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CURRENT RADIATION SAFETY PRACTICES OF UNITED STATES DENTAL HYGIENISTS

by

Kimberly Lintag
B.S. May 2016, Old Dominion University

A Thesis Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

DENTAL HYGIENE

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May 2018

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ABSTRACT

CURRENT RADIATION SAFETY PRACTICES OF UNITED STATES DENTAL HYGIENISTS

Kimberly Lintag
Old Dominion University, 2018
Director: Prof. Ann Bruhn

Problem: The purpose of this study was to determine licensed dental hygienists' current radiation safety practices.

Methods: Data was collected with a 22 item, IRB exempt online survey administered to a sample of 1,500 U.S. dental hygienists who were subscribers of a professional journal. Questions focused on respondents' use of ADA selection criteria guidelines, policies implemented by their dental practice, and hand-held portable x-ray device use and training. A response rate of 38% (N=566) was obtained. Cross tabulations were obtained using logistic regression and general linear models for significance at a 0.05 level.

Results: A majority of respondents had an associate's degree (62%), participated in a radiology course for two semesters or less (84%), and were aged 55 and above (41%) with 31 or more years of experience (38%). Dental hygienists were significantly more likely to select the appropriate criteria for determining radiographic need with more years of experience ($p=0.0340$; $SE=0.1093$). Dental hygienists with a bachelor's degree or higher were significantly more likely to use radiographic techniques that reduce radiation exposure than those with an Associate's degree ($p=0.0080$; $SE=0.0169$). Only 57% of respondents who currently use a hand-held portable x-ray device received training prior to use. Respondents were significantly more likely to wear a clinician lead apron when using a hand-held device if they had recently taken dental radiation safety continuing education (CE) courses ($p=0.0093$; $M=1.571$; $SD=1.222$).

Conclusion: Dental hygienists with more years of experience, a higher level of education, and recent CE course work were more likely to follow the ADA selection criteria guidelines and use the appropriate technique to reduce exposure to ionizing radiation.

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TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Figure Page

CHAPTER I

INTRODUCTION

Dental radiographs are an essential component of a complete treatment plan for oral disease management and diagnosis.[1] Radiation emitted to produce dental radiographic images is ionizing radiation, which contains enough energy to cause stable atoms to become unstable.[2-5] Since a threshold amount of ionizing radiation to which no biological risk could occur does not exist, there is a potential for adverse effects from dental radiation alone.[4,6-7] Ionizing radiation has the ability to damage DNA; therefore, dental radiographers should abide by the As Low As Reasonably Achievable (ALARA) principle to minimize the exposure to ionizing radiation.[1,6,8-10] Steps should be taken to minimize radiation exposure in dentistry and dental hygiene to protect both the patient and operator from the effects of radiation exposure.[11] The International Commission on Radiological Protection (ICRP) recommends clinicians follow the ALARA principle to minimize patient exposure to dental radiation.[6,10]

In accordance with ALARA, the American Dental Association (ADA) has provided selection criteria guidelines for prescribing dental radiographs and establishing the appropriate intervals and types of radiographs to be taken on an individual basis.[11-12] The ADA selection criteria guidelines recommend the use of clinical assessment findings to determine appropriate radiographs based on disease state, risk factors, age, and patient status (new or recall).[11] Dental hygienists can incorporate the selection criteria guidelines to provide recommendations for radiographs based on the patient's medical and dental history, as well as findings from the comprehensive clinical examination.[10-11]

Statement of the Problem

Minimal data is available on radiation safety practices in the dental field.[13-17] A survey on radiation safety practices will evaluate safety measures dental hygienists employ when exposing radiographs, including x-ray machine equipment factors and the utilization of the ADA selection criteria guidelines to determine the need for radiographs. No research could be found on whether United States practicing dental hygienists are currently implementing the ALARA principle when exposing their patients to dental radiation. Producing diagnostic radiographs while minimizing patient and clinician exposure to ionizing radiation is of utmost importance and should be valued by dental hygienists.

Research questions to be addressed are as follows:

1. What knowledge do practicing dental hygienists have regarding radiation protection standards?
2. Are dental hygienists using the ADA selection criteria guidelines when exposing radiographs in practice?
3. Do practicing dental hygienists employ safe radiographic practices to reduce patient exposure to dental radiation?
4. Do practicing dental hygienists receive regular training on radiation safety?
5. Do practicing dental hygienists employ safe radiographic practices to reduce their occupational exposure to dental radiation?

Significance of the Problem

Data analysis will reveal factors dental hygienists are currently implementing to determine need for exposing radiographs, such as use of clinical findings, medical and dental histories, and third party reimbursement. Survey results will determine the extent to which dental

hygienists are following the ALARA principle. The present study may also reveal recommended safety standards not being followed in practice. Data will provide important information concerning the percentage of dental hygienists using digital technology. Results may indicate a need for regular radiation safety courses to enhance knowledge retention of radiation safety practices. Exposing patients to ionizing radiation must have benefits that exceed the risks of exposure, and all efforts to produce diagnostic images while minimizing ionizing radiation exposure to the patient should be taken.[1,9-11] The current study may assist the American Dental Hygienists' Association (ADHA) and American Dental Association (ADA) to better emphasize the utilization of ADA selection criteria guidelines prior to exposing patients to dental radiation as the results of the study will identify any gaps in knowledge regarding radiation safety measures.

Definition of Terms

- As Low As Reasonably Achievable (ALARA): Principle radiographers should follow to minimize radiation exposure and risks to biological tissue and prevent damage to DNA.[4,18]
- Background (natural) radiation: Ionizing radiation that is always present and consists of cosmic rays from outer space, naturally occurring radiation from the earth, and radiation from radioactive materials.[4]
- Bisecting angle technique: A technique in which the central ray of the x-ray beam is directed perpendicular to an imaginary bisector of the angle formed by the image receptor and the long axes of the teeth used when the image receptor cannot be placed parallel to the teeth. Examples of instances when this method is used is when the patient has a

severe gag reflex, lack of cooperation, shallow palatal vault, and other difficulties due to patient anatomy.[18]

- Collimator: An equipment factor that minimizes the dimensions of the x-ray beam.[11]
- Critical organ: An organ that if overexposed to ionizing radiation could cause damage or long-term effects and are sensitive to ionizing radiation and susceptible to radiation damage. Critical organs include the thyroid gland, bone marrow, skin, and lens of the eye.[19]
- Dose: The amount of absorbed radiation to a patient when receiving radiation treatment, measured in grays or rads.[4]
- Dosimeter: A device that measures radiation over certain time periods.[4]
- Exposure: A measure of ionization produced in air by dental radiation.[4]
- Exposure time: The time between when the exposure button of the x-ray machine is pressed to when the x-rays are produced.[20]
- Genetic effects: Radiation effects that are passed onto future generations.[4]
- Hand-held portable x-ray device: A dental radiation emitting device that is held by the operator in situations where a traditional, wall-mounted x-ray machine is not available or when the patient cannot be moved to the x-ray machine. This device has an external backscatter ring shield that protects the operator from ionizing radiation.[21]
- Ionizing radiation: The type of radiation that results in the production of ions. [4,18]
- Kilovoltage: The penetrating power of the x-ray beam; represents the quality of the radiation generated.[20]
- Lead apron: Protective barrier made of lead or lead-equivalent materials that shields patients' gonadal areas from dental radiaton.[22]

- Long-term effects: Consequences from ionizing radiation that are seen after years, decades, or generations.[23]
- Milliamperage: The amount of electric current that, along with exposure time, control the density of a radiographic image; describes the amount of x-rays produced.[20]
- Paralleling technique: A technique in which the image receptor is positioned parallel to the long axes of the teeth and the central ray of the x-ray beam is directed perpendicular to both the teeth and the image receptor to image the entire tooth along with two millimeters of bone past the apices.[18]
- Position indicating device (PID): Also called beam-indicating device (BID). An open-ended, cylindrical or rectangular device attached to the tube head used to direct the x-ray beam.[18]
- Radiation safety: Implementing the ALARA principle to minimize radiation risks when exposing patients to dental radiation.
- Radiosensitive: Refers to tissues that are relatively susceptible to injury by ionizing radiation.[24]
- Risk: The likelihood of negative effects, including death, to occur from exposure to a hazard.[25]
- Scatter radiation: A type of secondary radiation that changes directions as a result of hitting the tissues of the patient's area of interest. [18]
- Selection criteria guidelines: Guidelines developed by an expert panel of healthcare professionals for deciding the type, number, and frequency of dental radiographs.[8] The ADA selection criteria guidelines were developed in 1987 and revised in 2012 by an expert panel of healthcare professionals to guide practitioners with deciding what types of

radiographs are recommended to be taken and the number and frequency of radiographs for an appropriate diagnosis.[11]

- Short-term effects: Consequences that are seen soon after exposure to radiation.[23]
- Stochastic effects: – When a biological response is based on the probability of occurrence rather than the severity of damage.[4] The effects of radiation that cause damage to DNA and could result in genetic defects and diseases such as cancer. Unlike deterministic effects, there is no threshold dose, meaning no safe dose exists for dental radiation.[26]
- Thyroid collar: A collar made of lead or lead-equivalent materials that are used to protect the thyroid gland during the exposure of intra-oral radiographs. The thyroid collar may be attached to the lead apron or detachable.[27]

Hypotheses

The following null hypotheses were tested at a 0.05 level of significance:

1. There will be no statistically significant difference between dental hygienists who graduated from an accredited dental hygiene program within the last ten years and dental hygienists who graduated from an accredited dental hygiene program over ten years ago in employing safe radiographic practices to reduce patient exposure to dental radiation.
2. There will be no statistically significant difference between dental hygienists with an Associate's Degree and a Bachelor's Degree in employing safe radiographic practices to reduce patient exposure to dental radiation.

Assumptions

This study was based on the following beliefs:

1. All respondents answered the survey questions honestly.
2. The respondents were able to comprehend the survey questions.

3. According to the ALARA principle, there are radiation safety measures that dental hygienists should implement by utilizing equipment factors and the ADA selection criteria guidelines.
4. All email contact information of the random sample of respondents was updated and accurate.

CHAPTER II

REVIEW OF THE LITERATURE

To provide a theoretical framework for this study, recent and relevant literature is included regarding radiation exposure and radiation safety standards.

Radiation Exposure

On average, about half of the annual dose of radiation exposure in the United States comes from background radiation present naturally in the environment, specifically from radon gas in the soil.[4] Exposure to dental radiation is minimal compared to the amount of radiation the population is exposed to from the environment;[12] however, increased exposure to artificial sources of radiation contribute to long-term effects from radiation.[4,6] Artificial sources of radiation include: dental x-rays, medical x-rays, nuclear medicine, building materials, televisions, and radiation therapy.[28]

Dental x-rays are ionizing radiation, which have the potential to produce unstable ions.[4-5,10] Unstable ions passing through tissues can create changes at the cellular level, resulting in biological changes.[4,10] Measures to minimize radiation exposure are important as long-term effects to low doses of ionizing radiation over time are not well known but may lead to cancer, embryological defects, low birth-weight babies, cataracts, and genetic mutations.[4,6] Ionizing radiation also has the potential to lead into stochastic effects, such as salivary gland tumors and thyroid cancers.[2,6] Since dental hygienists are responsible for the exposure of dental radiographic images, it is important for dental hygienists to implement the As Low As Reasonably Achievable (ALARA) principle to minimize patient exposure to dental radiation. Following the ALARA principle allows clinicians to obtain diagnostic radiographs while minimizing the biological effects that may result from increased exposure to ionizing radiation.[1,4,6,9-10] Minimizing

exposure to dental x-rays by practicing the ALARA principle is supported by numerous radiation control and safety professional organizations such as the American Dental Association (ADA), National Council on Radiation Protection and Measurements (NCRP), and the International Commission on Radiological Protection (ICRP).[4,6,11] The ADA, NCRP, and ICRP have information regarding radiation and its effects on the human body as well as methods to reduce patient exposure to radiation to support the ALARA principle.

