Knowledge and Attitude of Dentists regarding Radiation Safety in government Dental clinics in Khartoum, Sudan

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Abstract

The level of knowledge and the attitude of dentists regarding radiation safety will have a direct impact on patient exposure to radiation.

Aim: The aim of the present study was to evaluate the knowledge and attitude of dentists regarding radiation safety in government dental clinics in Khartoum, Sudan.

Materials and Methods: A cross-sectional study using an administered structured questionnaire was carried out. The questionnaire consisted of 13 questions that included the demographic data of dentists, basic knowledge regarding radiation safety, knowledge of methods of dose reduction and the attitude of dentists regarding radiation safety. One hundred and sixty seven dental practitioners participated in the study.

Results: The response rate was 90%. The majority were female, 59%, in the age group younger than 29 years with clinical experience less than 10 years. Only fifteen of the respondents identified themselves as specialist. Half of the respondents did not know that the thyroid gland is the most radiosensitive organ in the head and neck region. Forty four percent believed that the dose for panoramic radiography was higher than that for full mouth periapical radiographs. Forty percent had no idea that a relationship exists between the length of the x-ray cone and the amount of the dose and 44% who knew that the relationship existed, failed to explain that the long cone is more effective for reducing the patient dose. Forty seven percent of the respondents had no idea that there is a relationship between the speed of the film and the amount of dose and 44% who knew that the relationship existed, failed to explain that the fast film is more effective for reducing the patient dose. Sixty six percent had no idea that a relationship exists between collimation of the x-ray tube and patient dose. Forty six percent who knew the relationship existed, failed to explain that rectangular collimation is more effective for dose reduction. Seventy two percent of the dentists did not know what a safe distance from the radiation source was. Forty seven percent did not use film holders when taking periapical radiographs.

Conclusions: This study clearly illustrates that there is a lack of knowledge regarding radiation safety in dentists in the government dental clinics in Khartoum, Sudan. Therefore there is a need to increase their knowledge regarding methods of radiation dose reduction (to patient) as well as improving their attitude regarding the radiation safety.

Declaration

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that it has not previously in its entirety or in part been submitted at any university for a degree.

Yasir Mohamed Elmukhtar **September 2015**

Signature … 

Dedication

Dedicated to:

My beloved family for their continuous love and for believing in me.

And

To the soul of my father.

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List of Abbreviations

ALARA	As Low As Reasonably Achievable
CBS	Central Bureau of Statistics
CPD	Continuing Professional Development
CT	Computed Tomography
EMRO	Eastern Mediterranean Region
OHD	Oral Health Directorate
OPG	Orthopantomograph
ICRP	International Commission of Radiological Protection
DNA	DeoxyriboNucleic Acid
SPSS	Social Package of Statistical analysis

Chapter 1

Introduction

The Republic of Sudan is a country in Northern East Africa, with a total area of 1, 881,000 million square kilometres. It was regarded as the third largest country in the region before the July 2011 secession of South Sudan. Sudan shares borders with seven African countries: Egypt and Libya in the north, Chad and Central Africa in the west, South Sudan in the south, and Ethiopia and Eritrea in the east. It also neighbours Saudi Arabia across the Red Sea to the east. Sudan belongs to the EMRO region of the World Health Organization. According to the 2008 census (CBS, 2008) the total population is 33,419,625. The official language is Arabic.

Khartoum is the capital of the country. It covers an area of 20, 000 square miles comprising three main cities, Khartoum, Bahri and Omdurman, and it is administratively divided into seven localities .The total population is 5,706,507 which makes it the most populous state comprising 17.1% of the total population (CBS, 2008).

Health care services in Khartoum are provided by different providers in both public and private sectors. The Ministry of Health, Khartoum State is the main public service provider. There are 140 public dental clinics located in different hospitals and health-care centres in Khartoum that provide oral health-care services for about 150,000 people per annum.

The heightened risk of radiation for patients in Radiology compared to other diagnostic services, underscores the need for practitioners to have a basic knowledge of patient protection during radiological examinations (Wright, 2012).

Problem Statement

Radiation modalities need to be used cautiously because of the hazardous effects of radiation for health care workers, patients and the general population. It has been reported that there is an association between prolonged dental exposure and increased incidence of head and neck tumours (Schonfeld *et al*. 2011).

Justification

Limited information is available on the situation of dental radiography and radiation protection in Sudan. No evidence was found of previous studies regarding radiation safety performed in Sudan.

The present study is an attempt to determine dentists' knowledge and attitudes regarding radiation safety in Khartoum and to provide base line data prior to conducting intervention, with long term goals of increasing dental practioners awareness and practise of radiation safety.

Chapter 2

Literature Review

Studies have shown that exposure to ionizing radiation can be potentially harmful to the individual being irradiated. There are two types of radiation and their effects that we are concerned about:

A. Ionizing radiation

Characterized by high energy that is capable of displacing an electron from the atom or molecule. Then the molecules will be electrically charged (Wakeford, 2004).
The effect of ionization in living tissue leads to disturbance of the atom and at the end will lead to cell death and malignant changes of the cell (White & Mallya 2012).

B. Non ionizing radiation

This type of radiation has low energy and less capability to remove the electron and ionize matter, for example: microwaves, magnetic energy (Wakeford, 2004).

2.1 The effect of ionizing radiation

Exposure to ionizing radiation without the necessary precautions may have serious consequences for the patient, operator, and the population. This hazard to the body has been divided into somatic and genetic effects. The genetic effect may occur later in descendants of the irradiated individual (White & Mallya 2012). The somatic effect can be divided into deterministic and stochastic effect.

2.1.1 Deterministic effect

These effects are observed after a threshold dose and are characterized by cell death. Below the threshold dose no clinical signs are seen (White & Mallya 2012).
The following are characteristic of deterministic effects:

- Effects on cells of bone and cartilage by disturbing the remodelling activity, affecting the growth and maturation of bone (Furstman, 1972).
- The male gonads are affected which results in reduced sperm formation (Hohl *et al.* 2005).
- It affects the female ovarian tissue by disturbing their function (Meirow & Nugent 2001).
- Radiation can cause damage to the bone marrow affecting the synthesis of blood cells resulting in leucopoenia and anaemia (Kujawa *et al.* 2004).

2.1.2 Stochastic effect

The effect is on the DNA which is responsible for malignant changes of the cells which may lead to cancer and is not linked to the threshold dose. Even a small dose can induce it (White & Mallya 2012), for example:

- Radiation exposure can cause malignant transformation of the thyroid (Sansare *et al.* 2011) and salivary gland (Michael *et al.* 2007).
- Radiation exposure to the pregnant patient may induce cancer in the embryo, especially within the first three months (Fenig *et al.* 2001).

In dental Radiology the deterministic effect is unlikely due to low dose, but there is still a chance for its occurrence especially when high doses are used, for example in CT scans (White & Mallya 2012). Studies have linked some types of cancer to prolonged exposure to dental radiation (Claus *et al*. 2012).

It is therefore important to apply strict guidelines regarding radiation safety and to apply legislation to ensure a safe environment for the health worker, patients, and the public.

2.2 Guidelines for radiation protection

The international commission on Radiological protection (ICRP) published the first guidelines in 1924 regarding radiation safety. These guidelines emphasize adherence to the ALARA principle (As Low as Reasonably Achievable) (ICRP Publication 103, 2007).

