**Deanship of Graduated Studies**

**Al-Quds University**

# "Assessment of Radiation Protection Awareness, Policies and Practices among Palestinian Radiographers in Governmental Hospitals-Palestine."

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**M.Sc. Thesis**

**Jerusalem-Palestine**

**1439/2018**

# “Assessment of Radiation Protection Awareness, Policies and Practices among Palestinian Radiographers in Governmental Hospitals-Palestine.”

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**A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Environmental and Earth Science/Graduated Study, Al-Quds University.**

**1439/2018**

Al-Quds University
Deanship of Graduate Studies
Environmental and Earth Science

**Thesis Approval**

**"Assessment of Radiation Protection Awareness, Policies and Practices among Palestinian Radiographers in Governmental Hospitals-Palestine."**

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Master thesis submitted and accepted, Date: 19th May, 2018

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Jerusalem-Palestine

1439/2018

## Dedication

I dedicate this dissertation to my beloved parents; Fathieh and Hassan; May GOD let them rest in mercy and peace.

To my well-regarded sisters and brothers, and

To those who treasure Palestine as a homeland.

To the people of Palestine, in an attempt to create a safer health care system by encouraging the responsible use of technology.

Mohammad Saeed Hassan

## Declaration

I certify that this thesis submitted for the degree of Master, is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed:

Mohammad Saeed Mohammad Hassan

Date: 19/05/2018

## Acknowledgments

*I highly express my special thanks and gratitude to my supervisor: Dr. Adnan Lahham for his efforts, direction and supervision. I will never forget such a cordial supervisor. Without his support, this work could not be achieved.*

*I am very grateful to all radiographers who have devoted some of their time to help me complete this study.*

*I deeply thank my beloved family who stood by me and supported me throughout the process of the completion of this research project.*

*"By exploring how the lens of radiology has changed our medical vision, we can better understand what radiologic imaging reveals and avoid the mischief that might result from failing to recognize the blind spots of this technology."*

*Richard B. Gunderman*

## Abstract

This study aimed at assessing the radiation protection awareness and knowledge levels, practices and policies of radiation protection, while the main goal was to develop and promote an approach to the radiation protection policy dealing with the awareness and management structure and regulate the policies of utilizing medical imaging uses in governmental hospitals in the West Bank, Palestine. A written seven-page questionnaire (interview schedule) booklet was constructed from previously used questionnaires. The study was carried out over a 9-month period from June 2017 to February 2018. One hundred forty-two ($n$=142) responded to the study, of them 10 respondents were excluded for the pilot study, yielding (89.3%) response rate.

The study showed that male participants represented ($n$=127; 96.2%), the highest percentage ($n$=71; 53.8%) were less than 10 years' experience, while the job tenure ranged from 1-33 years, whereas the vast majority of radiographers ($n$=114; 86.4%) attained the bachelor degree. The study revealed that the percentage of awareness and knowledge of radiation protection, policies, and practices among Palestinian radiographers was (67.93%), (43.33%) and (67.94%), while the overall percentage score was relatively inadequate (59.73%). About 5.2% did not know what as low as reasonably achievable (ALARA) stands for. Furthermore, knowledge of organ sensitivities to ionizing radiation was not encouraging as expected as about (25%) underestimated or did not know the right answer. Strikingly, (22%) of the study subjects wrongly estimated or did not know that magnetic resonance imaging (MRI) does not emit radiation. More than (37%) were always adherent to wear personal protective equipment (PPE). It is not surprising that the vast majority (84.4%) of radiographers never had or rarely attended specific training events about radiation protection. About half of respondents had a positive attitude about having a manual guidance clarifying radiation protection guidelines, policies and regulations issued and governed by MoH. Imprecisely, about half of radiographers overestimated approximate effective dose received by a patient in a single-view chest x-ray. Outstandingly, less than half do not trust thermolumencent dosemeter (TLDs) readings. Furthermore, results showed there were significant differences between the knowledge and awareness and gender variable, whereas the females possessed better radiation protection knowledge and awareness compared with males. In the multiple regression model, the most item that affected practice was the academic level ($p$=0.004), nonethless, gender did not reach statistical significance.

It is notable that the evaluation of the radiation protection awareness, policies and practices is essential. Results showed that a marginal number of radiographers received radiation safety training. Education is ultimately the only way to increase awareness of the potential risks of ionizing radiation, leading to changes in behaviour and practice, especially in view of optimisation, justification and dose limitation. The non-differentiation of the variation between stochastic and the non-stochastic effects of radiation signifies that they were unaware of the probability of occurrence of radiation biological damage, either by underestimation or by overestimation of radiation biological hazard effects. National legislations in Palestine are lacking; such enactment of laws and regulations will give impetus to regularization of radiographic practice to conform to international safety standards. Adherence to safe radiation

practices was violated by most of radiographers especially using personal protective equipment (PPE). However, radiographers in governmental hospitals were generally apathetic to radiation protection practices.

All radiographers should ensure a harsh adherence to radiation safety practices. Intervallic quality assurance tests should be enforced. A '**Palestinian Radiation Protection Initiative (PRPI)**' is proposed in this study with a novel philosophy, concept and methodology. The present initiative details the discussions and recommendations derived from the International Commission on Radiological Protection (ICRP) and the Global Initiative on Radiation Safety in Health Care Settings convened by WHO in 2008. The researcher proposes this initiative to muster the health sector towards a safer and applicable use of radiation in health care. This initiative aims to assemble health authorities, national organizations, professional bodies, scientific societies, academic institutions and experts in concerted actions to improve the implementation of radiation protection procedures in medical imaging settings. It consists of eight (8) members from the four (4) universities, Ministry of Health (MoH) and the Palestinian Medical Imaging Association (PMIA) for enhancing collaboration and engaging key stakeholders and proposing a roadmap. The MoH will work with the stakeholders to develop and implement this initiative on radiation protection, which aligns with the WHO agenda to: indorse development; promote health security; fortify health systems; bind research, information and evidence; enrich partnerships; and improve performance. Hopefully, this initiative is to be duly incorporated by reference and enthusiastically to be considered legally binding upon all citizens, health bodies and educational organizations of Palestine.

**تقييم الوقاية الاشعاعية؛ الوعي والممارسات والسياسات بين فنيي الاشعة والتصوير الطبي الفلسطينيين في المستشفيات الحكومية في فلسطين**

**ملخص**

**إعداد: محمد سعيد محمد حسان**

**إشراف: د. عدنان اللحام**

هدفت هذه الدراسة إلى تقييم مستويات الوعي والمعرفة والممارسات في الوقاية من الإشعاع الطبي، في حين كان الهدف الرئيسي هو تطوير وتسويق نهج لسياسة الحماية من الإشعاع التي تعالج الوعي والإدارة، وتنظم سياسات استخدام التصوير الطبي في المستشفيات الحكومية في الضفة الغربية، فلسطين.

تم تطوير إستبانة مؤلفة من سبع صفحات (جدول مقابلة كبديل) من إستبانات ودراسات سابقة. تم إجراء الدراسة على مدى فترة 9 أشهر من يونيو 2017 إلى فبراير 2018. وقد استجاب للدراسة مائة واثنان وأربعون ($n$=142) من أصل ($n$=159) مبحوثاً، استُثني منهم 10 للدراسة التجريبية، مما أسفر عن معدل استجابة (89.3%).

أظهرت الدراسة أن المشاركين الذكور يمثلون ($n$=127; 96.2%)، وكانت النسبة الأعلى ($n$=71; 53.8%) أقل من 10 سنوات من الخبرة، في حين تراوحت مدة العمل بين 1- 33 سنة، كما أن الغالبية العظمى من الفنيين ($n$=114; 86.4%) حاصلون على درجة البكالوريوس. وقد أثبتت هذه الدراسة أن النسبة المئوية للوعي والمعرفة بالوقاية من الإشعاع والمعرفة والسياسات والممارسات بين فنيي الأشعة والتصوير الطبي الفلسطينيين في المستشفيات الحكومية بلغت (67.93%) و (43.33%) و (67.94%) على التوالي، في حين كانت النسبة المئوية للوعي الكلي غير كافية نسبياً (59.73%). هناك حوالي (5.2%) لا يعرفون ما ترمز إليه (ALARA). وعلاوة على ذلك، فإن معرفة الأعضاء الأكثر حساسية للإشعاع المؤين لم تكن مشجعة كما كان متوقعاً، حيث أن حوالي (25%) من أفراد العينة قدروا باستخفاف أو لم يعرفوا الإجابة الصحيحة. ومن المدهش حقاً أن (22%) ممن خضعوا للدراسة قد أساؤوا التقدير أو أنهم لم يعرفوا أن التصوير بالرنين المغناطيسي لا ينبعث منه الإشعاع. أكثر من (37%) كانوا دائماً ملتزمين بارتداء معدات الوقاية الشخصية (PPE). وليس من المستغرب أن الغالبية العظمى (84.4%)من الفنيين أنهم نادراً ما حضروا أو لم يحضروا نهائياً دورات تدريبية محددة حول الوقاية من الإشعاع. وقد أفاد حوالي نصف الفنيين بوجود دليل إرشادي يوضح مبادئ وسياسات للوقاية من الإشعاع صادر عن وزارة الصحة، كما أظهر نصف

الفنيين بشكل غير صائب أنهم قد بالغوا في تقدير الجرعة الفعالة التقريبية التي يتلقاها المريض بعدد مماثل لصورة الصدر بالأشعة السينية. وبشكل إستثنائي، فإن أقل من النصف لا يثقون بقراءة مقياس التألق الحراري (TLD)، كما أظهرت النتائج وجود فروق ذات دلالة إحصائية بين المعرفة والوعي ومتغير الجنس، في حين أن الإناث لديهن معرفة ووعي أفضل في مجال الوقاية من الإشعاع مقارنة بالذكور. في نموذج الإنحدار المتعدد، كان معظم العناصر التي أثرت على الممارسة المستوى الأكاديمي ($p$=0.004)، ومع ذلك، فإن الجنس لم يرتق إلى مستوى الدلالة الإحصائية.

من الجدير بالذكر أن تقييم وعي فنيي الأشعة حول الوعي والسياسات والحماية من الإشعاع أمر ضروري. وتظهر النتائج أن عددا هامشياً من الفنيين تلقى التدريب على السلامة الإشعاعية. والتعليم هو في نهاية المطاف السبيل الوحيد لزيادة الوعي بالمخاطر المحتملة للإشعاع المؤين، مما يؤدي إلى تغييرات في السلوك والممارسة، ولا سيما في ضوء التحسين (الأمثلة) والتبرير والحد من الجرعة. إن عدم التفريق بين التأثير العشوائي الحدوث والتأثير الحتمي للإشعاع يدل على أنهم لا يدركون احتمال حدوث ضرر بيولوجي إشعاعي، إما من خلال التقدير المغالى فيه أو الإستخفاف بتقدير آثار المخاطر البيولوجية الإشعاعية. في السنوات القليلة الماضية، قطعت وزارة الصحة الفلسطينية شوطاً مهماً في تطوير قطاع التصوير الطبي، من حيث تطوير نوعية الأجهزة المستخدمة إلى استخدام أنظمة رقمية، واستحداث دليل للسياسات والإجراءات في أقسام التصوير، وتدريب بعض الكوادر وقد سبق كل ذلك استحداث الإدارة العامة للخدمات الطبية المساندة، وما تلا ذلك أيضاً من تطوير للهيكلية الإدارية في قطاع التصوير الطبي في وزارة الصحة. تؤكد هذه الدراسة أن تطبيق أنظمة الوقاية الإشعاعية وفق المعايير العالمية هو جهد تراكمي متواصل يستدعي تظافر كل الجهود ذات العلاقة، وفي مقدمتها قطاع البحث العلمي في الجامعات، وتسعى هذه الدراسة إلى تقديم دراسة ميدانية تقدم وصفاً رقمياً للواقع وتتمنى أن تشكل إضافة نوعية ومساهمة في مسيرة الجهد الدؤوب الذي تقوم به وزارة الصحة الفلسطينية من أجل تطوير منظومة الوقاية الإشعاعية. غير أن التشريعات الوطنية في فلسطين غير متوفرة، وإن هذه التشريعات –لو سُنّت–ستُعطي زخماً لتسوية الممارسات الإشعاعية لتتوافق مع معايير السلامة الدولية لأجل إقرار تشريعات وقوانين ذات العلاقة. تم انتهاك ممارسات الإشعاع المأمونة من قبل معظم الفنيين، وخاصة باستخدام معدات الوقاية الشخصية (PPE) أثناء تنفيذ الإجراءات، ومع ذلك، فإن الفنيين في المستشفيات الحكومية كانوا غير مبالين لممارسات الحماية من الإشعاع بشكل عام.

وينبغي أن يبدي جميع فنيي الأشعة والتصوير الطبي إلتزاماً صارماً بممارسات السلامة الإشعاعية، وينبغي عليهم كذلك تنفيذ اختبارات ضمان الجودة بشكل دوري. كما وتقترح هذه الدراسة إطلاق "**المبادرة الفلسطينية للوقاية من الإشعاع**" (PRPI) بفلسفة مُستَحْدَثة ومُبتكَرة ومفهوم ومنهجية جديدة، تشرح المبادرة الحالية بالتفصيل المناقشات والتوصيات المستمدة من المبادرة الدولية للوقاية من الإشعاع والمبادرة العالمية بشأن السلامة الإشعاعية في إعدادات الرعاية الصحية التي عقدتها منظمة الصحة العالمية في عام 2008. يقترح الباحث هذه المبادرة لحشد قطاع الصحة نحو استخدام أكثر أمناً وقابلاً للتطبيق للإشعاع في الرعاية الصحية. وتهدف هذه المبادرة إلى توحيد وتضافر جهود السلطات الصحية، والمنظمات الوطنية، والهيئات المهنية، والمؤسسات العلمية والأكاديمية والخبراء من أجل تحسين تنفيذ إجراءات الحماية من الإشعاع في عملية التصوير الطبي. وتتكون هذه المبادرة من ثمانية (8) أعضاء من جامعات الوطن الأربع (4) ووزارة الصحة (MOH) ونقابة التصوير الطبي الفلسطينية (PMIA)لتعزيز التعاون وإشراك أصحاب الشأن الرئيسيين واقتراح خارطة طريق. وهذه المبادرة الوطنية تقودها وزارة الصحة الفلسطينية بالشراكة مع قطاع البحث العلمي في الجامعات ونقابة التصوير الطبي لتطوير سياسة الوقاية الإشعاعية. ستعمل وزارة الصحة وبالشراكة مع أصحاب المصلحة على تطوير وتنفيذ هذه المبادرة بشأن الحماية من الإشعاع، والتي تتماشى مع جدول أعمال منظمة الصحة العالمية من أجل: تعزيز الأمن الصحي؛ تعزيز النظم الصحية؛ ربط البحوث والمعلومات والأدلة؛ إثراء الشراكات وتحسين الأداء. نأمل أن يتم دمج هذه المبادرة حسب الأصول وحماسة ليتم اعتبارها ملزمة قانونًا لجميع المواطنين والهيئات الصحية والمؤسسات التعليمية في فلسطين.

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## List of Acronyms and Abbreviations:

| Abbreviation | Abbreviations Expansion |
|---|---|
| ALARA | As low as reasonably achievable |
| ARS | Acute Radiation Syndrome |
| CPHL | Central Public Health Laboratory |
| CT | Computed tomography |
| CXR | Chest X-Ray |
| ED | Emergency Department |
| ICRP | International Commission on Radiological Protection |
| LNT | Linear non-threshold |
| MDCT | multidetector computed tomography |
| MIT | Medical Imaging Technologist |
| MRI | Magnetic Resonance Imaging |
| NBG | Natural Background Radiation |
| PMIA | Palestinian Medical Imaging Association |
| PRPI | Palestinian Radiation Protection Initiative |
| PPE | Personal Protective Equipment |
| RCR | Royal College of Radiologists |
| RP | Radiation Protection |
| TLD | Thermoluminescent Dosimeters |
| UNSCEAR | United Nations Scientific Committee on the Effects of Atomic Radiation |
| US | Ultra Sound |

# Chapter One: General Introduction

## 1.1 Introduction

The growing utilization of medical imaging has improved the eminence of health care, and swayed even those critical clinicians who initially had counted more on the clinical examination than on imaging data. The use of radiation in medical practices has evolved since its beginning, and 30% to 50% of medical decisions are based on radiological examinations. However, it is still limited by its relevant hazards to patients and healthcare providers (Sani et al., 2009). Medical ionizing radiation deliver the major contribution from artificial sources while most of this contribution comes from diagnostic x-rays (above 90%) (Sullivan et al., 2010). The large number of x-ray examinations executed annually is the leading cause for this situation. A report issued by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2000) approximates that the yearly number of all forms of medical x-ray examinations carried out in the world was about 2100 million in 2000, conforming to a yearly frequency of 360 examinations per 1000 persons globally. This rate of recurrence is about 10% higher than the previous estimate of 330 per 1000 for the period 1991–1995 indicating an increase in practice. The prospective stochastic and even deterministic detriments of ionizing radiation to humans have become broadly discussed in medicine, among patients, in the media and by policy makers. It is fundamental that medical imaging radiographers[1] should be entirely aware of these detriments, to independently understand their scientific basis and to apply medical diagnostic and interventional radiation cautiously, considering the benefits with the risks, and to assist the community to accomplish the best use of imaging tools. Hence, radiation protection has become a top priority of the medical imaging radiographers (Shiralkar et al., 2003). Ionising radiation in medical applications stands for the majority of radiation doses from artificial sources to which the general population is exposed. This is the outcome of a progressively increasing stipulate for radiological examinations with exacting situation to computed

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[1] ***Radiographers***: *also known as radiologic technologists, diagnostic radiographers and medical radiation technologists are healthcare professionals who specialise in the imaging of human anatomy for the diagnosis and treatment of pathology. Radiographers are infrequently, and usually erroneously, known as x-ray technicians, however, in our study, we used the most popular term "radiographer", while in other literature studies the other terms are used interchangeably.*

tomography (CT), which alone accounts for about 50 % of the synoptic medical radiation exposure (Hricak et al., 2011). Nevertheless, this has been accompanied by a rich development of imaging technology over the last decade; it is often degenerated by an indigence of appropriateness and optimisation criteria by both referring physicians and radiological staff (Brenner et al., 2007; Mettler et al., 2008; Costello et al., 2013). The average radiation dose received annually by the public is 2.5 mSv, and 15% of them are related to medical exposures. Among all radiological examinations, the doses of CT are the highest. The typical exposure dose for an abdominal CT is 9 mSv and that for one chest radiograph is 0.02 mSv. The dose of radiation given in any diagnostic procedure should be enough to answer the relevant clinical question, but as low as reasonably achievable to lower the risk to the patient, as well as the radiographer (Sullivan et al., 2010). Thus, it is important that doctors who request imaging are well-trained in deciding the diagnostic imaging indicated, and have an accurate knowledge of the associated risks. Likewise, there is diminutive or no understanding by the requesting medical doctors. Though this has been accompanied by an accelerated progress of imaging technology, it is often worsened by a lack of appropriateness and optimisation criteria by both referring physicians and radiological staff. Inopportunely, the studies show that there is a wide spread underestimation of radiation doses among pediatricians and physicians. An understanding of radiation safety principles and their application in practice are critical for all health care workers.

International Commission on Radiological Protection (ICRP) in 1977 proposed that patients must go through exposures of low dose and accounted for their exposures (ICRP, 1977). Therefore, As Low as Reasonably Achievable “ALARA” principle was made compulsory during dentist routine work (White and Pharoah, 2004). Notwithstanding, dentists do not completely implement ALARA principles in their routine work (Kantor, 2006; Lee and Ludlow, 2013). As a result, stochastic effect has more influence on dentist and patients due to missing threshold dose. Despite the fact that X-rays helps in disease diagnosis, but dentists should also be alert to the probability of its biological hazards (Haring and Lind, 1996).

A further serious implication for the patient is the side effects of exposure to radiation. Exposure to ionising radiation during imaging examinations should follow the ‘As low as reasonably achievable’ (ALARA) principle and the requisition of an x-ray examination should be considered carefully by the referring officer to ensure that the benefits outweigh the risks. Essentially, if an examination is not going to alter clinical management, then, that examination should not be performed. The consequence of these unnecessary x-ray examinations (Paolicchi et al., 2013; Singh et al., 2009) may be expressed as maleficence in the name of beneficence. Clearly, unnecessary imaging examinations waste finite health funds and other resources. This will diminish the capacity of the public health system to provide other services that are required (Singh et al., 2009; Miglioretti et al., 2013).

Biological hazards are grouped into: Non-stochastic and stochastic effect. Non-stochastic or deterministic effects are those effects in which above threshold dose cell injury starts to appear (Arnout and Jafar, 2014). In stochastic effect, there is no determined dose that could lead to biological damage, and damage to cells occurs at any level of doses. High dose ionizing radiation has both deterministic and stochastic effects, but low doses radiations have principally stochastic effects (Ramanathan and Ryan, 2015).

There are three essential methods used to minimize external exposure to radiation in radiation safety: time, distance, and shielding (Figure 1.1).

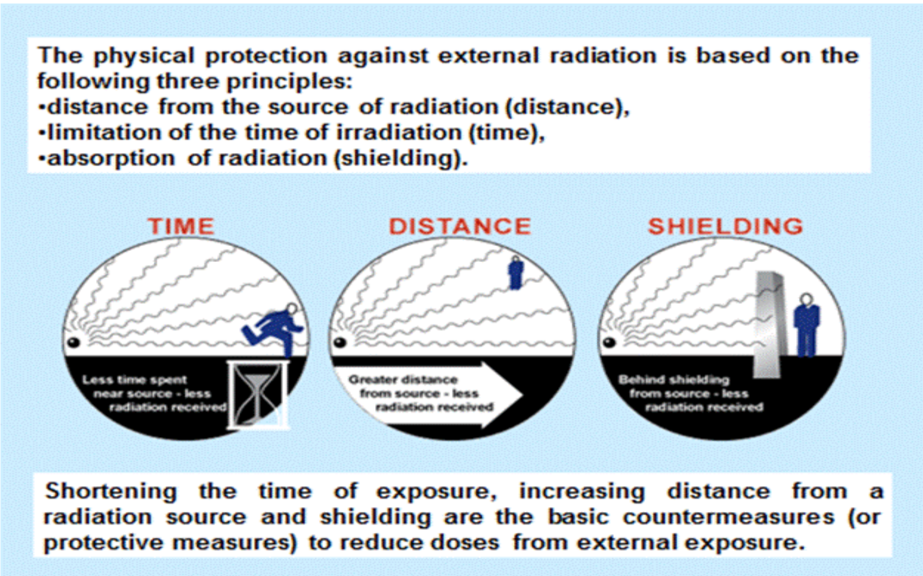


Figure 1.1: Methods used to minimize external exposure to radiation in radiation protection: time, distance, and shielding. (Hill and Einestein, 2016).

Considered opinions on radiation protection standards are extremely reliant upon a) scientific knowledge that is evaluated in successions by countrywide committees and by the United Nations Scientific Committee on Effects of Atomic Radiation, and b) the recommendations made by the International Commission on Radiological

Protection (ICRP) that look for to take account of such scientific development (UNSCEAR, 2000).

The number of CT examinations performed each year is increasing. The mean frequency of CT examinations in countries with Level 1 healthcare2 (i.e. > 1 physician / 1,000 people) was 57/1,000 in the 90's and is now over 127/1,000. With the increasing use of multidetector CT, there is a consistent increase in the population dose, which could be further boosted by incorrect use and / or unsuitable exposure settings (WHO, 2008).

Radiation protection awareness level affects the staff behavior. Staff accomplishment will not be safe and be resulted in adverse effects if they have insufficient data related to radiation safety (Prabhat et al., 2011).

Palestine, as a developing country, has started to deliberate lately on moving toward providing quality services in hospitals. Since 2011, access to quality health services has been on the strategic plan of the Palestinian Ministry of Health. To meet this goal, MoH has extended its partnership with East Jerusalem hospitals on quality improvement efforts and accreditation. Despite these enterprises, hospitals and health policymakers in Palestine still need the evidence and baseline patient and staff safety data that are essential for creating views and plans on improving safety and maintaining positive interventions after implementation (MoH Health Strategy, 2010).

This study is the first systematic analysis -to the knowledge of the researcher- of radiation protection in medical imaging Departments in Palestinian governmental hospitals. The results of this study will be helpful to improve patient as well as staff safety in these MoH hospitals and others from the private sectors. Moreover, findings of this study can form the baseline for future plans to improve safety of care in medical imaging Departments. This assessment could help organizations in underlying ‘‘root causes’’ for radiation protection, and for generating improvement and optimization initiatives for managers and staff involved in radiographers and patient care.

## 1.2 Historical Overview of Medical X-Rays

Over more than hundred (100) years have passed, and since the discovery of x-rays in 1895, and the first applications of ionising radiation, x-rays have become an integral part of any health care system. Within 12 months of the discovery, papers appeared in the literature reporting adverse effects from high exposure. After Rontgen’s discovery of X-rays, the American engineer Wolfram Fuchs (1896) gave what is generally recognised as the first protection advice. This was:

- "make the exposure as short as possible";
- "do not stand within 12 inches (30 cm) of the X-ray tube"; and
- "coat the skin with Vaseline (a petroleum jelly) and leave an extra layer on the most exposed area".

Hence, the three rudimentary creeds of practical radiological protection; time, distance and shielding – had been verified (Clarke and Valentin, 2009).

In 1925, the first International Congress of Radiology, held in London, deliberated the need for a protection committee, and considered establishing international protection standards, which was established at its second congress in Stockholm in 1928. The paper of Clarke and Valentin, 2009, surveyed the evolution from the early controls on worker doses to sidestep deterministic effects, through the documentation of stochastic effects, to the concerns about public exposure and increasing stochastic risk estimates. They identified the key features of the recommendations made by ICRP from 1928 up to the most recent in 2007 (Clarke and Valentin, 2009).

X-rays have been utilized for both diagnostic and therapeutic purposes, and its use for medical purposes has continued to grow, as well as attempts on studying radiation effects on human health to establish, practice and develop radiation protection (RP) philosophies, principles and mechanisms to protect human and environment from harmful health effects of ionising radiation (Ratnapalan et al., 2008).

At present, radiological imaging is the second most promptly growing area of the health care industry (Lee et al., 2007). The use of x-rays as a diagnostic tool and their involvement towards patient management is colossal. The profits of ionising radiation to the patient are significant in terms of relief, diagnostic and therapeutic efficiency. Nevertheless, x-ray examinations can be expensive and x-rays are potentially hazardous (Tavakoli et al., 2003).

The need to improve and develop radiological protection and safety in the medical field has been addressed (Holmberg et al., 2010). Reports and guidelines have been published on the European level for the benefit of the patients undergoing medical exposures and medical professionals working with medical exposures (European commission, 2009). Specifically, the importance of radiation education and training of medical professionals have been highlighted as a key issue in certifying proper radiation protection and safety in health care. These initiatives and activities certainly have increased knowledge and emphasised important areas to address in the medical sector. Besides, poor knowledge, in general, may also lead to misconception about medical x-rays (European Commission, 2014).

## 1.3 Framework of the Thesis

This investigation was developed around a framework that drew on several areas of study in order to establish its objectives. The thesis has been divided into six chapters, with chapter one focusing on the introduction to assist in the management process and provide all staff with a reference guide on radiation protection protocols and the selection of evidence based appropriate imaging requisitions. Chapter one also examines the risks associated with exposure to medical radiation, reviews the role of the radiographer.

Chapter two provides an overview, update and critical appraisal with regard to the literature of over-utilisation of diagnostic imaging examinations employing ionising radiation. As a literature review, the chapter provides a critical and analytical approach that objectively examines publications in terms of differences of opinion. In addition, an operational definition and a theoretical framework will be conducted.

Chapter three denotes to the conceptual framework that was developed for this study by the researcher, discusses the principles of evidence-based medicine and its application to medical imaging requisition in reducing unnecessary examinations. It also provides in detail the research methods. It includes an overview of the research design and procedures, the targeted population, the justification for using a self-administered questionnaire design.

Chapter four describes the results are mainly presented as tables and charts or figures, while raw data are displayed in appendices. Brief discussion and preliminary conclusions are drawn. A description of the data collection and data analysis procedures are also provided. This chapter also incorporates the discussion of the outcomes with respect to the original hypotheses. An examination undertakes the significant implications of the findings of the research on improving the appropriateness of imaging examination utilisation.

Chapter five draws conclusions with regards to the important outcomes and its contribution to awareness, policies and practices including the recommended future actions, future scope and strategies for wider dissemination.

This study focuses on the current state of knowledge and the major elements of scientific uncertainty in the context of protection policy and risk assessment and awareness that have the greatest potential to address these uncertainties.

## 1.4 Current Stats of the Art

Diagnostic imaging services are being delivered through medical imaging departments in all MoH hospitals in Palestine including West Bank and Gaza Strip hospitals. In the year 2015, the total number of diagnostic medical images delivered in these hospitals was 1,159,952 medical images; in which 126,265 ultra sound images, 88,191 CT scan images, 926,550 plain x-rays, 11,541 MRI images, 820 mammographic images and 6585 added as others (Table 1.1) (MoH, 2015).

Table 1.1: Distribution of radiology in MoH hospitals by modality type & region, Palestine, 2016.

| Type | West Bank | % | Gaza Strip | % | Palestine | % of total |
|---|---|---|---|---|---|---|
| Ultra Sound | 50,864 | 8.9 | 75,401 | 12.8 | 126,265 | 10.9 |
| CT (Computerized Tomography Scan) | 53,130 | 9.3 | 35,061 | 6 | 88,191 | 7.6 |
| Mammography | - | - | 820 | 0.1 | 820 | 0.1 |
| MRI (Magnetic Resonance Imaging) | 6,457 | 1.1 | 5,084 | 0.9 | 11,541 | 1.0 |
| X-Ray | 461,953 | 80.7 | 464,597 | 79.1 | 926,550 | 79.9 |
| Others | - | - | 6,585 | 1.1 | 6,585 | 0.6 |
| **Total** | **572,404** | **100** | **587,548** | **100** | **1,159,952** | **100** |

*Source: Ministry of Health, PHIC, Health Status in Palestine, 2015, October 2016.*

There are thirteen (13) Palestinian governmental hospitals in the West Bank named as follow; (MoH, 2016).

