

KNOWLEDGE, ATTITUDE, AND PRACTICE OF CLINICIANS PRACTISING AT THE KENYATTA NATIONAL HOSPITAL, ON IONIZING RADIATION

A dissertation as partial fulfillment of the requirements of the University of Nairobi, for the Award of the Degree of Master's in Medicine in Diagnostic Radiology

Principal investigator:

Dr. Gecaga W. Wendy

MBChB, University of Nairobi

Assistant Director of Medical Services, Ministry of Health

Kenya.

Currently a part two Resident, M.Med program in Diagnostic Imaging and Radiation Medicine,
University of Nairobi

DECLARATION

I, **Dr. Gecaga W. Wendy** declare that the work contained herein is the original idea and has not been presented at any other place in Kenya to the best of my knowledge.

Signature.....Date.....

APPROVAL BY SUPERVISOR

This research proposal has been submitted with my approval as a university supervisor.

SUPERVISOR:

1. Dr. Gladys Mwango
Consultant Radiologist and Lecturer
University of Nairobi
Department of Diagnostic Imaging and Radiation Medicine.

Signature.....Date.....

2. Dr. Timothy Mutala
Consultant Radiologist and Lecturer
University of Nairobi
Department of Diagnostic Imaging and Radiation Medicine.

SignatureDate.....

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DEDICATION

This dissertation is first dedicated to the almighty God for without him none of this would have been possible.

Secondly to my husband and children for being so understanding and giving me the support that I so much needed.

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ACRONYMS AND ABBREVIATIONS

AAA:	Awareness Appropriateness Audit
AAPM:	American Association of Physicists in Medicine
AP:	Antero-posterior
BEIR:	Biological Effects of Ionizing Radiation
CO:	Clinical Officer
CRCPD:	Conference of Radiation Control Programme Directors
CT:	Computed Tomography
CXR:	Chest Radiograph
DRL:	Diagnostic Reference Level
EC:	European Commission
FDA:	Food and Drug Administration
Gy:	Grays
HRCT:	High Resolution Computed Tomography
IAEA:	International Atomic Energy Agency
ICRP:	International Commission on Radiological Protection
IPSM:	Institute of Physical Sciences in Medicine
IR:	Ionizing Radiation
IR (ME) R:	Ionizing Radiation Medical Exposure Regulations
KMPDB:	Kenya Medical Practitioners and Dentists Board of Kenya
KNH:	Kenyatta National Hospital
KUB:	Kidney, Ureter and Bladder
LET:	Linear Energy Transfer
MO:	Medical Officer
MRI:	Magnetic Resonance Imaging
mSv:	Millisieverts
NCRP:	National Council on Radiation Protection and Measurement.
NRPB:	National Radiation and Protection Board
RCR:	Royal College of Radiologists
RNI:	Radionuclide Imaging
SHO:	Senior House Officer

Sv: Sieverts
UK: United Kingdom
UNSCEAR: United Nations Scientific Committee on Effects of Atomic Radiation
US: Ultrasound
WHO: World Health Organization

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ABSTRACT

Background

The World Health Organization (WHO) Global initiative report on Radiation Safety in the Health Care Setting of March 2010 states that low dose ionizing radiation used in diagnostic imaging has the potential to cause detrimental health effects¹.

Statement of the problem

The level of awareness of radiation risk among the clinicians in Kenya has not been documented.

Aim of the study

The aim of this study was to evaluate and document the knowledge, attitude and practice of the teaching hospital clinicians towards the use of ionizing radiation (IR).

Study setting

Kenyatta National Hospital

Study design

A descriptive cross-sectional study

Methodology

The study participants were a total of 170 who were distributed as follows: 25 Consultants, 66 Residents, 21 Medical Officers and 58 Clinical Officers. Sampling was by using simple random method. The data was collected using well-structured self-administered questionnaires and analyzed using SPSS 17

Study duration

The study duration was 10 months from August 2013 to May 2014

Results

More consultants, residents and medical officers correctly classified the imaging modalities that use ionizing radiation compared to the clinical officers (CO) $p < 0.004$. Health workers with no ionizing radiation (IR) training were less likely to correctly identify all the imaging modalities that use IR compared to those with IR training (50.9% versus 27.5%; OR = 0.37, 95% CI 0.18-0.72). Significantly more consultants, residents and medical officers were able to classify MRI and US as not using IR compared to the CO $p < 0.001$. When it came to identifying that an abdominal CT has the highest radiation dose, those with formal training (69.8%) fared significantly better than those with no formal training (37.1%) $p < 0.001$. Length of professional

experience, field of clinical training, and formal training in IR of the clinicians had no influence on their knowledge of IR doses. With respect to organ sensitivity only 72 clinicians rated bone marrow as a very sensitive organ. More clinicians rated gonads, thyroid, skin and brain as more sensitive than bone marrow. Of the 170 health workers, 148 (87.1%) reported that IR use in diagnostic imaging could cause harmful health effects. In their practice only 7 (4.2%) considered ionizing radiation dose an important factor when referring patients for imaging. Of the 170 clinicians, 97 (57.1%) referred patients for ionizing radiation investigations where the results would not alter the diagnosis or treatment plan. All the cadres of clinicians responded that they rarely informed their patients on the inherent risks of IR and there was no significant difference in their responses $p = < 0.05$.

Of the 170 clinicians, only 1 (0.6%) had attended a CME on IR protection.

Conclusion

The results from this study show that health workers lack the basic knowledge on ionizing radiation doses and its harmful effects, which impacts negatively on their attitude and practice. The implications here are serious for the patient as they are possibly being exposed to unnecessary radiation, which could increase their risk of carcinogenesis.

Recommendations

The only way to bridge this gap is by increasing clinician awareness about ionizing radiation through continuous medical education, development of imaging referral guidelines and incorporating a module on medical radiation and its risks during their training programs

INTRODUCTION

When the World Health Organization (WHO) launched the Global Initiative on Radiation Safety in the Health Care Setting in December 2008² its aim was to mobilize the health sector on the safe use of radiation in medicine. This was by formulating a common set of global referral guidelines for appropriate use of medical imaging². Up to 2012, there were 5 billion medical imaging examinations performed worldwide, of which 50% involved the use of ionizing radiation³. Data from the KNH medical records 2011/2012 shows that 80% of the imaging studies performed use ionizing radiation (IR)⁴.

The different biological effects of IR can be classified as deterministic versus stochastic, acute versus delayed, high dose versus low dose and somatic versus hereditary and/or in-utero effects⁵.

Deterministic effects are those that above a threshold dose will occur with certainty but below that threshold, they do not occur. These effects are mostly seen in cases of high dose acute exposure, for example, in-utero effects of IR such as early death of conceptus, mental retardation, malformations, and early childhood cancers⁵.

Stochastic effects are those, for which there is no threshold dose and can occur at any dose, no matter how minimal. The probability of these effects occurring increases with dose but the severity is independent of dose. These effects can be somatic or hereditary and examples include various cancers (solid, skin, thyroid, bone), leukemia, genetic abnormalities and cataracts⁵.

It has been shown that some of the underlying reasons for excessive usage of medical imaging include:

- Availability of medical insurance tends to result in overuse of imaging modalities
- Self-referral commonly seen in patients who come for annual total body CT (Computed Tomography) scans just to check that they have no tumors
- Defensive medicine: Where diagnostic or therapeutic measures are applied principally to safeguard against possible accusation of malpractice rather than to benefit the patient
- Lack of appropriateness criteria and referral guidelines, and where available many physicians don't know about them or just ignore.

- Duplication of imaging studies because the physicians disregard or mistrust the patients previous images ⁶.

The aim of this study was to determine the knowledge, attitude and practice of clinicians at a national teaching hospital and attain a preliminary insight into the current use of ionizing radiation in Kenya.

Further more the data collected from this study will be used to inform the clinicians on their level of understanding of IR and therefore for their education

STATEMENT OF THE PROBLEM

Several studies have shown that clinicians lack knowledge in ionizing radiation and especially its potential harmful effects, which has contributed to uninformed requesting habits for radiological procedures⁷⁻¹¹.

In the United Kingdom it has been found that approximately 100-250 deaths occurred each year from cancers directly related to medical exposure to radiation¹². In the United States it is estimated that 29,000 future cancers will originate from CT scans done in 2007 alone¹³.

It is documented that 35% of these CT scans were performed in patients aged 35-54yrs, and 15% were done in patients less than 18yrs¹³.

In Kenya the use of CT scan has increased by 80% in the last decade. A study done in three radiology centers in Nairobi showed that the recorded doses for CT brain, chest, and abdomen in adults were up to four times more than the International Recommended Diagnostic Reference Level (DRL)¹⁴. While a multi-pronged approach is required to drastically reduce the radiation risk through optimization of patient protection using optimally performing X-ray equipment, the application of good radiographic technique, and continuous assessment of radiographic image quality¹⁵. It is imperative that the knowledge, attitude and practice of the requesting clinician on IR be also documented. Also appropriateness guidelines need to be implemented which will prevent unnecessary scans being done in the first place .

LITERATURE REVIEW AND BACKGROUND

Ionizing radiation is the portion of the electromagnetic spectrum with sufficient energy to pass through matter and physically dislodge orbital electrons to form ions¹⁰. It exists in two forms: as electromagnetic waves, that is x-rays and gamma rays, and as particles, which include alpha and beta particles, neutrons and protons.

Most human exposure to IR comes from natural sources from the earth as seen in the following diagrammatic representation¹⁶. (Figure 1 below).

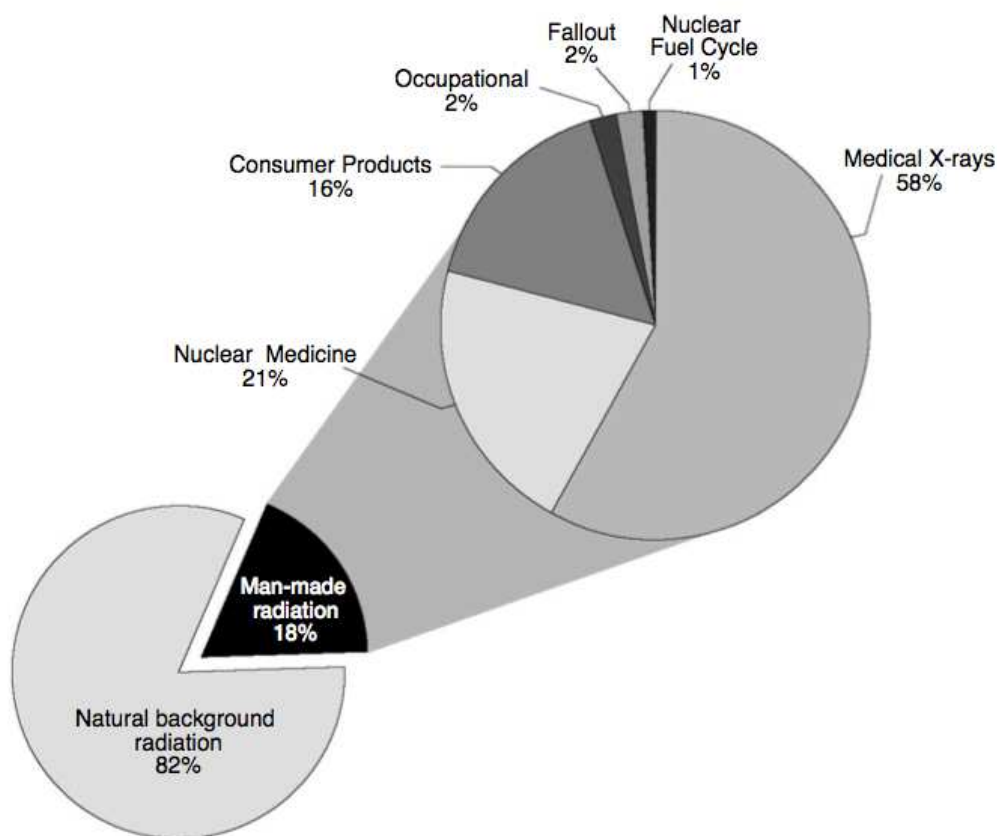


Figure 1: A diagrammatic representation of the sources of radiation adapted from BEIR V11¹⁶

Natural sources include cosmic rays originating from the sun and the stars; terrestrial radiation from soil, rocks, air, water and organic matter (plants and animals); and internal radiation in the form of radioactive carbon and potassium in our bodies¹⁷. These natural radiation sources account for 82% of the total radiation on earth. Artificial sources account for 18% of the radiation, with nuclear medicine accounting for 21% and medical x-rays accounting for 58%¹⁷. The medical imaging modalities that use IR are conventional, computed and digital radiography, fluoroscopy, mammography, computed tomography (CT) and radionuclide imaging (RNI).

