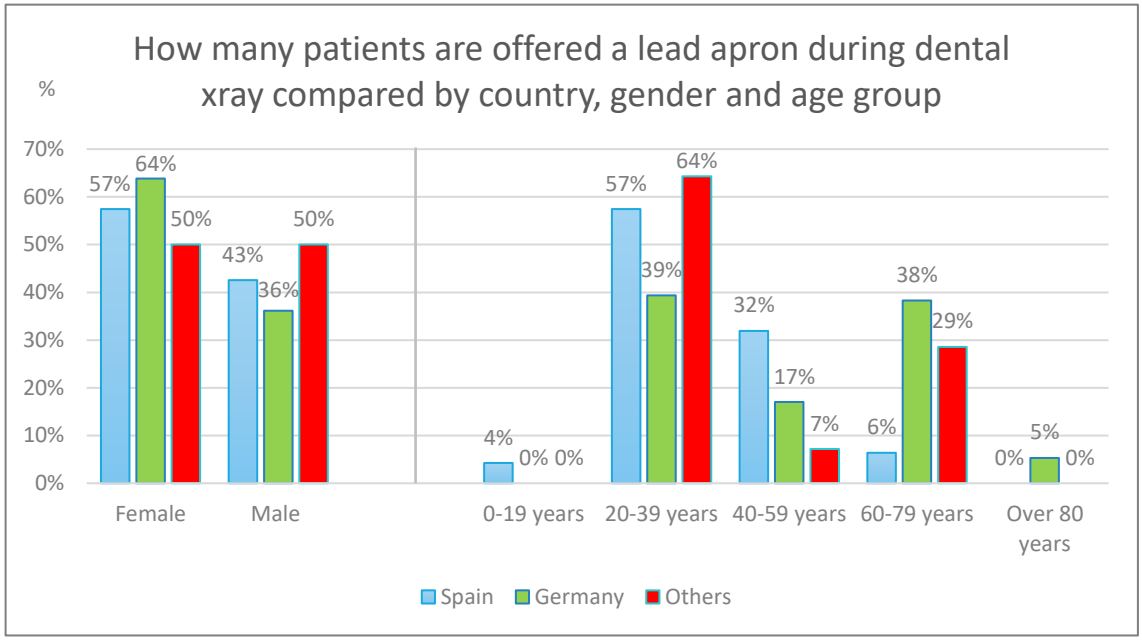

Figure 7: How many patients are offered a lead apron during dental Xray compared by country, gender and age group

These two Figures 8-9 provide insights into patients' reactions when not given protection (whether they ask for it) and whether they feel at risk without protection in Spain, Germany, and Other Countries.

Germany has the highest number of patients (66%) who would ask for protection, compared to 56% in Spain and only 38% in Other Countries. Spain is more evenly divided, with 52 people (44%) not asking for protection. Other Countries have the lowest rate of people asking for protection, with only 38% saying yes, while 63% do not ask for it. (Figure 8)

In all three regions, more people feel at risk without protection than those who ask for it (Figure 9).