1. Abu Al Hasan Qasem (Yatta)
2. Al Husien (Beit Jala)
3. Al Muhtaseb (Hebron)
4. Al Watani (Nablus)
5. Alia (Hebron)
6. Darweesh Nazzal (Qalqilia)
7. Jericho
8. Khaleel Suluiman (Jenin)
9. Palestine Medical Complex/Ramallah (PMC)
10. Rafidia (Nablus)

11. Thabit Thabit (Tulkarm)
12. Tubas Turkish
13. Yasser Arafat (Salfit)

Every year MoH purchases modern and updated equipment and machines. The future figure in MoH is to add and construct new hospitals such as Hugo Chávez, Khaled Al Hasan, Halhol and Dora, also to add the mammography modalities in PHC in all governorates to the Picture Archiving and Communication System (PACS), and finally, the breast ultrasounds in PHC's and hospitals.

Recently, tremendous development has taken place in the field of x-ray diagnostic imaging in the West Bank. Newer modalities are being applied in minor and major hospitals, and latest radiological equipment are being imported and installed. Besides, small x-ray "set-ups" are being added when possible. This quantitative and qualitative increase may have a positive impact on the health service system of the country; but the lack of control can cause a serious problem especially radiation hazard to the radiation workers as well as public (Table 1.2).

Table 1.2: Medical imaging modalities in MoH hospitals, 2017.

| No: | Hospital Name | CR System | DR System | CT Scan | MRI |
|---|---|---|---|---|---|
| 1 | **Alia** | Carestream, Direct View QTY 2 | ShimadzuRAD Speed | Philips, Brilliance 16 | Philips, Ingenia 1.5 Tesla |
| 2 | **Beit Jala** | Carestream, Direct View QTY 2 | ShimadzuRAD Speed | Philips, Brilliance 16 | NA |
| 3 | **Jericho** | Agfa, CR 30m | ShimadzuRAD Speed | Hitachi, under installation | NA |
| 4 | **PMC** | Carestream, Direct View QTY 2 and Vita QTY 1 | ShimadzuRAD Speed QTY 2 | Philips, Brilliance 64 and Philips, Ingenuity 128 | GE |
| 5 | **Salfit** | Two CRs will be transferred here | NA | NA | NA |
| 6 | **Qalqilia** | Agfa, CR 30m | NA | Philips, Brilliance 64 | NA |
| 7 | **Rafidia** | Carestream, Direct View QTY 2 | ShimadzuRAD Speed | Philips, Brilliance 16 | NA |
| 8 | **Al Watani** | Agfa, CR 30m | NA | NA | NA |
| 9 | **Tulkarm** | Agfa, CR 30m | ShimadzuRAD Speed | Philips, Ingenuity 128 | NA |
| 10 | **Jenin** | Carestream, Direct View QTY 2, another will be installed | ShimadzuRAD Speed | GE, Light Speed QX/LVFX | Philips, Ingenia 1.5 Tesla |
| 11 | **Tubas** | Carestream, Direct View QTY 1 | NA | NA | NA |
| 12 | **Yatta** | Two CRs will be transferred here | NA | NA | NA |
| 13 | **Al Mauhtaseb** | Fuji | NA | NA | NA |

*Source: Ministry of Health, 2017, CR: computerized radiography, DR:digital radiography.*

Presently, there are two magnetic resonance imaging (MRI) machines, eight (8) computed tomography machines and about 20 X-ray equipment in governmental hospitals. There are around 174 qualified professionals (radiologists, radiographers), but, unfortunately, radiation oncologists, medical physicists/radiation safety officers, radiation therapists, nuclear medicine physicians, nuclear medicine technologists are not available in the field of diagnostic radiology and radiotherapy in governmental hospitals (Table 1.3).

Table 1.3: Number of radiographers and radiologists distributed in all West Bank governmental hospitals (*n*=174).

| No: | Hospital | Radiographer | Radiologist |
|---|---|---|---|
| 1 | **Alia** | 19 | 2 |
| 2 | **Beit Jala** | 12 | 2 |
| 3 | **Jericho** | 8 | 0 |
| 4 | **PMC** | 33 | 3 |
| 5 | **Salfit** | 6 | 2 |
| 6 | **Qalqilia** | 9 | 1 |
| 7 | **Rafidia** | 21 | 3 |
| 8 | **Al Watani** | 5 | 1 |
| 9 | **Tulkarm** | 10 | 1 |
| 10 | **Jenin** | 16 | 0 |
| 11 | **Tubas** | 6 | 0 |
| 12 | **Yatta** | 8 | 0 |
| 13 | **Al Mauhtaseb** | 6 | 0 |
| **Total** | | **159** | **15** |

*Source: Ministry of Health, 2017.*

As for PACS, there will be a server room in each hospital, and the data center will be in Palestine Medical Complex (PMC). It is necessary to train the employees and the staff in two phases, as well as required to fully understand the system and works completely. External doctors can access the BACS system anytime, anywhere.

MoH takes into consideration that 13 PHC will be connected to BACS in the future after HIS is connected to these centers and the CR's installed. Additionally, three Ultrasounds for breast cancer (Elastography US) in 3 major hospitals will be connected to BACS in the early future (MoH, 2017).

Moreover, MoH seeks to transfer Arabic patients' names from Avicenna (Ibn Sina) in the HIS to modalities as Roman and returns it back to Arabic names in HIS. Therefore, all Roman Arabic patient's names need to be converted to Roman in PACS in order to be read by modalities, as well as to save time that will be consumed in writing the patients' names from health information system (HIS).

## 1.5 Current Radiation Protection Philosophy

Over 100 years, the existing RP attitude is based on an advancement of the philosophy, perception and methodology through the international efforts (Clarke and Valentin, 2009). It is built on the Linear non-threshold (LNT) hypothesis with the highlighting that at low doses and low dose rates above the UNSCEAR's global mean natural background radiation (NBG) dose of ~2.4 mSv $y^{-1}$ (UNSCEAR, 2000), the dose is proportionate to the extra risk. LNT hypothesis affirms that any radiation dose level, regardless how trivial it is, has a definite point of health risk as genetic defects or cancer (International Commission on Radiological Protection, 2007).

Moreover, (RP) philosophy is founded on three major values specifically; 'optimisation', 'justification' and 'dose limitation'. 'Optimisation' is the odds of experiencing exposure, the total number of people exposed and the scale of their specific doses that must kept as low as reasonably achievable (ALARA), bearing in mind economic and social factors. 'Justification' is any decision that changes the radiation exposure situation and should do more good than harm. The 'dose limit' is the overall dose to any single from 'regulated sources in planned exposure situations', which should not overdo the applicable confines specified by the ICRP 103 for personnel and community (International Commission on Radiological Protection, 2007).

In Palestine, however, fulfilment of advanced knowledge and awareness is a key element in improving the protection of the public, radiation workers and patients from the adverse health effects of radiation. There might be extensive uncertainty predominantly with regard to health risks in Palestine.

Ministry of Health (MoH) is the main provider of health care in Palestine including medical imaging services. Until recently, radiation protection in medical imaging is a neglected area of research in Palestine. While adequate evidence about the radiation protection issue in public hospitals in general is almost still missing, rare researchers had been conducted to perceive radiation protection in medical imaging departments in Palestinian governmental hospitals. Hence, it is tremendously significant to consider the safety of both the patient and the medical professional performing the radiological procedures. This study aims to assess radiation protection awareness, policies and practices regarding radiation protection in Palestinian governmental hospitals.

## 1.6 The Mainstays of Radiation Protection

There are three props that provide the roots that any radiation protection (RP) culture has to go forward.

1. Science and knowledge,
2. Essentials and recommendations and,
3. Practical implementation in international standards and regulations.

Lochard (2014) set an outline over the continuing efforts of ICRP's committee concerning the ethical basis of RP. He pointed up that the ICRP importance to embrace a 'cross cultural' attitude must be broadly applicable worldwide as international recommendations. A series of public ethical values and acceptable to cultures have been recognized which equally agreed with ICRP's principles of RP:

- Magnanimity without harming: do more good than harm,
- Judiciousness and rationality: keep exposure as low as reasonably achievable (ALARA),
- Fairness, admissibility and impartiality: do not surpass the levels judged publically deplorable and lessen inequities in the dose distribution,
- Self-respect and sovereignty: deal with people with admiration and implicate stakeholders.

The safety culture idiom in the meantime is well-established, conversely to the original term RP culture which can be regarded as part of the common industrial safety culture. Nonetheless, it outspreads far-off ever since radiation involves RP in medicine and in daily life. The RP culture requisite a stable system for all fields of application.

Harrison (2014) described the ICRP role, and how principles and recommendations progress from the scientific basis. The objective was to cope and control exposures to ionising radiation so that deterministic effects are banned and the risks of stochastic effects are lessened to a reasonably achievable magnitude. A way to improve risk management is to integrate radiation protection and safety activities in a management system.

Crick (2014) explained how the scientific findings are evaluated by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). He denoted to the problems that need more clarity over the science−policy interface and to the complexity to connect confidence with science. He also, elevated the quantities and units that need to be addressed with the outmost care and variations must do more good than harm.

Dahlgren (2007) indicated a good approach for improving risk management is by integrating radiation protection and safety activities in a management system which is a consistent framework to develop accomplishments throughout the organisation by developing and implementing policies, description of processes, as well as decision on responsibilities, accountabilities, level of authority and interactions of those managing, performing and assessing work. In addition, management system includes a tool for reconsideration and requires assessment of activities on different organisational ranks containing self-monitoring activities.

The requirement for such a system for patient safety in health care has been indicated, but also radiation protection and safety activities could be included. That is, a management system can comprise corporate guidelines, processes and routines supporting radiation protection activities (Levi, 2013).

## 1.7 Radiation Health Effects

Ionizing radiation has sufficient energy to cause chemical changes in cells and damage them. Some cells may die or become abnormal, either temporarily or permanently. By damaging the genetic material (DNA) contained in the body's cells, radiation can cause cancer. Fortunately, bodies are extremely efficient at repairing cell damage. The extent of the damage to the cells depends upon the amount and duration of the exposure, as well as the organs exposed (Tatsuzaki, 2013).

There are two broad categories of health effects: acute (short-term) and chronic (long-term). A very large amount of radiation exposure (acute exposure) can cause sickness or even death within hours or days. Such acute exposures are extremely rare. In general, the amount and duration of radiation exposure affects the severity or type of health effect.

First category consists of exposure to high doses of radiation to short phases of time producing acute or short-term effects. High doses can kill too many cells that tissues and organs are smashed, and this sequentially may bring about a rapid whole body response frequently called the Acute Radiation Syndrome (ARS) (Gupta, 2014).

The second category signifies exposure to low doses of radiation over a prolonged period of time, producing chronic or long term effects, and tend to damage or change them. Low doses spread out over long periods do not cause an immediate problem to any body organ. They occur at the level of the cell, and the results may not be observed for many years (Gupta, 2014).

While the biological effects are severe and serious, the energy absorbed is low, e.g. once unloading a fatal dose of 10 Gy, the body temperature will simply escalate by 0.02 $^{o}$C, however, the dose may indicate death of all exposed entities (Tatsuzaki, 2013).

The acute biological effects can take place within few hours to several days, whereas the long-dated effects typically look like several years after the exposure (Tatsuzaki, 2013).

Ionizing radiation biological effects are to be categorized in relation to the characteristics of effects, occurring times and the object that shows the effects (Table 1.4) (Figure 1.2) (Tatsuzaki, 2013).

Table 1.4: Biological effects of ionizing radiation (Tatsuzaki, 2013).

| **Characteristic of effects** | **Occurring time** | **Object** | **Effects on organs** |
|---|---|---|---|
| Deterministic Effects | Acute Effects | Somatic Effects | Skin damage<br>Damage of reproductive system<br>Damage of blood forming system<br>Damage of digestive system<br>Damage of central nervous system |
| | | | Cataract, Damage of immunization system |
| Stochastic Effects | Latent Effects | Genetic Effects | Cancer |
| | | | Hereditary Effects |

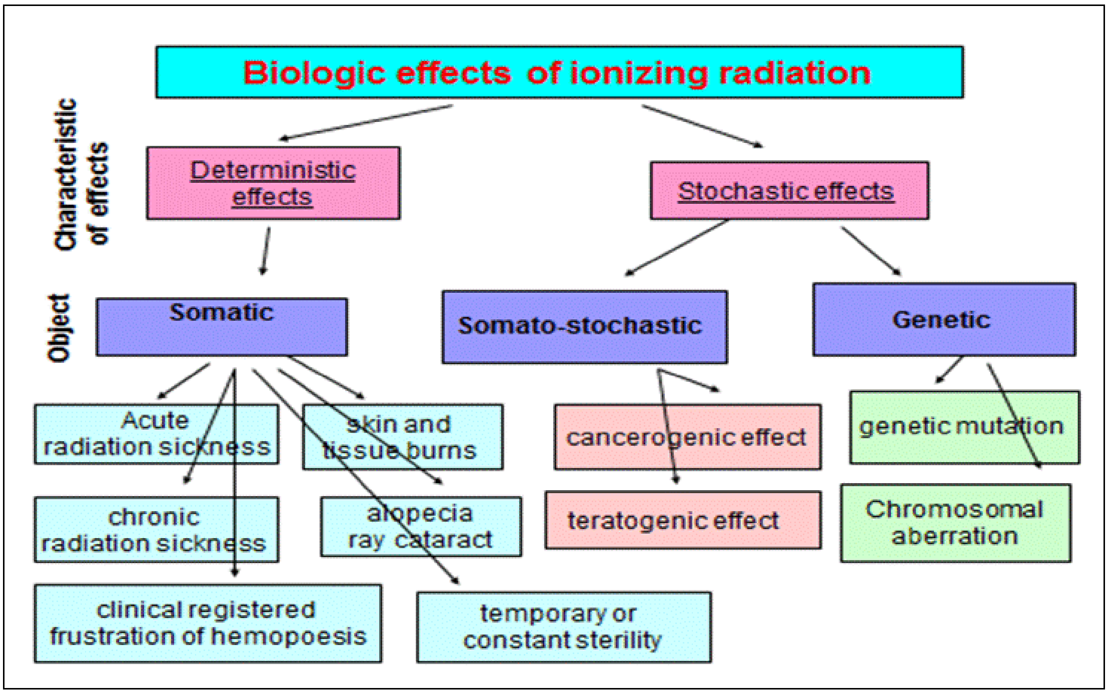


Figure 1.2: Biologic effects of ionizing radiation (Tatsuzaki, 2013).

## 1.8 Linear No-Threshold Risk Model of Radiation Protection

Some radiation risks are related to radiation dose by the linear, no-threshold model, which is a common agreement amongst specialists. Since it is the most conservative, the U.S. Nuclear Regulatory Commission (NRC) accepts this model.

LINEAR: An increase in dose results in a proportional increase in risk.

NO-THRESHOLD: A dose, no matter how small, produces some risk.

Risk does not start at zero (0) since there is menace of cancer, notwithstanding no work-related exposure. The gradient of the line just means that a person that receives 5 rems/year experiences 10 times as much danger as a person receives 0.5 rems/year. Exposure to radiation is not a promise of detriment. However, further exposure means more risk, and there is no dose of radiation so small that it will not have some effect (Gupta, 2014).

Contemporary discipline advocates there is some cancer risk from any exposure to radiation. While experts disagree over the exact definition and effects of “low dose”, U.S. radiation protection standards are based on the premise that any radiation dose brings some risk, and that risk increases directly with dose. The scheme of assessing risk is called the "linear no-threshold model (LNT)". The risk of cancer from radiation also depends on age, sex, and factors such as tobacco use. https://www.epa.gov/radiation/radiation-health-effects.

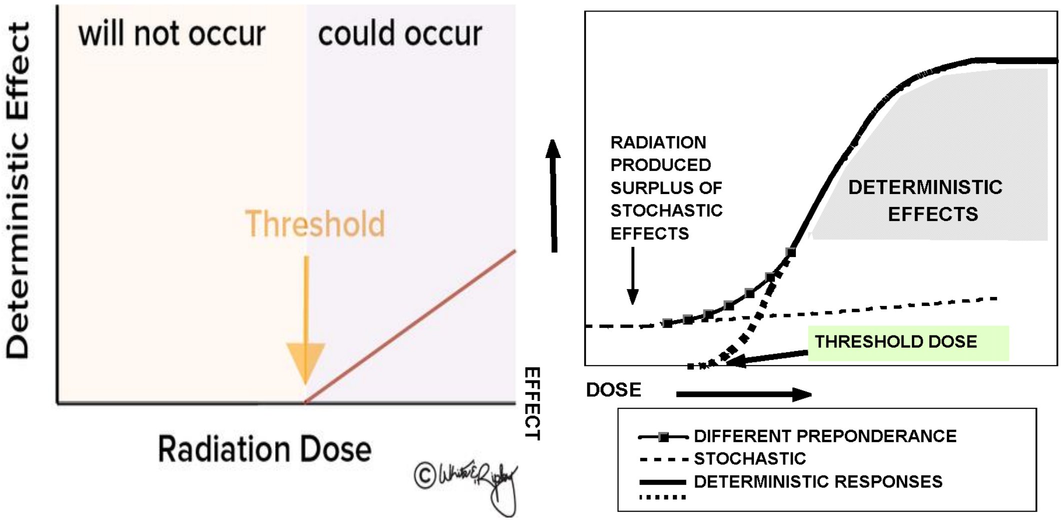


Figure 1.3: Linear No-Threshold Risk Model. (Tatsuzaki, 2013).

## 1.9 Influencing Factors for Unnecessary X-ray Examinations

The main factors inducing in the requisition of unnecessary examination include; lack of awareness and knowledge of medical radiation, dread of medical litigation, the most important factor, which is the absence of proper clinical training and financial incentives, payment arrangements and influence of patient:

### 1.9.1. Lack of Awareness and Knowledge of Radiation:

Correia et al., 2005 determined that there were documented information sustaining the evidence that clinicians and some radiologists commonly have deficient awareness and knowledge of radiation exposure from medical diagnostic procedures and the associated risks.

A lot of studies identified some needless exposure to radiation to be as a result of the behavior of radiographers and radiologists who may take shortcuts during the execution of examinations, providing a fewer consistent examination and exposing the patient gratuitously to further radiation. They are mostly unaware of the environmental effect, as well as the biological risks from exposure to ionising radiation, for procedures they propose and/or perform every day. Nol et al. (2005 & 2006) identified that humble training and knowledge resulted in avoidable exposures and repeat examinations by the radiographers. To overcome this, was through education, training and increasing awareness to the risk of exposure to radiation. Moreover, the studies support the notion that patients are not provided with information concerning the dangers, benefits and level of radiation dose received from these procedures.

For instance, Quinn et al., (1997) investigated radiation protection awareness in non-radiologists. The mainstream of respondents were not aware that patients do not have a yearly dose limit, and the majority did not know the relative radio-sensitivity of different organs.

### 1.9.2 Medical Panic:

The dread of medical litigation has been underlined as a causative factor to the unnecessary requests with clinicians sometimes requesting diagnostic requests in order to reduce the risk of malpractice legal responsibility (Cameron et al., 1999; Neale, 2004). A medical litigation crisis may well get worse further before there is a substantial enhancement (Cohen et al., 2005). Seventy-seven percent (77%) of all Irish doctors from trainees to consultants commented they fear a legal complaint (Birchard, 2001). The Irish government identified that the cost to cover doctors in case of litigation in the health system has triplicated in 10 years (Saunders, 2001). Obviously, for the referring doctor, avoiding malpractice also results in avoiding mistakes and consequently refining patient care. Even though the protective use of diagnostic requests could improve clinical consequences for some patients, it deteriorates clinical consequences for others. Furthermore, defensive demanding exacerbates the estimated results of all patients whose clinical strategies are altered and may reduce the overall quality of patient care (DeKay and Asch, 1998). Sox (1989) determined that the concern of the doctor is with evading faults that might bring harm to the patient and result in a court case.

A request for an imaging test (for many doctors) is a stress-free way to sidestep errors. The furthermost factor to requesting inappropriate tests was identified to be the fear of litigation (Allison, 1993).

### 1.9.3 Training of Diagnostic Policies:

Diagnostic policies selection for patients who come to the emergency department look like to be relatively straightforward. Nevertheless, the manner for the change and assortment of suitable imaging examinations approaches for patients presenting to emergency department has shown the evidence over time to be poorly carried out by some clinicians. Absence of training given medical students about the main beliefs that underline clinical decision-making could be the problem (Isouard, 1996).

One of the principal features of an exceptional clinician is the capacity to make balanced decisions that guide to finest beneficial consequences. Medical Imaging examinations must be requested only when the information presented from the history, physical examination, and previous imaging examinations are insufficient to handle the questions. Examinations must not be requested to confirm a finding (NHRMC, 1986). Conventionally, not every examination engaged is an effective device to diagnose an illness, e.g., kidney, ureter, and bladder (KUB) radiography is traditionally used as the first imaging modality for patients at the outset time episodes of renal colic. Nevertheless, recent studies have shown that KUB has only a sensitivity of (42% to 59%) for the discovery of calculi, and specificity around seventy seven percent (77%) (Levine et al., 1997; Anfossi et al., 2003). Gaining of diagnostic awareness and enhancement of patient health frequently are commonly special goals. The mainstream of clinical situations permit the search of perfect diagnostic knowledge (Isouard, 1996).

Yet, in situations, it is gratuitous to attain validation, particularly when a definite diagnosis does not run to a variation in clinical management; for example, the super vision of rib fractures continue the same regardless of x-ray confirmation because rib fracture is the most common thoracic injury. The sternness of the injury accompanying with this harm encourages patients to request from their clinician to perform diagnostic tests so as to conclude the cause and receive the appropriate treatment. It is known that plain radiography is not ideal for the diagnosis of rib fractures. Besides, clinical examination is not perfect for this diagnosis. Radiographs are specific but not very sensitive (for undisplaced fractures), and clinical examination is sensitive but not specific (Griffith et al., 1999).

### 1.9.4 Financial Incentives and Payment Structures:

Monetary encouragements and payment structure permanently represented an important factor inducing the demand of imaging tests (Spettell et al., 1998). There is broad literature displaying that non-radiologist interest in the diagnostic imaging colleagues in the physicians with a financial of their patients ask for more imaging than same specialty without financial interest. New possibilities for self-referral and a proliferation of "joint medicine and industry, and acceptance ventures", emerged from collaborations between with a growing environment of business-type competition, of a for-profit orientation, in the 1980s have all further accentuated and compounded the issue (Gray, 1986; Mitchell, 1995; Spettell, 1998). Common self-referral examples are obstetricians (or their staff) performing ultrasound examinations, internists performing and interpreting chest and orthopaedic surgeons performing and interpreting musculoskeletal radiography,

More commonly, physicians refer patients to their own imaging facilities or the facilities of their organisation (Greeson, 2004).

### 1.9.5 Patient Influence

Additionally, physicians think (most of the time) that patients expect radiography. Similarly, preferences and needs of patients play an imperative role in inducing doctor's requisition behavior, e.g., the request of ankle radiograph is inclined by the emergency department practice (Long, 1985; Lloyd, 1986). Patients, who suffer disquiet and ache confront with tiring doctors whom they have not seen before and who will not be under their surveillance care.

Wilson et al. (2002) investigated that the patient's role on imaging referral when presenting with low back pain and respiratory difficulties was found to communicate their wishes to physicians, concerning radiological examinations they consider are necessary. Efforts are suggested to educate patients where radiological studies are essentially medically designated and that may have a significant role, paired to image demand guidelines.

Van Der Weijden et al. (2003) conducted a study about the Dutch general practitioners' request-requisition behavior for patients come with impenetrable grievances. They found that thirteen percent (13%) of consultations convoluted grumbles considered as unexplained by general practitioners (GPs). The Dutch College of General Practitioners (DCGP) recommended an attentive, waiting attitude concerning the summons for inexplicable complaints.

## 1.10 Problem Statement

Since the evolvement over 100 years ago, diagnostic imaging techniques are gradually used to diagnose a varied scope of diseases and injuries. 30%-50% of medical decisions are based on radiological examinations (Sani et al., 2009).

Locally, Plain x-rays encompass 79.9% of all radiological examinations carried out in the Palestinian MoH exams in 2015. However, CT comprises 7.6% of examinations according to Palestinian MoH; it makes a 40% contribution to the collective dose of radiation ionizing radiation causes genetic damage, which is linked to cancer induction, but this varies depending on the duration and the dose of exposure (Table 1.5).

Table 1.5: Number of exams per hospital in the last three months, October 2017.

| No: | Hospital Name | X-ray | CT Scan | MRI |
|---|---|---|---|---|
| 1 | **Alia** | 14521 | 2656 | 1653 |
| 2 | **Beit Jala** | 16076 | 2267 | NA |
| 3 | **Jericho** | 9000 | NA | NA |
| 4 | **PMC** | 234469 | 5156 | 947 |
| 5 | **Salfit** | 7540 | NA | NA |
| 6 | **Qalqilia** | 8023 | 1366 | NA |
| 7 | **Rafidia** | 24950 | 2916 | NA |
| 8 | **Al Watani** | 3330 | NA | NA |
| 9 | **Tulkarm** | 11696 | 1383 | NA |
| 10 | **Jenin** | 13841 | 2169 | 1064 |
| 11 | **Tubas** | 5419 | NA | NA |
| 12 | **Yatta** | 3250 | NA | NA |
| 13 | **Al Mauhtaseb** | 181 | NA | NA |
| **Total** | | **35229** | **17913** | **3664** |

*Source: Ministry of Health, 2017.*

Nevertheless, misconceptions about radiation are common, causing fear and concerns that may negatively affect patient care. Previous studies have shown that physicians tend to underestimate the risks to patients of radiation exposure. The level of awareness concerning radiation protection influences the staff behavior. If they have not enough information related to radiation safety, awareness, practices and policies, their action will not be safe and be resulted in adverse effects. Medical radiation can be somewhat elucidated by the imprecise and recurrently deficient knowledge among professionals about radiation protection issues and radiation doses of commonly performed imaging procedures. Such lack of awareness about radiation risk can be enormously hazardous when high dose examination are conducted without optimisation, resulting in a possibly substantial threat for patients.

Despite the small, but definite risk to radiographers' health, investigations involving radiation are an accepted and fundamental part of medical practice. In Palestine, the Palestinian Medical Imaging Association (PMIA) estimated 6-7 deaths occurred from the year 2010 from cancers most probably related to medical exposure to radiation. An injury was discovered after 11 years from the beginning of the career, another after 15 years, while the rest were discovered while being around retirement age. Ten (10) others suffered cancer (five of them worked in MoH hospitals). Statistics do not give a strong relationship between the characteristic of these injuries and its numbers and the nature of the work they do. Nevertheless, after deep research and scientific studies, it was indicated that there were risk factors on medical imaging from ionising radiation that could be linked to cancer induction if underestimation to the risks of radiation safety precautions were being disregarded.

A number of surveys concerning this issue have been conducted among health care professionals around the world. Locally, studies on medical radiographers' awareness of radiation are lacking. Therefore, it is extremely important to consider the safety of both the medical professional performing the radiological procedure. The goal is not to eliminate all errors; rather, we should focus our attention on conditions that may reflect systemic problems or lead to misconception of the real harm. Our current challenges will be to address new policies and procedures, so, we need a better understanding of the frequency and causes of adverse effects, particularly those that are most likely issued by the MoH.

## 1.11 Justification and Significance of the Study

No researches had been conducted to perceive radiation protection in medical imaging departments in Palestinian governmental hospitals. Adequate evidence about the radiation protection issue in public hospitals sector in general is still absent.

In 2014, a lot of labor strikes took place in governmental hospitals in a protest against their working conditions and the risks they may be exposed to, particularly the risk of cancer. The decision to the strike came in the wake of increasing in the number of radiographers with this disease, where three radiographers working in Ramallah hospital out of seven suffering from leukemia.

Claims that contributed to such poor conditions were unfitting working conditions such as over load with long working hours, inadequate radiology protocols, disuse of some equipment, claims of inadequate number of personnel. Moreover, claims of so many unjustified excessive number of radiographic examinations in governmental radiographic units, in addition to bad monitoring of occupational dose (20mSv/year) subsidized so the situation is getting worse. Other triggers such as absence of knowledge and awareness toward potential hazard effects of radiation, lack of laws and legislations regarding radiation protection in the West Bank and lack of commitment to safety standards supported ill-coping measures to conquer these conditions.

Yet, the researcher has -over years of practice in MoH hospitals in this region- noticed an upward of lack of appropriateness and optimisation criteria by radiological staff and a low level of awareness concerning radiation protection. There seems to be a decrease in the knowledge of radiation protection. This study was proposed in an attempt to identify and describe radiation protection awareness and knowledge, practices and policies for x-ray examination to propose and market an approach to the radiation protection policy dealing with the appropriate awareness and management structure and regulate the policies of utilizing medical imaging uses in governmental hospitals as well as the private sector in the West Bank, Palestine.

Knowing radiographers' knowledge about x-rays has an important significance for stemming the trend and consequently not only reducing wastage of resources, but also protecting technologists and patients from unwarranted radiation. These results can help to formulate a plausible strategy for the reduction of unwarranted x-ray examinations. Consequently, creation and successful implementation of feasible strategies that will raise knowledge and awareness will need to be informed by research to propose a radiation safety policy initiative.

## 1.12 Overall Aim and General Objectives of the Study

The main aim of this study is to develop and promote an approach to the radiation protection policy dealing with the appropriate awareness and management structure and regulate the policies of utilizing medical imaging uses in governmental hospitals in the Palestine.

**General objectives:**

1. To assess the radiation protection awareness and knowledge levels of medical radiation radiographers working in the Palestinian governmental hospitals in the West Bank, Palestine.
2. To assess the radiation protection practices and policies of medical radiation radiographers working in the Palestinian governmental hospitals in the West Bank, Palestine.

## 1.13 Feasibility of the Study

The particular interest of the researcher was to oversight the conditions of the radiographers in the Palestinian governmental health system as a member of this team, accompanied with the membership in the Palestinian Medical Imaging Association (PMIA) motivated the researcher to take up this study. Moreover, PMIA is very cooperative in providing lists of the names of technologists as well as the governmental hospitals from MoH, and to present a baseline study contributing in a radiation protection policy for the governmental hospitals.

## 1.14 Limitations of the Study

There are some limitations during conducting this study; these limitations are summarized as follows:

1. The exclusion of other factors that may affect awareness, policies and practices of radiation protection of MITs due to time limitation.
2. Unavailability of relevant local literature and lack of resources in assessing awareness, policies and practices of radiation protection.
3. The financial limitation since the study was self-funded.
4. Researcher's bias may influence responses of subjects as working in the same field and known by some participants in the study during carrying out semi-structured interviews.

## 1.15 Hypotheses of the Study

1. There are no statistically significant differences at ($\alpha \leq 0.05$) in the radiation protection awareness and knowledge, polices, and practices of radiographers according to academic education.
2. There are no statistically significant differences at ($\alpha \leq 0.05$) in the radiation protection awareness and knowledge, polices, and practices of radiographers according to years of practice.
3. There are no correlations at ($\alpha \leq 0.05$) between the radiation protection awareness of radiographers and practices.
4. There are no correlations at ($\alpha \leq 0.05$) between the radiation protection policies and practices of radiographers.
5. There are no statistically significant differences at ($\alpha \leq 0.05$) in the radiation protection awareness and knowledge, polices, and practices of radiographers according to gender.
6. There will be no significant prediction of practice by gender, years of practice, level of academic education, knowledge, and policies (Multiple Regression Model).

