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Effects of Exposure to Radiation on the Immunity Status of Medical Radiographers at Governmental Hospitals-Gaza Governorates

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Effects of Exposure to Radiation on the Immunity Status of Medical Radiographers at Governmental Hospitals- Gaza Governorates

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Dedication

This work was dedicated

To my dearest and beloved mother and father

To my sisters, brothers, and my whole family

To all my relatives and friends

To all my colleagues both in the work and University

To all participants of my study both in radiology and lab

To everyone helped and cooperated with me specially at data collection stage

With my love and respect

Mousa Hafez ALnahhal

Declaration

I certify that this work provided for the Master Public Health/branch Epidemiology, unless otherwise referenced is my own work. This thesis has not been submitted elsewhere for any other higher degree in any university or institution.

Signed:

Mousa Hafez Alnahhal

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Abstract

Long-term exposure to low doses of ionizing radiation may affect cells, tissues, and body systems and result in various adverse health effects. Immunity system is known to be highly radiosensitive; therefore it's susceptible to radiation. Medical radiographers are occupationally exposed to chronic levels of ionizing radiation that may affect their immune response. So, the aim of this study was to investigate effects of exposure to radiation on the immunity status of medical radiographers at governmental hospitals-Gaza governorates.

The study design was a case control study conducted in six main hospitals. A total of 92 medical radiographers exposed to chronic ionizing radiation compared with control group of 97medical laboratories who never exposed to chronic radiation. The cases and controls had the same age, gender, years of experience, and smoking status. A questionnaire and blood tests were the tools of the study.

The study reported a response rate of 83.6 % for exposed group and 74.6 % from control group for the questionnaire. While the response rate of the venous blood samples was 58.8 % and 60.2 % for exposed and non-exposed groups respectively controls in case of venous blood sampling.

The results revealed that several health complains such as headache were higher among medical radiographers (46.7%) compared to medical laboratories (10.3%) with highly statistically significant level (p.0.000). Regarding immunity systems, the study found that clinical symptoms such as gastritis, sore throat, repeated infections, and sinusitis were prevailing among exposed group compared with non-exposed group with statistically significant differences ($p<0.05$). Other clinical symptoms such as skin diseases, fever, and pallor did not reached the statistically significant levels ($p>0.05$). About venous blood samples, our study results found that mean difference of Immunoglobulin G and A were higher among medical radiographers (1279±359), (215 ±108) compared with the control group (1225±209) and ((1202±89) with no statistically significant level ($p=0.324$ and 0.498) respectively. In addition, white blood cells and lymphocytes counts showed some variations between exposed and control group with no statistically significant differences.

In conclusion, significant health complaints and clinical symptoms were recorded among medical radiographers compared with the matched control group. Thus, personnel monitoring for ionizing radiation, periodic medical examination, and increasing level of protection for MRs is of utmost importance.

Table of Contents

List of Tables

List of Figures

List of Annexes

List of Abbreviations

CBC	Complete Blood Count
CI	Confidence Interval
CNSC	Canadian Nuclear Safety Commission
EGH	European Gaza Hospital
EPA	Environmental Protection Agency
GG	Gaza Governorate
GS	Gaza Strip
IAEA	International Atomic Energy Agency
ICRP	International Committee of Radiation Protection
IgA	Immunoglobulin A
IgG	Immunoglobulin G
IR	Ionizing Radiation
LDIR	Low Doses of Ionizing Radiation
MLs	Medical Laboratories
MOH	Ministry of Health
MRs	Medical Radiographer
NAS	National Academy of Science
NCRP	National Council on Radiation Protection and Measurements
NOHSC	National Occupational Health and Safety Commission
NRC	National Research Council
OR	Odds Ratio
PCBS	Palestinian Central Bureau of Statistics
RSNA	Radiological Society of North America
SD	Standard Deviation
SPSS	Statistical Package for the Social Science
UNSCEAR	United Nation Scientific Committee on Effects of Atomic Radiation
WBCs	White Blood Cells
WHO	World Health Organization

Chapter (1) Introduction

1.1 Background

Ionizing radiation (IR) has been present since the earth was created. It includes both natural and man-made radiations (UNSCEAR, 2008). IR such as X-ray, gamma ray, alpha, beta particles are capable of removing electrons from its orbits and causing ionization of the atom (CNSC, 2012; WHO, 2014). The use of IR in medicine began with the discovery of x-ray in 1895 by Rontgen. Today, IR has many benefits and used in several different fields such as industry, security purposes as well as medicine. Medicine is considered the single largest man-made contributor to radiation exposure (UNSCEAR, 1982). IR such as X-ray is being used extensively in diagnosis of many diseases and therapy of cancer patients (NAS, 2006).

On the other hand, IR can cause many diseases such as cancer, cataract, congenital anomalies, and skin burns (Baker, Bromilow, and Costigan, 1990; Zakora, 2001; Bashore, 2001; Tuncel, 2002). Also, exposure to acute large doses of IR can cause death within few days or months, while exposure to small doses over time may affects and increase the risk of cancer and genetic mutations (Zakora, 2001; Bashore, 2001; NAS, 2006).

Immunity system is one of the most important and highly specialized structures in the human body. It consists of cells and tissues that work to protect against infections and cancer (UNSCEAR, 2006). Immunity system produces five main antibodies called immunoglobulin (Ig) including IgA, IgD, IgG, IgE, and IgM, to fight against antigens (Porovsky and Tetenev, 2002). Additionally, it is a leader in manifesting the immediate response to any external influence including ionizing radiation (Demaria et al. 2005).

Immunity system is one of the most radiosensitive systems in the body. This may explain the vulnerability to IR (Hrycek and Stieber, 1994; Prasad, 1995). Moreover, long term exposure to even low doses of IR can affects proliferating immune cells (Vakifahmetoglu et al. 2008). IR can also cause disturbances of the immunity system including immunosuppression in case of high exposure dose and immune-stimulation in case of exposure to low doses (Hrycek and Stieber, 1994). Workers of radiology are among persons who are exposed to low doses of IR that have shown immunocompromising effects due to occupation (Cameron, 1992; Soldatov and Ushakov, 1995).

There are few studies investigated the effects of low doses of ionizing radiation (LDIR) on the immune status of radiology workers. A study conducted by Godekmerdan et al, (2004), found lower concentrations of immunoglobulin serum among radiology worker compared to controls. Similarly, Oskouii et al. (2013) showed that the mean serum IgA and IgM levels were lower among radiology worker than those of control group. On the other hand, Moghaddam et al, (2004) and Daoud et al, (2008) found no statistically significant difference between exposed and control group regarding serum immunoglobulin. In this study we aimed to investigate the effects of exposure to radiation on the immunity status of medical radiographers working in governmental hospitals-Gaza Governorates.

1.2 Problem statement

It is well established that ionizing radiation has negative biological effects on living organisms (Brant and Helms, 1999). Some parts of the body are more sensitive to radiation-induced damage than others. Immunity system is highly radiosensitive, which may affected by exposure to even low doses of ionizing radiation (LDIR).

