A SURVEY OF THE RADIATION PROTECTION PRACTICE OF DIAGNOSTIC IMAGING FACILITIES USING IONIZING RADIATION IN SOMALIA

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2022

Declaration

I **Dr. Omar Hassan .A .** declare that the work contained in this research in my original idea and has not be submitted at any university for a degree to the best of my knowledge.

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SUPERVISOR'S APPROVAL

This research dissertation has been submitted for examination with my approval as a university supervisors:

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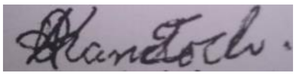

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ACRONYMS AND ABBREVIATIONS

AERB	Atomic Energy Regulatory Board
ALARA	As low as reasonably achievable
CT	Computerized Tomography
DNA	Deoxyribonucleic Acid
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IEC	International Electrotechnical Commission
IR	Ionizing radiation
ISO	International Organization for Standardization
KAP	Knowledge Attitude and Practice
KNH	Kenyatta National Hospital
KSA	Kingdom of Saudi Arabia
MCH	Mother and Child Hospital
RP	Radiation protection
RPB	Radiation protection board
SPSS	Statistical Package for the Social Sciences
UK	United Kingdom
USA	United States of America

OPERATIONAL DEFINITIONS

Diagnostic imaging facilities

Any facility involved the use of ionizing radiation generating equipment's like conventional radiography, fluoroscopy, or CT

Radiation health workers

Any person who is occupationally exposed to ionizing radiation like radiographers and radiologists

In-house trained radiographers

Are radiographers who acquired skills at the workplace without any formal training

ABSTRACT

Background

The use of Ionizing radiation plays an important role in medicine either to detect diseases or to treat cancers. A balanced approach is therefore required, to ensure that the benefits always outweigh the risks such as having radiation safety measures in place. However, there is no information regarding RP practice and awareness of radiation health workers in Somalia. Currently, there is no information available on RP practice in Somalia

Aim

To determine the current status of radiation protection practice in diagnostic imaging facilities in Somalia.

Materials and methods

A descriptive cross-sectional survey was conducted in diagnostic imaging facilities using ionizing radiation located in Somalia from September-December 2020. The study included 45 facilities and 75 radiation health workers from six out of the seven regions in Somalia, representing 86% of the country. The survey was performed using a validated checklist for inspection of facilities developed by IAEA, self-administered questionnaire adapted from previous studies for workers. Measurements of scatter radiation inside and outside Xray/CT rooms was done using calibrated survey meter. Descriptive and inferential data analysis was carried out using SPSS version 23, and the results presented in a tabular format.

Results

Among the 45 facilities investigated, there were 55 machines. Of these, 75.6% (n =34) of the facilities had only conventional radiography machines, 22.2% (n =10) had both conventional radiography and computed tomography machines while one facility had only computed tomography machine. The vast majority of the facilities 68.8% (n= 31) surveyed did not have radiologists, 20.1% facilities had radiologists onsite while the remainder used teleradiology. Demographic data from the study revealed male predominance of 91% among the radiation health workers with a Male: Female ratio of 10:1. Regarding educational level, 54.4% of the radiation health workers were formally trained. Of the trained workers, the largest group comprised of formal radiographers of which 60% were trained to diploma level. There was a marked absence of medical physicists and radiation protection officers. In regards to radiation safety in facilities, about half of x-ray/CT rooms were built with adequate safety measures while most of the facilities still lacked essential protective equipment. The majority of the X-

ray/CT rooms, 81.8% (n =45) had lead aprons. Gonad and thyroid shields were found in very few of the facilities, (< 15%). None of the facilities had lead rubber gloves and flaps.

Regarding the level of ionizing radiation knowledge among the radiation health workers; the study showed that 58.3% of radiologists, 44.6% of the trained radiographers were able to correctly answer the knowledge questions compared to only 19.3% of the non-formally trained radiographers ($p<0.0001$). in addition, this study found out that none of the workers had initial or periodic radiation safety training while only two workers had personnel monitoring devices (TLD), but they were not in use due to lack of TLD readers. High scatter radiation readings were observed in 22.2% of control lead glass/radiographers sitting position and in 31.7% of radiographer's entry doors. There was also high exposure beyond the level of 1 mSv/year for the public in 40% facilities mainly found in the side rooms/external wall.

Conclusion

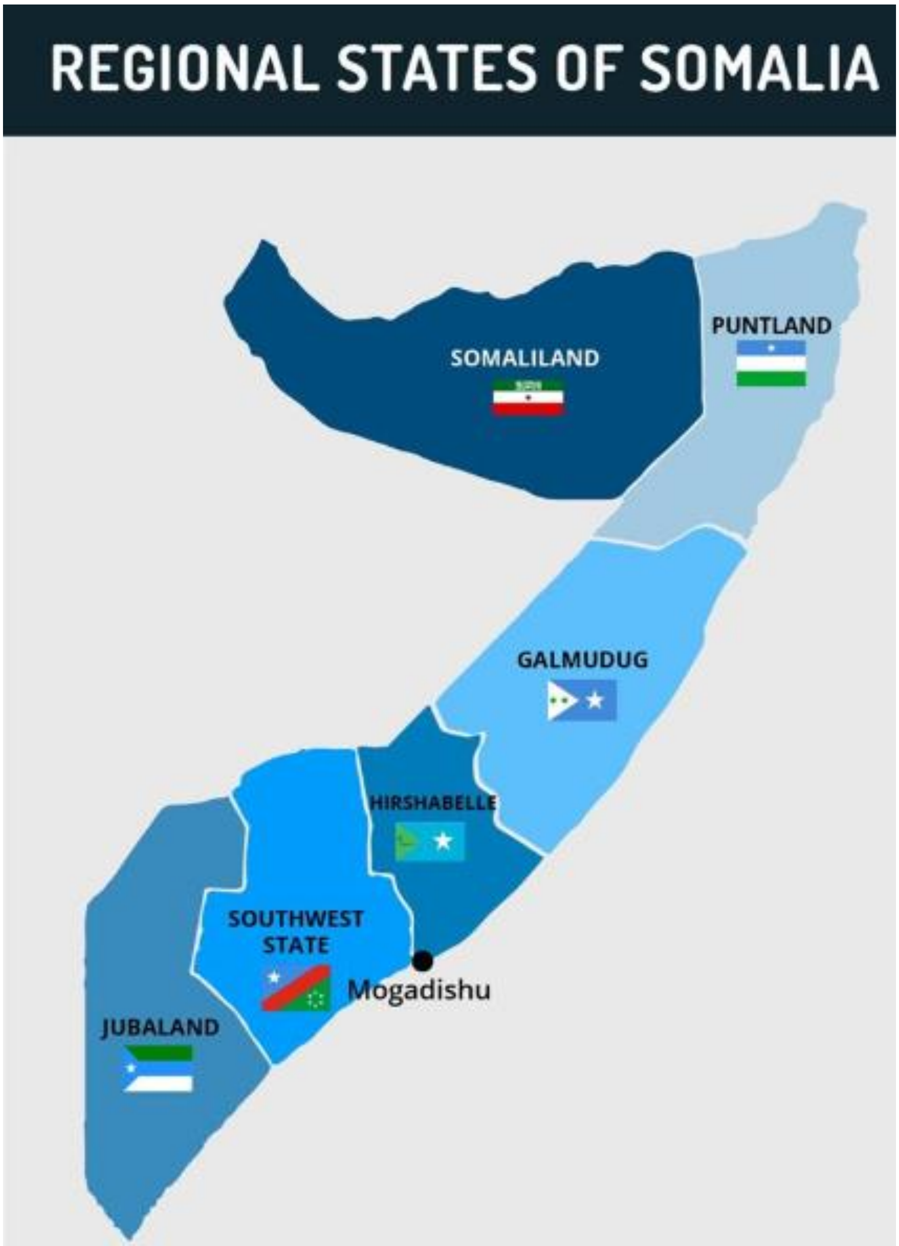
This study provides crucial data about the radiation protection practice in Somalia. In general, there is inadequate staffing levels, paucity of well-trained radiation health workers and inadequate radiation safety measures in place. In addition, there is lack of essential personal protective equipment and monitoring devices for workers. This study has also revealed low level of knowledge on radiation protection among radiation health. In assessing radiographers' and public exposure, this study has found high risk involved in about half of the investigated facilities.

CHAPTER ONE

1.1 Introduction

Somalia is located in the horn of Africa with a human population of **12,316,895** according to UNFPA 2014 estimates**(Tab. 1-1)**. It is administratively divided into six federal states; Somaliland, Puntland, Galmudug, Hirshabelle, Southwest, and Jubaland with Mogadishu as the capital city of the country **(Fig. 1-1).** Mogadishu is the most populous city with a population of **1,650,227**(1).

Figure 1-1: Somalia map (1)



The most populous towns are Mogadishu, Hargeisa, Kismayo, Baydhabo, Beledweyne, Burao, Galkaio, Garowe, Bosaso, Jawhar, Guriel, Dusmareb and Borama with populations ranging between eight to nine million (1).

Table 1-1: Somali population in 2014(1)**.**

Region	Urban	Rural	Nomads	IDPs *	Total
Awdal	287,821	143,743	233,709	7,990	673,263
Woqooyi Galbeed	802,740	138,912	255,761	44,590	1,242,003
Togdheer	483,724	57,356	154,523	25,760	721,363
Sool	120,993	13,983	187,632	4,820	327,428
Sanaag	159,717	30,804	352,692	910	544,123
Bari	471,785	65,483	133,234	49,010	719,512
Nugaal	138,929	31,047	213,227	9,495	392,698
Mudug	381,493	79,752	185,736	70,882	717,863
Galgaduud	183,553	52,089	214,024	119,768	569,434
Hiraan	81,379	135,537	252,609	51,160	520,685
Middle Shabelle	114,348	249,326	100,402	51,960	516,036
Banadir	1,280,939			369,288	1,650,227
Lower Shabelle	215,752	723,682	159,815	102,970	1,202,219
Bay	93,046	463,330	195,986	39,820	792,182
Bakool	61,928	134,050	147,248	24,000	367,226
Gedo	109,142	177,742	144,793	76,728	508,405
Middle Juba	56,242	148,439	131,240	27,000	362,921
Lower Juba	172,861	161,512	124,334	30,600	489,307
All Regions	**5,216,392**	**2,806,787**	**3,186,965**	**1,106,751**	**12,316,895**

Healthcare was initially public system but due to civil war is now mainly replaced by the private sector. Despite this privatization, the health system is still regulated by the ministry of health of the federal government of Somalia. As of 2016, there were **113** district hospitals, **35** regional hospitals, and **357** Mother and Child Hospitals**(Tab. 1-2)**(2).

Table 1-2: Reported functioning public and private health facilities in 2015(2)**.**

Health facility type	Central and South Somalia	Puntland	Somaliland	Total
PHUs	244	129	123	496
HC/MCH Centers	169	84	104	357
RHC/District Hospital	87	5	21	113
Regional /Tertiary Hospital	11	8	16	35
Total	**511**	**226**	**264**	**1001**

While medical practice using ionizing radiation is being carried out in the country, there is no regulatory framework backed by law in place. Also, there is no formal radiological training school resulting in the frequent use of teleradiology as a way of countering the shortage of radiologists. However, no documentation indicates the level of radiation safety practice and awareness amongst the radiology personnel. In addition, most of the "radiographers" on-site had some in-house training or skills acquired at the workplace without any formal training. To the author's knowledge, there has been no study conducted to evaluate the radiation protection practice in Somalia.