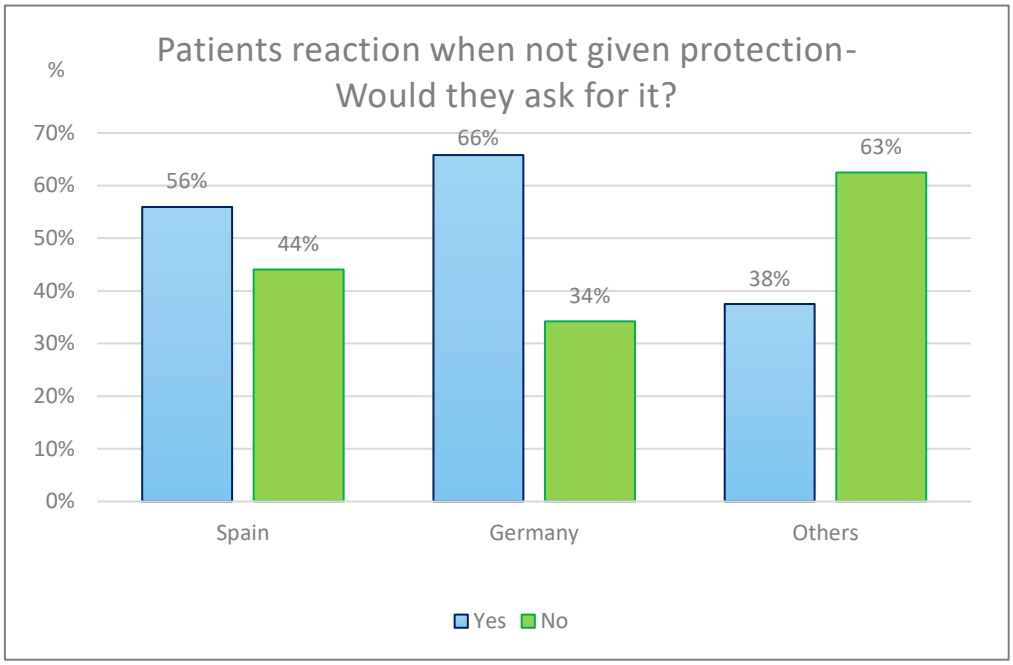

Figure 8: Patient reactions when not given protection—Would they ask for protection?

Spain has the highest number of patients feeling at risk with 68%. Germany follows with 63% feeling at risk, but less patients in Germany (37%) do not feel at risk. Compared to Spain 32% feel no risk. Other Countries show the lowest level of concern, with 55% at feeling risk, and 45% not perceiving any risk (Figure 9).

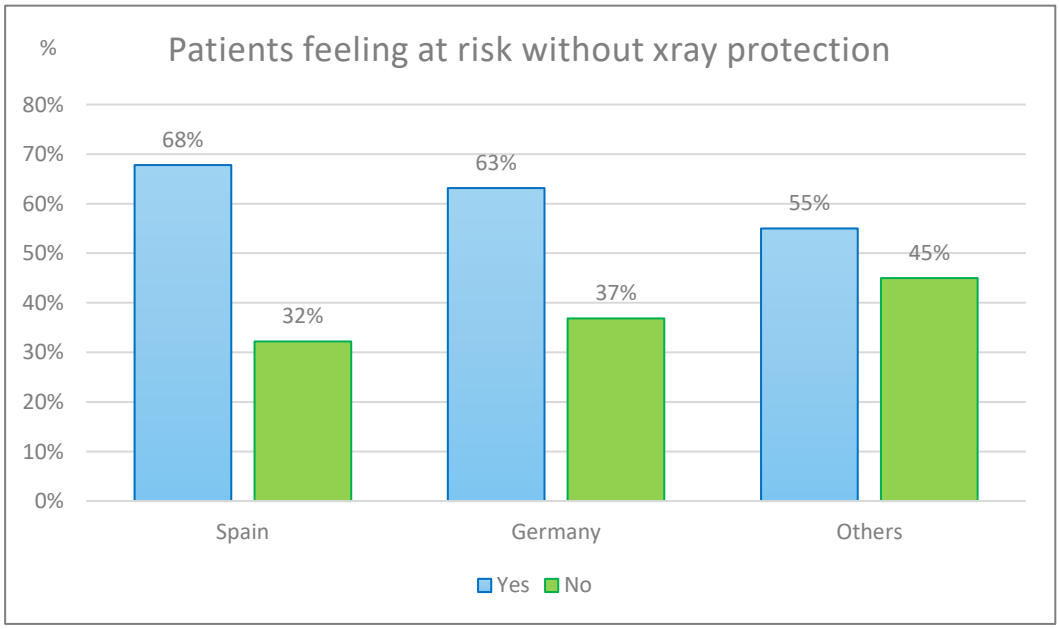

Figure 9: Patients feeling at risk without Xray protection

4.5 Special Cases and Additional Factor

The frequency of dental visits in special situations (pregnancy or cancer treatment) and the use of lead aprons in such cases. Full-mouth X-rays are the most common type across all countries. Spain has the highest number of full-mouth X-rays (53%), followed closely by Germany (51%). Other countries have the lowest rate (43%) (Figure 10).

Germany has the highest number of patients receiving X-rays of only a part of the mouth (45%), compared to 30% in Spain and 50% in Other Countries. A significant number of patients in Spain (18%) reported not having an X-ray at all, whereas Germany (4%) and Other Countries (8%) had much lower numbers in this category (Figure 10).

