Dental X-ray and Mammography Safety

Definition: Radiation safety inspections of dental X-ray offices determine the type of imaging system, provide estimates of patient exposure, measure the quality of image processing, and evaluate X-ray machine performance. An indicator of unnecessarily high radiation exposure is determined by comparing average estimated patient radiation exposure (entrance skin exposure) from dental intra-oral X-ray procedures to national averages. Mammography facility inspections provide estimates of radiation dose to the breast (glandular dose) and data on image quality score (the ability of the image to show fine detail). Indicators of mammography quality are mean glandular dose and the percent of mammography facilities issued violations for not meeting FDA radiation standards. Image quality score is used as an indicator of the ability of the mammography X-ray system to allow accurate diagnoses to be made.

Summary

Health care X-ray facilities and equipment are inspected to protect patients, the general public, and workers. The goal is to achieve the best diagnostic quality image for the least amount of radiation exposure to the patient. Dental intra-oral X-rays and mammography are two common health care procedures using X-rays.

Radiation exposure from dental intra-oral X-rays depends primarily on the type of imaging system used. Digital imaging systems result in less radiation exposure than use of E/F-speed film. The use of E/F-speed film results in less exposure than the use of D-speed film. In Washington, the use of D-speed film has been decreasing, while use of digital systems has been increasing. The number of dental facilities using digital image systems increased steeply from 1% in 1998 to 24% in 2005. In 2005, 71% of Washington dental offices inspected still used D-speed film.

The number of mammography facilities with inspection violations in Washington decreased from 53% in 2002 to 20% in 2005. As image quality scores have improved on average, the mean glandular dose has increased both in Washington and nationally.

Introduction

More than 5,900 X-ray facilities operate in Washington. Major users of X-ray devices are: dentistry, industry, medicine, chiropractic medicine, veterinary medicine, podiatry, education, research, and law enforcement. This chapter focuses on two common types of X-ray procedures with national comparison values or standards: dental intra-oral radiography and mammography.

X-ray examinations account for much of the public's exposure to ionizing radiation. Regulations and inspections of medical and dental X-ray devices minimize unnecessary radiation exposure and help assure that patients receive the best diagnostic quality images with the least amount of radiation exposure.

Many technical factors influence patient radiation exposure. These include the type of imaging system, how the X-ray machine is operated, how well the film is processed, and equipment performance. For example, using a faster-speed film decreases patient exposure by shortening X-ray exposure time.

Radiation safety inspectors estimate patient radiation exposure from a specific X-ray procedure by measuring radiation at the point where it enters the patient. (See Technical Notes for a discussion of radiation measurement units.)

Description of Potential Indicators

The indicators of potential health hazards in dental and mammography facilities focus on unnecessary radiation exposure for the patient, worker, and general public.

Hazard indicators. Because radiation exposure depends on the type of dental equipment used, inspectors measure the proportion of dental facilities that deliver lower radiation doses.

Exposure indicators. The amount of radiation to which a patient is exposed from an X-ray procedure is expressed as millirad to a specific site, such as entrance skin exposure (ESE) for dental intra-oral X-rays or mean glandular dose for mammograms. The number of repeat dental intra-oral X-ray procedures

or mammograms is another exposure indicator. Appropriate exposure is that which achieves an optimal balance between level of radiation exposure and the ability of an X-ray procedure to produce a diagnostic-quality X-ray image.

Protective indicators. The proportion of X-ray facilities inspected and meeting safety standards is a protective indicator. Indicators of inadequate protective efforts include the number or proportion of patients receiving more radiation exposure than intended or misadministration of an X-ray procedure such as exposing the wrong patient or wrong body part. X-ray facilities in Washington are expected to report these types of incidents voluntarily.

Regulators review construction plans for new or remodeled medical facilities to ensure adequate shielding of stray radiation for the safety of workers and the general public. In Washington, about 200 construction plans are reviewed each year.

Health outcome indicators. Excessive radiation exposures from X-ray procedures can result in reddening of the skin, burning of the skin and other tissues at much higher exposures, and an increased risk of cancer. Localized health effects such as skin reddening are not normally tracked. It is difficult to attribute cases of cancer specifically to medical X-ray procedures.