Selection Criteria Guidelines

The American Dental Association (ADA) and the United States Food and Drug Administration (FDA) have developed selection criteria guidelines that recommend appropriate intervals for exposing patients to dental radiation.[11] The ADA selection criteria guidelines were developed in 1987 and revised in 2012 by an expert panel of healthcare professionals to guide practitioners in determining types of radiographs to be exposed and the number and frequency of radiographs for an appropriate diagnosis.[11] Suggested intervals are recommended on an individual patient basis after a complete medical and dental history has been obtained and a comprehensive clinical examination has been performed.[11] Benefits of exposing patients to radiation should exceed the possible risks and add new information, aiding in the formulation of a comprehensive treatment plan; dental healthcare professionals must make every effort to obtain the patient's most recent radiographs to minimize exposure.[1,9-11,29-30]

Selection criteria guidelines can be used to determine need for radiographs based on the patient's oral disease status prior to exposing patients to dental radiation.[11] For example, after conducting a caries risk assessment and clinical examination, posterior bitewing radiographs are recommended every six to eighteen months for adults at an increased risk for developing caries and every twenty-four to thirty-six months for adults at a lower risk for developing caries.[11]

Posterior bitewing radiographs are recommended more frequently for children: every six to twelve months for an increased risk of developing caries and every twelve to twenty-four months for a decreased risk.[11] Dental radiographic intervals are reassessed throughout a patient's lifetime because risks for developing dental caries change over time.[11] The patient's medical and dental histories, disease risk factors, age, dentition, and new or recall status must be considered by dental hygienists to assist in determining radiographic intervals specific to individual patients.[11] Periodontal disease can be diagnosed clinically; however, dental radiographs are necessary to supplement findings by revealing the amount of bone level present, extent of furcation involvement, tooth to root ratio, widened periodontal ligament space, and periapical involvement.[11] The ADA guidelines suggest that radiographic recommendations depend on clinical signs and symptoms, such as unexplained sensitivity of teeth, clinically impacted teeth, and mobility.[11]

Radiation Safety Measures to Protect the Patient

The ADA selection criteria guidelines recommend the use of F-speed film or digital image receptors to limit radiation exposure to the patient.[9,11] For film based imaging, utilizing an E-speed or F-speed film will reduce the patient's dose by 30-40% and 60%, respectively, compared to that of D-speed film.[29-31] Digital image receptors further reduce patient exposure to radiation.[11] There are three types of digital image receptors currently available for use: the charge coupled device (CCD), complementary metal oxide semiconductor active pixel sensor (CMOS-APS), and photostimulable phosphor (PSP) plate.[32] CCD and CMOS-APS sensors are direct digital image receptors that produce an immediate image by converting x-rays into an electronic signal sent to the computer.[33] PSP plates are indirect digital image receptors similar to film and must be inserted into a laser scanning device before the image can be viewed on the

computer monitor.[33] Claims of up to 55% reduction in radiation exposure were found when comparing digital imaging to E-speed films.[34]

An image receptor's dynamic range refers to the interval of radiation exposure settings able to produce an image with acceptable density and contrast.[35] A wide dynamic range allows the operator to utilize a wide range of exposure settings to obtain a diagnostic image and may not alert the operator if the patient is being overexposed as the differences in the density and contrast of the image are not as easily seen.[35] The wider the dynamic range of the image receptor, the less sensitive the sensor is to radiation; decreased sensitivity could result in higher radiation exposure.[34]A narrow dynamic range, on the other hand, requires the operator to utilize exposure settings that are relatively precise to obtain a diagnostic image.[35] Image receptors with a narrow dynamic range more easily alerts the operator because exposure settings outside of the narrow range may not even capture an image.[35] PSP plates have a wider dynamic range compared to direct digital image receptors; therefore, PSP plates are less sensitive to radiation than both direct digital image receptors, requiring an increase in radiation exposure.[34,36-37] Direct digital image receptors are more ideal in terms of radiation safety because they have a narrower dynamic range than indirect digital image receptors and require less radiation exposure to produce an image.[38]

The Position Indicating Device (PID) of the x-ray machine also affects patient radiation exposure. Rectangular PIDs minimize radiation exposure compared to round PIDs because aligning the rectangular PID to the rectangular image receptor prevents excess tissues from being exposed.[9,11,29] A longer PID will also reduce radiation exposure because the distance from the source of radiation and the area to be imaged is increased, decreasing the area of the primary x-ray beam.[11] PIDs are available in three lengths: 8 inches, 12 inches, and 16 inches. Aside from increasing the distance between the source of the radiation and the teeth of interest, x-ray

machines should be checked periodically to ensure the equipment is properly functioning.[9] Defective x-ray machines may result in the drifting of the PID, which can produce un-diagnostic images and need for retake exposures.

Exposure factors such as: milliamperage, exposure time, and kilovoltage settings should be changed depending on the area to be imaged because of differing bone densities in various parts of the oral cavity. For example, higher exposure settings are needed to image the posterior areas of the mouth due to greater bone density, while lower exposure settings can be used to image the anterior region where the bone is less dense.[39] When exposing pediatric patients to radiation, it is important to consider that bone structures of children under twelve years old are less dense than those of adults;[11] therefore, exposure times should be reduced by approximately 30% for children.[40] Children may also be more susceptible to radiation injury compared to adults because of their younger, more rapidly dividing cells, which are more radiosensitive than older adult mature cells.[10,41]

Lead aprons are used to protect the patient from scatter radiation that might impact critical organs and tissues. It is even more crucial that the lead apron come with a thyroid collar to protect the thyroid gland, especially for children, women of childbearing age, and pregnant women.[5,10-11,18,29,42] Thyroid collars can reduce exposure from 33% in children to 63% in adults.[43-44] The National Council on Radiation Protection (NCRP) Report 145 states that a lead apron is not required if all safety measures provided in the report are followed correctly, including the use of rectangular collimation, fast image receptors, and the selection criteria guidelines.[45] However, thyroid collars should be used on all exposures for both children and adults except when there is a potential of interfering with the examination, which occurs during the exposure of a panoramic image.[42,45] The ADA references the American College of

Obstetricians and Gynecologists (ACOG) in expressing the safety of exposing pregnant patients to dental radiation during any stage of the pregnancy as long as abdominal and thyroid shielding is used.[46]

Proper radiographic technique is also important in reducing patient radiation exposure.[18] The paralleling technique is considered the gold standard, and requires the image receptor to be placed parallel to the teeth being imaged with the central rays of the x-ray beam directed perpendicular to the teeth of interest and image receptor.[18,45] The paralleling technique should be the first technique the operator attempts to use; however, an alternative approach may be used in instances when the image receptor cannot be placed parallel to the teeth, such as when the patient has a severe gag reflex, lack of cooperation, shallow palatal vault, and other difficulties due to patient anatomy. The bisecting angle technique, which places the image receptor as close to the tooth as possible, makes the image receptor diagonal to the long axis of the tooth instead of parallel. The central rays of the x-ray beam are then directed at a right angle halfway between the teeth and the receptor, thus bisecting the two angles.[18] The bisecting angle technique is less ideal because it may result in image distortion from an increased vertical angulation.[18] The use of the bisecting angle technique increases the radiation exposure of the thyroid gland and the lens of the eye due to the increased vertical angulation.[47] The bisecting angle technique also results in greater radiation to the patient due to the use of a shorter PID, decreasing the distance from the x-ray source to the image receptor. Although the bisecting angle technique may increase radiation exposure to the patient and may result in image distortion, clinicians should choose the most ideal technique to incorporate based on the unique characteristics of the patient to prevent retakes, therefore reducing patient radiation exposure.

Regular training in radiation safety is important for reinforcing good safety practices and staying current on safety standards that can improve the diagnostic quality of radiographs and minimize radiation exposure.[11] A study conducted in Europe revealed that repeated reinforcement is important in achieving long-term knowledge retention.[48] A considerable amount of knowledge is lost six to twelve months after information is learned;[48] therefore, it is ideal that clinicians be refreshed on radiation safety and educated on any advancements in radiation practice as years of experience increase. Attending Continuing Education (CE) classes on radiation safety could help clinicians minimize patient exposure and keep up to date on radiation safety protocols.

Radiation Safety Measures to Protect the Clinician

Due to the potential for dental healthcare professionals to be exposed to ionizing radiation from scatter radiation, measures should be taken to reduce or eliminate operator exposure.[5] Dosimeter badges are available to monitor the occupational effective dose the operator is being exposed to over time, which must not exceed 5 rem (50 mSv) a year.[29] Although the annual dose limit is 50 mSv, the average annual effective dose is about 1 mSv, revealing that the NCRP recommendations have had a great influence on dental radiation safety standards.[4] The operator should not hold the PID during an exposure—if x-ray machines are unstable or drifting is occurring, immediate inspection of the unit is necessary.[29] Each state has different laws regarding dental x-ray machines; for example, The Virginia Department of Health mandates that dental x-ray machines be inspected every three years.[49]

Hand-held Portable X-ray Devices

Hand-held portable x-ray devices are increasingly found in dental practice settings because of their ease of use and portability.[50] Hand-held portable x-ray devices are used for

radiographic examinations where a traditional, wall-mounted x-ray machine is not available or when the patient cannot be moved to the x-ray machine. The Food and Drug Administration must certify hand-held portable x-ray devices as safe. Safety requirements for hand-held portable x-ray devices include inherent tube head shielding, additional shielding around the PID, and a leaded acrylic external backscatter ring shield.[50] The round PID of a hand-held portable x-ray device has a collimator of 2.4 inches, which restricts the size and shape of the x-ray beam to a smaller surface area compared to a collimator of 2.75 inches in a traditional, wall-mounted x-ray machine.[50] Scatter radiation is reduced in hand-held portable x-ray devices because a smaller area is exposed to radiation; however, the American Dental Association recommends the use of an operator lead apron if the backscatter ring shield is not used.[11]

Manufacturers of portable radiographic equipment usually advise three specific instructions regarding protecting the operator from radiation exposure via the backscatter ring shield of the device: hold the device at the mid-torso level, orient the backscatter ring shield to protect the operator, and keep the PID as close to the patient's face as possible.[11,50] According to the specific manufacturer of the device, no additional operator radiation safety precautions are needed if these instructions are followed.[11] The use of hand-held portable x-ray devices are considered safe when used according to the manufacturer.[50-51]

Danforth, Herschaft, and Leonowich researched operator exposure to scatter radiation when using handheld x-ray devices in both typical and atypical imaging positions.[21] A typical imaging position refers to a position where the operator is holding the hand-held portable x-ray device at mid-torso parallel to the floor, and an atypical imaging position refers to any other position where the hand-held portable device is not held at mid-torso, with an increase or decrease in vertical angulation.[21] The backscatter ring shield is only effective in protecting the

operator from scatter radiation if it is held upright with the PID parallel to the floor, at the mid-torso level, which is the typical imaging position.[11,50] The hand-held portable x-ray device is held at the typical imaging position when bitewing radiographs are being exposed;[8] however, increased vertical angulation results during the exposure of periapicals (PA's) and occlusal images.[52] Participants of Danforth et al. wore clinician lead aprons with an attached thyroid collar for all exposures.[21] Dosimeter badges were used to monitor exposure doses of the thyroid, chest, abdomen, reproductive regions, fingers, and feet.[21] To test exposures from atypical imaging positions, bench specimens, anthropology specimens, and supine positioned manikins were used.[21] Danforth et al. revealed average operator deep doses ranging from 0.33 mrem for the thyroid, 3.6 mrem for the abdomen, and 9.5 mrem for the reproductive area.[21] The operator exposure to radiation when using hand-held portable x-ray devices in atypical imaging positions in Danforth et al. was 0.4536 mSv, which is 0.9% of the annual maximum permissive dose (MPD) compared to the occupational exposure annual MPD of 50 mSv.[21] Although operators are exposed less than the MPD, operators may choose to adorn radiation protective aprons.[21] According to the results of Danforth et al., the use of operator radiation protective aprons are not necessary as long as all safety protocol measures are followed.[11,21] The ADA has not provided specific instructions in obtaining appropriate training to use hand-held portable x-ray devices; however, the European Academy of DentoMaxilloFacial Radiology (EADMFR) wrote a position paper suggesting that individuals provide proof of training for safe use of hand-held portable x-ray devices to make sure individuals understand the risks involved and radiation safety measures to take prior to use.[53] It is beneficial for operators to incorporate radiation safety measures to protect themselves of scatter radiation and maintain the recommended occupational effective dose limits.

A literature search on dental radiation safety practices in the United States was conducted using the following databases with Medical Subject Headings (MeSH) and keywords: Cochrane Database of Systematic Reviews, Pubmed, Dentistry and Oral Sciences Source, CINAHL, Education Resources Information Center (ERIC), and ScienceDirect. No studies were identified on dental radiation safety practices in the United States, but four studies were found from Nigeria, India, England, and Wales.[13-16] A study by Chaudhry et al., on general dentists practicing in the National Capital Region shows that more research is needed to ensure that practicing dentists and dental hygienists, especially in the United States, are implementing appropriate radiation safety measures to protect the patient and operator.[13] Davies, Grange, and Trevor conducted a survey of dental practitioners in the northeastern portion of England; results revealed that a significant percentage of practices were not utilizing methods to reduce radiation exposure to their patients.[15]

In summary, steps to minimize radiation exposure in both the patient and the clinician should be made to ensure that the As Low As Reasonably Achievable (ALARA) principle is followed. Considering equipment factors that reduce radiation, following the ADA selection criteria guidelines, and utilizing the proper radiographic technique can help the clinician reduce patient radiation exposure. Regular training in radiation safety is needed to keep current with the advancements in technology along with their safe use. The purpose of this study was to gather information on radiation safety methods that registered dental hygienists in the United States are currently implementing. Currently no studies could be found on radiation safety practices of United States dental hygienists; therefore, data analysis could assist the dental hygiene profession as it relates to protecting all individuals involved in radiographic examinations from the effects of ionizing radiation found in dental radiation.