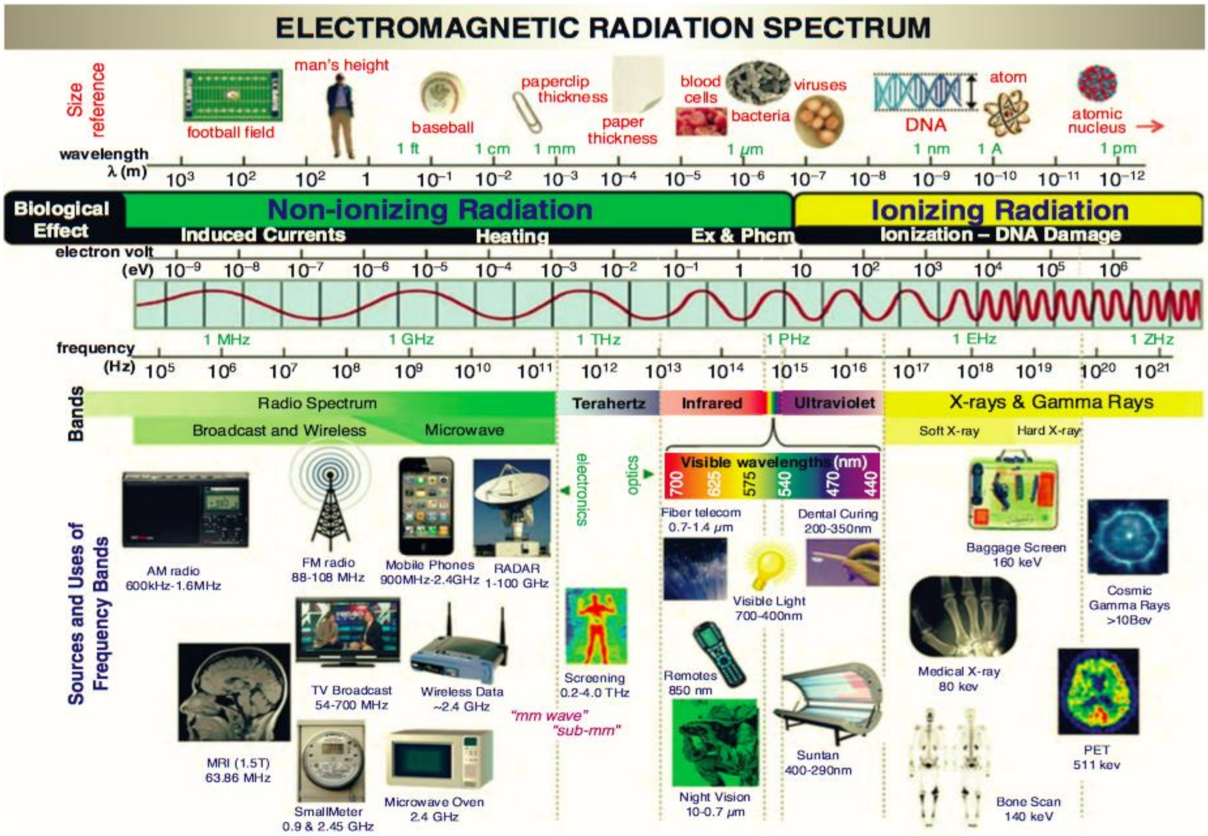
It is against this backdrop of knowledge gaps in the level of radiation safety practice and awareness among radiation health workers in Somalia that this survey aimed to address. This research has provided baseline data that may be useful in the establishment of radiation protection infrastructure in Somalia.

CHAPTER TWO

2.0 Literature Review

Radiation is energy emitted from a source in the form of particles, rays, or waves(3). It is classified as being either ionizing or non-ionizing radiation **(Fig.2-1)**. Ionizing radiation (IR) is a type of radiation with enough energy to remove electrons from molecules or atoms. Examples include particles (neutrons, beta, or alpha) or electromagnetic waves (gamma or X-rays)(4). Whilst, non-ionizing radiation is any type of electromagnetic radiation that has insufficient energy to cause ionization. Magnetic fields, electric, infrared, visible radiation, radio waves, microwaves, and ultraviolet are examples of non-ionizing radiation(5).

Figure 2-1: Electromagnetic spectrum(6)**.**



The natural sources of IR may originate from outer space(cosmic) or naturally occurring radionuclides (Terrestrial) in soil, air, rocks, water, food, and in the human body itself **(Tab. 2-1)**(7).

Table 2-1: Public exposure to natural radiation(7)

Source		Annual effective dose(mSv)	
		Average	**Total range**
Cosmic radiation	Directly ionization and photon component	0.28	
	Neutron component	0.10	
	Cosmogenic radionuclides	0.01	
	Total cosmic & cosmogenic	0.39	0.3-10[a]
External terrestrial radiation	Outdoors	0.07	
	Indoors	0.41	
	Total external terrestrial radiation	0.48	0.3-1.0[b]
Inhalation	Uranium &thorium series	0.006	
	Radon	0.15	
	Thoron	0.1	
	Total inhalation exposure	1.26	0.2-10[c]
Ingestion	^{40}k	0.17	
	Uranium and thorium series	0.12	
	Total ingestion exposure	0.29	0.2-1.0[d]
Total		2.4	1.0-13

a- Range from sea level to high ground elevation
b- Depending on the radionuclide composition of soil and building material
c- Depending on the indoor accumulation of radon gas
d- Depending on the radionuclide composition of food and drinking water

On the other hand, manmade radiation sources include diagnostic radiology(main contributor), interventional radiology, nuclear medicine, radiotherapy, and the fallout from nuclear weapons**(Tab. 2-2)**(7).

Table 2-2: Worldwide levels of occupational exposure due to diagnostic radiology (UNSCEAR 2008) (7)**. Data from the UNSCEAR Global survey of occupational radiation exposures**

Period	Monitored workers (10^3)	Measurably exposed workers (10^3)	Annual collective effective dose(man Sv)	Average annual effective dose(mSv)	
1975-1979	630		600	0.9	
1980-1984	1060		720	0.7	
1985-1989	1350		760	0.6	
1990-1994	950	350	470	0.5	1.3
1995-1999	6670		3300	0.5	
2000-2002	6670		3300	0.5	

2.1 Health effects of ionizing radiation

Ionizing radiation may have serious health effects for the patient, health workers, and the public if used improperly without necessary precautions. The biological effects of IR are divided into two types: deterministic(tissue reaction) and stochastic effects(7).

Tissue reactions are those effects that result only when many cells in an organ or tissue are damaged or killed. They have a threshold below which the effects do not occur(8). Examples of these effects include nausea, vomiting, headache, skin burn, hair loss, sterility, cataracts, and fetal abnormality(7,9–12). Conversely, stochastic effects occur when there is damage to the DNA resulting in malignant changes of the cells with no recognized threshold dose(13). Examples are genetic defects, cancers, risks to the embryo, and fetus during pregnancy(3,14–16).

Some studies done in developed countries found a significant relationship between the radiation dose from CT and the occurrence of cancers like leukemia, multiple myeloma, and thyroid cancer (17,18).

2.2 Principles of radiation protection

According to ICRP recommendation 103, the general principles of RP in medical applications are summarized as: one, justification whereby all practices must produce sufficient benefit to the exposed patient and exposure must be justified. Two, optimization in which all justifiable practices must be kept as low as reasonably achievable and doses to patients shall be optimized, and finally dose limitation. However, for the case of the patient dose reference levels is applicable(19,20).

The inappropriateness of radiation exposure depends on sociodemographic and clinical characteristics such as age, gender, referring clinician, and medical imaging examination. Therefore, optimization of radiation doses with the use of specified imaging protocols, well-justified indications for CT, quality assurance programs, and training of radiographers will reduce the unnecessary radiation doses. The establishment of the diagnostic reference level is recommended for further dose reduction(21,22).

The practice of justification, ALARA principle, and dose reference levels in the developed countries are currently well established. However, there are not enough published studies concerning such experience in the third world. About 10% were stopped from unjustified or additional radiation exposure in a study conducted in India(23).

A study done in some African countries found that patient doses were higher compared to the researches done in developed countries suggesting that patients were exposed to unnecessary radiation. In Cameroon DRLs values were between the standard in some European and African countries(22,24,25). Studies done in Kenya showed that measured patient doses were above the DRLs available in the published data indicating the need for radiation optimization locally(26,27). This study postulates that the situation in Somalia may be even more grave considering the lack of governmental regulation.

2.3 The role of governments, regulatory body and facilities in radiation safety

Regulations are essential for ensuring the radiation safety of all activities that may cause harm to the workers, patients, and the environment. A survey of some radio-diagnostic facilities in Nigeria revealed that the majority of them were converted from buildings designed for other purposes(28). Yet the government has the role of establishing a national policy for radiation safety that includes setting up a regulatory body that develops strategies and procedures to implement laws and policies. On the other hand, facilities should ensure that no person is exposed without an appropriate referral, and the person should be informed about the benefits and risks(29,30).

The IAEA's legislation permits the Agency to set up safety standards to protect health and reduce hazards to life and environment, which states can apply. In the mid-1990s, a major amendment of the IAEA's safety standards program was launched to update the whole corpus of standards, so the IAEA is working to encourage the universal acceptance and employ of its safety standards(29).

Kenya had the first radiation protection ordinance in 1948 which established a radiation board (RPB). The current act (The Nuclear Regulatory Act No. 29 of 2019) was passed by parliament in December 2019 which ensures that all facilities using ionizing radiation are licensed and have appropriate radiation measures in place. The Kenya Nuclear Regulatory Authority also licenses the radiation health workers(31). Currently, in Somalia, facilities with ionizing radiation and the radiation health workers practice without any form of regulatory body backed by law.

2.4 Radiation protection measures

The IAEA requires that radiation protection measures be instituted to ensure RP and safety to the patient, the health worker, and the public at large. These RP measures are found in IAEA safety standards series No. SSG-46 and include the following(32):

2.4.1 Safety of facilities

The location, design and X-ray room layout must be precisely considered from a radiation protection perspective and it should be located where is easily accessed by all patients whilst the distance and shielding which are factors pertinent to dose reduction are combined in the design to reduce workers and public exposure**(Fig. 2-2,2-2)**. A study conducted in Nigeria revealed that only one center out of five complied with the 16 m^2 minimum room dimension required for an x-ray room (32–37).

