Population Dose from Dental Radiology: 2010

Executive Summary of Results

The Health Services Executive (HSE) has a legal obligation, under Article 12 of the European Commission Medical Exposures directive (1997)\(^1\) and Article 22.6 of Statutory Instrument 478 (2002)\(^2\), to collect and publish statistics on population dose levels from the use of medical ionising radiation. In 2008 the first modality chosen to be surveyed by the National Radiation Safety Committee was CT, and this was completed in 2010. Being the first such population dose survey the development of protocols and procedures for survey took longer than would be expected for future surveys. In 2010 the second modality chosen survey of by the Population Dose Sub-Committee of the NRSC was Dental Radiology, to coincide with the 2010 “Review of Compliance with Patient Radiation Protection Legislation”\(^8\).

The Review of Compliance recorded examination frequency for dental radiology, from all dental practices, both public and private, on the HSE register of ionising radiation installations.

This survey found there to be 511 dental x-ray units per million of the population, compared to other European countries, where a range of 350 – 1390 dental x-ray units per million of the population have been reported\(^7\).

The Collective Effective Dose to the population from dental radiology was found to be 6manSv. This could be compared to the Collective Dose from CT of 1368manSv.

The Dose per Caput from dental radiology (Collective effective dose averaged over the population) was found to be 1.3µSv (0.0013mSv). This can be compared with international reports of 1.8µSv dose per caput from dental radiology in the UK\(^{17}\) and 6.4µSv in the USA\(^{15}\).
Introduction

The Health Services Executive (HSE) has a legal obligation, under Article 12 of the European Commission Medical Exposures directive (1997)\(^1\) and Article 22.6 of Statutory Instrument 478 (2002)\(^2\), to collect and publish statistics on population dose levels from the use of medical ionising radiation.

In 2008 the Population Dose Sub-Committee\(^3\) recognised that it would not be practicable or meaningful to produce a report annually to cover all modalities. Thus it was decided to deal with a specific modality annually on a five year cycle basis. The first modality selected was Computed Tomography.

In 2010 the NRSC completed a Survey of Dental Compliance with SI478, 2010. This included questions on frequency of examination. Given the high response rate to this survey the NRSC chose to utilise the frequency data obtained to review population dose was Dental radiology. The scope of the 2006 report of the Radiological Protection Institute of Ireland (RPII) “Radiation Doses Received by the Irish Population”\(^5\) did not include dental radiology and so this is the first report to consider population dose from dental radiology to the Irish population.
Methodology

To assist member states with the implementation of Article 12 the European Commission published European Guidance on Estimating Population Doses from Medical X-ray Procedures\(^7\). This document has been useful to the Population Dose Sub-Committee in formulating methodology and in reporting on population dose.

Numbers of dentists using radiography

The 2010 Review of Compliance\(^4\) provided data on the number of dentists associated with the use of ionising radiation equipment, and this data is a useful comparison to that reported by other European countries as contained in RP-1547:\(^7\).

Dental X-ray Equipment and Locations

The register of all ionising radiation installations in Ireland, both public and private, held by the HSE provided data on the numbers and locations of dental x-ray equipment in Ireland. The Review of Compliance relates to examination frequency from Dental Radiology for the twelve month period January to December 2010.

Frequency of Dental X-ray use.

An 82.7% response rate to the 2010 Survey of Dental Compliance with SI\(^478\)\(^4\) provided data on the estimated number of dental x-rays per practice over a two week period. This was extrapolated to an annual figure (assuming 46 working weeks\(^8\)) and further extrapolated to a national figure. This provided information on the estimated annual frequency of dental x-ray examinations.

Effective Dose Determination

Irish statutory instruments SI 125(2000)\(^9\) and SI\(^478\) (2002)\(^2\) enact the European Council Directives 96/29\(^10\) and 97/43/EURATOM\(^1\) which take into account the 1990 recommendations of the International Commission on Radiological Protection (ICRP)\(^1\)\(^1\) on protection against the risks associated with ionising radiation, which do not weight highly the radiosensitivity of the salivary gland. However, in recent years the ICRP have revised their view of the radiosensitivity of some organs, increased the risk factor associated with radiation exposure to the salivary glands, and published their most recent recommendations ICRP-103 in 2007\(^1\)\(^2\). The European Commission is revisiting the Directive 97/43/EURATOM\(^1\) in light of these revised recommendations.

The Dose Reference Level (DRL) for intra-oral examinations were approved by the Dental Council in 2010\(^6\) at 4mGy Entrance surface dose, based on European recommendations\(^7\). No DRL has been set for panoramic, lateral cephalometry or cone beam CT (CBCT), and it was therefore not possible to determine population dose using DRL.

Dental x-ray units generally do not provide a direct measure of the effective dose to the patient, but rather indirect indications such as exposure time are provided. Collating suitable data for conversion to effective dose, in order to calculate population dose, would be resource intensive for each dental practice, with the effort required not commensurate with the expected proportion of collective dose to the
population from medical diagnostic procedures. European surveys on population
dose\(^7\) that have included dental radiology indicate that dental radiology contributes
less than 1\% to the total collective dose from diagnostic medical exposures.

Routine biennial quality assurance of dental x-ray units is carried out by the Radiation
Protection Advisor appointed to the location. While the responsibilities of the RPA do
not extend to patient protection, and accordingly issues relating to patient doses, in
practice RPAs may make a measurement of patient doses during their QA testing.
Intra-oral x-ray dose can be recorded as Entrance Surface Dose mGy, for which
conversion factors to Effective Dose are available. The dose for panoramic x-rays is
generally recorded as Dose Width Product mGycm, a parameter for which the
conversion factor to effective dose is not readily available. It was therefore not
possible to obtain sufficient information on the effective dose from dental x-ray
examinations from biennial QA reports.