Medical radiographers (MRs) work in radiology are exposed to long term and chronic LDIR that may affect their immune response due to occupation. In the Gaza Strip hospitals, there is ignorance and lack of monitoring of the immunity status of MRs who occupationally exposed to long term LDIR. Recently, several health complaints are recorded in the radiology departments of Gaza Strip, which may be attributed to exposure to LDIR. In addition, the daily overload in radiology departments and the insufficiency of MRs increase the possibility of high exposure. All the above mentioned risks and threats produce significant health problems for MRs. This research was conducted to investigate the effects of exposure to radiation on the immunity status of MRs at governmental hospitals of the Gaza Governorates (GG).

1.3 Justification

There is no research conducted before in Gaza Strip about the effects of IR on the immunity status of radiology works. Since workers of radiology especially medical radiographers exposed to radiation while dealing with many diagnostic imaging machines in their occupation, this may pose risks to them.

Additionally, immunity system is considered as one of the most important systems in the body and also it's highly sensitive to ionizing radiation. Medical radiographers are exposed to this radiation due to their work and we had to do this research to evaluate their immunity status.

Furthermore, since monitoring of personnel occupationally exposed to ionizing radiation consists of regular film badges (dosimetric) control and periodic health examination, in Gaza governmental hospitals there is no regular monitoring for ionizing radiation of medical radiographers and no periodic medical examinations for medical radiographers.

Moreover, there was a problems found in the radiation protection in some radiology departments and centers in Gaza hospitals. Also, there was a problem in applying the protective measures among radiographers which may causes risks to their health. In addition, some health complaints among medical radiographers during working were appeared. So it calls for research.

Finally, there was a national priority to conduct this research. Also, there is lack of research in this area and to determine effects of ionizing radiation on the radiology workers.

1.4 Aim of the study

The current study aimed to identify the effects of ionizing radiation on the immunity status of Medical Radiographers (MRs) at governmental hospitals- Gaza Governorates (GG).

1.5 Objectives of the study

1. To assess the health status of medical radiographers (MRs) as compared to medical laboratory technologists (MLTs) in governmental hospitals-Gaza Governorates.
2. To determine the clinical symptoms that appear during working in radiographic departments compared to medical laboratory departments.
3. To comparatively assess the health status of MRs according to different variables of the study such as years of experience, using protective measures, and weekly working hours.

1.6 Research questions

1. Are there any health complaints among MRs, compared to MLs, related to the immunity system deficiency?
2. Is there any clinical symptoms common among MRs compared to MLs?
3. Is there periodic monitoring system on radiation observed by MRs?
4. Is there a standard protective program performed in the radiology departments?
5. Is there any relationship between exposure to ionizing radiation and the appearance of the immunity system depression symptoms?

1.7 Context of study

The study was conducted in six main governmental hospitals of Gaza Governorates (GG). The hospitals are Al Shifa Medical complex, Nasser Medical Complex, European Gaza Hospital (EGH), Abu Yousef Al Najjar hospital, Kamal Edwan Martyr hospital, Al Aqsa Mrtyrs hospital. Therefore, the context of the study involves some information about the place of study which includes the selected main six governmental hospitals and radiological services in these hospitals. It also includes information about socio demographic, economic, political, environmental factors of GG, and the Palestinian health care system.

1.7.1 Socio-demographic context

Palestine has an important geographical and strategic location in Middle East. Palestine is surrounded by Lebanon, Syria, Egypt, and Mediterranean Sea. The total surface area of the historical Palestine is about 27.000 Km2 (PCBS, 2015). Palestine has been occupied in

1948 by Israel and the two remaining parts are separated geographically (West Bank (WB) and Gaza Strip (GS) after the war in 1967.

Gaza Strip is an elongated zone located on the southeastern coast of Palestine with coordination of Latitude N 31° 26' 25" and Longitude E 34° 23' 34". The area is bounded by the Mediterranean in the west, the 1948 cease-fire line in the north and east and by Egypt in the south and also Jordan from the East. The total area of the Gaza Strip was 365 km2 with approximately 40 km long and the width varies from 8 km in the north to 14 km in the south (UNEP, 2013).

1.7.2 Gaza Strip population

Gaza Strip is a highly crowded populated area, where approximately 1,853,000 people live in 365 km2, of them 49.33% males and 50.67% females. The estimated density is 4,000 people per square kilometer distributed across five governorates. Gaza Strip is divided into five governorates: North Gaza governorate, Gaza governorate which is the biggest governorate, Mid-Zone governorate, Khan Younis governorate and Rafah governorate.

The majority of people live in refugee camps (PCBS, 2015). This high population density in Gaza Strip increases the over load on the hospitals care which stress on the great need for proving the diagnostic radiology services in governmental hospitals-Gaza Strip.

1.8 Radiological services in governmental hospitals- Gaza Governorates (GG)

According to the Ministry of Health (MOH) records, (2014), there are ten governmental hospitals provided radiological services. Six hospitals out of ten hospitals are main hospitals in Gaza Strip which provide different radiological services. There are three big hospitals provided imaging facilities and have different imaging modalities which include

conventional X-ray, fluoroscopy unit, lithotripsy, Computed Tomography Scan, mammography, Panorama, and C-arm. Those hospitals are Al Shifa Medical complex, Nasser Medical Complex, and EGH. The other main governmental hospitals are Abu Yousef Al Najjar hospital, Kamal Edwan Martyr hospital, Al Aqsa Mrtyrs hospital which provided the basic imaging facilities including conventional and fluoroscopic imaging modalities.

The same records of hospitals directorate general reported that about 46837 radiological procedures were done in 2014; of them 438016 routine X-ray examinations, and 2276 fluoroscopy procedures, 26407 CT scan procedures, 1474 panorama procedures and 564 mammography examinations. This is a highly burden to the MRs and added to the workload and increasing the time working in the radiology departments (MOH, 2014).

Al Shifa Medical Complex is located in Gaza city, Gaza governorate. It includes three hospitals: the surgery hospital, internal medicine hospital and obstetrics and women hospital. The total clinical capacity is about 500 beds. Radio-diagnostic center in Al Shifa Medical Complex includes: six basic X-ray, one CT scan, two fluoroscopy, one mammography, one panorama, three portable C-Arm and some of portable X-ray machines. This center provides approximately 169969 medical imaging procedures per year. There are 50 MRs and 14 radiologists working in radiology.

Nasser Medical Complex is located in Khan Younis city, Khan Younis governorate. It contains two hospitals: Nasser and Mubarak hospitals. It is provides medical, surgery, radiological, children and obstetrics and women services. Total clinical capacity about 258 beds. Radiology department in Nasser Medical Complex includes: two basic X-ray, one CT scan, one mammography, one fluoroscopy, one panorama, one portable C-Arm and

some of portable X-ray machines. This center provides approximately 82241 medical imaging procedures per year. There are 27 MRs and 5 radiologists working in radiology.