The ultimate goals in applying the ALARA principle are:

- To reduce the hazard of radiation to the patient in dental radiography
- To guarantee adequate safety to operators
- To guarantee adequate protection of the surrounding public who are not receiving radiation but may unintentionally be exposed

The ICRP has classified people who may be exposed to ionizing radiation by a dental x-ray machine into: patient, radiation operators and general public (ICRP Publication103, 2007).

2.2.1 Patient Protection

The quantity of radiation that the X-ray machine produces and that reaches the patient is called radiation exposure. The amount of exposure a patient receives from dental radiography depends on many factors: selection criteria, film speed, collimation, technique and exposure factors (White & Pharoah 2009).

(A) Selection criteria

Dental radiographs should be requested after a clinical examination of the patients and a review of past health history has been performed. A dentist should not prescribe dental radiographs routinely without full justifications for each radiological examination (ICRP Publication 103, 2007).

(B) Film and Digital Imaging

The intraoral film comes in different speeds (D, E and F). The fast speed film (F speed) is more sensitive to x-rays than the E and D speed films (Alcaraz *et al*. 2009). This will reduce the exposure time which will lead to a reduction of the patient dose. The use of digital radiography as compared to analogue radiography reduces radiation dose to the patient (Alcaraz *et al*. 2009).

The use of rare-earth intensifying screen film combinations are recommended in extra oral radiography because it will reduce the radiation dose to the patient (White & Pharoah 2009).

(C) Collimation of the tube

Collimation of the X-ray beam limits the size and shape of the X-ray beams either at the tube head or at the end of the directing device (Hoos & Razzano 2010). This can be achieved by using rectangular collimation which will reduce the dose to the patient from two to four times, compared to round collimation and will not affect the quality of the X-ray beam (Hoos & Razzano 2010).

The use of a long X-ray cone collimator will increase the source object distance thereby reducing the patient dose as the X-rays are less divergent and therefore lead to less tissue irradiation (White & Pharoah 2009).

(D) Film holding device

The use of film holding devices allow for accurate placement of the film. This prevents unnecessary exposure to the operator and decreases the re-taking of radiographs (White & Pharoah 2009).

2.2.2 Operator protection

The staff that are occupationally exposed to radiation on a daily basis are advised, according to the ICRP guidelines, to stay away as far as possible from the radiation source and on the use of the proper shielding material.

The purpose of shielding around the radiation sources is to provide a safe environment for the operator and to protect the patient and surrounding population (ICRP Publication 103, 2007).

Periodic inspection of X-ray devices are necessary to exclude those that do not conform to international criteria for radiation safety (Mutyabule & Whaites 2002).

Accumulative dose must be monitored for the radiation worker annually and must not exceed 20mSV (ICRP Publication 103, 2007).

One of the methods recommended to reinforce the awareness of radiation safety is to increase knowledge regarding radiation hazards and its effects.

Radiation safety protection measures should be taught at dental student level and followed by continuing educational courses for general dental practitioners (Aps, 2010).

2.2.3 The public protection

Strict policies must be implemented to protect the public from the source of radiation and the general population should not receive doses more than 1mSVper year (ICRP Publication 103, 2007). Other recommendations by the ICRP include:

- Proper location of the X-ray equipment so that the X-ray beam is not pointing toward the doors , windows or into the adjacent waiting area.
- Proper shielding thickness around the wall and door.
- Multiple warning signs around the radiation room.

2.3 Knowledge and attitude studies

The level of knowledge and the attitude of dentists regarding radiation safety will have a direct impact on patient exposure to radiation (Shahab *et al*. 2012). Many studies have been done to determine the knowledge and attitude of dentists regarding radiation safety.

Shahab *et al*. (2012) reported a study pertaining to radiation safety to assess the knowledge of dentists with regard to basic information in relation to radiation protection and methods of reducing the radiation dose to the patient. The majority of dentists did not employ appropriate procedures to decrease exposure to unwanted radiation.

Mutyabule and Whaites (2002) conducted a study to assess radiation protection measures in dental practices in Uganda. It was found that operators lacked sufficient knowledge regarding radiation safety protection measures.

Aps (2010) assessed dentists' knowledge regarding radiation safety. The dentists were asked about various methods of dose reduction to the patients. The results of the

study highlighted the need to increase knowledge of dental practitioners regarding radiation safety and methods of dose reduction.

Lee and Ludlow (2013) assessed the attitude of dentists regarding radiation safety. The dentists were asked about primary knowledge of radiation safety and the method of reducing the dose to the patient such as speed of the film, collimation of the X-ray tube and the regular use of shielding. Results of the study confirmed that there is a demand to reinforce the dentist's working knowledge about the issue of radiation safety.

Math *et al.* (2014) assessed the understanding of dentists regarding radiation safety standards with regards to the X-ray machine, collimation of the tube, regular use of a film holder, shielding and the position of the operator during radiation exposure. The result of this study also highlights the need to increase the practitioner's awareness and attitude regarding radiation hazard and use of appropriate methods to reduce the radiation dose.

Jacobs *et al.* (2004) conducted a study regarding the perceptions of the dentists of radiation protection. The results of this study concluded that there was a need to apply strict guidelines toward radiation safety.

Comparative studies done by Nakfoor and Brooks (1992) to assess the diligence of dentists regarding radiation safety revealed that the majority of dentists are less compliant with international radiation safety standards.

Summary

It is clear from the literature that dentists' knowledge regarding the hazards of radiation and the application of proper methods to reduce unnecessary radiation is lacking.

Chapter 3

Aim and Objectives

3.1 Aim

To evaluate the knowledge of the dentists regarding radiation safety in the government dental clinics in Khartoum, Sudan.

3.2 Objectives

- To determine the dentist's knowledge and attitude regarding radiation safety.
- To explore whether safety measures are implemented.
- To make suggestions for the continuing professional education programmes.

Chapter 4

Methodology

4.1 Study design

A descriptive, cross sectional study.

4.2 Study site and study population

All 167 registered dentists practicing in the government dental clinics in Khartoum were included in the study. The lists of dentists working in these clinics were obtained from the directorate of oral health, Ministry of Health Khartoum.

4.3 Inclusion criteria

Health care workers who qualified as dental practitioners working at the governmental dental clinics.

4.4 Exclusion criteria

Health care workers not qualified as dental practitioners, for example:

- Dental students

- Dental assistants
- Dental radiographers
- Dentists not working in the government dental clinics

4.5 Data collection method

This study was conducted among dentists who attended a CPD lecture at the ministry of health in Khartoum on the 9th of June 2014.

A self-administered anonymous questionnaire was distributed to the dentists (Appendix 1) and then collected after the CPD lecture.

The questionnaire included the following:

(1) Demographic data of the respondent's gender, age, title of dentist (general, specialist), clinical experience.

(2) Knowledge regarding radiation safety.

(3) Knowledge regarding method of dose reduction to the patients.

A. Length of the x-ray tube

- The importance of length of the tube in dose reduction.
- Which one is more efficient in radiation dose reduction to the patient: long or short tube.

B. Speed of the film

- The importance of film speed in dose reduction.
- Which one is more efficient in radiation dose reduction to the patient: slow or fast speed film.

C. Collimation of the x-ray tube

- The importance of collimation in dose reduction to the patient.

- Which one is more efficient in radiation dose reduction: round or rectangular collimator

(4) Behaviour of dentist

A- Safe distance from the x-ray tube

B- Position of the operator behind protective barrier

C- Regular use of lead apron and thyroid shield for the patient

D- The use of film holder while taking of the periapical radiograph

4.6 Data analysis

The collected data was categorized, coded and entered into the computer. The data was captured in Excel. Basic descriptive analysis was done using the Excel environment. The database was imported into SPSS to perform complex statistical analyses. Descriptive statistics were used to describe the demographic factors. The independent t-test was used to determine associations between the scale variables of the sample.