CHAPTER III

METHODOLOGY

Exempt approval from the Old Dominion University (ODU) College of Health Sciences (COHS) Institutional Review Board (IRB) was obtained for the protection of human respondents. Upon exempt IRB approval, a 22-item investigator-designed survey was administered online via Qualtrics (Provo, Utah) to practicing dental hygienists who were subscribers of a professional dental hygiene journal. The professional dental hygiene journal exported their full list of subscribers in alphabetical order, and the first 1,500 individuals on the list were chosen as the sample population. The inclusion criteria consisted of only dental hygienists in the US who were currently practicing dental hygiene. The survey was pilot tested to twenty-nine dental hygiene faculty members from Old Dominion University who reviewed the questionnaire for content validity and then revised based on faculty members' recommendations. The survey was developed to determine current radiographic safety methods and techniques implemented by a convenience sample of U.S. dental hygienists (N=1,500) and was made available for forty-seven days. Responses were reported and analyzed in group format to preserve respondents' identities.

A survey cover letter was included explaining the purpose of the study, respondents' confidentiality, instructions for completing the survey, inclusion/exclusion criteria, and references to contact if there were any questions or concerns about the survey or their rights as a research respondent. Subjects were informed via the cover letter that submitting the survey would be acknowledged as their consent to participate in the research. The survey consisted of two sections (Appendix A). Section A included six demographic questions related to education, time invested in radiology safety courses, primary work setting, age, years of dental hygiene

experience, and location of current practice. Section B questioned respondents about radiation safety practices implemented in their practice to protect the patient and clinician from ionizing radiation exposure. Also, questions were included regarding the use of the ADA selection criteria guidelines in practice and policies implemented by practice settings, and four questions addressed the use of a hand-held portable x-ray device.

Statistical analysis was performed using Statistical Analysis Software (SAS®) software version 9.4.[54] Data was analyzed for distribution differences and statistical significance using descriptive statistics, logistic regression models, and general linear models. All null hypotheses were tested at 0.05 level of significance, indicating that the researchers were 95% confident that the expected value fell within two standard deviations of the mean.

CHAPTER IV

RESULTS

Of the 1,500 email surveys sent, 566 were valid for analysis resulting in a response rate of 38%. Three surveys were excluded since the respondents stated that they were not dental hygienists who regularly expose radiographs. A majority of respondents had an associate's degree (62%), while only 38% had a bachelor's degree or higher. A majority of respondents participated in a radiology course for two semesters or less (84%). Most respondents were aged 55 and above (41%) with 31 or more years of experience (38%). Practicing dental hygienists in the Eastern region of the United States had the highest percentage of participation (37%). Table 1 summarizes the sample population's demographics. Frequencies of each survey response is found in Appendix B.

Table 1. Demographic Statistics for the Sample (N=566)

Demographics	n	%
Level of education		
Associate's degree	351	62%
Bachelor's degree or higher	215	38%
Number of semesters in a radiology course		
One or less	238	42%
Two	240	42%
Three	34	6%
Four	54	10%
Age		
20-24	13	2%
24-34	102	18%
35-44	87	16%
45-54	131	23%
55 and above	233	41%
Years of clinical experience		
0-10	176	31%
11-20	76	13%
21-30	99	18%
31+	215	38%
Region of the United States		
West	120	21%
Central	55	10%
Midwest	136	24%
Mid-Atlantic	47	8%
East	208	37%

Cross tabulations were performed to determine if years of experience were a predictor of radiation safety behaviors. A cross tabulation between years of experience as a dental hygienist and use of a thyroid collar during intraoral images was done via the general linear model (GLM) test**.** There was no statistically significant difference between years of experience as a dental hygienist and use of a thyroid collar during intraoral images (p=0.1568). Frequencies are provided in Table 2. Of the individuals with 11-20 years of experience as a dental hygienist, 83% reported always using a thyroid collar during intraoral images, also represented by a higher mean than the other categories (Table 3).

Table 2. Frequency of Respondents' Years of Experience and Use of Thyroid Collar During Intraoral Images

Frequency
Row Percent
Column Percent

Use of Thyroid Collar	Years of Experience			
	0-10	**11-20**	**21-30**	**31+**
Never	9 48% 5%	1 5% 1%	5 26% 5%	4 21% 2%
Sometimes	22 34% 12%	5 8% 7%	14 22% 14%	23 36% 11%
Most of the Time	12 27% 7%	7 16% 9%	6 13% 6%	20 44% 9%
Always	133 30% 76%	63 15% 83%	74 17% 75%	168 38% 78%

Note: Row percentages are read as follows: "Of the respondents who never use a thyroid collar during intraoral images, 48% have 0-10 years of experience as a dental hygienist." Column percentages are read as follows: "Of the individuals with 11-20 years of experience, 1% never use a thyroid collar during intraoral images."

Table 3. Mean Values of Respondents' Years of Experience and Use of Thyroid Collar During Intraoral Images

Years of experience	n	Use of Thyroid Collar	
		Mean	Std Dev
0-10	**176**	3.52840909	0.90034265
11-20	**76**	3.73684211	0.64017541
21-30	**99**	3.50505051	0.91889172
31+	**215**	3.63720930	0.74790151

Survey data was analyzed to determine if the ADA selection criteria guidelines were being utilized and if other radiation safety precautions were being followed. Respondents were given nine items related to the selection criteria guidelines and asked to select which items they used to determine the need for radiographs in their practice. Table 4 summarizes the responses, with a majority of respondents utilizing all items with the exception of third party reimbursement.

Table 4. Respondents' Criteria Used to Determine Need for Radiographs

	Yes	No
Suspected caries	**99%** 562	**1%** 4
Periodontal involvement	**98%** 555	**2%** 11
History of previous radiographs	**95%** 537	**5%** 29
Defective restorations	**92%** 522	**8%** 44
Impaction/missing teeth	**96%** 546	**4%** 20
Growth abnormality/delayed eruption	**97%** 549	**3%** 17
Suspected pathology	**96%** 543	**4%** 23
Unexplained sensitivity/pain	**96%** 546	**4%** 20
Third party reimbursement	**31%** 173	**69%** 393

New variables were created by adding up the criteria respondents used to determine the need for radiographs, where a higher value indicated more criteria to determine the need for radiographs. A cross tabulation of level of education and criteria used to determine the need for radiographs was done via the GLM test. Level of education was not statistically significant in predicting whether respondents followed a criterion to determine the need for radiographs ($p=0.5575$) shown in Table 5.

Table 5. Cross Tabulation of Level of Education and Need for Radiographs

Statistic	DF	Value	P-value
Chi-Square	5	3.9437	0.5575

A post hoc test was run to determine the relationship between level of education and each of the individual items listed as the criteria used to determine the need for radiographs via the GLM test. There was a statistically significant difference between level of education and the use of periodontal involvement as a criterion for determining the need for radiographs (p=0.0462). Frequencies and p-values of the individual items used to determine the need for radiographs have been provided in Table 6.

Table 6. Frequency of Respondents' Level of Education and Criteria Used to Determine Need for Radiographs

	Associate's degree	Bachelor's degree or higher	P-value
Suspected caries	**61%** 348	**38%** 214	0.5913
Periodontal involvement	**60%** 341	**38%** 214	0.0462
History of previous radiographs	**59%** 335	**36%** 202	0.4358
Defective restorations	**56%** 319	**36%** 203	0.1274
Impaction/missing teeth	**59%** 337	**37%** 209	0.4537
Growth abnormality/delayed eruption	**60%** 341	**27%** 208	0.7832
Suspected pathology	**59%** 334	**37%** 209	0.2300
Unexplained sensitivity/pain	**59%** 336	**37%** 210	0.2231
Third party reimbursement	**19%** 110	**11%** 63	0.6097

A cross tabulation between years of experience and the criteria dental hygienists use to determine the need for radiographs was done via logistic regression. There was a statistically significant difference in the criteria dental hygienists used to determine the need for radiographs based on years of experience (p=0.0340) as seen in Table 7. Respondents were more likely to select the appropriate criteria for determining the need for radiographs with more years of experience as a dental hygienist.

Table 7. Predicting Years of Experience with Criteria to Determine Need for Radiographs

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	P-value
Intercept	1	-1.1453	0.9176	1.5581	0.2119
Criteria to Determine Need for Radiographs Based on Years of Experience	1	0.2318	0.1093	4.4961	0.0340

Respondents were also asked to respond using a seven point Likert scale on radiographic technique to determine if efforts were made to reduce radiation exposure to patients. More respondents used the bisecting technique for acquiring periapical radiographs (61%) over the paralleling technique (56%). Almost all respondents knew that exposure settings should be changed for child patients (90%), but only three-fourths of respondents believed exposure settings should be altered depending on the area of the mouth being imaged. Table 8 summarizes the responses.

Table 8. Respondents' Responses for Determining Radiographic Technique

Radiographic Technique	Somewhat agree – Strongly agree	Neither agree nor disagree	Somewhat disagree – Strongly disagree
My first choice when acquiring periapical x-rays is to put the sensor/film far away from the tooth (paralleling technique).	**56%** 322	**17%** 97	**27%** 147
My first choice when acquiring periapical x-rays is to put the sensor/film as close to the tooth as possible (bisecting angle technique).	**61%** 345	**18%** 101	**21%** 120
My decision to use the paralleling technique or bisecting angle technique depends on the unique characteristics of the patient.	**85%** 477	**9%** 53	**6%** 36
Exposure settings should be altered depending on the area imaged.	**72%** 411	**18%** 99	**10%** 56
Exposure settings should be altered for child patients.	**90%** 513	**6%** 37	**4%** 16
Exposure settings for digital and film vary.	**86%** 486	**10%** 58	**4%** 22
Intervals for exposing radiographs depend on the patient's disease state and radiation exposure history.	**86%** 490	**7%** 37	**7%** 39

To predict level of education based on radiographic technique, a model based on logistic regression was proposed. New variables for radiographic technique were created as a point system, where a higher value indicated more criteria to reduce radiation exposure. The logistic regression determined a significant difference ($p=0.0080$) between level of education and radiographic technique, revealing that clinicians with a Bachelor's degree or higher were more likely to use radiographic techniques that follow the ALARA principle compared to those with an Associate's degree (Table 9).

Table 9. Predicting Level of Education With Radiographic Technique

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	P-value
Radiographic Technique	1	0.0448	0.0169	7.0274	0.0080

To determine which items regarding radiographic technique were significant based on level of education, a post hoc test was conducted. Cross tabulations were performed to determine the relationship between level of education and each of the individual items presented in the radiographic technique question using the GLM test. There was a statistically significant difference between level of education and utilizing the paralleling technique as the first choice over the bisecting technique (p=0.0052), altering exposure settings depending on the area imaged (p=0.0065), and altering exposure settings for child patients (p=0.0347). Respondents with a Bachelor's degree or higher were more likely to utilize the paralleling technique over the bisecting technique, change the exposure settings depending on the area imaged, and change exposure settings for child patients than respondents with an Associate's degree. Table 10 lists the associated p-value for each of the seven items.

Table 10. Tests of Association Between Respondents' Level of Education and Radiographic Technique

Radiographic Technique	Level of Education	Mean	SD	P-value
My first choice when acquiring periapical x-rays is to put the sensor/film far away from the tooth (paralleling technique).	Associate's Degree	4.538	1.943	0.0052
	Bachelor's Degree or higher	4.995	1.768	
My first choice when acquiring periapical x-rays is to put the sensor/film as close to the tooth as possible (bisecting angle technique).	Associate's Degree	3.171	1.747	0.8258
	Bachelor's Degree or higher	3.205	1.802	
My decision to use the paralleling technique or bisecting angle technique depends on the unique characteristics of the patient.	Associate's Degree	5.832	1.383	0.2957
	Bachelor's Degree or higher	5.958	1.409	
Exposure settings should be altered depending on the area imaged.	Associate's Degree	5.222	1.468	0.0065
	Bachelor's Degree or higher	5.563	1.392	
Exposure settings should be altered for child patients.	Associate's Degree	6.074	1.131	0.0347
	Bachelor's Degree or higher	6.270	0.953	
Exposure settings for digital and film vary.	Associate's Degree	6.077	1.211	0.6755
	Bachelor's Degree or higher	6.033	1.243	
Intervals for exposing radiographs depend on the patient's disease state and radiation exposure history.	Associate's Degree	5.909	1.399	0.6510
	Bachelor's Degree or higher	5.963	1.339	

Respondents stated when they provided patients with a lead apron prior to taking dental radiographs. 89% of respondents reported always using a lead apron during radiographic procedures. Table 11 highlights comments on the use of a lead apron organized into themes with frequency of respondents. In addition to using a lead apron, a majority of respondents always provided their patients with a thyroid collar during intraoral exposures (78%), while 8% provided the apron most of the time (8%), sometimes (11%), and never (3%).

Table 11. Respondents' Responses on Use of a Lead Apron During Radiographic Procedures

Comment	n	%
Always	496	89%
Almost always	47	8%
Pregnant or based on patient request	10	2%
Never use a lead apron	6	1%

Note: Seven respondents incorrectly responded to the question on the use of a lead apron and have been excluded in the percentage.

Respondents provided their practice policy on exposing radiographs on pregnant patients. Half of the respondents did not expose radiographs on pregnant patients unless absolutely necessary due to pain or dental emergencies. Table 12 groups comments into categories with frequency of respondents.