The European Gaza hospital is located in Khan Younis city, Khan Younis governorate. It provides medical, surgical, pediatric and radiological services. The total clinical capacity is about 207 beds. Radio-diagnostic center in European Gaza hospital includes: two basic X-ray, one CT scan, one mammography, one fluoroscopy, one fluoroscopic lithotripsy, two portable C-Arm and some of portable X-ray machines. This center provides approximately 66980 medical imaging procedures per year. There are 26 MRs and 8 radiologists working in radiology.

Abu Yousef Al Najjar Martyr hospital is located in Rafah governorate, southern borders of Gaza Strip. It provides medical, surgical, pediatric and radiology services. The total clinical capacity is 40 beds. Radio-diagnostic center in Abu Yousef Al Najjar hospital includes: two basic X-ray, one fluoroscopy, one portable C-Arm and some of portable X-ray machines. This center provides approximately 43628 medical imaging procedures per year. There are 16 MRs and 3 radiologists working in radiology department.

Kamal Adwan Martyr hospital is located in Jabalya refugee camp, North Gaza governorate. It provides surgical, pediatrics, radiological and medical services. The total clinical capacity is about 73 beds. Radio-diagnostic center in Kamal Adwan Martyr hospital includes: two basic X-ray, one fluoroscopy machine, two Portable, C-Arm and some of portable X-ray machines. This center provides approximately 70733 medical imaging procedures per year. There are 16 MRs and 3radiologists working in radiology.

Al Aqsa Martyrs hospital is located in Dier El Balah city, Mid-Zone governorate. It provides medical, surgical, pediatric, and radiological and women obstetrics services, the clinical capacity is about 103 beds. Radio-diagnostic center in Al Aqsa Martyrs hospital includes: one basic X-ray, one fluoroscopy, two C-Arm and one portable X-ray machines. This center provides approximately 53967 medical imaging procedures per year. There are 16 MRs and 5 radiologists working in radiology.

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1.8 Layout of the study

This study consists of five main chapters includes: introduction, literature review, methodology, results and discussion, and finally the conclusion and recommendations. Started with chapter one which included general background about the current topic, the problem statement, objectives, and justification of the study.

In chapter two, the researcher has highlighted the conceptual framework of the study including the study variables and factors that may or may not affect the study outcome. After that, the researcher has reviewed the literature and related studies. This has included scientific data about topics related to the subject such as history of ionizing radiation, biological effects of ionizing radiation, immune system, immunoglobulin and complement levels and the design and facilities of the radiology departments, x ray rooms, precautions and control measures at radiology departments.

Chapter three of the methodology contains more detailed information and procedures about the methodologies underlining the present work. The chapter was evolved the material and methods needed to perform the current study including the study design, study population, sample and study settings, ethical considerations, study instruments and tools, data management and the statistical analysis and tests.

The bulk of data and the core of the work are presented in results and discussion section which aligned to chapter four. In this chapter the researcher presented and discussed his results and outcomes with respect to the available published previous studies. He mentioned these results as self-explanatory tables which make it easy for the readers to understand and comment on the results.

Conclusions and recommendations that harvested from the present work are mentioned in the last chapter, chapter five. All conclusions and recommendations are formulated upon the results of the present study with evidences from the current situation of the MRs and radiographic departments at the Gaza Strip.

Chapter (2) Literature Review

2.1 Introduction

Since research is rarely conducted in a vacuum, a researcher usually conducts thorough the literature review in order to familiarize himself/herself with the existing knowledge base (Polit and Beck, 2003). A literature review provides a background to one's research (Brettle and Gambling, 2003).

In this chapter, the study conceptual framework was presented, then a literature review that consists of two parts. The first part contains scientific data about main different topics such as ionizing radiation, types, its sources, and immunity system, and immunoglobulin. The second part includes the previous studies about the impact of ionizing radiation on the immunity system of MRs.

2.2 Conceptual framework

This study is a case control design performed to investigate the effects of IR on the immunity status of MRs who occupationally exposed to chronic LDIR during their work in radiology departments at governmental hospitals- Gaza Governorates in order to identify the effect of IR on their immunity status. Medical radiographers were compared with control group of medical laboratories technologists who don't work in radiology and have never been exposed to IR. The study tools are laboratory tests including total serum immunoglobulin (IgG, IgA) and a questionnaire. Figure (2.1) describes the conceptual framework.

Ionizing radiation

Ionizing radiation is a type of radiation that has enough energy to remove tightly bound electrons from the orbit of an atom, causing the atom to become charged or ionized (WHO, 2014).

Immunity System

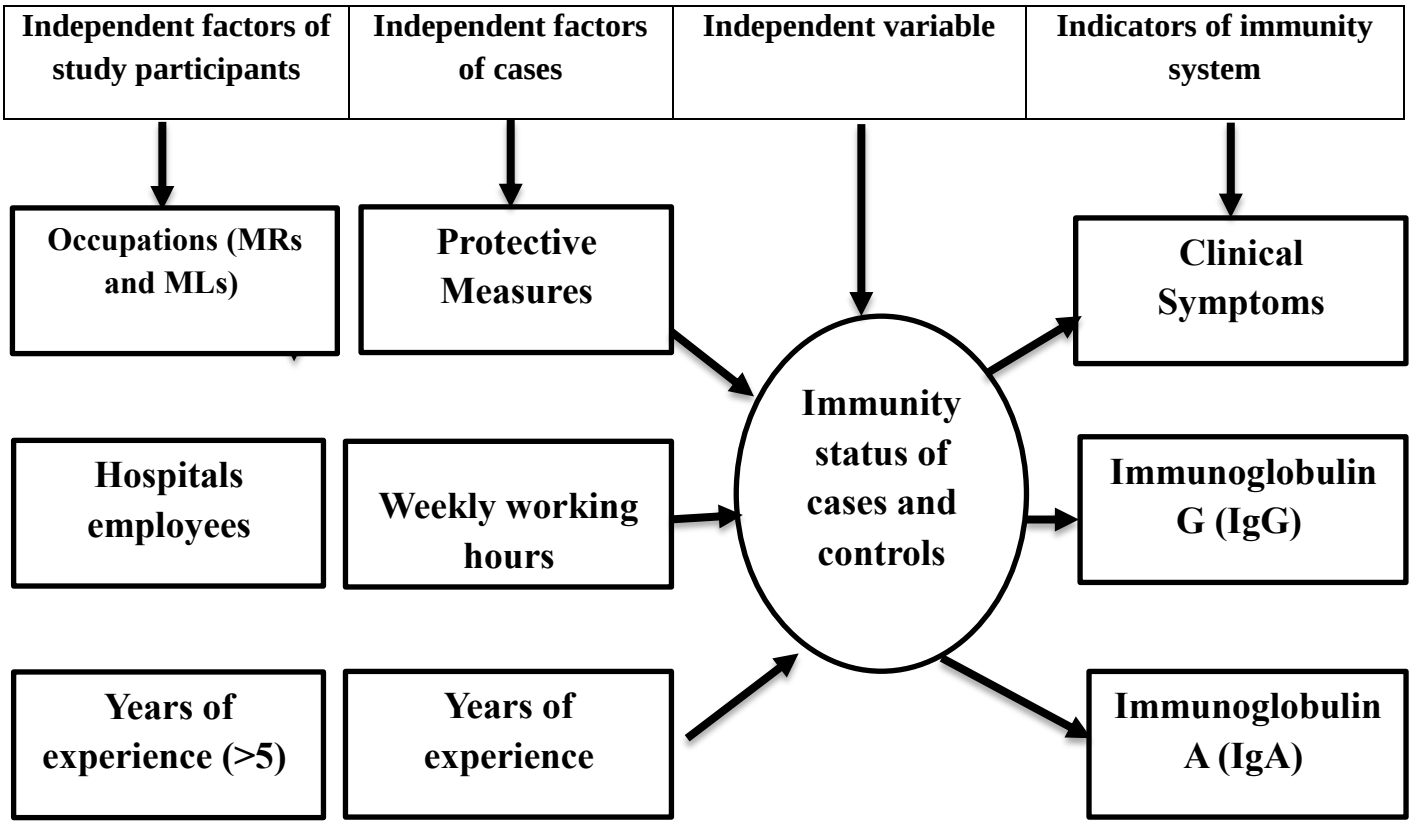
The immunity system is a complex system consists of cells, tissues and organs spread throughout the body and work together to protect against diseases such as cancer and infections caused by pathogens (UNSCEAR, 2006).