Dental X-ray Exposures

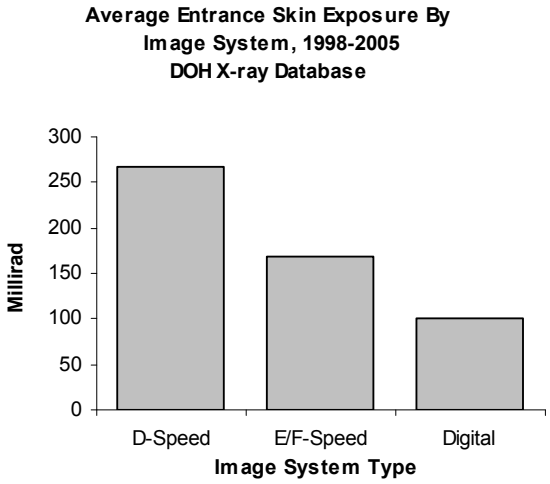
A dental facility provides care of the mouth, teeth, tongue, gums, and jaws. More than 2,900 dental X-ray facilities are located in Washington, and each one is inspected every five years to determine if it meets state radiation safety standards.

A dental radiation safety inspection determines the type of imaging system (D-speed film, E/F-speed film, or digital), estimates patient exposure, measures the quality of the image processing, and checks the X-ray machine settings and performance.

Dental intra-oral procedures are addressed in this chapter because these are the most common dental X-ray procedures.

Type of Imaging System and Patient Exposure

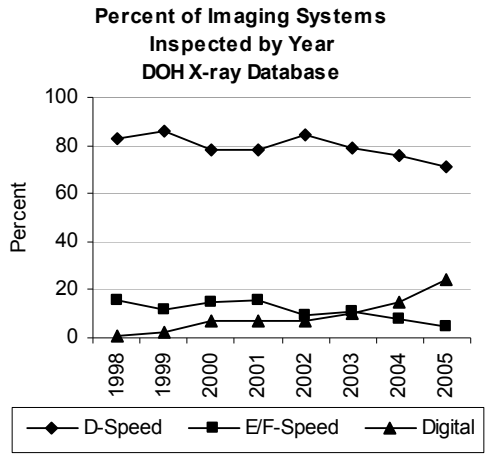
Image systems using D-speed film by design require higher patient exposure than E/F-speed film or digital systems. Based on Washington State inspection data from 1998 through 2005, use of D-speed film resulted in an average entrance skin exposure (ESE) of 268 millirad, while E/F-speed film resulted in average ESE of 169 millirad. Use of a digital system resulted in an average ESE of 100 millirad, a 63% lower patient exposure than D-speed film.



The latest national comparison data for patient exposures from dental intra-oral X-ray procedures is from 1999. Comparing data for 1999 only, Washington State's average ESE value for D-speed film was 251 millirad, which exceeded the 1999 national average ESE value of 195 millirad. The reason for this difference is not known. Washington's average ESE value for E/F-speed film, 147 millirad, was very close to the 1999 national average ESE value of 148 millirad. A national comparison value for digital systems is not available.

Time Trends

In Washington, the use of D-speed film has been decreasing, while use of digital systems has been increasing. In 2005, 71% of dental facilities inspected in the state used D-speed film imaging systems, down from 86% in 1999. In 2005, E/F-speed film and digital systems were used in 5% of dental facilities inspected. From 1998 to 2005, the percent of inspected dental facilities with digital imaging systems grew from 1% to 24%.



Mammography

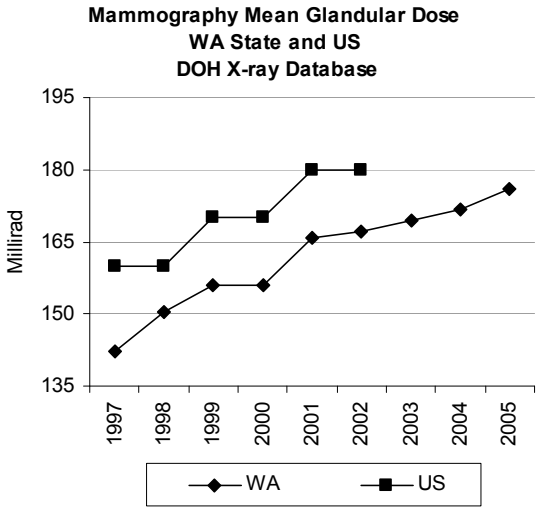
Screening mammograms detect breast cancer at its earliest, most treatable stage. Public health agencies recommend that women 40 and older should get a screening mammogram every one to two years. The Washington Behavioral Risk Factor Surveillance System survey for 2004 indicates 62% (±3%) of women ages 40–49 reported having a mammogram in the past two years. Among women ages 50 and older, 79% (±1%) reported having a mammogram in the past two years.