Figure 2-2: General X-ray room with chest stand (37)

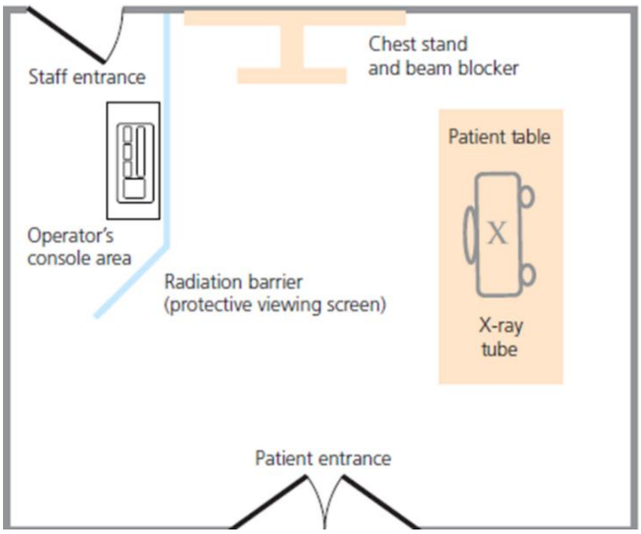
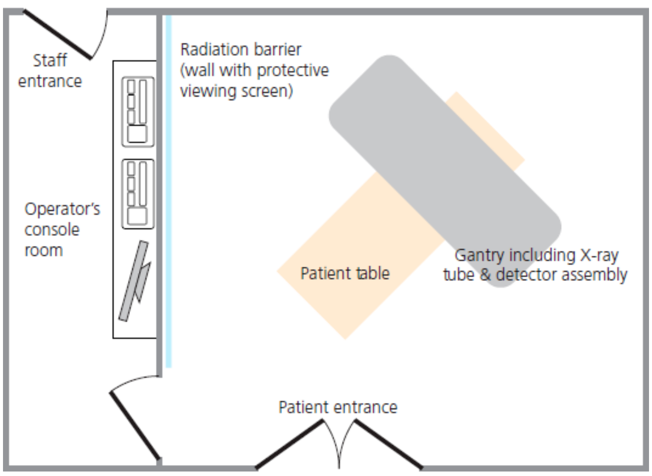


Figure 2-3: Computed Tomography room(37)



General safety features of facilities include shielded barrier, lead glass, warning signs/lights at the entrance door, personal protective, and radiation monitoring devices. A study aimed to evaluate the level of radiation protection systems available in the diagnostic radiology facilities in North East India(2016) revealed that the majority of facilities did not comply with the radiation safety codes framed by the AERB and IAEA(32,38). Although, the required lead thickness in general radiography room is 2-2.4 mm while the shielding requirements for new multi-slice CT systems are between 3-4 mm lead or its equivalent. Studies done in some X-ray facilities in Sudan and Nigeria noted that there were limited lead lining of the walls and doors in some centers while some had no lining(35,37,39,40).

It is necessary to reduce hazardous effects of ionizing radiation using certain measures including continuous workplace radiation monitoring using survey meter, periodic inspection, and quality control of Xray equipment(41,42).

2.4.2 Radiation protection of workers

The ICPR has recommended that the maximum permissible dose limit of radiation worker per year should not exceed 20 millisieverts but this need to be reduced by using personal monitor device to measure the amount of radiation received by the worker and The RP devices including lead aprons, lead gloves, lead eye goggles, thyroid shields, and gonad shields(20,32).

Based on the published studies, there is inadequate availability of radiation protection devices in some countries like Sudan and Palestine, while in others the devices are available but no one is using them on a routine basis(39,40,43–45).

2.4.3 Public protection

Rigorous policies must be in place to protect the public from the source of IR and the permissible dose limit to members of the public should not be more than 1 mSv per year (ICRP Publication 103, 2007). Other recommendations by the ICRP and IAEA include(20,42,46):

1. Appropriate location of the X-ray machine so that the beam is not pointing toward the doors, windows, or into the adjacent waiting area.
2. Shielding and other protective measures optimized for restricting public exposure to IR.
3. Adequate control over entries into controlled areas and appropriate warning signs around the radiation room.

Some studies done in Europe and America reported an increased incidence of cancer among the residents living close to nuclear facilities. Thyroid, lung, breast, brain cancers, and leukemia have been reported in these studies(47–50).

2.5 Knowledge and practice of radiology workers

The level of knowledge and the performance of radiology workers concerning radiation protection have a direct effect on the patient, operator, and public exposure to radiation. If there is no enough awareness related to radiation safety, the radiographer's action will not be safe and results in potential health hazards(51). It has been shown a positive association exist between the attitude of radiographers and their knowledge(44).

Many studies (Tab 2-3) have been done on the KAP of radiation workers towards radiation protection. One study done in Italy revealed that the majority of radiographers had sufficient awareness with regards to radiation safety but most of them underrated the radiation dose of radiological procedures(52). In yet another study conducted in Iran found the level of RP KAP was not adequate(53). Furthermore, Adhikari and Montenegro (2012) assessed the status of RP at different hospitals in Nepal which revealed almost all radiation workers were aware of radiation hazards but half of them did not know the dose limit for radiation workers. in the same study, around 65% of the workers were never monitored(54). Studies done in some African countries reported that dose monitoring for radiographers was a big challenge despite the availability of the dosimeter devices which could be related to their attitude(55–57).

A study conducted in Iran (2011) showed that there is a significant association between radiographers' awareness about Maximum permissible dose and their education level. It has also been found that continuous education and training can uplift KAP among radiology workers and in turn minimize personal, patient as well as public doses from medical diagnostic examinations(51,53).

Gacega *et al.* (2015) carried a study regarding the knowledge and attitude of clinicians practicing at Kenyatta national hospital(Kenya) on ionizing radiation that revealed the majority of them lack the basic knowledge on IR doses and its health effects, which impacts negatively on their attitude and practice(58). No information is available or published concerning the knowledge and attitude among the radiation health workers in Kenya to the best of my knowledge.

Table 2-3: Example of KAP studies

Author	Year	Place	Adequacy of RP
Cletus Uche Eze	2013	Nigeria	Adequate knowledge Poor adherence to RP practice
Madhu Sharma	2016	Ghana	Inadequate
Masonumi Hamed	2018	Iran	Inadequate
Rania and Mohamed M Abuzain	2015	KSA	Adequate
Surendar Maharjan	2017	Nepal	Adequate
F.Paolicchi	2015	Italy	Adequate

KSA: Kingdom of Saudi Arabia

CHAPTER THREE

3.1 Justification

Studies conducted in some X-ray facilities located in Nigeria and India revealed that the majority of them were not in line with the safety standards in X-ray facilities of the AERB and the IAEA(38,40). These studies from African and Asian countries showed that there was inadequate RP and monitoring practice despite the existence of regulations, while in developed countries the RP culture is well established (38,54,57,59).

Somalia is a country that has just recently emerged from a long-standing civil war and with a large private run health sector does not have any national laws and regulations in place. The present study is an attempt to determine the RP practice in diagnostic imaging facilities in Somalia and provide baseline data that may initiate steps towards the establishment of the radiation protection act and the development of a radiation safety culture to benefit workers, patients, and the public. Currently, there is no information available on RP practice in Somalia.

3.2 Statement of the problem

The use of Ionizing radiation plays an important role in medicine either to detect diseases or to treat cancers. A balanced approach is therefore required, to ensure that the benefits always outweigh the risks. The lack of Radiation Protection and regulatory infrastructure to manage the radiological practice in Somalia can lead to a serious problem such as increased malpractices and radiation health hazards among workers, patients, members of public as well as the environment.

3.3 Research question

What is the radiation protection measures available in diagnostic imaging facilities using ionizing radiation in Somalia?

3.4 Objectives

3.4.1 Broad objective

To determine the current status of radiation protection practice in diagnostic imaging facilities in Somalia.

3.4.2 Specific objectives

1. To determine the specific RP measures (Safety of workers and facility layout) in place in diagnostic imaging facilities located in Somalia.
2. To measure the scatter radiation in diagnostic imaging facilities using ionizing radiation in Somalia
3. To assess knowledge, attitude and practice towards radiation protection of radiation health workers at diagnostic imaging facilities in Somalia

CHAPTER FOUR: STUDY METHODOLOGY

4.1 Study design

The study was carried out using a descriptive cross-sectional study design to survey diagnostic imaging facilities using ionizing radiation and radiation health workers in Somalia.

4.2 Study site and population

All diagnostic imaging facilities using ionizing radiation located in large populous towns in Somalia(Mogadishu, Hargeisa, Baydhabo, Galkaio, Garowe, Jawhar, Guriel, and Dusmareb) are included in this study after obtaining written informed consent. In addition, all radiation health workers practicing in these centers that accepted to be recruited into the study.

4.2.1 Inclusion criteria

1. All diagnostic imaging facilities in Somalia in the 13 most populous towns
2. All radiation health workers in these facilities who accepted to participate

4.2.2 Exclusion criteria

1. Diagnostic imaging facilities using IR but chose to decline the consent
2. Facilities using other sources of ionizing radiation like mammography or nuclear medicine
3. Diagnostic imaging facilities using non-ionizing radiation sources like ultrasound and MRI
4. Non-functioning facilities
5. Radiation health workers not working in the radiology field

4.3 Sampling method

Purposive sampling(60,61)

4.4 Sample size

The desired sample size was calculated using Yamane's formula

$$n = \frac{N}{1+N(e)^2}$$

Where:

n= signifies sample size

N= signifies the estimated numbers of Diagnostic imaging facilities and radiation workers in Somalia

e=signifies the margin error

N= Estimated number of diagnostic imaging facilities in Somalia is 50

N= Estimated number of radiation health workers in Somalia is 65

1. Diagnostic imaging facilities

   N= 50 being the number of diagnostic imaging facilities in Somalia eligible for recruitment in the study

   e= 0.05 margin error

   Hence n=45 facilities

2. Radiation health workers

   N= 65 being the number of radiation health workers in Somalia eligible for recruitment in the study

   e= 0.05 margin error

   Hence n=55 workers

4.5 Study Duration

September-December 2020

4.6 Recruitment and Consenting Procedure

Purposive sampling method was used to select participants. The subjects recruited for this study were identified from eight large populous towns in Somalia representing 86% of the country in the event they met the inclusion criteria. Those who do not met the inclusion criteria was excluded. Before the assessment was done, written informed consent was obtained by the principal investigator.

4.7 Material for data collection

The assessment was carried out using: (i) Observational checklist of the diagnostic imaging facility adapted from IAEA(41,42) to inspect the implementation of radiation safety measures, filled by the researcher with the following parts: general information of the facility, verification of general safety and verification of workers and public protection. (ii) Measurements of scatter radiation using a survey meter (RADALERT 100X S/N:X02734) **(Fig. 6)** calibrated by International medcom, Inc (IMI). Measurements were carried out during patient exposure/phantom in different rooms such as inside the X-ray/CT and control room, sides of the room, the corridor along with the reception, waiting area, and the main entry door. The cumulative dose rate was calculated by multiplying the measured readings at different locations by weekly workload by 50 weeks a year. (iii) A self-administered questionnaire adapted from a previous study with amendments was filled by the radiation health workers in the presence of the researcher(52). Out of the 112 questionnaires distributed, 75 of them were filled that represented 67% response rate. The questionnaire included demographic data of the respondent, general knowledge, and behavior of radiation health workers regarding radiation protection.

Figure 6: Survey meter

4.8 Data analysis and presentation

The data generated was analyzed using statistical package SPSS version 23 and the results presented as means, medians and percentages in a tabular format.

4.9 Ethical consideration

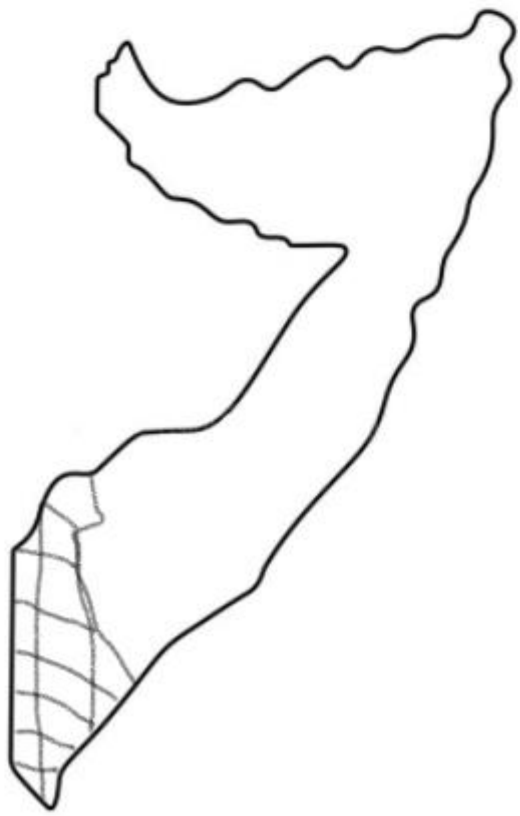
This study commenced after approval from KNH-UoN ethical review committee and MoH, Somalia. Participation was entirely voluntary and they were requested to sign informed consent forms. Anonymity was achieved by not using the participant/ facility name in the questionnaire/ checklist. The study findings and data collection tools were kept in a secure place.