Medical Radiographer (MR)

The Medical Radiographer is a healthcare professional who works as part of a multidisciplinary health care team, having responsibility for the production of medical images to assist medical diagnosis and medical decision making. The procedures performed to achieve optimal outcome for the patient with minimal occupational risks for the MRs (James and Patrick, 2003).

Medical Laboratories (MLs)

A Medical Laboratories (ML) are a healthcare professionals who collect samples and perform different tests such as chemical, hematological, immunological, and microscopic to analyze body fluids), tissues, and other substances. MLs work in clinical laboratories at hospitals, private centers, and industrial labs (Wikipedia, 2015).



Matching factors are Age, Gender, Years of working experience, and Smoking Status

Conceptual framework

2.3 History of ionizing radiation

IR has always presented in the environment. Before the 1890s, there were only natural sources of radiation such as radiation from cosmic sources, and radioactive material inside the body and in rocks, soil, and air (NAS, 2006). In 1895, X-ray discovered by Roentgen, since that time, people began to be aware of the magical presence of the invisible rays that could use to see inside the body. This is followed by accidents and disasters related to IR such as the bombs on Hiroshima and Nagasaki in Japan at the end of the world war II, as well as the Chernobyl nuclear reactor accident, and all of these man-made have had adverse health effects on people (UNSCEAR, 2006).

Nowadays IR is used throughout a wide range of occupations such as industries, security purposes, as well as medicine. Medicine is considered as the single largest man-made contributor to ionizing radiation exposure (UNSCEAR, 1982). IR such as medical X-ray that used in radiology departments is being extensively used in diagnostic of many diseases and therapy of cancer patients. However, ionizing radiation has adverse effects on the health (Mehta, 2005).

2.4 Sources of ionizing radiation

2.4.1 Natural ionizing radiation sources

Ionizing radiation was presented naturally in the environment from cosmic and terrestrial sources. Cosmic radiation primarily consists of positively charged ions from protons to iron and larger nuclei derived sources outside our solar system (Feng and et al. 2002). The second source of natural IR is the terrestrial radiation "earth radiation" which includes radiation from the soil, rocks, and building materials such as radionuclides in granite, stones, sandstone, limestone, where its amount varies geographically (NAS, 2006).

Furthermore, radon gas is emanates from the ground. Radon and its isotopes, parent radionuclides, and decay products all contribute to an average inhaled dose (UNSCEAR, 2008). Finally, endogenous radiation which refers to the radiation produced within the human body, it comes from radioactive isotopes in food, water and from the human body itself, which makes each and every one of us a source of radiation (Bury, 2002).

2.4.2 Man-made ionizing radiation sources

Man-made radiation sources were discovered at the end of the nineteenth century. People are exposed to man- made radiation from different sources such as medical treatments and activities involving radioactive material (UNSCER, 2006).

The use of ionizing radiation in medicine both in diagnosis and therapy has been widespread since the discovery of X-rays by Wilhelm Conrad Roentgen in 1895, and radioactive sources have been used in radiotherapy since 1898. Advances in the latter half of the 20^{th} century increased the use of medical radiation, and some newer techniques, particularly radiotherapy, computed tomography, positron emission tomography, and interventional radiation involving fluoroscopy, use higher radiation doses than do standard diagnostic X-rays. Radiation therapy may involve use of external beams of radiation, typically high-energy X-rays 4 to 50 MeV and low-energy cobalt-60 gamma rays 1-2 MeV (UNSCEAR, 2006).

Moreover, IR is used in industrial processes. Industrial radiography uses gamma radiation to examine welded joints in structures. In the oil industry, gamma radiation or neutron sources are used to determine the geological structures in a bore hole (NCRP, 1989).

2.5 Types of radiation

2.5.1 Ionizing radiation

Ionizing radiation is radiation that has sufficient energy to remove electron from its orbit around the atom, thus causing ionization of the atom (CNSC, 2012). Ionizing radiation either in the energy such as x ray and gamma ray or in the form of particles such as alpha, beta particles or neutron, all have short wavelength and higher frequency (WHO, 2014).

2.5.1.1 Medical X-Ray

X-ray is a form of short wavelength electromagnetic radiation which will penetrate all organs of the body and are a significant external radiation hazard. The energy of the X-ray photons is an important factor in determining the magnitude of the external radiation hazard (Burnham, 2001). Most X-rays have a wavelength in the range of 0.01 to 10 nanometers, corresponding to frequencies in the range 30 petahertz to 30 exahertz (3×10^{16}Hz to 3×10^{19} Hz) and energies in the range 100 eV to 100 keV X-ray is emitted by electrons, they can be generated by an X-ray tube, a vacuum tube that uses a high voltage to accelerate the electrons released by a hot cathode to a high velocity. The high velocity electrons collide with a metal target, the anode, creating the X-rays (Whaites et al. 2002).

2.5.2 Non ionizing radiation

Non ionizing radiation is the term given to radiation in the part of the electromagnetic spectrum where there is insufficient energy to cause ionization. It includes electric and

magnetic fields, radio waves, microwaves, infrared, ultraviolet, and visible light. They have short frequency and long wavelength (WHO, 2014).

2.6 Health effects from exposure to ionizing radiation

The health effects of ionizing radiation (IR) are broadly classified as stochastic effects (cancer and heritable effects) and deterministic effects (tissue reactions). The stochastic effects (no threshold dose): are those in which the probability of the effect occurring does not depends on the amount of radiation dose, this type of effects increases as a radiation dose increases. So, there is no threshold dose for the stochastic effect. Stochastic effects can cause cancer, or have influence on gene-material affecting future generations (Prasad, 1995; NOHSC, 2002; ICRP, 2007; EPA, 2009).

