1.1 General view:

Medical uses of ionizing radiation are amongst the longest established applications of ionizing radiation. Current estimates put the worldwide annual number of diagnostic and interventional radiological procedures at over 3000 million and at over 5 million radiation therapy treatments. These medical uses bring considerable public health benefits.

However, ionizing radiation can cause harm and a systematic approach should be applied to ensure that there is a balance between being able to utilize the benefits from medical uses of ionizing radiation and minimizing the risk of radiation effects to patients, workers and members of the public.

The radiation risks to people and the environment that may arise from the use of radiation and radioactive material must be assessed and must be controlled by means of the application of standards of safety. Exposure of human tissues or organs to radiation can induce the death of cells on a scale that can be extensive enough to impair the function of the exposed tissue or organ. Effects of this type, which are called ‘deterministic effects’, are clinically observable in an individual only if the radiation dose exceeds a certain threshold level. Above this threshold level of dose, a deterministic effect is more severe for a higher dose.

1.2 Problem statement:

Lack of radiation protection due to untrained engineer and negligence of safety that need to be assessed.

1.3 Objective:

1.3.1 General objective:

To protect people and the environment from harmful effects of ionizing radiation.

1.3.2 Specific objectives:

- Assess the system of protection and safety aims to, manage and control exposure to radiation so that radiation risks, including risks of health effects and risks to the environment, are reduced to the extent reasonably achievable.
- To provide recommendations and guidance on meeting the requirements for the safe use of radiation in medicine.
- Ensuring radiation protection and safety of radiation sources with regard to patients, workers, careers and comforters, volunteers in biomedical research, and the public in medical uses of ionizing radiation.

1.4 Methodology:

Gathering information from text books, paper, internet and visiting some hospitals to meet with engineers and technicians of radiology department and measuring to assess the radiation protection standards by analyzing these information.

1.5 Thesis lay out:

This thesis consists of seven chapters, chapter one illustrate a brief introduction and general view about the project. Chapter tow containing theoretical fundamental, when chapter three presents the back ground studies of radiation protection assessment during the last years. In chapter four the methodology was discussed and the collecting data analyzed to get best result. Chapter five shows the practical assessment of radiation protection and result discuss in chapter six. Chapter seven include conclusion and recommendation. Finally the reference illustrated flowed by the appendices.

2.1 X-Ray Radiation:

Radiation can simply be described as energy moving through space. It can take many forms, including visible light, X-Ray, gamma-rays, microwaves and radio waves. It is an electromagnetic radiation of high energy and very short wavelength (between ultraviolet light and gamma rays) as shown in Fig (2.1a & b).It is able to pass through many materials opaque to light .X-Ray is a form of ionising radiation. X-Ray are sometimes defined as having wavelengths between 10^{-10} and 10^{-12} m.

Ionizing radiation has many uses, including sterilization of food and medical equipment, creation of medical images, and is even used in the treatment [1]. X-Ray are a type of radiation that are created using large amounts of electricity. X-Ray are used in medical imaging much like a camera uses visible light to create an image. X-Ray pass through the body and create an image on film based on how many X-Ray get absorbed and how many pass through. These films are commonly referred to as "X-Ray," but X-Ray are actually the type of radiation that is used to produce the image. [2].

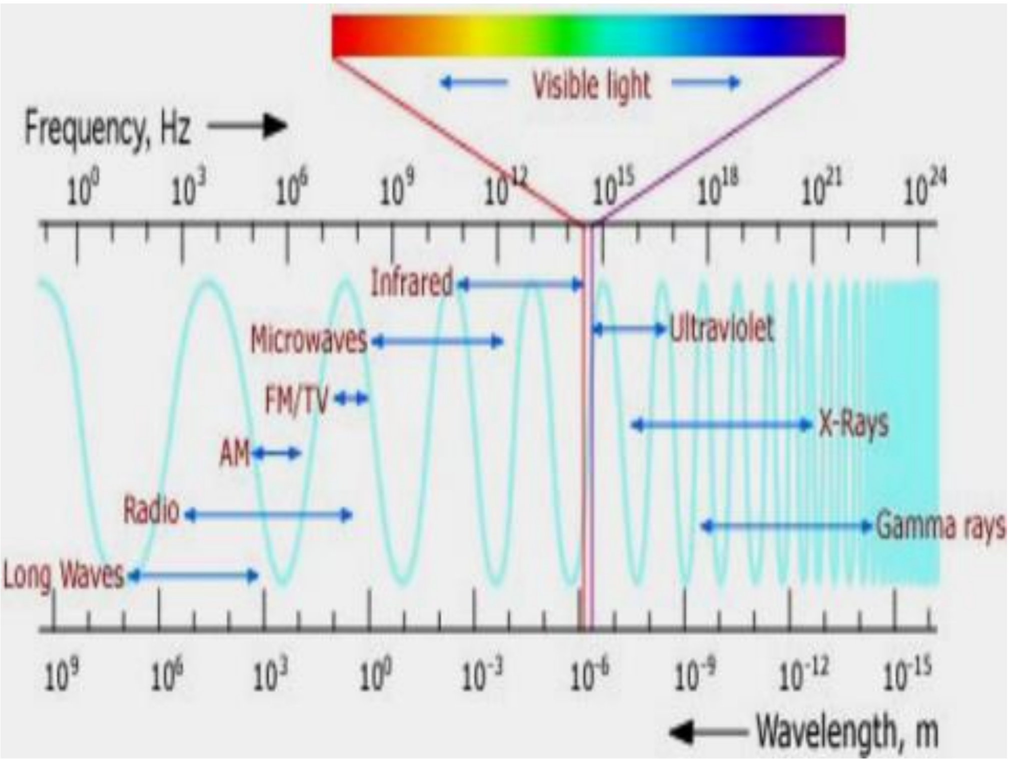

Figure (2.1a): X-Ray as a part of the electromagnetic spectrum

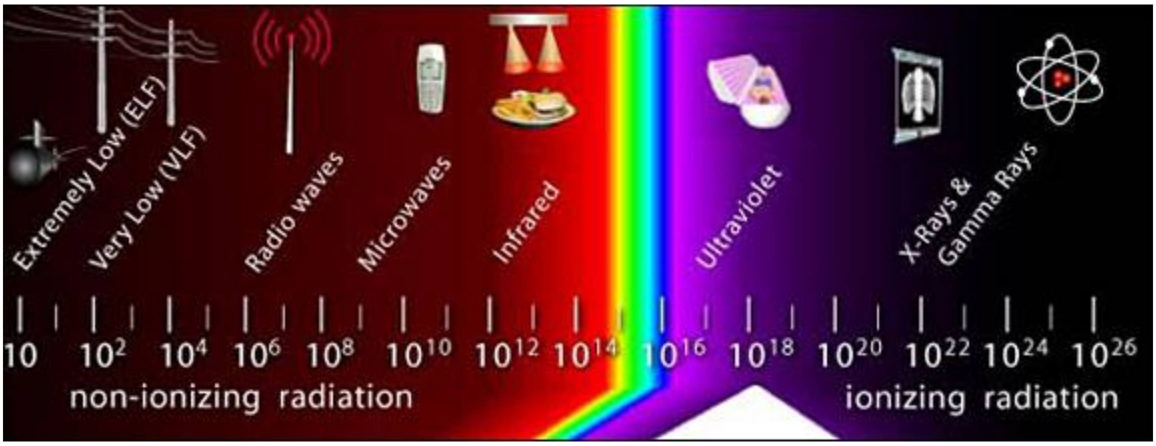

Figure (2.1b): X-Ray

2.1.1 Radiation source:

Radiation is all around us. Currently, two main sources of ionizing radiation are from natural background radiation and medical exposure. Natural background radiation comes from the Sun (cosmic radiation), the earth (mostly Radon gas) and from naturally radioactive substances in our body. Natural background radiation exposure accounts for an average of 3.1 mSv/yr with variations depending on where you live [3].

2.1.2 X-Ray properties:

According to its wavelength and frequency the X-ray can be characterized by:

1. Visible light and X-rays both travel in straight lines, and cast a shadow when they interact with a solid object.
2. X-Ray have more energy than visible light, and can go much deeper into and through objects. An X-Ray beam is absorbed differently by different parts of the body, and these differences make shadows that are used to create an image or picture.
3. A dense structure, such as bone, absorbs a high percentage of an X-Ray beam (appears light grey on the image); whereas low-density structures, such as soft tissues (e.g. muscle and skin), absorb a small percentage (appears dark grey). Metal objects will usually show up as white and air will usually appear black.

4. Man-made X-Ray are electrically generated and are only present when the X-Ray machine is switched on, just like a light bulb.
5. Once the X-Ray machine is switched off, there is no radiation coming from the X-Ray machine. Computed tomography (CT) is a specialized X-Ray examination using powerful computers to make the pictures. Having an X-Ray or CT examination does not make a patient radioactive.

2.2 X-Ray hazard:

Each individual X-Ray examination or isotope scan carries the level of risk. To estimate the effect of having many examinations, the risks for each one are simply added together. If you have already had a large number of X-Ray and the total risk is causing you concern, the need for each new examination should still be judged on its own merits. Before going ahead, your doctor must be able to reassure you that there is no other way of providing new information that is essential for the effective management of your medical problem.

Approximate estimates of the chance or risk that a particular examination or scan might result in a radiation-induced cancer later in the lifetime of the patient are shown in the table (2.1):

Table (2.1): Approximate estimates of the chance or risk of radiation.

X-Ray examination (Nuclear medicine or isotope scan)	**Equivalent period of natural background radiation**	**Lifetime additional risk of cancer per examination***
Chest Teeth Arms and legs Hands and feet	A few days	NEGLIGIBLERISK Less than 1 in 1,000,000
Skull Head Neck	A few weeks	MINIMAL RISK 1 in 1,000,000 to 1 in 100,000
Breast [mammography] Hip Spine Abdomen Pelvis CT scan of head (Lung isotope scan) (Kidney isotope scan)	A few months to a year	VERY LOW RISK 1 in 100,000 to 1 in 10,000
Kidneys and bladder {IVU} Stomach — barium meal Colon — barium enema CT scan of chest CT scan of abdomen (Bone isotope scan)	A few years	LOW RISK 1 in 10,000 to 1 in 1,000

When X-Ray, or any ionizing radiation, pass through the body they cause electrons to be ejected from atoms, leaving behind positive ions. These positive ions, or free radicals, can cause damage to DNA. DNA can also be damaged directly by radiation, If DNA is damaged, and there are three possible outcomes:

1. The cell dies, occurs with very high doses.
2. The cell repairs itself perfectly, when it exposed to certain dose.
3. The cell repairs itself with mistakes (rare).

The inaccurate repair of DNA is rare, but can cause a cell to act wildly or grow into a cancer. Oftentimes it takes decades for cancer to be detected following radiation exposure [4].

One of the riskiest of all diagnostic tools is the X-Ray machine. Most people who visit a doctor will experience at least one exposure to these high-frequency waves of ionizing radiation (X-Ray). These are the facts that have been discovered *so far* about the adverse side effects of X-Ray:

- If infants are exposed to X-Ray while still in the mother's womb (in utero), their risk of all cancers increases by 40 percent, of tumors of the nervous system by 50 percent, and of leukemia's by 70 percent.
- Today there are thousands of people with damaged thyroid glands, many of them with cancer, who were radiated with X-Ray on the head, neck, shoulder or upper chest 20-30 years ago.
- 10 X-Ray exposures at the dentist's office are sufficient to produce cancer of the thyroid.
- Multiple X-Ray have been linked with multiple myeloma – a form of bone marrow cancer.
- Scientists have told the American Congress that X-radiation of the lower abdominal region puts a person at risk for developing genetic damage that can be passed on to the next generation. They also linked the 'typical diseases of aging, such as diabetes, high blood pressure, coronary heart disease, strokes and cataracts, with previous exposure X-Ray.