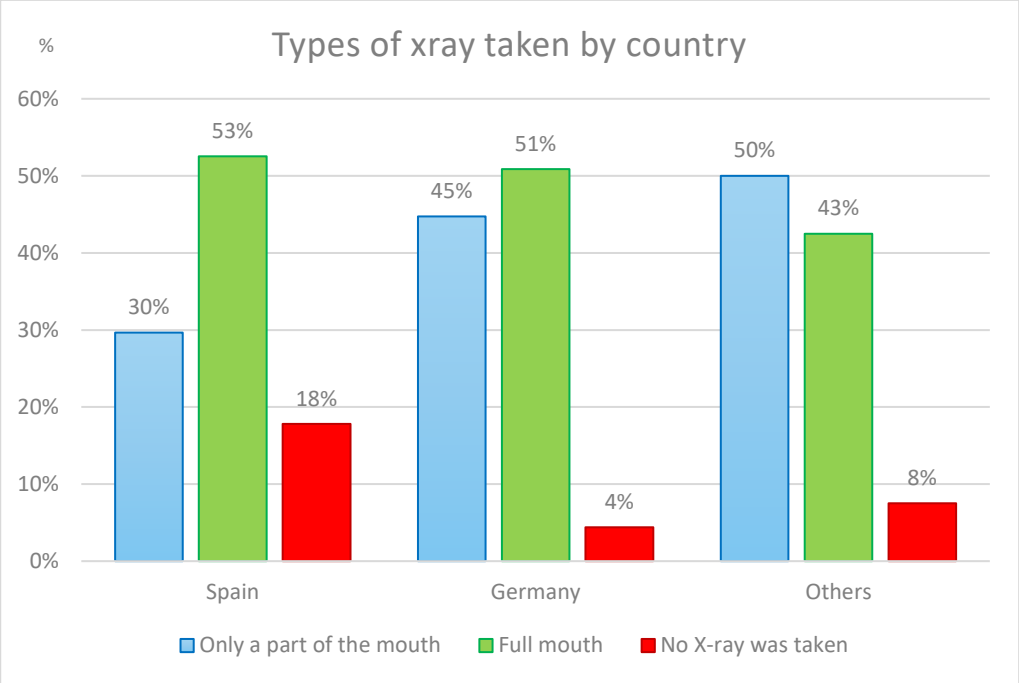

Figure 10: Types of x-rays taken by country

Very few patients reported visiting the dentist during pregnancy or cancer treatment.
Only 1 person in Spain and Other Countries reported such a visit. Germany had slightly more cases (3). In all cases, when an X-ray was taken, a lead apron was used. The numbers match exactly, meaning that in all cases where an X-ray was done during pregnancy or cancer treatment, a lead apron was provided (Figure 11).

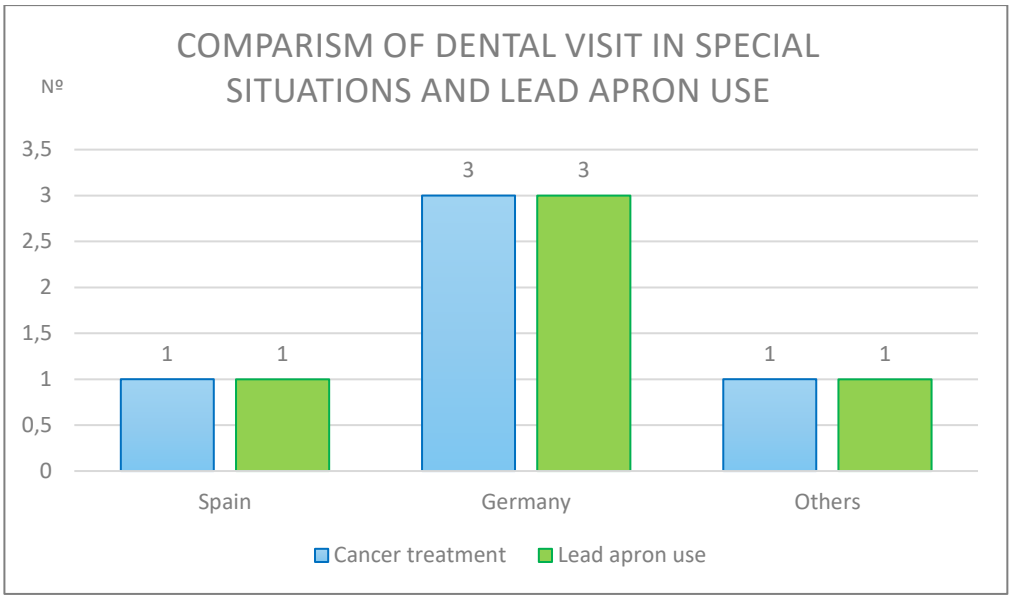

Figure 11: Comparison of dental visits in special situations (pregnancy or cancer treatment) and lead apron use.

Germany has the highest number of pregnant individuals using the lead apron while visiting the dentist (12), but Spain and Other Countries have significantly fewer cases (1 and 3, respectively). Most pregnant individuals in Spain (8) and Germany (18) did not use the lead apron while visiting the dentist. On the other hand, in Other Countries, they use more the lead apron while being pregnant (3 Yes, 2 No) (Figure 12).