The deterministic effects (threshold dose): are those effects resulting if the effect will only be clinically observable if the radiation dose is above some threshold. The magnitude of this threshold will depends on the dose rate (i.e. dose per unit time), linear energy transfer of the radiation, the organ or tissue irradiated, the volume of the irradiated part of the organ or tissue, and the clinical effect of interest. These effects occur because of large number of killed cells which cannot be compensated. The degree of damage (severity) increases the more the threshold value is exceeded (ICRP, 2007; EPA, 2009).

Moreover, IR has an adverse effect on the health and can cause many diseases. IR can destroy all living cells or make them functionally abnormal (Baker, Bromilow, and Costigan, 1990). Studies of populations with occupational radiation exposure are of relevance for radiation protection in that most workers have received protracted low-level exposures (a type of exposure of considerable importance for radiation protection of the

public and of workers). The study of Dickie (2004) in Australia revealed that 431 cases of cancer per year could be attributed to diagnostic x-ray. While in the United Kingdom there were 700 cases of cancer per year that could be attributed to diagnostic x-rays. Sigurdson et al. (2003) in their study, which was conducted in United State, revealed that medical radiographers (MRs) had an elevated risk for cancer as breast, melanoma and thyroid cancers. This may be attributed to their occupational radiation exposures.

Furthermore, the risk of cancer increases among MRs with long duration of work in radiation fields, so, it is important to keep monitoring the health status of the medical radiation workers (Bianca, 2005; Kleinerman, 2006; Jabeen et al. 2010). In addition, MRs are exposed to various hazards rather than cancer due to their occupational exposure; they are prone to develop immune system, thyroid and cardiovascular diseases (Zakora, 2001; Sigurdson et al. 2003; Duckie et al. 2004; Volzke et al. 2005; Meo et al. 2006; Linet et al. 2006).

Individual epidemiologic studies of occupational exposure to ionizing radiation, however, face a number of obstacles with respect to assessment of the dose-response relationship in the low-dose region (NRC, 2006).

Based on analysis of historical data and computer modeling, Filene and colleagues have estimated severity of biological response by measuring the absolute level of lymphocytes, granulocytes, and platelets in the absence and presence of infection or blood loss. Using the degree of hematopoietic response, one may develop an algorithm according to which patients may be triaged to observation in an ambulatory setting, observation on a hospital or admission to the medical intensive care unit (Fliedner et al. 2001).

2.7 Immunity system

The immunity system is made up of a network of cells, tissues and organs that work together to protect the body from infections and cancer (UNSCEAR, 2006). The immune system is a highly specialized structure, which consists of lymphoid organs, their cells, macrophages, blood cell (neutrophil, eosinophil and basophil, granulocytes), the complement system, interferon, lysozyme, and other factors. (Porovsky and Tetenev, 2002; UNSCEAR, 2006).

The immune system can be classified into subsystems, such as the innate immune system versus the adaptive or acquired immunity system, or humoral immunity versus cell-mediated immunity. The innate is always ready to fight the antigens before enter the body, which includes the physical barriers such as skin, chemicals in the blood, and immune system cells that attack foreign cells in the body. Acquired immunity on the other hand, refers to the specific immune response and it is more complex than innate system and is activated only after a pathogen has entered the organism. Acquired immunity consists of B and T lymphocytes (Beck and Habichi, 1996; UNSCEAR, 2006).

For protection of the organism, the immunity system is a leader in parallel with the nervous and endocrine systems manifesting the immediate response to any external influence, including ionizing radiation. Destroying cells with a foreign or changed genome at this cascade of pathological reactions, the immune system maintains the integrity and genetic homogeneity of the organism at that actively participating in all pathological and reparative processes happening in the organism. Nevertheless, the immune system often takes direct part in the genesis and the maintenance of a pathological condition (allergic and autoimmune diseases, immunodeficiency) (Alvarez et al. 1999; Demaria et al. 2005; Brush et al. 2007).

Furthermore, some parts of the body are more sensitive to radiation-induced damage than others. Radiation damage to the cells of the body depends on how sensitive the cells are to ionizing radiation. Generally, the most sensitive cells are those that divide rapidly or those that are in the process of dividing. These cells are most vulnerable to IR because it is difficult or impossible for them to repair any damage that may occur during cell division. Immunity system is considered as highly radiosensitive; therefore it's susceptible to IR (UNSCEAR, 2012).

2.7.1 Humoral immunity

Humoral immunity consists of different components such as antibodies (immunoglobulin) (Ig), B cells, and the complement system. The antibodies or immunoglobulins are the major components of humoral immunity. Also, the immunity system produced five main immunoglobulins (IgA, IgD, IgG, IgE, and IgM) (UNSCEAR, 2006).

2.7.1.1 The immunoglobulin (Ig) serum

The immunoglobulin (Ig) or antibodies are proteins made by the immune system to fight antigens. It is created by the B cell receptors (BCR) found in B cells. Immunoglobulins are usually Y-shaped and consist of two light chains and two heavy chains. The type of heavy chains determines the immunoglobulin iso-type (IgA, IgD, IgG, IgE, and IgM, respectively) (Goldsby, Kindt, and Osbonrne, 2000). IgG has the high percentage (76%) of antibodies in the blood stream, followed by IgA, (15%) and IgM (8%). Immunoglobulin test measures the level of immunoglobulin or antibodies in the blood. IgA, IgG, and IgM

tested together and can give doctors important information about the function of the immune system especially relating to infection or autoimmune.

In addition, serum immunoglobulin levels are determined routinely in clinical practice because they provide key information on the humoral immune status. Low immunoglobulin (Ig) levels define some humoral immunodeficiencies (Buckley, 1986). In contrast, high immunoglobulin levels (polyclonal gammopathy) are observed in liver diseases, chronic inflammatory diseases, hematological disorders, infections and malignancies (Dispenzieri, Gertz, and Therneau, 2001). Moreover, immunoglobulin levels aid in the diagnosis of some disorders, particularly liver diseases (Alvarez, 1999).

Immunoglobulin G (IgG)

Immunoglobulin G (IgG) is a protein and type of antibody. It consists of four peptide chains- two heanvy chains and two light chains arranged in the a Y-shaped. IgG is the predominant serum form, representing approximately 76% of serum antibodies in humans (UNSCEAR, 2006). In addition, IgG is the most common type of antibody found in the blood. By binding many kinds of pathogens such as viruses and bacteria, IgG protects the body from infections. The measurement of IgG can be a diagnostic tool for certain conditions. It has a normal range from 700 mg/dl to 1600 mg/dl. In addition, low IgG is an indication for immunosuppression, while high IgG is related to certain inflammatory conditions (carniero, 2003; Racine et al. 2011).