- It is estimated that at least 4,000 Americans die each year from X-Ray related illnesses.
- In the UK (United Kingdom), one fifth to one half of all X-Ray given to patients are without real necessity. In the US (United State), the FDA (Food and Drug Administration) reports that as much as one third of all radiation is unnecessary.
- In the UK, X-Ray ordered by doctors account for over 90 percent of the total radiation exposure of the population (Cambridge University Press, 1993).
- In Canada, almost everyone gets an annual X-Ray of one sort or another.
- Old X-Ray equipment still used in many hospitals gives off 20 to 30 times as high a dose of radiation as is necessary for diagnostic purposes.

Unless it is for a real emergency situation, X-Ray should be avoided as far as possible because their harmful side effects may pose a greater health risk than does the original problem. As a patient you have the right to refuse X-Ray diagnosis. By discussing your specific health problem with your physician, you can find out whether exposure to X-Ray is really necessary or not. Many physicians today share this concern with their patients and try to find other ways to determine their exact condition [5].

2.3 Radiation protection:

Radiation protection, sometimes known as radiological protection, is defined by the International Atomic Energy Agency (IAEA) as "The protection of people from harmful effects of exposure to ionizing radiation, and the means for achieving this". The IAEA also states "The accepted understanding of the term radiation protection is restricted to protection of people. Suggestions to extend the definition to include the protection of non-human species or the protection of the environment are controversial"[6].

Ionizing radiation is widely used in industry and medicine, and can present a significant health hazard. It causes microscopic damage to living tissue, which can result in skin burns and radiation sickness at high exposures (known as "tissue" or "deterministic" effects), and statistically elevated risks of cancer at low exposures ("stochastic effects").Fundamental to radiation protection is the reduction of expected dose and the measurement of human dose uptake. For radiation protection and dosimetry assessment the International Committee on Radiation Protection (ICRP) and International Commission on Radiation Units and Measurements (ICRU) have published recommendations and data which is used to calculate the biological effects on the human body, and set regulatory and guidance limits.

2.3.1 International Standards:

Three international organizations recommend radiation protection levels: the International Commission on Radiological Protection (ICRP), the International Atomic Energy Agency (IAEA) and the International Commission on Radiation Units and Measurements (ICRU).

- **ICRP: It is established in 1928** during **t**he Second International Congress of Radiology, initially concerned with the safety of medical radiology, it now covers safety for all sources of radiation. Its mission is "to deal with the basic principles of radiation protection and to leave to various national protection committees the responsibility of introducing the detailed technical regulations, recommendations or codes of practice best suited to the needs of their individual countries." The ICRP is the principal source of recommendations on safe radiation levels. Members come from many countries and include scientists, physicians and engineers.
- **IAEA:** Organized in 1956 to promote the peaceful uses of nuclear energy, the IAEA is a specialized agency of the United Nations. The IAEA publishes both standards and recommendations in addition to books on

nuclear science and technology written by consultants or groups of experts invited from member states.

- **ICRU:** Created in 1925, the ICRU develops international recommendations regarding quantities and units of radiation and radioactivity, procedures for their measurement and application in clinical radiology and radiobiology, and physical data needed to ensure uniformity in reporting on their applications.

2.3.2 General rule for radiation protection:

As a radiation safety principle for minimizing radiation doses and releases of radioactive materials by employing all reasonable methods. The ALARA law (As Low As Reasonably Achievable) should be applied with regulatory requirement for all radiation safety programs.

2.3.2.1 The Radiation Safety Division and ALARA :

The RSO (Radiation Safety Organization) provides guidance for the ALARA program as the manager and technical supervisor of the Radiation Safety Division. In turn, the RSD staff are responsible for contributing to the success of the ALARA program in the following ways:

1) Providing technical support and guidance to the PIs (Principle Investigation) and their staff for implementation of the ALARA concept.

2) Performing routine lab inspections to identify possible ALARA issues.

3) Monitoring g of worker radiation doses with the assignment of dosimeter and use of bioassays as deemed appropriate.

4) Reviewing occupational doses and respond to situations in which the investigation levels are exceeded.

5) Providing training and consultation to workers to ensure doses are maintained ALARA.

2.3.2.2 Practical investigations (PIs):

The PI and research staff, with the support of the RSD, should ensure that the ALARA principle is being used in all lab operations. This includes the proper use of shielding and dosimetry combined with contamination control techniques. All employees bear a responsibility for their own personal safety in such work areas as:

1) Awareness of potential radiation hazards, exposure levels and safety controls in their work areas.

2) Awareness of operating and emergency procedures.

3) Awareness of practices that do not seem to follow the ALARA philosophy.

4) Compliance with reporting incidents and possibly unsafe working conditions to their supervisors and, if appropriate, to the RSD staff.

5) Compliance with wearing personnel dosimeter and ensuring its return to the RSD at the proper exchange frequency.

6) Compliance with providing bioassay samples to the RSD as needed.

2.3.2.3 Mitigation of external radiation exposures

The three (3) major principles to assist with maintaining doses ALARA are:

1) Time: minimizing the time of exposure directly reduces radiation dose.

2) Distance: doubling the distance between your body and the radiation source will divide the radiation exposure by a factor of 4.

3) Shielding: using absorber materials such as Plexiglas for beta particles and lead for X-Ray and gamma rays is an effective way to reduce radiation exposures [7].

The annual occupational dose limits have been derived from a study of the observed biological effects of radiation on humans and animals during the 20^{th}century.

These maximum limits are promulgated on the basis that when applied to occupationally exposed radiation workers they will result in a level of risk no greater than that in other occupations which are deemed to have high safety standards.

Table (2.2): Maximum Annual Occupational Dose Limits

Whole Body	5000 millirem
Extremities	50000 millirem
Lens of the Eye	15000 millirem
Fetus	500 millirem
Individuals in the General Public	100 millirem

500 millirem for the fetus is during the gestation period The ALARA concept imposes lower operational dose limits that are even more restrictive than the maximum legal dose limits in the table above. This ensures an enhanced safety factor for what are already considered to be safe annual doses for radiation workers.

Licensees are required to attempt to prevent pregnant workers from exceeding ~ 55 millirem during any one month. The desire is to avoid a large dose to the fetus during the $8^{th}$to the 15^{th}weeks of the pregnancy as this is the period during which it is most sensitive to potential radiation-induced effects. Thus, it is incumbent upon the pregnant employee to strongly consider officially notifying the RSD as soon as she is aware of her pregnancy.

2.3.3 Important points to remember:

➤In radiology departments, every effort is made to keep radiation doses low and, wherever possible, to use ultrasound or MRI which involve no hazardous radiation.

➤The radiation doses from X-Ray examinations or isotope scans are small in relation to those we receive from natural background radiation, ranging from the equivalent of a few days' worth to a few years.

➤The health risks from these doses are very small in relation to the underlying risks of cancer, but are not entirely negligible for some procedures involving fluoroscopy or computed tomography (CT).

➤You should make your doctor aware of any other recent X-Ray or scans you may have had, in case they make further examinations unnecessary.

➤The risks are much lower for older people and a little higher for children and unborn babies, so extra care is taken with young or pregnant patients.

➤If you are concerned about the possible risks from an investigation using radiation, you should ask your doctor whether the examination is really necessary. If it is, then the risk to your health from not having the examination is likely to be very much greater than that from the radiation itself.

2.4 Radiation dose:

In addition to the dose reduction principals we use for our patients, protective equipment plays a key role in decreasing exposure for hospital workers. The IRCP has set a limit for occupational exposure at 20 mSv/year. Here are some common scenarios where healthcare workers are exposed to radiation and how to minimize the effects:

2.4.1 Interventional Radiology and Fluoroscopy:

The International Atomic Energy Agency (IAEA) has created two posters with suggestions on how to reduce radiation exposure during fluoroscopy and interventional procedures for both patients and staff. [8].

- **Radiation to the Eye (Lens):**

Chronic radiation to the lens of the eye has been shown to cause cataracts. The ICRP has set an occupational equivalent dose limit of 20 mSv per year to the lens. While a radiologist performing up to 200 CT guided procedures annually would not exceed those limits, those performing certain fluoroscopic or angiographic procedures could exceed these limits. Leaded glasses can provide protection

- **Radiation to the Hands:**

While the hands are not particularly radiosensitive, they are often in the direct path of X-Ray during procedures. The ICRP has set an occupational equivalent dose limit of 500 mSv per year to the hands. Radiation reducing sterile gloves can reduce exposure [9].There are tables below that shown general dose for fluoroscopy (2.3), common radiation exposures (2.4) and biologically significant radiation exposures (2.5).

Table (2.3): general dose for fluoroscopy

	rem/year	
	General	**Stanford**
Adult workers	5.0	0.5
Eye lens	15.0	1.5
Skin, organ, extremities	50.0	5.0
Child	0.5	0.05
Declared Pregnant Women	0.5	0.05
Members of the Public	0.1	0.01

Table (2.4) : common radiation exposures

Natural Background radiation	150 – 300 mrem/year
Chest radiograph	15-65 mrem/view
Screening Mammography	60 – 135 mrem/view
Computerized body tomography (20 slices)	3,000 – 6,000 mrem

Table (2.5): biologically significant radiation exposures

Significant	**Mrem**
Risk of contracting cancer increased 0.09%	1,000
Temporary Blood Count Change	25,000
Permanent sterilization in men	100,000
Permanent sterilization in women	250,000
Skin Erythema	300,000

Diagnostic uses of X-Ray involve the differential absorption of different body parts for the X-Ray used. Almost all tissue will stop some X-Ray and cast a shadow on the fluoroscope. Diagnostic X-Ray machines operate at energies less than 150 keV. For greater contrast it is sometimes necessary to insert a material with greater absorption than the organ. Barium salts and iodine compounds are either fed or injected into patients for this purpose. Permissible dosage equivalents recommended by ICRP clarified in table (2.5) below [10].

Table (2.6): Permissible dosage equivalents recommended by ICRP

Exposed Group	**Blood Forming Organs. Gonads, Lens of Eye**	**Other Organs**
Radiation workers	5 rem,'yr after age 18; no more than 2.5 rem in any 3-month period	Skin. bone. thyroid. rem/yr; hands. fore-arms. 75 rem/yr; other organs. 15 rem/yr
Members of the public in vicinity of a controlled area	O .5 rem/yr	Skin. bone thyroid, 30 rem/yr for adults, 1.5 rem/yr for children to age 16; hands. feet, forearms, 7.5 rem,'yr: other organs. 1.5 rem/yr

2.5 Personal protective equipment:

Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, or coveralls, vests and full body suits.

All personal protective equipment should be safely designed and constructed, and should be maintained in a clean and reliable fashion. It should fit comfortably, encouraging worker use. If the personal protective equipment does not fit properly, it can make the difference between being safely covered or dangerously exposed. When engineering, work practice, and administrative controls are not feasible or do not provide sufficient protection, employers must provide personal protective equipment to their workers and ensure its proper use.

Employers are also required to train each worker required to use personal protective equipment to know:

- When it is necessary
- What kind is necessary
- How to properly put it on, adjust, wear and take it off
- The limitations of the equipment
- Proper care, maintenance, useful life, and disposal of the equipment

If PPE is to be used, a PPE program should be implemented. This program should address the hazards present; the selection, maintenance, and use of PPE; the training of employees; and monitoring of the program to ensure its ongoing effectiveness.

2.5.1 Maintaining PPE:

An effective system of maintenance of PPE is essential to make sure the equipment continues to provide the degree of protection for which it is designed. Therefore, the manufacturer's maintenance schedule (including recommended replacement periods and shelf lives) must always be followed.

Maintenance may include; cleaning, examination, replacement, repair and testing. The wearer may be able carry out simple maintenance (e.g. cleaning), but more intricate repairs must only be carried out by competent personnel.

The costs associated with the maintenance of PPE are the responsibility of the employer.

2.5.2 Storage for PPE

Where PPE is provided, adequate storage facilities for PPE must be provided for when it is not in use, unless the employee may take PPE away from the workplace (e.g. footwear or clothing).

Accommodation may be simple (e.g. pegs for waterproof clothing or safety helmets) and it need not be fixed (e.g. a case for safety glasses or a container in a vehicle).

Storage should be adequate to protect the PPE from contamination, loss, damage, damp or sunlight.

Where PPE may become contaminated during use, storage should be separate from any storage provided for ordinary clothing.