Table 12. Practice Policy of Respondents on Exposing Dental Radiographs on Pregnant Patients

Comment	n	%
Pain/dental emergency	276	49.64
Depending on trimester	64	11.51
Need written permission/clearance from OB/physician	46	8.27
No radiographs taken on pregnant patients	76	13.67
Depends on which dentist is seeing patient and their beliefs	3	0.54
Knows guidelines (safe to expose pregnant patients) but not following the guidelines	7	1.26
Patient's decision to take radiographs	6	1.08
If the benefit outweighs the risk	7	1.26
No reason not to take radiographs according to ADA and ACOG; follows guidelines	8	1.44
Routine annual radiographs	2	0.36
Double apron	57	10.25
Dental hygienist knows radiographs are safe as long as ALARA principles are followed, but dentist does not allow	2	0.36
Use lead apron	1	0.18
Take CBCT on all patients	1	0.18

Note: Ten respondents were excluded in the percentage because they never encountered or exposed a pregnant patient. Examples include those who work in a pediatric office, geriatric office, independent hygiene practice, male prison, or dental hygiene program.

Questions on equipment factors, such as PID length, PID shape, and image receptor used, were asked. 96% of respondents reported using a round PID, and 4% used a rectangular PID. A majority of respondents utilized a short PID over a long PID (72%). Respondents identified the image receptors their practice currently incorporated as follows: D speed film (7%), E speed film (6%), F speed film (7%), photostimulable phosphor plate (24%), and direct digital image receptor (79%).

A majority of respondents indicated not wearing a dosimeter badge to measure how much radiation they are exposed to (78%), while 22% did report using a radiation monitoring device. A majority of respondents admitted holding the PID in place during an exposure (52%). Of the 295 individuals who responded yes to holding the PID in place, 20% held the PID in place 1-5 times in the last ten years and 50% have held it more than 20 times. Explanations for holding the PID in place have been provided in Table 13.

Table 13. Situations Respondents Have Held PID in Place During an Exposure

Children
Child patient unable to sit still
Child with gag reflex
Child who keeps pushing sensor out
Frightened child
Patient Characteristics
Severe gag reflex
Patient cannot stay biting, unable to close, or cannot hold jaw still
Patient with psychological issues
Geriatric patients
Small mouths
Comfortable to patient/Easier for patient in pain and having trouble biting down
Handicapped patient/patient with severe disabilities
Patient in a hurry
Nervous or anxious patients
Difficult patients/patient not cooperating
Large tori
Narrow arch
Wisdom teeth
Edentulous patients
Severe gag reflex and panorex not working
Equipment Characteristics
If tubehead drifts
Lack of stabilization
Ease of Capturing Image
No other possible way to get exposure and needed for proper diagnosis
Difficulty with obtaining correctness
To steady the sensor
Can’t get a good x-ray with image receptor holding device
X-ray won’t stay where you need it to
Eliminated retaking film
Anytime I need the correct angulation to get best quality x-ray
Couldn’t get a shot for some reason
Extremely challenging radiographs
When trying to get an image in an emergency situation

Respondents were asked how many times they have taken a continuing education (CE) course or in-service training in dental radiation safety in the last five years. A majority of respondents indicated they have not taken any CE courses in dental radiation safety in the last five years (41%). 34% of respondents reported taking one CE course, while only 25% reported

taking two or more CE courses. A cross tabulation between the frequency of taking a continuing education course in dental radiation safety in the last five years and PID characteristics currently used by U.S. dental hygienists was done via logistic regression (Table 14). There was a statistically significant difference in the use of a rectangular PID based on frequency of continuing education course completion (p=0.0008) as seen in Table 15. An increase in continuing education courses in radiation safety was related to the increased use of a rectangular PID. Distributions of dental radiation safety continuing education courses and the use of a rectangular PID with 95% confidence limits are found in Figure 1.

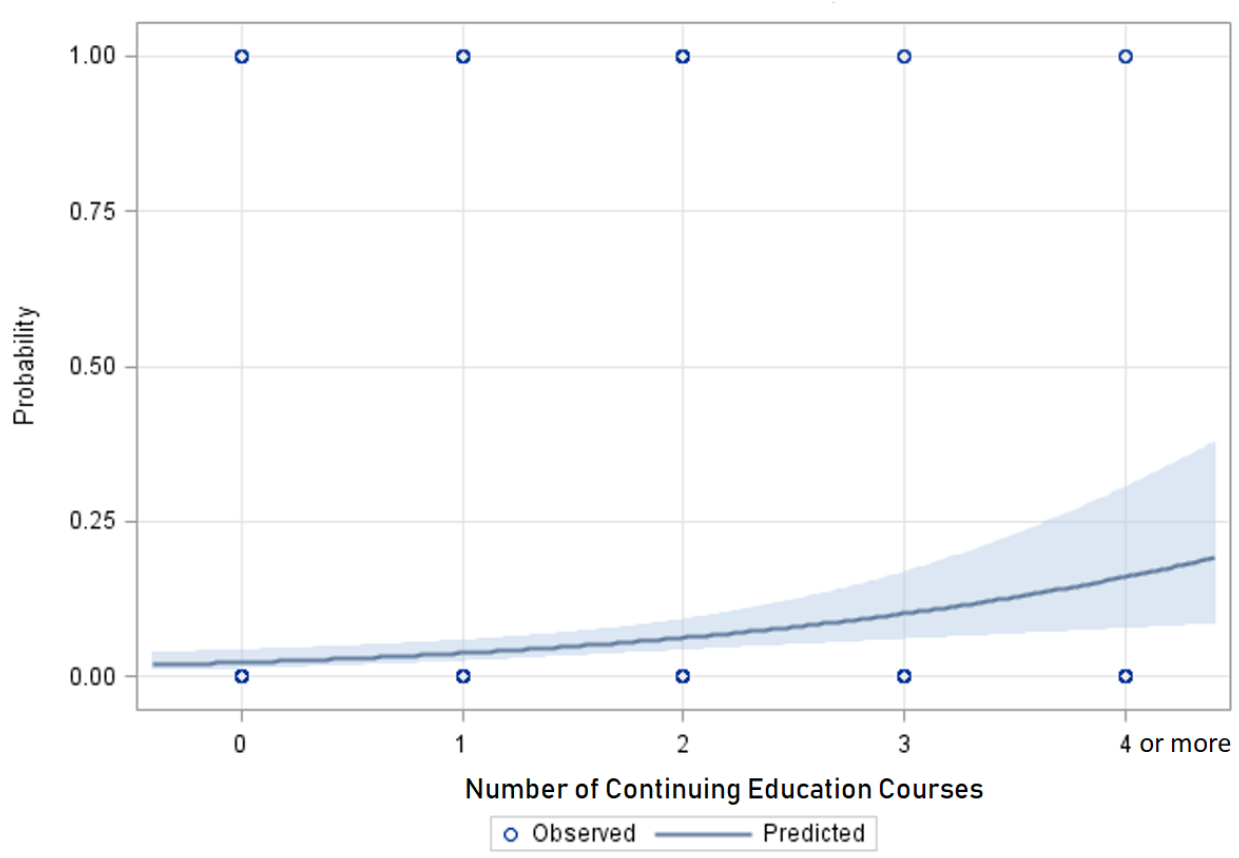
Table 14. Frequency of Respondents' Dental Radiation Safety Continuing Education Courses in the Last Five Years and PID Characteristics

Frequency of Continuing Education Courses	PID Shape		PID Length	
	Round	Rectangular	Long	Short
0	**98%** 227	**2%** 5	**26%** 61	**74%** 171
1	**97%** 187	**3%** 6	**27%** 53	**73%** 140
2	**90%** 74	**10%** 8	**29%** 24	**71%** 58
3	**92%** 34	**8%** 3	**27%** 10	**73%** 27
4 or more	**86%** 19	**14%** 3	**36%** 8	**64%** 14

Table 15. Cross Tabulation of Continuing Education Courses in the Last Five Years and PID Shape

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	P-value
Intercept	1	-3.7628	0.3336	127.2286	<.0001
PID Shape Based on CE Courses in the Last Five Years	1	0.5278	0.1579	11.1749	0.0008

Figure 1. Probability Distribution for Dental Radiation Safety Continuing Education Courses in the Last Five Years and Rectangular PID With 95% Confidence Limits



A cross tabulation between the frequency of taking a continuing education course in dental radiation safety in the last five years and use of a thyroid collar during intraoral images was done via logistic regression**.** There was no statistically significant difference between taking continuing education courses in dental radiation safety and use of a thyroid collar during intraoral images (p=0.5631). Of the respondents who have not taken any continuing education courses in dental radiation safety in the last five years, 3% have never used a thyroid collar, while all respondents who have participated in four or more continuing education courses in the last five years used a thyroid collar. Table 16 summarizes the frequency of taking a continuing education course in dental radiation safety with the use of a thyroid collar during intraoral images.

Table 16. Frequency of Respondents' Continuing Education Courses in the Last Five Years and Use of Thyroid Collar During Intraoral Images

	Use of Thyroid Collar				
Number of Continuing Education Courses	Never	Sometimes	Most of the time	Always	P-value
0	**3%** 8	**10%** 22	**9%** 20	**78%** 182	0.5631
1	**3%** 6	**12%** 24	**8%** 15	**77%** 148	
2	**6%** 5	**11%** 9	**7%** 6	**76%** 62	
3	**0%** 0	**14%** 5	**8%** 3	**78%** 29	
4 or more	**0%** 0	**18%** 4	**5%** 1	**77%** 17	

Respondents were asked four questions on the use of a hand-held portable x-ray device. Most respondents indicated not using hand-held x-ray equipment (88%), while only 12% of

respondents currently use a hand-held portable x-ray device. The 67 respondents who currently use a hand-held portable x-ray device were asked follow-up questions pertaining to the device. Only 57% of these respondents received training prior to exposing patients with hand-held radiographic equipment, while 43% did not receive training. A majority of respondents reported keeping the PID as close to the patient's face as possible (92%); 92% had an external shield on the PID of the device; 22% used a clinician dosimeter badge; and 21% reported wearing a clinician lead apron when using a hand-held portable x-ray device. Respondents who noted that they currently use a hand-held portable x-ray device were asked if they aimed the PID straight ahead with the x-ray device parallel to the floor at the clinician's mid-torso level for all exposures. Less than half of the respondents reported holding the hand-held portable x-ray device at mid-torso level (38%). Table 17 summarizes respondents' responses on holding the hand-held x-ray device at mid-torso level.

Table 17. Respondents' Indication of Holding Hand-Held X-ray Device at Mid-Torso Level

Comment	n	%
Yes	22	38%
Efforts are made to keep x-ray cone at mid-torso level	15	26%
Knows they should but don't always do it	1	2%
No	18	31%
Varies from patient to patient	2	3%

Note: Four respondents did not adequately or correctly respond to the question and were excluded in the percentage.

A cross tabulation between the use of a backscatter ring shield with hand-held portable x-ray equipment and use of a clinician lead apron was done via the GLM test**.** There was no

statistically significant difference between use of a backscatter ring shield and use of a clinician lead apron (p=0.9461); however, of the respondents who do not use a backscatter ring shield, only 20% use a clinician lead apron. Frequencies have been provided in Table 18.

Table 18. Respondents' Use of Backscatter Ring Shield and Clinician Lead apron

	Clinician Lead Apron	No Clinician Lead Apron	P-value
Backscatter Ring Shield	**21%** 13	**79%** 48	0.9461
No Backscatter Ring Shield	**20%** 1	**80%** 4	

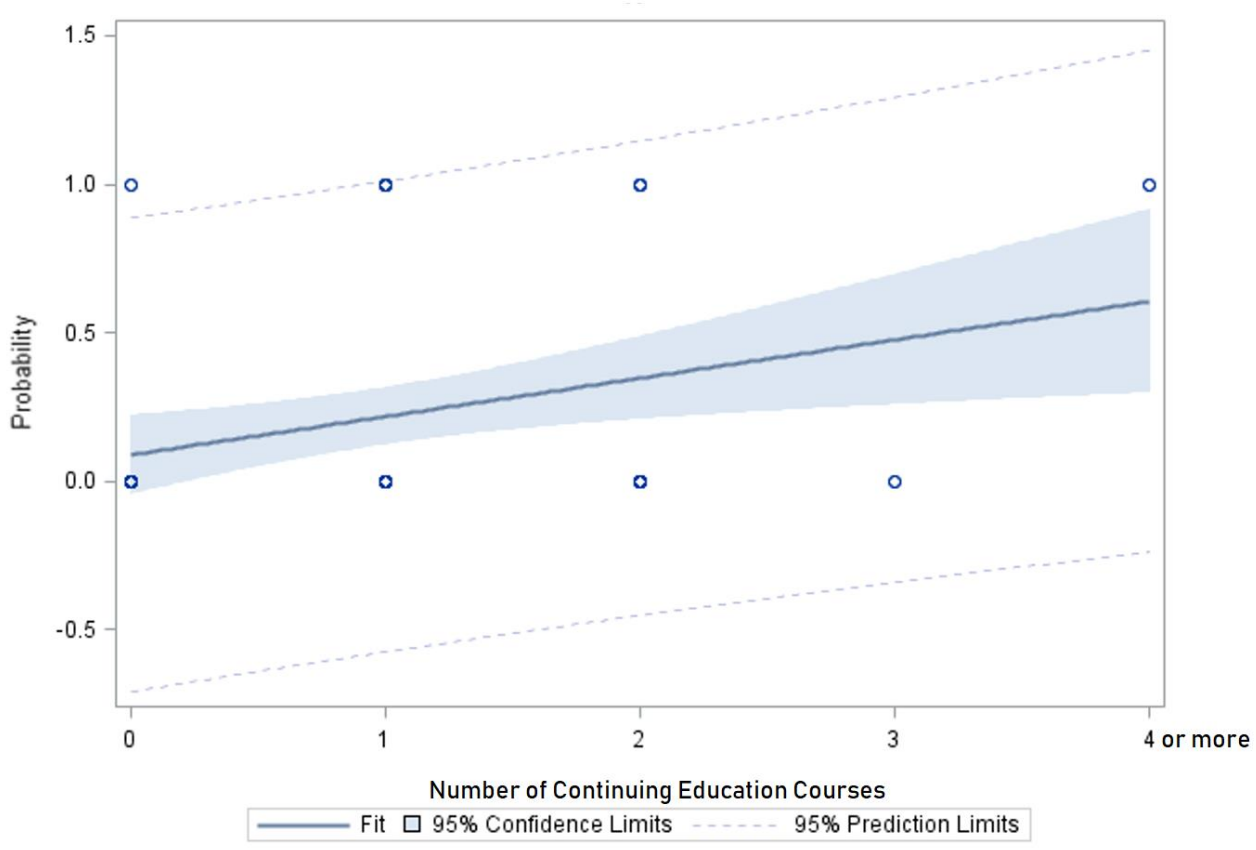
Note: Only 66 respondents responded to the corresponding questions, so 500 respondents are excluded from the percentage.