Immunoglobulin A (IgA)

IgA is a type of antibody that plays a critical role in mucosal immunity. IgA accounts up to 15% of the total immunoglobulin produced in the entire body (Fagarasan and Honjo, 2003). It is the main immunoglobulin that found in mucous secretions, including tears, saliva, sweat, and secretion from genitourinary tract, gastrointestinal tract, prostate and respiratory epithelium (Carniero, 2003). Decrease or absent of IgA occurs in clinically significant immunodeficiency. It has a normal range from 70 mg/dl to 400 mg/dl.

Immunoglobulin M (IgM)

Immunoglobulin M, or IgM for short, is a basic antibody that is produced by B cells. IgM is by far the physically largest antibody in the human circulatory system. It is the first antibody to appear in response to initial exposure to an antigen. The spleen, where plasmablasts responsible for antibody production reside, is the major site of specific IgM production. It has concentration in the blood stream from 5-8 % (Racine, McLaughlin, and Jones, 2011)

Immunoglobulin E (IgE),

IgE is associated mainly with allergic reactions (when the immune system overreacts to environmental antigens such as pollen or pet dander). It is found in the lungs, skin, and mucous membranes. It has a concentration about 0.15 % of total antibodies (Racine, McLaughlin, and Jones, 2011).

Immunoglobulin D (IgD),

IgD is exists in small amounts in the blood, is the least understood antibody (Racine, McLaughlin, and Jones, 2011).

2.8 The effects of ionizing radiation on the immunity system

It has long been known that high dose ionizing radiation (IR) can damage the immune system. However, some recent studies have shown that low levels can stimulate it, at least for short periods (UNSCEAR, 2009). The cells of immunity system are known to be the most sensitive to ionizing radiation in the body. This may explain the vulnerability of the immune system to exposure to ionizing radiation (Hrycek and Stieber, 1994). Therefore, IR can induce alterations of the immune response, including immunosuppression (depression) or immunostimulation (Hrycek and Stieber, 1994; UNSCEAR, 2006). Immunosuppression induced by radiation leads to the development of immune deficiency syndrome - infectious, allergic, autoimmune processes and related chronic diseases (Beck and Habicht, 1996; UNSCEAR, 2006).

Regarding the effects of radiation on the humoral immunity, a study conducted in Iran by Ghiassi el al. (2004) on the Ramsar residents found that total serum immunoglobulin IgG, IgA, IgM were not different, whereas a significant increase in IgE levels was observed in Ramsar residents exposed to high doses of radiation. The authors interpreted this results as radiation induced immunostimulations due to a shift from a T-helper 1 (Th1) to Th2 response. While no differences were found in the expression of CD69 (Cluster differentiation) (a marker of lymphocyte activation) in unstimulated CD4+ helper T- cells of Ramsar residence, a finding that the auther considered as an indication of a higher risk of proto-oncodgene activation.

Additionally, regarding human data about the effects of exposure to low doses of radiation (LDIR), some authors have reported evidence for effects after chronic LDIR irradiation; others have not found such evidence. In the same way, when the impact on the immune system of living in areas with high levels of natural radiation was analyzed, the results were controversial, and the significance of these findings remains unclear.

Moreover, immune cells are known to be vulnerable to radiation, through induced apoptosis (programmed cell death) in mature T and B lymphocytes (long-lived white blood cells responsible for adaptive immunity) and by lethal damage in bone marrow stem cell precursors of monocytes and granulocytes (short-lived white blood cells responsible for innate immunity) as well as natural killer cells (lymphocytes responsible for innate immunity) (Kusunoki et al. 2010).

All the above mentioned immune system findings results from experimental studies and large scale epidemiological assessments of survivors of the bombing of Hiroshima and Nagasaki by nuclear weapons, residents of areas in Russia and the USA contaminated by nuclear weapons production, and Chernobyl accidents. In addition, its health consequences with regard to ionizing radiation have been well studied.

Although few data are available on the effects of low dose exposure on human, some reports suggest that chronic low dose radiation exposure can lead to effects on human immune system. Chang et al. analyzed the immune status in residents of buildings constructed using cobalt 60-contaminated steel rods. They evaluated clustered differentiation (CD) CD3+CD4+CD8 markers in lymphocyte subsets in 196 exposed participants with mean cumulative excess dose of 196 milli Sievert (mSv). These results compared with those obtained in 55 close relatives considered to be the non-exposed reference population. They analysis was restricted to individuals with no apparent history

of medical conditions that could compromise their immune profile. The mean percentages of CD4+ T-lymphocytes and CD8+ cell counts in the exposed group were moderately increased compared with the reference population. In addition, changes in the percentages of CD4+ were significantly associated with radiation dose. Low CD4+/CD8+ ratios are observed in primary and secondary immune deficiencies, and this ratio has been proposed as a method for estimation of the cellular immune status (Hernberg, 1999). The results presented by Chang et al. suggest that protracted gamma radiation exposure in a residential environment may induce a dose dependent decrease of cellular immunity. However, these findings should be interpreted cautiously, taking into account the wide range of cumulative doses and their protraction among the exposed subjects. A new analysis of these results separating subgroups of people with narrow dose range could allow higher quality conclusions to be drawn.

Tuschl et al. (1990) conducted a study on employees working at the research reactor of the Austrian Research Center, exposed during the preceding 3 month to very low doses of gamma radiation. The percentages of CD2+ and CD4+ and natural killer cells were investigated in peripheral blood lymphocytes. Except for a slight increase in the relative number of cells expressing CD2, radiation association changes were not observed.

UNSCEAR, (2009) and Kusunoki et al. (2010) reported increase in autoimmune diseases among Chernobyl workers and residents which were not found among atomic bombing survivors or among the US group studied. It has also been suggested that effects on the immune system may help to explain an association between diseases other than cancer and radiation exposure, recently found among atomic bombing survivors. Takeuchi, Shibata, and Nasu (1992) and Takeuchi, Shibata, (1997) suggested that the X-rays had a destructive

effect on immune cells with functional impairment. In addition, antibody production and mitogenic activity were also sensitive to X-ray irradiation.

Titov et al. (1995) investigated the production of immunoglobulins in children living around the Chernobyl nuclear power plant (NPP). They found a decrease in B-cell numbers, a transient decrease of IgM and IgG and an increase of IgA levels (in both serum and saliva) during the first months following the accident. Over a six year period of living in contaminated areas, children exhibited increasing production of IgG and IgM. A correlation was found between the changes in B-cells of immunity and the levels of 137Cs (Cesium 137) contamination. There was also a strong correlation between the production of natural (heterophilic) antibodies and dose to the thyroid due to incorporation of 131I (in the range 0.1–1 Gy). Higher accumulation of 131I (Iodine) resulted in decreased titres of these antibodies. High levels of heterophilic antibodies correlated with high levels of IgE (Immunoglobulin E). Altered production of subclasses of IgG associated with the increasing biosynthesis of IgE suggests that T-cells may have been driven towards the T-helper 2 (Th2) profile. However, trying to find a causal association between radiation exposure and these changes in Th2 profile would be speculative, because no data about confounding factors such as parasite infections in these children were taken into account.