CHAPTER FIVE: RESULTS

5.1 Sample population

A total of 75 radiation health workers and 45 facilities in six out of seven regions in Somalia were studied forming 86% of the country (Figure 1). Jubaland was excluded for security reasons due to ongoing conflicts/fighting during the study period.

Figure: Somalia map: The shaded region is not included in this study



5.2 Characteristics of diagnostic imaging facilities in Somalia

Forty five out of the 57 facilities visited accepted to participate in this study with about 80% response rate. Some of the reasons cited were facilities being too busy and had no time for the study. Some owners said they did not want their deficiencies in RP practice to be exposed.

Among the 45 facilities investigated, there were 55 machines (for more information see ***table 1***). The CT service was only available in Benadir, Somaliland, and Puntland regions.

Table 1: Characteristics of diagnostic imaging facilities (n=55)

			Regions in Somalia					
Characteristics		**Total** n (%)	Benadir (n)	Galmudug (n)	Hirshabelle (n)	Puntland (n)	Somaliland (n)	Southwest (n)
Type of facilities	Public	11(24.4)	4	3	1	1	1	1
	Private	34(75.6)	8	4	2	9	10	1
Types of machine	Conventional radiography only	34(75.6)	9	7	3	7	6	2
	CT only	1((2.2)	0	0	0	1	0	0
	Both	10(22.2)	3	0	0	2	5	0
Category of facilities	Facilities with Radiologist on site	9(20.1)	4	0	0	0	5	0
	Facilities using teleradiology	5(11.1)	1	0	0	4	0	0
	Facilities with no radiologist on site or teleradiology	31(68.8)	7	7	3	6	6	2

n= number of facilities

5.3 Radiation workers in Somalia

From all the 45 facilities, there were only 13 radiologists. All were male with 38.4% (n=5) having experience of five years and above as illustrated in table 2.

There was a total of 99 radiographers. Out of these, only 48.5% (n=48) had formal education. Slightly more than half, 51.5% (n=51) did not have formal education.

Table 2: Gender, education levels and distribution of radiation health workers

			Regions in Somalia					
		Total n (%)	Benadir (n)	Galmudug (n)	Hirshabelle (n)	Puntland (n)	Somaliland (n)	Southwest (n)
Radiologists		**13**						
Gender	Male	13 (100)	7	0	0	0	6	0
	Female	0	0	0	0	0	0	0
Years of experience	0-2 years	4(30.7)	3	0	0	0	1	0
	3-5 years	4(30.7)	3	0	0	0	1	0
	Above 5 years	5(38.4)	1	0	0	0	4	0
Radiographers		**99**						
Formal radiographer		48(48.5)						
Gender	Male	39(81.2)	24	0	0	7	8	0
	Female	9(18.7)	6	0	0	0	3	0
Level of education	Post graduate	2(4.2)	1	0	0	1	0	0
	Bachelor	17(35.4)	7	0	0	4	6	0
	Diploma	29(60.4)	20	0	0	3	6	0
Years of experience	0 -2 years	14(29.1)	2	0	0	0	12	0
	3 -5 years	18(37.5)	15	0	0	3	0	0
	Above 5 years	16(33.3)	11	0	0	5	0	0
Non-formal radiographer		51(51.5)						
Gender	Male	50(98.0)	17	8	3	8	12	2
	Female	1(2.0)	1	0	0	0	0	0
Years of experience	0 -2 years	12(23.5)	0	3	0	4	5	0
	3 -5 years	26(51.0)	12	2	1	2	7	2
	Above 5 years	13(25.5)	6	3	2	2	0	0
Med physicist		0	0	0	0	0	0	0
Radiation protection officer		0	0	0	0	0	0	0

5.4. Radiation safety: General features

5.4.1 Xray/CT room design and layout

The findings as presented in Table 3 showed that all of the computed tomography rooms met the recommended room size.

In conventional radiography rooms, 79.5% (n =35) met the required room size while 20.5% (n=9) did not met the room size requirements. The average wall thickness in CT rooms was 35 (SD±10) cm with the least having wall thickness of 30cm and the thickest with 44 cm. In Conventional radiography rooms, the average wall thickness was 36(SD±20) cm with the least having 10cm and the thickest wall with 50cm.

Table 3 also shows that all of the CT rooms and 59.1%(n=26) of conventional radiography rooms were built using heavy stones. Other materials used for the conventional radiography rooms included (n =14) used bricks, (n =2) used wood while one facility used fabricated material and another one used concrete.

The facilities were also assessed whether they had lead lining on the doors and walls. In the CT facilities, 81.8% (n =9) of the facilities had lead lining on both doors and walls while among the conventional radiography rooms, only 36.3% (n =16) had lead lining on walls and doors while more than half, 52.2% (n =23) did not have any lead lining.

Table 3: Xray/CT room design and layout

		Type of machine n (%)	
Parameters		**Computed tomography**	**Conventional Radiography**
Room Size	Required size	11 (100)	35(79.5)
	Does not meet	0	9(20.5)
Wall thickness	Mean (SD)	35 (±10cm)	36 (±20cm)
	Min-Max	30cm - 44cm	10cm - 50cm
Wall material	Bricks	0	14(31.8%)
	Concrete	0	1
	Fabricate house	0	1
	Heavy stones	11 (100)	26(59.1)
	Wood	0	2
Control room	Control room located outside with view window made of lead glass	10(90.9%)	18(41.0%)
	Control room located inside with protective barrier	1	14(31.8%)
	Radiographer operates from inside without protective barrier	0	12(27.2%)
	Wall only	0	2

Lead lining	Doors only	1	3
	None	1	23(52.2%)

5.4.2 Xray/CT room and equipment

The survey also sought to investigate X-ray/CT room and equipment safety measures as shown in Table 4. The analysis revealed that almost all of the CT facilities, 90.9% (n =10) and half of the conventional radiography facilities, 47.8% (n =21) were located in an isolated area. The majority of the CT rooms, 81.8% (n =9) and only 40.9% (n =18) of the conventional radiography were built with adequate safety measures. The warning signs were present in only one CT and 2 conventional radiography facilities. Only 4(36.4%) CT and 2(4.5%) conventional radiography rooms had a red light show at the door and console during the exposure. There was a poor area radiation survey with only one facility reported possessing a survey meter instrument although it was not being used.

In evaluating the equipment, there was no quality control measures conducted periodically in all the facilities investigated. Only 13.3%(n=6) facilities subjected their equipment to routine maintenance by the machine provider

Table 4: Xray/CT room and equipment

		Type of machine n (%)	
		Computed tomography	Conventional radiography
Xray/CT room			
Is the X-ray/CT room located in an isolated area?	Yes	10 (90.9)	21 (47.8)
	No	1(9.1)	23(52.2)
Is the X-ray/CT room built with adequate safety measures?	Yes	9(81.8)	18(40.9)
	No	2(18.2)	26(59.1)
Entry to X-ray/CT rooms posted appropriately	Yes	9(81.8)	30(68.1)
	No	2(18.2)	14(31.9)
Does the red light show at the door and console during an exposure?	Yes	4(36.4)	2(4.5)
	No	7(63.6)	42(95.5)
Do facilities have appropriate warning signs (in the local language)?	Yes	1(9.1)	2(4.5)
	No	10(90.0)	42(95.5)
Do facilities possess appropriate functioning survey meter?	Yes	1(9.1)	0
	No	10(90.9)	44(100)
Area’s exposure rate surveys are performed at appropriate intervals?	Yes	0	0
	No	11(100)	44(100)
Equipment			
Is the X-ray/CT machine subject to periodic quality control?	Yes	0	0
	No	11(100)	44(100)
Is the X-ray/CT machine subject to routine maintenance by authorized service agents?	Yes	5(45.4)	1(2.2)
	No	6(54.6)	43(97.8)
Are the exposure controls clearly marked?	Yes	11(100)	44(100)
	No	0	0

5.5 Radiation Safety: health worker and public protection

Verification of radiation health workers and public protection was conducted as shown in Table 5. All CT facilities and 59.1% (n=26) of the conventional radiography had a protective barrier. Majority of the CT facilities, 90.9% (n =10) and 81.8% (n =35) of the conventional radiography had lead rubber aprons. Few of the facilities, 27.3% (n =3) of the CT and 9.1% (n =4) of conventional radiography had gonad and thyroid shields. However, none of the facilities had lead rubber gloves and flaps.

Table 5: Personal protective equipment

		Type of machine	
		CT Machine	Conventional radiography
Protective barrier	Yes	11(100)	26 (59.1)
	No	0	18(40.9)
Lead rubber apron	Yes	10(90.9)	35(81.8)
	No	1(9.1)	9(18.2)
Lead rubber flaps and gloves	Yes	0	0
	No	11(100)	44(100)
Gonad shield	Yes	3(27.3)	4(9.1)
	No	8(73.7)	40(90.9)
Thyroid shield	Yes	4(36.4)	4(9.1)
	No	7(63.6)	40(90.9)

The study also investigated the public protection measures put in place by the facilities as shown in Table 6. Most of the facilities, 81.8% (n =9) of the CT facilities and 38.6% (n =17) of the conventional radiography had the floor plans and arrangement of equipment appropriate considering public areas adjacent to the Xray/CT rooms. None of the facilities conducted routine periodic measurements of exposure rates in areas adjacent to the X-ray/CT room. In assessing the visitor's control, 90.9% (n = 10) of the CT facilities had restricted access while 38.6% (n =17) of conventional radiography rooms had adequate control over entries. All CT facilities and 59.1%(n=26) of conventional radiography provide their visitors with adequate information.

Table 6: Public protection

		Type of machine	
		CT Machine	Conventional radiography
Are the floor plans and arrangement of equipment appropriate considering public areas adjacent to the Xray/CT room	Yes	9(81.8)	17(38.6)
	No	2(18.2)	27(61.4)
Are routine periodic measurements of exposure rates in areas adjacent to the Xray/CT rooms?	No	11(100)	44(100)
Is adequate information provided to visitors?	Yes	11(100)	26(59.1)
	No	0	18(40.9)
Are there adequate controls over entries into Xray/CT rooms?	Yes	10(90.9)	17(38.6)
	No	1(9.1)	27(61.4)

The direction of the beam was assessed as illustrated in table 7. The findings revealed that 54.5%(n=6) CT facilities and 47.7%(n=21) conventional radiography directed their beam to an open area as recommended while 27.2%(n=3) CT and 25%(n=11) conventional radiography facilities directed the beam to the corridor. The beam was also directed to the consultation room, immunization room, pharmacy, waiting area, operation theatre, residential house, stairs, and store.

Table 7: Direction of the beam

		Computed tomography	Conventional radiography
Direction of the beam	Consultation room	0	1
	Corridor	3	11(25%)
	Immunization room	0	1
	Office	0	1
	Open area	6(54.5%)	21(47.7%)
	Pharmacy	0	1
	Stairs	1	0
	Store	0	2
	Waiting area	1	2
	Residential house	0	2
	Operation theatre	0	1

5.6 Training on Radiation protection and radiation monitoring of health workers

In all facilities, all occupationally exposed personnel were not provided with initial safety training and there are no written safety policies as well as no work instructions established in writing. This assessment found that only two radiation health workers had personal monitoring devices (TLD), although they were not using them. The reason given was the lack of TLD reader machines in Somalia.