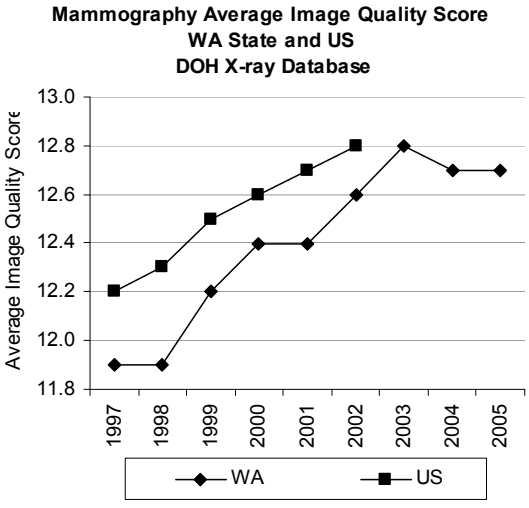
National mammography quality standards are set by the U.S. Food and Drug Administration (FDA) through The Mammography Quality Standards Act (MQSA), which Congress enacted in 1992.[1] Inspections are conducted by Washington State Department of Health staff who have been trained by the FDA. Mammography facilities that do not comply with standards are issued citations and are required to correct those violations or risk the loss of federal certification for mammography.

About 150 mammography facilities operate in Washington. Facilities are inspected annually to ensure that standards are met in terms of operator experience and training; X-ray machine performance, including mean glandular dose (patient exposure to the breast in units of millirads) and image quality or resolution score (ability to see fine detail); and quality control measures, such as weekly image quality tests and daily processor performance tests. A lower mean glandular dose is not necessarily better, because image quality might suffer if the amount of radiation is not sufficient to ensure a diagnostic-quality radiograph. The image quality score is derived from the number of objects visible in a breast model and indicates the quality of fine detail in the X-ray image.

Time Trends

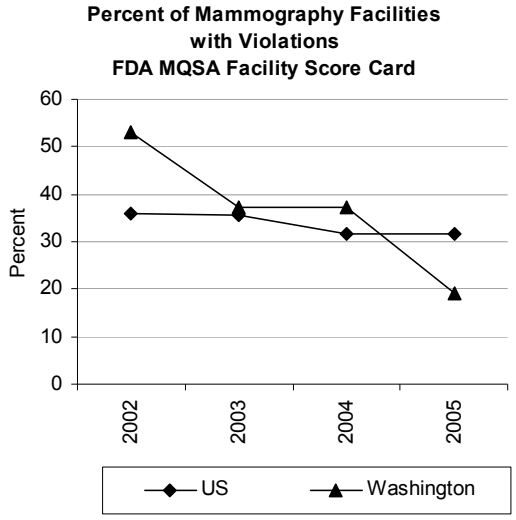
The mean glandular dose has been steadily increasing in Washington State and nationally. From 1997 to 2005, the mean glandular dose rose from 142 millirad to 175 millirad, well below the maximum glandular dose allowed by the FDA (300 millirad). The most recent national data are from 2002, when the mean glandular dose was 180 millirad.





From 1997 through 2002, image quality scores increased in Washington State and nationally. Since 2003, Washington State image quality scores have been stable in the range of 12.6 to 12.8. The last reported national average was 12.8 in 2002. The maximum possible image quality score is 16.

From 2002 to 2005, the percent of mammography facilities in Washington State with violations of MQSA standards decreased from 53% to 20%. Nationally, the percent of mammography facilities with violations has remained about 34%. In 2005, there were no serious violations in Washington, while 2% of facilities nationwide had serious violations.



Year 2010 Goals

There are no *Healthy People 2010* objectives that pertain to X-ray procedures or inspections.

Intervention Strategies

Regulatory and educational strategies seek to produce the best diagnostic quality X-ray radiographs for the least amount of radiation exposure. These strategies involve:

- Routinely inspecting X-ray facilities to assure compliance with relevant radiation safety standards, taking enforcement actions when required, and fielding an adequate number of trained inspectors
- Ensuring X-ray operator competence and certification, proper maintenance of equipment, and safe operating procedures
- Educational outreach to health care providers, workers, and patients on ways to reduce unnecessary radiation exposure from X-rays and to improve facilities' quality assurance practices.