## 1.16 Study Assumptions

The followings are the assumptions of the study

1. Sufficient number of professionals will participate, respond and cooperate in filling the study instrument.
2. All items and concepts, in the study instruments will be understood and clear for participants.
3. All the participants will fill in the questionnaires honestly and sincerely that will reflect the real situation of their perceptions.
4. Valid and reliable data are provided by participants.

# Chapter Two: Literature Review

## 2.1 Introduction

Natural and synthetic sources of ionising radiation play a role to human exposure and comprise a risk for human health. Revelation of the populace to natural radiation is to some scope inescapable and medical use of radiation is now a crucial part of contemporary healthcare. The exposure of workers, and to a smaller extent of the public, to low levels of radiation from ionising radiation, has become a fundamental part of industrialized society. Radiation protection standards depend on the existing knowledge of the risks from radiation exposure. Whichever over-, or under-, estimation of these risks could guide either to needless limit or to a lower level of health protection than projected.

Much is known about the quantitative effects of exposure to ionising radiation, though substantial reservations and conflicting views stay behind about the health effects at low doses. The significance of low dose risk research is now acknowledged worldwide. The United States and Japan as well as Europe have created large programmes of low dose risk research. Many of the larger Member States of the European Union also have considerable research activities in low dose risk.

## 2.2 Literature review

There is a growing awareness of the possible risks accompanying with ionizing radiation engaged in medical imaging, especially following recent publicity.

Using a questionnaire, Quinn et al. (1997) demonstrated the radiation protection awareness in non-radiologists. An underestimation of radiation dose was made by all respondents ($p<0.001$). The mainstream of respondents were not aware that patients do not have a yearly dose limit, and most of them did not know the relative radio-sensitivity of different organs. To put right this in the future, Quinn and his coworkers suggested that ceremonial enforced lessons at undergraduate level.

Including 15 radiology consultants, 10 radiology registrars, 10 senior MRSs, and 40 junior MRSs, Nicholson et al. (1999) explored the awareness of imaging staff to the radiation dose differences in four London hospitals. A solitary respondent distinguished the dose dissimilarities and recognized the attitude that results in lower effective dose.

Ionising radiation from medical applications symbolizes the mainstream of radiation doses from non-natural sources to which the common people are exposed. This is the outcome of a progressively rising order for radiological examinations with meticulous orientation to multidetector computed tomography (MDCT), which only accounts for about 50% of the whole medical radiation exposure (Hricak et al., 2011). Despite the fact that the spectacular progression of imaging technology the preceding decade, it is frequently degenerated by the need of correctness and optimisation condition together by referring physicians and radiological personnel (Mettler et al., 2008; Costello et al., 2013). Recently, studies have documented increasing patient radiation exposures due to proliferated utilisation of diagnostic imaging studies, mostly computed tomography (CT). For example, a retrospective study of radiation doses in a cohort of patients with Crohn’s disease conducted over a 15-year period. This study confirmed that increasing numbers of CT exams were carried out with average cumulative effective doses rising from 7.9 to 25 mSv when the first 5 years of the study phase were compared with the ending 5 years (Desmond et al., 2008). Eighty-five percent (85%) of the radiation dose at some stage in the final 5-year period was attributable to CT. Almost 16% of patients received cumulative effective doses greater than 75 mSv, and such levels of radiation exposure have been reported to be associated with a 7.3% increase in mortality from cancer (Cardis et al., 2007). Another separate study, CT has been shown to account for merely 6% of diagnostic procedures, thus far represented 47% of the whole radiation dose received by patients (Hart and Wall, 2004). Moreover, the referrals for pediatric CT studies have increased exponentially, raising considerable anxiety concerning cancer risk in this highly radiosensitive people (Brenner et al., 2001). Unexpectedly, concerns are growing over the risks associated with these high levels of exposure, particularly the potential increased lifetime risk of cancer (Brenner et al., 2007). Lately, hard work by both traders and the public were executed to lessen radiation doses, and educate users and patients to the subject of radiological protection (Mahesh and Durand, 2012; European Society of Radiology, 2011). This growing use of medical radiation can be somewhat elucidated by the imprecise and repeatedly insufficient acquaintance amongst professionals about radiation protection matters and radiation doses of commonly performed imaging procedures (Yurt et al., 2014). Such insufficiency of awareness about radiation risk can be enormously hazardous when high dose examinations, such as multiphase MDCT studies, are performed without optimisation, resulting in a potentially momentous biological duration risk for patients. Radiation hazard can be particularly relevant for young patients, chiefly children, whose high biological susceptibility and long life expectancy have a propensity to raise the probability of the possessions of not only cancer but also other non-cancerous diseases. In this regard, evidence exists that imaging parameters for pediatric investigations are repeatedly not accustomed to the slighter sizes of children matched up to adults, resulting in an needlessly high radiation exposure (Nosek et al., 2013; Vassileva et al., 2013).

The new Council Directive 2013/59/Euratom of the 5th December 2013, which involves "laying down fundamental safety standards for protection against the dangers arising from exposure to ionising radiation", is balanced to support this need for change, obliging all professionals a superior duty of care to properly justify and optimize each radiological procedure (European Council Directive, 2013). Moreover, the "Guidelines on radiation protection education and training of medical professionals in the European Union no. 175 (2014)" have set the minimum knowledge expected of each practitioner involved in radiation protection (European Commission, 2014). These guidelines clearly state the core learning outcomes in radiation protection for radiographers, such as:

"*To use the appropriate medical devices in an effective, safe and efficient manner*"

"*To use effective, safe and efficient radiation protection methods in relation to staff, patients and the general public applying current safety standards, legislation, guidelines and regulations*"

"*To apply the concepts and tools for radiation protection optimisation*"

Information campaigns such as Image Gently, Image Wisely, and the mainly fresh Eurosafe crusade have paid precise consideration to the elementary task of staff training in radiation protection, drawing attention to the role of severe mutual aid along with all radiographers (Goske et al., 2008). Within the radiological team, radiographers play an important role, as they are most directly concerned in conducting examinations and consequently characterize the most recent gatekeeper in the radiation protection chain.

Nol et al. (2005 & 2006) known that poor training and knowledge resulted in preventable exposures and replicate examinations by medical radiation scientists. The method of overwhelming this was through education, training, and raising awareness to the risk of exposure to radiation.

Clinicians and radiologists are generally unaware of the environmental impact, as well as the biological risks from exposure to ionising radiation, for procedures they perform each day. There are known reports sustaining the principle that clinicians, and even some radiologists, commonly lack the awareness and knowledge of radiation exposure from medical diagnostic procedures and the associated risks (Correia et al., 2005).

Moreover, Thomas et al. (2006) demonstrated the awareness of radiation protection issues in pediatricians to be low, with underestimation of relative doses and risks. In chest radiograph (CXR) equivalents, (87%) of all responses and (94%) of CT evaluations were underestimated. While there were (14%) of pediatricians remembered any applicable teaching during their specialty training, it was only (15%) of respondents were familiar with the "As low As Reasonably Achievable" (ALARA) principle. CT is estimated to be responsible for about (70%) of the collective radiation dose delivered to patients (Mettler et al., 2000; Dixon and Goldstone, 2002). Lee et al. (2004) studied the radiation dose awareness and CT potential risks among patients and radiologists. All the physicians and radiologists were ineffectual to assess the dose for one CT scan precisely matched with that for one chest x-ray. Barely (9%) of the physicians and (3%) of the patients said that there was enlarged risk accompanying with CT scan. Only (47%) of radiologists supposed there was increased risk irrespective of their practiced knowledge and experiences.

Abu Arrah et al. (2011) concluded a strong relation between cancers and radiation exposure and radiation might damage DNA in the cell. Therefore, radiation protection program must be applied in the radiology department. Moreover, the radiographer should have high level of awareness and risk assessment for radiation. Personal radiation monitoring is one of the main radiation protection, especially for pregnant worker and her fetus. This study was conducted to evaluate the application, awareness and risk assessment levels of radiation protection among radiographers at hospitals in Yogyakarta Special Region, Indonesia. It was a descriptive study, applying a cross sectional survey at hospitals in Yogyakarta. The subjects were radiographers of both governmental and private hospitals. There were 101 respondents from 124 radiographers. The data obtained were tabulated and analyzed using Chi Square test. The study revealed that 69.3% of the respondents had low application level of radiation protection, 19.8% did not know the meaning of ALARA (As Low As Reasonably Achievable), 50.5% were not aware of Inverse Square Law. The study also reported that 36.6% of the respondents did not know the amount of radiation that entered their body last year, 61.4% of radiographers thought that the risk assessment of radiation was not enough. While 18.8% of radiographers never used any radiation-monitoring device, 90.1% stated that there was no additional protection or radiation monitoring to the pregnant radiographer. However, there were no significant differences between duration of working, type of imaging modality, academic level, and training course for radiation protection. In conclusion, there was no difference in the application, awareness, and risk assessment levels of radiation protection among the radiographers at the hospital in Yogyakarta Special Region between duration of working, type of medical imaging modality, academic level, and training on radiation protection. In addition, the application, awareness, and risk assessment levels of radiation protection were not sufficient.

Lee et al. (2004) informed that not nearly all patients undergoing CT scans were told about the radiation risk. Accordingly, this may be somewhat verified by missing the knowledge among referring doctors and radiographers concerning the radiation dose of frequently carried out examinations (Shiralkar et al., 2003; Arslano et al., 2007), despite years of clinical experience (Mubeen et al., 2008; McCusker et al., 2009). Working in hospitals and medical institutes has effects on the personnel's health. In the United States, daily 9000 health care provider experience occupational related injuries (Hatam et al., 2010). In addition, 75% of the reports suggest that the hospital staffs in England are exposed to harmful factors and 17% are susceptible to a number of work-related diseases (Gunnell et al., 2004). As long as ionizing radiations and other hazardous agents exist in hospitals, serious care is obligatory for protecting both the staff and the patients (DelliFraine et al., 2013). Nevertheless, so far, restricted study has been done to estimate radiation knowledge among staff or patients.

A system for restraining the doses received by radiation-exposed workers was recommended by the International Commission on Radiological Protection (ICRP) (ICRP, 2012). The report addresses radiation safety practices in industrial and medical institution, control of radionuclide in the environment, protection of the public and assessment of radiation risk. An input part of managing radiation safety is throughout education. All individuals implicated in radiation usage have to know what radiation is and how to switch it since the number of diagnostic radiology procedures performed continues to rise per annum. With this growth, there should be concern for practice radiation safety (Adejumo et al., 2012).

Copious aspects can move up the patients' radiation dose such as disproportionate radiation field, long periods of radiation, close range of radiation source to the body, and avoiding use of lead shielding. For this reason, radiographers, in the course of using their knowledge of radiation safety protection, can lessen absorption of radiation in both themselves as well as patients, while maintaining the diagnostic value of the radiographic image (Rahimi et al., 2007). Appropriate use of personal protective equipment and monitoring the instructions and regulations for protection against ionizing radiation can significantly decrease needless exposure. Consequently, radiographers' knowledge of such standards and observances can play an imperative role in protection against radiation (Bezanjani, 2009).

In a local study, Hamarsheh and Ahmead, 2011, conducted a study in two (2) Palestinian hospitals aimed to assess physicians' knowledge about the risks associated with the use of radiological examinations. A questionnaire answered by 163 physicians revealed many gaps in knowledge. Only one-third of physicians had received a radiation protection course during their undergraduate study or in the workplace. Few physicians were able to answer correctly many scientific, knowledge-based questions. For example, only 6.1% of the respondents were able to identify the ALARA principle and 98.2% did not know that there is no safe dose limit according to international recommendations. Physicians' practices in terms of frequency of use of routine X-rays and discussing the risks with patients were also poor. These results clearly indicate the need to increase Palestinian physicians' knowledge and awareness about the potential hazards associated with the use of radiological examinations.

Results of Elamin descriptive cross–sectional study that was conducted in six Sudanese governmental and private hospitals with a simple random sample of 50 radiographers in Khartoum State, Sudan, in 2013, showed that radiographers within a good knowledge of radiation hazards and protection. Nevertheless, commitment to radiation protection practices among these radiographers was poor. There is inadequate radiation protection devices (film badge dosimeters (FBDs) availability was only 12%)) and monitoring (environmental monitoring availability was only 38%) in both functional government and private hospitals. There were radiation accidents due to overexposure as injuries, abortion and sickness cases. The study recommended conducting continuous service training for radiology staff at all levels about radiation protection and safety. Furthermore, publicize the culture of wearing personal protective equipment (PPE), and all possible safety measures including the equipment for measuring radiation. Radiographers in Khartoum, Sudan, should embrace current trends in radiation protection and make efforts more concerted to apply their knowledge in protecting themselves and patients from harmful effects of ionizing radiation (Elamin, 2013).

A descriptive, cross–sectional study was administered to patients and personnel, also making a review on the radiation-safety status in the hospitals. In evaluating the level of awareness and safety condition in 18 hospitals of Shahid Beheshti University of Medical Sciences, Tehran, Iran, 218 patients and 173 staff took part in the survey.

The results have shown 71.1% good radiation-safety awareness among staff. Besides, the level of staff awareness was not associated with educational level, gender, field of study, age and job experience. On the other hand, only 6% of the patients have shown a good awareness level. In addition, as it illustrated by the results there was a significant relation between awareness level and age ($P<0.017$), job ($p<0.000$) and educational level ($p<0.004$). Furthermore, the radiation safety status in 5 medical nuclear centers and 18 radiology facilities was 70% and 74%, respectively. Radiation safety awareness, unluckily, is commonly insufficient among radiologists and predominantly poor in patients. The study definitely recommended that patients should have more practical training and information available in this context (Dehghani et al., 2014).

In an Algerian study, four major Algerian hospitals were selected: three public university hospitals (A), (B), (C) and one cardiology hospital (D). This study aimed to assess patient dosimetry in interventional cardiology (IC) and radiology (IR) and radiation safety of the medical operating staff. The data collected cover radiation protection tools assigned to the operating staff and measured radiation doses to some selected patient populations. The analysis revealed that lead aprons are systematically worn by the staff, but not lead eyeglasses, and only a single personal monitoring badge is assigned to the operating staff. Measured doses to patients exhibited large variations in the maximum skin dose (MSD) and in the dose area product (DAP) (Khelassi-Toutaoui et al., 2015).

Yurt et al., 2014, reported in their study that 92 participants were asked about the safe dose of ionising radiation in radiologic examinations with the aim to evaluate the knowledge and perception and mitigation of hazards involved in radiological examinations. This study focused on healthcare personnel who are not in radiation-related occupations, but who use ionising radiation as a part of their work. The results found that an awareness of the health risks associated with ionising radiation is lacking, and furthermore, that this is in general agreement with the results of other similar surveys. Courses on radiation, and the biological effects of radiation should be included in the training of healthcare professionals, both during and after their education, to increase awareness of the safety protocols required to protect from the hazardous effects of ionising radiation.

A prospective cross-sectional survey was conducted on 112 radiology practitioners and radiographers working at a primary pediatric referral center in Malta. Part of the survey asked participants to indicate the typical effective dose (ED) for several commonly performed pediatric imaging examinations. Overall results revealed that imaging practitioners demonstrated poor awareness of radiation doses associated with several pediatric imaging examinations, with only 20 % providing the correct ED estimate for radiation-based examinations. Nearly all participants had undertaken radiation protection training, but the type and duration of training undertaken varied. When asked about the use of referral guidelines for pediatric imaging, 77.3 % claimed that they 'did not' or 'were not sure' if they made use of them. The study concluded poor awareness of radiation doses associated with pediatric imaging examinations and the non-use of referral guidelines may impede imaging practitioners' role in the justification and optimisation of pediatric imaging examinations. Education and training activities to address such shortcomings were recommended (Portelli et al., 2016).

A descriptive survey research design was carried out using a Kang’s questionnaire conducted by Jeong and Jang in Korea, in 2015. The participants were 184 operating room nurses from 6 affiliated hospitals. This study investigated the correlation between knowledge and performance of radiation protection among operating room nurses. Study results showed that there were no significant differences in knowledge of radiation protection according to general and occupational characteristics. Nevertheless, there were significant differences in performance of radiation protection according to gender, age, education, clinical experience, exposure duration (more than 10 years), and special health screening. Knowledge and performance of radiation protection had a significant positive correlation ($r=0.23$, $p<0.01$). This study concluded that educational programs are needed to improve performance of radiation protection among operating room nurses (Jeong and Jang, 2015).

A meta-analysis of leukemia risk from low-dose exposures combined the results of 10 studies (mainly on occupational exposures) and showed a pooled risk estimate of ERR 0.19 (95% CI 0.07-0.32) per 100 mGy (Daniels and Schubauer-Berigan, 2011).

A systematic review of cancer risk from diagnostic X-rays showed no clear excess from nine case-control studies of prenatal exposure published after 1990 (OR 0.99, 95% CI 0.87-1.13), though it did not include the early Oxford Survey (Schulze-Rath et al., 2008). Brent, 1999, maintained that preconception effects are principally stochastic effects, while intrauterine effects are mainly deterministic effects. The stochastic genetic risks are lower than the deterministic risks at equivalent exposures. He also argued that the radiation effects on embryo/fetus vary with amount of radiation and stage of development of the embryo/fetus, which is rapidly developing so is more sensitive to a possible radiation effect than an adult is. Principal effects are loss of pregnancy, malformations, and mental retardation:

- Without radiation exposure, risk of spontaneous abortion is 15%.
- Without radiation exposure, risk of genetic disease is 11%.
- Without radiation exposure, risk of major malformation is 3%.
- Without radiation exposure, risk of growth retardation is 3% (Brent, 1999).

A recent large case-control study found no significant excess of all cancers (OR 1.14, 95% CI 0.90-1.45) or leukemia (OR 1.36, 95% CI 0.91-2.02) associated with any diagnostic radiation in utero (Rajaraman et al., 2011). Also, a cohort study with 5,590 pregnant women who had been exposed to ionising radiation for diagnostic purposes showed no clear excess cancer incidence (HR 0.68, 95% CI 0.25-1.80 based on four childhood cancers) (Ray et al., 2010). A German cohort of more than 78,000 children who had undergone diagnostic radiographic examinations also showed no excess of childhood cancer (RR 0.97, 95% CI 0.75-1.23), or trend across dose categories (Hammer et al., 2011).

Studies in high natural background areas in India and China have not been able to show elevated cancer rates when comparing populations with annual doses of around 1 mSv versus 4 mSv (and cumulative doses up to several hundred mSv) (Nair et al., 2009, Tao et al., 2012).

The results of these studies do not of course exclude the existence of a health effect in the mSv dose levels. They are indeed compatible with risk estimates from studies of higher doses and mainly indicate that risks at low doses are not significantly larger than predicted from high-dose studies.

Epidemiological studies have not found major differences in health risks from ionising radiation between subgroups of the population defined by hereditary factors. Among patients receiving radiotherapy for retinoblastoma, a childhood tumor of the eye, those with the hereditary bilateral form of the disease have a higher risk of secondary sarcoma. Breast cancer patients who are carriers of the rare missense variant form of the ataxia telangiectasia gene have shown to be at an increased risk of contralateral breast cancer following radiotherapy compared with other patients receiving radiotherapy for their first breast cancer.

## 2.3 Conclusions Drawn from the Literature Review

In the above section, the studies and the literature pointed out approve the significance of x-ray services management as well as unprovoked use of radiological imaging. Most of the studies reviewed pursue to assess awareness that may be used to staunch the illiterate knowledge of x-rays management. Numerous researches have been conducted in an endeavor to detect the likely cause. Reviewed studies focus on the radiation protection awareness level that affects the staff behavior. In order to change the illiterate knowledge of x-rays for radiographic services carried out by radiographers, which result in the inappropriate use of x-rays, a multifaceted national operational policy about radiation protection is required. This approach requires sound knowledge and awareness that may generate improvement and optimization initiatives for managers and staff involved in medical imaging radiographers and patient care.

# Chapter Three: Conceptual Framework and Research Methodology

## 3.1 Introduction

Radiographers are confronted with arguments that may lead to encounters between them, the radiologists and the referrers, while the radiographers' main aim is to attain excellence to patient care. Ethical anxieties and dilemmas that radiographers come upon have increased over the years, while these ethical issues have to be taken into consideration when taking professional decisions. However, in this study, we will try to identify some issues that may be a matter of controversies, and identify reasons for inadequate justification and look at differences in such reasons between governmental hospital radiographers.

## 3.2 Conceptual framework of the Study

Conceptual framework of the study is considered as a guide/blueprint for the research process. The framework, which was developed after a thorough literature review, includes different factors that affect the radiation protection process.


Figure 3.1: Conceptual framework of the study (created by the researcher, 2017).

## 3.3 Operational Definitions

**X-rays:** X-rays are (photons) that can be emitted from radionuclides or from certain devices. X-rays, in the main, have lesser energies than gamma rays, but x rays are entirely qualified for piercing and passing through the human body. Medical x-rays are the single largest source of made-up radiation exposure. Lead could be used to reduce the dispersion of x rays as a shielding material. In this study, x-rays are harmless if being used with care. While the benefits conspicuously equalize the risk of harm, the range of radiation used in most investigations is very small. To achieve the needed results, medical imaging radiographers should use the least amount of radiation needed. Images transfer trifling risks and should be performed only when nominated (Novelline, 1997).

**Radiation protection:** Denotes to avoiding non-stochastic effects and controlling the stochastic effects to an acceptable level. Radiation protection encompasses suitable use of radiation, and optimization based on the concept of using the lowest possible exposure dosage within reasonably achievable limits (ALARA). The International Commission on Radiological Protection (ICRP) has warned of the risks of occupational radiation exposure. However, regardless to a smaller extent of the dose, long-term exposure can increase the stochastic effects, such as cancer and leukemia, and can evidently disturb skin lesions, alopecia, leukopenia, infertility, cataracts, and the fetus. Consequently, for inhibition of damaging effects of radiation and proper medical care, occupational exposure in radiographers and radiologists, proper awareness of safety management of radiation emitting equipment are immediately needed (Dong, 2003**)**.

**The justification principle**: The decision that adjusts the radiation exposure situation should do more good than harm, signifying that individual should accomplish adequate individual or societal benefit to equipoise the damage it causes, either by compering a new radiation source, or by decreasing the current exposure or by dipping the risk of probable exposure. Justification means that the examination must be medically indicated and useful (Do, 2016). Justification is one of the most serious steps in radiation protection. Numerous studies have evidently shown a discrepancy in knowledge about the risks of x-ray among medical professionals, both referring doctors and radiological staff. The first step is to create the awareness of the radiation exposure effect based on an understanding of the potential effects of x-ray examinations. Radiologists and clinicians have to know the diagnostic potential and the biologic effect of the investigations they demand and/or do; in line with this, they will choose the finest diagnostic lane, possibly dodging radiation exposure by using ultrasound or MRI, maybe using the best x-ray-based imaging test and perhaps even by picking out additional diagnostic tools (ESR, 2011). In its 1990 and 2007 recommendations, the International Commission on Radiological Protection (ICRP) has stated as a principle of justification that ‘Any decision that alters the radiation exposure situation should do more good than harm (ICRP, 1991, ICRP, 2007).

**The optimisation principle:** The International Commission on Radiological Protection (ICRP) has defined this principle as the process to keep the level of individual does, the number of people exposed, and the possibility of acquiring exposure as low as reasonably achievable below the applicable dose restrictions, with economic and social factors being considered. Using the margin of benefit over harm, the level of protection has to be the highest under the central situations. Consistent with the ICRP recommendations, this process of optimisation below limitation should be applied whatsoever the exposure situation; i.e. planned emergency, and existing (ICRP, 1991, ICRP, 2007).

**Basis for radiation protection policies:** It is assumed that any radiation dose, disregarding how small, could give some effects. Ionizing radiation is capable of producing biological effects that are detrimental to health. The purpose of a radiation safety program is to avoid unnecessary radiation exposures, and to control the basic exposures. Each person who is significantly exposed to ionizing radiation shall be informed of the risks and of appropriate protection methods, and shall accept personal responsibility for using the available protection (University of Utah, 1996).

**Deterministic effect**: "Detrimental health effect for which the severity varies with the dose of radiation, and for which a threshold usually exists (i.e., causally determined by preceding events). The effect is not observed unless the threshold is exceeded, although the threshold dose is subject to biologic variation. Once the threshold dose is exceeded in an individual, the severity of injury increases with increasing dose. Examples of deterministic effects include skin injury, hair loss, and cataracts" (Stecker et al., 2009).

**Stochastic effects:** "Malignant disease and heritable effects for which the probability of an effect occurring, but not its severity, is regarded as a function of dose without threshold" (Do, 2016).

**Dose:** "General term used to denote mean absorbed dose or effective dose. The particular meaning of the term should be clear from the context in which it is used. In this document “dose” means the absorbed dose to tissue unless otherwise specified" (Stecker et al., 2009).

**Effective dose:** is "The sum, over specified tissues, of the products of the dose in an organ and the tissue weighting factor for that tissue. Current techniques for estimating effective dose use computer simulation based on a “model” body and statistical simulations of radiation exposure. This yields only a gross approximation of effective dose. The stochastic risk to an average member of an irradiated population is expressed in terms of Sieverts (Sv). Effective dose is often used in the literature to roughly estimate the radiogenic risk to an individual. Age and sex modifiers, appropriate to the irradiated individual, should be applied to such calculations." (Stecker et al., 2009).

**Absorbed dose:** "The energy imparted per unit mass by ionizing radiation to matter at a specified point. The International System of Units (SI) unit of absorbed dose is the joule per kilogram. The special name for this unit is the Gray (Gy). For purposes of radiation protection and assessing dose or risk to humans in general terms, the quantity normally calculated is the mean absorbed dose in an organ or tissue" (Stecker et al., 2009). For diagnostic radiation:

- Typical absorbed dose: 20 mGy
- Typical effective dose: 15 mSv
- Typical equivalent dose: 20 mSv (Stecker et al., 2009).

**As Low As Reasonably Achievable (ALARA):** "Acronym for "As Low as Reasonably Achievable." It means making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical. Be consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations. These means are in relation to utilization of nuclear energy and licensed materials in the public interest" (Shapiro, 2002).

**Ionizing radiation:** "Ionizing radiation is a type of energy released by atoms that travels in the form of electromagnetic waves (gamma or X-rays) or particles (neutrons, beta or alpha). The spontaneous disintegration of atoms is called radioactivity, and the excess energy emitted is a form of ionizing radiation. Unstable elements, which disintegrate and emit ionizing radiation, are called radionuclides" (WHO, 2016).

**Linear-non-threshold (LNT) model:** The assumption that the risk of cancer increases linearly as radiation dose increases. This means, for example, which doubling the dose doubles the risk and that even a small dose could result in a correspondingly small risk. It is impossible to know what the actual risks are at very small doses. In the low dose range, radiation doses greater than zero will increase the risk of excess cancer and/or heritable disease in a simple proportionate manner (ICRP, 2007).

## 3.4 Research Methodology

### 3.4.1 Research Design:

Burns & Grove (2005) defined research design as "a blueprint for a study". According to Polit and Beck (2008), a survey is "a non-experimental research design aiming to obtain information about people’s preferences, attitudes and activities". On the other hand, Kasunic (2005) defines a survey study as "a data gathering and analysis approach in which respondents answer questions or respond to statements that were prepared in advance". Generally, "a cross-sectional survey attempts to provide a snapshot of how things are at the given time at which information are collected" (Denscombe, 2007). This was a cross-sectional study over a 9-month period from June 2017 to February 2018.

### 3.4.2 Quantitative Approach:

A quantitative approach was monitored in this study. Mouton (2001) deliberates that "a quantitative research design gives a broad view of population through a study of a representative sample". Bowling and Ebrahim (2005), considers that "there are many quantitative methods for measuring people’s psychological attributes such as preference for a specific health service". The systematic collection of quantitative information by doing a survey was the approach employed in this study. This approach was chosen because the study aimed at quantifying the radiation protection awareness, knowledge and practices levels of medical radiation radiographers working in the Palestinian governmental hospitals in the West Bank, Palestine.

### 3.4.3 Pilot Study:

Delport (2005) advocates that newly-constructed questionnaire must be systematically pre-tested before being utilized in the main study. Therefore, prior to the actual study, the tool was pre-tested on selected radiographers from three hospitals. This is consistent with Boynton (2004) who considers that a questionnaire must be pre-tested on participants who are representatives of the sample. The pre-test was utilized to help assess the process as well as identify problems that might be related to the questionnaire.

Ten (10) radiographers from radiology departments tested a pilot survey. As a result, insignificant alterations were made to examine the clarity, validity and comprehensiveness of the instrument. The feedback received on the pilot was used to finalize the presentation and wording of the questionnaire and to clarify any unclear question. This was done without the prior knowledge of the medical imaging radiographers, so they could not prepare and were less likely to avoid participating. Questionnaires were collected immediately after completion and were anonymous. The researcher excluded himself and the radiographers who had been involved in testing the pilot questionnaire, while the data gathered from piloting were not included in the main study.

### 3.4.4 Content Validity

Content validity is termed as "the adequate sampling of the relevant material or content that the measuring instruments purports to measure" (Rosnow & Rosenthal, 2005). To heighten content validity, the questionnaire was pre-tested on designated medical imaging radiographers. The responses from the pre-testing sample were used to appraise the clarity of the questions. According to Marshall (2005), this recounts to content validity. The questionnaire used in this study was founded on a systematic literature review, and the aim was to use as much of the presented literature in the expansion of the questionnaire. Likewise, (Stommel & Wills, 2004) argue that experts might be involved in the radiology field, to estimate the content validity of specific questions. As a result, in order to find out the instrument validity, it was exposed to valuation and proof-reading by the radiographic managers. The contents of the questionnaire had been validated by radiographic managers with many years expertise, and were deemed valid for use among radiographers for the assessment of the study objectives.

Corrections were carried out to parts of the questionnaire that were either unclear or hard to be understood. Modifications were made to five questions based on the responses from the pre-testing sample and annotations from the group of experts. For example, most of the pre-tested sample said that question number 16 was not clear.

Accordingly, modifications were executed to this question. Three questions were detached entirely.