2.5.3 Provision and replacement of PPE:

Some organizations and departments operate central stores that deal with the provision of PPE. In most cases, individual units/service areas are responsible for arranging the supply of required PPE to staff.

Regardless of the arrangements for supply, it is a management responsibility to ensure the provision of correct PPE. When considering arrangements for providing replacement PPE it must be remembered that unless a task requiring PPE can be stopped, avoided or delayed until new PPE is obtained, replacement PPE must always be readily available.

2.5.4 Duties of employees regarding PPE:

The Personal Protective Equipment at Work Regulations place duties on employees to take reasonable steps to ensure that PPE provided is properly used. The Regulations also place the following duties on employees:

- PPE must be worn and used in accordance with the instructions provided to them.
- Employees must take all reasonable steps to ensure that PPE is returned to the accommodation provided for it after it has been used (unless the employee may take PPE away from the workplace e.g. footwear or clothing).
- PPE must be examined before use.
- Any loss or obvious defect must be immediately reported to their supervisor.

- Employees must take reasonable care for any PPE provided to them and not carry out any maintenance unless trained and authorized.

2.5.5 Types of PPE:

The shielding achieved by the PPE at a specific X-Ray energy (expressed as kVp) should be as great as, or greater than, the shielding which would be achieved by a 0.5 mm thickness of non-alloyed lead at that same specific energy. This equivalency of shielding should be over the range of energies used in a particular room or application.

- **Leaded glasses:**

Safety glasses with side shields and brow bars as shown in figure (2.2) are the minimum eye protection for handling blood or other potentially infectious materials.

In procedures where scatter radiation to the lens of the eye could approach the annual dose equivalent limit of 150 millisieverts the use of leaded glasses is recommended.

Figure (2.2): Eye protection (glasses)

- **Protective gloves:**

Protective gloves or gauntlets must possess at least 0.5 mm lead equivalency throughout the glove, including fingers and wrist as shown in figure (2.3).

Figure (2.3): hand protection (gloves)

- **Lead aprons:**

The effectiveness of lead aprons that shown in figure (2.4) in reducing exposure to leakage or scatter radiation relates directly to their physical construction, fit, and how they are used.

- **Construction:**

Any toxic material used for the attenuation of X-Ray in PPE should be sandwiched between inert materials or encapsulated in a substance which does not allow the toxic material to come in contact with the wearer. The attenuating material should be affixed to the encapsulating material to prevent the material from sagging, delaminating, tearing or distorting over time.

Figure (2.4): Body protection

- **Fit:**

The fit of the protective equipment should be such that all of the organs and parts of the body which are intended to be protected are protected in all postures and attitudes (relative orientation to the X-Ray source or scattering object) assumed by the worker during an X-Ray procedure. This may involve custom fitting; but at the very least, the worker should have a choice of sizes.

The fit of wrap-around aprons should be such that the overlapping material provides appropriate and adequate shielding. The area of the body covered by this material should include the entire front of the body (anterior surface) and should extend to the posterior midline of the body.

The thyroid collar and apron should fit together in a complementary fashion so that there are no gaps between them.

- **Use:**

If a worker's duties necessitate turning his or her back to the scattering object (patient) for a significant portion of time (based on the risk assessment), the lateral and posterior layers of the protective equipment should provide appropriate and adequate shielding. In dose-intensive applications such as angiography, heart catheterization and interventional imaging, open-backed aprons are not acceptable for use by anyone other than the fluoroscopist controlling the foot pedal or exposure switch.

Ergonomic issues should be considered when purchasing an apron. Lumbar support in the form of weight belts and padded shoulders can improve the product comfort, and reduce the risk of back injury. Separate skirts and tops can redistribute weight so as to bear on several large body joints. Manufacturer’s instructions should be followed regarding maintenance and storage. For example, aprons should be hung up when not in use. They should never be folded, wrinkled or creased.

- **Thyroid collars:**

This thyroid Collar in figure (2.5) is designed as an all purpose general radiation protection garment.

Figure (2.5): Standard Thyroid Collar

Personal protective equipment, or PPE, is designed to provide protection from serious injuries or illnesses resulting from contact with chemical, radiological, physical, electrical, mechanical, or other hazards. Careful selection and use of adequate PPE should protect individuals involved in chemical emergencies from hazards effecting the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing. No single combination of protective equipment and clothing is capable of protecting against all hazards. Thus PPE should be used in conjunction with other protective methods, including exposure control procedures and equipment [11].

- **Thermo luminescent dosimeter(TLDs):**

A thermo luminescent dosimeter, or TLD, is a type of radiation dosimeter. A TLD measures ionizing radiation exposure by measuring the intensity of visible light emitted from a crystal in the detector when the crystal is heated. The intensity of light emitted is dependent upon the radiation exposure. Materials exhibiting thermo luminescence in response to ionizing radiation include but are not limited to calcium fluoride, lithium fluoride, calcium sulfate, lithium borate, calcium borate, potassium bromide and feldspar[12].

In radio metallurgy laboratories there is a chance that TLDs may get lost without the knowledge of the TLD user, and this may lead to a false effective dose. An RFID-based TLD monitoring system that acknowledges the use of TLDs through self-operating software can prevent the misuse of the detector. This device can be used both for environmental monitoring and for staff personnel in facilities involving radiation exposure, among other applications.

The TLDs contain crystals of the lithium fluoride (LiF) and calcium fluoride (CaF_2) type. When a TLD is exposed to ionizing radiation at ambient environment, the radiation interacts with the crystal in the TLD and ionizes some of the crystal atoms, producing free electrons. Some of these free electrons of higher energy are trapped in the crystal. When the TLDs are heated in a reader machine back at the laboratory, heating causes the trapped electrons to release from the crystals and relieve the captured energy as light, hence the name thermo luminescent. The amount of light is counted by the photomultiplier tubes of the reader machine. As the amount of light is proportional to the radiation absorbed by the crystal, the ambient radiation level at the monitoring site over the measurement period can be calculated. The crystals can then be re-used after annealing to remove any residual energy [13] [14].

Figure (2.6): TLDs

2.6 General X-Ray room:

An area of 33 m^2 has been suggested for general X-Ray systems .The boundaries to all occupied areas (walls, doors, doorframes, floor, ceiling, windows, window frames and the protective viewing screen) must be shielded appropriately. Generally this requirement will be met by 2 mm of lead, or its equivalent with other material Workload, distances and occupancy in adjoining areas may serve to reduce this requirement, for example, a policy of shielding to the 2.24 mm level may reduce problems that may arise with future change of use and occupancy in the areas adjacent to the room.

Walls should be marked with the lead equivalent thickness for future reference. The 2.24 mm shielding is adequate to deal with secondary or scattered radiation and assumes the boundaries will not normally be exposed to the primary beam. Where this may happen additional shielding is required, for example an additional lead beam blocker may be required behind a chest stand or vertical Bucky. This additional shielding should extend over the range of possible tube movements when it is directed towards the wall.

The design of diagnostic medical Facilities where ionizing radiation is used, the room has been designed with a number of features in mind. There is good access through the patient doors, to allow patients on trolleys to be brought into the room and ensure ease of access to the table. The staff entrance is placed so that the door to the corridor is behind the protective barrier. This protects both staff entering this area and the corridor if the door is inadvertently opened. The protective barrier is composed of a lead- ply or equivalent lower section and a lead glass upper section which allows a panoramic view of the room.

Patient changing facilities must be provided and should be close to a general X-Ray room. Cubicles may be designed as individual changing rooms, which open directly into the X-Ray room. This will allow for changing arrangements consistent with good radiation protection practice, greater privacy, security and perhaps faster patient throughput. The main alternative is to group the cubicles together close to the X-Ray room but not adjoining it, and allow for a sub-waiting area from which the changed patients are escorted to the X-Ray room .The advantage of this design is that there are less access points into the X-Ray room. Cubicle doors leading into the X-Ray room must provide adequate radiation protection and the lock should be controlled from the X-Ray room to prevent inadvertent access.

Jerome Njoku et.al (2016), Use of ionizing radiation in diagnostic radiography could lead to hazards such as somatic and genetic damages. Compliance to safe work and radiation protection practices could mitigate such risks. The aim of the study was to assess the knowledge and radiation protection practices among radiographers in Lagos, Nigeria.

The study was a prospective cross sectional survey. Convenience sampling technique was used to select four X-Ray diagnostic centers in four tertiary hospitals in Lagos metropolis. Data were analyzed with Epi- info software, version 3.5.1.

Average score on assessment of knowledge was 73%. Most modern radiation protection instruments were lacking in all the centers studied. Application of shielding devices such as gonad shield for protection was neglected mostly in government hospitals. Most X-Ray machines were quite old and evidence of quality assurance tests performed on such machines were lacking [15].

Joan E Enabulele & BO Igbinedion (2014), Their objective to assess dental students' knowledge of dental radiation protection and practice as well as correlating their knowledge to practice on dental radiography. A cross-sectional questionnaire based study on radiation protection among dental students. Correct responses to the questions were allocated 1 mark while wrong response received no mark. Statistical analysis was performed using SPSS version 17 (Chicago, IL.). Pearson's coefficient correlation analysis was performed to establish relationship between various variables with the significant level set at 5%.

The study was conducted among 78 final year dental students, of which 32 were females and 46 were males. The mean score of the students on knowledge of radiobiology was 1.85 ± 1.19. Knowledge of radiation protection was abysmally poor with mean score of 0.92 ± 0.80 while the mean score of radiation protection practice was 2.69 ± 1.42. There was no significant correlation between the number of radiographs taken and knowledge of radiation protection or practice. A greater proportion of students with "good" radiation protection knowledge in comparison to those with "poor" knowledge kept a distance of over 3 meters from the patients/ X-Ray tube, wore lead apron, used the lowest possible settings on the X-Ray machine and used collimators. Most (75.6%) of the students thought they did not have adequate knowledge on radiation protection [16].

Rasha F. Abdellah et.al (2015), Doctors who request imaging must be well trained in deciding whether diagnostic imaging is in-dictated and have an accurate knowledge of the associated risks. Although radiological doses are low and the chance of late effect is minimal, it should be kept as low as reasonably achievable. This cannot be achieved without a proper knowledge and adherence to safe practices. This cross-sectional study investigates the level of physicians' knowledge about radiation safety and their attitude towards radiation protection. A self-administered questionnaire, for radiation safety was sent to a purposive sample of 120 physicians at Suez Canal University Hospital. Eighty questionnaires were filled by participants (response rate; 66.7%). The sample included 22 radiologists, 15 oncologists, 25 surgeons and 18 orthopedists. Most participants did not receive any radiation safety-related training (88.8%). Radiologists and oncologists were exposed to ionizing radiation more frequently; however, their knowledge was as low as that of other physicians. The overall knowledge score ranged from 40%-60% (mean; 56.5 ± 15.2), with a low score among surgeons and orthopedics. The most deficient knowledge was in the dose of background radiation and the radiation dose received by patients in each type of radiation procedure. Adherence to safe radiation practices was violated by most of participants, especially surgeons and orthopedics, but they Attributed it to the poor applicability of the protective measures during performing the procedures. This study concluded that physicians at the Suez Canal University Hospital had deficient knowledge, unsafe practices and negative attitude towards radiation safety policies & precautions [17].

Br Dent J. (2013), to illustrate the authors' experience in the provision of radiation protection adviser (RPA)/medical physics expert (MPE) services and critical examination/radiation quality assurance (QA) testing, to demonstrate any continuing variability of the compliance of X-Ray sets with existing guidance and of compliance of dental practices with existing legislation.

Data was collected from a series of critical examination and routine three-yearly radiation QA tests on 915 intra-oral X-Ray sets and 124 panoramic sets. Data are the result of direct measurements on the sets, made using a traceably calibrated Uniforms Xi meter. The testing covered the measurement of peak kilo voltage (kVp); filtration; timer accuracy and consistency; X-Ray beam size; and radiation output, measured as the entrance surface dose in milliGray (mGy) for intra-oral sets and dose-area product (DAP), measured in mGy.cm(2) for panoramic sets. Physical checks, including mechanical stability, were also included as part of the testing process.