5.7 Responsibilities and justification of medical exposure

Regarding assessment of medical exposure, Table 8 shows that no patient was exposed without a written prescription by a medical practitioner in almost all of the CT facilities 90.9%(n=10). However, in 56.8% (n=25) of conventional radiography procedures are done after authorization by a qualified medical practitioner.

In none of the facilities participating in this study were the CT imaging requests justified or counter-signed by a radiologist prior to imaging. However, all the CT facilities and in 66% (n =29) of conventional radiography facilities there was a designated appropriately qualified radiation practitioner been designated as having overall responsibility for patient protection and safety.

Table 8: Medical exposure

Medical exposure		Type of machine	
		CT n (%)	**Conventional radiography**
Responsibilities and Justification			
No patient exposed unless is prescribed by a medical practitioner	Yes	10(90.9)	25(56.8)
	No	1(9.1)	19 (43.2)
Are the diagnostic medical exposures justified by considering the benefits and risks of alternate techniques that do not involve medical exposure?	Yes	0	0
	No	0	0
Has an appropriately qualified practitioner been designed as having overall responsibility for patient protection and safety?	Yes	11(100)	29(66)
	No	0	15(34)

5.8 Measurements of scatter radiation

Measurements of scatter radiation to the workers and public were conducted using a "Survey Meter: RADALERT 100X S/N:X02734". Complete measurements were done in 30 facilities that had adequate protective equipment; 8 facilities were assessed partially while 7 facilities were not measured at all because of lack of personal protective equipment.

The findings as presented in Table 12 showed that conventional radiography had a higher weekly average of 61(SD±39) with a minimum of 6 and a maximum of 240 weekly workloads on a single machine compared to computed tomography machines with an average of 53(SD±35) with a minimum of 15 and maximum of 120 weekly workloads.

In all the facilities, background radiation was within normal limits. In 27.3%(n=3) of the CT facilities investigated, there was a high exposure at the control lead glass, 18.2%(n=2) facilities had high exposure at the radiographer sitting position while 45.5%(n=5) had high exposure at the radiographer entry door. When assessing the exposure to the public, 27.3%(n=3) of the CT facilities had high exposure at the corridors along reception, left side and the back side of the room while 36.3%(n=4) had high exposure at the main entry door, the front side and the right side of the CT room.

In conventional radiography 20%(n=5) of the facilities had high exposure at the control lead glass, 24%(n=6) facilities had higher exposure at the radiographer sitting position while 26.7%(n=8) facilities had high exposure at the radiographer entry door.

Measurements taken outside X-ray room showed that 36.7%(n=11) of conventional radiography had high exposure at the corridor along reception, 12%(n=2) at the main entry, 53.3%(n=16) of conventional radiography were highly exposed on the front and the back side. 48.5%(n=16) showed high exposure at the right side, and 42%(n=13) facilities were highly exposed to scatter radiation on the left side.

Table 9: Scatter radiation in diagnostic imaging facilities

	Type of machine		
	Level of exposure	CT n (%)	Conventional radiography n (%)
	Mean (SD)	53(±35)	61(±39)
Weakly work load	Min-Max	15 - 120	6 - 240
Exposure to the radiographer			
Background	Acceptable exposure	11(100)	33(100)
Control lead glass	Acceptable exposure	8(72.7)	20(80)
	High exposure	3(27.3)	5(20)
Radiographers sitting	Acceptable exposure	9(81.8)	19(76)
	High exposure	2(18.2)	6(24)
Radiographers' entry door	Acceptable exposure	6(54.5)	22(73.3)
	High exposure	5(45.5)	8(26.7)
Exposure to the public			
The corridor along reception	Acceptable exposure	8(72.7)	19(63.3)
	High exposure	3(27.3)	11(36.7)
Main entry	Acceptable exposure	7(63.7)	22(88)
	High exposure	4(36.3)	3(12)
Front	Acceptable exposure	7(63.7)	14(46.7)
	High exposure	4(36.3)	16(53.3)
Back	Acceptable exposure	8(72.7)	14(46.7)
	High exposure	3(27.3)	16(53.3)
Right area	Acceptable exposure	7(63.7)	17(51.5)
	High exposure	4(36.7)	16(48.5)
Left area	Acceptable exposure	8(72.7)	18(58)
	High exposure	3(27.3)	13(42)

5.9 KAP towards radiation protection among radiation health workers

5.9.1 Overall knowledge on radiation protection among radiation health workers

The study sought to investigate the level of knowledge on RP among radiation health workers in Somalia, the results showed that the knowledge among radiologists was 58.3%, radiographers had 44.6% while non-formally trained radiographers had the lowest level of knowledge on radiation protection with 19.3%($p<0.0001$). This assessment was done by calculating the overall percentage of correctly answered in knowledge section of the questionnaire (*Table 10*).

Table 10: Correct average answer score on radiation protection among cadres

Radiation health worker cadre	Overall Percentage correctly scored (%)
Radiologists	58.3%
Radiographers	44.6%
Non-formally trained radiographers	19.3%

Chi square = $x^2(2) = 32.686$, $p<0.0001$.

5.9.2 Level of radiation protection knowledge and radiation healthcare worker cadre

In determining the association between knowledge and radiation health worker cadre, Fischer's exact test was conducted to investigate the existing association as shown in Table 10. The findings showed that all the radiologists, 46.1% (n =18) of the radiographers and only 1 (n=) one of the non-formal radiographers were able to identify all the imaging modalities that use ionizing radiation. The findings were statistically significant (p=0.035).

Regarding patients most sensitive to radiation; 66.6% (n =8) of radiologists, 33.3% (n =13) of radiographers and 11.1% (n =2) of non-formal radiographers correctly identified these patients (p= 0.022). There was poor knowledge on which tissues were more susceptible to ionizing radiation-related damage, only 8% (n =2) radiographers correctly answered. These findings were not statistically significant ($p>0.05$).

The analysis established that, 83.4% (n =10) of radiologists, 35.8% (n =14) of the radiographers, and 4.2%(n=1) of the non-formal radiographers correctly identified diseases that may be result of stochastic radiation (p = 0.001). The analysis further identified that 50%

(n =6) of radiologists and 33.3% (n =13) of radiographers correctly acknowledged the annual limit for radiation to individuals. Only 2 radiologists and 5.2 % (n =2) of the radiographers knew the approximate effective radiation dose received by an adult in standard chest radiography. The majority of radiation health workers affirmed that collimation of the x-ray beam will affect reducing radiation. Half of radiologists, 50% (n=6), 64.2% (n =25) of radiographers and one non-formal radiographer correctly identified how far the operator be positioned from the x-ray tube. This association was significant(p=0.005).

Table 11: Association between knowledge and radiation healthcare worker cadre

		Cadre			
		Radiologists	**Radiographers**	**Non-formal radiographers**	**P value**
Which imaging modality uses ionizing radiation	Conventional radiography	12 (100%)	29(100)	24(100%)	
	Computed Tomography	12 (100%)	29(100)	19(79.2%)	0.035
	Fluoroscopic studies	12(100%)	29(74.3%)	1(4.1%)	
	Radionuclide imaging	12 (100%)	18(46.1%)	1(4.1%)	
Which of the following patients are most sensitive to ionizing radiation?	Correct (1-year old female)	8 (66.6%)	13(33.3%)	3(12.5%)	0.022
	Incorrect	4 (33.4%)	26(66.7%)	21(87.5%)	
Which of the following tissues is more susceptible to ionizing radiation	Correct (Breast)	0	2 (5.2%)	0	
	Incorrect	12(100%)	37(94.8%)	24(100%)	
Which of the following diseases may be a result of stochastic radiation	Correct (Leukaemia)	10 (83.4)	14(35.8%)	1	0.001
	Incorrect	2(16.6)	25(64.2%)	23(95.8%)	
What is the annual limitation dose for individuals	Correct (20mSv)	6 (50%)	13 (33.3%)	0	0.381
	Incorrect	6(50%)	26(66.7%)	24(100%)	
What is the approximate effective radiation dose received by an adult in standard chest radiography	Correct (0.02mSv)	2(16.6%)	2 (5.2%)	0	0.091
	Incorrect	10 (83.4%)	37(94.8%)	24(100%)	
Do you think collimation of the x-ray beam will affect reducing radiation	Correct (Yes)	12(100%)	39(100%)	21(87.5%)	0.318
	Incorrect	0	0	3(12.5%)	
How far should the operator be positioned from the x-ray tube?	Correct (3m)	6(50%)	25(64.2%)	1	0.005
	Incorrect	6(50%)	14(35.8%)	23 (95.8%)	

5.9.3 Radiation protection practice

The study showed that all the radiologists (100%), 94.8%(n=37) of the formal radiographers and 83.4%(n=20) of non-formal radiographers affirmed use of lead apron during radiological procedures as shown in table 11.

There was low utilization of thyroid shield with only 25% (n =3) radiologists, 43.5% (n =17) formal radiographers, and one non-formal radiographer affirming use. No radiation health worker reported possessing or using lead gloves. Almost all of the radiation workers reported not using gonad shields and protective eye glasses.

Table 12: Performance towards radiation protection during practice

		Cadre		
		Radiologists=12	Radiographers =39	Non-formal radiographers=24
Lead apron	Yes	12 (100)	37(94.8)	20(83.4)
	No	0	2(5.2)	4(16.6)
Thyroid shield	Yes	3(25)	17(43.5)	1(4.2)
	No	9(75)	22(56.5)	23(95.8)
Gonad shield	Yes	0	4(10.4)	0
	No	12(100)	35(89.6)	24(100)
Protective eye glasses	Yes	1(8.4)	4(10.4)	0
	No	11(91.6)	35(89.6)	24(100)
Dosimeter	Yes	0	2(5.2)	0
	No	12(100)	37(94.8)	24(100)
Lead gloves	No	12(100)	39(100)	24(100)
Using light beam diaphragm cone	Yes	12(100)	39(100)	24(100)
	No	0	0	0
Using wall shield during work	Yes	12(100)	35(89.6)	13(54.2)
	No	0	4(10.4)	11(45.8)
Would you use a lead apron and thyroid shield for patient protection	Always	1(8.4)	4(10.4)	1(4.2)
	Occasionally	8(66.6)	28(71.7)	10(41.6)
	No	3(25)	7(17.9)	13(54.2)