### 3.4.5 Questionnaire (Interview Schedule):

A written seven-page questionnaire booklet was constructed from previously used questionnaires and designed consisting of direct questions, mostly requiring tick answers or single numerical responses. The questions were designed to assess the level of knowledge regarding ionising radiation in medical imaging. The questionnaire covered eight main areas. The first part involved the consent form for subjects participating in the research study explaining to them the purpose of the study, and appreciating their participation in the study. The second part requested socio-demographic data and included questions to retrieve about the gender, years of practice, formal academic education and place of work. The third part aimed to investigate how far radiation protection knowledge and awareness they have, while the forth one asked about optimisation and justification. Moreover, the fifth part asked about radiation protection practice they would be of providing concise and accurate information on the specific risks and assessed knowledge regarding established facts from the literature. Furthermore, respondents were requested in the sixth part if they had ever attended teaching/training and/or refresher courses on radiation protection. In the seventh part, radiographers were questioned about guidelines and policies. Respondents were then asked to estimate the correct answer of radiation dose assessment in the eighth part for commonly requested diagnostic imaging modes; plain radiographs, CT scans, MRI and mammogram. They were instructed to consider one chest x-ray as one arbitrary unit (CXR) and to approximate the equivalent number of units of radiation exposure. Questions were in yes/no, don't know, or a multiple choice format with three to five options and only one correct answer. One point was given for each correct answer and zero point for each wrong or missing answer, respectively. Unanswered questions were scored as incorrect.

The questionnaire was administered over a 9-month period from June 2017 to February 2018, distributed across thirteen different governmental hospitals in the West Bank, Palestine. Participants were asked to complete the survey within 10-15 minutes. Although few of the respondents have returned the questionnaires promptly, others did it after a few days. Additionally, there was difficulty in retrieving the handed out questionnaires and in applying them to a greater number of radiographers, probably due to the fact that the questionnaire approached knowledge on a theme that is still poorly explored formally. However, to solve the potential issue of any bias, we made our effort to expand recruitment and improve the participation rate by targeting the whole population registered in the Palestinian Medical Imaging Association who are working not less than a year in the hospitals. The researcher was able to clarify any ambiguous questions and ensure that the respondent answers all the questions. For this study, a questionnaire was designed in a way that it could also be used as a structured interview schedule. It had to be done this way because some potential respondents might be on duty and others might not, or others might understand what is written or asked, while others might need clarification. It is therefore referred to interchangeably as questionnaire or interview schedule while ended with a short "thank you" message.

Levels of exposure to ionising radiation from medical imaging vary by country, organization and the imaging equipment used. In formulating our questionnaire, we used data from the US National Council on Radiation Protection and Measurements (Morris et al., 2004).

Results of this survey may provide health care providers and planners with information that will help them redesign radiographic services and allocate public health services efficiently.

### 3.4.6 Study Population and Subjects:

Burns and Grove (2005) designate population as "the entire set of individuals having some common characteristics". Therefore, for the purpose of this study, the target population included all radiographers providing imaging services in the governmental hospitals where the researcher is employed. The researcher surveyed all eligible radiographers, with a high response rate, making it likely that the sample was representative. However, this is a true representation of the actual composition of the staff employed in Palestinian MoH hospitals.

Recruitment was done by convenience sampling of all radiographers exposed to ionizing radiation in radiology departments on a voluntary basis. The participants were informed that the results would be used only for a scientific study.

### 3.4.7 Sampling:

In this study, the researcher employed a non-probability sampling procedure namely convenient sampling design. Convenient sample, according to Brink (2006), "comprises of the most readily available or most convenient group of people".

### 3.4.8 Inclusion Criteria:

Inclusion and exclusion criteria were set for probable participants in the study. According to Stommel and Wills (2004), "inclusion and exclusion criteria are a way of defining who is eligible to become a respondent and who is not".

The eligibility criteria for the selection of research participants in this study included the following:

- The study population included all governmental radiographers working in the hospitals' radiology departments.
- There was no upper year-practice limit, as the opinions of longer-year-practice radiographers were considered worthwhile.
- Radiographers who gave consent and agreed to participate in the study.

### 3.4.9 Exclusion Criteria:

The followings were excluded:

- Radiographers who practice medical imaging since less than a year.
- Radiographers who did not want to take part in the study.
- Radiographers who work in private hospitals, or governmental directorates.
- The researcher excluded himself and the radiographers who had been involved in testing the pilot questionnaire.

### 3.4.10 Ethical Considerations:

Ethics is defined as "the study or science of moral values or ethical principles, which include beneficence, justice and autonomy" (Mosby's Medical, Nursing and Allied Health Dictionary 2002:416). In view of this, the researcher took into consideration the following principles of ethics during the study.

#### 3.4.10.1 Permission to Conduct a Study:

Formal letters were sent from Al-Quds University to Ministry of Health (MoH), in which the study purpose was explained. An official permission had been asked for the researcher to visit the hospitals to distribute the questionnaires and to facilitate data collection procedures. The researcher had visited the targeted hospitals in order to get to know the place and to explain the research purpose despite the researcher himself as one of its personnel.

#### 3.4.10.2 Participants' Informed Consent:

A one-page information sheet was attached to the questionnaire. Participants were given full explanations about the research, including the purpose, nature of the study and importance of participation before submitting the questionnaire. In addition, the participants were assured confidentiality of information and voluntary participation, and were given total freedom to accept or reject participation in this research (Annexes1 & 3).

**3.4.11 Data Collection**:

The surveys were handed out during working hours at different days and times of the day, except weekends at radiology departments. Participant anonymity was assured; no names were required on the questionnaire. Participants were requested to complete the survey in one sitting, but, unfortunately, a lot of them postponed and dawdled filling in the questionnaire, for which delayed the researcher sometime to conduct this study.

**3.4.12 Statistical Analysis:**

Statistical analysis was performed and data from completed surveys were collated and coded using Excel (Microsoft, Redmond, Wash, USA) and Statistical Package for Social Sciences (SPSS), (version 21.0) for statistical analysis (SPSS Inc, Chicago, Ill, USA). Level of knowledge and practices were calculated as a percentage of correct answers in each section. Levels less than 50% were considered poor knowledge, unsafe practices or negative attitude. Before analysis, all variables were reviewed for accuracy of data entry, missing values and outliers using SPSS. For continuous variables, we used an independent *t* test and analysis of variance to compare demographic groups. The $\chi 2$ test was used to compare differences in proportions for categorical variables (with $\alpha \leq 0.05$). The researcher was assisted by a bio-statistician from whom a pre-coded template was received in preparation for numerical data analysis.

## 3.5 Conclusion

This chapter deliberated the methodology used to undertake this study. This included, research design, data collection, study population, sampling and sample size, pre-testing, data analysis and ethical consideration.

# Chapter Four: Results and Discussion

## 4.1 Introduction

This chapter introduces the survey's results, including the characteristics of the respondents as well as the means, percentages and frequencies of the responses for each of the survey's items. Moreover, the results of the hypotheses are presented. This is the first survey conducted in Palestine, the best of what we know, with the aim to evaluate awareness and knowledge of radiation protection and radiological dose assessment among Palestinian medical imaging radiographers. The findings from this large survey may reveal an imprecise awareness and training of radiographers, and confirm prior studies assessing awareness of radiation protection issues and knowledge of radiation doses.

## 4.2 Socio-Demographic Characteristics of the Respondents

In this study, we were able to recruit one hundred fifty-nine 159 participants. Participants filled one hundred forty-two (142) questionnaires giving a response rate of 89.3% and of these, ten (10) questionnaires were excluded for the pilot study. Table 4.1 lists a summary of the gender, professional practice time and educational background of the participants. As shown in Table 4.1, the participating radiographers were asked questions on their demographic status; male participants represented (*n*=127; 96.2%) of participants compared to (*n*=5; 3.8%) females.

This percentage is in line with the composition of the Palestinian labor force. The results of the Palestinian Central Bureau of Statistics survey show that the participation rate of women in the Palestinian labor force during the year 2016 was 19.4% of all working-age females in 2016 compared to 10.3% in 2001. The male participation rate was 71.6%, more than 3 times the female participation rate (PCBS, 2016). This indicates that this sector is a male sector. Most radiographers tend to study medical imaging and be hired because they can sustain longer periods than females can do, as well as their ability to cope with work pressure that requires inordinate effort, as well as the difficulty of night work, which is difficult for some to accept for females in the culture of Palestinian society.

Regarding the job tenure variable, Table 4.1 shows that the highest percentage (*n*=71; 53.8%) were less than 10 years' experience, while the job tenure ranged from 1-33 years. This fits in with the features of the Palestinian society, since the majority of them are youth, while the advantage of this period of youth age means ambition to more work, liberality and strength, and this period of the person is enough to acquire many skills as well as increase in experience.

In Table 4.1, the vast majority of radiographers (*n*=114; 86.4%) attained the bachelor degree, and this is a large proportion, signifying that the study sample is of a high scientific qualification, who can deal with the paragraphs of the questionnaire. This is normal because this job requires excessive scientific knowledge. The Palestinian society is one of the most educated people in the Arab world, and the community with the least illiteracy rate.

Table 4.1: Distribution of subjects according to personal & work characteristics (*n*=132).

| No: | Group | Subgroup | Frequency | Percentage * |
|---|---|---|---|---|
| 1 | **Gender** | Male | 127 (96.2) | (96.2) |
| | | Female | 5 (3.8) | (3.8) |
| | **Total** | | **132** | **100** |
| 2 | **Time of professional practice** | < 10 Years | 71 | (53.8) |
| | | 10 – <20 Years | 28 | (21.2) |
| | | ≥ 20 Years | 33 | (25.0) |
| | **Total** | | **132** | **100** |
| 3 | **level of academic education** | Diploma degree | 12 | (9.1) |
| | | Bachelor degree | 114 | (86.4) |
| | | Higher than bachelor's degree | 6 | (4.5) |
| | **Total** | | **132** | **100** |

*n*, number of respondents; %, corresponding percentage in relation to the total.*

## 4.3 Radiation Protection Knowledge and Awareness

Each person animated in this world is being unprotected from ionizing radiations. The risk of ionizing radiation from medical imaging is not inconsequential. Currently, it is thought that a linear affiliation subsists between radiation exposure and cancer evolution. Even though the risk to a person may be unimportant, recurrent exposure of individual patients and exposure of enormous numbers of people over time may guide to a substantial increase in cancer occurrences. Likewise, it is alleged that up to a third of all requested radiological studies are needless (Arslanoglu et al., 2007; Seyed et al., 2008). Consequently, the use of substitute medical imaging practices using less radiation should be deliberated when quantifiable decisions are being taken. It is therefore important to underline the accurate use of diagnostic x-rays, which necessitates a sufficient knowledge of radiation protection.

Concerning the questionnaire section related to general radiation protection knowledge and awareness (Table 4.2); twenty-six of participants (*n*=26; 19.7%) showed that they were very confident and rated their knowledge of ionizing radiation risk as excellent. On the other hand, (*n*=95; 72.0%) of them were moderately confident as appraised their knowledge of ionizing radiation risk as good, while (*n*=11; 8.3%) thought that they were less confident in their knowledge of ionizing radiation risk as they graded themselves as insufficient.

Our study results align with that of Poalicchi and co-workers (2016), who argued that 90% of radiographers stated to have sufficient awareness of radiation protection issues while most of them underestimated the radiation dose of almost all radiological procedures. Moreover, these study results are in line with that of El Dahshan et al., 2017, who observed that the majority of study subjects were aware about radiation hazard and safety, whereas 96.8% of participants were aware about radiation hazards and the awareness about importance and standard of radiation safety is 97.9%, 73.1% respectively. Elamin, 2013, said that radiographers in Khartoum State, Sudan, showed that radiographers within a good knowledge of radiation hazards and protection. The results have shown 71.1% good radiation-safety awareness among staff (Dehghani et al., 2014).

Radiation protection is the professional nucleus of radiographers; thus, absence of basic radiation protection awareness is objectionable. As written in the BSS 59/13, the radiographer plays an important role representing the last gatekeeper in the radiation protection chain. Even if this lack of awareness could represent only a small risk for the individual patient, the danger becomes significant when considered at a population level (Paolicchi., 2013). On such major themes, it is suggested investigating the causes of this lack of knowledge, and then to plan actions in order to remove these reasons. From the researchers' point of view, unawareness may depend on:

- The absence of correct groundwork within university courses. Nonetheless, lately, the Palestinian Medical Imaging Associations (PMIA) have worked in collaboration with the Palestinian universities in holding workshops, symposiums and seminars to improve teaching, and radiographers' performance, but maybe additional steps have to be taken.
- Less training proceedings for the employed staff, and lack of interest in the participants.
- The increasingly difficult training caused by the evolution of technological complexity.

The researcher perceives that radiographers, who follow the instructions, and regulations, which were issued by the radiologists, MoH, or ICRP, who all must justify and optimize the procedure beforehand, have to control the radiation dose of the radiological examinations. If the radiographer does not have an appropriate awareness of the radiation protection issues, he/she may be blamable for unnecessarily increasing the radiation dose provided to the patient for a given imaging test.

Likewise, a hundred (*n*=100; 75.8%) of the study subjects correctly distinguished the difference between stochastic and the deterministic (non-stochastic) effects of radiation. This, however, is not the case with the rest of respondents (*n*=32; 24.2%) who stated they did not differentiate the variation between stochastic effects and the deterministic (non-stochastic) effects of radiation. This means that they were unaware of the probability of occurrence of radiation biological damage, either by under or by over estimation of radiation biological hazard effects. Despite the fact that general radiography delivers low doses well below 10mGy, it is believed that stochastic effects befall even at low doses. Hereafter, the International Commission on Radiation Protection (ICRP) considers it scientifically reasonable to assume that the incidence of induced cancer or hereditary effect rises in proportion to increased absorbed dose (Matthews and Brennan, 2008). Unevenly, it is anticipated that 5% of a population exposed to 1 Sv of effective dose will develop cancer during their lifetime, usually after a latency period of years to decades. In children, young adults and during pregnancy the risk is considerably higher, with biologically more sensitive tissue, whereas, in the population of Western European patients with a peak age of 60–70 years, it is reduced to 2–3% as a consequence of the age-related lower biological impact of ionizing radiation (European Society of Radiology (ESR, 2011)).

This is incompatible with Poalicchi et al (2016), who contended that about half of respondents were not able to differentiate between deterministic and stochastic effects. However, this mistaken knowledge builds some worries on radiographers' abilities, which are essential to optimize radiological examinations being undertaken on daily work. A radiographer who is poorly informed can place the patient at a higher risk by not optimizing all radiation-related imaging parameters and, likewise, might give mistaken answers to patients' questions related to the risk of the examination, as confirmed in previous studies.

Notably, one hundred-sixteen (*n*=116; 87.9%) of participants were very self-assured that they were familiar with the ALARA principle of the International Commission on Radiological Protection (ICRP), which is considered to embody the basic principles of radiation protection, whereas (*n*=16; 12.1%) indicated they did not identify the ALARA principle issued by the International Commission on Radiological Protection (ICRP). Out of those who replied positively, (*n*=110; 94.8%) correctly identified what the ALARA principle stands for "As Low as Reasonably Achievable".

The existing guidelines are founded on the traditional hypothesis that there is no safe level of exposure. Even the minimum exposure has some likelihood of causing a stochastic effect, such as cancer. This supposition has led to the general philosophy of not only keeping exposures below recommended levels or regulation restrictions, but, sustaining all exposure "as low as reasonable achievable" (ALARA) as well. ALARA is a rudimentary prerequisite of current radiation safety practices. It involves that every reasonable effort must be made to keep the dose to workers and the public as far below the required limits as possible (Hill and Einstein, 2016).

Our study results are consistent with Abu Arrah et al., study 2011, who stated that 19.8% did not know the meaning of ALARA (As Low As Reasonably Achievable), however, these study results were inconsistent with the study of Hamarsheh and Ahmead, 2011, who informed that only 6.1% of the respondents (physicians) were able to identify the ALARA principle. According to the ALARA (As Low As Reasonably Achievable) principle, it is possible to considerably lower the dose of ionizing radiations during tests. The as low as reasonably achievable (ALARA) principle, which highlights utilizing techniques and procedures to keep exposure to a level as low as reasonably achievable, should be trailed to minimize the risk of radiation exposure to medical professionals. Personnel shielding options (e.g., aprons, thyroid shields, and eye protection) should be used to effectively attenuate scattered x-ray levels (Greenlee et al., 2011). The radiation dose in any diagnostic procedure has to be sufficient to reply the relevant question, however, as low as reasonably achievable to decrease the risk to the patient. New imaging equipment permit adaptation for patient size and anatomy to let stronger commitment to the ALARA principle, e.g. using adjusted CT settings in children compared to adults (Paterson et al., 2001).

However, the researcher may suggest that ALARA can be promoted by:

- Providing suitable training for personnel to boost radiation awareness.
- Posting and labeling to alert staffs to the presence of potential radiation hazards.

- Affording appropriate personnel protective equipment.
- Searching the deficiencies, steering reviews and radiological assessment to determine areas for improvement.
- Drafting radiological safety procedures and suggesting policies or procedures for effectiveness.

Additionally, the vast majority (*n*=91; 68.9%) correctly identified the form of radiation protection for individuals who are often exposed to radiation. They identified that lead apron, maximizing the distance from the radiation source, and minimizing the amount of exposure time will lessen radiation to the least dose. Abu Arrah et al., 2011, contrasted our study results, where they stated that 50.5% were not aware of Inverse Square Law. It is also important to remember that the inverse square law applies to point sources. It cannot be applied to a source the size of patients for a quick determination of dose as a function of distance. Nevertheless, the use of distance remains beneficial in dose reduction. Highest distance reliable with good patient care is extremely fortified and results in dose reduction (Daniel et al., 1996) The majority identified the form of radiation protection for individuals who are often exposed to radiation regarding the impact of different solutions to help workers feel safe from ionizing radiation, using protective items (lead apron shielding, time and distance). Thus, it is necessary to reduce occupational radiation exposure as much as possible by employing prevention strategies, such as proper time, distance, and shielding techniques (Parmeggiani, 1983). Among those strategies, shielding effectively reduces exposure, and wearing personal protective equipment to shield inevitable direct or indirect radiation exposure is advisable. Many studies suggest that it is necessary to use protective equipment when potentially being exposed to radiation. Simple protective equipment used by doctors and nurses conducting endoscopic retrograde cholangiopancreatography (ERCP) could reduce more than 90 % of radiation exposure doses (Sander and Brunner, 1992).

Nonetheless, (*n*=12; 9.1%) underestimated or said they do not know the form of radiation protection. The researcher perceives that this might be a deficit in the knowledge of basic scientific principles. This inaccurate knowledge raises some doubts on radiographers' skills, which are fundamental to optimize daily radiological examinations. A poorly knowledgeable radiographer can put the patient and himself at a higher risk by not optimizing all radiation-related imaging parameters and, furthermore, might give inaccurate answers to patient questions related to the risk of the examination, as confirmed in previous studies.

Moreover, (*n*=18; 13.6%) of participants mistakenly stated that male sexual category are more likely to develop a radiation-induced cancer than other gender categories, and conversely, almost three-quarters of those respondents (*n*=99; 75%) correctly stated that female sexual category is more likely to develop a radiation-induced cancer than other gender categories. However, (*n*=15; 11.4%) underestimated or did not know the correct answer.

Paolicchi et al., 2013 indicated that about half of participants believed that radiation-induced cancer is not dependent on age or gender.

The latest unanimity by international and national organizations on radiation risk is that the risk of radiation-induced cancer and hereditary disease is assumed to increase with increasing radiation dose with no threshold (Wall et al., 2006). This signifies that each exposure to the x-ray by the patient counts, and the values accrue. By feature of the differences in their gender, health status of men against women and boys against girls can be significantly different. However, this is correct nonetheless of any exposure to radiation. Many studies have found that a number of chief illnesses are inclined by gender, e.g., female breasts are more sensitive to ionizing radiation than male breasts. Although men can develop breast cancer, it is exceptionally uncommon. The risk for radiation-induced breast cancer in men is insignificant. Females have a higher risk of radiation-induced:

- Lung cancer
- Thyroid cancer
- Breast cancer

Accordingly, x-ray exposure is an important public health issue chiefly in women where imaging of the lower body exposes ovaries to radiation (https://www.radiologyinfo.org/en/submenu.cfm?pg=safety)

Furthermore, knowledge of organ sensitivities to ionizing radiation was not also encouraging as expected with only ninety-nine (*n*=99; 75.0%) participants fittingly classified that gonads are the most susceptible organs that are sensitive to ionizing radiation damage more than other classifications, whereas, (*n*=13; 9.8%) underestimated or did not know the right answer.

It is mandatory, according to International Commission for Radiation Protection (ICRP), radiation safety standards for gonads shields should be used for the protection of the gonads when the pelvis is not part of the anatomical area being examined. The gonadal shielding use is indispensable when a woman of childbearing age comes to undergo for x-ray examinations

Strikingly, (*n*=9; 6.8%) of the study subjects underestimated or did not know that magnetic resonance imaging (MRI) does not emit radiation. It is concerning that, a small proportion of participants incorrectly considered that fluoroscopy does not expose patients to a dose of radiation; (*n*=15; 11.4%), while (*n*=104; 78%) appropriately identified that MRI does not release radiation. The assessment of participants' knowledge of principles of MRI yielded a disappointing result with 22%. Excepting magnetic resonance imaging (MRI) and ultrasonography, exposure of patients in conventional or plain film radiography involves ionising radiation. Conventional radiography grants vast benefits on patient management, but this benefit is not without radiation risks. Researchers have argued that diagnostic imaging, which includes conventional radiography, carries small but real risks (Lockwood et al., 2007).

This result is consistent with previous studies reporting that MRI was associated with radiation by participants in dissimilar percentages to that observed in our study; Günalp et al., 2014 who found that there were still medical practitioners who fail to recognize MRI as radiation-free modality. Conversely, and inconsistent with Yurt et al., 2014 study, they argued that only 1 of 10 participants was able to give an answer for the dose evaluation of abdominal magnetic resonance imaging (MRI) of chest x-ray. In addition, this is reliable with Paolicchi et al., 2013 who recounted that about 5 % of the radiographers claimed that pelvis magnetic resonance imaging exposed patients to radiation. On the contrary, 7.0 % of the radiographers stated that mammography does not use ionising radiation. Additionally, these results are coherent with previous studies, which reported that MRI were associated with radiation by 8%–28% of respondents (Shiralkar et al., 2003; Jacob et al., 2004; Arslanoglu et al., 2007; Zhou et al., 2010).

The researcher observes that it seems to reflect a deficit of knowledge of basic scientific principles. It may be explained by the fact that MRI is infrequently requested from emergency department, is often difficult to access and is more likely to be requested by the senior members of staff. Although a smaller proportion of radiographers are associated MRI to work on this equipment, this potentially has more clinical relevance because of the numbers of MRI requested.

Subjects reported that three quarters of cases (*n*=99; 75.0%) appropriately answered that children are those who are more sensitive to radiation more than other people, while, (*n*=13; 9.8%) of the respondents underestimated or did not know the right answer. Furthermore, (*n*=14; 10.6%) erroneously indicated that elderly are more sensitive to radiation than other age categories.

Studies advocate that exposure of fetus in utero in the course of pregnancy could lead to extensive variety of malformations. Primary childhood (up to 10 years) exposure carries a higher radiation risk, and the likelihood of introduction of cancer especially leukaemia is about two to three times higher than adults are (Børretzen et al., 2007). The reason could be that the pediatric patients are smaller body sizes compared to adults, quick cellular evolution, and after exposure longer period of survival life relative to adults. Children have a longer lifetime to manifest potential radiation injuries, some of which have long latency periods before they are expressed (Brenner et al., 2007). Strauss et al., 2010, indicated that cancer risk for a 4-year-old boy is likely 3-5 times greater than for a 40 year old man. Children's rapidly dividing cells are more radiosensitive than those of adults are. In 1989, a British review displayed that 4% of all CT examinations were executed for children younger than 15 years of age (Brenner et al., 2001); nevertheless, by 1999, this figure had increased up to 11.2% (Shrimpton and Edyvean, 1998).

In line with our study, Sullivan et al., 2010, indicated that 80% of the study group correctly answered that children were more sensitive to the effects of ionising radiation than adolescents, adults or the elderly. Furthermore, the lifetime attributable risk of fatal cancer for children exposed to radiation is substantially higher than for adults (Brenner et al., 2001). Moreover, in support of our study, radiation hazard can be particularly relevant for young patients, chiefly children, whose high biological susceptibility and long life expectancy have a propensity to raise the probability of the possessions of not only cancer but also other non-cancerous diseases. In this regard, evidence exists that imaging parameters for pediatric investigations are repeatedly not accustomed to the slighter sizes of children matched up to adults, resulting in needlessly high radiation exposure (Nosek et al., 2013; Vassileva et al., 2013). The present imaging approaches must be optimized in order to lessen the radiation exposure in pediatric patients (Kleinerman, 2006), who may be up to ten times more radiosensitive than adults may. Along the lines of this principle, we need two procedures to limit the doses: the first one related to the equipment itself whose design should be optimized for dose lessening, and the second one, is about the correct training for people to this correctly equipment (Strauss and Kaste, 2006). It is also likely to discuss the attitude towards a study whose image quality is not perfect, although good enough to clarify the clinical doubt with the obtained images. In such a condition, it is not desirable to iterate the scan in order to attain better images if such images will not offer additional applicable data.

The preoccupation with the knowledge that radiographers have on radiation knowledge and awareness involved in radiological procedures is increasing in the literature, and previous studies have demonstrated that such knowledge is inappropriate. From the obtained data, it was possible to realize that the very concept of ionizing radiation knowledge is heterogeneous and in some points needs to be improved, but insufficient among radiographers, and it is likely that many factors contributed to the "inadequate satisfactory" knowledge scores (67.93%) achieved in this study. There was a trend of gradually increasing overall knowledge scores as the level of employment of the radiographers increased. The outcome of the first section of the questionnaire reveals an underestimation and overestimation of various radiological procedures. No one was able to complete this section without making any mistake and, surprisingly, results showed that radiographers still have doubts about which procedures make use of ionising radiation and which do not, as found in the questions related to MRI. This might be a discrepancy in the knowledge of basic scientific principles. This inaccurate knowledge builds some uncertainties on radiographers’ skills, which are essential to optimize day-to-day radiological examinations. A poorly educated radiographer can put the patient and himself at a higher risk by not optimizing all radiation-related imaging considerations and, besides, might give imprecise answers to patients' questions related to the risk of the examination.

We recommend education and ongoing assessment during the study, and working duty years to improve understanding of radiation exposure. There is also a need for continued collaboration between radiologists, emergency physicians and radiographers in creating local protocols. It has been previously suggested that radiation doses and associated risks should be provided on imaging request forms. This may increase evenly, radiographers’ and doctors’ general awareness as well, and have a more competent effect on overall knowledge and behaviour. The patient’s personal aggregate accumulated dose of radiation could also be counted in on the formal imaging report, as already occurs in a number of UK hospitals (Grove, 2003). Education to mend awareness is compulsory to generate an alteration in behavior, especially in view of lessening the apparently inevitable increase in malignancies in the future.

Table 4.2: Questionnaire responses regarding radiation protection knowledge and awareness (*n*=132).

| No: | Questionnaire response | *n* | (%)* |
|---|---|---|---|
| Q 5 | **How do you consider your knowledge level about ionizing radiation risk?** | | |
| | Excellent | 26 | (19.7) |
| | Good | 95 | (72.0) |
| | Insufficient | 11 | (8.3) |
| Q 6 | **Do you know the difference between stochastic effects and the deterministic (non-stochastic) effects of radiation?** | | |
| | Yes | 100 | (75.8) |
| | No | 32 | (24.2) |
| Q 7 | **The radiation protection philosophy of the International Commission on Radiological Protection (ICRP) includes the ALARA principle. Do you know the ALARA principle?** | | |
| | Yes | 116 | (87.9) |
| | No | 16 | (12.1) |
| Q 8 | **If yes, ALARA principle stands for which of the following?** | | |
| | ***As Low as Reasonably Achievable*** | ***110*** | ***(94.8)*** |
| | Allowable Administered Radiation Alert | 6 | (5.2) |
| | I don't know | 0 | (0.0) |
| Q 9 | **According to your knowledge, what is the *form* of radiation protection for individuals who are often exposed to radiation?** | | |
| | Lead screen/Apron shielding | 12 | (9.1) |
| | Maximizing the distance from the radiation source | 4 | (3.0) |
| | Minimizing the amount of exposure time | 13 | (9.8) |
| | ***All of the above*** | ***91*** | ***(68.9)*** |
| | I don't know | 12 | (9.1) |
| Q 10 | **Which gender of patients is the *most* sensitive to ionizing radiation?** | | |
| | Male | 18 | (13.6) |
| | ***Female*** | ***99*** | ***(75.0)*** |
| | I don't know | 15 | (11.4) |
| Q 11 | **Which one of the following organs is *more* susceptible to ionizing radiation damage?** | | |
| | Breast | 16 | (12.1) |
| | Bone | 0 | (0.0) |
| | Liver | 4 | (3.0) |
| | ***Gonads*** | ***99*** | ***(75.0)*** |
| | I don't know | 13 | (9.8) |
| Q 12 | **Which one of the following has *no* radiation risks?** | | |
| | Fluoroscopy | 15 | (11.4) |
| | ***MRI*** | ***104*** | ***(78.8)*** |
| | PET | 4 | (3.0) |
| | Technetium bone scan | 0 | (0) |
| | I don't know | 9 | (6.8) |
| | **Please, select which one of the following is the *most* sensitive to radiation** | | |
| | ***Children*** | ***99*** | ***(75.0)*** |
| | Adults | 0 | (0.0) |

| No: | Questionnaire response | *n* | (%)* |
|---|---|---|---|
| **Q 13** | Adolescents | 6 | (4.5) |
| | Elderly | 14 | (10.6) |
| | I don't know | 13 | (9.8) |

*Abbreviations: MRI: magnetic resonance imaging; CT: computed tomography; PET: Positron emission tomography. *Some percentages may be less or more than 100% due to rounding; ALARA: As Low As Reasonably Achievable.*

## 4.4 Optimisation and Justification

The participants were also questioned about optimisation and justification principles. Just fifty-nine (*n*=59; 44.7%) participants did not know and gave the erroneous answers that "dose optimization" concept is the dose that must be kept as low as reasonably achievable and compatible with the diagnostic information, however, (*n*=73; 55.3%) correctly identified the answer in the approved manner. Conversely, (*n*=83; 62.9%) did not know, or incorrectly gave wrong answers, nonetheless, (*n*=49; 37.1%) denoted correctly that the concept "dose justification" as any decision that changes the radiation exposure situation should do more good than harm (Table 4.3).

In Brazil, the Comissão Nacional de Energia Nuclear (CNEN) (National Commission of Nuclear Energy) established three basic radioprotection principles: justification, optimization and limitation of individual doses. The principle of justification means that any action concerning radiation must be justifiable in relation to other substitutions and deliver a net benefit to society. The optimization principle recognized that all exposures should be preserved as low as reasonably achievable (ALARA) which in turn enforces that doses on workers and general public should not go beyond the annual dose limits established by CNEN (Tauhata et al., 2003).