The Health and Safety Executive has expressed concern about the poor standards of compliance with the regulations during inspections at dental practices. Thirty-five percent of intra-oral sets exceeded the UK adult diagnostic reference level on at least one setting, as did 61% of those with child dose settings. There is a clear advantage of digital radiography and rectangular collimation in dose terms, with the mean dose from digital sets 59% that of film-based sets and a rectangular collimator 76% that of circular collimators. The data shows the unrealized potential for dose saving in many digital sets and also marked differences in dose between sets.

Provision of radiation protection advice to over 150 general dental practitioners raised a number of issues on the design of surgeries with X-Ray equipment and critical examination testing. There is also considerable variation in advice given on the need (or lack of need) for room shielding. Where no radiation protection adviser (RPA) or medical physics expert (MPE) appointment has been made, there is often a very low level of compliance with legislative requirements. The active involvement of an RPA/MPE and continuing education on radiation protection issues has the potential to reduce radiation doses significantly further in many dental practices [18].

Australasian Medical Journal (2015), the large number of diagnostic procedures undertaken in emergency departments (ED) is vital to the early diagnosis and treatment of patients. The use of ionizing radiation in diagnosis adds a lifetime attributable risk (LAR) of cancer depending on the region imaged, the frequency of imaging, and dose per exposure.

This pilot study aims to assess the degree of radiation awareness amongst ED doctors at major metropolitan and regional health services in Australia, in terms of the dose and risks associated with common imaging. Secondary aims were to provide a template to practically evaluate ED doctor radiation awareness, identify factors impacting upon radiation awareness (e.g., location, seniority of doctor), and to suggest practical means to improve radiation awareness.

Physicians in the EDs of two major health services (one regional and one metropolitan) in Australia were surveyed and asked to compare the radiation dose from each procedure to what the general population is exposed to naturally from background radiation. Additionally, the physicians were asked to estimate the LAR of cancer from each diagnostic procedure. These estimates were compared to literature-sourced values to assess the accuracy of physician responses.

Results showed that there was significant variance with regard to knowledge of dose and risk, and that respondents tended to greatly over exaggerate the radiation levels and risk associated with diagnostic imaging. Despite failing to attribute correct values, in many cases, respondents ranked scans correctly. Responses comparing differences amongst the two health services and amongst different levels of medical hierarchy largely overlapped with no clear difference between these factors [19].

M K A Karimetal (2014), in this paper, we evaluate the level of knowledge and awnareness among 120 radiology personnel working in 7 public hospitals in Johor, Malaysia, concerning Computed Tomography (CT) technology and radiation doses based on a set of questionnaires. Subjects were divided into two groups (Medical profession (Med, n=32) and Allied health profession (AH, n=88). The questionnaires are addressed: (1) demographic data (2) relative radiation dose and (3) knowledge of current CT technology. One-third of respondents from both groups were able to estimate relative radiation dose for routine CT examinations. 68% of the allied health profession personnel knew of the Malaysia regulations entitled 'Basic Safety Standard (BSS) 2010', although notably 80% of them had previously attended a radiation protection course. No significant difference ($p < 0.05$) in mean scores of CT technology knowledge detected between the two groups, with the medical professions producing a mean score of (26.7 ± 2.7) and the allied health professions a mean score of (25.2 ± 4.3). This study points to considerable variation among the respondents concerning their understanding of knowledge and awareness of risks of radiation and CT optimization techniques [20].

Mohamed Badawy et.al,(2016), although the exposure to nursing staff is generally lower than the allowable radiation worker dose limits, awareness and overcoming fears of radiation exposure is essential in order to perform routine activities in certain departments. Furthermore, the nursing staff, whether they are defined as radiation workers or not, must be able to respond to any radiological emergencies and provide care to any patient affected by radiation. This study aims to gauge the awareness of radiation safety among the nursing staff at a major hospital in different departments and recommend if further radiation safety training is required. A prospective multiple choice questionnaire was distributed to 200 nurses in 9 different departments. The questionnaire tested knowledge that would be taught at a basic radiation safety course. 147 nurses (74%) completed the survey with the average score of 40%. Furthermore, 85% of nurses surveyed felt there was a need for radiation safety training in their respective departments to assist with day to day work in the department. An increase in radiation safety materials that are specific to each department is recommended to assist with daily work involving radiation. Moreover, nursing staff that interact with radiation on a regular basis should undertake radiation safety courses before beginning employment and regular refresher courses should be made available thereafter[21].

B J Howard et.al (2010), the outcome of the PROTECT project (Protection of the Environment from Ionizing Radiation in a Regulatory Context) is summarized, focusing on the protection goal and derivation of dose rates which may detrimentally affect wildlife populations. To carry out an impact assessment for radioactive substances, the estimated dose rates produced by assessment tools need to be compared with some form of criteria to judge the level of risk. To do this, appropriate protection goals need to be defined and associated predefined dose rate values, or benchmarks, derived and agreed upon. Previous approaches used to estimate dose rates at which there may be observable changes in populations or individuals are described and discussed, as are more recent derivations of screening benchmarks for use in regulatory frameworks. We have adopted guidance and procedures used for assessment and regulation of other chemical stressors to derive benchmarks.

On the basis of consultation with many relevant experts, PROTECT has derived a benchmark screening dose rate, using data on largely reproductive effects to derive species sensitivity distributions, of 10 $\mu Gy\ h^{-1}$ which can be used to identify situations which are below regulatory concern with a high degree of confidence[22].

Alimen et.al (2014), the optimization of occupational radiological protection is challenging and a variety of factors have to be considered. Physicians performing image-guided interventions are working in an environment with one of the highest radiation risk levels in healthcare. Appropriate knowledge about the radiation environment is a prerequisite for conducting the optimization process. Information about the dose rate variation during the interventions could provide valuable input to this process. The overall purpose of this study was to explore the prerequisite and feasibility to measure dose rate in scattered radiation and to assess the usefulness of such data in the optimization process.

Using an active dosimeter system, the dose rate in the unshielded scattered radiation field was measured in a fixed point close to the patient undergoing an image-guided intervention. The measurements were performed with a time resolution of one second and the dose rate data was continuously timed in a data log. In two treatment rooms, data was collected during a 6month time period, resulting in data from 380 image-guided interventions and vascular treatments in the abdomen, arms and legs. These procedures were categorized into eight types according to the purpose of the treatment and the anatomical region involved.

The dose rate varied substantially between treatment types, both regarding the levels and the distribution during the procedure. The maximum dose rate for different types of interventions varied typically between 5 and $100mSvh^{-1}$, but substantially higher and lower dose rates were also registered. The average dose rate during a complete procedure was however substantially lower and varied typically between 0.05 and 1 mSv h^{-1}. An analysis of the distribution disclosed that for a large part of the treatment types, the major amount of the total accumulated dose for a procedure was delivered in less than 10% of the exposure time and in less than 1% of the total procedure time.

The present study shows that systematic dose rate measurements are feasible. Such measurements can be used to give a general indication of the exposure level to the staff and could serve as a first risk assessment tool when introducing new treatment types or X-Ray equipment in the clinic. For example, it could provide an indication for when detailed eye dose measurements are needed. It also gives input to risk management considerations and the development of efficient routines for other radiological protection measures [23].

4.1 Methodology:

The methodology for this paper includes empirical field observation and field level data collection through inventory questionnaire survey and interviews. A structured questionnaire was designed to collect information addressing the radiation protection assessment.

The collected data with the questionnaire survey were analyzed mainly with simple descriptive statistics.

4.1.1 Study Duration:

A period of seven months (from March to November).

4.1.2 Study population:

Forms were field through survey, measurement and personal interviews with the workers that interact with radiation; the form contained 12 hospitals in Khartoum state, in each hospital the meeting held with radiologist, technologist engineer and radiation protection officer.

4.1.3 Data collection technologies and tools:

Interviews guided by questionnaire which composed of 16 questions about radiation protecting such questions prepared in accordance with the observation statistical standards for easy to understand and answer question in a scientific and comprehensive (under specialist guider).

4.2 Data analysis:

Analysis of the questions were produced and stabilized to find the output of the questionnaire by visualization and interpretation. The result were treated in Microsoft Excel and analyzed using both descriptive and analytical statistics, which was done by statistician using computer based program Statistical Package for Social Sciences (SPSS).

- Responsibility for unnecessary exposure.

Table (4.1): responsibility for unnecessary exposure

	Frequency	**Percent %**
Only the referring physician	13	32.5%
Only the radiologist	0	0%
Only the medical specialist	0	0%
Only the radiographer	1	2.5%
All previous answers are correct	26	65%
Total	40	100%

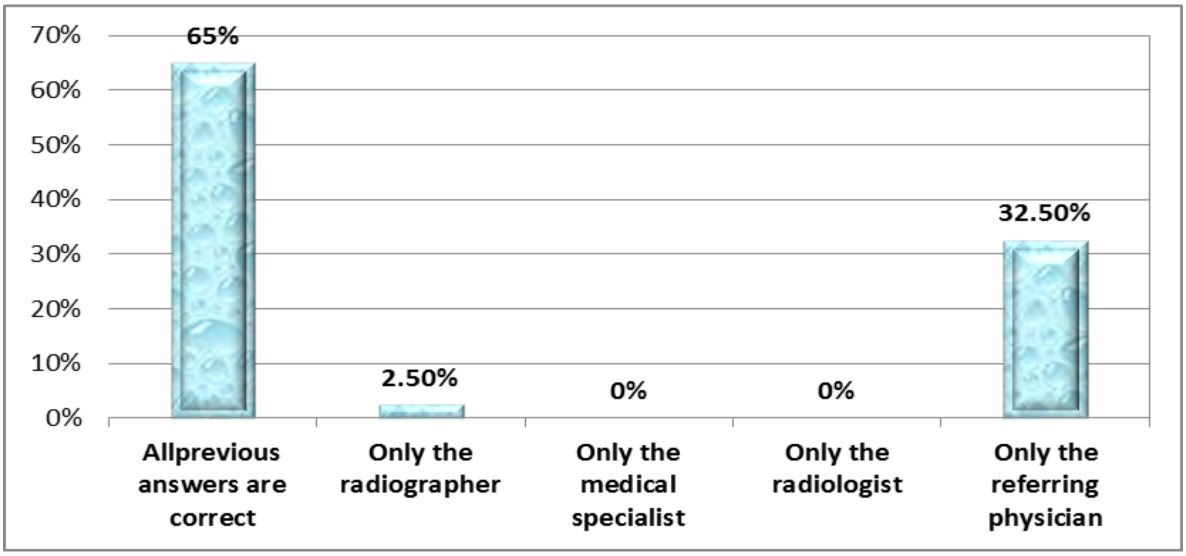

Figure (4.1): responsibility for unnecessary exposure

65% of population said the referring physician, the radiologist, the medical specialist and the radiographer are responsible for unnecessary exposure to ionizing radiation.