The advantage of these imaging modalities is their ability to demonstrate internal body structures such as bone, soft tissues, fluid and air. Cross-sectional imaging which gives the ability of sagittal, coronal and 3-dimensional reformats enables better arrangement of treatment plans essential in oncology and surgery. These modalities also enable us to visualize luminal structures such as blood vessels, fallopian tubes, biliary and pancreatic ducts, salivary ducts, mammary ducts, ureters, and urethras, large and small bowel. Functional imaging is made possible with the use of radionuclide imaging (RNI).

However despite all these benefits, the clinicians' awareness of the harmful effects of IR enables both the clinician and the patient make an informed decision on which is the best imaging modality for the patient's management and whether in fact the study is necessary especially where the treatment plan will not change.

To understand these harmful effects the clinician must be aware of IR dose terminologies and appreciate a few basics of radiation dose units.

The common units used in IR are Grays, Sieverts, rads and Linear Energy Transfer (LET)

Absorbed dose: this is a radiation quantity that refers to the radiation energy deposited in unit mass of matter. It is measured using Grays (Gy). $1\text{Gy} = 100\text{rads}$

Equivalent dose: this is the absorbed dose and factors in the different radiation types and energies. The units used are Sieverts (Sv), millisieverts (mSv), and rem (Roentgen equivalent in man)

Effective dose: this is the absorbed dose of different radiation types and energy and takes into consideration the different radio-sensitivities of different tissues in the body (tissue weighting factor). Units used are Sieverts (Sv), millisieverts (mSv).

Tissues with high tissue weighting factors are more sensitive to IR. Breast, bone marrow, colon, lung and stomach are the most radiosensitive. See **ANNEX 2**

Linear energy transfer/LET: this is the energy deposition per unit distance along ionization path. Units are keV/ μm

Interaction of ionizing radiation with body tissues and the hazardous effects

Biological Effects of Ionizing Radiation (BEIR) is a committee of the National Research Council of the USA, which publishes a series of reports informing the US government on the effects of ionizing radiation. The committee first published a report was in 1980 and they have since then written seven documents and made various commendations to date. All their documents have a common theme focusing on the health effects of IR¹⁸.

The BEIR reports are used as a reference in areas where man is interacting with IR and they highlight the effects of low levels of LET radiation on human body tissues, the most recent being BEIR VII June 2005¹⁶. Very high doses, more than 100mSv (as defined by BEIR report) can cause damaging effects to tissues that are seen within days of exposure.

Low dose LET radiation is defined as near zero to 100mSv and can cause late effects, such as solid cancers and leukemia. Low LET IR is used in medical diagnostic imaging; for example the chest radiograph (CXR) has approximately 0.1 mSv while total body CT has 10mSv¹⁶.

Conclusions made by the BEIR VII report indicate that at low doses such as those used in diagnostic imaging, there is a linear dose-response relationship between exposure to IR and the development of solid cancers and leukemia. While it is unlikely that there is a threshold dose below which cancers are not induced, at low doses the number of radiation-induced cancers will be comparatively small¹⁶. The lifetime risk model indicates that approximately 1 in 100 people will develop solid cancer and leukemia from a dose of 100mSv, and approximately 42 of these people will develop the same cancers from other causes. The lower the dose of IR, the lower the

cancer risk proportionally. At doses of 10mSV, 1 in 1000 people will develop cancer (See Table in ANNEX 3¹⁹).

Although IR can change the molecular structure of DNA it has been found that the genetic risks are very small compared to the baseline frequency of genetic diseases in the population¹⁶. Risks of developing cancer from low doses of IR are extrapolated from studies of the A-bomb Nagasaki, Hiroshima Japan survivors²⁰. These studies have shown that the risk of solid cancers increases with a linear increase in IR dose and that children are more radiosensitive than adults¹⁶. In the United Kingdom, the cumulative risk of cancer by the age of 75 years attributable to diagnostic X-rays is about 0.6%, which is equivalent to about 700 new cases of cancer per year²¹. Estimates of the attributable cancer risk ranged from 0.6% to 1.8% in developed countries, with Japan having the highest estimated annual exposure frequency in the world of more than 3%²². Among all the fifteen countries that participated in the study Japan also had the highest annual frequency of diagnostic x-rays.

Diagnostic reference levels

The term 'diagnostic reference level' (DRL) is now used in the context of the optimization of the radiological procedures of patients undergoing medical exposure. These levels are intended to act as a benchmark to compare doses from common diagnostic procedures²³.

Diagnostic reference levels are set by different bodies, both internationally and nationally, and are recognized by the ICRP. These include United States based agencies such as CRCPD, FDA, AAPM; United Kingdom based ones like IPSM, NRPB, and the European Union like the EC and IAEA.

The DRL are guidelines and not rigid figures that need to be strictly followed.

Kenya is a signatory of the NRPB. The NRPB review its DRL for radiographic and fluoroscopic examinations every five years the last being in 2010²⁴.

The last review on CT doses for standard CT protocols by the NRCP was in 2003²⁵.

Clinician's knowledge on ionizing radiation

In Africa, studies on physicians' knowledge on ionizing radiation have been conducted in Ethiopia ²⁵ and Nigeria ²⁶. These are developing countries with similar socioeconomic patterns as Kenya.

The Ethiopian study published in 2012, showed that only 30 of 114 doctors assessed scored 50% and above on knowledge of IR. This translates to only 26% of the clinicians having creditable knowledge in IR and includes 12 doctors who had received formal training in IR. 33.3% had no knowledge on the health risks associated with ionizing radiation. This study resulted in the authors recommending a major curriculum revision of both undergraduate and graduate medical education, to include knowledge on radiation and its potential health risks²⁵.

The Nigerian study also published in 2012, was conducted in two tertiary institutions, and involved all cadres of doctors ranging from consultants to house officers. Sixty-five doctors answered the questionnaire; of these, 96.9% knew that ionizing radiation can be hazardous to the patients, 80% were unable to estimate the radiation dose of different radiological examinations and only 14% knew that Magnetic Resonance Imaging (MRI) does not utilize IR²⁶.

The majority of the study participants in these two studies were resident doctors. In both studies the question on IR dose for different examinations was answered wrongly, with underestimation of doses. Also in the Nigerian study 80% of the respondents said that MRI uses IR while 86% said that US uses IR. According to the author this is because these imaging modalities were not widely available in the study locality²⁶.

Methods that can be used to assess the level of knowledge on IR dosage of different radiological examinations by health workers include: questionnaires which are formulated to use the number of chest radiographs or the number of days of background radiation^{27, 28} For example how many chest radiographs or how many days of background radiation are equivalent to one CT of the abdomen^{27,28}. This model is used by the Royal College of Radiologists (RCR) to give information to patients so that they can make informed decisions²⁹⁻³¹.

Studies done in Northern Ireland and Turkey noted that there was an underestimation of IR dose incurred by patients during radiological procedures by the physicians; by both junior doctors and consultants⁷⁻¹¹. These findings led to policy changes where all doctors had to undergo a one-day training course annually on radiation protection under the Ionizing Radiation Medical Exposure Regulations (IR (ME) R) of Northern Ireland⁷.

Radiology has also been introduced as part of the foundation courses undertaken in the second year of all postgraduate training programs in Northern Ireland and parts of the UK. All new doctors working in these regions are equipped with a basic fact sheet on radiation dose and associated risks of different radiological examinations⁷.

There were also cases of overestimation of IR. Studies conducted in Australia amongst medical students of whom 523 had received some formal teaching on radiology and 147 had not, showed that more than 50% of the cohort with no formal education over-estimated the radiation dose from a CXR compared to 35% of those with formal education¹⁰.

It has been shown that the use of referral guidelines especially by non physicians (chiropractors, physiotherapists and occupational therapists) has enabled them to correctly estimate IR of different imaging modalities, which has led to the informed use of IR, by these practitioners⁹. There are various referral guidelines available, and the most commonly known are, the European Commission Referral Guidelines of 2008, American College of Radiology Guidelines and Royal College of Radiology Guidelines³².

The European Commission Guidelines for Health Care Professionals who prescribe imaging investigations involving Ionizing Radiation 2008 covers topics such as radiation effects to the pregnant woman and fetus, effective radiation dose in different common radiological examinations, different techniques employed in CT, MRI, Ultrasonography (US), fluoroscopic studies, interventional studies, nuclear medicine, different clinical pathologies and their appropriate imaging investigations³². These guidelines are in the form of a booklet but can also be accessed on-line by clinicians whenever they wish to order a radiological exam.

Formal education in radiology has offered an advantage over where there has not been any formal teaching in IR. The clinicians who had received training in IR attained higher scores and were knowledgeable in regards to which modalities use IR, the approximate radiation doses of different radiological exams and were aware of the lifetime risk of developing cancer following CT abdomen examination⁹. In the Ethiopian study, the doctors with formal training had a mean score of 14.2 out of 19 compared to those with no formal training, who had a mean score of 9 in the knowledge based questions²⁵.

In the study involving 523 final year medical students in Australia who were exposed to a curriculum in clinical radiology, 67% of them knew that CT uses IR, 37% knew that an abdominal x-ray had higher radiation dose than CXR, 70% knew that CT can potentially increase one's lifetime risk of developing cancer. Only 3.6% said US uses IR and 14% said MRI uses IR¹⁰. Compare this with the 147 in the same study who were not exposed to the curriculum in clinical radiology. Of these, only 39% knew that CT uses IR, 16% knew that an abdominal x-ray had higher radiation dose than CXR, 34% knew that CT can potentially increase one's lifetime risk of cancer, 8.2% said US uses IR and 30% said MRI uses IR. Consequently, it is expected that more rational use of imaging studies will be seen in the medical students who have been exposed to the curriculum in clinical radiology. Furthermore this study showed that 87% of the students who had been exposed to the curriculum still felt that there was inadequate teaching in the area of radiation protection and IR doses indicative of an increased awareness in the potential health hazards of IR. As a result it was recommended that a dedicated module on radiation protection should be instituted¹⁰.

Overview of ionizing radiation training in Kenya

The University of Nairobi is the largest university in Kenya. The College of Health Sciences, which dates back to 1967 currently, produces approximately 256 doctors yearly³³. An overview of the curriculum offered to undergraduate medical students in the Department of Diagnostic Imaging and Radiation Medicine of the University of Nairobi is as follows: the undergraduate curriculum starts in 3rd year where they have 12 hours of lectures spread over 2 weeks with 2 hours dedicated to the adverse effect of radiation, US and MRI. Radiation protection principles and approach to imaging requests in clinical practice is also included. In the 4th year they have

lectures in pediatric radiology with more emphasis on the rational use of the different radiological procedures available while in 5th year they have 11 hours of lectures spread out in 2 months as well as a four-week rotation in the radiology department.

From this curriculum it is clear that a large proportion of lectures are in clinical radiology and only 2 hours is dedicated to radiation protection, which is taught in the 3rd year. It would therefore be important to evaluate the level of awareness of these young doctors on the potential health hazards of IR so as to inform the health educator on whether any curriculum changes should be considered.

Clinical officers form an integral part of the Kenyan medical care system. Clinical officer (CO) training normally takes 4 years, which includes 1 year of internship. The curriculum covers anatomy, biochemistry, physiology, and pathology for 2 years followed by supervised clinical practice and internship at a teaching hospital in the departments of medicine, surgery, obstetrics and gynecology, and pediatrics for the remaining two years³⁴. It is of interest that Radiology is not in the curriculum and that there is no formal rotation in the radiology department; however these health workers are allowed to request for imaging studies with potential health hazards. This study plans to document whether there are differences in knowledge gaps between the different cadres of health care professionals working at the KNH.

Demographic variables in ionizing radiation knowledge

Literature review has shown that there exist differences in knowledge gap that relate to gender age and length of professional experience^{9, 10, and 35}. According to the Medical Practitioners and Dentists Board of Kenya, KMPDB 2009; 30% of medical doctors are female and 70% are male³⁵. It would be interesting to find out whether there exists any knowledge gaps between the genders in the local medical fraternity although reasons for such differences, should they exist remain unclear.

In a developing country like Kenya the majority of the doctors who graduated 20 years ago were not exposed to CT or MRI so their knowledge of these modalities may be limited. This has been shown in a study from Turkey where 49% of doctors who graduated more than 10 years ago

thought that MRI uses IR⁹. However this study did not mention the percentage of the doctors who had trained less than 10 years ago who answered correctly to enable comparison.