5.10 Sample of Pictures Taken from Investigated Facilities

Image 1: Demonstrates direction of the beam to a neighbouring house

Image 2: Xray room without control panel

Image 3: X-ray room is made of wood

Image 4: Entry door to x-ray room which is made of aluminium

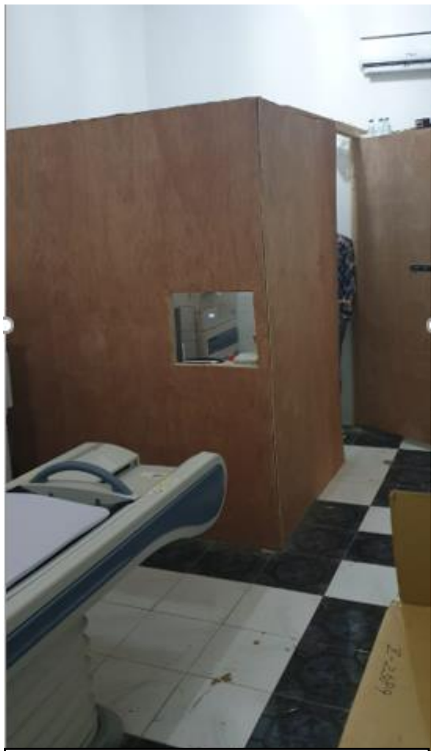


Image 5: Control room located inside CT room with uncovered roof

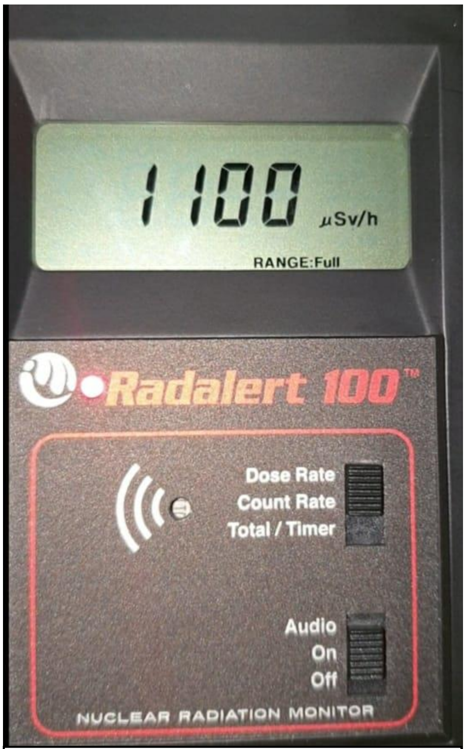


Image 6: Survey meter showing high reading at control lead glass

Image 7: Xray room made of wood

CHAPTER SIX: DISCUSSION

This study is the first sampling survey on radiation facilities in Somalia encompassing six out of the seven regions. The surveyed regions comprise 86% of the country and provides essential data about the current status of radiation protection practice. Demographic data from the study revealed male predominance among the radiation health workers of 91% with a ratio of 10:1. This result is similar to a study done in South Korea and China where the majority of radiographers were male(62,63).

Regarding educational level, Table 2 shows that 54.4% of the radiation health workers were formally trained. Of the trained workers, the largest group comprised of formal radiographers of which 60% were trained to diploma level. Kenya currently has approximately 1700 registered radiographers and approximately 80% of them have higher diplomas, this information received through SORK administrator on 18^{th} May 2021. The study findings compared favourably with studies from Ghana, Saudi Arabia and Indonesia which found that radiographers with diploma in radiography were 70%, 54% and 67.6% respectively (44,56,65).

Radiologists were found onsite in 20.1%(n=9) of the facilities whereas only 11.1%(n=5) used teleradiology. The vast majority of the radiation facilities 68.8% (n= 31) of the facilities surveyed did not have radiologists and this leaves most of the diagnostic films unreported which puts patient care at risk. These findings are similar to several countries in sub-Saharan Africa like Malawi where there is only one Government Consultant Radiologist who gives service to the public while Zambia, has only 5 radiologists working in public hospitals servicing a population of approximately 17 million(66,67). Neighbouring Kenya has 170 registered radiologists, 90% of them are estimated to be working in urban centers, with 76% concentrated in three major cities(68,69).

There was a marked absence of medical physicists. None of the facilities employed medical physicists or had designated radiation protection officers as illustrated in Table 2. Globally, Africa is one of the continents with very low number of medical physicists and is about 0.6 MP/mill, while 1.5 MP/mill in Asia, 2MP/mill in Latin America,13 MP/mill in Europe and 26 MP/mill in USA/Canada(70).

Regarding radiation safety training, this study has showed that none of the radiation health workers had initial or periodic of such training which may seriously hamper the creation of a radiation safety culture to enhance radiation risk awareness and minimize unsafe practices. A study carried out in Uganda showed that 68.2%(n=15) of radiographers reported that they had an initial training on radiation safety before they started working while only 9.9% of radiation workers received radiation safety training in a study conducted in Egypt(71,72). Furthermore, in Kashmir only 37.5%(n=3) radiologists and 23%(n=18) of x-ray technicians had radiation safety training(73). This indicates that there is critical need to build capacity in RP in many countries in the low and middle income countries.

6.2 Safety measures in facilities

A probably designed and shielded X-ray/CT room is important for the RP of the staff, patient, and general public. International organizations such as ILO, IAEA, and WHO have recommended room sizes of at least $24m^2$. This study showed that all (100%) CT and 79.5%(n=35) of conventional radiography rooms met the required room size. In contrast, a study done in Nigeria found that only one out of three investigated facilities complied with the minimum required room size. Our study however compares favourably with a study carried out in Sri Lanka which found that 86% of x-ray rooms met the recommended room size(34,74–76).

The present study has revealed that only 49% (n=27) of x-ray/CT rooms were built with adequate safety measures. This contravenes radiation safety guidelines set by IAEA(77). Some of the reasons that may be given for this finding could the lack of a national regulatory body to ensure the safe use of ionizing radiation and that most the facilities were housed in buildings not originally designed for hospital purpose. The latter reason is similar to a study done in Tanzania which reported that most rooms used to host x-ray machines were not originally intended for medical imaging which greatly challenges radiation safety measures(78). In contrast, a study conducted in Nepal found that all X-ray facilities were built according to safety criteria(54).

The current study found that there was absence of lead lining on doors and walls in 43.6%(n=24) of X-ray/CT rooms. A similar study carried out in Sudan reported a lack of lead lining in 75.9%(n=22) of governmental and 85.7%(n=18) of private hospitals(39). This lack of lead lining shows the significant risk to radiation leaks that may be experienced by the health workers, patients and general public.

Safety warning signs/lights and written safety policies are an important restriction that controls access to Xray/CT rooms and alerts workers, patients and members of the general public about the radiation hazards. The stipulated set of RP warning signs were present in only 5.4% (n=3) of rooms whereas in another 20%(n=11) had a red light only but no written safety policies. This compares with a study done in Nigeria that reported that warnings signs where present in 20%(n=3) of the centres while warning light were found in all (?) the centres but only 2 out of the 15 centres investigated were functioning (79). Studies conducted in Sri Lanka and India have found that only 12.5% and 33% of the X-ray rooms had warning lights and signs respectively. A study from Sudan has reported the presence of written safety policy in 6.9% and 23.8% of governmental and private hospitals respectively. In contrast a study carried out in Saudi Arabia, found that 92.2% of the participants reported the presence of written safety policies in their departments(39,43).

This survey found that there is no routine measurement of exposure rates outside X-ray/CT rooms. A study from Nigeria stated that only 20%(n=2) of investigated public centres routinely perform environmental monitoring(40). The current study has revealed that no quality control measures were conducted periodically in all the facilities investigated. These findings are in concordance with studies done in Nigeria, Libya, and Nepal(54,55,80).

The protective equipment is essential for personnel RP to reduce exposure and should be provided by the management. This survey found that most facilities lacked essential protective equipment. The majority of the X-ray/CT rooms, 81.8% (n =45) had lead aprons and very few of the facilities, (< 15%) had gonad and thyroid shields. However, none of the facilities had lead rubber gloves and flaps. A study conducted in Ethiopia reported the availability of protective equipment like lead apron, gonad shield, lead glove/glass but no thyroid shield was available in all the hospitals investigated(57). Another study done in Rwanda stated that the lead apron was available in 99.1% of the hospitals, thyroid shield in 74.7%, gonad shield in 70.6% and lead goggles in 30.1% of the surveyed hospitals(81). Furthermore, a study done in Saudi Arabia indicated that most (99%) of the hospitals have a lead apron and thyroid shields in place, but only about 50% have lead glasses(82).

It is essential to justify all medical exposures by considering the benefits versus risks and also to take into consideration relevant information from the previous examination to avoid unnecessary additional exposure. This study surprisingly found that none of the facilities participating in this study, had the CT imaging requests justified. This result is not in concordance with conducted in Sweden that found approximately 20 % of all CT examinations were not justified(83,84).

6.3 Scatter radiation in facilities

This study found that the scatter radiation measured at X-ray/CT rooms were higher than the permissible annual dose for radiographers. The high readings were observed in 22.2% of control lead glass/radiographers sitting position and 31.7% of radiographer's entry doors. There was also high exposure beyond the level of 1 mSv/year for the public in some facilities, mainly in the sides of the rooms (40.6%) as shown in *Table 12*. These results were comparable to a study done in Saudi Arabia which reported that staff as well as patients were at risk of exposure as levels exceeding the recommended limit were found in all the four hospitals investigated(82). Ojomolade(2017) in Nigeria also reported that 73% of the hospitals in his study had scatter radiation reaching to the radiographers(79). In contrast a study from India showed that occupational dose was below the annual limit for the radiation workers but higher doses were observed in public spaces outside x-ray rooms because more than 90% of the facilities used traditional doors made of wood, aluminum which are not effective as lead lined doors(74). In contrast, Geletu G, et al (2017) in Ethiopia reported safe working environment based on dose results in the investigated four hospitals to the workers and public(57).

6.4 Knowledge and practice of RP among radiation health workers

The study sought to investigate the level of knowledge on RP among radiation health workers in Somalia by calculating the overall percentage of correctly answered in the knowledge section of the questionnaire (Table 9). The results showed that the level of RP knowledge among the radiologists was 58.3%, radiographers 44.6%, while non-formally trained radiographers had the lowest level of knowledge at 19.3%.

Our study showed that all the radiologists and only 46.1% (n =18) of the formal radiographers identified all the imaging modalities that use ionizing radiation. In contrast, a study from Italy (2015) showed that only 5% and 4% of the radiographers respectively believed that abdominal ultrasound and pelvic MRI exposed patients to radiation(52). In this Italian study, 33.7% and 65.1% of the radiographers correctly identified radiation sensitive age-groups and organs. On the other hand our study showed low levels of knowledge on radiosensitive age-group and tissues among radiation health workers as illustrated in table 9(52).

The analysis of this study identified that 50% (n =6) of radiologists and 33.3% (n =13) of formal radiographers correctly acknowledged the annual radiation dose limit to individuals. A study conducted in Ghana, showed that 54% of the radiographers correctly answered the amount of annual dose limit for radiation health workers(56). Only 16% (n=2) radiologists and 5.2 % (n =2) of the formal radiographers knew the approximate effective radiation dose received by an adult in standard chest radiography. A similar study done in Jordan found weak radiation dose awareness among radiographers where the average total score was less than 50% (85).

It is important that occupationally exposed workers wear personal protective equipment for their safety. It is equally important that they use monitoring devices to ensure the annual dose limit is not exceeded. Our study found that the majority of workers 92% used lead apron. This is similar to two studies done in Rwanda and Saudi Arabia, where 99% of radiographers regularly wear lead apron(81,82). In contrary to this, a study conducted in Egypt stated low utilization(39.7%) of lead aprons despite the availability of these devices(71). This study also revealed low availability and utilization of thyroid shield, only 28% of radiographers used this device. This result is not in accordance with a study done in Ethiopia where there was no thyroid shield available in the four hospitals investigated(57). Also, a study in Egypt reported that 33.9% of radiographers used thyroid shield(71). However, two studies done in Rwanda and Ghana reported 62% and 52% of radiographers used thyroid shield respectively(56,86). In the present study no workers used TLDs or film dosimeter which ensures that occupational limit for workers is not exceeded. In contrary, a study done in Rwanda stated that 58.6% of radiographers used dosimeter while a study from Egypt reported that 54.5% have dosimeter but only 9.1% used them at work place(71,81). Also, a study carried out in Nigeria found that 50% of the participants were observed wearing dosimeter(55). However, a study conducted in Ghana reported that the dosimeter was never/rarely used by 66% of the radiographers(56). In addition, 60.4%(n=111) of radiographers possess dosimeter but only 55%(n=61) use the device during work in a study conducted in Palestine(45).