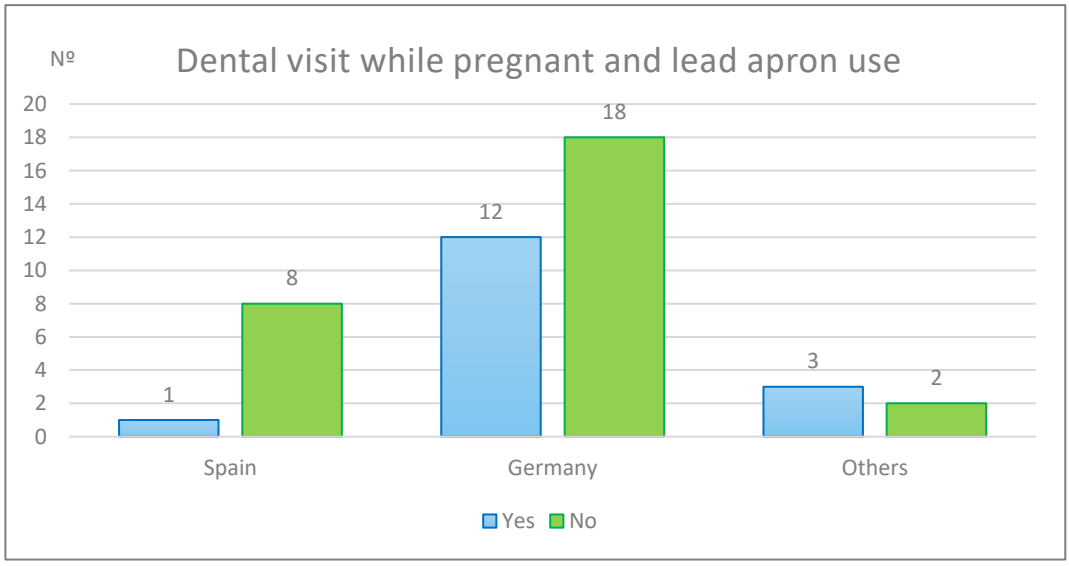

Figure 12: Dental visit while pregnant and lead apron use

4.6 Awareness of Other Radiation Sources

Most people are not aware of the collimator's role in radiation protection (Figure 13). In Spain, 82% of respondents were unfamiliar with its purpose, compared to 75% in Germany and 78% in Other Countries. Germany showed the highest level of awareness (25%), followed by Other Countries (23%) and Spain (18%) (Figure 13).

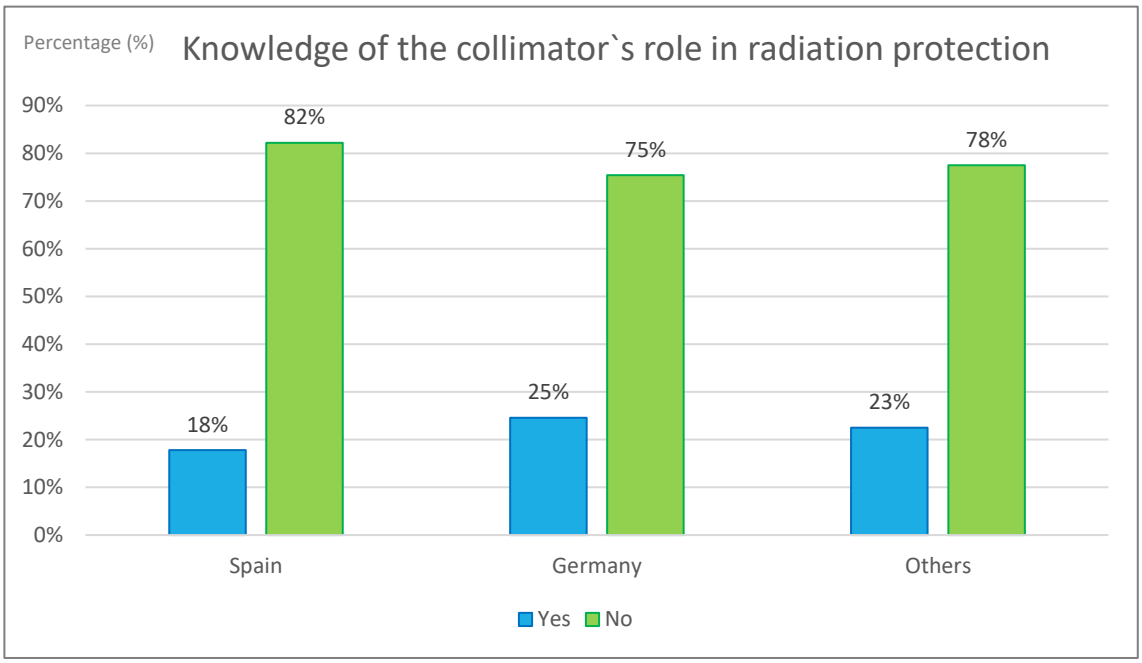

Figure 13: Knowledge of the collimator`s role in radiation

5 DISCUSSION

This study aimed to evaluate the use of lead aprons in dental clinics, comparing practices between Germany and Spain while also assessing radiation protection awareness, healthcare system differences, and patient concerns about ionizing radiation exposure. The results reveal significant disparities in healthcare structures, radiation protection measures, and patient awareness, highlighting areas for potential improvement.