4.7 Ethical considerations

The research was approved by the Research and Ethics Committee of the University of the Western Cape. Permission to carry out the study was sought from the Ministry of Health, Khartoum (Appendix 3). Participants were required to sign an informed consent form (Appendix 2).

Participation was entirely voluntary and the participants were allowed to withdraw from the study at any time should they wish to do so without any penalties.

Anonymity was achieved by not using the participant's name in the questionnaire.

Chapter 5

Results

5.1 Demographic characteristics

One hundred and sixty-seven dentists participated in the study. The overall response rate was 90% of which 59% were female and 41% male (Table 1). The breakdown of the demographics is as follows: 15 of the respondents were specialist dentist, 64% percent were younger than 29 years old. Twenty six percent were between 30-39 years old, 9% between 40-49 years old and the remaining 1% above the age of 50 (Table 1). The majority of dentists (82%) had less than ten years clinical experience, 15% had between 10-25 years' experience and 3% more than 25 years (Figure 1).

Table 1: Demographic characteristics of the respondents.

Characteristics	Number	Percentage (%)
Gender		
Male	69	41%
Female	98	59%
Total	167	100
Age group		
<29	106	64%
30-39	44	26%
40-49	15	9%
50-59	2	1%
>60	0	0%
Total	167	100%

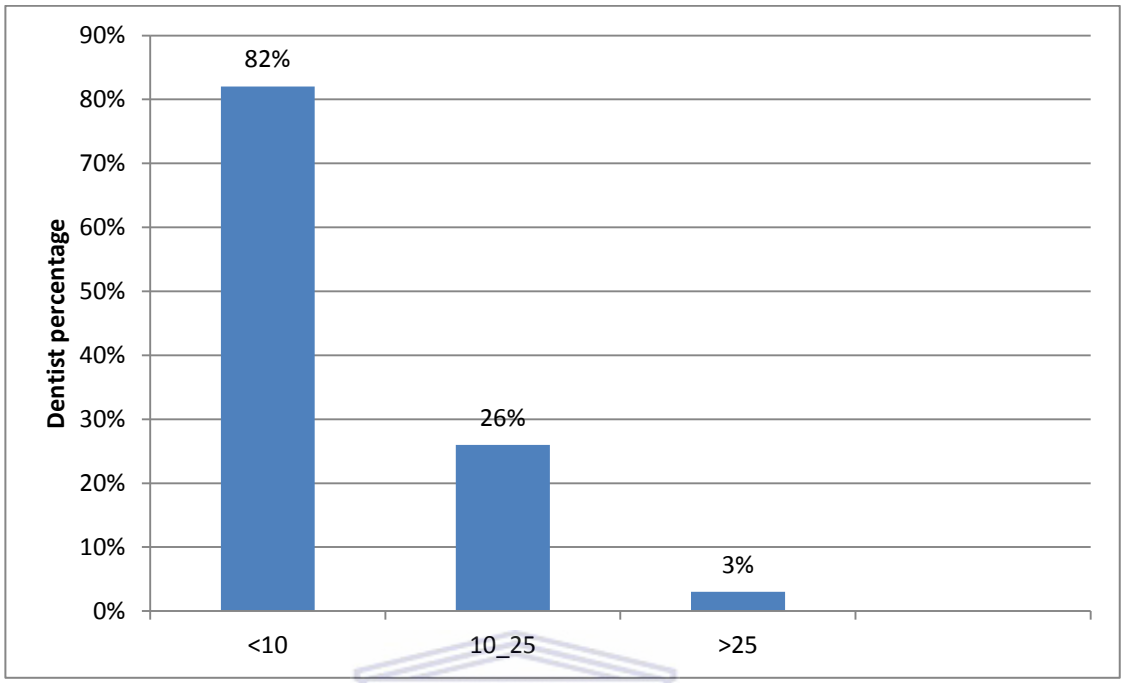

Figure (1): Years of clinical experience.

5.2 Basic knowledge regarding radiation protection

Half of the respondents did not know that the thyroid gland is the most radio-sensitive organ in the maxillofacial region (Figure 2). Forty four percent of the respondents did not know that full mouth periapical radiographs deliver more radiation to the patient than a single panoramic radiograph (Figure 3). No statistically significant difference was found between the different age groups, clinical experience, title (general dentist, specialist) and gender of the dentist (p-value >0.05).

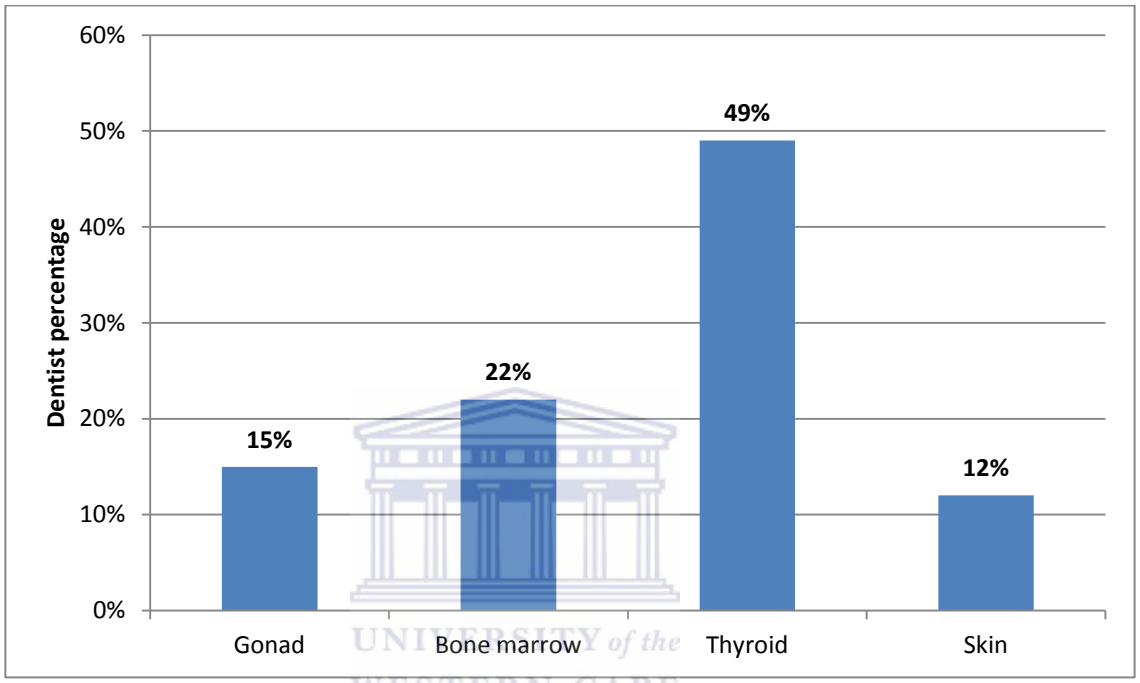

Figure (2): The most important organ in radiation protection in dental radiography.