- Is radiation safety committee in the place

Table (4.2): radiation safety committee

	Frequency	**Percent %**
Yes	11	27.5%
No	29	72.5%
Total	40	100%

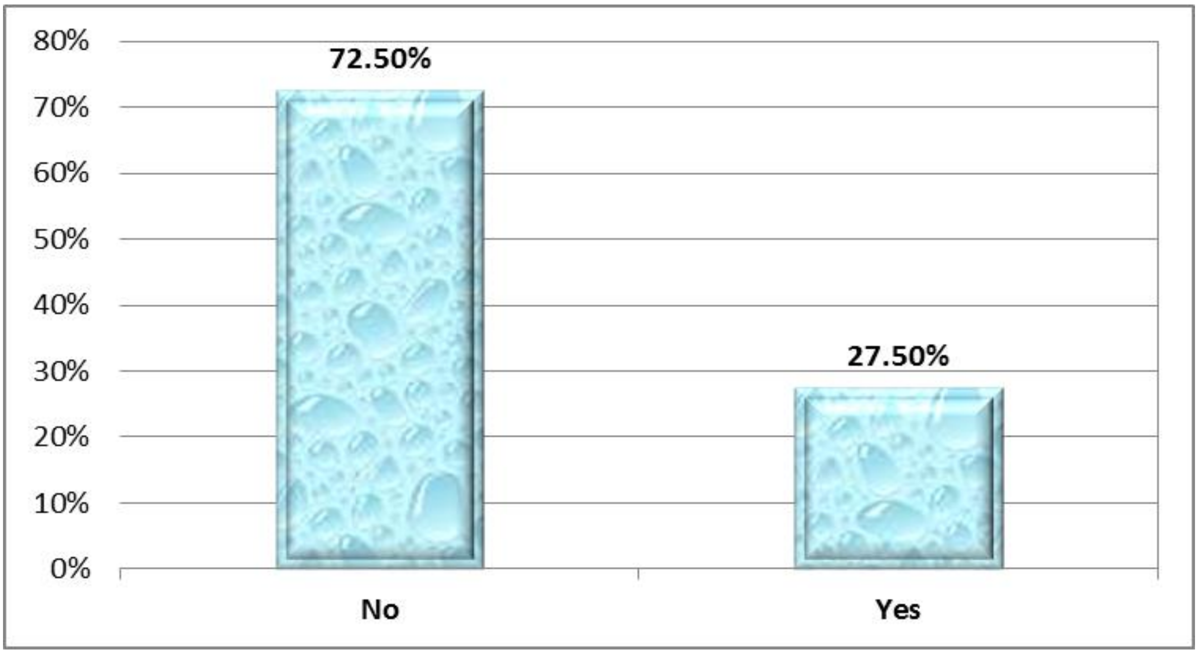

Figure (4.2): radiation safety committee

There are 75% of radiation department within the hospital have no radiation safety committee and 25% have.

Radiation safety committee has the authority to implement and enforce the radiation safety program encompassing the use, handling, storage and disposal of source of ionizing and non ionizing radiation in accordance with regulatory requirements of the CNSC and provincial and federal standers for the safe use of X-Ray committee devices.

- Safety of radiology department.

Table (4.3): safety of radiology department

	Frequency	**Percent %**
25%	0	0%
50%	4	10%
75%	26	65%
100%	10	25%
Total	40	100%

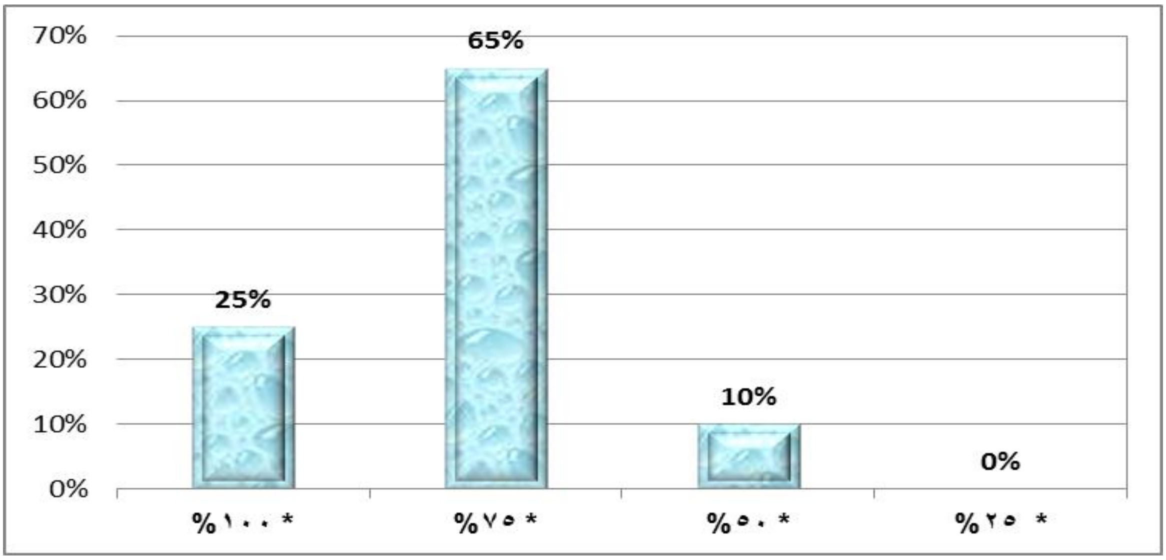

Figure (4.3): safety of radiology department

the study showing that there is 10(25%) radiology departments have safety percentage 100%,26(65%) have safety percentage 75%,4(10%) have asafty percentage 50%,and there is no radiology department safety in 25%.

- Dimensions of X-Ray room.

Table (4.4): Dimensions of X-Ray room

	Frequency	**Percent %**
25%	0	0%
50%	5	12.5
75%	30	75%
100%	5	12.5
Total	40	100%

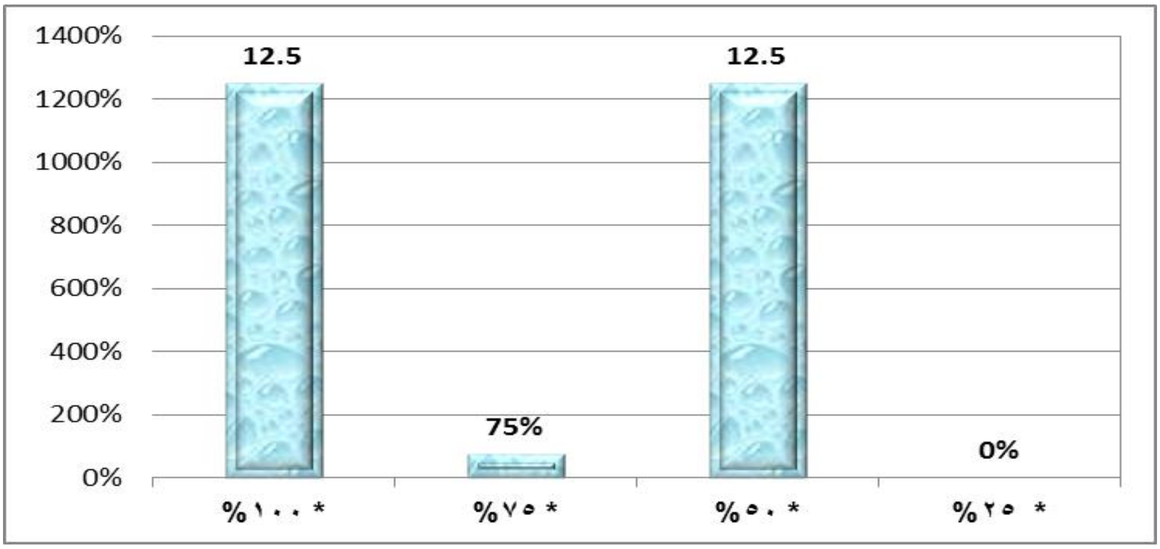

Figure (4.4): Dimensions of X-Ray room

Through this question the dimensions inside the X-Ray room, matching the standards of international safety within some hospital. If the X-Ray room dose not matching the standards that mean the leakage of radiation will increased and this will harm the patients, staff and other people within the area.

- Meal for workers.

Table (4.5): provided meal for workers

	Frequency	Percent %
Yes	6	15%
No	34	85%
Total	40	100%

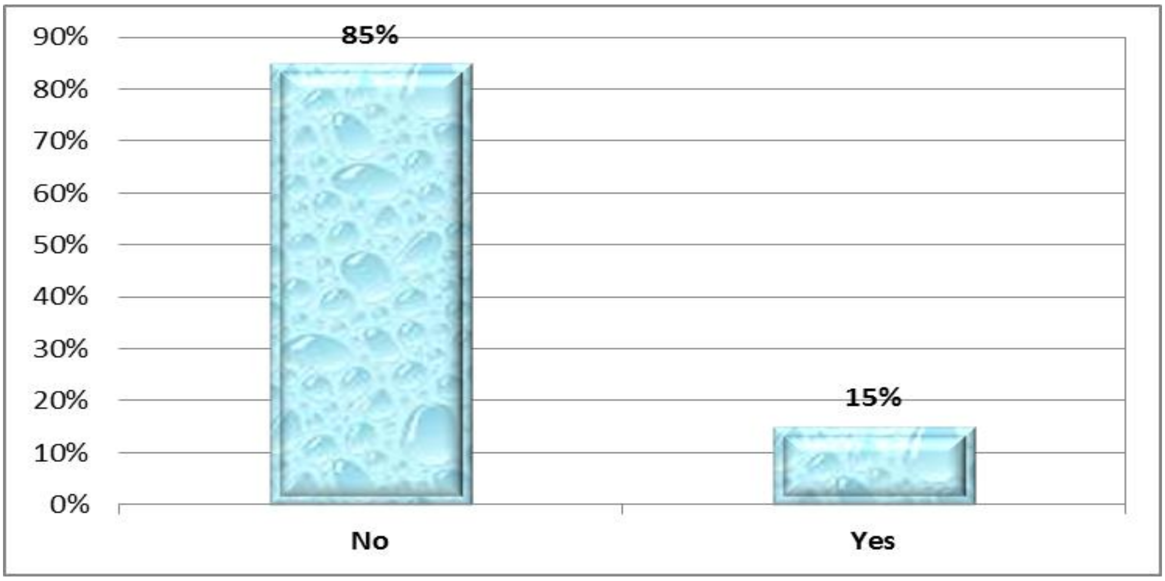

Figure (4.5): provided meal for workers

There is 15% of sample study provided meal for workers and 85% of them didn't. Milk, fish and egg can renew the cells that are damaged by radiation.

- Measuring of radiation dose annually for workers.

Table (4.6): measuring of radiation dose annually for workers

	Frequency	**Percent %**
Yes	2	5%
No	38	95%
Total	40	100%

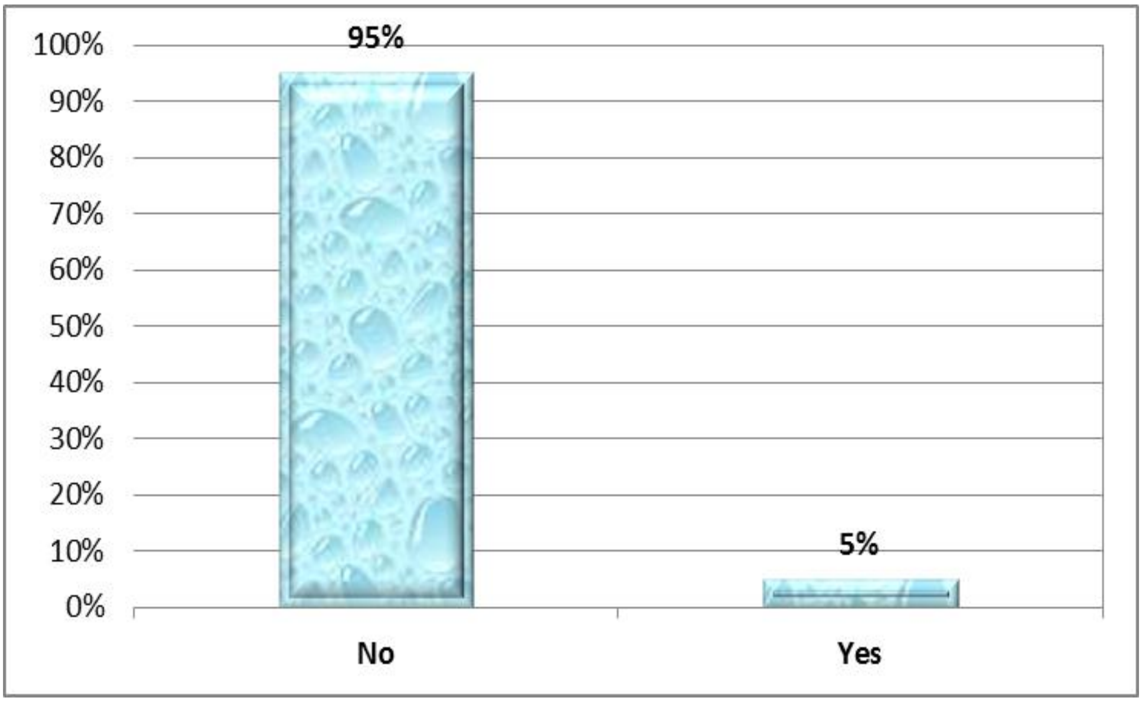

Figure (4.6): measuring of radiation dose annually for workers

This section evaluate the protection of workers annually, 95% of the field of study didn't measure the radiation dose annually because the TLDs aren't available .TLDs are conceder the role in demonstrating optimal level of exposure and compliance with dose level

- Ten days rule for female patient.