Healthcare System Differences and Their Impact on Radiation Protection

The findings indicate that Spain has a heavy reliance on private healthcare (92.37%), whereas Germany maintains a more balanced distribution between public and private sectors. This distinction may be due to the limited coverage of basic dental treatments by the public health system in Spain (34), which leads many Spaniards to rely on private healthcare.

Germany's insurance system enforces regulation (20), which could explain why radiation protection awareness is higher in Germany. Spain's transition in healthcare may contribute to the inconsistencies in radiation protection measures observed in this study (35). Private insurance coverage can lead to increased healthcare usage, which may collate with Spain's higher dental visit frequency (18).

The availability and implementation of radiation protection guidelines is influenced by the type of healthcare system. Public healthcare systems often enforce stricter regulations and uniform safety standards. In Spain, however, where private healthcare plays a larger role, there may be differences in radiation protection practices as private clinics may operate under different sets of regulations.

Lead Apron Usage and Protective Measures

One of the key findings is that Germany provides lead aprons more consistently across all patient demographics, particularly older adults (60-79 years), whereas Spain focuses more on younger adults (20-39 years).

This confirms that German clinics have stricter policies on radiation shielding, whereas Spain may be more selective in offering protection. The lower distribution of lead aprons in "Other Countries" suggests possible gaps in radiation safety practices that warrant further investigation.

Lead aprons remain widely used, although their necessity has been debated (5). Their effectiveness in reducing exposure and supporting continued use was demonstrated (1). International guidelines from the European Commission (26) and the IAEA (27) may help explain differences in compliance. Spain enforces lower dose limits for intraoral radiography, while Germany has higher thresholds but prioritizes advanced imaging techniques and selective shielding which may explain the results of the difference in using shielding between Germany and Spain (27).

Notably, female patients are more likely to receive lead aprons across all countries, raising questions about whether gender bias exists in radiation protection protocols. Additionally, young children (0–19 years) and elderly individuals (over 80) are the least likely to receive a lead apron, except in Germany, where elderly individuals receive slightly more protection. However, these results may be influenced by an imbalance in the age groups. A higher number of participants were aged between 20–39 and 40–59, meaning that the younger and older age groups were underrepresented.

Patient Awareness and Perceived Risk

The result of awareness and concerns about X-Ray exposure was unexpected, as higher awareness of protective measures would typically be associated with greater concern about X-ray exposure. Germany showed the highest awareness of lead apron use but the lowest level of concern, while Spain showed higher concern but only moderate awareness. This may be explained by greater trust in healthcare regulations in Germany, reducing individual worry despite good knowledge of protection.

Despite high levels of concern about X-ray exposure in Spain (68%), patients are less proactive in requesting protection when the dentist forget it compared to Germany, where 66% of patients actively ask for shielding. Better education programs improve radiation awareness, supporting the suggestion that Spain needs more public education initiatives (36)(37).

Germany's strong regulatory framework and higher patient education levels likely contribute to increased awareness and confidence in radiation safety.

Another critical finding is that while Germany and Spain have similar percentages of dental clinics displaying radiation warning signs (~63%), the presence of signs does not correlate with better explanations about X-ray risks. In Germany, only 30% of patients received an explanation about X-ray exposure, and in Spain, this number is likely even lower. This suggests that simply posting warning signs is insufficient; additional communication methods, such as verbal explanations or written brochures, may be needed to ensure patients understand radiation risks.

X-ray Practices and Their Variability

The study also reveals inconsistencies in X-ray usage across healthcare types and countries. Germany's public healthcare system provides more X-rays than Spain's, yet the overall frequency of X-ray use remains highly variable. Private healthcare clinics tend to use X-rays more frequently than public clinics, which may be linked to financial incentives or differences in clinical decision-making. Interestingly, Spanish patients are more likely to be unsure whether they had X-rays, whereas German patients appear better informed, reinforcing the importance of patient education.

One study compared intraoral and extraoral X-ray techniques, which may help explain why X-rays are used more frequently in some cases than others (3).