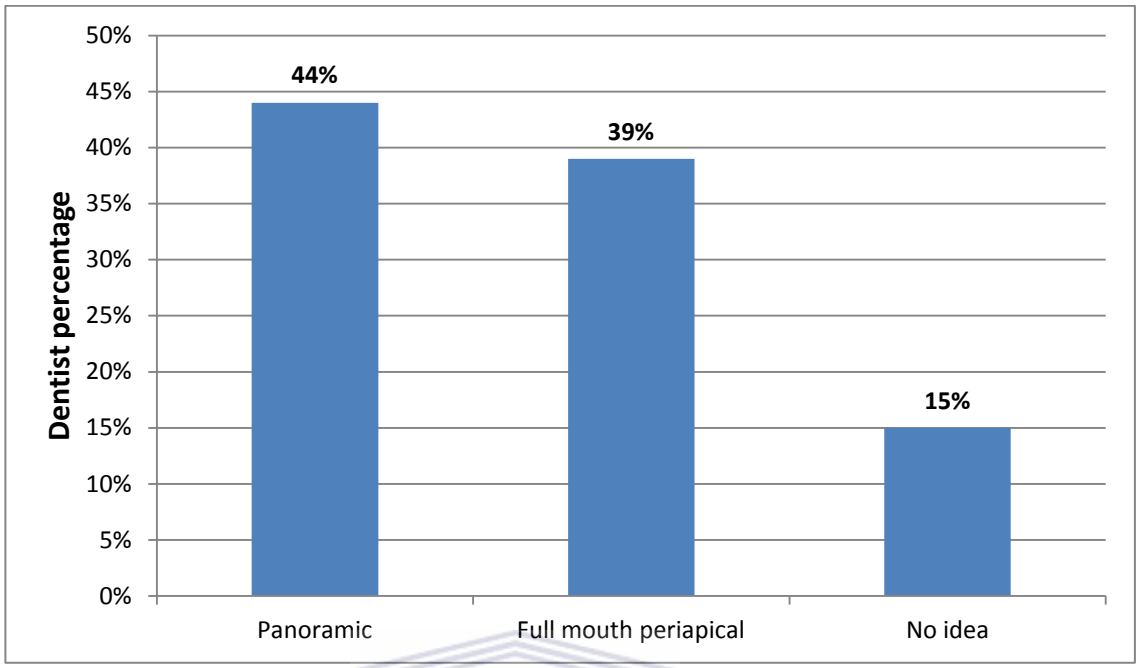

Figure (3): Results of the different radiographic techniques that deliver more radiation to the patient.

5.3 Knowledge of different methods of reducing patient dose

5.3.1 Length of the cone of the x-ray tube

Forty percent (sum total of "no" and "no idea") of the respondents did not know that there is a relationship between the length of the cone and the radiation dose delivered to the patient (Table 2).

Forty four percent of respondents knew that a relationship exists, but could not explain that a longer cone is more suited for dose reduction (Table 3). No statistically significant difference was found between the different age groups, clinical experience, title (general dentist, specialist) and gender of the dentist (p-value >0.05).

Table 2: Relationship between the length of the tube and radiation dose to the patient.

	Number	Percentage
Yes	100	60%
No	20	12%
No idea	47	28%
Total	167	100%

Table 3: Which type of cone delivers less radiation dose to the patient?

	No	Percentage
Short cone	44	44%
Long cone	56	56%
Total	100	100%

5.3.2 Speed of the film

Forty seven percent (sum total of "no" and "no idea") of the respondents did not know that there is a relationship between the speed of the film and the radiation dose delivered to the patient (Table 4).

Forty four percent of the respondents knew that a relationship exists but could not explain why fast speed reduced radiation dose (Table 5). No statistically significant difference was found between the different age groups, title (general dentist or specialist), clinical experience and gender of the dentist (p-value > 0.05).

Table 4: Relationship between the speed of the film and dose reduction to the patient.

	No	Percentage
Yes	89	53%
No	18	10%
No idea	60	37%
Total	167	100%

Table 5: Film speed versus radiation dose.

	No	Percentage
Slow speed	39	44%
Fast speed	50	56%
Total	89	100%

5.3.3 Collimation of the tube

Sixty six percent (sum total of "no" and "no idea") of the respondents had no knowledge that there is a relationship between collimation of the x-ray tube and the radiation dose delivered to the patient (Table 6).

Forty six percent of the respondents knew that a relationship exists but could not explain why the rectangular collimator is better to use in reducing patient dose compared to using a round collimator (Table 7). No statistically significant difference was found between the different age groups or the title (general dentist, specialist), clinical experience and gender of the dentist (p-value >0.05).

Table 6: Relationship between collimation of the tube and dose reduction to the patient.

	No	Percentage
Yes	**57**	**35%**
No	**19**	**11%**
No idea	**91**	**55%**
Total	**167**	**100%**

Table 7: Which collimator type delivers less radiation to the patient?

	No	Percentage
Round	26	46%
Rectangular	31	54%
Total	57	100%

5.4 Behaviour of the dentist

5.4.1 Position behind a protective barrier

The majority of the dentists (84%) mentioned that they stood behind a protective wall during radiation exposure (Figure 4). No statistically significant difference was found between the different age groups or title (general dentist, specialist), clinical experience and gender of the dentist (p-value > 0.05).