Table (4.7): ten days rule for female patient

	Frequency	Percent %
Yes	39	97.5%
No	1	2.5%
Total	40	100%

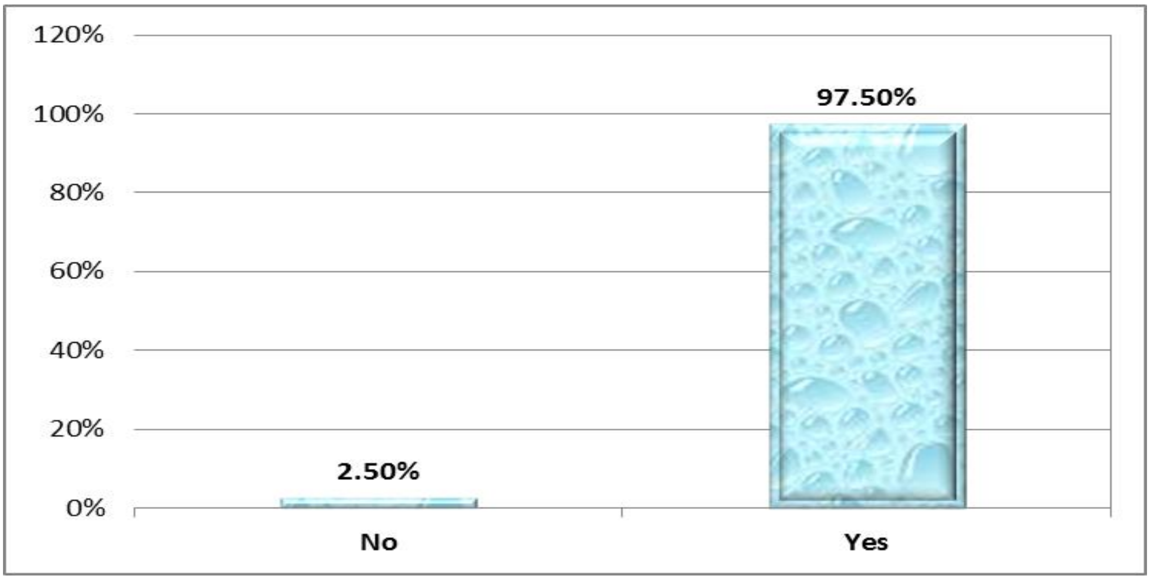

Figure (4.7): ten days rule for female patient

This section evaluates the protection of patients. This question is to important cause women may be pregnant and radiation can kill their babies. 97.5% workers in the sample study ask the female about the ten days rule, and 2.5% neglect this procedure.

- Radiation protection officer within the department.

Table (4.8): radiation protection officer within the department

	Frequency	Percent %
Yes	6	15%
No	34	85%
Total	40	100%

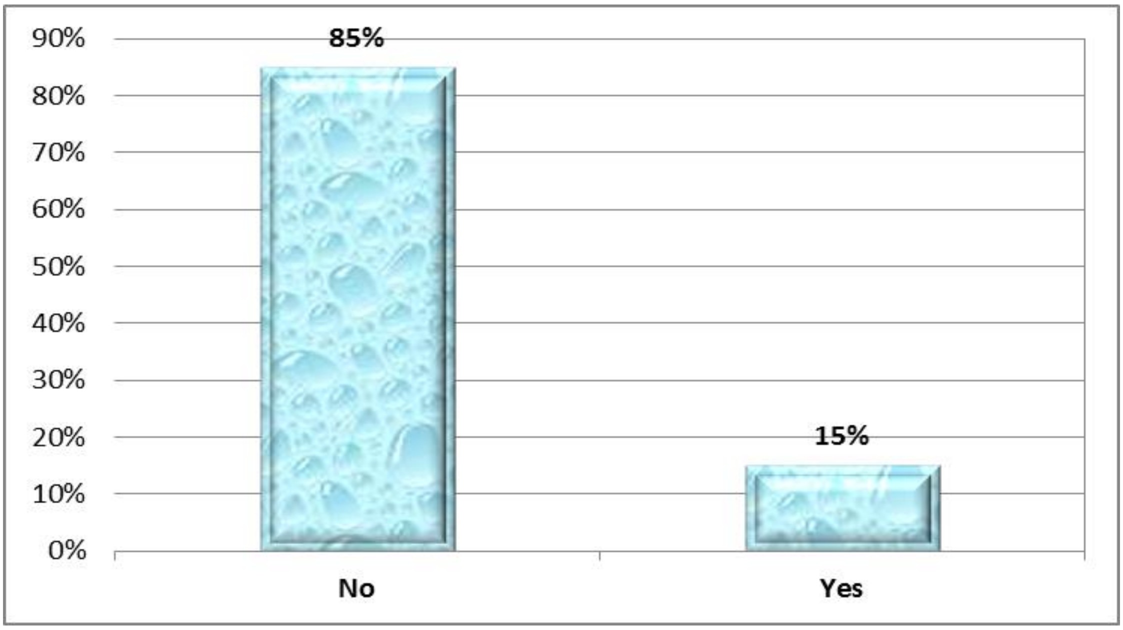

Figure (4.8): radiation protection officer within the department

85% of the hospitals have no radiation protection officer within the department .the radiation safety officer who is responsible for the day to day operations of the radiation safety program.

- The duration of the annual vacations.

Table (4.9): annual vocation

	Frequency	Percent %
15 days	1	2.5%
30 days	17	42.5%
45 days	22	55%
60 days	0	0%
Total	40	100%

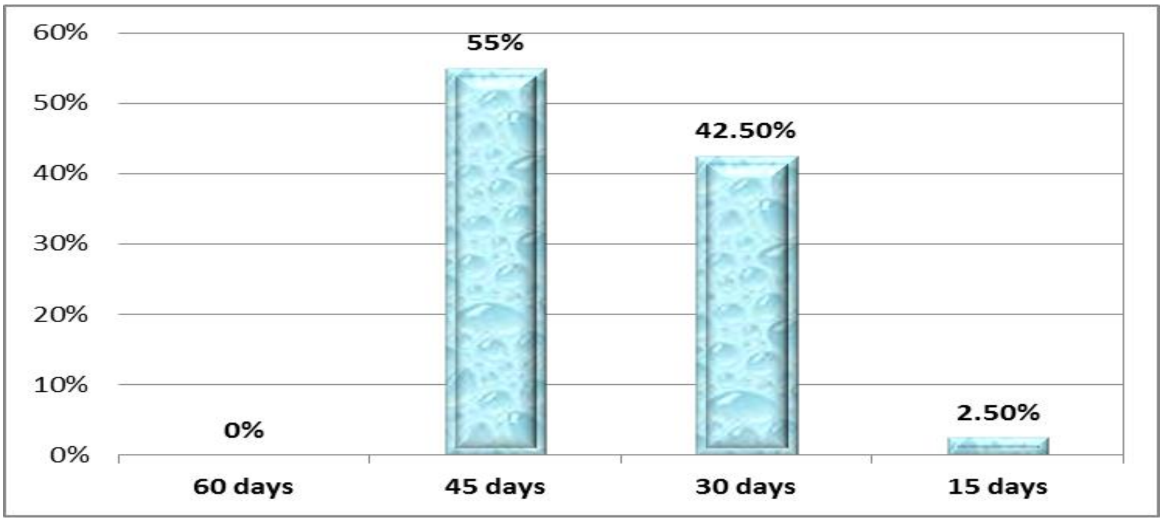

Figure (4.9): annual vocational

The vacation is so important point by means of protection. this question shows the duration of the vacation for workers ,22 (55%)hospitals of sample study have annual vacation of 45 days,17(42%) hospitals have 30 days and one(2.5%) have 15 day.

- Reject analysis system in the department.

Table (4.10): reject analysis system in the department

	Frequency	**Percent %**
Yes	11	27.5%
No	29	72.5%
Total	40	100%

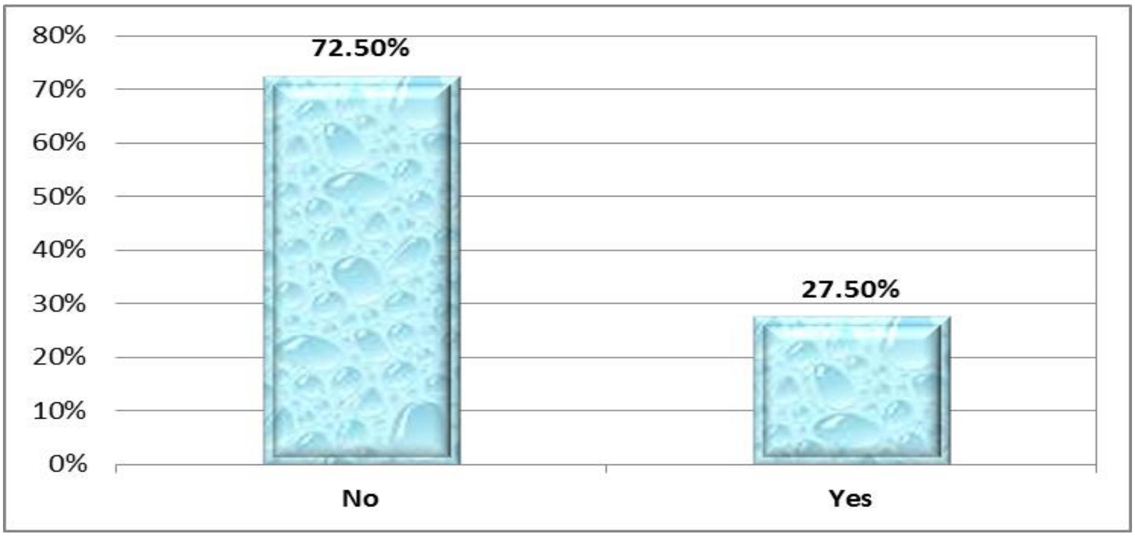

Figure (4.10): reject analysis system in the department

This section shows if the hospital concerned to know the resons that make the radiologist repeat the image or not and this procedure will prevent patient from exposed to unnessesary dose .

72.5 of the radiology department within the hospitals concerned about the reject analysis system and 27.5% of the hospital within the sample of study haven't.

- Asking about previous X-Ray film.

Table (4.11): asking about previous X-Ray film

	Frequency	Percent %
Yes	31	77.5%
No	9	22.5%
Total	40	100%

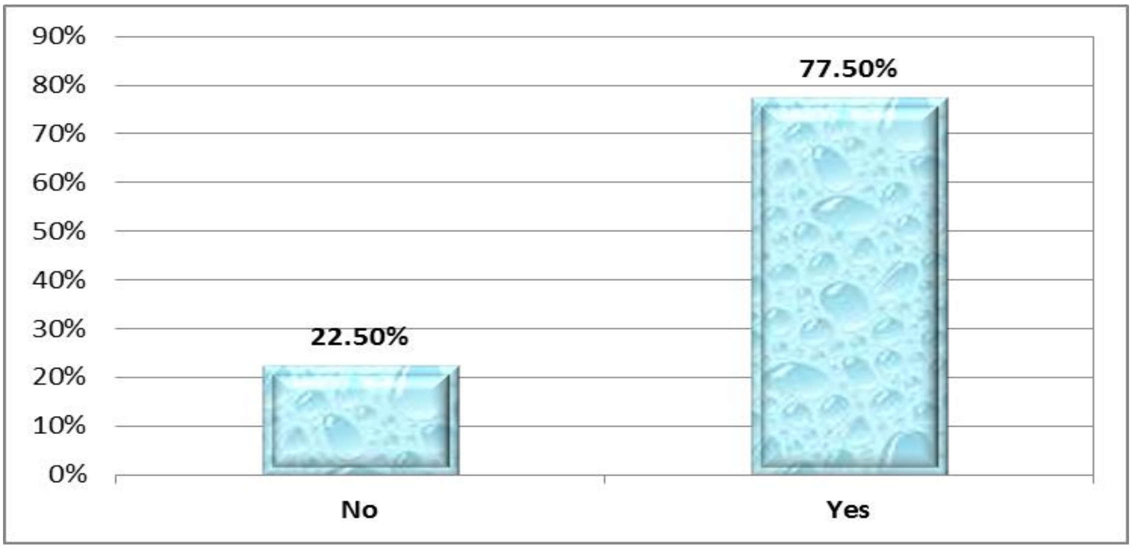

Figure (4.11): asking about previous X-Ray film

This question to protect patient, there're 77.5% of workers ask the patient about the previous X-Ray film and 22.5% didn’t ask.