Reitan et al. (1998) evaluated the immunological parameters which were registered in selected Norwegian individuals assumed to be exposed above average to fallout radionuclides from the Chernobyl accident. The doses from internal contamination with Cs134 and Cs137 were assessed by whole body counting, and ranged from about 0.01 to 10 mSv/ year. The immunological parameters stayed in general within normal limits, but showed nevertheless some correlation to dose. The significance of this finding is discussed,

but it is concluded that the Chernobyl accident did not influence the immune system in the population in a serious manner.

Bonggoo et al. (2013) conducted a study on effect of radiation on the immune response to cancers. In cancer patients undergoing radiation therapy, the beneficial effects of radiation can extend beyond direct cytotoxicity to tumor cells. Delivery of localized radiation to tumors often leads to systemic responses at distant sites, a phenomenon known as the abscopal effect which has been attributed to the induction and enhancement of the endogenous anti-tumor innate and adaptive immune response. The mechanisms surrounding the abscopal effect are diverse and include trafficking of lymphocytes into the tumor microenvironment, enhanced tumor recognition and killing via up-regulation of tumor antigens and antigen presenting machinery and, induction of positive immunomodulatory pathways. Here, we discuss potential mechanisms of radiation induced enhancement of the anti-tumor response through its effect on the host immune system and explore potential combinational immune-based strategies such as adoptive cellular therapy using ex vivo expanded natural killer (NK) and T cells as a means of delivering a potent effector population in the context of radiation-enhanced anti-tumor immune environment.

Vykhovanets el al. (2000) conducted a cross sectional survey on children living around Chernobyl to determine the effects of exposure to radiation on peripheral blood lymphocytes. Two hundred nineteen healthy children and children suffering from recurrent respiratory diseases aged 6-14 years who received both low doses of radiation to the whole body from Cesium (137)Cs and various doses of radiation to the thyroid from (131)I as fallout from the accident were assessed 5 (1991) and 8-10 years (1994-1996) after the accident. A total of 148 healthy children and children suffering from recurrent respiratory diseases living in non-contaminated areas were also evaluated as controls. Children with

recurrent respiratory diseases who lived around Chernobyl had a significantly lower percentage of T cells and a higher percentage of natural killer (NK) cells compared to control children with recurrent respiratory diseases during the study period. In contrast to the findings in 1991, a significant decrease in the percentage of helper-inducer cells was observed in children with recurrent respiratory diseases in 1994-1996. In contrast to 1991, there is a positive correlation between the percentage of helper-inducer cells, the helper-inducer/cytotoxic-suppressor cell ratio, and the dose of radiation to the thyroid of healthy children from (131) I in 1994-1996. There was a positive correlation between the doses of radiation to the thyroid from (131) I and the percentage of helper-inducer cells in children with recurrent respiratory diseases 5 years (1991) after the accident. Furthermore, the dose of radiation to the thyroid from (131)I correlated negatively with the percentage of T and B cells and positively with the percentage of NK cells in children with recurrent respiratory diseases 8-10 years (1994-1996) after the accident. These results raise the possibility that long-term exposure to low doses of (137) Cs may have altered the composition of the T-cell subsets and NK cells in children with recurrent respiratory diseases. The differences in the composition of the peripheral blood lymphocyte subsets between healthy children and those with recurrent respiratory diseases may be attributed to long-term low-dose exposure of the whole body to radiation from (137)Cs and exposure of the thyroid to radiation from (131)I subsequent to the Chernobyl accident.

There are limited numbers of studies investigating the effects of long term and chronic low-doses ionizing radiation exposure on the immune status of radiology workers; nonetheless, available studies do not reflect all components of the immune system.

Hrycek et al. (2002) examined the blood lymphocytes and serum interleukins (IL) in X-ray workers. The study consisted of 30 workers in x-ray and 18 persons as control group.

Subgroups with respect to gender and years of employment were selected. The study findings revealed significant increase in IL-2 levels in workers as compared to control group. Positive correlation between the number of lymphocytes and the concentration of IL-2 and the level of IL-4 was reported. The study found that the number of lymphocytes and interleukins concentrations don't depend on the employment period of radiology workers.

Serhatlioglu et al. (2004) a case control study conducted in Turkey on 51 persons working in radiology. The subjects aged between 21-57 years, grouped related to their sex and smoking status. The control group consists of 40 healthy non-smokers and had never been exposed to radiation. Venous blood sample were obtained from both subjects and control group and immunological analysis were performed. The results demonstrated that radiology staff occupationally exposed to ionizing radiation had lower levels of total serum immunoglobulin (IgG, IgA, IgM) than the control group with statistical significant level.

Godekmerdan et al. (2004): "diminished cellular and humoral immunity in workers occupationally exposed to low levels of ionizing radiation". A study conducted in Iran consisted of 50 workers in radiology compared with 35 matched control group by age. The study results revealed no statistically significant differences in groups in terms of other subgroups of lymphocytes ($p > 0.05$). In addition, levels of serum total IgG, IgA, IgM, C3, and C4 were determined as significantly lower in workers exposed to ionizing radiation compared with controls ($p < 0.001$). Serum IgA and IgM levels in radiology workers who were smokers were determined as lower compared with non-smoking radiology workers with statistically significant differences ($p < 0.05$).

Rees et al. (2004) found no significant changes in the immune profiles of 325 male workers occupationally exposed to external low-dose radiation at the British Nuclear Fuels

facility at Sellafield, United Kingdom. The cumulative exposure was higher than 200 mSv in a period from 19.1 to 45.7 years in one group and less than 27.5 mSv in a period of from 15.1 to 32.5 years in the other. No significant differences in circulating T- and B-cell total counts, Clustered Differentiation (CD) CD4+ and CD8+ T- cell subsets. This study took account of possible confounding factors such as age, sex, and cigarette smoking, and the sample size was sufficient to substantiate the conclusion that occupational exposure to low doses not affects the immune profile of workers.

Moghaddam et al. (2004), in their study, which was conducted in Iran, reported that some population of B lymphocytes increased in radiology workers compared to controls group. The study results showed no statistically significant difference in total immunoglobulin (IgG, IgA, IgM) and complement (c3, c4) levels between the exposed and non- exposed group ($p=0.13$). The study demonstrated that ionizing radiation received by radiographers does not affect the immune status of radiology workers.

Klucinski et al. (2005) assessed the blood serum immunoglobulin and C-reactive protein concentrations in workers of x-ray units. A case control study was conducted and consisted of 41 x-ray workers and the control group of 32 persons, immunoglobulin's (IgM, IgG, IgA) and C-reactive protein (CRP) concentrations were analyzed. The study group was subdivided by gender and smoking habit. The results reported a significant decrease in IgG level in the workers and the female subgroup. The same observation was made when smokers and nonsmokers of both groups were compared. Smoking workers showed lower concentrations of IgA than non-smokers. The remaining results of immunoglobulin and CRP concentrations did not show significant differences. The researcher concluded that occupational exposure to low levels of ionizing radiation is associated with suppressive

influence on the immunoglobulin production, especially IgG. In addition, smoking decreases the production of IgA in subjects of radiology.