The age of the medical doctor is an important variable as it infers longer working experience. In our local setting, 11% of doctors are more than 61 years and 17% are between 51-60 years of age. This makes the majority of the doctors 50 years and below³⁵. It is expected that the younger graduates would be more knowledgeable about CT and MRI that are newer modalities introduced in the radiology department locally. In a study done in Australia, senior doctors scored somewhat higher than junior doctors, but not significantly so (41% vs. 39%) in the knowledge based questions. However these results led to policy change, where a junior doctor must consult a senior doctor before ordering for a CT scan for a patient. Radiation doses and risks were added to the imaging request form so that the requesting physician could easily see the information and all radiological reports with the total accumulated radiation dose to the patient were recorded¹¹.

The findings in the Australian study can be contrasted to a study done in Turkey in a university hospital. The study participants consisted of 55 physicians of whom 32 were consultants and 23 were residents. In the study, 12.5% of the consultants did not know that CT and mammography uses ionizing radiation compared to the residents who all knew that these modalities use IR. On the question of CT scan increasing lifetime cancer risk, 40.6% of the consultants gave an incorrect response compared to 13% of the residents. This study showed that residents had more knowledge on IR than consultants³⁶. The author of this study concluded that the increased years of medical practice did not enhance the level of awareness regarding ionizing radiation.

A study done in Germany showed that the length of professional experience, field of clinical training, and hierarchical position of the different physicians did not have any influence on the knowledge possessed. There was no significant difference in their knowledge regarding effective dose of CT chest and CXR³⁷.

Clinician attitude and practice

As shown, there exists a huge knowledge gap in ionizing radiation amongst doctors.⁷⁻¹¹; therefore it should not be surprising that few of them actually inform their patients on the risks and benefits of IR. One study in the USA showed that, 7 out of 56 patients were informed about the risks and benefits of abdominal pelvic CT scan by their referring physicians³⁸.

It is also of concern that patients do not ask their doctors what the risks of ionizing radiation are. A study done in an emergency department of a hospital in Australia showed that only 23% of the total number of patients referred for imaging asked about the risks or benefits of IR¹¹. This same study revealed that the majority of the senior doctors (emergency department consultants and registrars) said that they took time to explain the risk and benefits of IR, especially to pregnant women who had to undergo CT abdomen, and to guardians of a child less than 6 years with minor head injury who had to undergo a CT head, which was in contrast to the junior doctors (interns and medical officers) who did not bother to explain. The reason given for this difference was that the senior doctors had a more paternalistic approach in dealing with this special group of patients¹¹.

It would also be of interest to find out what would be the most important and the least important consideration for a physician when referring a patient for imaging. In a study involving non-physicians (chiropractors, physiotherapist) and physicians, it was noted that non-physicians considered radiation dose to the patient as the most important consideration. This was explained in the study that non-physicians tended to use the referral guidelines more than the physicians⁸. A study done among pulmonologists in the USA showed that radiation dose to patients was ranked as the least important consideration when referring patients for HRCT (High Resolution CT)³⁹.

It has also been found that many physicians referred patients for imaging even when they knew the study was unlikely to affect treatment. Some of the reasons they gave were: the patient would feel they were being taken seriously, to fulfill patients' and relatives' expectations and as a result of heavy patient load to compensate for insufficient clinical exam⁸. This would explain why one

study in the United States showed that 20-77% of the imaging investigations requested were inappropriate of which 20-50% involved high radiation dose³⁸.

A Norwegian study emphasizes the importance of referral guidelines for physicians⁸ and for a basic simplified patient information sheet to be given to patients to read through to enable the patient to give informed consent prior to some of the imaging procedures. Picano and the RCR/UK give an example of this^{27, 40}. These guidelines explain radiation dose and associated radiation risk using tables; graphic representation and color coding that are easy for the patient and doctor to understand.^{27,28} (See **ANNEX 4**). Radiation risk is communicated to the non radiologists through equivalents of ordinary life activities for example a CT chest is equivalent to 400 CXR and equivalent to smoking 700 cigarettes. Expressing radiation dose as multiples of CXR is a simple way of communicating risk. This method has been endorsed by the European Commission Guidelines on Imaging 2001^{32,41}.

Statistics from the US and the UK have indicated a 20-fold and 12-fold increase respectively, in CT usage over the past two decades, with the *per caput* CT usage in the US being about five times that in the UK. In both countries, most of the collective dose from diagnostic radiology comes from high-dose (in the radiological context) procedures such as CT, interventional radiology and barium enemas. For these procedures, the relevant organ doses are in the range for which there is now direct credible epidemiological evidence of an excess risk of cancer, without the need to extrapolate risks from higher doses⁴². Current annual usage is estimated to be more than 3 million scans per year in the UK and more than 60 million per year in the US. Overall, the mean effective dose in the US from all medical X-rays has increased approximately seven-fold over this period, with the result that medical exposures now represent, for the first time, the greater part of the effective radiation dose to the US population⁴².

ANNEX 5 shows estimated lifetime cancer mortality risks from a single “generic” CT scan of the head or the abdomen, estimated by summing the estimated organ-specific cancer risks⁴². As an essential unit of the largest referral hospital in East and Central Africa, the Radiology Department of KNH receives request forms from clinicians from all over the country. As the Principal Investigator, I have personally observed that these request forms reflect a big deficiency

in knowledge on the risks of IR evidenced by the number of repeat examinations one patient undergoes; requests for the wrong imaging modality for a specific indication; pregnant patients being sent for CT scans, fluoroscopy and/or conventional radiographs; request for imaging modalities that use IR when safer alternatives are readily available and of diagnostic value, for example, venography when Doppler ultrasound can be used; and routine medical examinations for new students and new employees that demand for chest radiographs even when there is no clinical indication. All cadres of healthcare workers, from the community health worker, nurse, CO intern, MO and/ or consultant can request for any radiological exam. Some of these cadres have no basic knowledge in IR. There also appears to be inappropriate use of CT scan examinations for patients who have medical insurance or can afford to pay. Some examples of wrong requesting practices are presented in **ANNEX 6**. These observations are consistent with documentation from the European Commission Guidelines for Health Care Professionals who Prescribe Imaging Investigations Involving Ionizing Radiation 2008. The guidelines have shown that some of the causes of wasteful or unnecessary imaging include repeat investigations, doing investigations which are unlikely to affect management, investigating too often before disease process has regressed or responded to treatment, physicians ordering for wrong and inappropriate investigations, failing to provide adequate clinical summary by the referring physician thereby enabling the radiologist to use the best technique to answer the clinical question. This failure to provide adequate clinical data has led to repeat examinations or use of alternative examinations, which have higher radiation dose to patients and over-investigation⁴³.

In order to provide adequate radiation protection to the patient, justification and optimization are the most important considerations. For justification to take place one has to know the magnitude of radiation dose and the risk of detrimental effects⁸.

Some important policies were recommended by the IAEA as a result of studies on the level of awareness in IR among healthcare workers^{7,9,11,25,26,31,36,38,44,45-47}, which include the mandatory use of referral guidelines by physicians, which has led to an overall IR dose reduction by 20-40%. The triple AAA (Awareness, Appropriateness, and Audit) initiatives must be implemented by all concerned physicians^{39,40}.

STUDY JUSTIFICATION

No similar published studies have been done locally. Studies done in the region and elsewhere have shown that where the physician's knowledge in IR is deficient; it leads to wrong attitudes and practice⁷⁻¹¹.

Two statements recorded in international publications including IAEA 2010 are:

- “In Kenya, rural people believe x-rays are therapeutic and can cure their illness”⁴⁶
- “Most people believe that ionizing radiation examinations such as radiography of the chest and CT scanning will benefit them in the future”⁴⁹.

These two statements underscore the importance of this study.

Ionizing radiation is by far the commonest imaging tool in our country⁴ where a large percentage of the population are unable to access US or afford MRI if needed; and where the majority of the government-run hospitals have only general-purpose x-ray units which are used for conventional work and for blind fluoroscopic work.

It is irrefutable that IR plays a major role in clinical practice; however it also has detrimental health effects, which the clinician must be aware of so as to make an informed decision when requesting for imaging studies and thereby assist the patient to also give informed consent. This study will document the level of awareness on IR by clinicians in Kenya.

OBJECTIVES OF RESEARCH

General objectives:

To determine the level of knowledge on IR by different categories of clinicians, their attitudes, practice and considerations when requesting for IR –based imaging examinations and explore ways in which this knowledge gap if present can be reduced.

Specific objectives

1. To determine the knowledge of physicians on various aspects of IR in diagnostic imaging.
These include:
 - 1.1. What modalities use IR
 - 1.2. Radiation dose to patient
 - 1.3. Health risks associated with IR
2. To determine attitude and practice of clinicians with regards to IR
3. To determine how knowledge, attitude and practice are affected by different participant parameters such as age, sex, years of experience, category of clinician and formal training on IR.

STUDY METHODOLOGY

Study design

Across-sectional survey of clinicians' knowledge, attitude and practice towards ionizing radiation at KNH.

The study was conducted using a cross-sectional descriptive design to survey knowledge, attitude and practice of clinicians regarding ionizing radiation.

Study population

The different categories of clinicians were clinical officers (Cos), Medical officers (MOs), Residents/Senior House Officers SHO and Consultants.

Sampling method

Simple random sampling

Study Duration

August 2013 to May 2014

Sample size determination

Sample size was calculated using Fisher et al (1998) method.

$$n = Z^2 p \times q / d^2$$

Where:

n= desired sample size

Z= is the standard normal deviate. At 95% Confidence Interval, it was set at 1.96.

P= the proportion of the target population estimated to have a particular characteristic. Based on the Ethiopian study; this was set at 0.26²⁵.

q= 1-p

d= is alpha 0.05 for 95% CI

$$n = 1.96^2 \times 0.26 \times 0.74 / 0.05^2$$

n=296

The study population was less than 10, 000

Therefore $nf = n/1 + n/N$

Where $n =$

$n = 400$ being the number of clinicians in KNH eligible for recruitment in the study

$nf = 170$

The minimum sample size was calculated to be 170 clinicians

Materials and methods

This was a questionnaire-based study. The questionnaire covered the following areas:

1. Doctor demographics
2. Level of education/ competencies
3. Actual knowledge on IR doses used in commonly requested examinations
4. Cancer risk from IR
5. Radio sensitivity of different organs and subtypes of people
6. Attitude and practice of clinicians with respect to IR in terms of;
 - 6.1. Most important consideration in the use of IR
 - 6.2. Least important consideration
 - 6.3. Patient education
7. Preferred methods of filling the knowledge gap

The questions were mostly close-ended questions with a few open-ended questions. They were in three broad categories, which assessed knowledge, attitude and practice.

Questions on knowledge were closed questions subject to quantitative analysis.

As regards IR dose, participants were asked to consider a chest radiograph as one unit and how many chest radiographs are equivalent to other imaging studies that use IR, such as CT abdomen. Picano and RCR, as a way to simplify the whole concept of radiation doses to the patient and the non-radiologist physician outlined the rationale for this^{27, 28}. The radiation doses for the different radiological examinations were based on the latest NRPB data^{23, 24}

Questions on attitude and practice were both closed and open-ended type. The open-ended questions yielded qualitative data, which was essentially information of a subjective or perceptual nature.

A pretest of the questionnaire to establish its validity was carried out in the Radiology Department University of Nairobi using 2 first year residents in the radiology department and 2 medical officers. The principal investigator administered this.

The basis of the pretest was to:

- Certify the proper interpretation of the meaning of the questions
- Note comprehension difficulties and the need to clarify some questions
- Identify reaction of respondents and potential problem questions
- Check that the length of time for administering the questionnaire is reasonable.

Once this was done, alterations were made to the questionnaire based on the outcome of the pre-test. The Questionnaire was then given to the participants and answered in presence of the investigator to avoid referring to a text, another doctor or Internet. Answers were treated confidentially. Before answering the questions the participants were provided with a summary of how their input and the resulting research findings will benefit the patient and as well as improve their own understanding and knowledge of IR. They were also asked to sign informed consent forms.

Inclusion criteria

CO, MO, Consultants: Working in KNH and deployed in the ward, casualty department or specialized outpatient clinics.

Post graduate residents (SHO) working in the ward, casualty or outpatient departments and who routinely request for imaging.

Exclusion criteria

Postgraduate students doing their residency in radiology

Clinical Officers who have sub specialized in radiology

Consultant Radiologists

Statistical analysis and data management

This was a cross-sectional survey of a random selection of 170 hospital clinicians over a 12-month study period. This sample size comprised 40% of the hospital clinicians. Basic analysis of clinician's socio-demographic data was conducted using descriptive statistics.

Data on demographics was collected as categorical data and analyzed using frequency distributions to determine percentage of clinicians with specific traits. For example percentage male clinicians, percentage clinicians with more than 5yrs experience.

Data on knowledge was collected using six questions. This was used to determine level of clinician knowledge on IR .The percentage of clinicians giving appropriate responses to the knowledge questions was calculated. Chi square tests were used to compare demographic characteristics of clinicians with adequate knowledge.