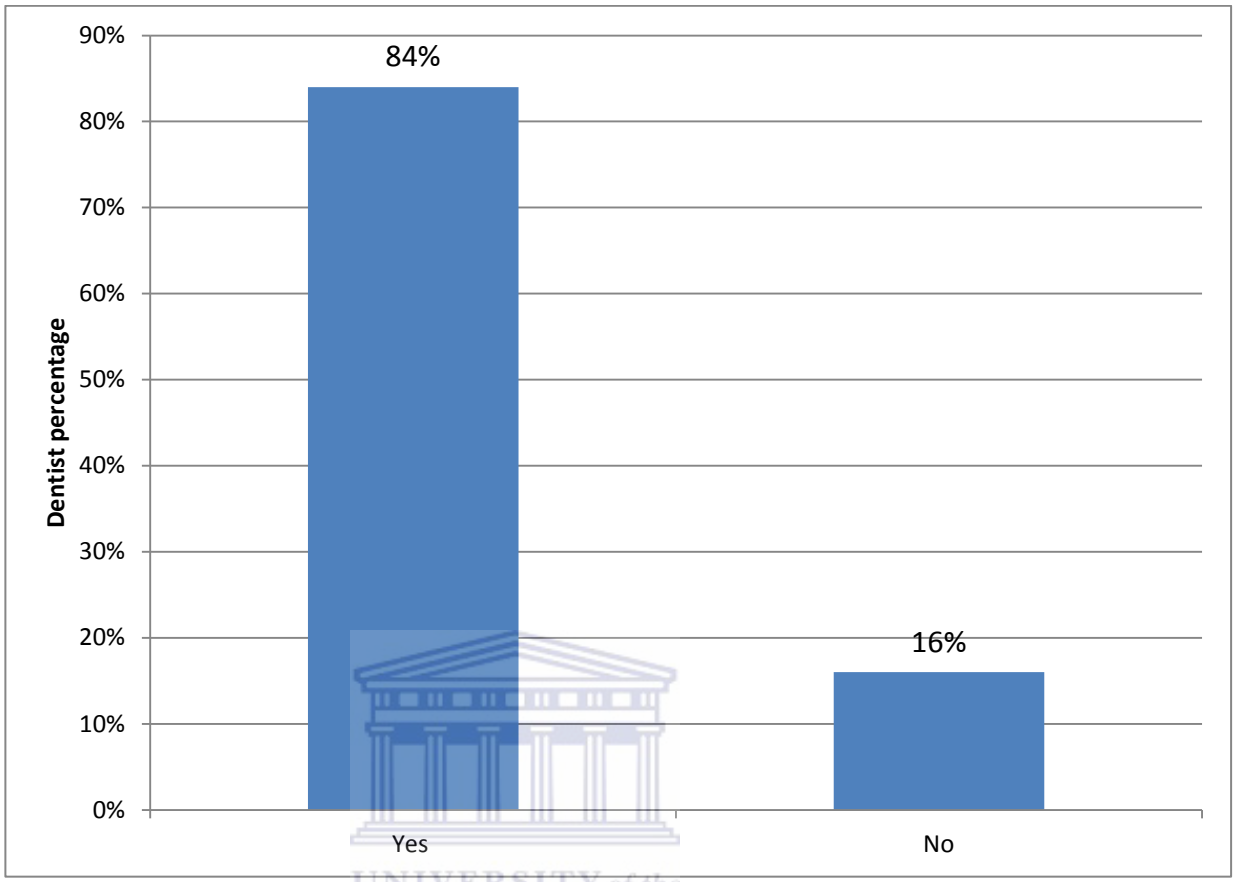

Figure 4: Position of operator behind a protective barrier.

5.4.2 Safe distance

Seventy two percent of the dentists had no idea what the safe distance was that the operator has to be from the radiation sources: 2% mentioned 1 meter, 11% mentioned 2 meters, 8% mentioned 3 meters, 2%, 4 meters, 4%, 5 meters and 2%, 6 meters (Figure 5). No statistically significant difference was found between the different age groups or title (general dentist, specialist), clinical experience and gender of the dentist (p-value >0.05).

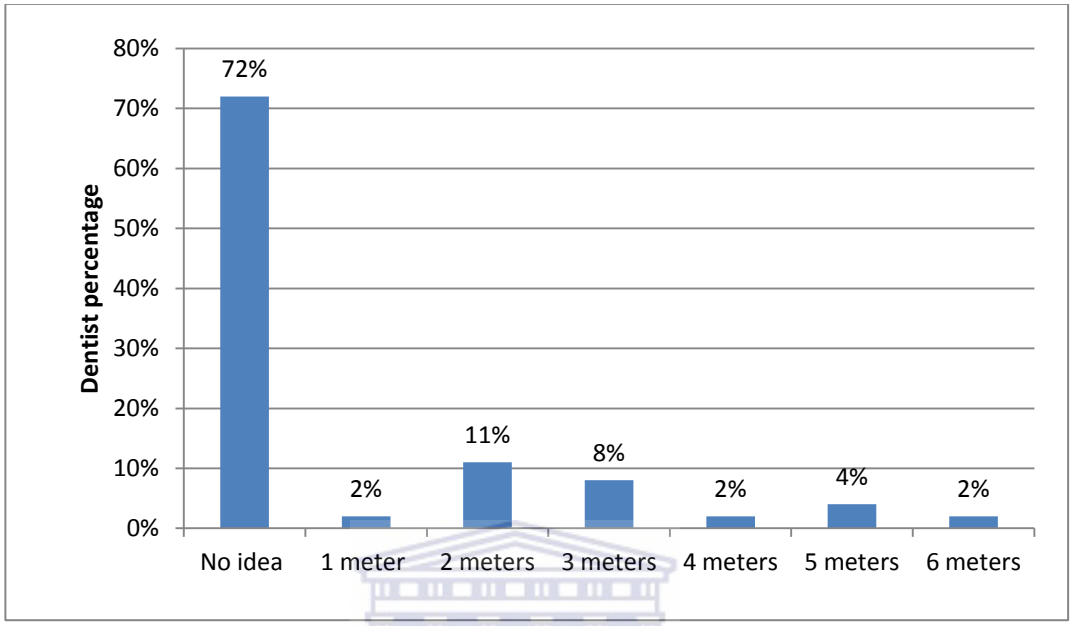

Figure 5: How far should the operator be positioned from the x-ray tube.

5.4.3 Lead apron and thyroid collar

Forty three percent of the dentists mentioned that they occasionally use a lead apron and thyroid shield. Twenty eight percent mentioned that they always used it and twenty nine percent mentioned that they did not use thyroid collars and lead aprons (Figure 6).

No statistically significant difference was found between the different age groups or title (general dentist, specialist) clinical experience and gender of the dentist (p-value > 0.05).

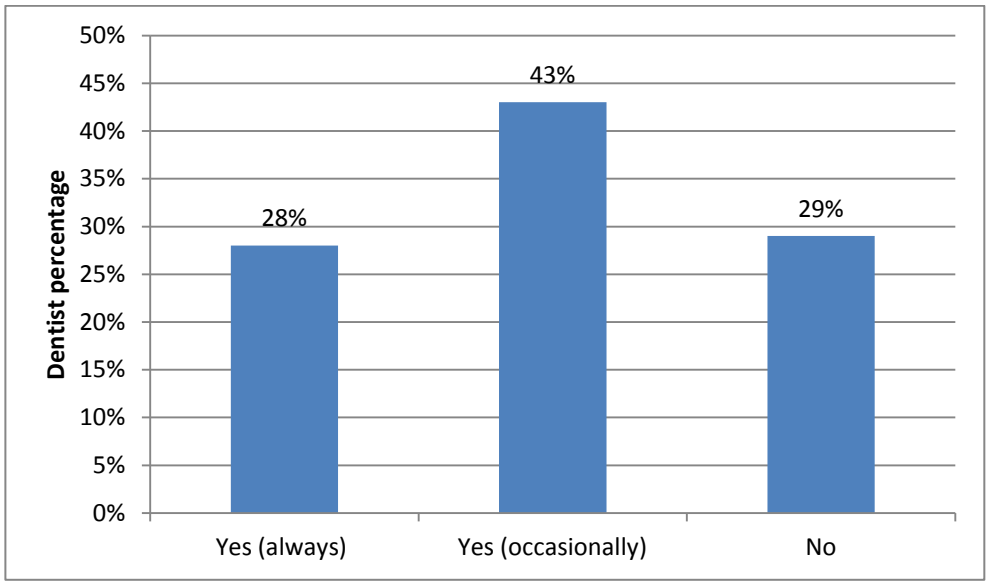

Figure (6): The use of lead apron and thyroid collar.

5.4.4 Using a film holder

Forty seven percent of the respondents mentioned that they do not use a film holder while taking radiographs (Figure 7). No statistically significant difference was found between the different age group or title (general dentist, specialist), clinical experience and gender of the dentist (p-value > 0.05).

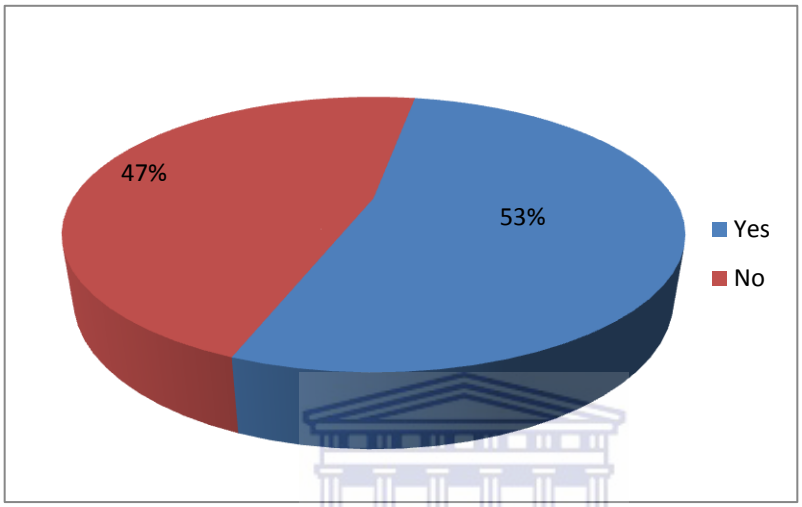

Figure (7): The use of a film holder.