A cross tabulation to determine a relationship between dental radiation continuing education courses and the use of a clinician lead apron when using the hand-held portable x-ray device was done using the GLM test. A statistically significant difference was found in the use of a clinician lead apron based on the amount of continuing education courses taken in radiation safety in the last five years (p=0.0093) (Table 19). Results revealed that dental hygienists were more likely to wear a clinician lead apron when exposing radiographs with a hand-held portable x-ray device if they had taken dental radiation safety continuing education courses in the last five years. Distributions of dental radiation safety continuing education courses and clinician lead apron with 95% confidence limits are found in Figure 2.

Table 19. Cross Tabulation of Dental Radiation Safety Continuing Education Courses in the Last Five Years and Clinician Lead Apron

Use of Clinician Lead Apron	Continuing Education Courses in the Last Five Years			
	N	**Mean**	**SD**	**P-value**
Yes	14	1.571	1.222	0.0093
No	52	0.788	0.893	

Figure 2. Probability Distribution for Dental Radiation Safety Continuing Education Courses in the Last Five Years and Clinician Lead Apron With 95% Confidence Limits

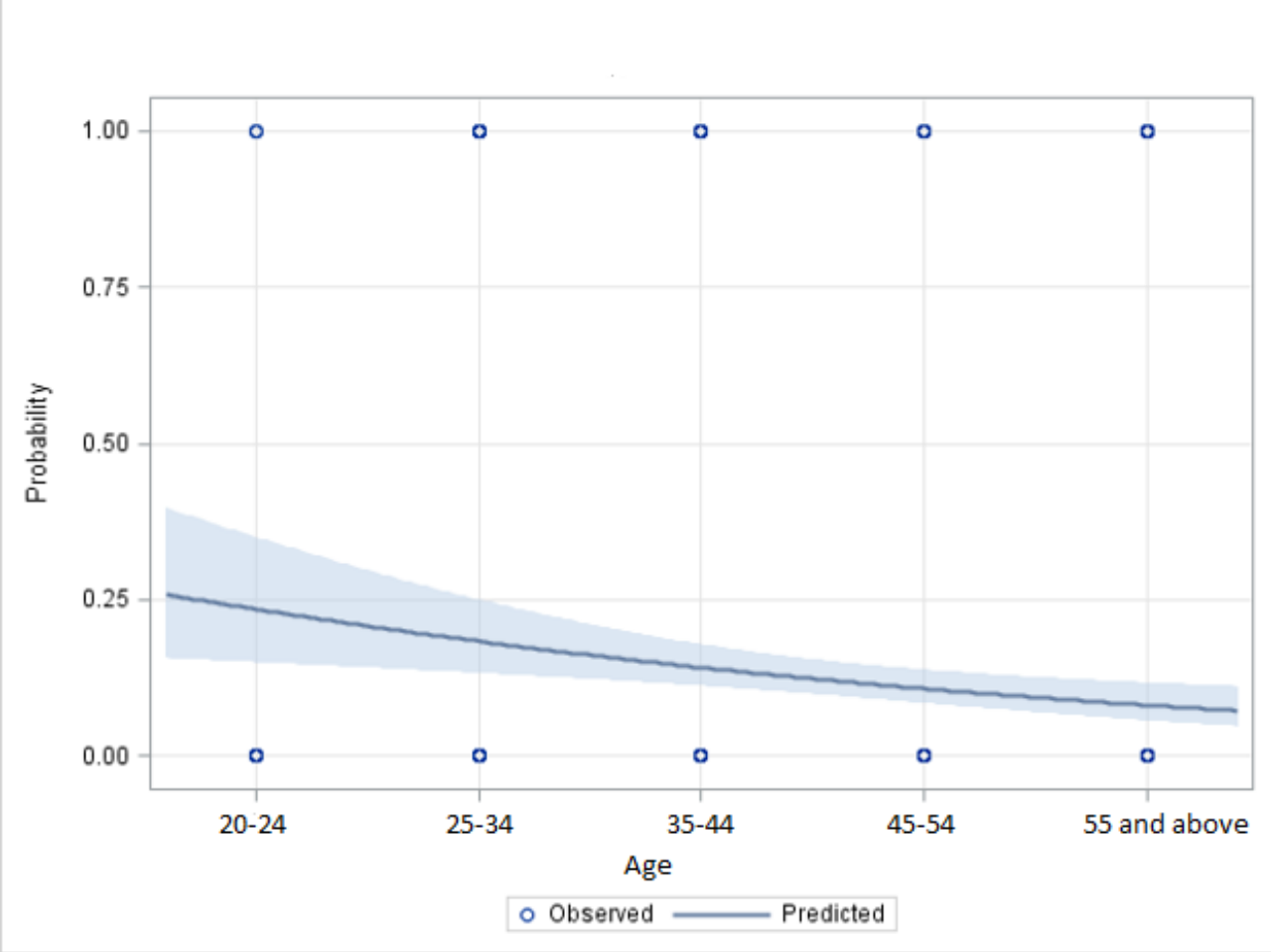


A cross tabulation was done to determine a relationship between age and the use of a hand-held portable x-ray device. A logistic regression was used to determine a significant difference (p=0.0025) between age and the use of a hand-held portable x-ray device, revealing that the chances of using a hand-held portable x-ray device were higher with a lower age range. 23% of respondents who used a hand-held portable x-ray device were 20-24 years of age (Table 20). Distributions of age and use of a hand-held portable x-ray device with 95% confidence limits are found in Figure 3.

Table 20. Cross Tabulation of Respondents' Age and Use of Hand-Held Portable X-Ray Device

Age	Probability	Lower 95% Confidence Limit	Upper 95% Confidence Limit	P-value
20-24 years old	23%	0.148869386	0.350044	0.0025
25-34 years old	18%	0.131648162	0.249782	
35-44 years old	14%	0.111125173	0.177872	
45-54 years old	11%	0.083502145	0.137248	
55 years old and above	8%	0.055642326	0.116463	

Figure 3. Probability Distribution for Respondents' Use of Hand-Held Portable X-ray Devices and Age With 95% Confidence Limits



CHAPTER V

DISCUSSION

In testing the hypotheses, respondents were more likely to implement safe radiation practices with more years of experience as a clinical dental hygienist and a higher level of education. A majority of respondents selected the appropriate criteria for determining the need for radiographs, such as suspected caries, periodontal involvement, history of previous radiographs, defective restorations, impaction/missing teeth, growth abnormality/delayed eruption, suspected pathology, and unexplained sensitivity/pain, with more years of experience as a dental hygienist. Most respondents were not basing radiographic examinations on dental insurance reimbursement intervals. Dental hygienists with a bachelor's degree or higher were found to be more likely to use radiographic techniques that follow the ALARA principle, such as utilizing the paralleling technique and changing the exposure settings depending on the area imaged compared to those with an associate's degree. Most respondents, especially those with a higher level of education, believed exposure settings should be reduced for child patients. Reducing the exposure time for children is important, as their cells are still developing and are more sensitive to radiation.[10,41] A higher level of education was correlated with a greater emphasis in radiation safety techniques and standards. Implementing safe radiation practices in the dental field is important for dental hygienists to prevent the negative implications associated with continued exposure to ionizing radiation.[1,6,8-10]

Radiation Safe Practices of U.S. Dental Hygienists

Data were analyzed to determine which radiation safety practices the respondents employed. Results of the current study suggest that a majority of dental hygienists were implementing the ADA selection criteria guidelines when determining the need for radiographs,

such as the use of clinical findings, the patient's disease state, and medical and dental histories. A majority of respondents indicated they always use a lead apron. The National Council on Radiation Protection (NCRP) Report 145 recommends that a lead apron is to be used at all times except when safety measures are followed, such as the use of rectangular collimation, fast image receptors, and the selection criteria guidelines.[45]

Compared to using film, radiation exposure is reduced with the use of direct digital image receptors when taking radiographs.[11] To date, no data has been gathered in the United States on the use of digital image receptors versus film. A majority of respondents reported using a direct digital image receptors, which have a narrower dynamic range than indirect digital image receptors. Direct digital image receptors alert the operator when exposure settings are outside of the narrow range, so settings must be relatively precise, requiring less radiation exposure to produce an image.[35] Indirect digital image receptors are less sensitive to radiation than direct digital image receptors, requiring an increase in radiation exposure.[34,36-37] The high percentage of respondents' use of direct digital image receptors implies that there is an overall decrease in radiation exposure; however, clinicians must realize that less radiation is required to produce an acceptable image.

Radiation Unsafe Practices of U.S. Dental Hygienists

Most respondents were not practicing safely overall, as was the case in Davies et al.'s survey of dental practitioners in the northeastern portion of England, where a majority of respondents did not utilize rectangular collimation, lead aprons, and thyroid collars.[15] Using the appropriate radiographic technique is important in reducing patient radiation exposure. A majority of respondents utilized the bisecting angle technique over the paralleling technique, although the paralleling technique is the gold standard in taking periapical images.[18,45] The

bisecting angle technique results in an increased vertical angulation and a higher amount of radiation. There is also a higher likeliness of retakes associated wit the bisecting angle technique because the technique is not as precise as the paralleling technique as it uses an approximation to determine the angle in which to direct the primary x-ray beam, further resulting in increased exposure. The bisecting angle technique should not be the first choice a clinician uses when placing the image receptor for all patients.

One-fifth of respondents neither agreed nor disagreed with changing exposure settings depending on the area imaged. Changing exposure settings based on the area of the mouth being imaged will help reduce radiation exposure, especially when less radiation is needed to image areas of the mouth that are not as dense. Aside from radiographic technique, dental hygienists should follow the appropriate criteria to determine the need for radiographs. Although a majority of respondents used the appropriate criteria to determine the need for radiographs, more than one-fourth of respondents did indicate exposing radiographs based on third party reimbursement, which should not be used as a deciding factor.

To reduce scatter radiation to the patient, PIDs should have rectangular collimation and an increased distance from the radiation source and area exposed. The use of a long PID is recommended to decrease the area of the primary x-ray beam;[11] however, only a quarter of respondents reported using a long PID and most reported currently using short PIDs. Results of the current study revealed that only 4% of respondents used rectangular collimation.

A thyroid collar is indicated for all exposures in both children and adults except during the exposure of a panoramic image. [42,45] Survey results revealed only about three-fourths of respondents provided their patients with a thyroid collar during intraoral exposures. Due to the radiosensitivity of the thyroid gland and the risk of developing thyroid cancer, a thyroid collar

should be used for all intraoral exposures. Even more alarming is that 1% of respondents indicated never using a lead apron and 3% indicated never using a thyroid collar. With such a low percentage of respondents utilizing rectangular collimation, all respondents should provide their patients with lead aprons during radiographic examinations.

Just over half of the respondents reported holding the PID in place, which the operator should not do in any given circumstance because of the increase in occupational exposure to radiation. A majority of respondents reported holding the PID when exposing radiographs on children; however, parents and guardians should be asked to hold the image receptor when the child is unable to sit still or occlude on the biteblock. A notable comment found was that the PID was held in place when the tubehead drifted; however, x-ray machines require immediate inspection of the unit if they are unstable or drifting.[29] With the high percentage of respondents holding the PID in place, there is a concern with scatter radiation to the operator, especially due to the low percentage of respondents using rectangular collimation. More than three-fourths of respondents reported not wearing a dosimeter badge to measure how much radiation they were exposed to. The Occupational Safety & Health Administration (OSHA) requires employees working in facilities with ionizing radiation to wear personal radiation monitors, such as dosimeter badges.[55]

Impact of Continuing Education (CE) Courses

Aside from periodic inspections of the x-ray unit, dental hygienists should regularly update continuing education (CE) courses in radiation safety; however, only a little over half of the respondents indicated taking at least one dental radiation safety CE in the past five years. It is recommended that radiation safety CE courses be updated every five years. For most

respondents, it had been too long since they learned radiation safety in their radiology course, as a majority of respondents had been practicing for 31 or more years as a clinical dental hygienist.