Clinician attitude and practice was inferred from responses to Likert scale items and open-ended questions that were analyzed using both descriptive and qualitative methods

Data was entered in a Microsoft Excel file, double-checked and analyzed with SPSS 17. Significance tests were performed using likely ratio tests.

A statistician was used to verify and help in the result's presentation.

Limitations

- Refusal of certain clinicians to take part in the study. Some of the reasons cited were the clinicians being too busy and having no time to answer the questions. Others said they knew very little about IR and did not wish to expose their deficiencies. Other clinicians gave no reason for declining to take part.
- The use of the Likert scale to quantitatively analyze attitudes and perceptions has disadvantages which include central tendency bias where participants may avoid extreme response categories, acquiescence bias where participants may agree with statements as presented in order to “please” the experimenter, social desirability bias where the participant may portray themselves in a more socially favorable light rather than being honest, lack of reproducibility and validity may be difficult to demonstrate well⁵⁰.

Ethical Considerations

1. Voluntary and informed consent: A summary of what the study is about and how the data collected from the participants will be used to benefit both the patient and clinician
2. Confidentiality: Only the principle investigator will know the identity and opinions of the participants. The data collected will be kept safe, will not be used to inflict harm or victimize any given person and will not be used by a third party without consent of participants
3. Disclosure of results: All interviewees will be told how the data will be used and who will be party to the data.

RESULTS

This was a study carried out in Kenyatta National Hospital involving 170 clinicians. The data was collected in a period of five months from August 2013 to December 2013. The questionnaire was in paper form and the investigator sat with the clinician as it was being filled out.

The results were categorized based on clinician demographics, knowledge, attitude and practice on ionizing radiation.

Clinician demographics

A total of 170 health workers participated in this study. All were practicing in Kenyatta National Hospital at the time.

There were different categories of clinicians, as illustrated in (Table 1)

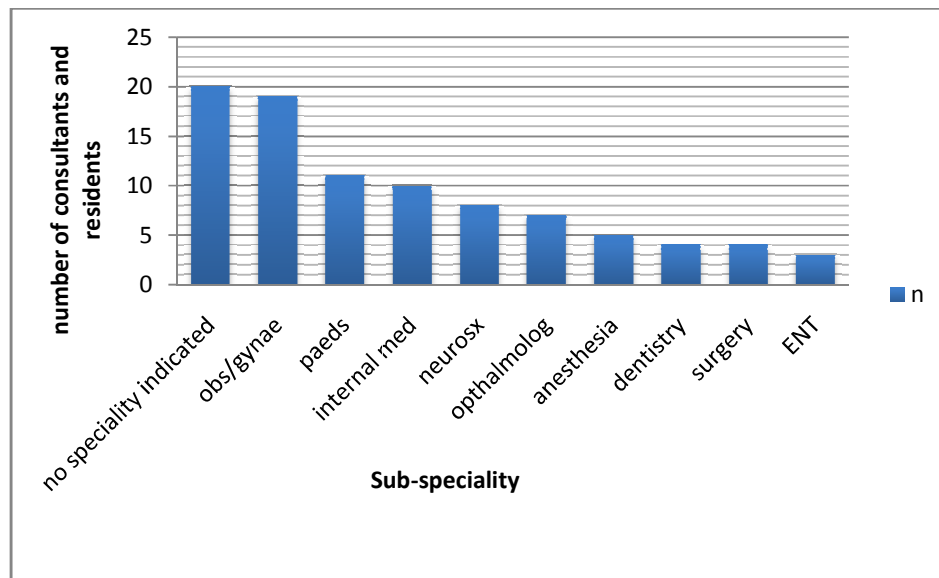
Consultant numbers were low because most said they were too busy to fill in the questionnaires, others said that matters of IR in diagnostic imaging are the premise of Radiologists.

Table 1: Table showing distribution of Clinicians that participated in the study

Clinician cadre	n	%
Consultant	25	14.7
Resident	66	38.8
Medical officer	21	12.4
Clinical officer	58	34.1
Total	170	100

In total the residents accounted for the largest percentage of health workers participating in the study, which was 38.8%.

Figure 2: Bar chart depicting the different sub-specialties of the 71 Residents and Consultants who indicated their specialty

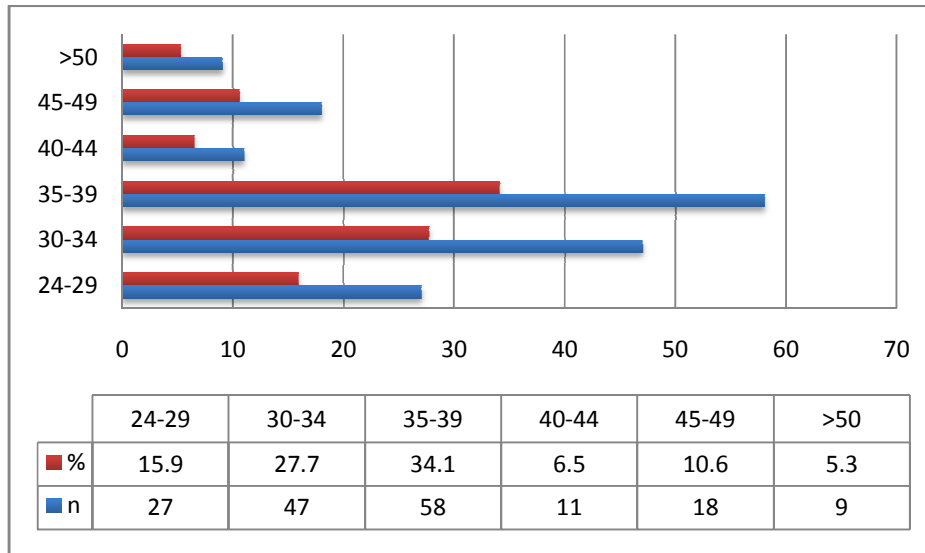


Of the consultants and residents, most came from the Obstetrics and Gynecology department (n=19) followed by Pediatrics (n=11) and Internal Medicine (n=10).

Table 2: Table showing sex distribution of clinicians

Sex	n	%
Male	84	49.4
Female	86	50.6
Total	170	100

Figure 3: Bar chart showing the age distribution of clinicians



The mean age of participating health workers was 35.8 years (SD 6.9), and 58 (34.1%) were aged between 35 and 39 years.

Table 3: Table showing years of clinical experience

Years of experience	n	%
< 2yrs	3	1.8
2-5yrs	60	35.3
>5yrs	107	62.9
Total	170	100

Table 4: Table showing clinicians with and without formal training on ionizing radiation

Formal training on ionizing radiation	n	%
Yes	53	32.7
No	109	67.3
No response	8	4.7
Total	170	100

Clinician knowledge on ionizing radiation

Table 5: Table showing correct identification of radiological imaging techniques that use ionizing radiation and techniques that do not use ionizing radiation

	n	%
Techniques using IR		
Conventional radiography (X Ray)	159	93.5
Computed tomography (CT)	148	87.1
Fluoroscopic studies (Barium)	151	88.8
Radionuclide Imaging (RNI)	143	84.1
Techniques not using IR		
Ultrasound	125	73.5
Magnetic resonance imaging	72	42.4
Correct classification of all 6 imaging techniques	58	34.1

43.5% and 74% of the clinicians said that MRI and US respectively use IR this difference is statistically significant $p < 0.001$

Table 6: Table showing comparison between the different cadre of clinicians and their correct classification of imaging modalities that use ionizing radiation and those that doesn't.

	Consultant	Resident	MO	CO
Imaging techniques using IR				
Conventional Radiography (X ray)	25(100.0)	65(98.5)	22(95.7)	47(83.9)
Computed Radiography (CT)	23(92.0)	56(84.8)	21(91.3)	48(85.7)
Fluoroscopic Studies (Barium Studies)	25(100.0)	63(95.5)	20(87.0)	43(76.8)
Radionuclide Imaging	25(100.0)	63(95.5)	19(82.6)	36(64.3)
Imaging techniques not using IR				
Ultrasound	21(84.0)	57(86.4)	21(91.3)	26(46.4)
Magnetic Resonance Imaging (MRI)	18(72.0)	39(59.1)	8(34.8)	7(12.5)

When it came to classification of imaging modalities which use IR, more consultants, residents and medical officers correctly classified the imaging modalities in all categories compared to the clinical officers $p < 0.004$.

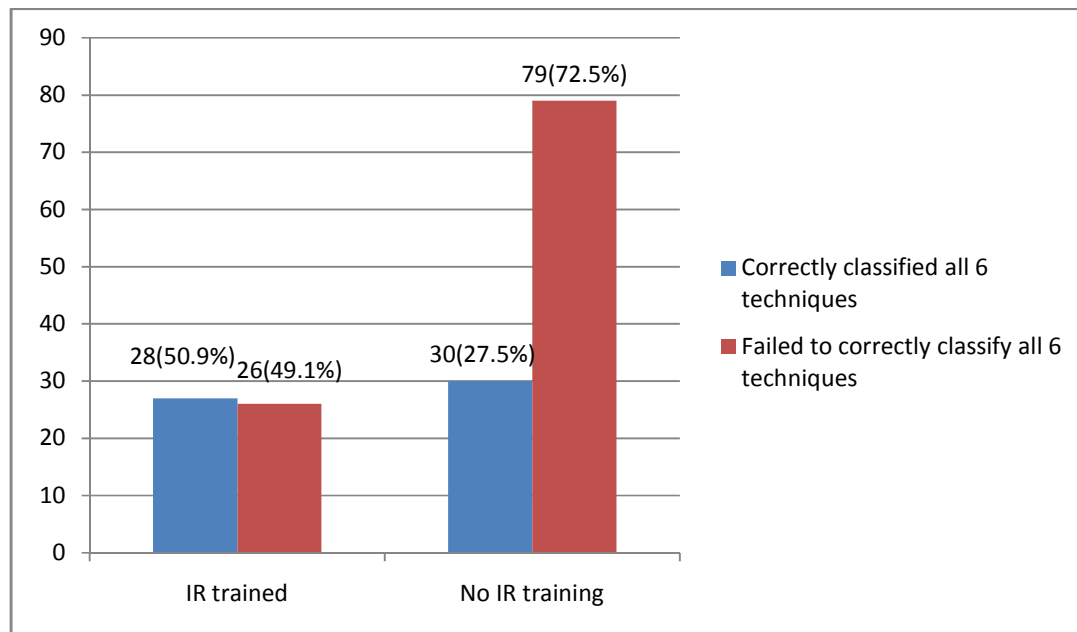
However all the cadre of clinicians were able to correctly state that CT uses IR $p = 0.73$. Significantly more consultants, residents and medical officers were to classify MRI and US as not using IR compared to the CO $p < 0.001$

Table 7: Table showing responses by different cadre of clinicians on which imaging modality has the highest radiation dose

	Consultant	Resident	MO	CO
Imaging technique with highest radiation dose				
Abdominal CT (correct)	19(76.0)	45(68.2)	10(43.5)	5(8.9)
Abdominal X-ray/ US or MRI (Incorrect)	6(24.0)	18(27.3)	13(56.5)	47(83.9)

The consultants (76%) and residents (68%) were more likely to correctly respond that an abdominal CT scan has the highest radiation compared to abdominal x-ray, US or MRI, than the CO (8.9%) and MO (43.5%). The difference was significant with a p value of < 0.001

Figure 4: Bar chart showing correct classification of imaging modalities that use ionizing radiation comparing the clinicians with formal training and those without



Overall, 58 (34.1%) of health workers were able to correctly identify all the four techniques that use IR and also identify the two techniques that do not use IR. There was a statistically

significant association between training in IR and health worker ability to correctly classify all the six technique on the basis of use or non-use of IR.

Health workers with no IR training were less likely to correctly identify all the techniques compared to those with IR training (50.9% versus 27.5%; OR = 0.37, 95% CI 0.18-0.72), (Figure 3)

Table 8: Table showing comparison between clinicians with formal training and those without, and their responses to radiation dose of a CXR, which imaging modality has the highest radiation dose and classifying which imaging modalities use ionizing radiation

	Formal training in IR protection			
	Yes		No	
Standard chest X-ray dose	n	%	n	%
Correct	5	9.6	7	6.5
Incorrect	47	90.4	100	93.5
Highest radiation dose				
Correct	37	69.8	39	37.1
Incorrect	16	30.2	66	62.9
Imaging techniques using IR (correct responses)				
Conventional Radiography (X ray)	52	98.1	103	94.5
Computed Radiography(CT)	46	86.8	98	89.8

Fluoroscopic Studies(Barium Studies)	48	90.6	99	90.8
Radionuclide Imaging	49	92.5	90	82.6
Imaging techniques not using IR (correct responses)				
Ultrasound	45	84.9	73	67
Magnetic Resonance Imaging (MRI)	32	60.4	35	32.1

90.4% of those with formal training and 93.5% of those with no formal training incorrectly answered the question on approximate dose of a CXR. P=0.49.