Our study results are in line with that of Jacob et al., 2004, who argued that only 56.7% of practitioners, who, under Ionizing Radiation (Medical Exposures) Regulations 2000, have responsibility for justifying procedures, passed the test. Besides, a number of participants' were not aware of the concepts of radiation safety principles such as justification and optimisation (Portelli et al., 2016). However, such insufficiency of awareness about radiation risk may be enormously hazardous when high dose examinations, such as multiphase MDCT studies, are performed without optimisation, resulting in a potentially momentous biological duration risk for patients (Nosek et al., 2013; Vassileva et al., 2013). The basic radiation protection principles of justification and optimization should be taken into consideration in this period of rapid increase of investigation following the availability of new equipment. International Basic Safety Standards (BSS) necessitate that an examination should be carried out only in the case of a justifiable clinical indication. In definite situations, non-ionising techniques such as ultrasound or magnetic resonance imaging (MRI) could possibly deliver alike information without irradiating the patient (International Atomic Energy Agency, 1996).

The researcher perceives that radiographers should be provided with intensive education programs on doses per application, risk/benefit analysis and biological effects of radiation. Besides, radiographers should attend obligatory radiation safety courses during their undergraduate studies. Moreover, they should join radiation protection and radiation safety training; attend updating courses about new technologies and devices, which can limit radiation dose without compromising the image quality. The establishment of standard protocols for the most frequent examinations will limit radiation dose only to the level really required.

Table 4.3: Questionnaire responses regarding describing the concepts "dose optimization and justification" (*n*=132).

| No: | Questionnaire response | *n* | (%)* |
|---|---|---|---|
| Q 14 | **Which one of the following best describes the concept "dose optimization"?** | | |
| | ***The dose must be kept as low as reasonably achievable and compatible with the diagnostic information.*** | ***73*** | ***(55.3)*** |
| | The level of protection is not necessary be the best under the main circumstances. | 23 | (17.4) |
| | There should **not** be restrictions on the doses or risks to individuals. | 15 | (11.4) |
| | The actual radiation doses are often much **higher** than the permitted limit. | 3 | (2.3) |
| | I don't know | 18 | (13.6) |
| Q 15 | **Which one of the following best describes the concept "dose justification"?** | | |
| | ***Any decision that changes the radiation exposure situation should do more good than harm.*** | ***49*** | ***(37.1)*** |
| | Integration of radiation protection and quality assurance. | 47 | (35.6) |
| | Increasing the support of medical physics in imaging. | 2 | (1.5) |
| | Unnecessary use of radiation is permitted. | 4 | (3.0) |
| | I don't know | 30 | (22.7) |

**Some percentages may be less or more than 100% due to rounding. Correct answer in* ***bold*** *and italics.*

## 4.5 Radiation Protection Practice

Results of Table 4.4 below show that only (*n*=51; 38.6%) were always adherent to wear lead aprons in using daily job radiation protection and personal protective equipment (PPE) during radiological procedures, however, less than half (*n*=60;

45.5%) testified that they sometimes use thyroid shields. Conversely, the majority (*n*=67; 50.8%) affirmed never using lead gloves, whereas, more than half (*n*=76; 57.6%) confirmed using eyeglasses occasionally, yet, about half (*n*=67; 50.8%) admitted never using gonadal shielding, occasionally, (*n*=119; 90.2%) were adherent to use collimation permanently.

Radiographers and radiologists should remain in the endangered area during exposure as far as reasonably possible. The ICRP states: "any person within 1m of an X-ray source or patient when the machine is operated at 100 kV should wear a protective apron of at least 0.35 mm lead or lead equivalency. Other staff in theatre should wear at least 0.25mm lead or equivalent aprons for protection." (ICRP, 1989). However, if a radiographer dresses up a single-sided apron, then it is important to face the source of radiation and not to avert from the source (WHO, 2004). Along with the ICRP Publication 57, lead rubber gloves should be at least 0.35 mm lead. Gloves should be used to protect workers' hands. Likewise, thyroid gland is quite sensitive to ionizing radiation. Consequently, it is recommended to use a radiation protection gadget on every occasion possible. There are numerous types of shields on the market. If not obtainable, a lead rubber apron with a high neckline can be used. Caution should be taken when using the shields to confirm not to be damaged, and they should be warehoused in a safe place when not in use. Gonads should be protected from being exposed to ionizing radiation. When gonads are within the primary beam or within 5 cm of it, shielding should be used if this can be done without concealing or eliminating information needed for diagnosis (WHO, 2004).

Abdellah et al., 2015, debated in their study that respondents used collimation more than they did other PPE and only, 52.5% used lead gloves. The use of other measures, such as thyroid shields and eyeglasses were less frequent than expected. This was matching to our study results, nonetheless, the results of Friedman et al., 2013, suggest that the use of the body and thyroid shields was high (99% and 73%, respectively), and no one used lead-lined glasses and gloves, while Moghimbeigi and Mojiri, 2011, reported that the minimum rate is related to their awareness about lead goggles by 28.2%. Furthermore, El Dahshan et al., 2017, observed that the majority of study subjects (68.2%) used PPE. Likewise, Adhikari et al., 2012, also argued about the impact of different solutions to help workers to be safe and feel safe from ionizing radiation, they found that more than 80% of the radiation workers know that using protective items (lead apron, lead glass, time and distance etc.) help to protect them from ionizing radiation. Additionally, our study results are in line with Heo et al., 2016, who reported that the mean rate of lead apron wearing during radiologic procedures was 48.0 %. Consequently, it is necessary to reduce occupational radiation exposure as much as possible by employing prevention strategies, such as proper time, distance, and shielding techniques (Parmeggiani, 1983). Among those strategies, shielding effectively reduces exposure, and, wearing personal protective equipment to shield inevitable direct or indirect radiation exposure is worthwhile. Many studies suggest that it is necessary to use protective equipment when potentially being exposed to radiation. Sander and Brunner, 1992, conveyed that simple protective equipment used by doctors and nurses conducting endoscopic retrograde cholangiopancreatography (ERCP) could reduce more than 90 % of radiation exposure doses, while Singer and his co-workers, 1989, stated that lead gloves reduce more than 99 % of radiation exposure doses during portable cervical spine radiography in the emergency room. Likewise, Niklason et al., 1993, quantified that lead aprons with thyroid collars reduce more than 97 % of radiation doses annually. Conversely, past studies have reported that radiation workers have insufficiently used the protective measures. There were 7.0–12.3% of radiographers did not use lead aprons (Mojiri and Moghimbeigi, 2001; Lee, 1991; Kim, 2000). Shielding in sensitive groups such as children and young patients should be used. When they are not in the primary beam, shielding to organs such as the thyroid, eye lens and breast can result in 40% to 80% reduction in radiation dose (Beaconsfield et al., 1998). By shielding the testes in abdominal procedures, a reduction of 95% in radiation dose can be achieved (Hidajat et al., 1996). Appropriate use of personal protective equipment and monitoring the instructions and regulations for protection against ionizing radiation can significantly decrease needless exposure. Consequently, radiographers' knowledge of such standards and observances can play an imperative role in protection against radiation (Bezanjani, 2009).

Published data indicate that PPE will lower the exposure by at least one half. Strict adherence to the radiation exposure guidelines is mandatory when using X-rays. In keeping with the ALARA principle, it seems logical that all radiographers should wear all PPE. However, the researcher perceives that the use of PPE becomes, eventually, a personal decision, but to disseminate the culture of wearing personal protective equipment (PPE) and all possible safety measures is highly preferred. It has been our experience that most radiographers decline the option of wearing PPE and, when worn, they are worn infrequently.

Table 4.4: Questionnaire responses regarding describing the radiation personal protective equipment (PPE) (*n*=132).

| No: | Questionnaire response | | *n* (%)* | |
|---|---|---|---|---|
| Q 16 | **How often do you use the following radiation protection/personal protective equipment (PPE), during radiological procedures?** | | | |
| | **Policies/equipment** | **Never** | **Sometimes** | **Always** |
| | Lead aprons | 13 (9.8) | 68 (51.5) | 51 (38.6) |
| | Thyroid shields | 29 (22.0) | 60 (45.5) | 43 (32.6) |
| | Lead gloves | 67(50.8) | 48 (36.4) | 17 (12.9) |
| | Eye glasses | 34 (25.8) | 76 (57.6) | 22 (16.7) |
| | Gonad shielding | 67 (50.8) | 24 (18.2) | 41 (31.1) |
| | Collimation | 4 (3.0) | 9 (6.8) | 119 (90.2) |

**Some percentages may be less or more than 100% due to rounding. This question was graded in a scale of 0 to 2 grades, where: 0 =* ***never****; 1 =* ***Sometimes****; 2 =* ***Always****.*

Table 4.5 below shows that (*n*=49; 37.1%) of participants simplify and illuminate all risks and benefits of the X-ray examination to the patient and patient's family when being asked for a clarification before achieving an X-ray procedure. However, (*n*=111; 84.1%) would (often more than 75% to always) ask a woman if she is married and pregnant before carrying out a radiological procedure, and (*n*=8; 6.1%) admitted they would never ask a married and pregnant before carrying out a radiological procedure. Nonetheless, (*n*=15; 11.4%) of the subjects would never request a written consent form from a pregnant woman before executing an x-ray examination, however, (n=89; 67.4%) would (often more than 75% to always) demand a written consent form from a pregnant woman before executing an x-ray examination.

Along with the International Commission on Radiological Protection (ICRP), thousands of pregnant women are exposed to medically indicated ionizing radiation each year. Regulation 7(5) entails the employer’s procedures to give instructions and information in cases where radioactive medicinal products are administered to a patient (Murray, 2012).

The incidence at which pregnant women are inadvertently exposed to ionizing radiation is unidentified (ICRP, 2000). Preceding an examination, the patient frequently can give sufficient data to evaluate the possibility of pregnancy (ICRP, 1991). All married patients of menstrual age (typically ages 12 through 50 years

(Wagner et al., 1997) should be questioned about pregnancy status using a standardized form and/or through direct questioning by the radiographer. To this former respect, answering patient queries concisely and accurately; inconsistent with our study results, Paolicchi, et al., 2013, testified that almost all participants (95%) showed an awareness of the need to communicate to the patient the possible risks related to radiation exposure. Conversely, and consistently, a survey conducted by Briggs-Kamara and co-workers (2013), showed that more than 60% of the radiographers did not give any explanation to patients before the procedure. This deficiency of tutoring may produce fear in patients and inhibit a good cooperation during the examination, in conjunction with a higher risk of requiring repeating it (European Council Directive, 2014). Likewise, Lee et al. (2004) informed that not nearly all patients undergoing CT scans were told about the radiation risk. Accordingly, this may be somewhat verified by missing the knowledge among radiographers concerning the radiation dose of frequently carried out examinations, despite years of clinical experience. Adhikari et al., 2012 indicated that about 74% of the radiation workers would like to receive more information about ionizing radiation risks in health effect, while, around 88.7% designated a radiation protection expert in the hospital for informing public on radiation risk. This would indicate the recruitment of a radiation protection officer in each hospital who is responsible for radiation protection, especially, when PACS is about to be installed. Goske and Bula, 2009, claimed that consistent and reasonable health information is the responsibility of health care providers and the right of the patient. The results of this Bernard's study, 2012, however, revealed that health care workers were careless in their giving out of information about x-rays. Better attention to health worker-patient communication might help health workers to build confidence and answer wisely to patient demand. Patients must feel free to ask about x-rays and get proper answers.

The researcher perceives that there is a need for a sustained teamwork between the radiographers, radiologists and emergency physicians in creating local protocols. The researcher suggests that radiation doses and associated risks should be provided on imaging request forms. This would allow the requesting doctor and the radiographer to consider this information and discuss the risks with the patient. This may increase radiographers' and doctors' general awareness altogether and have a more long-term effect on whole knowledge and behaviour. Besides, the patient's personal total accumulated dose of radiation could also be included on the formal imaging report, as already occurs in a number of UK hospitals (Grove, 2003). In radiology departments, it is imperative to have procedures to control the pregnancy status of female patients of reproductive age prior to any radiological examination that could cause a considerable dose to the embryo or fetus. One approach is the "ten day rule", which declares, "Whenever possible, one should confine the radiological examination of the lower abdomen and pelvis to the 10-day interval following the onset of menstruation." (ACOG Committee on Obstetric Practice, 2004).

Regarding the radiologic imaging of pregnant women, the National Council on Radiation Protection and Measurements (National Council on Radiation Protection and Measurements, 1977) published the following statement: “The risk (of abnormality) is considered to be negligible at 50 mGy or less when compared to other risks of pregnancy. However, the risk of malformations is significantly increased above control levels only at doses above 100-150 mGy. Therefore, exposure of the fetus to radiation arising from diagnostic procedures would very rarely because, by itself, for terminating a pregnancy.” Nonetheless, the American College of Radiology (American College of Radiology, 2005) set up the following as its policy concerning the use of therapeutic abortion: “The interruption of pregnancy is rarely justified because of radiation risk to the embryo or fetus from a radiologic examination.” Along with a statement published by the International Commission on Radiological Protection (International Commission on Radiological Protection, 2000). “Prenatal doses from most properly done diagnostic procedures present no measurably increased risk of prenatal death, malformation, or impairment of mental development over the background incidence of these entities.” Furthermore, the commission identified, “Fetal doses below 100 mGy should not be considered a reason for terminating a pregnancy” (ICRP, 2000, Publication 84). Lately, the American College of Obstetricians and Gynecologists (ACOG Committee on Obstetric Practice, 2004) issued the following policy statement: “Women should be counseled that x-ray exposure from a single diagnostic procedure does not result in harmful fetal effects. Specifically, exposure to less than 5 rad [50 mGy, 0.5 rem/year] has not been associated with an increase in fetal anomalies or pregnancy loss.” In many cases, especially with inpatients, pregnancy status is often available in the health information system (HIS). Pregnancy status must be documented before an order for radiological examination is accepted.

Despite the best efforts of numerous scientists, over the past fifty years, the risk remains unclear and poorly defined because pregnancy and radiation are two topics overloaded with emotion and opinion. Pregnant women who have received radiation doses while pregnancy are often alarmed because of emotional perceptions surrounding radiation. Hence, practices to maintain ALARA should be employed at all times; minimize time, maximize distance moreover, and use shielding whenever possible (Daniel et al., 1996).

When using ionizing radiation, the risks possibility to the embryo and fetus must be considered to explore female patients of reproductive age. Substitute imaging modalities and techniques not involving ionizing radiation should also be considered. A female patient of reproductive age who comes for an examination to irradiate the pelvic area should be asked whether she is, or might be pregnant. In case of uncertainty, then it is desirable, excluding an emergency, to postpone the examination until a pregnancy has been excluded. X-ray examinations of a pregnant woman should be postponed until after delivery, whenever possible. If the examination has to be carried out straightaway, the radiation dose must be kept at a minimum, without comprising treatment of the patient (WHO, 2004).

Seemingly, there are moral and legal allegations of exposure to ionizing radiation that have to be adopted, such as the right of a patient to be notified of the risks involved in the procedures to which he or she has been referred. The refutation of radiation safety may expose both staff and patients to risk of suffering increasing exposure to radiation hazards. However, upgrading in radiation safety awareness can endorse the level of safety and health in the studied hospitals.

Moreover, the researcher perceives that MoH has to set a screening policy to assist radiographers, radiologists and physicians in categorizing pregnant patients; preventing unnecessary irradiation of pregnant women; adapting examinations to manage radiation dose effectively; and developing strategies to quantify and evaluate the potential effects of radiation delivered to pregnant patients. The researcher may suggest specific goals for this screening policy to:

- Promote the knowledge and awareness of the radiographer, radiologists and physicians who all must be well educated and trained to achieve this goal. Specifically, a highly qualified and skilled radiographer can provide appropriate services using imaging techniques, taking into account gestation age at time of exposure,

- Support guidance on when and how to assess for pregnancy before imaging examinations using ionizing radiation,
- Indorse and recommend means to control, manage, and minimize radiation dose to pregnant or potentially pregnant patients, and
- Manage dose assessment, risk assessment, and communication issues following exposure of pregnant patients.
-

Table 4.5: Questionnaire responses regarding describing the radiation protection practice (clarification) (*n*=132).

| No: | Questionnaire response | *n* (%)* | | | | |
|---|---|---|---|---|---|---|
| | **For each of the following statements, select the response that most closely matches your opinion.** | | | | | |
| | **Item** | **Never** | **When asking for clarification** | **Rarely less than 25%** | **Sometimes 25%- 75%** | **Often more than 75%** |
| **Q 17** | Usually, before achieving an X-ray examination, do you outline (clarify) all risks and benefits of the X-ray examination to the patient and patient's family? | 40 (30.3) | 49 (37.1) | 29 (22.0) | 8 (6.1) | 6 (4.5) |
| | How often would you ask a woman if she is married and pregnant before performing radiological procedure? | 8 (.6.1) | 3 (2.3) | 6 (4.5) | 4 (3.0) | 111 (84.1) |
| | How often would you request written consent form from a pregnant woman before doing an x-ray examination? | 15 (11.4) | 0.0 | 18 (13.6) | 10 (7.6) | 89 (67.4) |

**Some percentages may be less or more than 100% due to rounding. This question was graded in a scale of 0 to 4 grades, where: 0 = **never**; 1 = **When asking for clarification**; 2 = **Rarely less than 25%**; 3 = **Sometimes 25%-75%**; 4 = **Often more than 75%.***

Regarding radiographers' practice in Table 4.6 below, (*n*=112; 84.8%) acceptably identified how ALARA is used in the practice of radiation protection as high KVp and low mAs, weheras, (*n*=109; 82.6%) disclosed that they would apply ALARA principle in their work.

Fauber et al., 2011 carried out an experimental design to study the influence of varying kilovoltage peak (kVp) and milliampere-seconds (mAs) on a male phantom pelvis when using a direct digital radiography (DR) flat panel detector. The radiation intensity was varied by decreasing mAs and raising the kVp. Image quality was evaluated by evaluating density, density variances, quantum noise and overall diagnostic quality. When the kVp was increased in 15% increments, and mAs divided by half, the radiation dose to the gonads significantly decreased. The lowest and highest kVp exposure groups produced the lowest values. However, the results showed that a pelvic DR image formed at 93 kVp and 12.5 mAs will reduce the gonadal dose while sustaining an image of diagnostic quality (Fauber et al., 2011).

Nevertheless, to apply (ALARA) principle, a dose of radiation given should be enough to answer the medical question, but as low as reasonably achievable (ALARA) to lessen the risk to the patient (Paterson et al., 2011). Contemporary imaging equipment permits adjustment for patient size and anatomy to allow closer adherence to the ALARA principle (e.g., using modified CT settings in children compared to adults, the amount of radiation is lessened by a factor 6-7) (Brenner et al., 2011). Nonetheless, this is important, since the lifetime cancer risk for children exposed to radiation is substantially higher than for adults (Jacob et al., 2004). However, WHO, 2004, issued tips to reduce dose through the selection of kVp and mAs:

- The higher the kVp selected, the more penetrating the beam= low dose.
- Use highest kVp possible to penetrate area of interest (the ALARA principle).
- mAs (tube current x time in seconds/milliseconds) has direct role in contributing to dose to patients; thus higher mAs=higher dose. Hence, keep mAs as low as possible without compromising image quality (the ALARA principle).

The process to decrease unwanted radiation dose to patients, optimal image quality should be achieved using the highest potential kVp for imagining of the anatomical parts to be scanned. If the examination requires soft tissues to be visualized, then the technique of low kV should be used. The dose is decreased when largely penetrating capacities of the X-ray beam are high (high kV). The selection of too much mAs, means that patient dose is increased. A very black radiograph indicates that the patient had inessential radiation because of high mAs factors. To lessen the necessity for repeats, it is recommended that basic quality assurance tests be carried out. Fog of the radiograph contributes to poor image development and details may not be visualized (WHO, 2004). At fixed kVp and filtration, radiation dose is related to mAs, indicating that by the reduction of mAs by half, the dose is also reduced by half. Conversely, noise is inversely related to mAs. Consequently, the decline by half of mAs will result in a 50 % increase in image noise (Tsapaki, and Rehani, 2007).

**There are some factors to minimize radiation dose to patients and staff:**

Some radiation protection measurements such as filtration of the beam, rectification, and tube shielding are not within a radiographer's control. Others are within the control of the radiographer to show how ALARA used in the practice of radiation protection and applied, as shown below.

- Limitation of field size to area of interest
- Use of fast screen-film combinations whenever appropriate
- Optimal film processing
- Use of automatic exposure timers if available
- Use of gonad shields
- Selection of grid
- Compression of obese patient
- Highest practicable kV and lowest mAs
- Reduction of number of repeats by careful patient positioning, and use of immobilization devices
- Performance of basic quality assurance tests
- No continuous radiation during fluoroscopy
- Only required staff allowed into room during radiographic examinations
- All staff should stand behind protective barrier during the exposure
- X-ray units must have adequate shielding
- Staff who are required outside the barrier must wear lead-rubber aprons
- Field size to be smaller than screen size during fluoroscopy
- Staff should stand outside the path of the primary beam, and as far away from it as possible
- Lead-rubber flaps to be used on image intensifiers to reduce scatter to staff (WHO, 2004).

The quality control of imaging methods should be arranged such that high image quality with a dose as low as reasonably achievable (ALARA) is maintained. The up-to-date perception for lessening the risk to the patient is to embrace the ALARA (as low as reasonably achievable) principle (ICRP, 1991). This principle can be realized in many ways. One of which is through technological inventions, which may offer ways of creating suitable images with reduced levels of radiation exposure. For instance, advances in cardiac CT technology the past five years have caused a decline in the minimum achievable dose from 10–16 mSv to as low as 1–3 mSv.

It has been stated, "Good radiological practice is something that can be taught". Tsapaki and Rehani, 2007, repeated this point of view specifically that just about 40% dose reduction is achievable by proper training. Expectantly, this study offers some additional knowledge on this (WHO, 2004).

Table 4.6: Questionnaire responses regarding describing the radiation protection practice (usage and application of ALARA) (*n*=132).

| No: | Questionnaire response | *n* | (%)* |
|---|---|---|---|
| Q 18 | **How is ALARA used in the practice of radiation protection?** | | |
| | ***High KVp, low mAs*** | ***112*** | ***(84.8)*** |
| | Low KVp, high mAs | 6 | (4.5) |
| | I don't know | 14 | (10.6) |
| Q 19 | **Do you apply ALARA as work principle?** | | |
| | Yes | 109 | (82.6) |
| | No | 23 | (17.4) |

**Some percentages may be less or more than 100% due to rounding. Correct answer in **bold** and italics.*

## 4.6 Training

It is not surprising that the vast majority (*n*=112; 84.4%) of radiographers had rarely or never attended specific training events about radiation protection, however, (n=94; 71.2%) of them admitted they need (further) training on radiation safety or radiation doses (Table 4.7).

The International Commission on Radiological Protection (ICRP) published in 2008 an updated report on ‘Radiological Protection in Medicine’ (Publication 105) (ICRP, 2008), and continues to work on RP-focused documents centered on specific areas where advice is needed. One of the ongoing drafts by the ICRP Committee 3 (RP in medicine) is the following:

- "Education and training in radiological protection for diagnostic and interventional procedures".

According to the Council of the European Union Medical Exposure Directive, a course on radiation protection should be part of the basic curriculum of medical schools (Linton and Mettler, 2003). Training is considered the first important step in radiation safety, and education is ultimately the only way to increase awareness of the potential risks of ionizing radiation. Yet despite not having some form of education on this subject previously, participants scored fairly. Nol et al., (2005 & 2006) identified that poor training and knowledge caused preventable exposures and duplicated examinations by medical radiographers. The overwhelming technique of this was through education, training, and raising awareness to the risk of exposure to radiation. Moreover, administrative training is required for all users, including those with equivalent radiation training.

These results matched that of Paolicchi et al., 2013, who reported that only 12.1% of participants attended radiation protection courses on a regular basis. After identifying the cause, it would be important to plan different actions to rectify this situation. Additionally, our results show that only 11.2% of physicians received radiation safety training and only 20.0% of them read about radiation safety. A higher rate of the respondents (55%) had attended an education program in Europe about radiation safety and the attendance was highest in Poland (82.6%) (Söylemez et al., 2013; Friedman et al., 2013). It was acknowledged that radiological courses surely increase awareness about radiation dose. There is a need to educate clinicians about ionizing radiation relevant to medical imaging and their clinical role to offer precise information to their patients (Soye and Paterson, 2008). Although many radiologic procedures are performed in India, most radiographers reported not being trained in radiation safety, even though most realized that training is necessary (Muthusami et al., 2014).

Some universities in the world have medical schools that offer training and give a bachelor degree in medical imaging. Nevertheless, locally, national universities pay not too much attention to provide radiation protection courses for their students during their undergraduate studies. Since after graduation, these radiographers will be the only health professionals having the authority to present the radiological examinations to the physician to make his appropriate informed clinical decision. Furthermore, since the radiographers are directly responsible for performing the radiology tests, they have a vital role in applying the safety plans. In addition, there is a lack of studies in Palestine about the hazards of unnecessary use of radiological examinations. There is only one study among physicians on the knowledge and awareness of radiation exposure during common radiological procedures; the result was poor (Hamarsheh and Ahmead, 2011).

Many factors contributed to these inadequate knowledge scores:

- The undergraduate never having formal training or extra radiation protection courses on this topic.

- The deficit of knowledge of basic scientific principles during their work.
- No organized continuous education in hospitals on radiation protection.

Summarizing, the results of this research emphasize the need for further education of present and future radiographers who should:

- Schedule continuing medical education on radiation protection in hospital practice, and be provided with intensive education programs on doses per application, risk/benefit analysis and biological effects of radiation.
- Attend obligatory radiation safety courses during their undergraduate studies, as well as current job working staff by regularly organizing seminars and symposia and longer follow up periods.
- Attend updating courses about new technologies and devices, which can limit radiation dose without compromising the image quality.
- Be familiar with software, which allows radiation dose monitoring of daily-performed examinations, as well as quality control program.
- Be setting up and periodically reviewing diagnostic reference levels for adult, pregnant and pediatric patients.

The increasing convolution of the techniques used in X-ray, radiotherapy, and nuclear medicine demands for the continuing education of the radiology personnel. Each national organization should pay attention to the matter and magnitude of programmes for the training of staff through refresher courses and conferences. Expenses should be covered to such training. Every national authority in line with the national legislation must regulate the policy governing certification and intervallic reviews of capacity (Braestrup and Vikterlof, 1974).

Moreover, each hospital has to have a medical radiation protection officer well trained and educated.

Table 4.7: Questionnaire responses regarding describing the radiation safety training (*n*=132).

| No: | Questionnaire response | *n* | (%)* |
|---|---|---|---|
| Q 20 | **Have you ever attended teaching/training and/or refresher courses on radiation protection?** | | |
| | Yes | 20 | (15.2) |
| | No | 112 | (84.8) |
| Q 21 | **Do you think you need (further) training on radiation safety or radiation doses?** | | |
| | Yes | 94 | (71.2) |
| | No | 38 | (28.8) |

**Some percentages may be less or more than 100% due to rounding*.

Levels less than 60% will be considered inadequate knowledge. However, adherence to radiation protection practices among these radiographers was acceptable and relatively good, but not adequate. There is inadequate commitment to radiation protection devices. However, the overall percentage score of radiation protection practice was 67.94%. Unfortunately, the percentage score of radiation protection practice is generally inadequate among radiographers. The researcher firmly recommends that:

- The radiographers should have (further) practical training and information available in this context.
- Manage dose assessment and risk assessment pre and post exposure of pregnant patients.
- The usage of high image quality with a dose as low as reasonably achievable (ALARA).
- Strict adherence to the radiation exposure guidelines is mandatory especially when using PPE.
- Support the knowledge and awareness of the radiographer, radiologists and physicians who all must be well educated and trained.
- The recruitment of a radiation protection officer in each hospital who is responsible for radiation protection and communication.

## 4.7 Guidelines and Policies

The majority (*n*=57; 43.2%) of the subjects correctly identified that all professionals (the referring physician, the radiologist, and the radiographer) are (medico-legally) prosecuted for the lack of appropriateness and optimisation criteria during a radiological examination performance.

Mitchell, 2003, conveys that information is an important factor conducting to an educated choice. Thus, patients can only make well-versed decision about x-ray examination when health care workers provide information. Mubeen et al., 2008, maintained that it is the responsibility of health care staff to communicate and deliver direct information about benefits and radiation risks to the patients submitting a radiological procedure. Nevertheless, Chesson et al., 2002, recounted in a study on what patients know about ultrasound, computerized tomography (CT) and Magnetic Resonance Imaging (MRI) obtained that many patients (72%) have spoken with family members or friends rather than health workers to get information. These results shed a shadow on the method health professionals communicate and give information. Regulations differ from country to another considerably; however, as a rule, the final legal responsibility for radiation protection lies, with the hospital management. This however, does not pardon members of the personnel from legal responsibility, if it can be recognized that injuries are attributable to desertion on their part. Thus, it is imperative, that the duties of each staff member should be obviously demarcated. Occasionally, it should be understood that exposure to ionizing radiations has been blamed for injuries that later verified to be caused by other reasons. Therefore, it is crucial not only to have sufficient protection but also to be able to evidence it in law court. Consequently, far-reaching records of radiation surveys and personnel monitoring are indispensable (Braestrup and Vikterlof, 1974). When planning good management of ionising radiation in medicine, key factors such as ensuring that health professionals work together and convincing them that radiation protection (RP) represents a substantial part of the quality management system in their clinical practice are of utmost importance (Vano, 2011). Radiation protection principles and United Kingdom legislation is the responsibility of all professionals working with radiation. Radiation regulations set out the legal capacity in which practices should be undertaken and frameworks under which individuals are required to act or carry out tasks. Entire healthcare professionals have a legal charge to act in the manner that is set out in local written procedures relating to the various regulations. Still, it is vital that they must also be aware of their professional responsibility in knowing whether that way of proceeding is an appropriate method to perform the safe effective practice delivery (Murray, 2012). There may be some reasons of incongruities to put responsibility on shoulders on any of them. The digitalization of radiology may have increased the psychosomatic and physical remoteness between the referral clinicians, radiologists and radiographers. Electronic referrals and reports, organized with decentralized immediate image access have lessened the need for physical meetings. The growing capacity of imaging procedures has put radiologists, clinicians and radiographers under pressure, leading to disorientation of responsibility.