An increase in continuing education courses in dental radiation safety had an impact on the safe use of equipment factors, such as the increased use of a rectangular PID. Although there was no statistically significant difference between continuing education courses and PID length utilized, a cross tabulation of the two variables revealed frequencies that showed an increase in the use of long PIDs as more CEs in radiation safety were taken. There was no statistically significant difference between continuing education courses and the use of a thyroid collar for intraoral images; however, individuals were more likely to use a thyroid collar as the number of dental radiation safety CE courses increased.

The American College of Obstetricians and Gynecologists (ACOG) states that pregnant patients may be exposed to dental radiation during any stage of pregnancy as long as a need exists and a lead apron and thyroid collar are used.[46] The ADA selection criteria guidelines should be used to determine the need for radiographs on pregnant patients and to establish appropriate intervals as they should be used for all patients. Responses regarding respondents' practice policy on exposing pregnant patients to radiation varied indicating many were not following ACOG guidelines. Only 1% of respondents were following recommendations; this small percentage of respondents knew that radiographs could be taken on pregnant patients as long as the ADA selection criteria guidelines were followed. Two respondents took routine annual radiographs on pregnant patients; however, annual bitewing radiographs are only recommended for patients at an increased risk of developing caries. Half of the respondents only took dental radiographs on pregnant patients based on clinical symptoms such as pain or in the case of a dental emergency. In 2011, an article in the *Journal of Dental Research, Dental Clinics,*

and Dental Prospects discussed that pregnant patients should not be exposed to dental radiation unless there is an absolute need; thus, half of the respondents were practicing based on old recommendations further emphasizing the need to keep current with continuing education courses in dental radiation safety.[56]

Respondents' Use of Hand-Held Portable X-ray Devices

Data analysis showed an increase in younger respondents' use of hand-held portable x-ray devices, with a majority of users between 20 and 24 years of age. Most respondents who reported currently using hand-held portable x-ray equipment kept the PID as close to the patient's face as possible and had an external shield on the device; however, less than half of respondents held the hand-held portable x-ray device at mid-torso level. One respondent mentioned that he or she was unaware that the PID should be held at mid-torso. A majority of respondents mentioned that it is impossible to hold the PID at mid-torso level for all exposures, as is the case with periapical images when an increased angulation is needed. One individual mentioned that he or she knew that the device should be held at mid-torso, but he or she did not always follow that instruction depending on the difficulty of the patient. Clinicians can minimize patient and operator radiation exposure when using hand-held portable x-ray devices with the use of image receptor holders and the paralleling technique. For example, if clinicians utilize image receptor holders and the paralleling technique and ask their patients to put their chin down so that the occlusal plane is parallel to the floor, clinicians would potentially be able to place the hand-held device at mid-torso level. Although Danforth et al. determined the operator exposure in atypical imaging positions to be 0.9% of the annual maximum permissive dose, proper training on hand-held devices will help minimize occupational radiation exposure by reducing the number of retakes associated with improper technique.[21] To protect the operator from scatter

radiation, manufacturers of hand-held portable x-ray equipment advise the operator to utilize a backscatter ring shield, hold the device at mid-torso level, and keep the PID as close to the patient's face as possible.[11,50] Danforth et al. discussed that the use of an operator lead apron was not necessary as long as all safety protocols are followed with hand-held portable x-ray equipment.[11,21] Results of the current study revealed all safety protocols were not being followed according to the manufacturer; therefore, respondents should be wearing operator lead aprons when using hand-held portable x-ray devices. It is important for clinicians to receive training prior to using the hand-held portable x-ray device to minimize operator exposure to ionizing radiation. Over half of the respondents who used a hand-held portable x-ray device received training prior to use on patients.

There was no statistically significant difference between the use of a backscatter ring shield and a clinician lead apron when using a hand-held portable x-ray device. Only one-fifth of respondents not using a backscatter ring shield wore a clinician lead apron, indicating that a majority of respondents were not protecting themselves from scatter radiation being emitted from the hand-held device. Results indicated the positive effects of dental radiation safety continuing education courses on the use of a clinician lead apron when utilizing hand-held portable x-ray devices. Respondents were more likely to wear a clinician lead apron when using a hand-held portable x-ray device if they attended dental radiation safety continuing education courses in the last five years. With the use of hand-held portable x-ray devices increasing,[50] the ADA should mandate training for hand-held portable x-ray devices to ensure patient and operator safety similar to recommendations found in the European Academy of DentoMaxilloFacial Radiology position paper.[53] Individuals should provide proof of training for safe use of hand-held devices to ensure their understanding of the risks involved and radiation safety measures prior to use.

Limitations

The internal and external validity of the current study might be affected by:

1. A convenience sample of 1,500 U.S. dental hygienists resulted in a potential for a low response rate.
2. The survey questions may have been misinterpreted or misunderstood by the respondents.
3. The survey assessment tool was researcher-designed.
4. Survey responses may not be accurate because respondents may have been reluctant to reveal any unethical behaviors implemented in their practice setting.
5. Survey respondents may have inadequately responded to the questions in order to receive the $50 gift card.
6. There are different regulations per state. For example, dental x-ray machines are inspected every 3 years in Virginia, every 4 years in Texas, and every 5 years in Utah.[57-59]

Although the current study had a low response rate, it is still an acceptable response rate compared to other response rates in dental hygiene research. A survey on mass fatality preparedness in dental hygiene education found in the Journal of Dental Education (JDE) had a response rate of 36%.[60] Other published articles in the dental hygiene profession found in the Journal of Dental Hygiene (JDH) had response rates of 27%, 32%, 35%, and 36% respectively.[61-64]

CHAPTER VI

CONCLUSION

With the negative effects of increased and long-term exposure to ionizing radiation, dental hygienists should implement the As Low As Reasonably Achievable (ALARA) principle when exposing patients to dental radiation. Results from the current study suggest U.S. dental hygienists are implementing some safe radiation practices; however, more efforts must be made to further reduce radiation exposure to patients and operators. Emphasis needs to be focused on completing continuing education courses on dental radiation safety more frequently. Staying current on dental radiation safety standards every five years will help reduce radiation exposure, especially when further research shows improvements in reducing exposure through technique and updating equipment, as was the case when digital technology was found to reduce radiation exposure compared to film. Continuing education courses will also update dental hygienists on new research; for example, many hygienists are not aware that it is safe to expose pregnant patients to dental radiation. More dental hygienists may take radiographs more frequently on pregnant patients if they are aware of how safe it is as long as ALARA principles are followed. Educating dental hygienists on utilizing the paralleling technique as the first option in placing the image receptor will also assist in reducing radiation exposure to patients. Lastly, dental hygienists should be trained on the use of a hand-held portable x-ray device prior to its use to include the proper technique depending on the recommendations of the specific manufacturer of the device. Dental hygienists should be educated on the importance of following ALARA in every day practice on every single patient.

Future research is needed to determine an effective approach to improving radiation safety among dental hygienists. Once measures have been taken to keep dental hygienists current

with radiation safety updates, more data should be collected to determine if continuing education courses on dental radiation safety have an effect on dental hygienists' implementation of safety standards. Dental hygienists need to be aware of the most current research on dental radiation, so benefits of taking dental radiographs outweigh the risks involved.

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APPENDIX A

SURVEY TOOL

OLD DOMINION UNIVERSITY
IDEA FUSION

Informed Consent

Cover Letter.
Hello, my name is Kimberly Lintag, RDH, BSDH, MS(c). I am a graduate student at Old Dominion University (ODU) conducting a research survey on current radiation safety practices implemented by U.S. dental hygienists. Please answer the questionnaire honestly and completely. Your participation in this survey is anonymous and will require about 15 minutes of your time to complete. Your participation is voluntary. You may refuse to participate by not completing this survey. Your completion of the survey serves as your voluntary agreement to participate in this research project. Upon completion of the survey, you will be redirected to an independent survey where you may submit your email to be entered into a drawing to win a $50 visa gift card. Your responses will remain anonymous; researchers will not know how any one person responded. Your responses will be reported in group form only. Please submit responses no later than December 8, 2017.

Q1. What is the highest level of education in dental hygiene you have obtained?

- Associate's degree
- Bachelor's degree or higher

Q2. In your dental hygiene program, how much time was invested in your radiology course?

- One semester or less
- One year (two semesters)
- Three semesters
- Two years (four semesters) or more

Q3. Are you working as a dental hygienist who regularly exposes radiographs? If not, please stop taking the survey at this point and exit out of the survey browser. If yes, please continue on with the survey.

Q4. What is your age?

- 20-24
- 25-34
- 35-44
- 45-54
- 55 and above

Q5. How many years have you been practicing as a clinical dental hygienist?

- 0-10 years
- 11-20 years
- 21-30 years
- 31+ years

Q6. Which region of the country do you practice in?

- West
- Central
- Midwest
- Mid-Atlantic
- East

Q7. Which of the following is used to determine the need for radiographs in your practice? Please select yes or no for each item below.

	Yes	No
Suspected caries		
Periodontal involvement		
History of previous radiographs		
Defective restorations		
Impaction/missing teeth		
Growth abnormality/delayed eruption		
Suspected pathology		
Unexplained sensitivity/pain		
Third party reimbursement		

Q8. When do you use a lead apron when exposing dental radiographs on your patients?

Q9. How often do you use a thyroid collar for protecting the patient during intraoral exposures (excluding panoramic radiographs)?

- Never
- Sometimes
- Most of the time
- Always

Q10. Describe your practice's policy on radiographic exposure to pregnant patients.

Q11. Do you use a round or a rectangular cone (PID)?

- Round PID
- Rectangular PID

Q12. Do you use a long or short cone (PID)?

- Long PID
- Short PID

Q13. Which of the following image receptors does your practice use? Please select yes or no for each item below.

	Yes	No
D speed film		
E speed film		
F speed film		
Photostimulable Phosphor (PSP) plate - indirect digital sensor that goes through a processing step		
Direct digital image receptor that is plugged into the computer's USB port		

Q14. Do you as a clinician use a dosimeter badge to measure how much radiation you are exposed to?

Q15. Please indicate how the below statements relate to you as a dental hygienist in your primary place of employment (where you work 50% or more of the time)?

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
My first choice when acquiring periapical x-rays is to put the sensor/film far away from the tooth (paralleling technique).							
My first choice when acquiring periapical x-rays is to put the sensor/film as close to the tooth as possible (bisecting angle technique).							
My decision to use the paralleling technique or bisecting angle technique depends on the unique characteristics of the patient.							
Exposure settings should be altered depending on the area imaged.							
Exposure settings should be altered for child patients.							
Exposure settings for digital and film vary.							
Intervals for exposing radiographs depend on the patient's disease state and radiation exposure history.							

Q16. Have you ever held the x-ray cone (PID) in place during an exposure? If yes, answer question 17. If no, skip to question 18.

Q17. How many times have you held the x-ray cone (PID) in place in the last 10 years? Include an explanation of the situations/circumstances you have held the PID in place.

- 1-5 times
- 6-10 times
- 11-15 times
- 16-20 times
- More than 20 times

Q18. How many times in the past five years have you taken a continuing education (CE) course or in-service training in dental radiation safety?

- 0
- 1
- 2
- 3
- 4 or more

Q19. Do you currently use a hand-held portable x-ray device, such as the NOMAD™? If yes, answer questions 20-22. If no, please submit your responses to the survey.

Q20. Did you have training on the use of hand-held portable x-ray devices before exposing patients with this device?

Q21. Do you implement any of the following when using hand-held portable x-ray devices? Please select yes or no for each item below.

	Yes	No
Keep x-ray cone (PID) as close to the patient's face as possible		
External ring shield on x-ray cone (PID) of device		
Clinician dosimeter badge		
Clinician lead apron		

Q22. Do you aim the hand-held portable x-ray cone (PID) straight ahead (x-ray device parallel to the floor) holding it at clinician's mid-torso level for ALL exposures? Please explain your answer.

.
Thank you for responding to the survey. Please click the >> to complete the survey. The >> button will also redirect you to our raffle page. To enter the raffle, please click the >> button and enter your email address for the drawing of a $50 visa gift card. Your responses will not be tied to your email address. If you choose not to enter the raffle, then simply click the >> button and exit out of the drawing page.