The Quality Assurance Audit (2020) evaluated X-ray use in undergraduate dental clinics, which may provide insights into educational gaps that could contribute to the study observed inconsistencies (2).

Radiation Protection During Special Conditions (Pregnancy & Cancer Treatment)

The data show that dental visits during pregnancy or cancer treatment are rare across all countries, but when an X-ray is performed, lead aprons are consistently used.

Germany has the highest number of patients receiving dental care during pregnancy, while Spain has the lowest. Women often lack awareness of safe imaging practices during pregnancy (8). Dose reduction strategies that support the use of shielding techniques are discussed in pregnant women (9).

A review of safety protocols highlighted the importance of properly communicating with pregnant patients (10).

Public Knowledge of Radiation Risks Beyond Dentistry

Interestingly, knowledge about collimators, which is a key radiation protection device, is very limited, with more than 75% of respondents unaware of their function. Even in Germany, which shows the highest awareness levels, only 28 people were familiar with collimators. This highlights a broader gap in public understanding of radiation protection measures.

Implications and Recommendations

The importance of collimation in reducing radiation exposure is emphasized as a key factor in the need for better education(11)(12). The findings of this study emphasize the need for standardized radiation protection guidelines across public and private dental clinics to ensure consistent patient safety. Spain could benefit from more public education initiatives aimed at increasing awareness of radiation protection and encouraging patients to advocate for shielding measures.

Given that warning signs alone do not effectively educate patients, dental clinics should implement additional methods, such as verbal explanations, written pamphlets, or digital resources, to improve communication about radiation risks.

Furthermore, addressing disparities in lead apron distribution across age groups is crucial. The lower protection rates for children and elderly patients suggest a need for more targeted safety protocols to ensure these vulnerable populations receive adequate shielding. Finally, teaching people more about radiation protection tools like collimators could help clear up confusion and help patients make better choices.

6 CONCLUSIONS

The primary goal of this study was to assess how often patients are offered a lead apron during dental X-rays, with a focus on comparing practices in Germany and Spain. The results show a clear difference: while over 82% of patients in Germany reported being offered a lead apron, only about 40% of patients in Spain had the same experience. This significant gap highlights a disparity in the implementation of radiation protection protocols, despite existing guidelines that recommend shielding, particularly for vulnerable groups.

Secondary objectives explored protection for high-risk patients, differences between public and private clinics, and potential areas for improvement. The data indicate that lead apron use is more consistent in Germany, especially in older populations, and that public healthcare systems tend to follow stricter safety protocols. However, children and elderly individuals remain less protected overall, suggesting the need for better enforcement of age-specific safety measures.

Additionally, awareness of radiation protection tools like collimators remains low, reinforcing the importance of patient education. To improve safety and standardized care, both countries would benefit from clearer regulations and from monitoring their enforcement. Furthermore, enhanced public awareness, and more proactive communication between dental professionals and patients regarding radiation risks and protection.

7 SUSTAINABILITY

This study contributes to sustainable healthcare practices by addressing the responsible use of radiological protection in dental settings, focusing on minimizing unnecessary radiation exposure. It aligns with the Sustainable Development Goal 12: "Responsible Consumption and Production," by evaluating and promoting efficient, evidence-based use of protective resources such as lead aprons and collimators. From an environmental perspective, we seek to educate dental professionals to encourage long-term reduction of their ecological footprint by ensuring the use and waste of equipment. Economically, improved awareness and consistent protection standards may reduce long-term healthcare costs by preventing radiation-induced conditions. Socially, the project encourages equity by highlighting disparities in protection practices among age groups, genders, and countries, promoting informed patient participation in healthcare decisions. By identifying gaps in public knowledge and advocating for improved education, the project fosters ethical responsibility and long-term public health awareness. These measures support a sustainable and fair healthcare system that prioritizes safety, prevention, and informed care.

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9 ANNEXES

INFORMED CONSENT

This survey is part of the Graduation Project in Dentistry at Universidad Europea of Madrid titled HOW MANY PATIENTS ARE OFFERED A LEAD APRON TO WEAR DURING DENTAL X-RAYS and directed by *ANA CECILIA HANDLER ARAGONA* The purpose of this work is *is to gather evidence on the use of lead aprons in dental clinics, specifically comparing practices between Germany and Spain* and the information will be collected through a brief survey.

Your participation in this study is voluntary. You may request to be withdrawn from the study without prior justification or prejudice to you. The information collected will be kept confidential and will not be used for any other purpose outside this research and research dissemination purposes. The data collected will be completely anonymous. No personal identifying information will be requested. Information collected in the survey will be treated in accordance with the provisions of Organic Law 3/2018, of December 5, Protection of Personal Data and Guarantee of Digital Rights.