Chapter 6

Discussion

The knowledge of radiation hazards will have a positive impact on the patient and will increase awareness of the operator regarding radiation safety. It will also improve the attitude of dentists towards the application of radiation safety measures.

6.1 Basic knowledge regarding radiation safety

The thyroid gland is the most radiosensitive organ in the head and neck region (Schonfeld *et al*. 2011). In the present study half of the dentists did not recognize that the thyroid gland is the most radiosensitive organ. This is similar to findings in India (Math *et al*. 2014), and high compared to Iran where 34% dentists did not know (Shahab *et al*. 2012).

A set of full mouth periapical radiographs results in a higher radiation dose to the patient than a panoramic radiograph (White & Pharoah 2009).

Fifty five percent of respondents in the present study did not know this which is almost similar to a study done in Iran where 46% of dentists also did not know (Shahab *et al*. 2012).

There is a general perception among dentists in Sudan that the radiation dose for panoramic radiography is high when compared to other conventional dental radiographic examinations. This could be due to the lack of knowledge of the radiation doses from the different radiographic techniques.

6.2 Knowledge regarding length of the cone

The use of a long cone decreases the dose to the patient compared to the short cone because the X-ray beam of radiation becomes less divergent and therefore less tissue irradiation occurs (White & Pharoah 2009).

The literature shows variations in the use of the long cone. Some countries reported a higher rate of usage for example: Turkey 53.3 %(IIguy *et al*. 2005), England and Wales 63% (Tugnait *et al*. 2003).

Other studies reported a lower rate of using the long cone. Fifteen percent of dentists in Iran (Shahab *et al*. 2012) and 11% of dentists in India (Math *et al.* 2014) reportedly were making use of long cones.

Forty percent of dentists in Sudan had no idea that there is a relation between the length of the cone and the amount of radiation dose delivered to the patient. Forty four of the respondents who knew the relation existed, failed to explain why the long cone is more effective in reducing the radiation dose.

This lack of knowledge could be due to the type of X-ray machines which are available in the government dental clinics which are ones with only short cones. It is however possible with these machines, that the focal film distance can be increased to reduce patient exposure. Most of the dentists in Sudan did not know this which may be due to the lack of undergraduate training as there is no clinical exposure for students in Radiology. Therefore there is no opportunity for applying the knowledge practically.

6.3 Knowledge regarding film speed

The improvement of film technology has resulted in the development of faster films. By moving from the D-speed film to the E-speed film, the radiation dose can be reduced by up to half without affecting the quality of the image (Farman & Farman 2000).

Studies have shown that the following countries reported lower usage of fast film: Spain 0.8% (Alcaraz *et al*. 2009), India 2% (Math *et al.* 2014), Turkey 10.2% (IIguy *et al*. 2005) and Uganda 22% (Mutyabule & Whaites 2002). Conversely a higher usage was reported in some countries namely Belgium 40% (Jacobs *et al*. 2004) and Greece 66% (Syriopoulos *et al*. 1998). In these studies it seemed that dentists are more prone to use faster speed film. This could imply that the awareness of using fast film is higher in certain countries due to the quality of education and exposure to optimal radiation practise and availability of different speed films.

In the present study 47 % of the respondents had no idea that there is a relationship between speed of the film and the amount of radiation delivered to the patient.

Forty four percent of the respondents, who knew that the relationship existed, failed to explain that the fast speed film is more suited for radiation dose reduction than slow speed film.

The lack of knowledge that fast films reduce radiation exposure compared to slow speed film could be due to the unavailability of the fast film in the government dental clinics in Sudan or the reluctance to change to a faster speed film.

6.4 Knowledge regarding collimation of the tube

Modification of the size and shape of the X-ray beam is considered an important factor in reducing radiation exposure to the patient. This can be achieved by changing from round collimation to rectangular collimation to ensure that less tissue will be irradiated. The effective dose will be reduced by almost 60% and will not affect the quality of the radiograph (ICRP Publications 103, 2007).

Studies have shown that dentists in Sweden 29% (Svenson.*et al.*1997), in Turkey 5.5% (IIguy *et al*. 2005) and in Belgium 6% (Jacobs *et al*. 2004) make use of rectangular collimation.

These studies confirmed that the majority of dentists do not use rectangular collimation. There is a perception amongst dentists that the use of these devices is associated with more cones cutting off the image.

In the present study 65 percent of the dentists had no idea that there is a relationship between the use of a collimating device and dose reduction. Almost half of the respondents who knew the relationship existed could not explain that rectangular collimation is better than round collimation in dose reduction. This notion is in correlation with studies from Turkey and Belgium wherein the use of rectangular collimation is not common amongst practitioners. (IIguy *et al*. 2005),(Jacobs *et al*. 2004). One would have to assume that other variables play a role in this decision, for example: the availability of the rectangular collimation; the lackadaisical attitude that some practitioners have regarding changing from round to rectangular collimation; the increased chance of cone cutting and the final implications thereof. The fact that 65 % of the participants were not aware of the effect of collimation on dose reduction could be attributed to lack of knowledge and insufficient number of dentists with post graduate qualifications. This could also imply that the curriculum of undergraduate education needs to be reviewed.

6.5 Position behind a protective barrier

In order to minimize the hazard of radiation to the operator, the design of the room must be such that the operator can stand behind a protective barrier with a suitable thickness to act as a shield, for example: a brick wall, lead barrier, lead glass (ICRP Publication 103, 2007).

In the present study the majority of the dentists mentioned that they stand behind a protective wall during radiation exposure. This is good practice that dentists are aware of the hazards of radiation exposure. The need for protection is important and the shield must be made of appropriate material thickness to provide sufficient protection for the operators.

6.6 Safe distance from x-ray source

According to the inverse square law the intensity of the X-ray beam is inversely proportional to the square of the distance from the X-ray source (White & Pharoah 2009).

The key factor in protection from ionizing radiation is to maximize the distance from the radiation source as far as practically possible. It is recommended that the operator should be at least two meters from the source of radiation.

The majority of dentists (72%) did not have any idea what the minimum distance should be from the radiation source.

Operator radiation protection is a very important factor. The results of the present study show that the majority of dentists had no idea about the safe distance from the radiation source. This is a worrying factor regarding radiation protection for practitioner as well as the patients.

6.7 Use of thyroid shield and lead apron

Thyroid shields and lead aprons will help in reducing the scattering dose to the thyroid gland, abdomen and gonads (ICRP Publication103, 2007). There is some debate in the literature about the regular use of lead aprons because the scattering radiation to the abdomen and gonad is negligible and there is no justification for the regular use thereof. However it is important to use a thyroid shield for children and the lead apron for the pregnant patient especially in the first trimester.

The present study shows that only 43 % of dentists occasionally use a thyroid shield and lead apron. This is a low figure when compared to a study done in Uganda where 77% of the practitioners mentioned that they did use a lead apron (Mutyabule & Whaites 2002).