Radiation protection to reduce dose to staff, patients, and members of the public is achieved by legislation and education. The responsibility of implementing legislation resides with the national authorities. Nevertheless, operators of ionizing radiation departments are responsible for keep their work in line with the ALARA principles (WHO, 2004).

However, realization of advanced knowledge and awareness is a key element in improving the protection of the public, workers and patients from the adverse health effects of radiation. There might be extensive uncertainty predominantly with regard to health risks in Palestine. Until recently, radiation protection in medical imaging is a neglected area of research. While adequate evidence about the radiation protection issue in public hospitals in general is almost still lacking, rare researches had been conducted to perceive radiation protection in medical imaging departments in Palestinian governmental hospitals and standardize legislations. Hence, it is extremely noteworthy to consider the safety of the patient, is the complete responsibility of the referring physician, the radiologist as well as the radiographer collectively are medico-legally prosecuted for the lack of appropriateness and optimisation criteria during a radiological examination performance. Safety measures to reduce dose to patients and staff should also be implemented in operating theatres. Operators of fluoroscopy units/C-arms, etc., who are not trained in radiation protection measures, should be forced by national laws to undergo basic training in radiation protection to avoid unnecessary dose to patients, staff, and the environment (WHO, 2004).

Radiographers, following the instructions given by the radiologists who must justify the procedure in advance, determine the radiation dose of the radiological examination. If the radiographer does not have an appropriate awareness of the radiation protection issues, he may be responsible for unnecessarily increasing the radiation dose delivered to the patient for a given imaging test.

Table 4.8: Questionnaire responses regarding describing the guidelines and policies (legally responsible) (*n*=132).

| No: | Questionnaire response | *n* | (%)* |
|---|---|---|---|
| **Q 22** | **In your opinion, which one of the following professionals is considered (legally) responsible for unnecessary exposure to ionizing radiation and/or improperly performed radiologic exam?** | | |
| | Only the referring physician | 28 | (21.2) |
| | Only the radiologist | 25 | (18.9) |
| | Only the radiographer | 8 | (6.1) |
| | ***All previous answers are correct*** | ***57*** | ***(43.2)*** |
| | I don't know | 14 | (10.6) |

**Some percentages may be less or more than 100% due to rounding*.

The greater proportion 65 (49.2%) of participants had a negative attitude about having a manual guidance clarifying current radiation protection guidelines, policies and regulations issued and governed by MoH, while 78 (59.1%) think there are no effective roles by hospital administrations in conducting radiation protection programmes. Neither 74 (56.1%) agreed that MoH is concerned about the protection of health and welfare of the staff relating radiation protection measures, nor the majority 83 (62.9) approved being given a vacation if had been monitored occupational excessive or uncontrolled doses since the TLD reading was high. (Table 4.9).

Dahlgren (2007), indicated a good approach for improving risk management by integrating radiation protection and safety activities in a management system, which is a consistent framework to develop accomplishments throughout the organisation by developing and implementing policies, as well as decision on responsibilities, accountabilities, level of authority and interactions of those managing, performing and assessing work. In addition, management system includes a tool for reconsideration and requires assessment of activities on different organisational ranks containing self-monitoring activities.

Adhikari et al., 2012, also argued about the impact of different solutions to help workers to be safe and feel safe from ionizing radiation, they found legal regulations (73.4%) help to protect them from ionizing radiation, as well as Elamin, 2013, study highlighted the presence of safety written policy (6.9%) in governmental hospitals. Moreover, El Dahshan et al., 2017, reported that (92.2%) have a safety written policy in their departments.

Radiographers' knowledge about their duties has an important significance for restricting the trend and, consequently, not only reducing wastage of resources, but also protecting radiographers and patients from unwarranted radiation. These results can help to formulate a plausible strategy for the reduction of unwarranted x-ray examinations. The researcher comprehends that a creation and successful implementation of manual guidance that will raise knowledge and awareness will need to be informed by research to propose an initiative of radiation safety policy. All instructions must conform the requirements and regulations and meet international standards. By establishing basic safety standard and radiation control authority, rules and regulations can be enforced in the country effectively and efficiently.

On the other side of the spectrum, it is concerning that personnel monitoring for radiation workers is a big problem. The result shows that around 62.9% of radiographers who are monitored for occupational excessive or uncontrolled doses, and their TLDs reading were elevated, they think MoH will not give them a vacation any way.

The routine monitoring of the staff must be executed uninterruptedly so that radiographers have not been unjustifiably exposed, and that the protective measures are efficient. Since humans cannot feel radiation, but must be contingent on instruments to detect the radiation level to which they are being exposed, monitoring platforms proper to the probable radiation hazard must be considered an essential part of each radiation protection Programme. The ICRP (1966) outlined two conditions under which employees are exposed to radiation:

(1) conditions such that the resulting doses might exceed three-tenths of the annual maximum permissible doses,

(2) conditions such that the resulting doses are most unlikely to exceed three-tenths of the annual maximum permissible doses.

The Commission recommends that workers whose conditions of work correspond to category (1) should be subject to monitoring-usually individual monitoring. In hospitals, where conditions differ from day to day, the exposure levels should be reserved under regular investigation by unremitting individual monitoring. This eludes annoying needless concern or giving a deceitful feeling of security (Braestrup and Vikterlof, 1974).

The researcher attributes not to concede a vacation may be due to the uncertainty of radiographers, as well as there has no precedent before from MoH to submit such a vacation. Moreover, this could be a systemic malfunction that should be renovated and systematized.

The survey results revealed that there is undeniably, a strong need to propose simple practice changes, in which laws and regulations can be proposed and applied to make it possible to give vacations to those who deserve.

Table 4.9: Questionnaire responses regarding describing the guidelines and policies (roles and guidance) (*n*=132).

| No: | Questionnaire response | Yes *n* (%)* | No *n* (%)* |
|---|---|---|---|
| **Q 23** | Do you think there is a manual guidance clarifying current radiation protection guidelines, policies and regulations issued and governed by MoH? | 67 (50.8) | 65 (49.2) |
| | Do you think there are effective roles by your hospital administration in making radiation | 54 (40.9) | 78 (59.1) |
| | Do you think MoH is concerned about the protection of health and welfare of the staff relating | 58 (40.9) | 74 (56.1) |
| | If you had been monitored occupational excessive or uncontrolled doses, and your TLD reading was high, do you think you will be given a vacation? | 49 (37.1) | 83 (62.9) |

**Some percentages may be less or more than 100% due to rounding*.

In Table 4.10, more than a half (77; 58.4%) of radiographers disagreed that there is a system or a protocol, which, clearly explains justification of the needed images to patients. However, over three-quarters of radiographers (100; 75.8%) felt that old equipment affected negatively the radiation protection precautions, while a marginal percentage (10; 7.6%) disagreed feeling confident and safe when caring for needing radiation protection precautions.

The radiation dose given in any diagnostic procedure has to be sufficient to reply the applicable clinical question but as low as reasonably achievable to lessen the risk to the patient (Health Physics Society, 2017). Up-to-date imaging equipment consents adjustment for patient size and anatomy. This is essential, e.g. as the lifetime attributable risk of fatal cancer for children exposed to radiation is markedly higher than for adults (Paterson et al., 2001). There must be regular quality control parallel to maintenance program for the X-ray equipment at regular intervals. The basic radiation protection principles of Justification and Optimization should be taken into consideration, in this period of rapid increase of investigation following the availability of new equipment.

Management units should be ultimately responsible to ensure that all aspects of safe work is being strictly adhered to, and that the equipment and the facilities in which such equipment is installed and used meets all applicable radiation safety standards. In addition, installed equipment in medical facilities must pass equipment acceptance test.

Absence of knowledge and awareness toward potential hazard effects of radiation, lack of laws and legislations regarding radiation protection in the West Bank and lack of commitment to safety standards supported ill-coping measures to conquer these conditions. Claims contributed to poor conditions were inacceptable working conditions such as over load with long working hours, poor radiology protocols, invalidity of some equipment and claims of inadequate number of personnel. Moreover, claims of so many unjustified excessive number of radiographic examinations in governmental radiographic units forced radiographers to feel unsafe.

Radiographers are in need to know (medico-legally) who is responsible for the lack of appropriateness and optimisation criteria during a radiological examination performance. While most of the radiographers denied having a manual guidance clarifying current radiation protection guidelines, policies and regulations have to be issued and governed by MoH, more than a half think there are no effective roles by hospital administrations in conducting radiation protection programmes. Half of subjects neither agreed that MoH is concerned about the protection of health and welfare of the staff relating radiation protection measures, nor approved the majority being given a vacation if had been monitored occupational excessive or uncontrolled doses since the TLD reading was high.

However, the overall percentage score status of guidelines and policies was poor (43.33%). This lack of knowledge of the guidelines and policies issues associated with ionising radiation means that the healthcare radiographers need to be more relevant with some polices. Based on the results reported here, it appears that the following are proposed:

- To formulate and agree the policy goals to be addressed by MoH;
- To develop a strategic research agenda and road map for such research in Palestine;
- To specify the essential elements of and next steps for establishing a sustainable operational framework for a manual guidance on radiation protection in hospitals and general practice.

Table 4.10: Questionnaire responses regarding describing the guidelines and policies (workplace and equipment) (*n*=132).

| No: | Questionnaire response | *n* (%)* | | | | |
|---|---|---|---|---|---|---|
| Q 24 | **For each of the following statements, select the response that most closely matches your opinion.** | | | | | |
| | **Item** | **Strongly Disagree** | **Disagree** | **Neutral** | **Agree** | **Strongly agree** |
| | In the place where I work, there is a system or a protocol, which clearly explains justification of the needed images to patients. | 22 (16.7) | 55 (41.7) | 26 (19.7) | 29 (22.0) | 0 (0) |
| | I feel that old equipment affect negatively the radiation protection precautions. | 2 (1.5) | 8 (6.1) | 22 (16.7) | 78 (59.1) | 22 (16.7) |
| | I feel safe when caring for needing radiation precautions. | 2 (1.5) | 8 (6.1) | 30 (22.7) | 80 (60.6) | 12 (9.1) |

**Some percentages may be less or more than 100% due to rounding. This question was graded in a scale of 1 to 5 grades, where: 1 = **Strongly Disagree**; 2= **Disagree**; 3 = **Neutral**; 4 = **Agree**; 5 = **Strongly agree**.*

## 4.8 Radiation Dose Assessment

Concerning the questionnaire section in which participants were asked to assign the right dose value to daily radiological procedures, more than a quarter (*n*=37; 28.0%) of radiographers were standing at a distance of two meters or less from source point during the radiological-guided procedure (e.g. C-arm without protection (Table 4.11)). Results also showed that less than three-quarters of radiographers (*n*=95; 72.0%) thought correctly that there is an increase in the lifetime risk of fatal cancer attributable to x-ray examinations such as abdomen x-ray, skull x-ray, and lumbar spine x-ray, as well as developing cancer from any CT scan examinations (*n*=106; 80.3%). However, most of radiographers (*n*=63; 47.7%) overestimated approximate effective dose received by a patient in a single-view chest x-ray, while (*n*=40; 30.3%) do not know.

Survey data show that radiographers generally underestimate the magnitude of radiation doses and their associated effects, and thus underestimate the risk to patients undergoing medical imaging procedures (Shiralkar et al., 2003). This view may be due to both the general lack of epidemiologic data specific to medical procedures and the nature with which radiation-induced injuries progress.

Radiation dose rates increase or decrease according to the inverse square of the distance from the source. Understanding the inverse square law can help personnel in decreasing their exposure to scattered radiation. The inverse square law states that exposure at a distance from a point of radiation is inversely proportional to the square of the distance, (Erica et al., 2011). Distance is the most important safety measure to reduce radiation dose to people not undergoing radiographic examination. A minimum of 2 meters from the X-ray tube is usually sufficient (WHO, 2004).

Likewise, "Stand behind the radiographer" (chosen by many participants) is usually going to be a safe place to stand in the surrounding area of a mobile X-ray tube, but this does not demonstrate knowledge of actual safe practice. To know the recommended minimum safe distance (3m) is essential from an occupational health and safety point of view, if nothing else" (Ackland et al., 2012).

Just 1 year after Ro¨ntgen's discovery of X-rays, the American engineer Wolfram Fuchs (1896) provided the first protection advice.

The first protection recommendations:

- make the exposure as short as possible;
- do not stand within 12 inches (30 cm) of the X-ray tube; and
- coat the skin with Vaseline and leave an extra layer on the most exposed area.

Within 1 year of dealing with radiation, consequently, the three elementary beliefs of radiological protection: time, distance, and shielding had been established. Radiation protection regulations were arranged in several countries in 1920s, but it was not until 1925 that the first International Congress of Radiology (ICR) held and deliberated establishing international protection standards (Clarke and Valentin, 2009).

This was in line with the study of El Dahshan et al., 2017, who reported in their research, that the distance from radiological machines in most departments are more than 2m with a percentage of 68.9%. Moreover, confirmed by Abdellah and colleagues, 2015, who indicated that the 28 physicians (35%) were standing at a distance of two meters or less from source point without protection.

Ionizing radiation could lead to some unwanted effects on the exposed individuals, predominantly raised lifetime risk for cancer. As a consequence, methods depending on ionizing radiations should be reasonably employed, taking their risks and benefits into consideration, and whenever possible, preference should be given to methods that do not rely on ionizing radiation, and to the application of the minimum dose needed to solve the clinical doubt (Madrigano et al., 2014). Diagnostic radiology is the single largest synthetic source of ionising radiation causing about 14% of total global exposure from fabricated and natural sources (Moores, 2006; de González & Darby, 2004). Critical worries about health risks in this regard have been mooted. In Japan, it was assessed that a cumulative cancer risk of 3.2% is imputed to diagnostic x-ray exposure (de González and Darby, 2004). In keeping with the same researchers, this is correspondent to 7587 cases of cancer per year. Other proof of radiation risk from x-rays comes from epidemiological studies of increased levels of cancer in the exposed human population (Wall et al., 2006).

Question regarding consequences (lifetime risk) of harm due to irradiation, responses were quite satisfying, signifying that most of the radiographers were aware on the harmful effects of radiation. Eisenberg and colleagues help seal the knowledge gap concerning the risk of cancer associated with exposure to low-dose ionizing radiation from medical imaging and therapeutic procedures in a contemporary cardiac population (Eisenberg et al., 2011).

During medical diagnostic imaging, it is documented that biological effects of ionising radiation cause cancer including low doses (Ron, 2003). All doses, no matter how low, have the possibility to cause harm. Medical surveys have shown a total lifetime related risk of cancer of 1 in 82 in high-use groups, (Griffey and Sodickson, 2009), and between 1 in 143 for a 20-year-old woman and 1 in 3261 for an 80-year-old man as a result of a single CT coronary angiogram (Einstein et al., 2007). It has been assessed that 100 to 250 deaths occur each year in the United Kingdom as a direct result of medical exposure to diagnostic radiation (Shiralkar et al., 2003). Even though the risk verified, only a few of the diagnosed cancers in their study were a direct result of radiation exposure from the medical imaging. For example, if we consider a lifetime risk of cancer of about 2.5% for every 1000-mSv dose among individuals between the ages of 40 and 60, we would expect one new cancer for every 2000 patients receiving a 20-mSv dose that is directly assigned the radiation exposure from the medical procedure (Vijayalakshmi et al., 2007).

There is little debate on the detrimental consequences in human beings for radiation doses above 100 mSv related to acute or long-term exposures. In keeping with epidemiological studies, radiation doses between 50 and 100 mSv (long-term exposure) or between 10 and 50 mSv (acute exposure) are associated with increased risk for some types of cancer (Brenner et al., 2001). The mean annual natural radiation (radioactive elements present in nature) exposure of human beings is 3 mSv. The majority of the radiological exams produce radiation doses ranging between 0.01 mSv and 30 mSv. Regardless of the wide variation, the mean dose reported in the literature, for chest radiography (anterior and lateral), for example, is 0.1 mSv, and for chest CT is 7 mSv, i.e., one chest CT scan is equivalent to 70 chest (anterior and lateral) radiographs (Cohen, 2002).

Our study results are in line with Madrigano et al., 2014 who underwent an Australian study with 680,211 people exposed to low dose ionizing radiation during CT scans in their childhood and adolescence, which evaluated the risk for developing cancer in people exposed at CT scans compared with the risk of unexposed individuals. Such a study utilized the comparison between groups to estimate the risk, and the researchers detected that the general cancer incidence in the exposed people group was 24% higher than in the unexposed group. An increase of 1.6% in risk for cancer for each additional CT scan was observed, and such a risk was higher in individuals of lower ages. The entire incidence for all collective cancers was 9.38 per 100,000 people/year. The effective dose per scan was projected to be 4.5 mSv (Mathews et al., 2013). Moreover, a cross-sectional study conducted in a tertiary hospital in Malaysia argued that in all, 37% of respondents were aware of an increased cancer risk from an abdominal CT scan, indicating that almost two-thirds did not perceive that there was such a risk. Only 23% of respondents were aware of the cancer risk in a child who undergoes abdominal CT. Of these, 20% of total respondents perceived the risk to be higher than that in adults (Kew et al., 2012).Furthermore, there is also the danger of underestimating the risks of imaging-related radiation, leading to unnecessary exposure of individual patients and the community.

Interestingly, despite underestimation of exposure for imaging, the actual estimated dose in mSv for a single chest x-ray was correctly identified by nearly (*n*=29; 22.0%) of radiographers. Surprisingly, about more than a half (*n*=77; 58.3%) of radiographers underestimated a chest x-ray perhaps indicating unfamiliarity with units of radiation, nonetheless, about one-fifth (*n*=26; 19.7%) overestimated conventional adult chest radiograph by signifying that it was equivalent to more than one CXR. It is possible that these radiographers were taking into consideration that two films are often requested with chest radiography (postero-anterior and lateral).

Of the total 205 consultants, 139 (91.2%) of consultants underestimated the radiation dose in CT scan of abdomen. (64.88%) were aware that plain x-ray abdomen involves the highest number of radiation exposure to the patient. 154 (75.1 %) of doctors think that one CT scan increase the life time risk of developing cancer and 51 (24.9%) responding that there was no increased cancer risk. (Kamble et al., 2015). In the same vein, Paolicchi and colleagues, 2013, reported that the dose of a postero-anterior chest x-ray amounts to about 0.02 mSv; 50.8 % of participants were able to recognize the correct dose, while 24.2 % of them overestimated it and 13.5 % of respondents reported a dose lower than 0.01 mSv.

Summarizing:

- The magnitude of control of the procedures should be considerate.
- Awareness guidelines for the public should be provided to the probability of its biological hazards explaining the risks of radiation doses, and not leaving companions with the patient in the same room.
- Quality assurance programmes in diagnostic radiology necessary to provide adequate confidence that the optimal quality of the perfect diagnostic process, with minimum exposure of patients and personnel have to be achieved.

Table 4.11: Questionnaire responses regarding describing the radiation dose assessment (*n*=132).

| No: | Questionnaire response | *n* | (%)* |
|---|---|---|---|
| Q 25 | **How far (at least) from the x-ray source do you stand without any protection during the radiological-guided procedure (e.g. C-arm)?** | | |
| | 1 meter | 11 | (8.3) |
| | 2 meter | *26* | *(19.7)* |
| | ***More than 2 meters*** | ***85*** | ***(64.4)*** |
| | I don't care about the radiation | 0 | (0) |
| | I don't know | 10 | (7.6) |
| Q 26 | **Do you think that there is an increase in lifetime risk of developing cancer from any x-ray examinations such as abdomen X-ray, skull X-ray, lumbar spine X-ray etc.?** | | |
| | ***Yes*** | ***95*** | ***(72)*** |
| | No | 10 | (7.6) |
| | I don't know | 27 | (20.5) |
| Q 27 | **Do you think that there is an increase in lifetime risk of developing cancer from any C-T scan examinations?** | | |
| | ***Yes*** | ***106*** | ***(80.3)*** |
| | No | 8 | (5.1) |
| | I don't know | 18 | (13.6) |
| Q 28 | **Approximate effective dose received by a patient in a single-view chest X-ray is about:** | | |
| | 1 mSv | 6 | (4.5) |
| | 0.5 mSv | 20 | (15.2) |
| | 0.05 mSv | 37 | (28.0) |
| | ***0.02 mSv*** | ***29*** | ***(22.0)*** |
| | I don't know | 40 | (30.3) |

**Some percentages may be less or more than 100% due to rounding.*

Regarding knowledge of radiation doses, most of respondents could not correctly state the radiation effective dose received by a patient in a single-view chest x-ray (in mSv) of a conventional chest x-ray. At the same time, only 33 (25.5), 65 (49.2), 47 (35.6), 46 (34.8), 107 (81.1) and 105 (79.5) of radiographers were able to correctly estimate the equivalent number of chest x-rays in different radiological investigations (ankle x-ray, abdomen CT, head CT, a two-view unilateral mammogram, abdomen Ultrasound and spine MRI respectively). The overall distribution of answers concerning commonly evaluated examination doses are shown in Table 4.12. About 67.4% (89/132), 50.8% (67/132), 36.4% (84/132) and 57.6% (76/132) of the respondents underestimated the relative radiation doses of commonly performed radiological investigations such as (ankle x-ray, abdomen CT, head CT, a two-view unilateral mammogram respectively; Table 4.12). In all, and strikingly, 18.9% (25/132) of respondents who overestimated and wrongly believed that abdomen ultrasound does involve radiation exposure; 20.5% (27/132) incorrectly believed that MRI emit radiation.

The fact that the overestimation of 18.9% (25/132) and 20.5% (27/132) of the study population who reported that ultrasound and MRI respectively used ionising radiation reflects an important gap in radiographers' knowledge. The number of radiographers who correctly quantified the approximate radiation dose of abdomen CT, head CT and a two-view unilateral mammogram was disappointing; with only 65 (49.2), 47 (35.6), 46 (34.8) of radiographers knowing the correct answer. In designing the questionnaire, we chose not to interrogate radiographers regarding the dose of diagnostic imaging studies in milliSievert. Instead, we converged on radiation exposures relative to that of a postero-anterior chest radiograph, i.e. the dose of an abdominal CT was expressed in terms of an equivalent number of chest radiographs. In our vision, quantifying CT doses in terms of an equivalent number of chest radiographs is a perceptible method of quantifying the high radiation doses involved in CT imaging and other procedures, and knowing comparative values should be a precondition for radiographs and referring physicians alike. The most poorly answered question concerned the radiation dose imparted by a chest radiograph. It is hoped that superior awareness of these relative doses by the introduction of steadfast instruction in radiation protection may help minimize in the increasing number of gratuitous CT referrals in corroboration of lower dose modalities or imaging modalities such as ultrasound and MRI.

Over the past few decades, progresses in medical imaging have had a significant power on medical practice. Unfortunately, many procedures subject patients to ionizing radiation causing injury. Study results show that radiographers underestimate the magnitude of radiation doses and their related effects, and consequently underestimate the risk to personnel and patients undergoing medical imaging procedures. This lack of knowledge could be due to both the general lack of epidemiologic data specific to medical procedures and the nature with which radiation-induced injuries progress. Also, Lower awareness about the radiation protection and radiation doses, may be due to the general hospitals in which they offer many services to the patients in all the governmental hospitals. Hence, extraordinary workload in these hospitals could be a reason for the obtained results; meaning, the radiographers in these hospitals do not have enough time for implementing every x-ray examination efficiently.

Surprisingly, results show that radiographers still have doubts about which procedures make use of ionising radiation and which do not, as found in the question related to MRI. There are radiographers failing to recognize that MRI as radiation-free modality. This result is consistent with previous studies reporting that MRI was associated with radiation by participants in dissimilar percentages to that observed in our study; Günalp et al., 2014 who found that there were still medical practitioners who fail to recognize MRI as radiation-free modalities. Conversely, and inconsistent with Yurt et al., 2014 study, they argued that only 1 of 10 participants was able to give an answer for the dose evaluation of abdominal magnetic resonance imaging (MRI) of chest x-ray. Portelli et al., 2016, reported in their study that only 20 % of the participating radiology practitioners and radiographers were aware of the estimated effective dose (ED). Moreover, while the majority were aware that MRI and ultrasound did not use ionising radiation, sixteen radiographers did not know this or else assigned an ED for such examinations. These results are reliable with previous studies, which informed that ultrasound scanning and MRI were associated with radiation by 4%–11% and 8%–28% of respondents, respectively (Jacob et al., 2004; Zhou et al., 2010).

In common with those previously published, Arslanoglu et al. 2007 informed that the knowledge of physicians and interns about radiation exposure is inadequate, and while 93.1% of the respondents did not know the radiation doses involved in radiological imaging procedures; additionally, 4% specified that ionising radiation is used during US, and 27.5% said that ionising radiation is used for MRI. Moreover, Shialkar et al. 2003 testified that 97% of physicians did not know the radiation doses received by patients during radiological investigations and that 5% claimed that ionising radiation is used during US and 8% claimed that ionising radiation is used in MRI. Jacobs et al. 2004 found that only 15%-29% of physicians knew the doses during chest x-ray examinations, and 10% identified that ionising radiation is used during US and 28% that ionising radiation is used for MRI. Quinn et al., 1997, reported that most physicians did not know the radiation doses received by patients during radiological procedures.

It is concerning that, a small proportion of radiographers considered that ultrasound and MRI expose patients to a dose of radiation. Despite the fact that one would probably expect radiographers to show a better understanding than other health professionals in this regard, this is contrary to what one would expect given that MRI and ultrasound are favorably performed during pregnancy in order to limit radiation exposure to the fetus (Kilpatrick and Orejuela, 2008). Regrettably, this seems to mirror a discrepancy of knowledge of basic scientific principles. It may be elucidated by the fact that MRI is uncommonly requested from emergency departments, is often difficult to access and is more likely to be requested by senior members of staff. Furthermore, though a smaller proportion of radiographers associated ultrasound imaging with radiation exposure, this potentially has additional clinical consequence because of the low numbers of ultrasounds requested.

Additionally, the small numbers of the right answers for the chest x-ray equivalent doses for other radiological applications show that the awareness of the relative health risks of different procedures is also poor. Any over-, or under-, estimation of these risks could lead either to unnecessary restriction or to a lower level of health protection than intended. The employment of a strategy to pursue radiation doses may help physicians, radiographs and patients stay aware of the cumulative exposure. Presently, health care and nuclear industries use such strategies to monitor exposure among employees (Mercuri et al., 2011). Nevertheless, as Rehani and Frush point out, there are currently no examples of good national programs to do so for patients (Rehani and Frush, 2010).

It is notable that the international organizations have published recommendations on the measurements and units that should be used in occupational dosimetry and designates yearly occupational dose limit. Dose limits to radiographers are expressed in terms of equivalent dose in an organ or tissue for exposure of part of the body and effective dose (ED) for whole body exposure. The (ICRP) that regulates dose limit explain that dose limit may be changed prospectively. Probable changes will communicate to new adverse effects of radiation in human that had not been detected yet. Consequently, staffs should be aware of dose limit and protect themselves effectively (Moghimbeigi and Mojiri, 2011).

The researcher recommends:

- To close the knowledge gap regarding the estimation of doses and consequently the risk of cancer associated with exposure from medical imaging.
- To close this knowledge gap by suggesting expanding the utilization of teaching and educating MRI and ultrasound in the national universities. This has been suggested by Al-Quds University to teach and educate the radiographers to perform ultrasound, and thus working in hospitals and centers.
- To minimize exposure; medical doctor should decide if using ionizing radiation procedure is essential or whether a substitute test is possible.

Table 4.12: Estimated cancer risk and radiation dose for common imaging examinations, based on classes of risk (Bands I to VI), developed by International Commission of Radiological Protection and endorsed by European Commission referral guidelines for imaging (*n*=132).

| **No:** | **Type of imaging or situation *(correct answer)*** | **Equivalent no. of CXR** | **Typical effective dose (mSv)** | **Comparable to natural background radiation** | **Underestimated*** | ***Correct §*** | **Overestimated** |
|---|---|---|---|---|---|---|---|
| **Q29** | Ankle x-ray | 0.5 | 0.001 | 3 hours | 89 (67.4) | ***33 (25.5)*** | 10 (7.5) |
| | Abdomen CT | 390-500 | 7.8-10 | 3 years | 67 (50.8) | ***65 (49.2)*** | 0 (0) |
| | Head CT | 50-300 | 2-2,8 | 8 months | 48 (36.4) | ***47 (35.6)*** | 37 (28.0) |
| | A two-view unilateral mammogram | 10-50 | 0.4-1.0 | 7 weeks | 76 (57.6) | ***46 (34.8)*** | 10 (7.5) |
| | Abdomen Ultrasound | 0.0 | 0.0 | 0.0 | 0 (0) | ***107 (81.1)*** | 25 (18.9) |
| | Spine MRI | 0.0 | 0.0 | 0.0 | 0 (0) | ***105 (79.5)*** | 27 (20.5) |

**Some percentages may be less or more than 100% due to rounding. CXR = one arbitrary unit equals to the radiation exposure from one chest x-ray. CT = computed tomography. MRI =magnetic resonance imaging. * Participants were instructed to estimate the radiation exposure for each modality in the equivalent number of CXRs (mSv); =milliSievert. The multiple-choice answer options were <1; 1–10; 10–50; 50–300; and >300. **§: Correct** answers are shown in **italics** and **bold.***

## 4.9 Radiographers' Perceptions towards the Justification of Medical Imaging Exams

Table 4.13 shows that (100; 75.8%) of radiographers had been faced with situations where a public patient requested an examination by justifying that the patient wants to reassure for health, while (32; 24.2%) reported negatively. Moreover, (96; 72.7%) of radiographers answered positively that physicians demand unnecessary examinations, of them, (52; 54.2%) believed that (25%-75%) of doctors overuse imaging services, while (48; 36.4%) do not protest the referring doctors when seeing an unjustified requisition, nonetheless, (49; 37.1%) of radiographers object the referring doctors when requesting unjustified requisition. Strikingly, (61; 46.2%) do not trust TLDs readings, while by little (14; 10.6%) reported with a percentahge of (More than 75%) they do trust TLDs readings.