Survey Powered By Qualtrics

APPENDIX B
SURVEY RESULTS

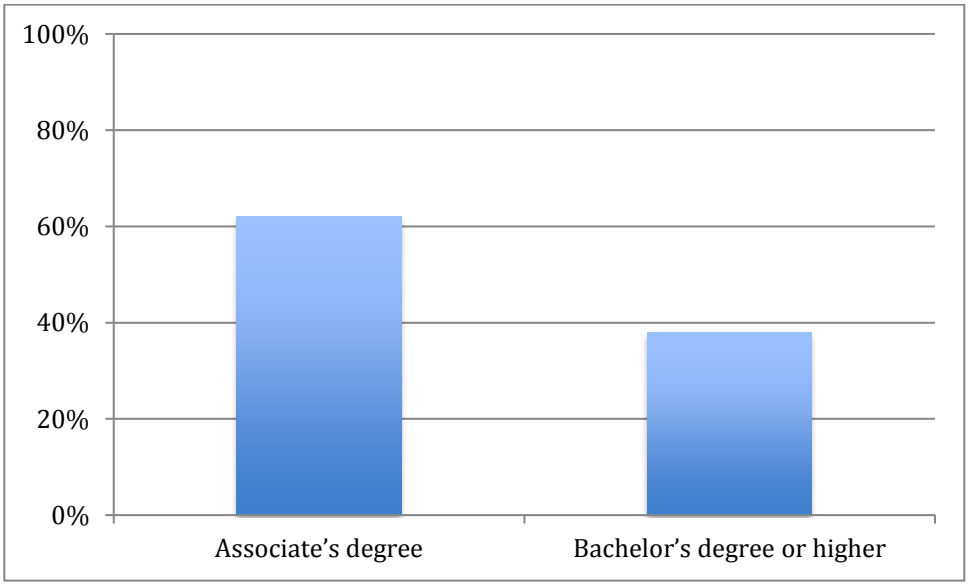
Survey responses from three out of the 569 respondents who completed the survey who responded "no" to question 3 were excluded from the survey, as shown in the table below.

Q3 Are you working as a dental hygienist who regularly exposes radiographs? If not, please stop taking the survey at this point and exit out of the survey browser. If yes, please continue on with the survey.

Q3	Frequency	Percent
Yes	566	99.47
No	3	0.53

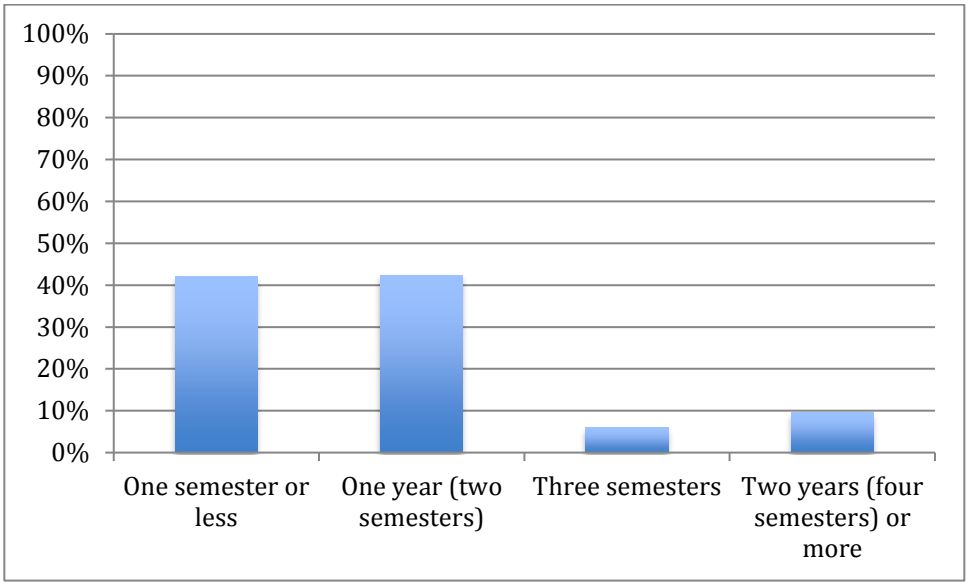
Frequencies of the remaining quantitative questions are provided below. Responses to question 17 and questions 20-21 were excluded if respondents responded "no" to the preceding question. A frequency of question 3 after excluding the three responses has also been provided.

Q1 What is the highest level of education in dental hygiene you have obtained?



Q1	Frequency	Percent
Associate's degree	351	62.01
Bachelor's degree or higher	215	37.99

Q2 In your dental hygiene program, how much time was invested in your radiology course?

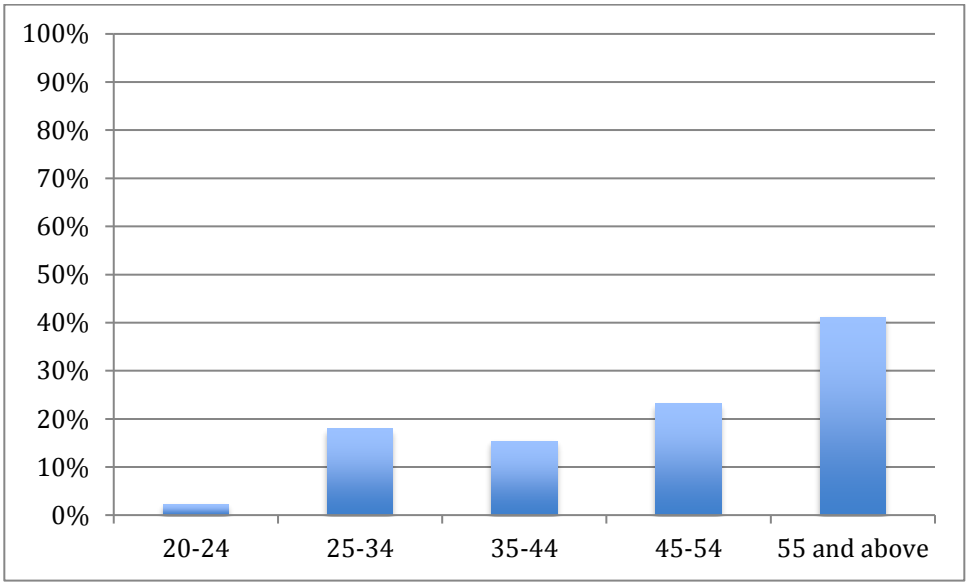


Q2	Frequency	Percent
One semester or less	238	42.05
One year (two semesters)	240	42.40
Three semesters	34	6.01
Two years (four semesters) or more	54	9.54

Q3 Are you working as a dental hygienist who regularly exposes radiographs?

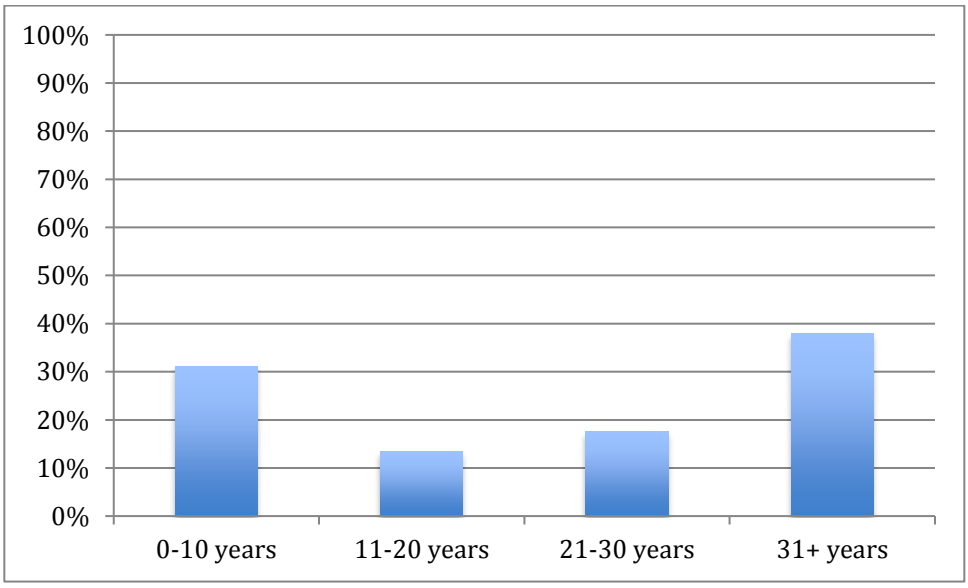
Q3	Frequency	Percent
Yes	566	100.00

Q4 What is your age?



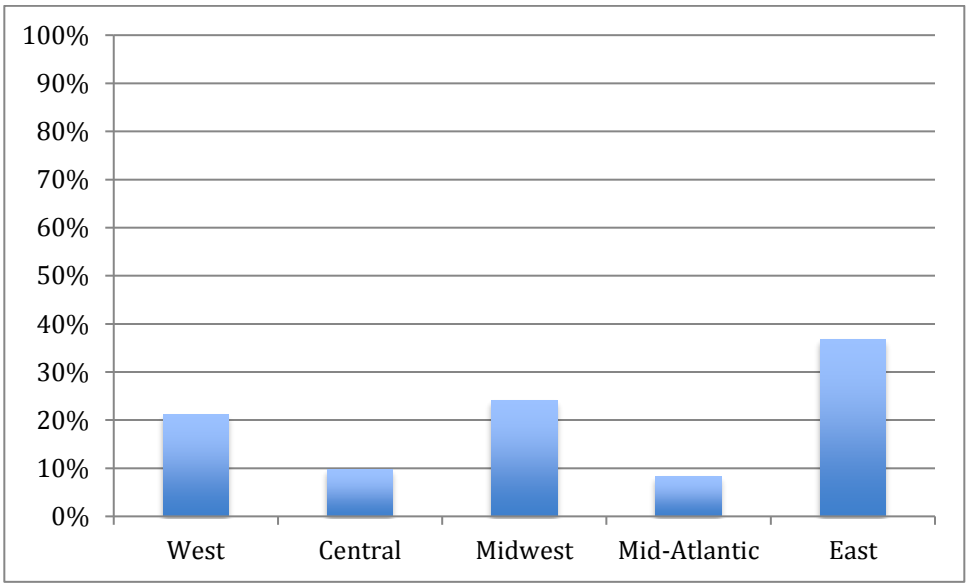
Q4	Frequency	Percent
20-24	13	2.30
25-34	102	18.02
35-44	87	15.37
45-54	131	23.14
55 and above	233	41.17

Q5 How many years have you been practicing as a clinical dental hygienist?



Q5	Frequency	Percent
0-10 years	176	31.10
11-20 years	76	13.43
21-30 years	99	17.49
31+ years	215	37.99

Q6 Which region of the country do you practice in?

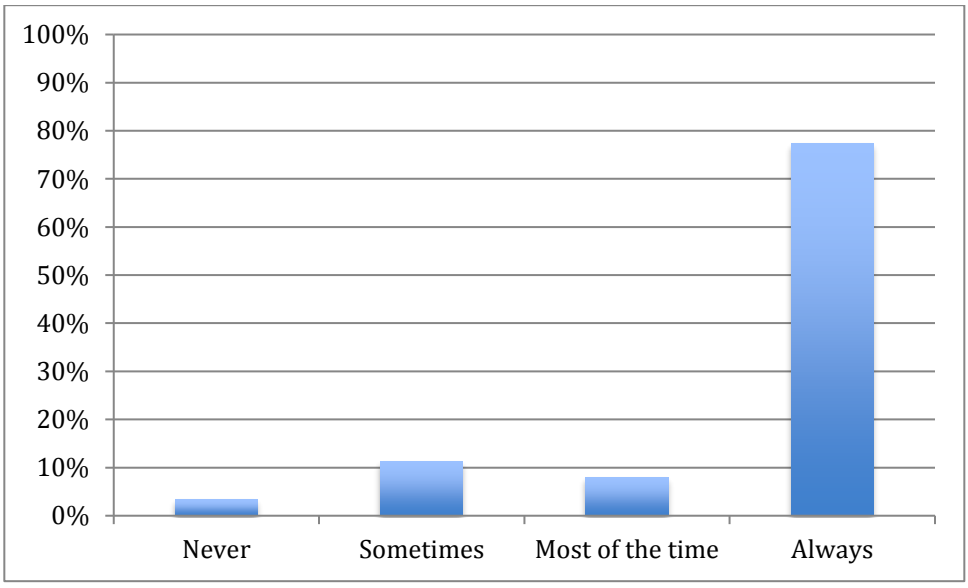


Q6	Frequency	Percent
West	120	21.20
Central	55	9.72
Midwest	136	24.03
Mid-Atlantic	47	8.30
East	208	36.75

Q7 Which of the following is used to determine the need for radiographs in your practice? Please select yes or no for each item below.