This low use of thyroid shields and lead aprons is of concern. It is therefore essential for lead aprons and thyroid shields to be available in the government dental clinics.

Clear guidelines must be provided to the dentist on the use of thyroid collars and lead aprons.

6.8 Use of film holder

The use of a film holder will reduce technical errors and also reduces the dose to the patient by preventing repetition of radiographs. This will also protect the patient's fingers from radiation if the patient has to hold the film in place.

In the present study 47 % of dentists indicated that they do not use film holders when taking radiographs. This response was similar to results from a study conducted in Syria (57%) (Salti & Whaites 2002) and higher when compared to a study in Turkey where 11.7% was reported (IIguy *et al*. 2005).

This may be due to the fact that dentists in Sudan prefer not to use a film holder as they find it complicated to use. It could also be due to the unavailability of film holders in their clinics.

Conclusions

This study clearly shows that there is a lack of knowledge among dentists working in the government dental clinics in Khartoum, Sudan, regarding the hazards of radiation and the methods of radiation protection.

Chapter 7

7.1 Recommendations

- In view of the findings of the present study, it is recommended that reinforcement of the level of awareness about radiation hazard should become a public health priority in any preventive plan for the Ministry of Health in Khartoum, Sudan.
- Regular emphasizing of the use of rectangular collimation, fast speed, film holding devices, thyroid shields for children and lead aprons for pregnant women.
- Proper design of the X-ray room as well as adequate shielding around it.
- Undergraduate curriculum must include radiation protection, radiographic techniques with clinical exposure as well as minimum clinical requirements.
- Continuing education training courses need to be established to suit the training needs of the dentists. Educational programmes should focus on the hazardous effect of radiation and improve the attitude of the dentist regarding radiation safety.
- Update clear guidelines regarding radiation safety.
- Further studies should be undertaken and include the private sector as well.

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Appendix 1: Questionnaire

1. Gender Male ☐ Female ☐
2. Age <29 ☐ 30-39 ☐ 49-49 ☐ 50-59 ☐ > 60 ☐
3. Title General dentist ☐ Specialist ☐
4. Years of experience since graduation <10 ☐ 10-25 ☐ >25 ☐
5. What is the most important organ in radiation protection in dental radiography? Gonad ☐ Bone marrow ☐ Thyroid ☐ Skin ☐
6. In your opinion which of the following radiographic techniques deliver more radiation to the patient? Pantomograph ☐ Full Mouth Periapical ☐
7. Do you think of the length of the cone will have an effect on reducing the radiation dose? Yes ☐ No ☐ No idea ☐
If yes which one delivers less radiation to the patient? Short cone ☐ Long cone ☐
8. Do you think the film speed will have an effect on reducing the radiation dose? Yes ☐ No ☐ No idea ☐
If yes which one delivers less radiation to the patient? Slow speed ☐ Fast speed ☐

9. Do you think the collimation of the x-ray beam will have an effect on reducing radiation dose?

Yes ☐ No ☐ No idea ☐

If yes which one delivers less radiation to the patient? Round ☐ Rectangular ☐

10. Would you stand behind a protective barrier during exposure of radiation to the patient

Yes ☐ No ☐

11. How far should the operator be positioned from the x-ray tube?

…… Meter No idea ☐

12. Would you use lead apron and thyroid shield for patient protection?

Yes (always) ☐ Yes (occasionally) ☐ No ☐

13. Would you use a film holder while taking periapical radiograph?

Yes ☐ No ☐

Appendix 2: Informed consent

Information to the Dentist

Dear Colleague

Greetings

My name is Dr. Yasir Mohamed Elmukhtar. I am dentist in the Ministry of Health, Sudan and doing my Master degree in the University of the Western Cape – South Africa. I am conducting research under the supervision of the Diagnostic Radiology Department.

The aim of this study is to evaluate the knowledge and attitude of dentists regarding to radiation safety in the governmental dental clinics in Khartoum, Sudan.

This study will be conducted among dental practitioners working at the government dental

Clinics in Khartoum, you are being invited to consider taking part in the study, by filling the questionnaire which include thirteen questions about primary knowledge regarding radiation safety, method of dose reduction and the behaviour of dentist toward radiation safety. Your participation is completely voluntary. If you are uncertain about participating, you can always ask questions, and I will try my best to clarify any areas of concern. The procedure will only be done with your permission and you have the right to withdraw at any time without any adverse consequences or penalties. If you have any queries, more information may be obtained from Dr. Yasir Mohamed Elmukhtar at telephone number 0744349458. If you are happy to take part in the study, please read and sign the attached consent form.

Thanking you in anticipation

Yours sincerely

Dr Yasir Mohamed Elmukhtar

Informed Consent

I

……

…. (Please PRINT) have been informed about the study entitled ”to be conducted by Dr. Yasir Mohamd Elmukhtar and have read the information sheet

I understand the purpose and procedures of the study.

I have been given an opportunity to ask questions about the study and have had answers to my satisfaction.

I understand that my participation in this study is entirely voluntary and that I may withdraw at any time,