- Radiation protection available for staff and patients.

Table (4.12): radiation protection available for staff and patients

	Frequency	**Percent %**
25%	0	0%
50%	6	15%
75%	25	62.5
100%	9	22.5
Total	40	100%

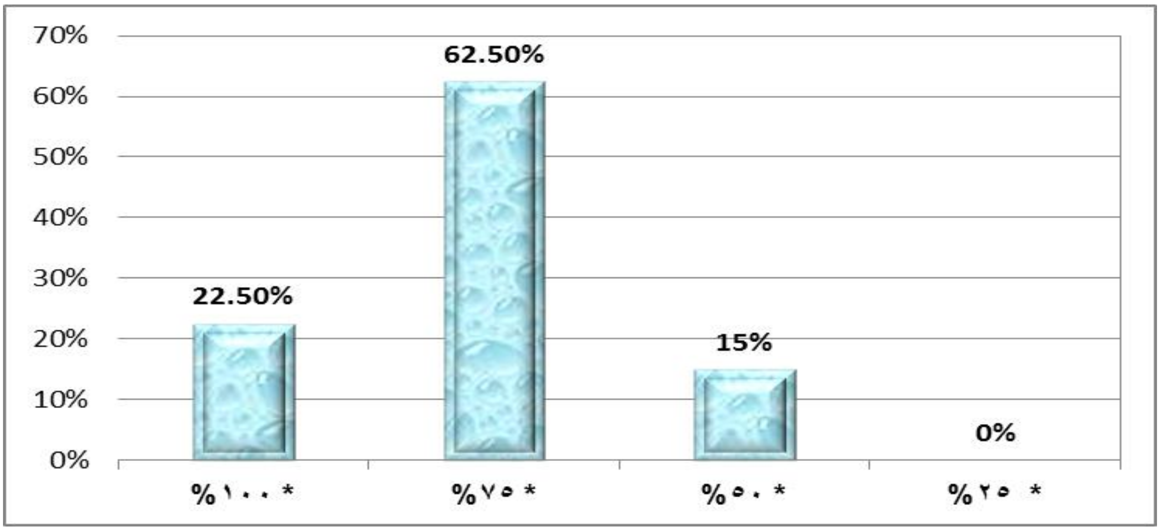

Figure (4.12): radiation protection available for staff and patients

- Table(4.12) and figure(4.12)showing that there is 9 hospitals(22.5%) have 100% radiation protection protocols to their patients and staff ,25(62.5) have 75% of radiation protection protocols,6(15%) have 50% of radiation protection protocol and no one have 25% of radiation protection protocols. Staff must be protected enough to reduce the hazard of disease and cancer.

- Daily working hours for workers.

Table (4.13): daily working hours for workers

	Frequency	**Percent %**
4	1	2.5%
5	0	0%
7	13	32.5%
8	26	65%
Total	40	100%

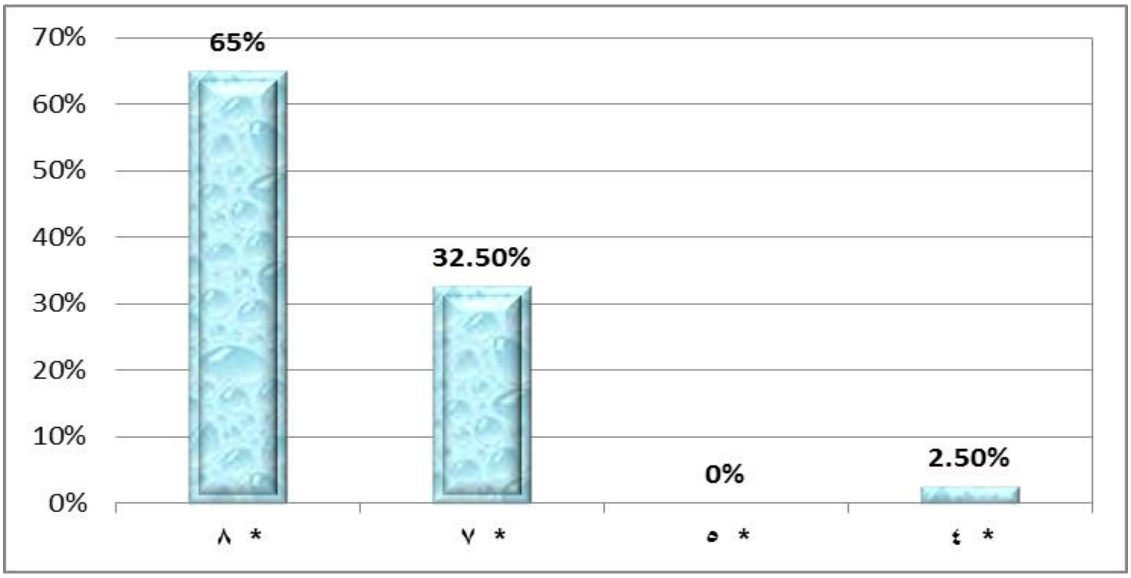

Figure (4.13): daily working hours for workers

Through this question I found that there are 26 hospitals (65%) have 8 working hours per day,13(32.5%) have 7 working hours per day ,one hospital has 4 daily working hours and no one (0%)has 5 daily working hours. Increasing daily working hours that mean workers exposed to more radiation and that means high risk.

- Hospitals license from the SAEC.

Table (4.14): hospitals that got the license from the SAEC

	Frequency	Percent %
Yes	40	100%
No	0	0%
Total	40	100%

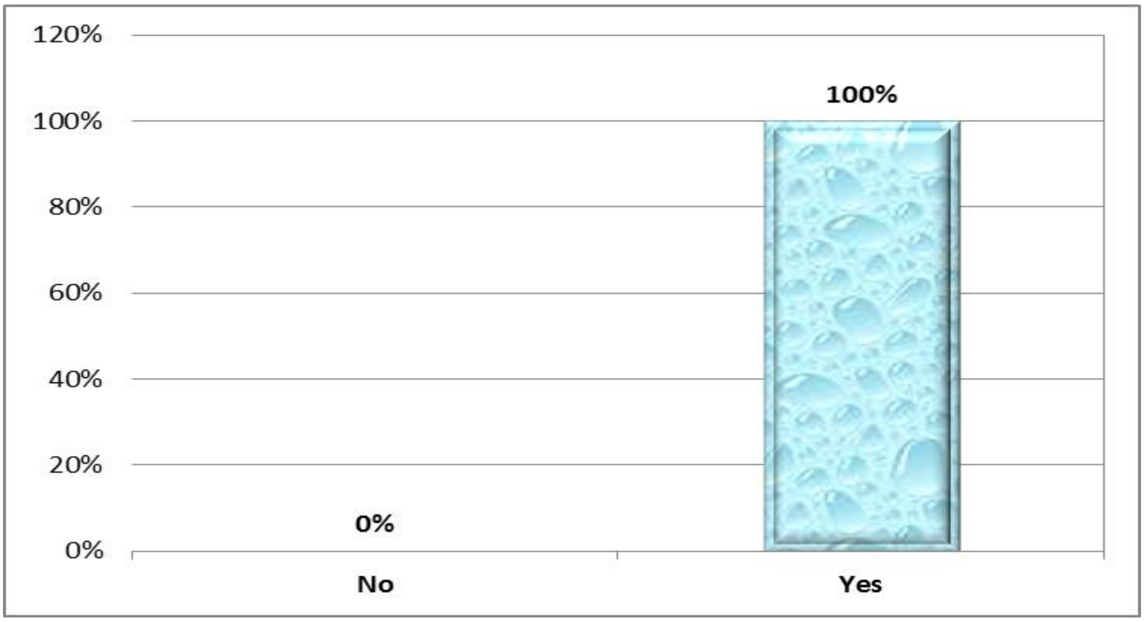

Figure (4.14): hospitals that got the license from the SAEC

The SAEC is the governmental organization in Sudan and it care for the national interest, at both the international and international levels, with respect to the atomic energy affairs.

- Employee's training of the standards of protection.

Table (4.15): training of employees to the standards of protection

	Frequency	Percent %
25%	4	10%
50%	4	10%
75%	22	55%
100%	10	25%
Total	40	100%

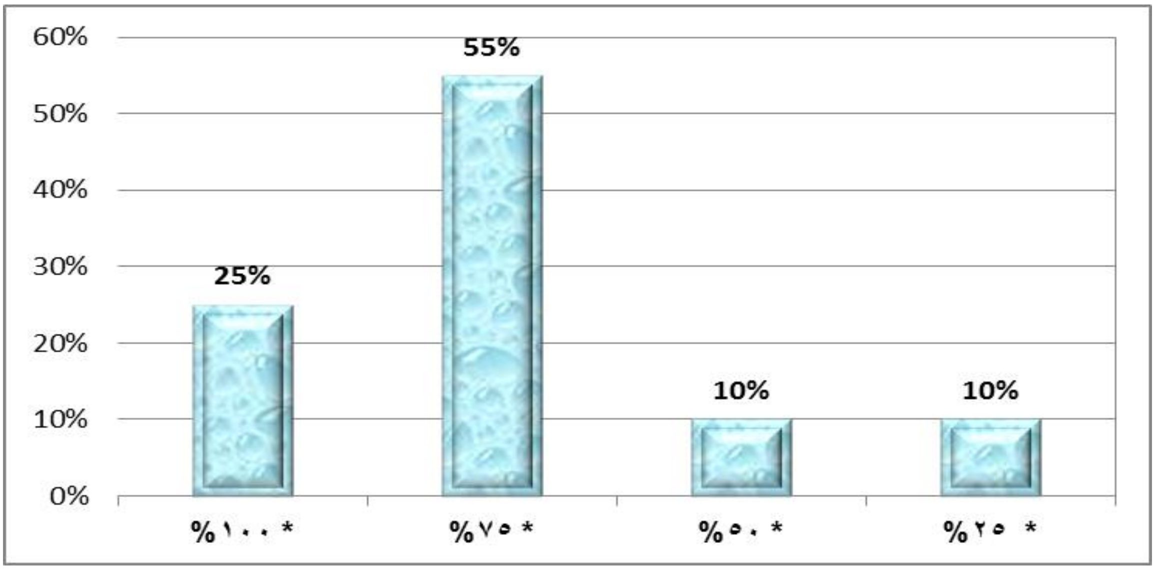

Figure (4.15): training of employees to the standards of protection

The evaluation of trained employee to the standards of protection represent in table(4.15) and figure (4.15), and this is one of most important point in hospitals10(25%) answered they are enough trained,22(55%) answer they are 75% trained,4(10%)said that they are 50% trained ,and 4(10%) said they are 25% trained. If workers don't trained enough that will harm patients.

- QC running routinely in the department.