There was no significant difference between the clinicians with formal training and those without in giving a wrong estimation of the dose of a CXR.

When it came to identifying that an abdominal CT has the highest radiation dose those with formal training (69.8%) fared significantly better than those with no formal training (37.1%) p= > 0.001.

Table 9: Table showing percentage male and female clinicians who responded that MRI uses ionizing radiation

	MRI uses ionizing radiation			
	Yes		No	
Gender	N	%	n	%
Male	52	61.9	32	38.1
Female	46	53.5	40	46.5

61.9% of the male and 53.5% of the female clinicians thought that MRI uses IR, there was no statistically significant difference in their response $p=0.27$

Table 10: Table showing KNH health workers' knowledge on doses of various imaging techniques

Imaging technique	Less than actual dose		Equal to actual dose		More than actual dose		Don't know	
	n	%	n	%	n	%	n	%
Standard chest radiograph	31	18.8	12	7.3	4	2.4	118	71.5
Lumbar spine X ray AP	96	56.5	28	16.5	3	1.8	43	25.3
Abdominal X ray AP	123	72.4	4	2.4	-	-	43	25.3
Abdominal pelvic CT with contrast	71	41.8	4	2.4	-	-	95	55.9
Head CT with contrast	40	23.5	61	35.9	26	15.3	43	25.3
CT chest	95	55.9	22	12.9	8	4.7	45	26.5
Abdominal ultrasound	-	-	97	57.0	28	16.5	45	26.5
Head MRI	-	-	50	29.4	74	43.5	46	27.1

Table 11: Table showing correct responses given by different cadre of clinicians on radiation doses when imaging different body parts

Imaging modality	Consultant	Resident	MO	CO
Lumbar spine Xray –Anteroposterior view	6(24.0)	6(9.1)	6(26.1)	10(17.9)
Abdominal XrayAnteroposterior	1(4.0)	0(0.0)	0(0.0)	3(5.4)
Abdominal pelvic CT with contrast	0(0.0)	2(3.0)	0(0.0)	2(3.6)
Head CT with contrast	8(32.0)	30(45.5)	4(17.4)	19(33.9)
CT chest	6(24.0)	11(16.7)	0(0.0)	5(8.9)
Abdominal ultrasound	22(88.0)	52(78.8)	12(52.2)	11(19.6)
Head MRI	11(44.0)	31(47.0)	4(17.4)	4(7.1)

All the cadres of clinicians fared poorly when it came to estimating the radiation dose when imaging different body parts . $p>0.05$

Table 12: Table showing correct responses based on clinician years of experience on radiation doses when imaging different body parts

Imaging modality	Experience			
	< 5 years		>5 years	
	n	%	n	%
Lumbar spine Xray –Anteroposterior view	9	14.3	19	17.8
Abdominal XrayAnteroposterior	2	3.2	2	1.9
Abdominal pelvic CT with contrast	2	3.2	2	1.9
Head CT with contrast	20	31.7	41	38.3
CT chest	5	7.9	17	15.9
Abdominal ultrasound	28	44.4	69	64.5
Head MRI	14	22.2	36	33.6

The clinicians with more than 5 years experience and those with less than 5 years experience all fared poorly when it came to estimating the radiation dose used when imaging different body parts. $p > 0.05$

Table 13: Table showing number of clinicians 170 who classified the different organs as very sensitive to ionizing radiation

Organ	n
Gonads	164
Breast	154
Lungs	131
Thyroid	118
Brain	114
Skin	108
Bone marrow	72

Table 14: Table showing KNH health workers' knowledge on risk of inducing cancer from abdominal CT scan

	n	%
Risk of inducing cancer from abdominal CT		
Below correct risk	7	4.1
Correct risk (1 in 2000)	7	4.1
Above correct risk	58	34.1
Did not know	98	57.7
Total	170	100

Clinician Attitude

Table 15:Table showing responses of clinicians to whether ionizing radiation has harmful effects or not

Harmful effects of IR Used in diagnostic imaging	n=number of clinicians	% Clinicians
Yes	148	87.1
No	20	11.7
Don't know	2	1.2
Total	170	100

Table 16: Table showing distribution of clinician responses on the harmful effects of ionizing radiation

Harmful effects	n	Percentage
Infertility	50	29.4
Breast cancer	43	25.3
Leukemia/lymphoma	18	10.6
Congenital malformations	15	8.8
Skin burns	11	6.5
Cervical/uterine/ovarian cancer	10	5.8
Cataracts/blindness	8	4.7
Psychological distress	5	2.9
Other cancers	5	2.9
Reduced libido	5	2.9
Skin cancer	4	2.3
Brain tumors	3	2.9

Lung cancer	3	1.7
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These results are in keeping with the responses received on organ sensitivity where most of the clinicians rated gonads as more sensitive to IR than bone marrow. (Table 13)

Table 17: Table showing importance of various considerations for health workers while requesting imaging examinations for patients at KNH

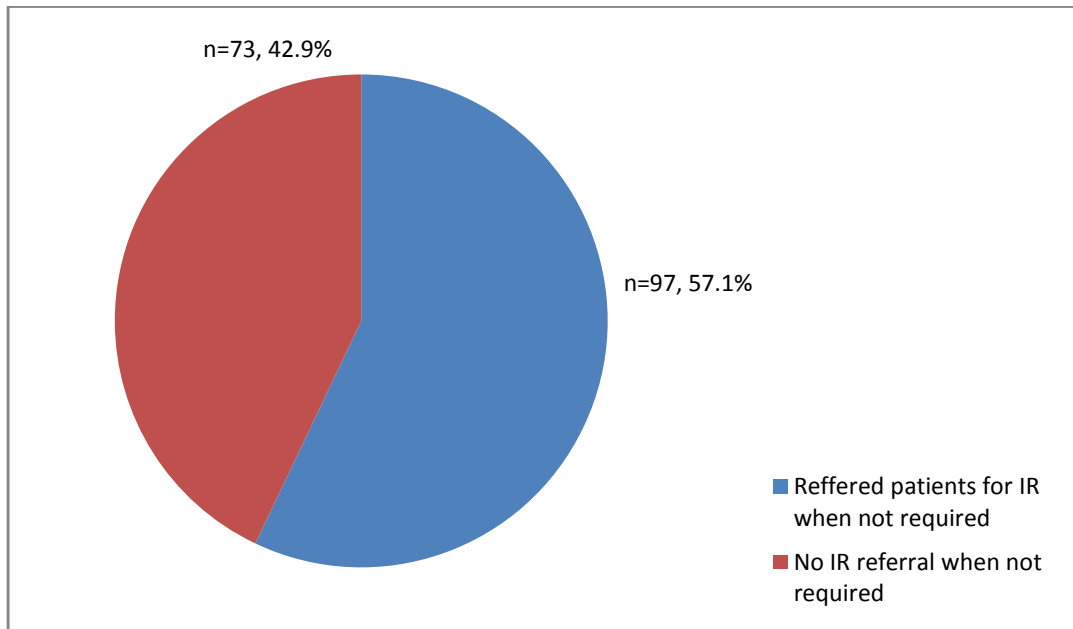
Item	Very important	Important	Moderately important	Least importance	Not important
Impact on the diagnosis	162(97.0)	5(3.0)	0(0.0)	0(0.0)	0(0.0)
Impact on the treatment	152(91.0)	14(8.4)	0(0.0)	1(0.6)	0(0.0)
Patient's wishes	35(21.0)	44(26.3)	60(35.9)	25(15.0)	3(1.8)
Radiation dose to the patient	7(4.2)	6(3.6)	29(17.4)	109(65.3)	16(9.6)
Cost	76(45.8)	80(48.2)	8(4.8)	2(1.2)	0(0.0)

Table 18: Table showing rating of most important consideration when referring patients for imaging

Most important consideration	% Response
Impact on diagnosis	97
Impact on treatment	91
Cost	45.8
Patient wishes	21
Radiation dose	4.2

Health worker practice

Figure 5: Pie chart showing health worker practices related to patient referral for ionizing radiation investigations



There were no significant differences in unnecessary referrals between health workers who reported having trained in IR 33 (62.3%) and those who had not trained in IR 61 (56%), $\chi^2 = 0.58$ (df= 1), $p = 0.45$.

Table 19: Table showing frequency with which clinicians make referrals for imaging studies that use ionizing radiation which will not influence their diagnosis or treatment.

Frequency of referrals	n	% Of clinicians
<1%	64	68.1
5%-10%	27	28.7
20%-50%	1	1.1
>50%	2	2.1
Total	94	100

97 clinicians responded that they referred patients for imaging when they knew that the results were unlikely to alter their diagnosis or treatment plan.

Of these 94 of them gave the frequency with which they did this, which is summarized above (Table 19)

Figure 6: Bar chart showing reasons why the 97 clinicians who refer patients for imaging when it will not alter the diagnosis or treatment do so.

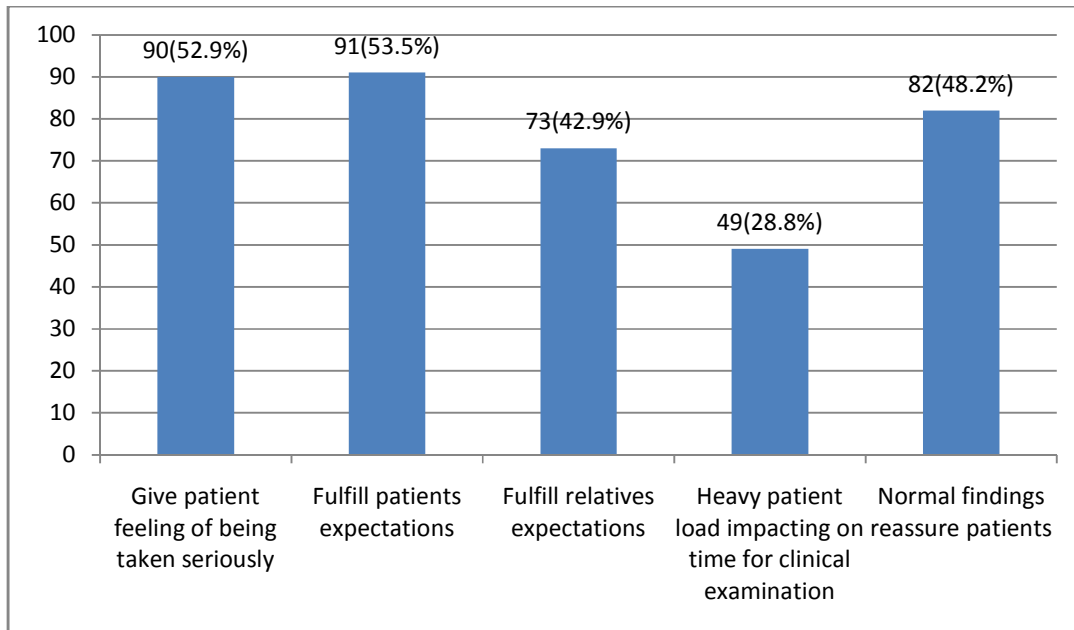


Table 20: Table showing health worker practices in KNH related to knowledge of ionizing radiation

	Very important	Important	Moderately important	Least importance	Not important
Impact of knowledge of ionizing radiation in different radiological exams on practice	55(94.8)	3(5.2)	0(0.0)	0(0.0)	0(0.0)
	Very frequently	Frequently	Occasionally	Rarely	Never
Inform referrals for imaging studies that use ionizing radiation on the risks	0(0.0)	4(2.4)	18(10.9)	106(64.2)	37(22.4)
Patients ask you to explain to them what examination they are going for, what it entails and its risks	0(0.0)	1(0.6)	14(8.5)	77(46.7)	73(44.2)

Table 21: Table showing frequency of informing patients on risks of ionizing radiation by different cadres of clinicians

	Reported frequency of informing referred patients on risks of IR							
	Frequently		Occasionally		Rarely		Never	
Cadre	n	%	n	%	n	%	n	%
Consultant	1	4.2	4	16.7	14	58.3	5	20.8
Resident	3	4.7	8	12.5	42	65.6	11	17.2
MO	0	0	2	8.7	20	89	1	4.4
CO	0	0	4	7.4	30	55.6	10	37