Do you give your consent to participate in the survey as a volunteer for the results to be used in the Final Degree Project HOW MANY PATIENTS ARE OFFERED A LEAD APRON TO WEAR DURING DENTAL X-RAYS?

Yes ☐ **No** ☐

For the purposes of the provisions of the regulation of the Organic Law 3/2018, of 5 December, on the Protection of Personal Data and Guarantee of Digital Rights, you are informed and expressly consent that the data provided in the survey may be used for the aforementioned purposes. This consent is granted without prejudice to all the rights that you have in relation to the aforementioned regulations, with the possibility of accessing the information provided, rectification, cancellation and opposition at any time you wish. For such purposes, you must write to the tutor Prof. *ANA CECILIA HANDLER ARAGONA (anacecilia.handler@universidadeuropea.es)*.

Annex 1: Encuesta español

1. ¿Qué edad tiene?
    a. 0-19 años
    b. 20-39 años
    c. 40- 59 años
    d. 60- 79 años
    e. más que 80 años

2. Sexo
    a. Masculino
    b. Femenino
    c. no especifico

3. ¿En qué país vive?
    a. Alemania
    b. España
    c. Otro

4. ¿Cuándo va al dentista, utiliza el sistema público o privado?
    a. Público
    b. Privado
    c. ambos

5. ¿Cuántas veces al año va al dentista?
    a. 1-3
    b. 4-6
    c. más de 6

6. Cuándo va al dentista a una revisión, ¿le hacen una radiografía?
    a. Si
    b. No
    c. a veces
    d. no recuerdo

7. ¿Le preocupa la exposición a los rayos- x?
    a. Si
    b. No

8. ¿Sabe que se le puede poner una protección cuando le realicen pruebas de rayos- x?
    a. Si
    b. No

9. ¿Ha visitado a su dentista estando embarazada?
    a. Si
    b. No
10. Señale si ha-visitado al dentista en-alguna de estas situaciones personales de salud:
    a. Situación normal de salud

b. Situación especial (embarazo, tratamiento de cáncer)
c. Ambas situaciones

11. ¿Qué tipo de radiografía le hicieron?
A) solo parte de la boca
B) completa de la boca
C) No me realizaron ninguna radiografía

12. ¿Cuándo visitó al dentista le explicaron las consecuencias de la exposición a los rayos X?
a. Si
b. No

13. ¿Cuándo le hacen radiografías en la clínica dental, le ofrecen el "delantal de plomo" (protección ante rayos- X)?
a. Si
b. No

14. ¿En su clínica dental habitual hay señales de advertencia por el uso del rayos- X?
a. Si
b. No

15. ¿Si le preparan para hacerse una radiografía y no le ponen la protección ante los rayos- x, usted proactivamente pediría al profesional esta protección?
a. Si
b. No

16. ¿Si el personal de la clínica no le pone la protección, se siente en riesgo ante de la exposición a los rayos- X?
a. Si
b. No

17. ¿Ha viajado usted en avión alguna vez?
a. Si (1-5 veces)
b. Si (6- 9 veces)
c. Si (más que 9)
d. NO

18. ¿Cuándo viaja en avión ¿le preocupa su exposición a radiaciones ionizantes?
a. Si
b. No

19. El colimador sirve para limitar el tamaño y la forma de los rayos X, reduciendo el riesgo innecesario a la radiación y mejorando la calidad de la imagen.
¿Conocía la importancia del colimador

a. Si
b. No

English version:

1. What is your age?
   a. 0-19 years
   b. 20-39 years
   c. 40-59 years
   d. 60-79 years
   e. Over 80 years

2. Gender
   a. Male
   b. Female
   c. Unspecified

3. Which country do you live in?
   a. Germany
   b. Spain
   c. Other

4. When you go to the dentist, do you use the public or private system?
   a. Public
   b. Private
   c. Both

5. How many times a year do you visit the dentist?
   a. 1-3
   b. 4-6
   c. More than 6

6. When you visit the dentist for a check-up, do they take an X-ray?
   a. Yes
   b. No
   c. Sometimes
   d. I don’t remember

7. Are you concerned about X-ray exposure?
   a. Yes
   b. No

8. Do you know that protective shielding can be used during X-ray tests?
   a. Yes
   b. No

9. Have you visited your dentist while pregnant?
   a. Yes
   b. No

10. Indicate if you have visited the dentist in any of these health situations:
    a. Normal health situation
    b. Special situation (e.g., pregnancy, cancer treatment)
    c. Both situations