In this study, about 27.2%(n=12) of X-ray rooms the radiographers operate from inside without a shielded protective barrier. This is in contrast to a study done in Rwanda which reported that only 16.4% of radiographers did not use shielded barrier while a study from Ghana showed that 42% of participants did not use wall shield during exposure(56,81).

6.5 Conclusion

This study provides crucial data about the radiation protection practice in Somalia. Generally, it was observed that there exist inadequate staffing levels, paucity of well-trained radiation health workers, inadequate radiation safety measures in place such as poor design and shielding of the x-ray/CT rooms. In addition, there was lack of essential personal protective equipment and monitoring devices for workers. This study has also revealed low level of knowledge on RP among workers especially where there was no initial or periodic radiation safety training. In assessing radiographers' and public exposure, this study found high risk involved in about half of the investigated facilities.

6.6 Study limitation

The major limitation was insecurity and conflicts in one region (Jubaland) which was excluded for security reasons. Another major limitation was refusal of some facilities and radiation health workers to participate in the study. Some of the reasons cited were the workers and facilities being too busy and had no time for the study. Some owners said they don't want their deficiencies in RP practice to be exposed despite the researcher explaining to them that the information collected would be confidential.

6.7 Recommendations

There is a strong need for a national regulatory body in the field of RP to ensure that radiation safety measures are implement through regular and periodic inspection of the facilities and enforcement of radiation safety measures. Study findings will be availed through a report to the Ministry of Health, Somalia, as it provides baseline information on the current state of RP in the country. Through capacity building and formulation of RP policies, the practice and culture of radiation safety will be ensured. Furthermore, the medical education institutions should increase their efforts and establish formal training programs for radiation health workers.

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Date:

Appendix 1: Questionnaire(52)

Section 1 - Personal details

1. Gender:
☐ Male
☐ Female

2. Nationality:
☐ Somali
☐ Others: specify…………

3. Formal training:
☐ Postgraduate
☐ Bachelor
☐ Diploma

4. Non-formal training
☐ 2 weeks
☐ 4 weeks
☐ 6 weeks

5. Level of experience:
☐ <2y
☐ 2-5y
☐ >5y

6. Hospital type:
☐ Public
☐ Teaching
☐ Private

7. Region:

- ☐ Mogadishu
- ☐ Puntland
- ☐ Jubbaland
- ☐ Southwest
- ☐ Hirshabelle
- ☐ Galmudug
- ☐ Somaliland

Section 2 - Radiation protection knowledge

1. Which imaging modality uses ionizing radiation?

- ☐ Conventional Radiography
- ☐ Computed Tomography
- ☐ Ultrasound
- ☐ Magnetic Resonance Imaging
- ☐ Fluoroscopic Studies
- ☐ Radionuclide Imaging
- ☐ Not sure

2. Which of the following patients are the most sensitive to ionizing radiation?

☐ 1-year-old male
☐ 1-year-old female
☐ 20-year-old female
☐ 40-year-old male
☐ Ionizing radiation damage risk is unrelated to the patient's age and sex
☐ Not sure

3. Which of the following tissues is more susceptible to ionizing radiation-related damage?

☐ Kidney
☐ Gonads
☐ Thyroid
☐ Brain
☐ Skin
☐ Breast
☐ Bone marrow
☐ Lungs
☐ Liver
☐ Muscle
☐ Not sure

4. Which of the following diseases may be a result of stochastic radiation damage?

☐ Dermatitis
☐ Leukemia

☐ Alopecia
☐ Cataract
☐ All answers are correct
☐ Not sure

5. What is the annual limitation dose for individuals?

☐ 10mSv
☐ 20mSv
☐ 40mSv
☐ 60mSv
☐ Not sure

6. What is the approximate effective radiation dose received by an adult in standard Chest radiography?

☐ 2msv
☐ 0.2msv
☐ 0.02msv
☐ 0.002msv
☐ Not sure

7. Do you think the collimation of the x-ray beam will affect reducing radiation dose?

☐ Yes
☐ No
☐ Not sure

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

☐ 1m
☐ 2m
☐ 3m
☐ Not sure

Section 3: Performance towards radiation protection during practice

1. Use of Personal Protective devices:

A. Lead apron

☐ Yes
☐ No

B. Thyroid shield

- Yes
- No

C. Gonad shield
- Yes
- No

D. Protective eye glasses
- Yes
- No

E. Dosimeter
- Yes
- No

F. Lead gloves
- Yes
- No

2. Practices regarding radiation protection:

A. Which monitoring device do you use?
- Film badge
- TLD
- Others…….
- Non

B. How frequently is the radiation dose checked from monitoring devices?
- Monthly
- Bimonthly
- Trimonthly
- Bi-annually
- Other

C. Using light beam diaphragm, cone, and grid
- Yes
- No

D. Using wall shield during work
- Yes
- No

3. In your department, is there a safety warning sign?
- Yes
- No

4. In your department, is there lead lining of walls and doors?
- Yes

- ☐ No

5. Would you use a lead apron and thyroid shield for patient protection?
   - ☐ Yes (always)
   - ☐ Yes (occasionally)
   - ☐ No

Date: ……

Appendix 2: Checklist for diagnostic imaging facilities(41,42)

I. Identifying information

1. Type of facility: ……………………………………………

2. Address of facility: Region: ………………………………
   City: ……………………….

3. Name and qualifications of any qualified experts:
   a) Medical Physicist:
      Available: Yes: ….. No: …..
      Number......................................
      Degree..
      Experience..................................

   b) Radiologist:
      Available: Yes: ….. No: …..
      Number......................................
      Degree..
      Experience..................................

   c) Radiation protection officer:
      Available: Yes: ….. No: …..
      Number......................................
      Degree..
      Experience..................................

   d) Radiographer:
      Available: Yes: ….. No: …..
      Number......................................
      Degree..
      Experience..................................

II-VERIFICATION OF SAFETY

II-1. Radiation generating equipment

Type of X-ray/CT equipment	Manufacturer	Model No	Max. kV	Max. mA	Max. mAs	Weekly workload

II-2. Design of premises

The general layout of the Xray/CT rooms by showing adjacent rooms, corridors, thickness, and construction material of walls and beam directions.

III-3. Shielding design

	Yes	No
Is there lead lining of doors and walls?		
Are appropriate accessories available? 1. Mobile protective barrier 2. Lead rubber apron 3. lead rubber gloves 4. Lead rubber flaps 5. Gondolashield		
Comments:		

IV-4. Control panel

Is there a clear view of the patient from the control position?	Yes	No
Is the view window made of lead glass? If "No" describe method used ………………………………………………		
Are the exposure controls clearly marked?		

Does the red light show at the console during an exposure?		

V-5. Area radiation surveys

	Yes	No
Operator possesses appropriate, functioning survey instrument(s)?		
Suitable function checks are performed on instruments before use?		
Area exposure rate surveys are performed at appropriate intervals?		
Comments:		

II-6. Warning signs and labeling

	Yes	No
Do controlled areas have appropriate warning signs (in the local language)?		
Entry to X-ray/CT rooms posted appropriately?		
Illuminated warning signs/lights functioning (where required)?		
Notices to workers are displayed as required?		
Comments:		

II-7. Safety operations — management

	Yes	No
Does management provide adequate staffing levels?		
Has management provided the radiation protection officer authority to stop unsafe operations?		
Does management provide adequate resources for personnel training (time and money)?		
Does management provide adequate equipment?		
Comments:		

II-8. X-ray/CT rooms and equipment

	Yes	No
Is the X-ray/CT room located in an isolated area?		
Is the X-ray/CT room built with adequate safety measures?		
Is access to the X-ray/CT equipment adequately controlled to prevent unauthorized use?		

Equipment compliance and maintenance (quality control)		
Is the X-ray/CT equipment subject to periodic testing (a QC program) to ensure the design and operating characteristics comply with the IEC/ISO or other requirements of the Regulatory Body?		
If so, at what frequency?		
Is the X-ray/CT equipment subject to routine maintenance by authorized service agents?		
Comments:		

III-VERIFICATION OF WORKER PROTECTION

III-1. Training and instruction of workers

	Yes	No
All personnel using or responsible for the use of the X-ray/CT equipment have prescribed qualifications and/or training?		
All occupationally exposed personnel are provided with initial safety training?		
Is there a safety written policy?		
Refresher radiation safety training is provided periodically?		
Comments:		

III-2. Work instructions

	Yes	No
Are work instructions established in writing?		
Are the workers (including nurses attending patients) instructed in the implementing procedures?		
Do workers have adequate supervision to ensure rules, procedures, protective measures, and safety provisions are followed?		
Comment:		

III-3. Personnel radiation monitoring

	Yes	No
Is personal monitoring provided? If "yes" by whom……………………….		
Are personnel dosimetry records available?		
Dosimetry reports are promptly reviewed by the RPO?		
Is it evident that personal dosimeters are being worn by workers?		
Individual workers are informed of their monitoring results when each monitoring report is received (regardless of the dose measured)?		
Personnel monitoring records are maintained?		
Comments:		

IV-VERIFICATION OF PUBLIC PROTECTION

IV-1. Control of visitors

	Yes	No
Are visitors permitted in controlled areas?		
Is adequate information provided to visitors entering controlled areas?		
Are there adequate controls over entries into controlled and supervised areas and appropriate postings? provided? legible? Local language?		
Comments:		

IV-2. Sources and monitoring of public exposure

	Yes	No
Are the shielding and other protective measures optimized for restricting public exposure to external sources of radiation?		
Are the floor plans and arrangement of equipment appropriate considering public areas adjacent to the installation?		
Are routine periodic measurements of exposure rates in areas adjacent to the X-ray/CT room?		
Comments:		

VI-MEDICAL EXPOSURE

VI-1. Responsibilities and justification

	Yes	No
Is there a safety written policy?		
Are the examinations with X-ray/CT are authorized by appropriately Qualified Practitioners?		
Has an appropriately Qualified Practitioner been designated as having overall responsibility for patient protection and safety?		
Does this Qualified Practitioner ensure that exposures are justified?		
No patient exposed unless is prescribed by a medical practitioner?		
Are the diagnostic medical exposures justified by taking into account the benefits and risks of alternate techniques that do not involve medical exposure?		
Comments:		

VI-2. Operational considerations

	Yes	No
Has the operator established Dose Guidance (or Reference) Levels?		
Have dose measurements been made at the facility for comparison to these levels?		
Do medical practitioners ensure that appropriate equipment is used, that the exposure of patients is the minimum necessary to achieve the diagnostic objective, and take into account relevant information from previous examinations to avoid unnecessary additional exposure?		
Do the medical practitioner, the technologists, or other imaging staff select the parameters such that their combination produces the minimum patient exposure consistent with acceptable image quality and the clinical purpose of the examination?		
Are radiological examinations causing exposure of the abdomen or pelvis of women who are pregnant avoided unless there are strong clinical reasons for such examinations?		
Are the diagnostic examinations causing exposure of the abdomen or pelvis of women of reproductive capacity planned to deliver the minimum dose to an embryo or fetus		
Comments:		

Appendix 3: Measurements of scatter radiation

	Scatter measurements(µSv)	Calculated Annual Dose(mSv)
Background radiation		
Control lead glass		
Radiographer’s sitting position		
Radiographers entry door		
The corridor along with the reception		
Main entry door		
Outside X-ray/CT room		
1. Front		
2. Back		
3. Right		
4. Left		
The instrument used: SE Inspector USB survey meter **Comments:**		

Appendix 4: Informed consent form

This informed consent form is for radiation health workers and owners of the diagnostic imaging facilities in Somalia. I am requesting these people to participate in this research project whose title is:

A SURVEY OF THE RADIATION PROTECTION PRACTICE OF DIAGNOSTIC IMAGING FACILITIES USING IONIZING RADIATION IN SOMALIA

Principal investigator: Dr. Omar Hassan Ahmed
Supervisors: Dr. Gladys Mwango, Dr. Enock Anyenda, and Mr. Arthur Koteng
Institution: Department of Diagnostic Imaging and Radiation Medicine, School of Medicine, University of Nairobi

This informed consent form has three parts:

I. General information about the research
II. Certificate of consent
III. Statement by the researcher/research assistant

You will be given a copy of the full informed consent form

Part 1: General information

Introduction

My name is Dr. Omar Hassan Ahmed, a postgraduate student in radiology at the University of Nairobi I am carrying out a Survey of the Radiation protection practice of diagnostic imaging facilities using ionizing radiation in Somalia.