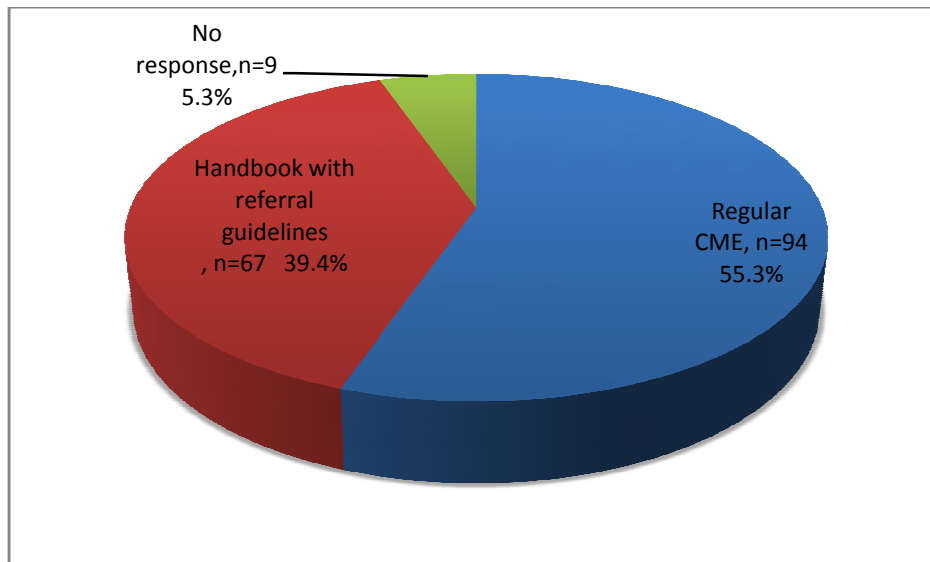
All the cadres of clinicians responded that they rarely informed their patients on the inherent risks of IR there was no significant difference in their responses $p = < 0.05$

Preferred method of learning

Table 22: Table showing percentage of clinicians who have attended continuous medical education (CME) on ionizing radiation protection

Attended continuous medical education On ionizing radiation protection	n	% Clinicians
Yes	1	0.6
No	169	99.4
Total	170	100

Figure 7: Pie chart showing preferred mode of learning



DISCUSSION

The objective of this study was to assess the knowledge, attitude and knowledge of 170 clinicians working in Kenyatta National Hospital on ionizing radiation.

Health worker knowledge

Classification of modalities that use ionizing radiation

With regards to classifying which imaging modalities use IR, 84.1%-93.5% correctly said that conventional radiography, CT, fluoroscopic studies and RNI utilize IR (Table 5).

More consultants, residents and medical officers correctly classified the imaging modalities compared to the clinical officers $p < 0.004$ (Table 6).

However all the cadre of clinicians were able to correctly state that CT uses IR $p = 0.73$

Significantly more consultants, residents and medical officers were able to classify MRI and US as not using IR compared to the CO $p < 0.001$ (Table 6). This implies that the clinical officers could be refusing to send patients for US and MRI when indicated thinking it exposes the patients to ionizing radiation.

This can be related to a study in Australia that showed that the senior consultants scored higher in the knowledge-based questions compared to the junior doctors¹¹. The results of the Australian study led to policy change in the hospital whereby investigations involving high dose radiation have to be countersigned by a senior consultant¹¹. Perhaps such a situation needs to be replicated locally.

Of note 43.5% and 74% of the clinicians said that MRI and US respectively, use IR. This difference was statistically significant ($p < 0.001$ Table 10) which showed that the clinicians were surprisingly more knowledgeable about MRI than US; Conversely, 42.4% and 73.5% of the clinicians were able to correctly state that MRI and US respectively do not utilize IR. They fared significantly poorly compared to other studies, In Europe and Turkey and Hong Kong where more clinicians correctly said that MRI and US do not use IR^{9, 31, 45}. However they performed better than clinicians from a similar study carried out in Nigeria where only 14% and 20% of the clinicians correctly responded that MRI and US respectively do not use IR²⁶. According to the author this is because these imaging modalities were not widely available in the study locality²⁶

In two studies it was found that more females than male said that MRI uses IR^{9,11}. This was attributed to the fact that men are more interested in the technical aspect of things than women^{9,11}. In contrast to this study where 61.9% of the male and 53.5% of the female clinicians thought that MRI uses IR, there was no statistically significant difference in their response $p=0.27$ (Table 9)

Health workers with no IR training were less likely to correctly identify all the techniques compared to those with IR training (50.9% versus 27.5%; OR = 0.37, 95% CI 0.18-0.72)(Figure 4).When it came to identifying that an abdominal CT has the highest radiation dose, those with formal training (69.8%) fared significantly better than those with no formal training (37.1%) $p < 0.001$. (Table 8)These study findings clearly indicate that formal education in IR provides several advantages as the clinician is better able to classify studies that use IR, estimate the dose of IR for different imaging studies and therefore make appropriate decisions when requesting for imaging that uses ionizing radiation. .^{5,10,11,25}

Knowledge of ionizing radiation doses

90.4% of those with formal training and 93.5% of those with no formal training incorrectly answered the question on approximate dose of a CXR ($p=0.49$).

There was no significant difference between the clinicians with formal training and those without in giving a wrong estimation of the dose of a CXR.(Table 8)

This study and others show that majority of the clinicians don't know the approximate dose of a CXR.^{7, 25, 31, 32, 51}. This is of concern as a CXR is one of the commonest examinations requested by clinicians.In this case the clinicians with formal training had no distinct advantage over those with none which suggests that the training given in radiation protection in the curriculum is insufficient. All the cadres of clinicians fared poorly when it came to estimating the radiation dose when imaging different body parts ($p>0.05$) (Table 10).

For three modalities: AP abdominal X ray, Abdominal CT with contrast and standard chest radiograph less than 10% (2.4% to 7.3%) of health workers correctly identified actual doses

administered during examination. The same lack of knowledge on IR dose of different imaging studies has been reported in several studies^{11,25,36,37,47, 51, 52}.

Studies have shown even where clinicians were exposed to a curriculum in ionizing radiation 87% of them still felt there was inadequate teaching in the area of radiation protection¹⁰.

. Studies have reported contrasting results. One showed that the level of knowledge increased with seniority of the clinician¹¹ while another study showed that more consultants gave incorrect responses to the IR dose of different imaging modalities compared to the residents²⁵

The senior doctors were able to respond correctly to questions on radiation dose due to use of referral guidelines¹¹

In order to provide adequate radiation protection to the patient, justification and optimization are the most important considerations. For justification to take place one has to know the magnitude of radiation dose and the risk of detrimental effects⁸. There was underestimation of IR dose of high dose imaging modalities in this study and others.^{8,9,26,37,51} This finding is important, as it could explain why there is irrational use of studies that use ionizing radiation as evidenced by repeat examinations which do not contribute to the diagnosis or change in management⁴³.

In this study and one carried out in Germany¹⁷ it was shown that length of professional experience had no influence on the knowledge of IR doses. In contrast other studies showed that clinicians with less clinical experience were able to correctly estimate IR dose of different imaging studies^{45, 51} compared to those with more clinical experience the reason for this was not given..

Knowledge on health risks of ionizing radiation

34.1% of clinicians overestimated the lifetime risk of inducing cancer from an abdominal CT compared to 4.1% who gave an underestimate (Table 14).

Only 7% gave a correct response and the largest percentage 57.7% had no idea⁵³. This effectively means that 98 out of 170 clinicians are sending patients for CT scans without any idea of its potential hazards! Similar findings have been reported in studies in the USA²⁴ and Ethiopia

³⁸ where 8.8% and 9% of the clinicians gave correct responses respectively these studies have a very similar demographic profile like this study where the study participants range from junior doctors to senior consultants ^{24,38}

In contrast to other studies where 12.5%⁵⁰ 28%⁵¹ and 37%⁵² of clinicians gave the correct response which could be attributed to the fact that the participants were all very senior doctors (senior house officers, residents, and lecturers).

With respect to organ sensitivity only 72 clinicians rated bone marrow as a very sensitive organ. More clinicians rated gonads, thyroid, skin and brain as more sensitive than bone marrow. (Table 13) Of the 170 health workers, 148 (87.1%) reported that IR use in diagnostic imaging could cause harmful health effects however, 20 (11.7%) reported that IR has no harmful effects while 2 (1.2%) did not know (Table 15). Furthermore only 18 (10.6%) of the clinicians said there was increased risk of developing leukemia or lymphoma while 50 (29.4%) said there was risk of infertility. These results are in keeping with the responses received on organ sensitivity where most of the clinicians rated gonads as more sensitive to IR than bone marrow (Table 13).

In comparison, a study done in Hong Kong reported that 94% (59/63) health workers were aware of the increased risk of developing leukemia, whilst 98% (62/63) knew that radiation exposure during pregnancy increases the risk of abnormalities in the fetus⁴⁵. The author did not elucidate the reason for such good scores.

Health worker attitude

Most clinicians considered the impact on diagnosis (97%) and treatment(91%)as the most important consideration when referring patients for imaging compared to 4.2% who considered that radiationdose was a most important factor(Table 17,18).Several studies have reported similar findings where most clinicians rated the impact on diagnosis and treatment as the most important consideration when referring patients for imaging^{8, 26, 45}and very few considered radiation dose as an important consideration when referring patients^{39,45}. In regards to ordering studies vis-à-vis patient's wishes, studies done in Norway and Nigeria have shown that more clinicians rated radiation dose as more a more important consideration than patients wishes^{8, 26}.

This study showed that 35(21%) clinicians thought that patients' wishes were the most important consideration when referring patients for imaging compared to 7 (4.2%) who said radiation dose. Fifty-four (94.8%) of the 58 health workers responding to the question on the impact of IR knowledge on their practice admitted that knowledge on IR was very important in their practice(Table 20).

Health worker practice

Fifty-seven percent (57.1%) health workers reported that they referred patients for IR investigations in cases where the results were unlikely to alter their diagnosis or treatment(Figure 5) Of these 94, 64(68.1%) said these referrals accounted for < 1% of their total referrals (Table 19).There were no significant differences in unnecessary referrals between health workers who reported having trained in IR (62.3%) and those who had not trained in IR (56%), $\chi^2 = 0.58$ (df= 1), $p = 0.45$.

Studies have reported that 83.1-88.3% of the clinicians made referrals for imaging when they knew the outcome was unlikely to change their diagnosis or treatment⁸. The reasons given by health workers to explain these referrals were; to give patients the feeling that they were being taken seriously 90 (52.9%), fulfill patient expectations 91 (53.5%) or reassure patients based on normal findings of IR studies 82 (48.2%) (Figure 6). These findings mirror those of our local setting.

Most of the health workers (64.2%) reported that they rarely informed patients whom they referred for imaging studies on the potential risks of IR. Similarly patients either rarely (46.7%)

or never (44.2%) asked health workers to explain to them what examinations they were going for, what the examinations entailed or the accompanying risks (Table 20).

Similar findings have been seen in other studies where most of clinicians (81.8%) did not inform their patients on the risks of IR⁵¹ while 11.2% and 22% did inform their patients^{38, 51}. One study showed that senior doctors were more likely to explain the risks of IR to their patients than junior doctors. The reason given for this was that senior doctors had a more paternalistic attitude⁵⁵.

In this study all the cadres of clinicians responded that they rarely informed their patients on the inherent risks of IR and there was no significant difference in their responses $p = >0.05$. (Table 21). Only 14 (8.5%) of the clinicians reported that patients occasionally asked them for any information regarding IR. In our setting this very low percentage may be due to patient illiteracy or fear of questioning the doctor. However it has been shown that even in regions where literacy levels are high, most patients do not ask the doctor about IR information. A study done in Australia reported that only in a quarter of cases (23%) did the patients ask about the effects and risks of radiation from diagnostic imaging indicating the large level of trust that patients place in their doctors¹¹.

Other studies carried out in the UK showed that patients who asked more questions, expressed more concerns, and were more anxious received more information than patients asking fewer questions, expressing fewer concerns and showing less anxiety⁵³.

Preferred method of learning

Of the 170 participating health workers only 1 (0.6%) reported having attended CME on radiation protection of patients (Table 22). When asked how they would prefer this information to be imparted 94 (55.3%) indicated a preference for regular CMEs and 67 (39.4%) small handbooks with imaging referral guidelines (Figure 7).

CONCLUSIONS

The following conclusions can be drawn from this study:

1. Clinicians lack knowledge on ionizing radiation doses of different imaging modalities and yet still request for the examinations even when not clinically indicated.
2. There is a significant knowledge gap between the senior clinicians (consultants, residents, medical officers) and junior clinicians (clinical officers) when it comes to some aspects of ionizing radiation.
3. The clinicians with formal training had a very small advantage over those with no formal training as regards IR knowledge.
4. Deficiency in knowledge on IR and its potential risks leads to wrong attitudes and poor practices.