11. What type of X-ray did they take?
    a. Only a part of the mouth
    b. Full mouth
    c. No X-ray was taken

12. When you visited the dentist, did they explain the consequences of X-ray exposure?
    a. Yes
    b. No

13. When you get X-rays at the dental clinic, do they offer the “lead apron” (protection against X-rays)?
    a. Yes
    b. No

14. Does your regular dental clinic display warning signs about X-ray use?
    a. Yes
    b. No

15. If you are prepared for an X-ray and not given protection against X-rays, would you proactively ask the professional for it?
    a. Yes
    b. No

16. If the clinic staff does not provide protection, do you feel at risk from X-ray exposure?
    a. Yes
    b. No

17. Have you ever traveled by plane?
    a. Yes (1-5 times)
    b. Yes (6-9 times)
    c. Yes (more than 9 times)
    d. No

18. When traveling by plane, are you concerned about exposure to ionizing radiation?
    a. Yes
    b. No

19. The collimator is used to limit the size and shape of X-rays, reducing unnecessary radiation risk and improving image quality.

Were you aware of the importance of the collimator?
a. Yes
b. No

Deutsche Version

1. **Wie alt sind Sie?**
   a. 0-19 Jahre
   b. 20-39 Jahre
   c. 40-59 Jahre
   d. 60-79 Jahre
   e. Über 80 Jahre

2. **Geschlecht**
   a. Männlich
   b. Weiblich
   c. Nicht angegeben

3. **In welchem Land leben Sie?**
   a. Deutschland
   b. Spanien
   c. Andere

4. **Nutzen Sie beim Zahnarztbesuch das öffentliche oder private System?**
   a. Öffentlich
   b. Privat
   c. Beide

5. **Wie oft gehen Sie im Jahr zum Zahnarzt?**
   a. 1-3 Mal
   b. 4-6 Mal
   c. Mehr als 6 Mal

6. **Wird bei einem Kontrolltermin beim Zahnarzt eine Röntgenaufnahme gemacht?**
   a. Ja
   b. Nein
   c. Manchmal
   d. Ich erinnere mich nicht
7. **Machen Sie sich Sorgen wegen der Strahlenbelastung durch Röntgenstrahlen?**
   a. Ja
   b. Nein

8. **Wissen Sie, dass während Röntgenuntersuchungen ein Schutz verwendet werden kann?**
   a. Ja
   b. Nein

9. **Waren Sie während einer Schwangerschaft beim Zahnarzt?**
   a. Ja
   b. Nein

10. **Geben Sie an, ob Sie den Zahnarzt in einer der folgenden Gesundheitssituationen besucht haben:**
    a. Normale Gesundheitssituation
    b. Besondere Situation (z. B. Schwangerschaft, Krebsbehandlung)
    c. Beide Situationen

11. **Welche Art von Röntgenaufnahme wurde gemacht?**
    a. Nur ein Teil des Mundes
    b. Gesamter Mund
    c. Es wurde keine Röntgenaufnahme gemacht

12. **Wurden Ihnen beim Zahnarztbesuch die Folgen der Strahlenbelastung durch Röntgenstrahlen erklärt?**
    a. Ja
    b. Nein

13. **Wird Ihnen bei Röntgenaufnahmen in der Zahnarztpraxis eine „Bleischürze“ (Schutz vor Röntgenstrahlen) angeboten?**
    a. Ja
    b. Nein

14. **Gibt es in Ihrer regulären Zahnarztpraxis Warnschilder zur Verwendung von Röntgenstrahlen?**
    a. Ja
    b. Nein

15. **Wenn Sie für eine Röntgenaufnahme vorbereitet werden und keinen Schutz gegen Röntgenstrahlen erhalten, würden Sie den Fachmann aktiv danach fragen?**
    a. Ja
    b. Nein

16. **Fühlen Sie sich bei einer Röntgenaufnahme ohne Schutz durch das Klinikpersonal einem Risiko ausgesetzt?**
    a. Ja
    b. Nein

17. **Sind Sie schon einmal mit dem Flugzeug gereist?**
    a. Ja (1-5 Mal)
    b. Ja (6-9 Mal)
    c. Ja (mehr als 9 Mal)
    d. Nein

18. **Machen Sie sich bei Flugreisen Sorgen wegen ionisierender Strahlung?**
    a. Ja
    b. Nein

19. **Der Kollimator dient dazu, die Größe und Form der Röntgenstrahlen zu begrenzen, wodurch das unnötige Strahlenrisiko reduziert und die Bildqualität verbessert wird.**
Waren Sie sich der Bedeutung des Kollimators bewusst?
a. Ja
b. Nein