Table (4.16): running of QC in the department

	Frequency	**Percent%**
Yes	11	27.5%
No	29	72.5%
Total	40	100%

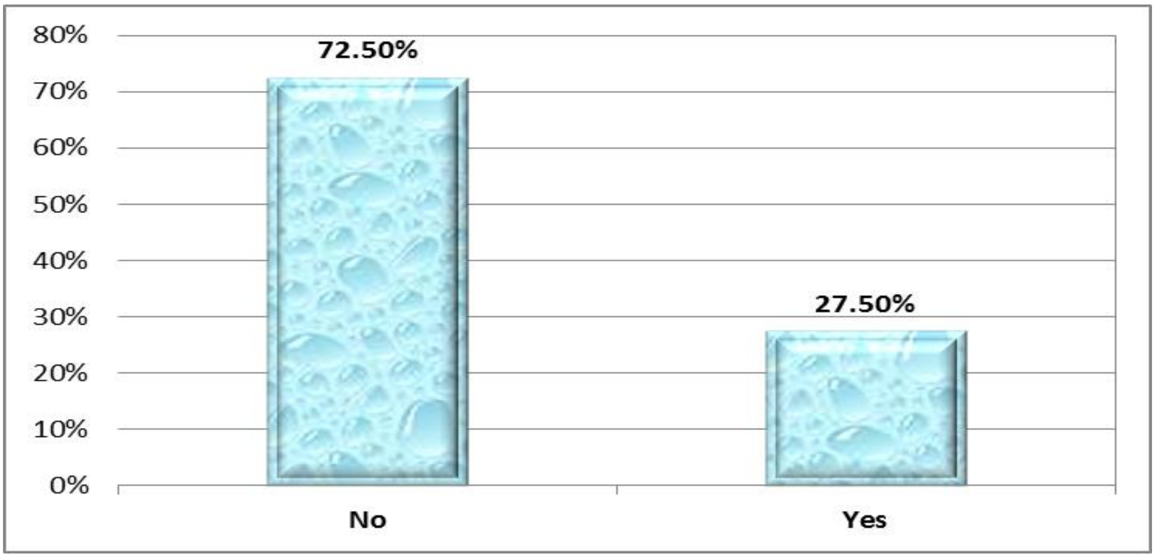

Figure (4.16): running of QC in the department

This analysis is the most important question that shows if they apply the quality control proceedure in our hospitals.the answer present that 29 (72.5) say yes they are applly QC and 11(29%)of sample study said no.

4.3 Result of data analysis:

Tale (4.17) illustrates the result of the most effective questions of questionnaire.

Table (4.17): Result of data analysis:

Meals for workers	TLDs	Radiation protection officer within the department	Reject analysis system	Asking about X_Ray previous film	QC running annually
15%	5%	15%	27.5%	77.5%	27.5%

5.1 Department design:

The area of diagnostic imaging is currently undergoing great change, with hospitals becoming more and more reliant on the use of digital imaging techniques. There is a requirement to create adaptable facilities, in order to meet the pace of clinical and technological development, not only in patient diagnosis and treatment, but also in many other aspects of care and organization.

Radiology Department is located on the western side of the hospital, Services for patients with non- residents numbering between (20-25) in a day, department site makes it easy to access.

5.1.1 X-Ray **room design:**

Radiology room dimensions 5*4, and control room adjacent to the X-Ray room, there’s door between them coated with lead and window which the patient is monitored through it. Ground is ceramic and the wall also were coated.

5.1.2 Equipment specification:

X-Ray that use in hospital which leakage radiation measured in it is a mmobile X-Ray unit (shimandzu Japan) with specifications shown in table (5.1).

Table (5.1): Specifications of X-Ray

40 kv	150 kv
0.51 mAs	80 mAs

5.2 Measurement tools:

Calibrated RADos was used for measurement figure (5.1A and B), to check the staff and patient safety.

The X-Ray sensors are orientation independent so the only thing you need to do is to place it in the X-Ray beam and turn on the instrument. The rest is automatic – no menus, no selections.

A RADOS system typically consists of a large collection of standard commodity servers, also known as storage nodes. Common use cases for a Ceph RADOS system are as a standalone storage system or as a back end for Open Stack Block Storage.

RADOS has the ability to scale to thousands of hardware devices by making use of management software that runs on each of the individual storage nodes. The software provides storage features such as thin provisioning, snapshots and replication. An algorithm called controlled replication under scalable hashing (CRUSH) determines how the data is replicated and mapped to the individual nodes.

5.2 Specification of RADos:

Certificate No :SAEC/36/016

Date of calibration: 4\\5\2016

Calibration factor C=0.97

Re Calibration Due: 4\5\2017

Khartoum _Sudan

0.05µrem/h	10Sv/h
5µrem/h	1000rem/h

Figure (5.1A):**RADos**

Figure (5.1 B):**RADos**

5.3 Procedure:

The measurements take place during a chest X-Ray and abdomen examination with three different exposure factors, the measurement point concerned on the lead glass window and the door as shown in fig(5.2 C and D), result illustrated in table (5.1) and table (5. 2).

Fig (5.2 C): measurement procedure

Fig (5.2 D): measurement procedure

5.4 Result:

Result during chest examination (mAs=12).

Table (5.2) measure the leakage at the glass window

KVP	Leakage µsv/h
52	0.2
57	0.3
60	0.4

Result during abdomen examination (mAs=20).

Table: (5.3) measure the leakage at the door.

KVP	**Leakage μs/|h**
78	0.7
80	0.8
85	1

5.5 Discussion:

The result from the practical; that done by measuring the radiation leakage via chest and abdomen shows that leakage increasing while KVP increased. That mean the door and the window need to re protect to avoid hazard and leakage.

Discussion:

The purpose of radiation protection is to provide an appropriate level of protection for humans without unduly limiting the beneficial actions giving rise to radiation exposure. Radiation protection is to prevent the occurrence of harmful deterministic effects and to reduce the probability of occurrence of stochastic effects (e.g. cancer and hereditary effects).

The implementation of radiation protection for patients, technicians, and public is inevitable, and is mainly a vital responsibility of every radiation personnel either manager or worker. The safety of all radiological and medical imaging centers in Sudan is controlled by the SAEC, these radiation centers must meet compliance or otherwise they would face penalty. Safety Standards can only be implemented through an effective radiation safety infrastructure. The results of this study reveal low personal and environmental radiation monitoring by hospitals in Khartoum state. Also it was noticed during field visits in this study, that there is poor record keeping in both private and government hospitals, but it is worse in private hospitals, with limited space and lack of reference tools records, that mean poor safety as shown in figure (4.3). This means if old X-Ray sheet lost repeat X-Ray will be done with more radiation exposure for both patients and technicians.

The personal protection requirements of workers and patients in the radiated area is one of the basics preventive measures in all health care & radiation safety policies, but Sudanese technicians still suffer from carelessness and lack of knowledge about these basics. In addition the governmental facilities have a poor work environment, lowest availability of radiation safety tools (apron, gloves, and glasses) regarding to safety and security system. Also there is a big problem about equipment; many of them don’t meet neither international nor Sudanese standards and still under use. Also they use out of date equipment includes equipment which needs to be replaced, discarded or need maintenance.

Shielding is essential issue in radiology department to protect the patients and popular (when not being examined), the X-Ray department staff, visitors and the public and persons working adjacent to or near the X-Ray facility

Unfortunately, this study revealed the poor shielding lead plaster/lead lining of walls and some doors, so X-Ray rooms are not protected as it must be in standards. There was a poor availability of lead rubber aprons in governmental and private hospital and technicians were poorly use these safety devices.

In the field of radiation, a dosimeter is a measuring device used to measure radiation dose, and it cannot be applied as a radiation protection tool. To measure an occupational radiation, it is well known that the Sudanese worked policy depends on a committee from the SAEC that have a visit every a considerable time, to the hospital, to ensure that the occupational dose is within the permissible limit. Personal dosimeters must be worn by all X-Ray workers while on duty .In this study only 5% of technicians mentioned that dosimeter are available in their work places.

Unfortunately, this study revealed in some hospitals the equipment didn’t positioned so that the primary radiation beam is directed at the operator’s console, windows, doors, offices, and waiting areas.

This study reported that most Sudanese technicians, working at Khartoum, have poor awareness to radiation hazards, radiation safety standards, and importance of radiation safety. This may be due to the lack of both personal and environmental safety devices in their work place, or it may be due to their carelessness to wear PPE (Personal Protective Equipment) during any imaging procedure, it should be strongly recommended them to improve their knowledge around importance of wearing PPE, and update them through growing their expertise. PPE reduces the risk of injury or harm to users caused by hazards present in the workplace. PPE is ultimately used to minimize the risk of injury, which can be include injuries to the lungs (from breathing in contaminated air), the head and feet (from falling materials), the eyes (from flying particles or splashes of corrosive liquids), the skin (from contact with corrosive materials and the body (from extremes of heat or cold).

The most important results is the radiation protection are not applied as it should in the X-Ray centers, and most important things that there is no device to measure personal exposure for technicians. The reason of that is the high cost of hardware and calibration fees

Ionizing radiation presents an invisible form of health hazard to users of radioactive substances and irradiating apparatus. Although the common radiation quantity encountered in an academic setting is usually relatively low, the cumulative effects could be significant. Therefore personal protective equipment must be used, and exposure monitoring performed, to ensure the safety of radiation workers. Thermoluminescent Dosimetry (TLD) is the primary form of personnel radiation exposure monitoring.

The floor of the X-Ray room didn't shielded for the primary radiation beam. The operator's console area should be located so that: it is adjacent to the staff entrance door; the operator has a clear panoramic view of the patient and the access doors to the room; and radiation is scattered at least twice before entering the protective area but Sudanese technicians still suffer from carelessness and lack of knowledge about these basics .

The protective screen should be at least 2 m in height and of sufficient width to allow at least two people stand behind the screen during an exposure, unfortunately in all hospital in a population that is not achievable.

In the other hand the 10-day rule was established by the International Commission on Radiological Protection to minimize the potential for performing X-Ray exams on pregnant women. The basis of the rule was to do abdominal and pelvic X-Ray exams only during the 10 days following the onset of menstruation. We know much more today about radiation and pregnancy, and we know that substantial doses (~10 rem; more than is received from routine diagnostic medical X-Ray exams) are necessary to cause birth defects or malformations. Since organogenesis starts 3 to 5 weeks post conception, it was felt that radiation exposure in early pregnancy couldn't result in malformation. Now the focus is shifted to a missed period and the possibility of pregnancy. If there is a missed period, a female should be considered pregnant unless proved otherwise. In such a situation, every care should be taken to explore other methods of getting the clinical information by performing exams that do not use ionizing radiation. The radiation dose to the unborn child should be estimated by a medical physicist/radiation safety specialist experienced in dosimetry. The patient can then be advised about potential risks.

This study revealed that one of the root causes of excessive radiation exposure arises from the fact that many in the healthcare field who work with radiation have received only rudimentary radiation training. Training programs on radiological protection; image quality and equipment; the biological effects and risks of ionizing radiation; lesions in patients and operators; patient’s reference levels; occupational dose limit and preventive actions. The use of ionizing radiation involves risks that are justified in diagnostic and therapeutic procedures. The awareness and knowledge of these risks minimizes the damage, optimizing the quality of images and safe use of ionizing radiation.

The study reported low degree in their knowledge of radiation protection program, indicated the need for additional awareness, and lack of some important protection tools. The level of radiation protection improved by recommendation that was illustrated which would assist them in minimize the risks to people with in radiation area.

Commonly there is no cooperative from the most hospitals staff specially the workers in this field, and that can be an obstructed of all researchers and their aims to improve the radiation protection.

7.1 Conclusion:

Radiation survey for diagnostic radiology was done in 12 different hospitals around the Khartoum State. Personnel monitoring for radiation workers is a serious problem. The result shows that around 95% of workers are not monitored for radiation. The medical physicists surveying observed that TLDs are not applied for personnel monitoring. There is a great need for rules, and regulations of radiation protection act in the field of radiation in medical field. QC schedules not follows as it should be.

The work show that, applied of radiation protection procedure in the Khartoum State hospitals are not sufficient enough to give the purpose employed it, that were evident by the above studies e.g. availability of Thermal Lumen enthuse Detectors (TLDs) which is 5%, meal that provided to the workers which is 15%.

7.2 Recommendations:

- An ideal design and proper installation, continuous quality program should be applied.
- Safety equipment should be provided to all radiological departments.
- The safety committee's role should be more than monitoring the occupational dose, and there periodic visits duties should include general updating revisions to all most recent safety procedures for staff and patients.
- Actively participating in quality assurance programs organization-wide (use of image wisely, image gently approach) and promoting this participation to community.
- Continuing education and professional developed programs chances should be provided to staff members in order to keep skills and knowledge up to date to achieve high standard work.
- The technician should fowled exposure factors chart.
- Special considerations should apply regarding to the females (workers, patients).

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