RECOMMENDATIONS

1. A senior clinician should countersign all referrals that require the use of high dose ionizing radiation. Similar recommendations were made in a study done in Australia¹¹.
2. Use of imaging referral guidelines. One study showed that the clinicians who used referral guidelines were able to correctly estimate IR dose when imaging different body parts⁹.
These referral guidelines can be in form of a booklet, which the clinicians carry in their pocket or can be online and accessed through the Internet.
3. Radiation doses and risks should be included in the imaging request form so that the requesting physician can easily see the information and review if the examination is still necessary.
4. Information on radiation protection should be disseminated through continuous medical education (CME), as preferred by majority of the clinicians.
5. Revision of the undergraduate and postgraduate curriculum to include more hours and subject content in radiation protection.
6. A basic simplified information sheet should be given to patients to read through, to enable them to give informed consent prior to some of the imaging procedures.
These measures could be outlined and enforced at a national level by the Ministry of Health and the Kenya Radiation and Protection Board.

It is hoped that the implementation of the above measures outlined may enable us meet the triple A initiatives as required by the IAEA Radiation Protection of Patients

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REFERENCES

1. WHO activities on Radiation Protection and Human Health. Mario Del Rosario Perez (Department of Public Health and Environment). Reported at the 1^{6th} IACRS meeting ILO HQ Geneva Switzerland 12-13th May 2011. Global Initiative Report on Radiation Safety in the Health Care Setting of March 2010. Available from:
http://www.ilo.org/wcmsp5/groups/public/ed_protect/protrav/safework/documents/presentation/wcms_166053.pdf
2. WHO Global initiative on radiation safety in health care settings. Technical meeting report. 15th-17th December 2008. L. Lau and M. Pérez (co-rapporteurs). Available from:
http://www.who.int/ionizing_radiation/about/GI_TM_Report_2008_Dec.pdf.
3. Roobottom CA, et al. "Radiation-reduction strategies in cardiac computed tomographic and angiography". *Clin Radiol.* (2010). 65 (11): 859–67.
4. Kenyatta National Hospital. Nairobi. Kenya; Department of Health Information Systems: Data on total number of radiological examinations performed in 2011/2012. Unpublished.
5. Tole NM, PhD. Associate Professor of Medical Physics. Department of Diagnostic Imaging and Radiation Medicine. University of Nairobi. Lecture notes 2011. Biological Effects of Ionizing Radiation.
6. Hendee WR, et al. Addressing overutilization in Medical Imaging. *Radiology.* (2010) .10:1148.
7. Soye JA, et al. A survey of awareness of radiation dose among health professionals in Northern Ireland. *Br J Radiol.* (2008). A: 555-628
8. Borgen I, et al. Clinician Justification of Imaging : Do radiation Issues play a role ? *European Society of Radiology.*(2010) . 1: 193-200
9. Arslanoglu A, et al. Doctors' and intern doctors' knowledge about patients' ionizing radiation exposure doses during common radiological examinations. *Diagn Interv Radiol.* (2007). 13: 53-55.
10. Sullivan JO, et al. An assessment of medical students awareness of radiation exposures associated with diagnostic imaging investigations. *Saudi med j.* (2011). 32: 5
11. Gerben B, et al. Doctor's knowledge of patients radiation exposure from diagnostic imaging requested in the emergency department. *Medical journal of Australia.* (2010) .193(8): 450-3

12. Royal College of Radiologists and National Radiological Protection Board Patient dose reduction in Diagnostic Radiology (Homepage on the Internet). Documents of the National Radiological Protection Board 1990: 1 :No 3 updated 2012 September 10. Available from <http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/Understanding Radiation Topics/Medical Radiation/medic Publications/>
13. Amy Berrington de González et al .Projected Cancer Risks From Computed Tomographic Scans Performed in the United States in 2007 .JAMA Internal Medicine [December 14, 2009; 169: 22](#)
14. Korir GK, et al. Patient Dose using MDCT in Kenya. Oxford Journal. Radiation Protraction Dosimetry. (2009). 201/ 10: 1093
15. *GK Korir, et al.* Establishing a quality assurance baseline for radiological protection of patients undergoing diagnostic radiology South African Journal of Radiology. 2011: 13: 3
16. Committee on Health Effects of Exposure to Low levels of Ionizing radiations (BEIR VII), Board of Radiation Effects Research. Health Risks from Exposure to Low levels of Ionizing Radiations; time for a reassessment?. Washington DC: Commission on Life Sciences, National Research Council; 1998. Available from <http://www.nap.edu/openbook.php?isbn=0309061768>
17. United States Nuclear Regulatory Commission.(Homepage on the Internet) Sources of Radiation . (Updated 2012 March 29). Available from: <http://www.nrc.gov/about-nrc/radiation/around-us/sources.html>
18. European Nuclear Society. Available from:<http://www.euronuclear.org/info/encyclopedia/beir.html>
19. Royal College of Radiologists. (Homepage on the Internet) Making the best use of clinical radiology services, 6thedn. London, UK: RCR ,2007. Available from: <http://www.rcr.ac.uk/publications.aspxPageID310&PublicationID362>
20. John B Cologne et al. Longevity of atomic bomb survivors. Lancet. (2000). 356:303-307.
21. Berrington De González A, et al. Risk of cancer from diagnostic X-rays: estimates for the UK and 14 other countries. Lancet. (2004). 363: 345-351.
22. International Commission on Radiological Protection ICRP. Report 2006-2008. (Homepage on the Internet) Dose reference levels. Available from: <http://www.nrc.gov/about-nrc/radiation/around-us/sources.html.pdf>

23. HPA-CRCE-034 - Doses to Patients from Radiographic and Fluoroscopic X-ray Imaging Procedures in the UK – 2010 Review Authors : Hart D, Hillier MC ,Shrimpton PC :
Publication date: June 2012. Available from:
<http://www.hpa.org.uk/Publications/Radiation/CRCEScientificAndTechnicalReportSeries/HPACRCE034/>
24. NRPB - W67 Doses from Computed Tomography (CT) Examinations in the UK - 2003 Review Authors: Shrimpton PC, Hillier MC, Lewis MA , Dunn M Publication date: March 2005
http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1253114172775
25. Zewdneh D, et al .Department of Radiology, College of Health Sciences / Addis Ababa University, Ethiopia. A Study of Knowledge & Awareness of Medical Doctors Towards Radiation Exposure Risk At TikurAnbessa Specialized Referral And Teaching Hospital, Addis Ababa, Ethiopia. (IOSR Journal of Pharmacy and Biological Sciences (IOSRJPBS). (2012). 2: 2278-3008
26. Ahidjo A, et al .Department of Radiology. University of Maiduguri Teaching Hospital, Borno State, Nigeria Federal Neuropsychiatric Hospital Maiduguri, Borno State, Nigeria. Referring doctors knowledge about radiation doses in patients undergoing common radiological examinations.Journal of Medicine and Medical Science. (2012). 3(4) :222-225
27. Picano E. Informed consent and communication of examinations: how to escape from a communication inferno risk from radiological and nuclear medicine BMJ. (2004). 329(7470): 849–851
28. Picano, E., How to properly communicate radiation risk to patient and doctor. BMJ. (2005). 10:329-348
29. Mettler FA , et al. CT scanning: patterns of use and dose. J RadiolProt. (2000). 20:353–359
30. Hadley JL,et al. Potential impact of the American College of Radiology appropriateness criteria on CT for trauma.AJR.Am J Roentengol. (2006) .186(4):937-42.
31. Shiralkar S, et al. Doctors’ knowledge of radiation exposure: questionnaire study. Br Med J (Clin Res Ed) . (2003).3.222-568.
32. European Commission. Radiation Protection 118: Referral Guidelines for Imaging. Luxembourg: Office for Official Publications of the European Communities, 2001. Available from
<http://europa.eu.int/comm/environment/radprot/118/rp-118-en.pdf>

33. University of Nairobi (Homepage on the Internet). College of Health Sciences. History and background. Available from <http://www.chs.uonbi.ac.ke>.
34. Kenya Medical Training College. (Homepage on the internet) . Academic Courses. Available from <http://www.kmtc.ac.ke/>
35. Kenya Health Workforce Training Capacity (Homepage on the Internet). A Situation Analysis by Kenya Health Workforce Project 2009. Available from <http://www.unfpa.org/sowmy/resources/docs/library/R200>
36. Aylin Yucel, et al. Physicians' knowledge about ionizing radiation and radiological imaging techniques: a cross-sectional survey .ActaRadiol. (2011). 52/5: 537-539.
37. Heyer CM, et al. Awareness of radiation exposure of thoracic CT scans and conventional radiographs: what do non-radiologists know?.Rofo. (2007) .179(3):261-7.
38. Catarige JC ,et al. Availability, requesting practices and barriers to referral for HRCT of lung : Results of a survey of United States pulmonologist AJR. (2003) .3 :585-589.
39. Lee CL, et al. Diagnostic CT scans Assessment of patient, physician, and radiologist awareness of radiation dose and possible risks. Radiology. (2004). 231:393-398
40. Mali EJ , et al . Cancer Risks from Diagnostic Radiology. British Journal of Radiology .(2008) .81: 362-378.
41. Guleria R, et al. Justification of diagnostic medical exposure: some practical issues. Report of an IAEA consultation.br j radiology. (2012) .85(1013):523-38.
42. Zamenhof R. Risk list. JPNM Physics, 1997 Available from <http://www.med.harvard.edu/JPNM/physics/safety/risks/risklist.html>
43. European Commission .Radiation Proection 118.Referral Guidelines for imaging.Guidelines for Healthcare Professionals who prescribe Imaging Investigations involving Ionising Radiation .Final Report to the European Commission for Grant Agreement .University Court of the University of Aberdeen .Professor Gillian Needham and Professor Jeremy Grimshaw SUBV99/134996(Updated 2008 March). Available from http://ec.europa.eu/energy/nuclear/radioprotection/publication/doc/118_update_en.pdf 43
44. Zhou GZ, et al. Student and intern awareness of ionising radiation exposure from common diagnostic imaging procedures. J Med Imaging RadiatOncol .(2010). 54: 17-23
45. SY Luk, Knowledge of Radiation Dose and Awareness of Risks: a Cross-sectional Survey of Junior Clinicians J Hong Kong Col Radiol. 2010;13:189-94

46. [Senem Divrik Gökçe](#), MD, et al. Radiology Residents' Awareness about Ionizing Radiation Doses in Imaging Studies and Their Cancer Risk during Radiological Examinations. *Korean J Radiol.* 2012 Mar-Apr; 13(2): 202–209
47. TY Kewet al , Doctors' Knowledge Regarding Radiation Dose and Its Associated Risks: Cross-sectional Study in a Tertiary Hospital in Malaysia Hong Kong J Radiol. 2012; 15:71-9
48. Sasha Henrique. IAEA Division of Public Information. Triple A investment in patients health. (Homepage on the internet) IAEA promotes Awareness, Appropriateness, and Audit of ionizing radiation. 2010 September Report. (Updated 2011 February 02). Available from <http://www.iaea.org/newscenter/news/2010/tripleinvestment.html>
49. Ludwig, R, et al. Effective patient education in medical imaging: Public perceptions of radiation exposure risk. *Journal of Allied Health.* (2002) .31:159-164
50. Likert scales...are the meaning of life. Bertram D (Home page on the Internet) Available from: <http://poincare.matf.bg.ac.rs/~kristina//topic-dane-likert.pdf>
51. Jacob K, et al. X-ray dose training: are we exposed to enough? *Clin Radiol.* 2004; 59: 928-34; discussion 26-7.
52. TY Kewet al , Doctors' Knowledge Regarding Radiation Dose and Its Associated Risks: Cross-sectional Study in a Tertiary Hospital in Malaysia Hong Kong J Radiol. 2012; 15:71-9
53. Amy Berrington de González et al .Projected Cancer Risks From Computed Tomographic Scans Performed in the United States in 2007 .*JAMA Internal Medicine* [December 14, 2009](#); 169: 22.