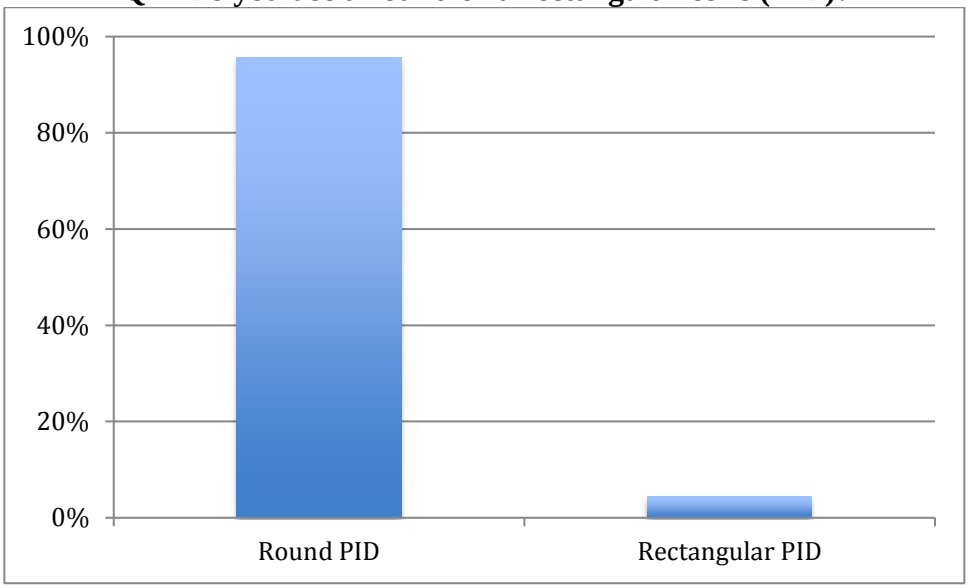
Q7	Yes	No
Suspected caries	**99.29%** 562	**0.71%** 4
Periodontal involvement	**98.06%** 555	**1.94%** 11
History of previous radiographs	**94.88%** 537	**5.12%** 29
Defective restorations	**92.23%** 522	**7.77%** 44
Impaction/missing teeth	**96.47%** 546	**3.53%** 20
Growth abnormality/delayed eruption	**97.00%** 549	**3.00%** 17
Suspected pathology	**95.94%** 543	**4.06%** 23
Unexplained sensitivity/pain	**96.47%** 546	**3.53%** 20
Third party reimbursement	**30.57%** 173	**69.43%** 393

Q9 How often do you use a thyroid collar for protecting the patient during intraoral exposures (excluding panoramic radiographs)?



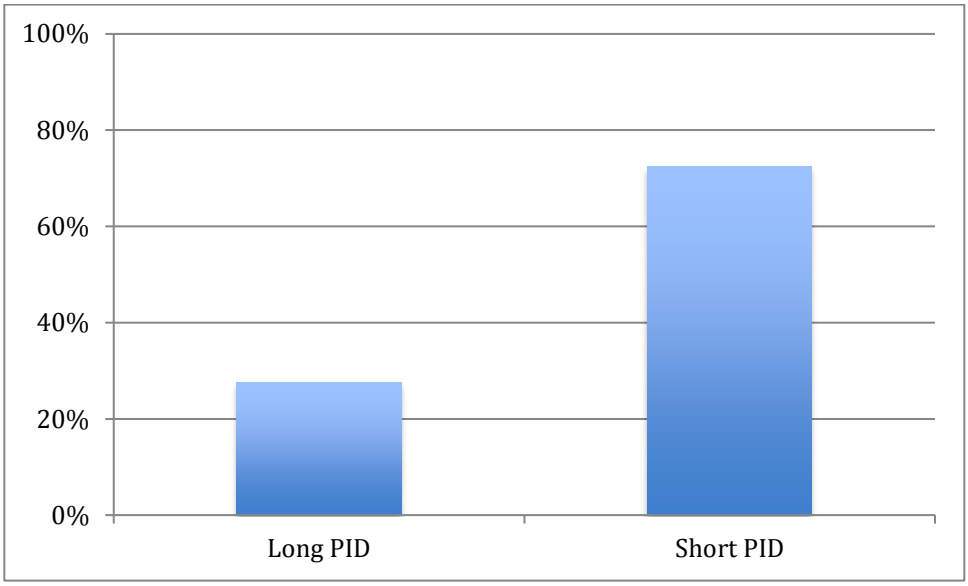
Q9	Frequency	Percent
Never	19	3.36
Sometimes	64	11.31
Most of the time	45	7.95
Always	438	77.39

Q11 Do you use a round or a rectangular cone (PID)?



Q11	Frequency	Percent
Round PID	541	95.58
Rectangular PID	25	4.42

Do you use a long or short cone (PID)?

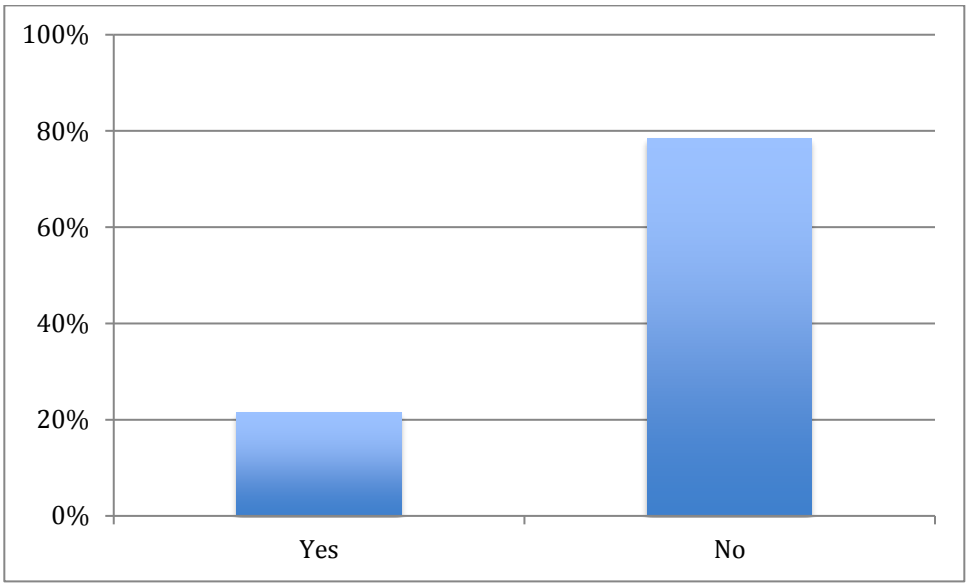


Q12	Frequency	Percent
Long PID	156	27.56
Short PID	410	72.44

Q13 Which of the following image receptors does your practice use? Please select yes or no for each item below.

Q13	Yes	No
D speed film	**7.42%** 42	**92.58%** 524
E speed film	**6.36%** 36	**93.64%** 530
F speed film	**7.07%** 40	**92.93%** 526
Photostimulable Phosphor (PSP) plate – indirect digital sensor that goes through a processing step	**23.50%** 133	**76.50%** 433
Direct digital image receptor that is plugged into the computer's USB port	**79.33%** 449	**20.67%** 117

Q14 Do you as a clinician use a dosimeter badge to measure how much radiation you are exposed to?

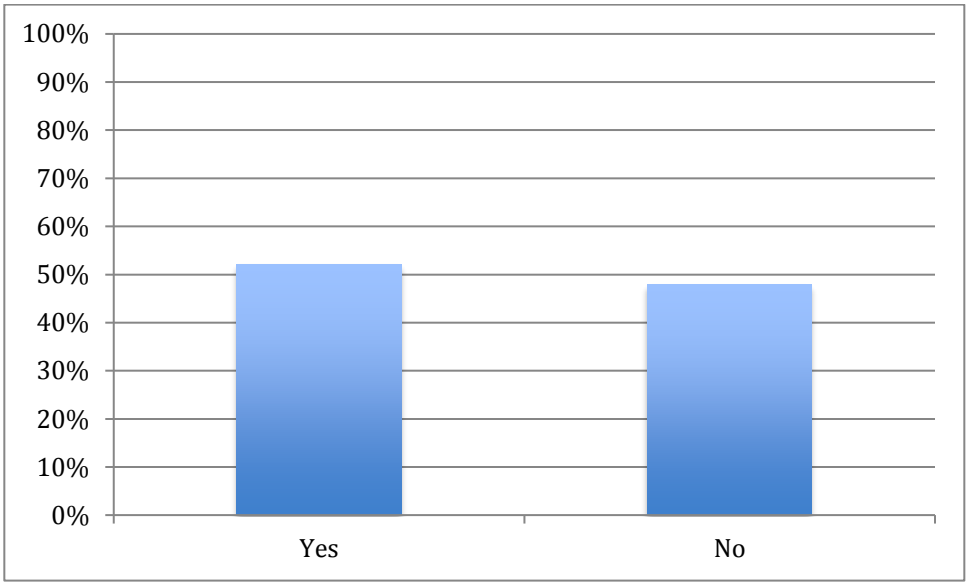


Q14	Frequency	Percent
Yes	122	21.55
No	444	78.45

Q15 Please indicate how the below statements relate to you as a dental hygienist in your primary place of employment (where you work 50% or more of the time)?

Q15	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
My first choice when acquiring periapical x-rays is to put the sensor/film far away from the tooth (paralleling technique).	23.14% 131	18.37% 104	15.37% 87	17.14% 97	7.07% 40	13.43% 76	5.48% 31
My first choice when acquiring periapical x-rays is to put the sensor/film as close to the tooth as possible (bisecting angle technique).	18.90% 107	24.38% 138	17.67% 100	17.84% 101	6.18% 35	9.72% 55	5.30% 30
My decision to use the paralleling technique or bisecting angle technique depends on the unique characteristics of the patient.	42.58% 241	31.27% 177	10.42% 59	9.36% 53	1.41% 8	3.53% 20	1.41% 8
Exposure settings should be altered depending on the area imaged.	24.03% 136	31.45% 178	17.14% 97	17.49% 99	3.71% 21	5.30% 30	0.88% 5
Exposure settings should be altered for child patients.	46.11% 261	36.22% 205	8.30% 47	6.54% 37	1.77% 10	0.71% 4	0.35% 2
Exposure settings for digital and film vary.	47.00% 266	32.86% 186	6.01% 34	10.25% 58	1.41% 8	2.12% 12	0.35% 2
Intervals for exposing radiographs depend on the patient's disease state and radiation exposure history.	42.40% 240	35.16% 199	9.01% 51	6.54% 37	1.59% 9	3.89% 22	1.41% 8

Q16 Have you ever held the x-ray cone (PID) in place during an exposure?



Q16	Frequency	Percent
Yes	295	52.12
No	271	47.88

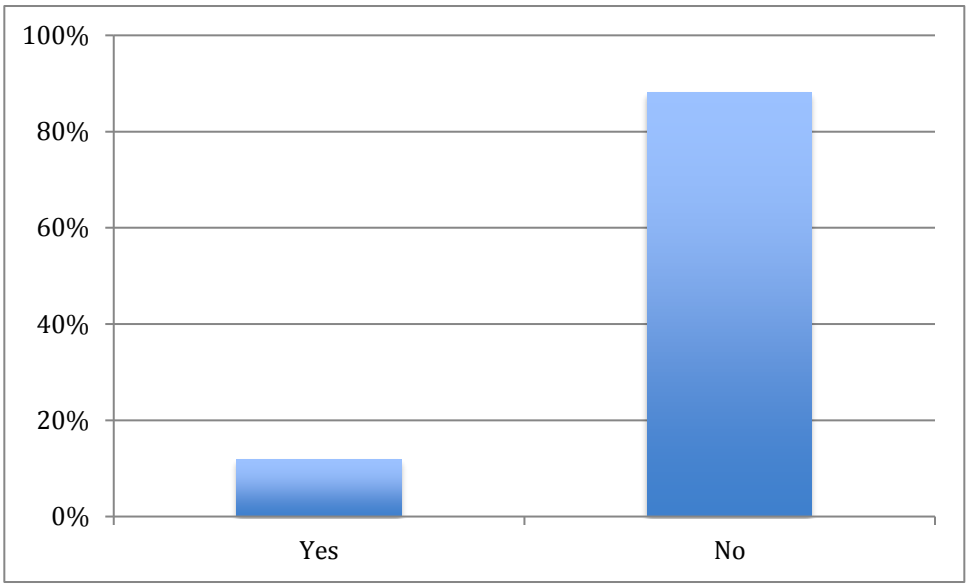
Q17 How many times have you held the x-ray cone (PID) in place in the last 10 years?

Q17	Frequency	Percent
Missing Data	2	0.68
1-5 times	58	19.66
6-10 times	18	6.10
11-15 times	29	9.83
16-20 times	42	14.24
More than 20 times	146	49.49

Q18 How many times in the past five years have you taken a continuing education (CE) course or in-service training in dental radiation safety?

Q18	Frequency	Percent
0	232	40.99
1	193	34.10
2	82	14.49
3	37	6.54
4 or more	22	3.89

Q19 Do you currently use a hand-held portable x-ray device, such as the NOMAD™?



Q19	Frequency	Percent
Yes	67	11.84
No	499	88.16

Q20 Did you have training on the use of hand-held portable x-ray devices before exposing patients with this device?

Q20n	Frequency	Percent
Yes	37	56.92
No	28	43.08

Frequency Missing = 2

Q21 Do you implement any of the following when using hand-held portable x-ray devices? Please select yes or no for each item below.

Q21	Yes	No	Missing Data
Keep x-ray cone (PID) as close to the patient's face as possible	**92.42%** 61	**7.58%** 5	1
External shield on x-ray cone (PID) of device	**92.42%** 61	**7.58%** 5	1
Clinician dosimeter badge	**21.82%** 21	**68.18%** 45	1
Clinician lead apron	**21.21%** 14	**78.79%** 52	1

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2016-Present	Virginia Dental Hygienists' Association
2016-Present	Tidewater Dental Hygienists' Association
2016-Present	American Dental Education Association
2015-Present	Old Dominion University Alpha Eta Honor Society for Allied Health Professionals
2015-2017	Old Dominion University Health Sciences Student Advisory Board
2014-2016	Old Dominion University Student Chapter of the American Dental Hygienists' Association