The average effective dose to the patient from each dental examination has, therefore,
been taken from data published by Ludlow\(^{18}\) in 2008. This publication takes into
account the ICRP 2007 recommendations\(^{12}\) on the radiosensitivity of the salivary
glands. A report on the DRL for Wicklow was published in 2008, indicating a DRL of
2.5mGy\(^{20}\), which is in keeping an average effective dose of 5\(\mu\)Sv as reported by
Ludlow\(^{18}\).

Additional effective dose information has been obtained from Poppe\(^{22}\), Vano\(^{23}\) using
the conversion coefficients of Looe\(^{21}\), and from Ngan\(^{24}\). The average effective dose
from CBCT has been taken from Ludlow 2006\(^{25}\) and Roberts\(^{26}\), assuming a small field
of view.

**Population Dose**
Population dose is reported as the annual Collective Effective Dose manSv and Dose
per Caput as recommended by RP-154\(^7\).

The collective dose is defined as the sum of the average effective dose for each
examination multiplied by the frequency of each examination.

The Dose per Caput is defined as the collective dose average over the whole
population

The population for 2010 has been taken as the same as that from the 2006 Census
4,429,848\(^{16}\)
Results

The Survey of Dental Compliance 2010 commenced in July 2010, and an 82.7% response rate was achieved.

Numbers of Dentists

The Dental compliance survey identified 1,670 dentists involved in the use of ionising radiation, covering 82.7% of clinical practices. This extrapolates to 312 dentists per million of the population involved with the use of ionising radiation.

The European Average number of dentists per million of the population is 740 compared to 606 dentists per million of the population registered with the Dental Council in Ireland. (fig1)

Number of Dental X-ray units for the population

There are 511 dental x-ray units per million0 of the population in Ireland in 2010. This is within the range reported for many other European countries from surveys undertaken between 1998 and 2003 (fig2).
Number of Dental X-ray Units per Million of the Population

Figure 2. Number of dental x-ray units per million of the population across Europe

Number of Dental X-rays per annum

RP-1547 and Rp-13619 report on the number of Dental x-ray examinations per year per 1000 of the population. Figure 3 illustrates the European comparison with the Irish data collected in the Review of Compliance.

The number of dental x-rays per 1000 in Sweden is out of line with that in the remainder of countries for which data is available. Excluding Swedish data the European average number of dental x-rays per 1000 is 277, compared to 193 dental x-rays per 1000 in Ireland.

Figure 3. Number of dental x-rays per annum per 1000 of the population. European data is taken primarily from RP-13619, supplemented by data from RP-1547

Effective Dose from Dental X-rays
Figure 4 illustrates the Effective Dose levels chosen to determine population dose. The average Effective Dose (µSv) for intraoral, panoramic, and Lateral Cephalometry x-rays has been taken from Ludlow et al (2008)18. This approach was also taken in the recent UK population dose17. The Effective Dose for a dental occlusal x-ray has been taken from Ngan et al, while the average effective dose for CBCT has been taken from Ludlow et al (2006)24.

![Effective Dose from Dental X-ray](image)

Figure 4. Effective from dental x-ray examinations

**Diagnostic Reference Levels for Dental X-ray**

The Diagnostic Reference Levels (DRL) for intraoral dental radiographs of 4mGy was approved by the Dental Council in 20106, was based on the recommendation of RP-13619. The DRL is the dose level not expected to be exceeded for standard procedures, for standard size patients, when good and normal practice regarding diagnostic and technical performance is applied.

The DRL is generally determined as the 75th Percentile of the dose distribution delivered for each examination, where the dose is a practicable parameter associated with that modality. In the case of Intraoral and Occlusal dental x-rays DRL is generally determined from the Entrance Surface Dose (ESD) or Dose Area Product (DAP), while for Panoramic, Lateral Cephalometry and CBCT it is determined from the Dose Area Product (DAP).

A report on the DRL for intraoral examinations in Wicklow was published in the Journal of the Irish Dental Association 2008, and indicated a DRL of 2.5mGy (ESD). A DRL of 2.5mGy is in keeping with an average effective dose of 5µSv as reported by Ludlow et al18.

A detailed survey of DRL levels for all dental x-ray examinations would greatly assist in validation of the approach taken here to adopt published figures on effective dose levels.

**Population Dose**
The average effective dose (\(\mu\text{Sv}\)) per dental x-ray examination type combined with the frequency of the x-ray examination has been used to determine the population dose from dental x-ray.

The Collective Effective Dose (CED) population from dental x-rays was calculated to be 6\(\text{manSv}\).

Taking the other CED from CT scans from the 2010 report\(^ {27}\) and assuming all other medical doses remain the same as the 2006 report\(^ {5}\), this translates to a total Collective Effective Dose for 2010 of 2050\(\text{manSv}\), of which less than 0.3% is attributable to dental x-rays.

The Dose per Caput was found to be 1.3\(\mu\text{Sv}\) (0.0013\(\text{mSv}\)) per head of the population, leading to a total Dose per Caput from all medical radiology of 0.48\(\text{mSv}\).

Figures 5 and 5 illustrate the breakdown by examination type to the overall frequency and CED from dental radiology. The Dental Council in 2010 issued guidance on the cessation of the use of vertex occlusal examinations and therefore it is expected at the next report on dental population dose will see a decline in the CED from this examination.
Recommendations for future work on Population Dose from Dental X-ray

1. It is recommended that an survey of Dose Reference Levels, in units of DAP(mGycm2), for dental x-ray examinations be undertaken.

2. It is recommended that any revision of the Code of Practice for Dentistry require biennial QA assessments to record the Dose Area Product from all dental examination types to facilitate conversion to effective dose and the determination of population dose.
References


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