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

Dr Yasir Mohamed Elmukhtar

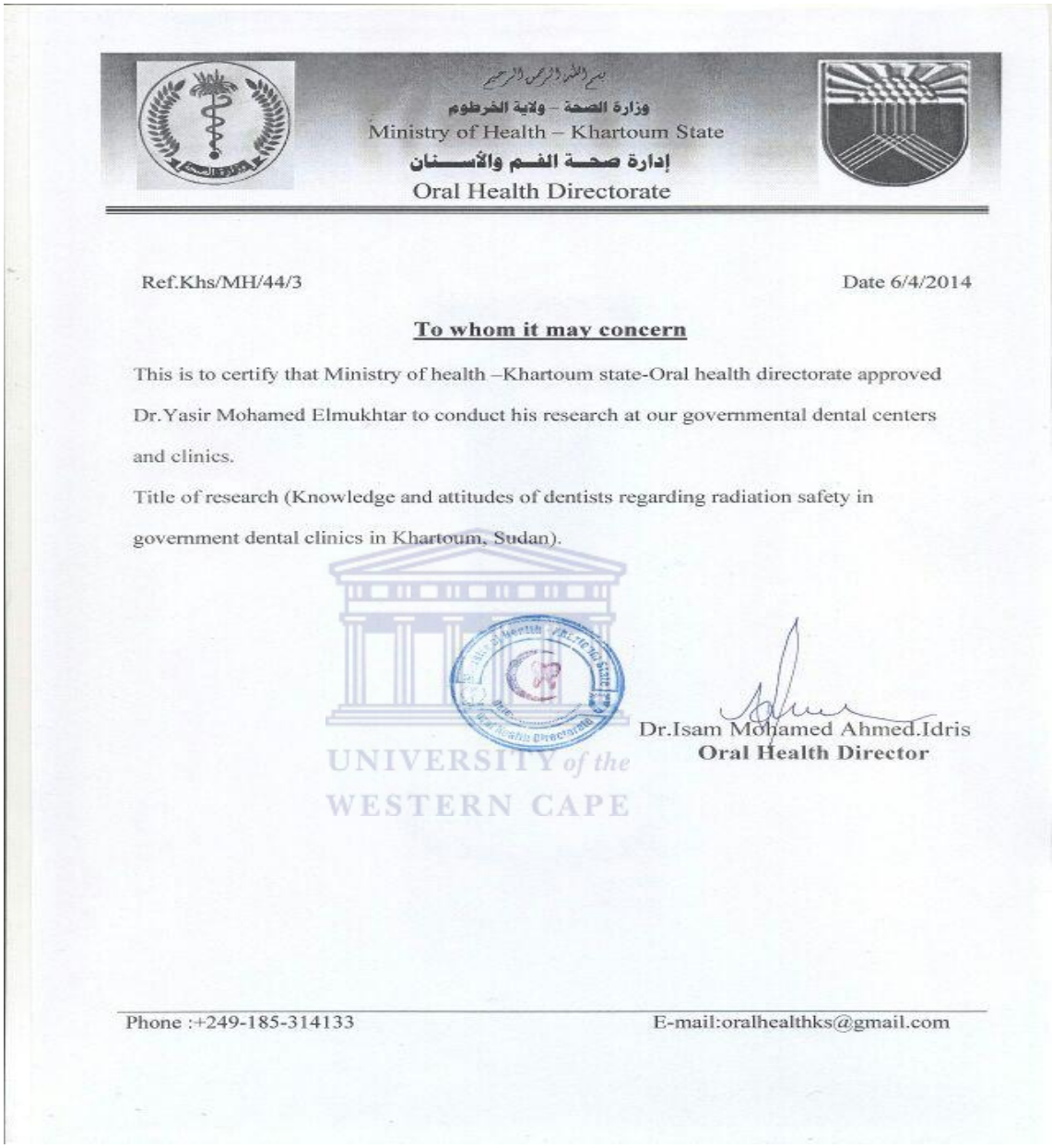
Phone no 0744349458

Email: yasermokhtar48@yahoo.com

Signature of Participant **Date**

_____ _____

Appendix 3: Ethical Approval Khartoum, Sudan



بسم الله الرحمن الرحيم

وزارة الصحة – ولاية الخرطوم

Ministry of Health – Khartoum State

إدارة صحة الفم والأسنان

Oral Health Directorate

Ref.Khs/MH/44/3 Date 6/4/2014

To whom it may concern

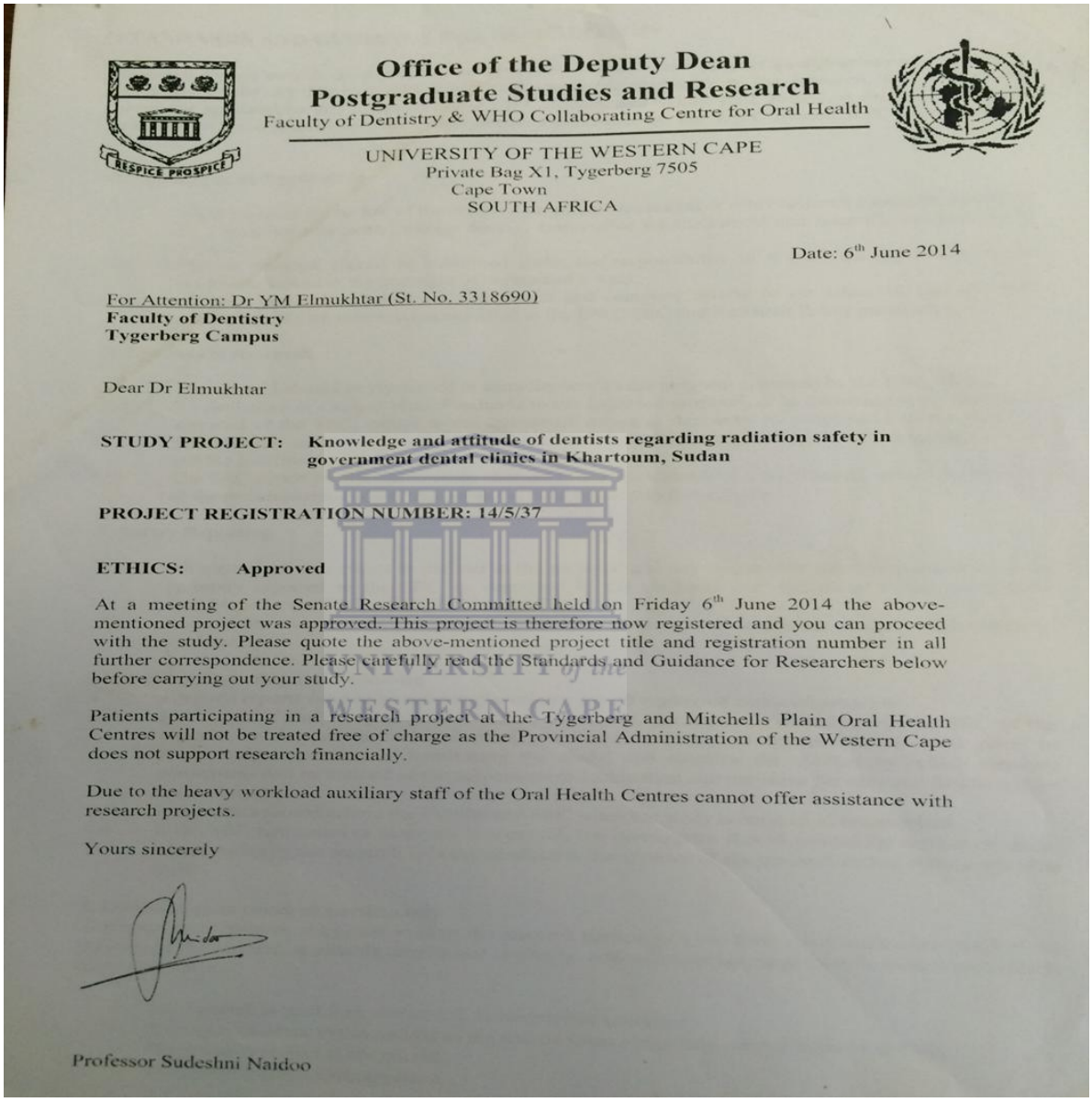
This is to certify that Ministry of health –Khartoum state-Oral health directorate approved Dr.Yasir Mohamed Elmukhtar to conduct his research at our governmental dental centers and clinics.

Title of research (Knowledge and attitudes of dentists regarding radiation safety in government dental clinics in Khartoum, Sudan).

Dr.Isam Mohamed Ahmed.Idris
Oral Health Director

Phone :+249-185-314133 E-mail:oralhealthks@gmail.com

Appendix 4: Ethical Approval University of Western Cape



Office of the Deputy Dean
Postgraduate Studies and Research
Faculty of Dentistry & WHO Collaborating Centre for Oral Health

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Private Bag X1, Tygerberg 7505
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Date: 6th June 2014

For Attention: Dr YM Elmukhtar (St. No. 3318690)
Faculty of Dentistry
Tygerberg Campus

Dear Dr Elmukhtar

STUDY PROJECT: **Knowledge and attitude of dentists regarding radiation safety in government dental clinics in Khartoum, Sudan**

PROJECT REGISTRATION NUMBER: 14/5/37

ETHICS: **Approved**

At a meeting of the Senate Research Committee held on Friday 6th June 2014 the above-mentioned project was approved. This project is therefore now registered and you can proceed with the study. Please quote the above-mentioned project title and registration number in all further correspondence. Please carefully read the Standards and Guidance for Researchers below before carrying out your study.

Patients participating in a research project at the Tygerberg and Mitchells Plain Oral Health Centres will not be treated free of charge as the Provincial Administration of the Western Cape does not support research financially.

Due to the heavy workload auxiliary staff of the Oral Health Centres cannot offer assistance with research projects.

Yours sincerely

Professor Sudeshni Naidoo