Notwithstanding the medical x-rays linked with recognized health risks, many patients yet favor or request to have an x-ray examination irrespective of the doctor's clinical valuation. For instance, results from a cross-sectional survey carried out in the United States of America (USA) showed that 63% of responders were never concerned about exposure to radiation when having an x-ray examination (Ludwig and Turner, 2002). Even with the fact that information resulting from x-ray investigations is often essential in clinical care, it is found at a risk that extremely few patients are aware of. Nevertheless, Goske and Bulas, 2009, ascribe deficiency of awareness by many patients to the fact that discussion of radiation risk is a multifaceted theme. Esteem for patient is one of the bases of current medical ethics. Yet, admiration for patient is not the only noteworthy moral commitment, according to Rogers, 2002. Correspondingly important is averting injury, acting for the good of the patient as well as bearing in mind resource allocation. Patient request for x-ray examination notwithstanding of its clinical benefits produce both gratuitous exposure to radiation and improper use of radiographic resources (Mendelson and Murray, 2007). In the hospital where the researcher works, striving to cope with staff shortage and financial demand, depletion of resources on unwarranted x-ray examinations may have an adverse effect on the endowment of legally required radiographic services (Hammett and Harris, 2002). In many countries, health authorities have issued regulations with the aim to control the 17 redundant use of diagnostic x-rays, bearing in mind the rising cost of diagnostic imaging and its related risks (Triantopoulou et al., 2005). Nevertheless, these efforts have brought in slight success. In addition, this failure may be indorsed to the fact that not enough is known about the contributing factors of radiological use, especially, not much is known about factors that influence patient demand for x-ray examination as stated by Wilson et al., 2001. Even if the patient asks for x-ray exam, his prospect should not decree management and clinical care. Finally, one must question what the clinical values of these x-rays are for patients. Thus, radiographers should try to respond to patients' demands for unnecessary x-ray examinations definitely and answer patients' queries concisely and accurately, because patients' requirements are a mutual part of clinical meeting (Gallagher et al., 1997). Thom et al., 2002, pointed out that the patients who have low level of trust in the physician may demand services such as x-ray examination or medication more often. However, researchers have proposed that health workers and specifically doctors could instead stimulate from patients their expectations (Little et al., 2004). Such as, instead of giving in to a patient's request, the respondents saw the requests as a stimulus to engage in further diagnostic investigative or patient education (Tentler et al., 2008). The same could be done for patients who demand x-ray examinations. Rogers, 2002, in a study conducted in Australia, displays that some general practitioners (GPs) use stratagems such as stating the dangers of x-ray exposure and the price of x-rays as a way of discouraging patients from demanding x-ray examinations. However, lack of methodical advice, guidelines and advising by health care providers about medical x-ray could also be a sign to a patient's demand for x-ray examinations. Consequently, the way the radiographer advises the patient the first time he/she requires an x-ray could have an impression even in cases where the doctor does not request x-rays.

However, the researcher perceives that strategies to improve communication to patients on radiological risk to avoid any tendency to self-refer for certain medical exposures are also essential.

The needless use of x-ray exams and the accompanying radiation risk continue to be a major concern to many health workers, patients and authorities in some countries (Mubeen et al., 2008). However, some patients believe that x-rays are necessary as a diagnostic instrument in many conditions where the doctors' clinical decision indicates they are not necessary. This aligns with the results of the study of Balagué and Cedraschi, 2006, on the importance of radiological imaging which revealed that 72% of the patients investigated, believed radiological imaging as ''very important''.

The results of these researches and many other studies produce the question of the reasons for the importance that patients discuss on radiological examinations. Researchers approximate the size of unnecessary radiological examinations in the United States of America to be in the range of 10%-50%. However, Picano, 2004, testifies that up to a third of radiological examinations are entirely, or partially inapplicable. Little and colleagues, 2004, in a study carried out in the United Kingdom (UK), showed that medical doctors believed that about half of the examinations were only marginally needed, or were not needed at all. Likewise, Levin and Rao, 2004, claim that much of this increase in request is excessive and immoderate. Therefore, the number of radiological exams executed is excess to necessities of those essentially required for diagnostic objectives (Cascade et al., 1998).

This may cause an important economic bearing. Besides, the decrease would allow quicker accessibility to radiographic services to those patients who actually require them. It is imperative for doctors who demand x-ray exams be well qualified in deciding whether diagnostic imaging is designated, but also have a perfect knowledge of the associated risks. This is principally vital in the emergency department (ED), where many radiological imaging tests are requested daily. Some patients with a pitiable educational background may not have the security and confidence to ask a request for information. Sometimes, the radiographer believes that patients want to be engaged at all levels in their care and the related decision-making. This could be a burden when some patients put forth pressure on doctors to prescribe or perform particular examinations. Under certain circumstances, the doctor may submit to their desires. Physicians who are overloaded can find it easier to refer patients for radiological examination than to discuss about radiation risks. Radiographers also, due to their heavy workload they would not have adequate time to explain about radiation consequences and risks. Similarly, they might feel that they do not have the information or abilities to challenge a decision for referral by a clinician (Gruppetta, 2009). An important part of quality assurance in monitoring is judging the trust of the TLDs results. However, to what level is it practical to trust that the reported number is a good estimate of the true dose value? The greater this belief, the self-assurance or likelihood that the measured value is within assured clear range around the true value, or rather that the correct value is within a definite range of the detected value, the better the belief of the quality of the measurement. TLDs are periodically tested in a quarterly interval basis. The researcher observed that TLDs were collected to send them for personal periodical monitoring to be processed to determine the dose received while radiographers were without TLDs for at least 18 days in one of the governmental hospitals. This interval is not being read and recorded at all, which may create a gap in continuous reading for radiographers who did not put on their own TLDs for 18 days, which may lead to errors pointing to a lack of trust by the radiographers provoking unnecessary anxiety or uncertainty or giving a false feeling of security. Besides, TLD readings were delayed more than 18 days to be received. Clarke and Valentin, 2009 says that thermoluminescent dosimeters can measure doses as low as 1 millirem. They have a precision of approximately 15% for low doses. This precision improves to approximately 3% for high doses. The researcher noticed that some radiographers were not putting on their own TLDs all the time, while some of them put TLD on areas where it is not worn in the right place to capture the exposure received with reasonable accuracy. The way in which the dosimeters are to be worn must be specified. They should be placed on the most highly exposed part of the surface of the trunk, which is normally the chest. Correspondingly, the researcher noticed that most of the radiographers do not read their own processed doses, and sometimes do not see these readings at all. However, they think, no matter how these readings are high or low, readings have no value, because no procedure is being taken even to high doses consequently. The researcher perceives it is important to keep records of all monitoring badge results, so, the researcher perceives that dose records must be well documented in a computerized dose management system with a feature to view the dose history of an individual at any given time. There should be no interval reading gaps where the TLDs are changed regularly so that the dose received can be measured effectively and recorded. To record the approximate level of whole-body exposure, radiation monitoring TLDs have to be worn continuously during working hours. More attention should be paid where radiographers should know more about their TLD readings. Every department should appoint one person to be responsible for the TLD service and record keeping and for taking action when the readings are high. Likewise, the researcher also, attributes that because of cancer cases (estimated 6-7 deaths) occurred from the year 2010 from cancers most probably related to medical exposure to radiation. Nevertheless, after deep research and scientific studies, it was indicated that there were risk factors on medical imaging from ionising radiation that could be linked to cancer induction if underestimation to the risks of radiation safety precautions were being disregarded. One of the reasons to these cases is that the leakage from the equipment to the panel control and eventually harm the radiographer.

A number of surveys concerning this issue have been conducted among health care professionals around the world. Locally, studies on medical radiographers' awareness of radiation are lacking. Therefore, it is extremely important to consider the safety of the radiographer performing the radiological procedure. The goal is not to eliminate all errors; rather, we should focus our attention on conditions that may reflect systemic problems or lead to misconception of the real harm. Our current challenges will be to address new policies and procedures, so, we need a better understanding of the frequency and causes of adverse effects, particularly those that are most likely issued by the MoH.

The detailed evaluation of the answers given by the personnel working with radiation might provide good indication about the strategy to adopt in designing training program, very much needed.

Table 4.13: Questionnaire responses regarding describing the radiographers' perceptions towards the justification of medical imaging exams (*n*=132).

| No: | Questionnaire response | *n* | (%)* |
|---|---|---|---|
| Q 30 | **Have you been faced with situations where a public patient requested an examination by him/herself justifying that the patient wants to reassure for health?** | | |
| | Yes | 100 | (75.8) |
| | No | 32 | (24.2) |
| Q 31 | **Do you believe that medical doctors request unnecessary examinations?** | | |
| | Yes | 96 | (72.7) |
| | No | 36 | (27.3) |
| Q 32 | **If yes, to what percentage you believe they overuse imaging services?** | | |
| | Less than 25% | 31 | (32.5) |
| | 25% - 75% | 52 | (54.2) |
| | More than 75% | 13 | (13.5) |
| Q 33 | **Do you question (do you protest) the referring doctors when you see an unjustified requisition?** | | |
| | Never | 48 | (36.4) |
| | Less than 25% | 49 | (37.1) |
| | 25% - <50% | 25 | (18.9) |
| | 50% - 75% | 4 | (3.0) |
| | More than 75% | 6 | (4.5) |
| Q 34 | **Do you trust the readings of TLDs?** | | |
| | Never | 61 | (46.2) |
| | Less than 25% | 21 | (15.9) |

| No: | Questionnaire response | *n* | (%)* |
|---|---|---|---|
| | 25% - <50% | 22 | (16.7) |
| | 50% - 75% | 14 | (10.6) |
| | More than 75% | 14 | (10.6) |

**Some percentages may be less or more than 100% due to rounding. **TLD**: thermoluminescent dosimeters.*

## 4.10 Results of Hypotheses of the Study

This study investigated the radiographers' awareness of the radiation protection working in the radiology departments in the governmental hospitals in the West Bank. The radiation protection was investigated in three fields including radiology knowledge, policies, and practices. In addition, we investigated the relationships between the radiographers' awareness of the three fields and such factors as gender, work experience, academic degree. The following hypotheses were formulated in null form in tune with the present study. To answer the research hypotheses of the study, the researcher used Anova, t-test and Pearson Correlation.

**Hypothesis (1):** There are no statistically significant differences at ($\alpha \leq 0.05$) in the radiation protection awareness and knowledge, polices, and practices of radiographers according to gender.

In order to test the Ho1, t-test correlation was applied. An inspection of Table 4.14 (Figure 4.1) reveals that the t-test correlation between the level of knowledge (0.016) according to gender variable is significant at $\alpha \leq 0.05$ level. This means there are significant differences between the knowledge and gender variable. Therefore, this hypothesis is rejected since the *p*-value is less than (0.05). However, females possessed significantly better radiation protection knowledge (86.22) when compared with males (67.21). Likewise, females had a marginally better radiation protection practice and polices (68.32), (56.00) when were compared with males (67.93), (42.83) respectively.

This finding is inconsistent with the findings of Kargar et al., 2017, who demonstrated that there was no relationship between the radiographers' gender and their awareness in the preceding fields. Likewise, there was not any significant relation between radiation-safety knowledge and age, gender, field of study and level of education as depicted by Dehghani et al., 2014. Moreover, in the same vein, the level of staff awareness was not associated with educational level, gender, field of study, age and job experience.

The researcher attributes that it could be explained by the fact female in general may be more interested in the knowledgeable aspects of imaging and radiation. Many females were willing to learn more about radiation than males.

Table 4.14: Hypothesis 1: differences according to gender.

| **Group Statistics** | | | | | t-test for Equality of Means | | |
|---|---|---|---|---|---|---|---|
| | Gender | N | Mean | Std. Deviation | t | df | Sig. (2-tailed) |
| Knowledge | Male | 127 | 67.21 | 17.34 | -2.438- | 130 | 0.016 |
| | Female | 5 | 86.22 | 5.69 | | | |
| Practice | Male | 127 | 67.93 | 10.87 | -.081- | 130 | 0.936 |
| | Female | 5 | 68.32 | 6.52 | | | |
| Policies | Male | 127 | 42.83 | 28.14 | -1.020- | 130 | 0.309 |
| | Female | 5 | 56.00 | 32.86 | | | |

**. Correlation is significant at the 0.05 level (2-tailed).*

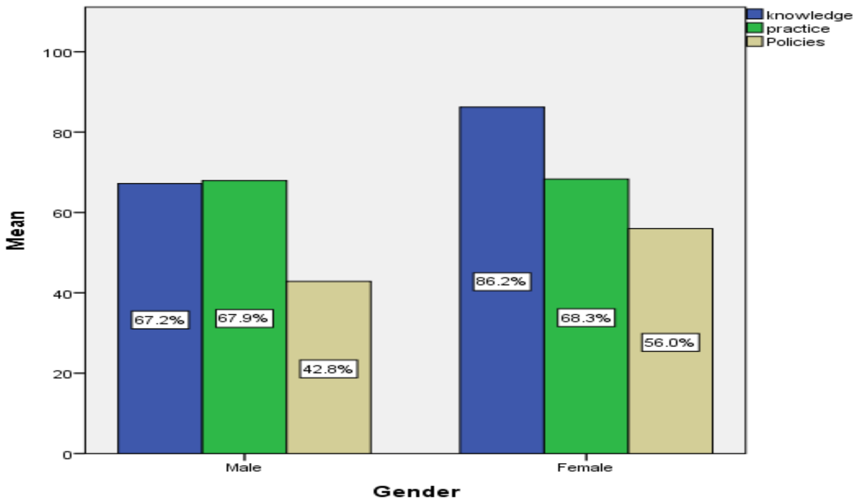


**Figure 4.1:** Differences in radiation protection awareness and knowledge, polices, and practices of radiographers according to gender**.**

**Hypothesis (2):** There are no statistically significant differences at (α≤0.05) in the radiation protection awareness and knowledge, polices, and practices of radiographers according to years of practice.

It is noted that the results of the hypothesis of Table 4.15 (figure 4.2) show that there are differences between knowledge and years of practice where p-value was 0.000 which is less than the value of significance (α≤0.05), leading to reject this hypothesis. However, a Post Hoc test was carried out to know the differences (Table 4.16). We notice from Table 4.16 below that through the Post Hoc test results the existence of means between radiographers who have <10 years and those who have >20 years of experience, in favour for those who have <10 years. For those radiographers who have <10 years, their mean score was higher than other means of other years of experience, signifying that the degree of knowledge was higher in those who have

<10 years. This indicates that the longer years of practice, the less knowledge the radiographer has. Correspondly, there are differences between practice and years of practice where p-value was 0.000 which is less than the value of significance (α≤0.05), leading to reject this hypothesis. Nevertheless, a Post Hoc test was carried out to know the differences (Table 4.17). We discern from Table 4.17 below that through the Post Hoc test results the existence of means between radiographers who have <10 years and those who have >20 years of experience, in favour for those who have <10 years. For those radiographers who have <10 years, their mean score was higher than other means of other years of experience, signifying that the degree of practice was higher in those who have <10 years. The researcher attributes that to the fresh study course of younger radiographers (or probably, also because of the recent change of radiographers educational system). In addition, the likely reasons for the drop in percent score in the higher experience groups seems to be due to the lack of interest with passing years, belatedness and other age related factors.

Conversely, there was no difference between polices and years of practice where p-value was 0.077 which is more than the value of significance (α≤0.05), leading to accept this hypothesis.

Table 4.15: Hypothesis 2: differences according to years of practice.

| **Descriptive** | | | | |
|---|---|---|---|---|
| **Subgroup (years of practice)** | | **N** | **Mean** | **Std. Deviation** |
| **Knowledge** | < 10 Years | 71 | 73.32 | 14.531 |
| | 10 – 20 Years | 28 | 67.42 | 16.187 |
| | > 20 Years | 33 | 56.77 | 19.149 |
| | Total | 132 | 67.93 | 17.424 |
| **Practice** | < 10 Years | 71 | 70.65 | 9.242 |
| | 10 – 20 Years | 28 | 67.94 | 8.209 |
| | > 20 Years | 33 | 62.12 | 13.269 |
| | Total | 132 | 67.94 | 10.725 |
| **Policies** | < 10 Years | 71 | 41.13 | 26.379 |
| | 10 – 20 Years | 28 | 37.86 | 28.461 |
| | > 20 Years | 33 | 52.73 | 30.748 |
| | Total | 132 | 43.33 | 28.302 |

| **ANOVA** | | **Sum of Squares** | **df** | **Mean Square** | **F** | **Sig.*** | **Remark** | **Decision** |
|---|---|---|---|---|---|---|---|---|
| **Knowledge** | Between Groups | 6179.908 | 2 | 3089.954 | 11.867 | .000* | Reject Ho | Significant |
| | Within Groups | 33589.902 | 129 | 260.387 | | | | |
| | Total | 39769.809 | 131 | | | | | |
| **Practice** | Between Groups | 1637.040 | 2 | 818.520 | 7.861 | .001* | Reject Ho | Significant |
| | Within Groups | 13431.709 | 129 | 104.122 | | | | |
| | Total | 15068.749 | 131 | | | | | |
| **Policies** | Between Groups | 4097.500 | 2 | 2048.750 | 2.621 | .077 | Accept Ho | Not significant |
| | Within Groups | 100835.833 | 129 | 781.673 | | | | |
| | Total | 104933.333 | 131 | | | | | |

**Significant at the 0.05 level (2-tailed).*

Table 4.16: LSD test to compare the means and significance of years of practice with knowledge.

| Field | Mean | Difference | < 10 Years | 10 – 20 Years | > 20 Years |
|---|---|---|---|---|---|
| **Knowledge** | 73.32 | < 10 Years | --- | 5.897 (0.104) | 16.550 (0.000)* |
| | 67.42 | 10 – 20 Years | -- | -- | 10.653* (.011) |
| | 56.77 | > 20 Years | -- | -- | -- |

**The difference between means is significant at the 0.05 level*

Table 4.17: LSD test to compare the means and significance of years of practice with radiation practice.

| Field | Mean | Difference | < 10 Years | 10 – 20 Years | > 20 Years |
|---|---|---|---|---|---|
| **Practice** | 70.65 | < 10 Years | --- | 2.701 (0 .238) | 7.057* (0.002)* |
| | 67.94 | 10 – 20 Years | -- | -- | 8.524 (0.000)* |
| | 62.12 | > 20 Years | -- | -- | -- |

**The difference between means is significant at the 0.05 level*

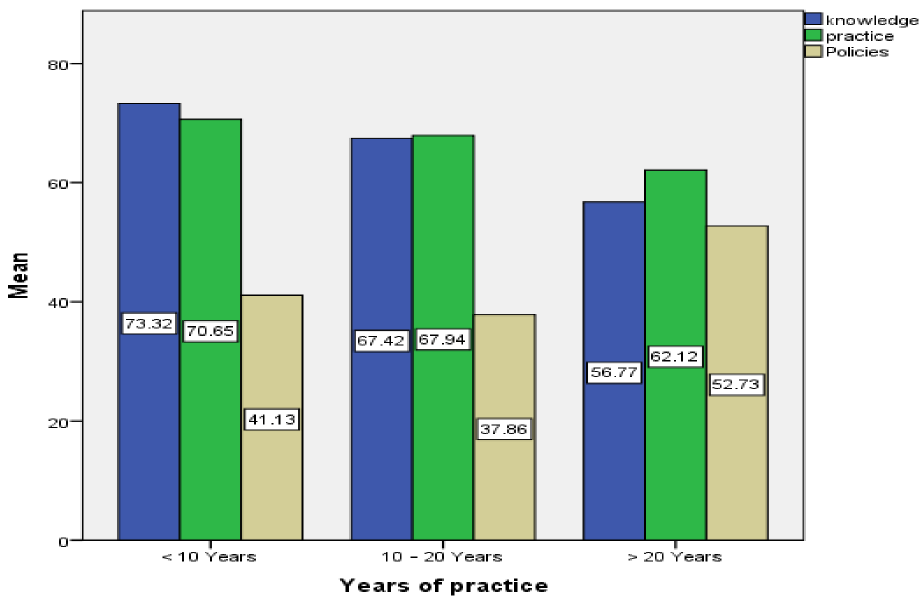


**Figure 4.2:** Differences in radiation protection awareness and knowledge, polices, and practices of radiographers according to years of practice.

Our study findings are consistent with that of Paolicchi et al., 2013, who argued that a small but significant difference in knowledge was found depending on the level of experience; young radiographers (with less than 3 years of experience) show to have a slight increase in score when compared with older radiographers. Moreover, Dehghani et al., 2014, reported that results depicted young people (20-30 years) have a higher awareness level than other age groups. Nevertheless, our results contrasted the results of Moghimbeigi and Mojiri, 2011, who informed that the existence of statistically significant relationship (*p*=0.03) between work experiences and awareness of radiation effects show that a few radiographers with low experiences have less information about mentioned subject. Although they have been educated freshly, but there is insufficient information around radiation effects signifying to a surprising and alarming result. A strongly recommendation for them to improve their knowledge around biological effects and update them through growing their expertise. Shah et al., 2011, stated in their study that it was further observed that the score of 16-20 year-experience duration group was 88%, which was higher than all other groups indicating that educational background, and duration of experience in the medical radiation science profession affects the awareness levels. In a study carried out by Fattahi et al., 2013, a significant negative correlation was observed between the work experience and total awareness score. This discrepancy between the findings of the mentioned study and those of our study can be attributed to the radiographers' being away from academic education, lack of persistent studies, as well as the unavailability of sufficient education facilities for the radiographers in the aforementioned study.

**Hypothesis (3):** There are no statistically significant differences at ($\alpha \leq 0.05$) in the radiation protection awareness and knowledge, polices, and practices of radiographers according to academic education.

It is noted that the result of the hypothesis of Table 4.18 (figure 4.3) show that there are differences between knowledge and academic education where p-value was 0.005 which is less than the value of significance ($\alpha \leq 0.05$), leading to reject this hypothesis. However, a Post Hoc test was carried out to know the differences (Table 4.19). We notice from Table 4.19 below that through the Post Hoc test results the existence of means between radiographers who have higher than bachelor's degree and those who have diploma degree, in favour for those who have higher than bachelor's degree. For those radiographers who have higher than bachelor's degree, their mean (80.9%) was higher than other means of other academic education levels, signifying that the degree of knowledge was higher in those who have higher than bachelor's degree. This indicates that the higher academic education, the more knowledge the radiographer has.

Correspondly, there are differences between practice and academic education where *p*-value was 0.001 which is less than the value of significance ($\alpha \leq 0.05$), leading to reject this hypothesis. Nevertheless, a Post Hoc test was carried out to know the differences (Table 4.20). We discern from Table 4.20 below that through the Post Hoc test results the existence of means between radiographers who have higher than bachelor's degree and those who have diploma degree, in favour for those who have higher than bachelor's degree. For those radiographers who have higher than bachelor's degree, their mean (75.8%) was higher than other means of other academic education levels, signifying that the degree of practice was higher in those who have higher than bachelor's degree.

Conversely, there was no difference between polices and academic education where p-value was 0.182 which is more than the value of significance ($\alpha \leq 0.05$), and the mean (30%) leading to accept this hypothesis.

Further, Moghimbeigi and Mojiri, 2011, argued that there is a statistical relationship between awareness of dose limit and radiographers' education level ($p$=0.008). Dehghani et al., 2014 contrasted our results and reported that there was not any significant relation between radiation-safety knowledge and level of education. Conversely, Kargar et al., 2017, said that the findings showed that there was a relationship between the radiographers' academic degree and their awareness of the radiation protection, i.e., the total awareness scores increased by higher academic degree. In other words, the radiographers with higher academic degrees had less radiation exposure than those with lower degrees due to better recognition of the radiation protection rules. Thus, apparently, continuing education is indispensable for the radiographers. Correspondingly, Saberi et al., 1998, testified a significant correlation between the education levels of staff and the repeated radiographic films, i.e., this amount could be reduced by increasing the radiographers' awareness level.

The researcher perceives that education is ultimately the only way to increase awareness of the potential risks of ionizing radiation as well as it is necessary for the staff to pass on-job short-term courses to acquire excellent level of awareness.

Table 4.18: Hypothesis 3: differences according to academic education.

| **Descriptive** | | | | |
|---|---|---|---|---|
| **Subgroup** (academic education) | | **N** | **Mean** | **Std. Deviation** |
| **Knowledge** | Diploma degree | 12 | 54.91 | 21.068 |
| | Bachelor degree | 114 | 68.62 | 16.572 |
| | Higher than bachelor's degree | 6 | 80.93 | 12.261 |
| | Total | 132 | 67.93 | 17.424 |
| **Practice** | Diploma degree | 12 | 58.13 | 9.334 |
| | Bachelor degree | 114 | 68.56 | 10.523 |
| | Higher than bachelor's degree | 6 | 75.83 | 2.137 |
| | Total | 132 | 67.94 | 10.725 |
| **Policies** | Diploma degree | 12 | 55.00 | 33.166 |
| | Bachelor degree | 114 | 42.81 | 27.764 |
| | Higher than bachelor's degree | 6 | 30.00 | 24.495 |
| | Total | 132 | 43.33 | 28.302 |

| ANOVA | | Sum of Squares | df | Mean Square | F | Sig.* | Remark | Decision |
|---|---|---|---|---|---|---|---|---|
| **Knowledge** | Between Groups | 3102.065 | 2 | 1551.032 | 5.457 | .005 | Reject Ho | Significant |
| | Within Groups | 36667.744 | 129 | 284.246 | | | | |
| | Total | 39769.809 | 131 | | | | | |
| **Practice** | Between Groups | 1573.583 | 2 | 786.792 | 7.521 | .001 | Reject Ho | Significant |
| | Within Groups | 13495.166 | 129 | 104.614 | | | | |
| | Total | 15068.749 | 131 | | | | | |
| **Policies** | Between Groups | 2731.579 | 2 | 1365.789 | 1.724 | .182 | Accept Ho | Not significant |
| | Within Groups | 102201.754 | 129 | 792.262 | | | | |
| | Total | 104933.333 | 131 | | | | | |

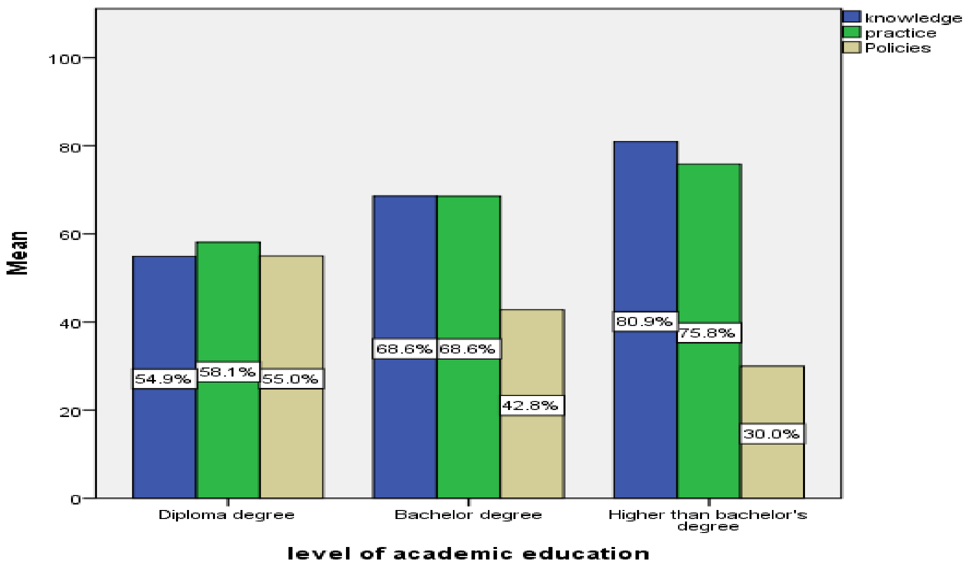


**Figure 4.3:** Differences in radiation protection awareness and knowledge, polices, and practices of radiographers according to academic education.

Table 4.19: LSD test to compare the means and significance of academic education with knowledge.

| **Field** | **Mean** | **Difference** | Diploma degree | Bachelor degree | Higher than bachelor's degree |
|---|---|---|---|---|---|
| **Knowledge** | 54.91 | Diploma degree | --- | -13.709-* (008)* | -26.019-* (.002)* |
| | 68.62 | Bachelor degree | -- | -- | -12.310- (.084) |
| | 80.93 | Higher than bachelor's degree | -- | -- | -- |

Table 4.20: LSD test to compare the means and significance of academic education with practice.

| **Field** | **Mean** | **Difference** | Diploma degree | Bachelor degree | Higher than bachelor's degree |
|---|---|---|---|---|---|
| **Practice** | 58.13 | Diploma degree | --- | -10.434-* (001)* | -17.708-* (.001)* |
| | 68.58 | Bachelor degree | -- | -- | -7.274- (.092) |
| | 75.83 | Higher than bachelor's degree | -- | -- | -- |

**Hypothesis (4):** There are no correlations at ($\alpha \leq 0.05$) between the radiation protection awareness and knowledge of radiographers and practices.

To answer this research hypothesis of the study, the researcher used Pearson Correlation. The results of Table 4.21 below reveal that there is a significant and direct relationship between knowledge and practice, where the correlation was significant at the 0.01 level (2-tailed). This means that when radiographers' knowledge increases, their awareness of practice increases and their practice improves.

In conclusion, the radiological protection principles in practical field, the optimization of protection and the individual dose limitation should be incessantly implemented. Correspondly, dose limitation for occupationally exposed individuals is essential to lessen the level of risk and confirms protection for radiographers. Knowledge and practices have strong direct effects in technical protection against health hazards associated with radiation exposures. The radiographers have to be knowledgeable on radiation protection precisely protect themselves, the patients, and others around the patients. Hence, it is concluded that it is necessary for the staff to pass short-term courses to gain excellent level of awareness.

Table 4.21: Correlations between the radiation protection awareness of radiographers and practices.

| Correlations | | knowledge | practice |
|---|---|---|---|
| **Knowledge** | Pearson Correlation | 1 | .357** |
| | Sig. (2-tailed) | | .000 |
| | N | 132 | 132 |
| **Practice** | Pearson Correlation | .357** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 132 | 132 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Hypothesis (5):** There are no correlations at ($\alpha \leq 0.05$) between the radiation protection policies and practices of radiographers.

To answer this research hypothesis of the study, the researcher used Pearson Correlation. The results of Table 4.22 below alluded that there is not any significant relationship between knowledge and practice, where the correlation was not significant (0.578). This means that radiation protection policies has no effect on practices of radiographers.

This result was a rather expected finding since no official referral guidelines and regulations issued and applied by MoH for all imaging examinations at the hospitals. Nonetheless, effective measures are needed to establish, legalize and reinforce the use of guidelines, particularly since they are specifically will be designed to help health professionals in deciding the most appropriate imaging examinations for clinical indications. Thus, joint with the inadequate level of awareness and knowledge regarding radiation protection, practices and policies demonstrated by this study's participants, it is recommended that all radiographers are not only made aware of that such guidelines, but they should also be educated and trained on how to make effective use of them during the justification and optimization as well as dose limitation.

Table 4.22: Correlations between the radiation protection policies and practices of radiographers.

| Correlations | | | |
|---|---|---|---|
| | | Policies | practice |
| **Policies** | Pearson Correlation | 1 | .049 |
| | Sig. (2-tailed) | | .578 |
| | N | 132 | 132 |
| **Practice** | Pearson Correlation | .049 | 1 |
| | Sig. (2-tailed) | .578 | |
| | N | 132 | 132 |

**Hypothesis (6):** There will be no significant prediction of practice by gender, years of practice, level of academic education, knowledge, and policies (Multiple Regression Model).