See Related Chapters: Female Breast Cancer, Oral Health

Data Sources

Washington State X-ray facility database, 2006

Conference of Radiation Control Program Directors. Nationwide Evaluation of X-ray Trends (NEXT) Tabulation and Graphical Summary of 1999 Radiography Survey, November 2003, CRCPD publication E-03-6

U.S. Food and Drug Administration (FDA) Mammography Quality Standards Act (MQSA) Facility Score Card, http://www.fda.gov/cdrh/mammographpy/archives/scorecard-statistics-archive.html#0107

U.S. Centers for Disease Control and Prevention, Behavioral Risk Factor and Surveillance System survey, 2004

For More Information

Department of Health X-ray Hotline: (800) 299-9729

Department of Health X-ray website: http://www.doh.wa.gov/ehp/rp/xray/xrayhome.htm

Technical Notes

X-Rays are defined as electromagnetic waves emitted from the outer shell of the atom instead of the nucleus. They have no charge and are best shielded by thick layers of lead or steel. X-ray energy may cause an external or internal radiation hazard.[2]

The following paragraphs explain radiation measurement units and how they are used in this chapter.[2]

A **Roentgen i**s a unit of exposure to ionizing radiation. It is that amount of gamma or x-rays required to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air under standard conditions. It represents how much ionizing radiation enters a person's body.

Rad is a special unit of absorbed dose. It is a measure of the energy absorbed per mass of material. Dose refers to the amount of radiation energy that is actually absorbed by the tissues in the body. One Rad has 1,000 millirads. The unit used in countries other than the United States is the gray (Gy). One Gy equals 100 rad, and 100 millirads equals 1mGy.

REM (Roentgen Man Equivalent) reflects the radiation dose received by the body, after accounting for the potential for harm from different types of radiation. To convert rads to rems, the number of rads is multiplied by a number that reflects the potential for damage caused by a type of radiation. For beta, gamma, and X-ray radiation, this number is generally one. For some neutrons, protons, or alpha particles, the number is 20.[3] The unit used in countries other than the United States is the sievert (Sv). One Sv equals 100 rem.

For purposes of this chapter, millirad is the unit used for both exposure and dose. Technically, millirad is the unit for absorbed dose, millirem is a unit of dose equivalent, and milli Roentgen is

the unit used for radiation exposure. In the case of diagnostic X-rays and beta radiation, all three units are essentially equivalent numerically. These units are not equivalent in the case of alpha or neutron types of radiation.

Film speed used in dental intra-oral imaging systems: The X-ray film speed used for dental intra-oral examinations is D-speed (slowest), E-speed (faster), and F-speed (fastest). The faster the film used, the less exposure the patient experiences. This means a dentist using D-speed film uses more radiation exposure to obtain an X-ray image than if E- or F-speed film or digital imaging were used. It should be noted that E-speed film is no longer available, and the difference in speed between E- and F-speeds is small compared to the difference between them and D-speed film. Consequently, data for E- and F-speed are combined in the text and accompanying charts.

The national comparative value for patient exposure from a dental intra-oral examination is found in the Nationwide Evaluation of X-ray Trends (NEXT) documents. NEXT is a federal–state partnership between FDA and the Conference of Radiation Control Program Directors. Each year, the NEXT survey program selects a particular radiological examination for study and captures radiation exposure data. The dental intra-oral exam was done in 1999 and is used here for comparison purposes.

The commonly accepted phrase for the average radiation dose to the breast is mean glandular dose rather than average glandular dose. The term “average” rather than “mean” is used elsewhere in this document.

Endnotes

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[1] Spelic, D. C., Kaczmarek, R. V., Hilohi, M., & Belella, S. (2007). United States radiological health activities: inspection results of mammography facilities. *Biomedical Imaging and Intervention Journal*, *3*(3), e35.

[2] Radiation Glossary. (2007, October). Olympia, WA: Washington State Department of Health, Office of Radiation Protection webpage: http://www.doh.wa.gov/ehp/rp/radgloss.htm.

[3] HHIN. Hanford Health Information Network Glossary. (n.d.) Olympia, WA: Washington State Department of Health, Office of Environmental Health webpage: http://www.doh.wa.gov/hanford/glossary.html.