ANNEX: 1

QUESTIONNAIRE

1. What category of clinician do you fall under? Consultant (specify specialty)
.....
 Resident (specify which postgraduate program you are pursuing).....
 MO CO
2. Sex? Male Female
3. Age in years
4. How many years experience do you have working as a clinician? ≤1yr 2-5yrs >5yrs
5. When you were doing your training to become a clinician did you get any formal lessons on ionizing radiation protection? Yes no
6. Please tick which of the listed imaging modalities uses ionizing radiation? Conventional Radiography (X ray) Computed Radiography (CT) Ultrasound Magnetic Resonance Imaging (MRI) Fluoroscopic Studies (Barium Studies) Radionuclide Imaging
7. What is the approximate effective radiation dose received by an adult in a standard Chest Radiograph? 2msv 0.2msv 0.02msv 0.002msv don't know
8. What has the highest radiation dose? (choose one answer)
 Abdominal X-ray
 Abdominal US
 Abdominal CT
 Abdominal MRI

9. Consider each of the different imaging modalities and the equivalent number of chest radiographs they each represent.

Equivalent number of chest radiographs

Imaging modality	0	1-10	11-50	51-100	101-500
Lumbar spine Xray – Anteroposterior view					
Abdominal Xray Anteroposterior					
Abdominal pelvic CT with contrast					
Head CT with contrast					
CT chest					
Abdominal ultrasound					
Head MRI					

DRL used in this case are based on the USA NRCPB and on similar studies which have used the same model^{7,9,21}

10. Please tick the sensitivities of the different organs to ionizing radiation?

ORGAN	VERY SENSITIVE	MODERATELY SENSITIVE	MILDLY SENSITIVE
Breast			
Gonads			
Lungs			
Bone marrow			
Thyroid			
Brain			
Skin			

11. What is the risk of inducing fatal cancer from an abdominal CT?(choose one answer)

- 1 in 200
- 1 in 2000
- 1 in 20000
- 1 in 200000
- Don't know

12. Do you think IR used in diagnostic imaging can cause any harmful health effects?

- Yes no

13. If yes what are some of these harmful effects. List them below

.....

.....

.....

14. What is the most important consideration when referring a patient for imaging? Grade each answer between 1 to 5. (1) Very important (2) important (3) moderately important(4) of least importance (5) not important

- Impact on the diagnosis
- Impact on the treatment
- Patient's wishes
- Radiation dose to the patient
- Cost

15. Do you refer patients for imaging when you know that that is unlikely that the results will alter your treatment plan? Yes no

16. If yes what is the percentage of these referrals amongst all your referrals

- < 1 %
- 5% -10%
- 20 % -50%
- > 50%

17. What would be the reasons for making referrals when you know that the imaging will not change the treatment?(You can tick more than one answer)

- Give the patient a feeling of being taken seriously
- Fulfill patient expectations
- Fulfill expectations by relatives
- Heavy patient load leaving little time for a good clinical examination
- Normal result will reassure patient

Others (specify).....

18. Do you think knowledge of ionizing radiation in the different radiological exams you request for is important for your practice?

- Very important
- important
- moderately important
- least importance
- not important at all

19. Do you inform the patients you refer for imaging studies that use ionizing radiation on the risks?

- Very frequently
- frequently
- occasionally
- rarely
- never

20. How often do patients ask you to explain to them what examination they are going for, what it entails and its risks?

Very frequently

Frequently

Occasionally

Rarely

Never

21. In your practice as a clinician have you received any Continuous Medical Education/CME on radiation protection of patients yes no

22. How would you like this knowledge to be imparted? Regular CME Small handbook with imaging referral guidelines Others (specify)

ANNEX: 2

TABLE OF TISSUE WEIGHTING FACTORS OF DIFFERENT ORGANS

ICRP, 2007 Recommended weighting factors

Organ / tissue	w_T
Breast	0.12
Bone marrow	0.12
Colon	0.12
Lung	0.12
Remainder	0.12 ^a
Stomach	0.12
Gonads	0.08
Bladder	0.04
Liver	0.04
Oesophagus	0.04
Thyroid	0.04 ^c
Bone surfaces	0.01
Brain ^d	0.01
Salivary glands ^d	0.01
Skin	0.01

ANNEX: 3

IONIZING RADIATION DOSE AND RISK OF DEVELOPING CANCER

Investigation	Effective dose (mSv)	Equivalent no. of plain chest radiographs	Approximate equivalent period of natural background radiation ^a	Additional lifetime risk of fatal and non-fatal cancer ^b	RCR symbolic representation ^c
Plain posteroanterior chest radiograph	0.02	1	3 days	1:1000000	▲
Thyroid scintigraphy (⁹⁹ Tc ^m)	1	50	6 months	1:10000	▲▲▲
CT chest (non-contrast)	8	400	3.6 years	1: 1200	▲▲▲▲▲
CT abdomen	10	500	4.5 years	1:1000	▲▲▲▲▲
Multidetector CT cardiac (64 slice)	15	750	7 years	1:750	▲▲▲▲▲

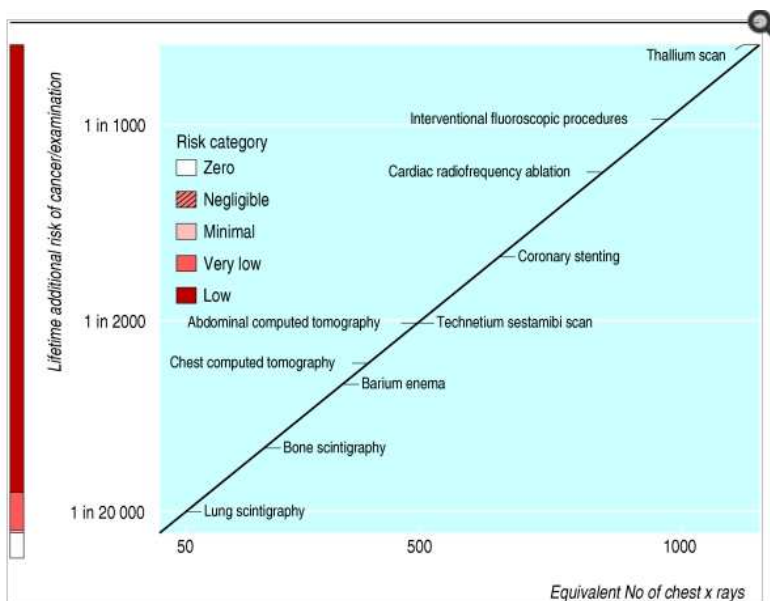
^aAverage background radiation is 2.2–2.4 mSv per year.

^bThese examples relate to a 50 year old man. Multiply by 1.38 for women, by 4 for children under 1 year, and by 0.5 in an 80 year old man.

^c▲ <1 mSv; ▲▲▲, 1–5 mSv; ▲▲▲▲▲, 5–10 mSv; ▲▲▲▲▲▲▲ >10 mSv.

ANNEX :4

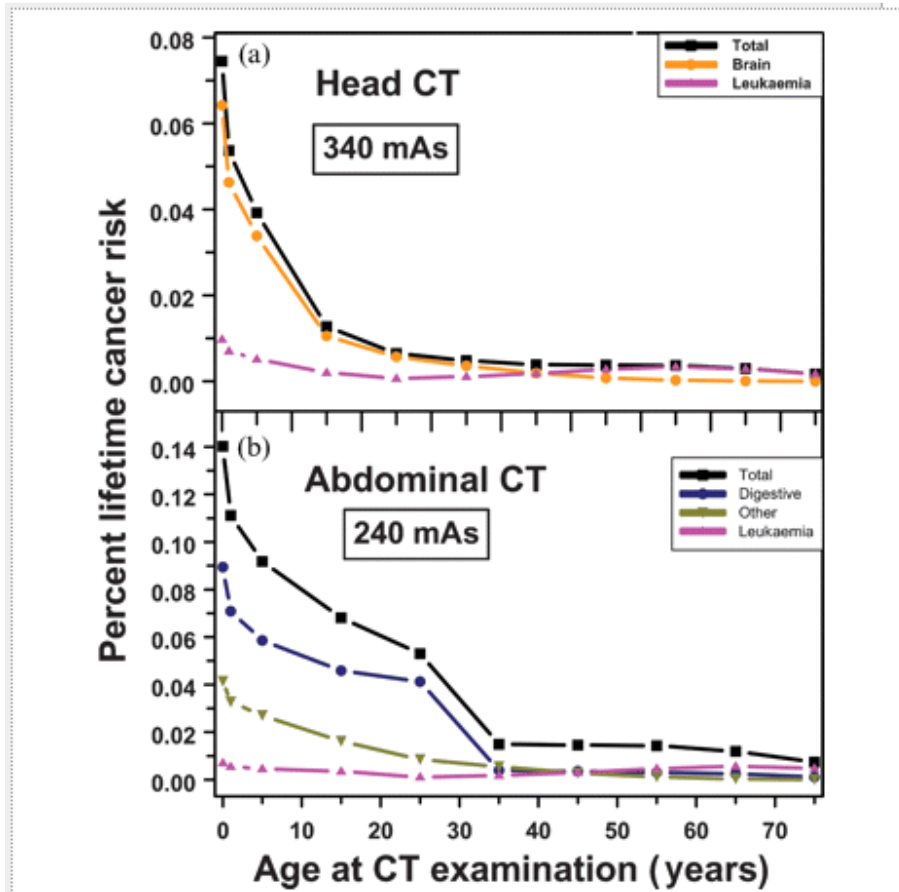
Color coded simplified graph showing radiation dose and associate risks of different imaging studies



Graphical presentation of cancer risk and radiation dose (in multiples of dose from a simple chest x ray) for some common radiological examinations

ANNEX :5

Estimated lifetime cancer mortality risks from a single generic CT head and abdomen



ANNEX: 6

Samples of wrong requesting practices

I. Patient details		II. Specimen destination	
Name: <u>Douglas mongwal</u>		Tick appropriate box <input type="checkbox"/>	
Age (yrs/months): <u>62y N</u>		Histology/Cytology <input type="checkbox"/> Bacteriology <input type="checkbox"/>	
Sex: <u>M</u> <u>F</u>		Serology <input type="checkbox"/> Parasitology <input type="checkbox"/>	
Residence / Village _____		Hematology <input type="checkbox"/> Biochemistry <input type="checkbox"/>	
IP/OP No: _____		Sputum New <input type="checkbox"/> Follow up <input type="checkbox"/>	
Report to (specify clinic/ward/clinician): _____		1 st <input type="checkbox"/> 2 nd <input type="checkbox"/> 3 rd <input type="checkbox"/>	
III. Previous Report: _____		Others Specify <input type="checkbox"/> _____	
Previous Lab No: _____			
IV. Specimen: <u>1</u>			
Collection date (dd/mm/yyyy): <u>1/1</u>			
V. Investigation requested: <u>HCO</u>			
VI. History (including drugs used):			
VII. Diagnosis: <u>? BPH -</u>			

RENTALIA NATIONAL HOSPITAL	
XRAY REQUEST FORM	
Type of investigation requested: <u>CT Scan Head</u>	Name: <u>Brian ODHIA</u>
Sex: <u>M</u> Age: <u>5yrs</u>	Hospital number: <u>65016</u>
Brief clinical history: <u>Sudden onset of scalp swelling, cystic in nature,</u>	Xray number: _____
Requesting Doctor: <u>Paratan</u>	Signature: _____ Date: <u>28/11</u>
<u>Please do ultrasound first</u>	
<u>28/11/2012.</u>	

ANNEX: 7

Consent for participation in the Study

My name is Dr. Gecaga W. Wendy. I am carrying out a study on the **Knowledge, Attitude, and Practice of Clinicians practicing at the Kenyatta National Hospital, on Ionizing Radiation.** I wish to recruit you into the study, the objective being to see if knowledge is deficient, the extent of this deficiency and how the knowledge gap can be bridged.

Through your participation, I eventually hope to change policy on how radiological requests involving use of ionizing radiation are made and find effective ways to educate clinicians on the same.

It is your choice to accept or refuse to enroll in the study. If you accept, you will be required to fill in a questionnaire. Do not write your name on the questionnaire.

All the information collected will be treated with confidentiality.

I freely give consent to take part in the study conducted by Dr. Gecaga. Wendy, the nature and effect of which she has explained to me, on (date)..... My participation is entirely voluntary and I am free to withdraw my consent at any time I wish. The results of this study will benefit me, other clinicians and most importantly patients

Signature of participant

.....

Signature of investigator/witness

.....

Dr. GecagaW. Wendy

Department of Diagnostic Imaging and Radiation Medicine: University of Nairobi

Phone: +254722-223058

Postal address: 2209- 00202 Nairobi

Email address: feb01ke@yahoo.com

ANNEX 8:**TIME PLAN**

	Jun- Dec 2012	Jan- Feb 2013	Mar- May	May- Oct	Oct	Nov- Dec	Jan- Mar 2014
Proposal write up	X	X					
Supervisors recommendations		X					
Ethics			X				
Pre-test questionnaire				X			
Data collection				X			
Data entry					X		
Data analysis						X	
Write up of results.							X

ANNEX 9:**BUDGET**

<u>ITEMS</u>	<u>COST</u>
Hard copy drafts of proposal. A total of 6 copies at 83/= each.	500/=
Internet costs	3000/=
Statistics from KNH Health Information Systems Department	500/=
Ethics fee	3000/=
Questionnaire printing. 190 copies at 15/= each	3000/=
Statistician fee for sample size calculation and data analysis	15000/=
Stationary (pens, pencils)	1000/=
Printing and Binding final publication	2000/=
Contingency funds	2000/=
TOTAL	30000