Here, we wanted to know how much do independent variables (gender, years of practice, level of academic education, knowledge, and policies) contribute to predicting and explaining the effect to dependent variable (practice) and see which one was the most effective variable in the practice.

A multiple linear regression was calculated to predict participants' gender, years of practice, level of academic education, knowledge, and policies based on their practice. A significant regression equation was found [$F(5,128)= 8.069$, $p<0.000$), with an $R^2$ of 0.243]. Participants predicted practice is equal to 51.411 + -5.126- + -2.769- + 6.920 + .153 + .062, where gender, years of practice, level of academic education, knowledge, and policies affected practice.

We notice from the table below the multiple linear regression estimates including the intercept and the significance levels. We find that F=8.069, the adjusted $R^2$ of our model is 0.212 with the $R^2 = 0.243$. This means that the linear regression explains 24.3% of the variance in the data. Which means that independent variables (interpretative) (participants' gender, years of practice, level of academic education, knowledge, and policies) could explain 21.2% of the changes in practice, while the rest is attributed to other confounders. In our stepwise multiple linear regression analysis, we find a non-significant intercept but highly significant practice coefficient. We can say that all of these independent variables were significant unless gender was not. The most item that affected practice was the academic level (0.004), followed by knowledge (0.006), then years of practice (0.012), and finally policies (0.044). In fact, gender did not reach statistical significance ($p$=0.255) in the multiple regression model.

Table 4.23: Correlations between the predictors: (constant), policies, gender, level of academic education, years of practice, and knowledge and between the dependent variable practices. (Regression model).

| **Model Summary** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | | | |
| 1 | .492[a] | .243 | .212 | 9.518 | | | |
| **ANOVA[b]** | | | | | | | |
| Model | | Sum of Squares | df | Mean Square | F | Sig. | Decision |
| 1 | Regression | 3654.885 | 5 | 730.977 | 8.069 | .000 | Reject |
| | Residual | 11413.864 | 126 | 90.586 | | | |
| | Total | 15068.749 | 131 | | | | |
| **Coefficients [c]** | | | | | | | |
| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | |
| | | B | Std. Error | Beta | | | |
| 1 | (Constant) | 51.411 | 7.552 | | 6.807 | .000 | |
| | Gender | -5.126- | 4.480 | -.092- | -1.144- | .255 | |
| | Years of practice | -2.769- | 1.083 | -.218- | -2.557- | .012 | |
| | level of academic education | 6.920 | 2.382 | .237 | 2.905 | .004 | |
| | knowledge | .153 | .054 | .249 | 2.816 | .006 | |
| | Policies | .062 | .030 | .163 | 2.038 | .044 | |

*a. Predictors: (Constant), Policies, Gender, level of academic education, Years of practice, knowledge. b. Dependent Variable: practice.* $_{C}$*. Dependent Variable: practice*

# Chapter Five: Conclusions and Recommendations

## 5.1 Conclusions of the Study

This study verified that overall mean score of radiation protection awareness, policies and practices among Palestinian radiographers in governmental hospitals is relatively inadequate (59.73%). It is notable that the evaluation of the radiographer's awareness about the radiation protection awareness, policies and practices is essential.

Our results show that only a marginal number of radiographers received radiation safety training. Education is ultimately the only way to increase awareness of the potential risks of ionizing radiation, leading to changes in behaviour and practice, especially in view of optimisation, justification and dose limitation. Overall, this study strengthens the idea that radiation protection training must be considered for all radiographers according to their role in dealing with the ionising radiation.

It follows from the aforementioned results that a deeper understanding that might be gained through further needed studies to formulate a clearer picture of the dimensions that a radiation protection awareness is to be applied. In all, and strikingly, the fact that the overestimation of ultrasound and MRI emit radiation reflects an important gap in radiographers' knowledge. However, to close this knowledge gap it is suggested expanding the utilization of teaching and educating MRI and ultrasound in the national universities, such as the promotion of teaching new master studies. This has been suggested by Al-Quds University to teach and educate the radiographers to perform ultrasound, and thus working in hospitals and centers.

Future studies could assess the reasons why some of the protective devices are not being used despite availability. Adherence to safe radiation practices was violated by most of radiographers especially using (PPE) during performing the procedures. However, radiographers in governmental hospitals were generally apathetic to radiation protection practices.

With the physicians requesting radiological examinations weighting the risk in relation to the benefits, it is crucial for them to have the knowledge on ionizing radiation and its risks. If that knowledge is incorrect, patients may be subjected to more than necessary radiation doses. Not surprisingly, concerns are growing over the low levels of awareness associated with risks, particularly the potential increased lifetime risk of cancer.

As we mentioned earlier in the study, in the last few years, the Palestinian Ministry of Health has taken an imperative step in the development of the medical imaging sector. The expansion was in terms of developing the quality of the equipment used, to the digital systems, the expansion of a guide for policies and procedures in the imaging departments and training of teams. However, this was proceeded by the establishment of the General Directorate of Paramedical Services, and the subsequent expansion of the administrative constitution in the medical imaging sector in the Ministry of Health. This study confirms that the application of radiation protection systems in accordance with international standards is a continuous cumulative exertion that calls for the convergence of all related efforts, foremost of which is the scientific research sector. This study seeks to provide a field study that offers a numerical description of the reality and coveting to constitute a qualitative addition and contribution to the incessant endeavor being undergone by the Palestinian Ministry of Health for the development of radiation protection system. Moreover, this study proposes a Palestinian Radiation Protection Initiative led by the Palestinian Ministry of Health in partnership with the research sector in the national universities and the Medical Imaging Association. The purpose is to promote a radiological protection policy and to offer a fitting support in the media, and at the formal level to adopt relevant legislations and laws to sustain this policy and achieve appropriate mechanisms for the implementation.

National legislations in Palestine are lacking; such legislations will give impetus to regularization of radiographic practice to conform to international safety standards. Besides, since appraising of radiographic practice is an internationally acknowledged part of radiation protection practices, it is vital to evaluate both knowledge and compliance to radiation protection practices among radiographers in Palestine.

## 5.2 Recommendations of the Study

Based on the findings of this study, the following recommendations are proposed:

1. All radiology departments in hospitals performing ionising radiation should ensure a harsh adherence to radiation safety practices to protect radiographers, patients and the public from detrimental effects of ionising radiation.
2. Intervallic quality assurance tests should become compulsory in all diagnostic x-ray facilities in the country.
3. Enactment of laws and regulations will give impetus to regularization of radiation protection practice to conform to international safety standards.

4. Since knowledge alone, though very important, cannot translate to adequate radiation protection, radiographers, accordingly, must modernize their knowledge often to comprise the most contemporary inclinations in radiation protection, and then make more resolute efforts to follow radiation protection protocols in their daily work routine.
5. Suggesting expanding the utilization of teaching and educating MRI and ultrasound in the national universities to close the knowledge gap as has been suggested by Al-Quds University to teach and educate the radiographers to perform ultrasound, and thus working in hospitals and centers.
6. Specific actions must be set up in order to increase the number of radiographers to fit with the workload and current and future modalities where available.
7. The recruitment of a radiation protection officer in each hospital who is responsible for radiation protection and communication who is well trained and educated.
8. Designing and implementing a comprehensive training program to all healthcare staff as doctors, nurses and personnel contact with radiology area.
9. Replication of the study on larger sample and different healthcare workers will be beneficial to decrease health hazards associated with radiation.
10. "It was also proposed (ICRP, 1951) that the Commission should 'recommend that all interested countries establish, each for itself, a central national committee to deal with problems of radiation protection – such a central committee to have sub-committees matching those of the International Commission on Radiological Protection as closely as their circumstances permit. So far as possible, members of the international sub-committees should be selected from the corresponding subcommittees of the various national committees. On matters of policy and formal agreements, communication will be from the central national committee to the International Commission. It is, however, recommended that direct communication on technical matters may be conducted between the corresponding national and international sub-committees' (Clarke and Valentin, 1996)".

Hence, the researcher proposes this national initiative:

## "Palestinian Radiation Protection Initiative (PRPI)"

### 1. Scope of Policy

This Palestinian Radiation Protection Initiative (PRPI) Policy covers the use of ionising radiation, including electrical equipment that produce x-rays, that are used by the radiographic staff, and involving personnel and public for activities under the control of MoH, as detailed and used across worldwide. This Initiative is constructed and based upon the recommendations of the International Commission on Radiation Protection (ICRP), and the International Commission on Radiation Units and Measurements (ICRU). The conceptual framework adopted by the ICRP in its publication ICRP 60 (ICRP 1991) is one of a System of Radiological Protection ICRP publication 60 (ICRP 1991) that was substantially revised and updated in 2007 with the publication of ICRP 103 (ICRP 2007).

In the year 2008, the World Health Organization issued its ‘Global Initiative on Radiation Safety in Health Care Settings', 2008, (http://www.who.int/ionizing_radiation/about/GI_TM_Report_2008) to manage the health sector for a better safe use of radiation. WHO Initiative strives to complement the International Action Plan for the Radiological Protection of Patients established by the IAEA in 2002. Development of actual challenges for users of radiation in the medical field, as well as the delivery and policy leadership for Health Authorities will improve protection of patients and healthcare workers (WHO, 2016). It is to be hoped that our initiative will integrate with that of WHO initiative for a better protection.

## 2. Statement of Intent

The Palestinian Radiation Protection Initiative (PRPI) will ensure, as far as is reasonably practicable, the health and safety of employees and other persons who may be exposed to hazards from the use of ionising radiation.

## 3. Exposure Levels

3.1. The (PRPI) will be committed to a policy of restricting exposure to ionising radiation in accordance with the ALARP principle (as low as is reasonably practicable), and ALARA principle (as low as is reasonably achievable).

3.2. The (PRPI) will ensure that all medical diagnostic radiological examinations will be implemented in accordance with the (IRMER 2000) and successive modifications, with the radiation dose to a patient being as low as is reasonably achievable to attain the requisite clinical purpose.

## 4. Legislative Framework

4.1 Newer modalities are being applied in major hospitals, and latest radiological equipment are being imported and installed. Besides, small x-ray “set-ups” are added almost every day. This quantitative increase may have a positive impact on the health service system of the country; but the lack of control can cause serious problems especially radiation hazard to the radiation workers as well as public.

4.2 Common objective of this proposed system is to establish and legalize uniform safety standards to protect the health of workers and patients, and to initiate steps towards the establishment of Palestinian laws, regulations and code of radiological practice in this field, which leads to the implementation of national, sustainable and regulatory framework.

4.3 Until now, there is no legislative body or any radiation protection action to set standards for radiation protection, radiological activities as well as any radiation monitoring system in Palestine. There is no legal framework in Palestine specifies the basic safety standards for radiation protection and safety, resulting in national requirements throughout Palestine to lay down the requirements for the protection of the health of workers and the general public against the dangers of ionising radiation. Besides, encapsulate the principles of justification, optimisation and dose limitation and apply them to a regulatory system that controls practices involving ionising radiation. Still, there is a need to further improve the protection and safety and to turn cumulated knowledge into operational activities in the hospitals. Justification and optimisation should be seen as key in implementing radiation protection in medicine. The scope not only includes patients, but also other individuals exposed either directly or indirectly. This includes those exposed in occupational health surveillance, health screening, research and medico-legal procedures. However, medico-legal procedures envisaged arising because of legal proceedings should be further revised and permanently updated.

## 5. Quality Control Committee

In 15/10/2015, a quality control program was proposed in the governmental surveyed hospitals in radiology facilities by a committee to apply total quality management in addition to the knowledge of plans, protocols, and applied policies in these departments according to urgent necessity to develop the health system in general, and radiology departments in specific. General Administration of Allied Medical Professions seriously seeks to promote best health services to the Palestinian citizen, which in turn imitate positive impacts on the population satisfaction and society, and eventually develop and raise indicators of quality level.

The committee denotes after field visits that these radiology departments lack largely to the existence of plans and clear polices to endorse the medical imaging radiographers, also, non-application of the safety rules inside these departments. The committee recommended the necessity of taking safety precautions and written instructions for the medical imaging radiographers and patients about the radiography hazard and safety procedures. Periodic tests to the TLD meter and radiation leakage from inside rooms were also recommended.

So far, there is a Radiation Monitoring Unit in the Palestinian Ministry of Health with deficient knowledge and inadequate applicability of the protective measures. Unfortunately, no policy exists within the Palestinian context in the Radiation Monitoring Unit regarding the issues to be addressed and the directions of radiation protection that currently offer the prospects for resolving this issue.

## 6. Personal Monitoring

6.1 All staff working routinely in the radiology departments will be subject to a programme of personal monitoring, the details of which will depend on the risk assessment that is carried out.

6.2 Dose investigation level will be set and stated in the risk assessment and local rules.

6.3 A legal advisor is to be assigned by MoH, or nominated deputy, will be responsible for checking personal dose records, and carrying out investigations into any dose above the specified level, in conjunction with the Central Public Health Laboratory (CPHL).

## 7 Modus Operandi

This study is about to create a prospective policy that will provide a sound conceptual basis on which to proceed, but, alone, it is not sufficient. It needs to be complemented by more strategic and practical considerations, in particular, how to translate the concept into practice in the light of a number of important impediments to its realization. Many difficulties lie ahead, not least because of the complexity of the issues of the large uncertainties that need to be overcome.

## 8 Establishment

The establishment of the following two elements will be critical in terms of making a road map and tangible progress:

8.1 A national organization capable of ensuring appropriate governance of radiation protection in this field, in the pursuit of a long-term shared vision: uniting the programmes of the various health bodies and educational organizations. Thus, ensuring long-term protection in accordance with an agreed strategy; interfacing with the many stakeholders, in particular regulatory bodies and the wide-ranging scientific community, overseeing knowledge management, training and education; the cooperation with the international organizations. For this purpose, it is proposed to set up a new Palestinian platform, to be named **Palestinian Radiation Protection Initiative (PRPI).**

8.2 A **scientific strategy** in order to structure the radiation protection programmes in the most effective way, taking into account available resources. This strategy will constitute the backbone of the radiation protection policy, and progressively bringing together research programmes, and scientific communities, facilitating linkage where needed between disciplines, and facilitating radiation protection into areas of high risk.

8.3 A detailed creation of a **national operational policy** about radiation protection is recommended for all diagnostic radiology facilities:

1. The national policy consists of planned and systematic actions providing confidence that a facility will produce permanently high-quality images with minimal exposure.

2. It relies on a clear definition of responsibilities of the team members and starts with the specifications of the equipment for purchase.
3. The policy has to guarantee periodic checks of all components of a diagnostic x-ray system such as utilizing periodic testing of the personal TLDs, wearing personal protection equipment and shielding, securing stability of workspace, confirming radiation exposure result and notifying abnormality, etc.
4. The national policy uses different adapted procedures for different radiological procedures, and thus, differs for radiography, CT and fluoroscopy. Images are compared to standards of acceptable image quality.
5. Monitoring and maintenance include a series of tests that can be performed by different assigned people; they are directed to x-ray generation, exposure, detector performance, post-processing and viewing at a workstation.
6. Dissemination of information regarding radiation protection to all professionals and general population should be one of the primary tasks.
7. This policy takes justification and legislation initiatives and is a strong partner in the cooperation to establish Palestinian referral guidelines for imaging.
8. This policy is incomplete without records, a manual and systematic educating and training for all persons involved in it.
9. In case of a problem, corrective actions must be in place.
10. The policy makers have to cooperate with international organizations, such as European Society of Radiology (ESR), the ICRP, IAEA, WHO, European Commission (EC), International Radiological Quality Network (IRQN), European Medical ALARA Network (EMAN), etc.
11. A way to improve risk management is to integrate radiation protection and safety activities in a management system. A management system is a standardized framework to improve activities throughout the organization by developing and implementing policies, description of processes, routines for work activities as well as decision on responsibilities, accountabilities, level of authority and interactions of those managing, performing and assessing work.
12. Finally, it has to be reviewed periodically for all components.

# 9 Objectives

9.1 To formulate and agree the radiation protection policy goals to be addressed by study and research.

9.2 To develop a strategic agenda and road map for radiation protection in Palestine.

9.3 To specify the essential elements of and next steps for establishing a sustainable operational framework for radiation protection in Palestine.

9.4 It is envisaged that this framework will enable interested parties to:

9.4.1 Programme and implement their activities in accordance with each other to get a strategic agenda and road map ("**structuring**").

9.4.2 Better integrate national activities and exploit synergies ("**integrating**").

9.4.3 Revise periodically the agenda/road map and ensure that it remains fully responsive to emerging needs ("**revising**").

9.4.4 Achieve effective collaboration with international radiation protection research programmes/activities elsewhere ("**international collaboration**").

## 10 Constitution of the Committee

The Disciplinary Palestinian Radiation Protection Initiative (DPRPI) will comprise:

10.1 Representatives of national health (or regulatory) bodies with a significant programme/activities or with a policy interest in radiation protection or of national institutes with a substantial health programme in this area such as the Palestinian Medical Imaging Association.

10.2 Representatives of the academic and research community with recognized high-level expertise in radiation protection research.

10.3 Representatives of Palestinian Ministry of Health (MoH).

10.4 The number of members should not exceed eight, and will be selected as follows:

10.4.1 Two members of the Palestinian Medical Imaging Association who are currently working in governmental hospitals.

10.4.2 Four member universities with significant radiation protection research activities/programmes who have expressed an interest in participating in the Disciplinary Palestinian Radiation Protection Initiative (DPRPI).

10.4.2.1 Al-Quds,

10.4.2.2 An-Najah National,

10.4.2.3 Arab American,

10.4.2.4 Bethlehem,

10.4.2.5 Two MoH members who are recognized with high-level expertise in radiation protection.

10.5 These eight members (representing the two Palestinian Medical Imaging Association (PMIA) members, and the four national university members, and two members of ministry of health) will propose candidates for membership of the (DPRPI). Based on these proposals, the final composition of the (DPRPI) will be agreed by representatives of the eight above members. Ensuring an appropriate balance between expertise in formal, radiographic and academic will be the main criterion in the selection process. This Policy, its Appendices and all other radiation safety documentation will be formally reviewed by the DPRPI once or twice yearly.

## 11 Terms of Reference and Constitution of the Palestinian Radiation Protection Initiative (PRPI)

### 11.1 Terms of Reference of the Committee

The committee shall meet every one or two years to fulfil the following terms of reference:

1. To liaise, co-ordinate and advise on all matters regarding ionising radiation safety and oversee the use of non-ionising radiation.
1. To draw up written systems of work and local rules and make recommendations to ensure compliance with statutory regulations.

2. To manage training/refresher courses and promote good radiation practices.
3. To be a forum for duty holders under the Ionising Radiation Regulations 1999 (IRR99).
4. Being a member of the ICRP.
5. To report to the four universities' managements, MoH and PMIA.

**11.2 HEED this NOTICE:** Hopefully, this paper is to be duly incorporated by reference and optimistically to be considered legally binding upon all citizens, health bodies and educational organizations of Palestine.

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## Appendix 1: Consent form for subjects participating in research study

### Bart I: Consent form for subjects participating in a research study

Version date: July, 2017

Title of Research: "**Assessment of Radiation Protection Awareness, Policies and Practices among Palestinian Medical Imaging Technologists in Governmental Hospitals, West Bank, Palestine.**"

Principle Investigator:

Mr. Mohammad Saeed Hassan, Earth and Environmental Sciences Master Student, 2016 at Al-Quds University/Department of Earth and Environmental Sciences, Telephone: +970599251645

Direct Supervisor: Dr. Adnan Lahham; PhD. Professor of Physics; Department of Earth and Environmental Sciences; Al-Quds University P.O.Box 20002 Telefax: +970-2-2796960 Mobile: 00972599922888 E-Mail: Lahham@science.alquds.edu

**Purpose of Research:**

We wish to identify the perceptions and actions taken regarding the radiation protection awareness, policies and practices among Palestinian medical imaging technologists in governmental hospitals, West Bank, Palestine during the year 2017. This may be encompassing important information to our research and the recommended results will be useful for planning and improvement of the knowledge of dose exposure levels and awareness of radiation protection issues and their implications.

We are highly appreciated with your cooperation if you could take the time to go through this questionnaire and answer the relevant questions. Hopefully, it will not take you longer than 10 minutes to fill in this questionnaire.

We appreciate your participation in this study and in providing the information needed for filling the questionnaire. We'll keep your information as confidential, maintain your privacy; and you have the right to participate and to leave the study at any time you decide with no any obligation, noting that the introduced information will not be used but for scientific research only. The researcher will offer you the results if you would like to. Please if you have any other queries, please do not hesitate to contact me.

Thank you for your time and kind consideration.

**Mobile: 0599251645**

**Mail: m.said.jurban@gmail.com**

Date of Approval: _____/______ /________

Researcher: Mohammad Saeed Hassan

## Appendix 2: Questionnaire

**Bart II: Socio-demographic factors**

Please answer the following questions by ticking (√) to the most closely answer that matches your opinion.

1. Gender
   - (a) Male
   - (b) Female

2. Years of practice
   - (a) < 10 Years
   - (b) 10 – <20 Years
   - (c) ≥ 20 Years

3. Please, state your level of academic education
   - (a) Diploma degree
   - (b) Bachelor degree
   - (c) Higher than bachelor's degree

4. Where do you work? (Hospital)

   **-------------------------------------------**

**Bart III: Radiation protection knowledge and awareness**

5. How do you consider your knowledge level about ionizing radiation risk?
   - (a) Excellent
   - (b) Good
   - (c) Insufficient

6. Do you know the difference between stochastic effects and the deterministic (non-stochastic) effects of radiation?
   - (a) Yes
   - (b) No

7. The radiation protection philosophy of the International Commission on Radiological Protection (ICRP) includes the ALARA principle. Do you know the ALARA principle?
   - (a) Yes
   - (b) No

8. If yes, ALARA principle stands for which of the following?
   - ***(j) As Low as Reasonably Achievable***
   - (k) Allowable Administered Radiation Alert
   - (l) I don't know

9. According to your knowledge, what is the form of radiation protection for individuals who are often exposed to radiation?
   (a) Lead screen/Apron shielding
   (b) Maximizing the distance from the radiation source
   (c) Minimizing the amount of exposure time
   ***(d) All of the above***
   (e) I don't know

10. Which gender of patients is the most sensitive to ionizing radiation?
   (a) Male
   ***(b) Female***
   (c) I don't know

11. Which one of the following organs is more susceptible to ionizing radiation damage?
   (a) Breast
   (b) Bone
   (c) Liver
   ***(d) Gonads***
   (e) I don't know

12. Which one of the following has no radiation risks?
   (a) Fluoroscopy
   ***(b) MRI***
   (c) PET
   (d) Technetium bone scan
   (e) I don't know

13. Please, select which one of the following is the most sensitive to radiation
   ***(a) Children***
   (b) Adults
   (c) Adolescents
   (d) Elderly
   (e) I don't know

**Bart IV: Optimisation and justification:**

14. Which one of the following best describes the concept "**dose optimization**"?
   ***(a) The dose must be kept as low as reasonably achievable and compatible with the diagnostic information.***
   (b) The level of protection is <u>not necessary</u> be the best under the main circumstances.
   (c) There should <u>not</u> be restrictions on the doses or risks to individuals.

(d) The actual radiation doses are often much higher than the permitted limit.
(e) I don't know

15. Which one of the following best describes the concept "**dose justification**"?

    ***(a) Any decision that changes the radiation exposure situation should do more good than harm.***
    (b) Integration of radiation protection and quality assurance.
    (c) Increasing the support of medical physics in imaging.
    (d) Unnecessary use of radiation is permitted.
    (e) I don't know

**Bart V: Radiation protection practice**

16. How often do you use the following radiation protection policies/personal protective equipment (PPE), during radiological procedures?

| Policies/equipment | Never | Sometimes | Always |
|---|---|---|---|
| J. Lead aprons | | | |
| K. Thyroid shields | | | |
| L. Lead gloves | | | |
| M. Eye glasses | | | |
| N. Gonad shielding | | | |
| O. Collimation | | | |

17. How is ALARA used in the practice of radiation protection?

    ***(a) High KVp, low mAs (optimisation)***
    (b) Low KVp, high mAs
    (c) I don't know

18. For each of the following statements, select the response that most closely matches your opinion.

| Item | When asking for clarification | Never | Rarely less than 25% | Sometimes 25%- 75% | Often more than 75% |
|---|---|---|---|---|---|
| A. Usually, before achieving an X-ray examination, do you outline (clarify) all risks and benefits of the X-ray examination to the patient and patient's family? | | | | | |
| B. How often would you ask a woman if | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| she is married and pregnant before performing radiological procedure? | | | | | |
| C. How often would you request written consent form from a pregnant woman before doing an x-ray examination? | | | | | |

19. Do you apply ALARA as work principle?
    (a) Yes
    (b) No

**Bart VI: Training**

20. Have you ever attended teaching/training and/or refresher courses on radiation protection?
    (a) Yes
    (b) No
21. Do you think you need (further) training on radiation safety or radiation doses?
    (a) Yes
    (b) No

**Bart VII: Guidelines and Policies**

22. In your opinion, which one of the following professionals is considered (legally) responsible for unnecessary exposure to ionizing radiation and/or improperly performed radiologic exam?

    (a) Only the referring physician
    (b) Only the radiologist
    (c) Only the radiographer
    ***(d) All previous answers are correct***
    (e) I don't know

23. For each of the following statements, select the response that most closely matches your opinion.

| Item | Yes | No |
|---|---|---|
| A. Do you think there is a <u>manual guidance</u> clarifying current radiation protection guidelines, policies and regulations issued and governed by MoH? | | |
| B. Do you think there are effective roles by your hospital administration in making radiation protection programmes? | | |

| | | | |
|---|---|---|---|
| C. | Do you think MoH is concerned about the protection of health and welfare of the staff relating radiation protection measures? | | |
| D. | If you had been monitored occupational excessive or uncontrolled doses, and your TLD reading was high, do you think you will be given a vacation? | | |

24. For each of the following statements, select the response that most closely matches your opinion.

| Item | Strongly Disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| A. In the place where I work, there is a system or a protocol, which clearly explains justification of the needed images to patients. | | | | | |
| B. I feel that <u>old</u> equipment affect <u>negatively</u> the radiation protection precautions. | | | | | |
| C. I feel safe when caring for needing radiation precautions. | | | | | |

**Bart VIII: Radiation dose assessment**

25. How far (at least) from the x-ray source do you stand <u>without any protection</u> during the radiological-guided procedure (e.g. C-arm)?
    (a) 1 meter
    (b) 2 meters
    ***(c) More than 2 meters***
    (d) I don't care about the radiation
    (e) I don't know

26. Do you think that there is an increase in lifetime risk of developing cancer from any x-ray examinations such as abdomen X-ray, skull X-ray, lumbar spine X-ray etc.?
    ***(a) Yes***
    (b) No
    (c) I don't know

27. Do you think that there is an increase in lifetime risk of developing cancer from any C-T scan examinations?
    ***(a) Yes***
    (b) No
    (c) I don't know

28. Approximate effective dose received by a patient in a single-view chest X-ray is about:
    (a) 0.5 mSv
    (b) 1 mSv
    ***(c) 0.02 mSv***
    (d) 0.05 mSv
    (e) I don't know

29. What is the dose in Chest x-ray equivalent for the following radiological investigations?

Please tick in the appropriate box.

| Investigation | Chest x-ray equivalent | | | | |
|---|---|---|---|---|---|
| | <1 Chest x-ray | 1-10 Chest x-ray | 10-50 Chest x-ray | 50-300 Chest x-ray | >300 Chest x-ray |
| Ankle x-ray | | • | | | |
| Abdomen CT | | | | | • |
| Head CT | | | | • | |
| A two-view unilateral mammogram | | | • | | |
| Abdomen Ultrasound | • | | | | |
| Spine MRI | • | | | | |

**Bart IX: Radiographers' perceptions towards the justification of medical imaging exams:**

30. Have you been faced with situations where a public patient requested an examination by him/herself justifying that the patient wants to reassure for health?
    (a) Yes
    (b) No
31. Do you believe that medical doctors request unnecessary examinations?
    (a) Yes
    (b) No

32. If yes, to what percentage you believe they overuse imaging services?
    (a) Less than 25%
    (b) 25% - 75%
    (c) More than 75%
33. Do you question (do you protest) the referring doctors when you see an unjustified requisition?
    (a) Never
    (b) Less than 25%
    (c) 25% - <50%
    (d) 50% - 75%
    (e) More than 75%
34. Do you trust the readings of TLDs?
    (a) Never

(b) Less than 25%

(c) 25% - <50%

(d) 50% - 75%

(e) More than 75%

**Thank you for answering the questions. This will help us in providing you with a better service.**

**Appendix 2: List of persons shared the questionnaire preparation and critique:**

| No: | Name | Title | Location |
|---|---|---|---|
| 1 | Dr. Adnan Lahham | PhD. Professor of Physics; Department of Earth and Environmental Sciences | Al-Quds University |
| 2 | MR. Osamah Ayesh | M.Sc. Health Management and Policies. B.Sc. Medical Imaging | MoH |
| 3 | Mr. Abd Alsalam Eweidat | M.Sc. Health Management and Policies. B.Sc. Medical Imaging | MoH, Lecturer: Al Quds Open University |
| 4 | Mr. Ala' Fayed | Statistician | Al Quds Open University |

**Appendix 3: The College letter to the health education director/MoH to facilitate the student's mission**


*Al-Quds University*

**Center for Radiation Science & Technology**

Jerusalem – Abu Dies

بسم الله الرحمن الرحيم

جامعة القدس

مركز علوم وتكنولوجيا الاشعاع

القدس – ابو ديس


الرقم: م.ع.ت.ا ٢٠١٧/٨/٢

التاريخ: ٢٠١٧/٨/٢.

من : د. عدنان اللحام / مدير مركز علوم وتكنولوجيا الإشعاع

بسم الله الرحمن الرحيم

حضرة مدير عام التعليم الصحي/وزارة الصحة الفلسطينية المحترم.

الموضوع : مساعدة الطالب محمد سعيد حسان.

تحية طيبة، وبعد :

يقوم الطالب محمد سعيد حسان من برنامج ماجستير الدراسات البيئية /جامعة القدس بإجراء بحث بعنوان :

"Assessment of Radiation Protection Awareness, Policies and Practices among Palestinian Medical Imaging Technologists in Governmental Hospitals, West Bank, Palestine."

كمتطلب لبحث رسالة الماجستير ، لذا نرجو من حضرتكم التكرم وتسهيل مهمة الطالب في جمع المعلومات الأولية الخاصة للدراسة من المستشفيات الحكومية في الضفة الغربية، علما بان هذه المعلومات خاصة للبحث العلمي فقط .

وتقبلوا فائق الاحترام والتقدير،،

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