Purpose of the research

The use of Ionizing radiation plays an important role in medicine either to detect diseases or to treat cancers. A balanced approach is therefore required, to ensure that the benefits always outweigh the risks. The lack of Radiation Protection and regulatory infrastructure to manage the radiological practice can lead to a serious problem such as increased malpractices and radiation health hazards among workers, patients, members of public as well as the environment. The purpose of this research is to find out the current status of radiation protection practice in diagnostic imaging facilities located in Somalia. Also, to assess the level of knowledge, attitude, and behavior towards radiation protection of radiation health workers in Somalia.

I am going to invite you to be a participant in this research. There may be some words that you may not understand. Please ask me to stop as we go through the information and I will clarify. After receiving the information concerning the study, you are encouraged to seek clarification in case of any doubt.

Participation/Right to refuse

Your participation is wholly voluntary. You have a right to refuse or withdraw your participation in this study at any point. If you agree to be a participant, you will be required to sign a consent form.

Study procedure

The research will be carried out using: (i) Observational checklist of the diagnostic imaging facility, to inspect the implementation of radiation safety measures, filled by the researcher. (ii) Measurement of scatter radiation using a survey meter (model: SE Inspector USB). Measurements will be carried out twice in different rooms such as inside the X-ray/CT and control room, the corridor along with the reception, waiting area, and the main entry door. (iii) A self-administered questionnaire that is filled by radiation health workers.

Confidentiality

The information collected will be treated with confidentiality and will only be available to the principal investigator and his supervisors. Anonymity will be achieved by not using the participant's name or facility name in the questionnaire.

Sharing the results

The study findings will be shared with the Ministry of Health, Somalia, and other international organizations like WHO and IAEA to assist them through capacity building and to establish a national policy for radiation safety.

Benefits

The information you provide will help us get baseline data that may be useful in the establishment of radiation protection infrastructure in Somalia, and how the knowledge gap can be bridged.

Risks

No risk or harm anticipated in this research. The assessment will be conducted during daily routine work in diagnostic imaging facilities and will not lead to additional radiation exposure to the patient or the radiation health workers.

Cost and compensation

There will no cost incurred for participating in this study nor will be any compensation offered. This proposal has been reviewed and approved by the UoN/KNH Ethics and Research Committee which is a committee whose task is to make sure that research participants are protected from harm.

Who should you contact?

If you have any questions to ask in the course of the research, you may contact any of the following:

1. Principal investigator:
   Dr. Omar Hassan Ahmed +254791157993 Email: doctoromarbadawi@gmail.com

2. Supervisors:
   Dr. Gladys Mwango +254720127553 Email: gladysmwango@gmail.com
   Dr. Enock Anyenda +254713990392 Email: enolando1216@gmail.com
   Mr. Arthur Koteng +254710119431 Email: aokoteng@gmail.com

3. Secretary, KNH-UoN ERC
   P.O Box 20723-00202
   KNH, Nairobi
   Tel:+25470207263009
   Email: KNHpan@Ken.Heathnet.org

Part 11: Certificate of consent

I ………………………………………………………………..have read the above information or it has been read to me. I have had the opportunity to ask questions and the queries have been answered to my satisfaction. I consent voluntarily to be a participant in this research.

Signature of participant…………………………………………Date:………………………...

Part 111: Statement by the research

I have accurately read out the information sheet to the participant, and to the best of my ability made sure that the participant understood that the following be done:

1. All information given will be treated with confidentiality
2. The results of this study will be published to inform on the ideal way to establish a radiation protection infrastructure in Somalia.

I confirm that the participant was allowed to ask questions about the study, and all the questions have been fully answered and to the best of my ability. I confirm that the participant has not been pressured into giving consent, and the consent has been given freely and voluntarily.

A copy of this informed consent form has been provided to the participant.

Name of researcher/research assistant………………………………………..

Signature………………………………………………………………………..

Date:…………………………………………………………………………….

Appendix 5: Foomka Ogolaanshaha

Formkaan waxaa loogutalagaly shaqaalaha raajada iyo milkiilayaasha xarumaha caafimaadka ee isticmaala raajada. Waxaan kacosanayaa in aad ka qeyb qaadataan baaritaankaan cinwaankiisu yahay:

A SURVEY OF THE RADIATION PROTECTION PRACTICE OF DIAGNOSTIC IMAGING FACILITIES USING IONIZING RADIATION IN SOMALIA

Principal investigator: Dr. Omar Hassan Ahmed

Supervisors: Dr. Gladys Mwango, Dr. Enock Anyenda and Mr. Arthur Koteng

Institution: Department of Diagnostic Imaging and Radiation Medicine, School of Medicine, University of Nairobi

Foomkaan wuxuu ka koobanyahay sedex qeybood:

1. Warbixin guud
2. Foomka lasasiixayo
3. Bayaanka baaraha

<u>Qeybta 1: Warbixin guud</u>

Magaceygu waa Dr.Omar Hassan Ahmed,ahna arday digta heerka labaad ee jaamacada Nairobi,qeybta raajada. waxaan wadaa baritaan kusaabsan sida xarumaha caafimaadka kuyaal somaliya ay u isticmalaan raajada iyo sida ay iskaga ilaaliyaan shucaaca kadhasha isticmaalkeeda.

Ujeedka baaritaanka

Ujeedka ugu weyn waa in laogaado isticmaalka raajada,sida ay xarumaha u ilaaliyaan in aysan waxyeelo soo gaarin bukaanka,shaqaalaha iyo bey'ada. Sido kale laogaado heerka aqoonta ee shaqaalaha raajada.

Kaqeybgalka baaritaanka

Xor ayaa u tahay in aad kaqeyb gashid baaritaankaan ama aad iska diidid.

Qaabka baaritaanka
Waxaa laisticmalayaa baritaankaan liisto ayku qoronyihiin waxyabaha muhiimka ah ay lagarabo xarumaha raajada isticmaalo in ay heystaan,sido kalena waxaan lacabiri donaa shucaaca heerka u gaarsiinanyahay. Shaqaalaha raajada wuxuu buuxin donaa foom ay ku qoranyihiin suaalo kusaabsan maclumaad guud.

Ilaalinta sirta
Magacyada xarumaha iyo shaqaalaha kaqeyb galayo baaritaankaan lama isticmaali doono, mana loo baahno in lagu qoro fooma. Wixii warbixino ah eel aga diyaariyo baaritaankan walaidinla wadaagi donaa.

Natiijada baaritaanka
Waxa lalawadaagi doonaa natiijada guud ee baaritaankaan wazaarada caafimaadka si ay u sameyso shuruuc hagta isticmaalka raajada iyo in ay kor u qaado aqoonta iyo xirfada shaqaalaha raajada.

Faidoyin
Waclumaadka lagahelo baaritaanka wuxu horseedi karaa in ay soomaliya yeelato shuruuc hagta isticmaalka raajada si looga hortago waxyeeladeeda.

Kharaha iyo kharashka
Wax yabayraatee khatar ah majiraan o kaso gaari karto baaritaankaan.
Wax lacag ah aad kuheleyso majiraan kaqeyb galkaada baaritaankaan.

Yaal laxiriireysaa
Hadii aad wax suaalo ah qabtid waxaa laxariiri kartaa:

4. Principal investigator:

   Dr. Omar Hassan Ahmed +254791157993 Email: doctoromarbadawi@gmail.com

5. Supervisors:

   Dr. Gladys Mwango +254720127553 Email: gladysmwango@gmail.com

   Dr. Enock Anyenda +254713990392 Email: enolando1216@gmail.com

   Mr. Arthur Koteng +254710119431 Email: aokoteng@gmail.com

6. Secretary, KNH-UoN ERC

   P.O Box 20723-00202

   KNH, Nairobi

   Tel:+25470207263009

   Email: KNHpan@Ken.Heathnet.org

Qeybta 2: Sixiixa ka qeyb galaha

Anigoo ah ……………………………………………Waxaan ogolaaday in aan ka qeybgalo dirasadaan uu sameynayo Dr.Omar Hassan uuna si faahfaahsan iigu sharaxay,wixii suaalo ah an qabayna laiga qanciyay. waxaan aaminsanahay baaritaankan in ay faaiido iigu jirto aniga,shaqaalaha kale ee raajada iyo bukaankaba.

Saxiixa kaqeybgalaha………………………………. Date: ……………………..

Qeybta 2: Bayaanka baaraha

Waxaa cadeynayaa in aan siwaafi ah ugu sharxay kaqeybgalaha baaritaanka waxkasta eek u saabsan baaritaankaan. Kaqeybgalaha waxaa lo ogolaaday in uu suaalo weydiiyo ama wixi haraxaad u baahan loosharxo.

Waxaan kaloo cadeynayaa wixi maclumaad ah eel aga uruuriyo baaritaankaan aanan lalawaagi doonin jiho aan munaasab eheyn.

Nuqul foomkaan waxaan lasiiyay kaqeybgalaha.

Magaca baaraha:……………………………………

Saxiiixa:…………………………………………….

Tariikhda:………………………………………….

Appendix 6: Budget

Table 2: Proposed study Budget (Self-sponsored)

Item	Unit cost in kshs	Duration	Amount in kshs	Justification
Research assistants (RA)	1000 per day for 5 RA	15 days	75,000	Payments for 5 research assistants during data collection
Training for RAs	500 per day for 5 RA	One day	2,500	Snacks during training
Transportation for the RA	100 per day for the 5 RA/15 days	15 days	2,500	Transportation for 5 RA
Airtime for the RA	50 per day for 5 RAs/15days	15 days	3,750	Will be used for communication
Stationery and printing costs	55,000	Variable	55,000	Printing, photocopies and

				binding during proposal and thesis development
Air ticket to: Mogadishu Hargeisa Bosaso Kismayo Baydhabo Galkaio Garowe Jawhar Beledweyne Borame	485,000 Go/back ticket	1	485,000	The researcher will go to different cities in Somalia for data collection and this amount will be used for Go/Back Air Ticket
Transportation and accommodation for the researcher	100,000	Variable	100,000	The researcher will use this amount for accommodation and transportation during data collection
Statistician	30,000	Variable	30,000	Data analysis
Subtotal			**753,750**	
Contingency (10%)			75,375	10% of the budget will be used as a contingency
TOTAL			**829,125**	

Appendix 7: Timeline of events

Activity	Sept-Dec 2019	Mar 2020	Aug-Sept 2020	Oct 2020	Nov 2020
Proposal write up	**x**				
Submission to ERC and corrections		**x**			
Data collection			**x**		
Data entry				**x**	

and analysis					
Report writing and dissertation submission					**x**