Prabhakara and Lakshman, (2005) conducted a study in India related the risk on radiographers in the workplace in Vzag Steel hospital. The study aimed to assess the health risks from ionizing radiation they chronically exposed. The study consisted of nine (male) radiographers aged from 35 to 45 years were matched by control group of 24 persons matched by age and sex. The study tool was a questionnaire containing item about symptoms appeared during working hours. All participants were non-smokers. The results revealed that radiographers were highly suffered from symptoms like headache and tiredness during working day compared with the control group. The study reported that symptoms like headache and skin irritation were persistent in two radiographers during and off work. A visual observation revealed that all radiographers were using the protective measure and film badges during working hours.

Daoud and et al. (2008), studied the hematological and immunological concentrations of Customs Clearance Workers (CCW) in Alexandria Port as they exposed to low doses of ionizing radiation while using various electronic and imaging machines for security purposes. The study was comparative cross sectional; includes 40 male Customs Clearance Workers (CCWs), and the comparative population included 40 male workers who were never exposed to any type of ionizing radiation. A questionnaire besides both CBC and total serum immunoglobulin (IgG, IgM, IgA) are investigated for both groups. The results of the study revealed higher prevalence of general manifestations such as pallor, fever, and repeated infections among CCWs compared to unexposed group. Neurological manifestations such as headache and fatigue were prevailing in exposed group of CCWs. About the CBC test, it shows that mean total leucocyte count was significantly decreased

in among CCWs compared to unexposed group. However, the mean values of both RBCs and platelets counts were not significantly lowered among CCWs. Finally, regarding the immunoglobulin levels, the study found no significant differences between CCWs and control group regarding their IgG, IgM, and IgA concentrations

Zakeri et al. (2010) examined the effects of low-dose X-ray radiation exposure on chromosomal damage and on selected indices of cellular and humoral immunity in interventional cardiologists (ICs). They Found that the frequencies of aberrant cells, chromosome breaks and dicentrics plus centric rings were significantly higher in the exposed group compared to the control group clinical physicians (P=0.05; P=0.01; P= 0.001, respectively), without positive correlation between the frequency of dicentric and centric ring aberrations and the cumulative doses of the ICs (P= 0.24). A significant increase was observed in the expression of activation marker CD69 on TCD41 stimulated cells in serum immunoglobulin G and interleukin (IL)-2 (P<0.05) and a significant decrease in serum IL-10(P< 0.05) in the ICs compared with that of the control group. There was no statistical difference between the two groups in terms of number of white blood cells and lymphocytes, CD31, CD41and CD81 T cells, CD191 and CD161 561 cells and concentrations of interferon (IFN)-g, IL-4, IL-6 and IL-8 cytokines.

Sahel et al. (2012) investigated the effects of Ionizing Radiation on some blood parameters in 49 radiation workers of Kermanshah hospitals (cases) and 49 persons as control group who have never exposed to long term radiation but were matched with the cases regarding intervening variables were assessed. The data was analyzed using SPSS version 20 and statistical tests such as Student's t-test. Results showed, no statistically significant differences in lymphocytes count between workers of radiology and group of controls (p>0.05). However, total serum immunoglobulin G and M was found lower in radiology

workers compared to the control group ($p<0.05$). IgA was higher among radiology with no statistical significant compared to controls.

Oskouii et al. (2013) conducted a study on the humoral immunity of 45 radiology staff occupationally exposed to low levels of ionizing radiation and compared to 35 subjects as control group. Findings reported that IgA, IgM, c3, c4 levels were as significantly lower in the radiology workers exposed to ionizing radiation compared to the controls ($p<0.05$). A significant difference was showed in IgA, IgM levels and age in radiology workers ($p<0.05$). A statistical significant difference between IgA, IgM and C3 and working period was found in this study.

Saleh et al. (2013) investigated the immunological effects of ionizing radiation on 20 health care workers of nuclear medicine unit and the same number of matched controls from the administrative staff. Socio demographic and medical history was collected by semi structured questionnaire, after that CBC and lymphocytes subsets was done to all participants. The results showed that radiology workers showed more bleeding tendency ($P= 0.04$) and more repeated infections ($P=0.02$) than controls. Also, mean lymphocytes count was lower in exposed group than control ($P=0.03$), while the other blood parameters were not statistically significant, also mean CD4 of exposed was lower than control ($P=0.01$). In contrast to mean CD8, there was statistically significant difference between the two groups regarding CD56 ($P=0.01$) and CD4/ CD8 Ratio ($P=0.033$).

Mohammed et al. (2013) conducted a case control study to determine effects of radiation on hematological parameters in X-ray technicians. Results showed significantly higher percentages of lymphocytes in X-ray technicians than the control group (7.5% vs. 2.7%, $p=0.01$). However, no statistically significant difference was observed in RBCs and WBCs

or platelets between the groups. Also, they found positive correlation between atypical lymphocytes percentage in the exposed group and duration of exposure to radiation in years (p=0.005).

Klucinski et al. (2014) assessed the possible effects of ionizing radiation on B cells of x ray workers. The study group consisted of 47 x ray workers and the control group consists of 38 persons. The study group divided into 2 groups by the length of employment below and over 15 years and analysis adjusted for age and smoking habit was performed. The results reported significant increase in the total number of CD19 in the group of workers in comparison with controls. Also, the study showed a decrease in other B cells populations among the x ray workers. The increase in the total of CD19 + cells along with the associated decrease in some B cells populations such as CD5+CD19 cells percentage in the study group may suggest B cells dysfunction in the immune response. It should be emphasized that exposure to low level of IR associated with significantly lower concentrations of IgG, IgA, and IgM immunoglobulin and radiology units are possible sources of microbial cross transmission (Godekmerdan et al, 2004; Klucinski et al, 2005; Drop et al, 2009).

Shahid and et al. (2014) investigated the effects on hematological parameters of workers exposed to ionizing radiation. The study covered 92 persons working in different radiology departments (diagnostic and therapeutic) compared with 52 persons as control group. The results exhibited lower ranges of the lymphocytes among radiology workers compared to control group and the differences was statistically significant. Neutrophils also was decreased and statistically significant and p-value below 0.05. The researcher found that these associations were weak but reached the statistically significant level.

Rybkina et al. (2014): "Expression of blood serum proteins and lymphocytes differentiation clusters after chronic occupational exposure to ionizing radiation". The study conducted to investigate the effects of ionizing radiation on the immunity status of Mayak workers occupationally exposed to chronic gamma rays. The study consisted of 77 workers occupationally exposed to radiation. The control group included 43 participants matched age and sex and never exposed to ionizing radiation. The results reported decreased levels of immunoglobulin G, T-lymphocytes, and interleukin-8 among workers exposed to ionizing radiation compared to the others in the control group. Also, IgG, IgM, matrix proteinase-9, and concentrations of natural killers were all found higher in workers of radiation than the control group. Absolute T-lymphocytes concentrations were not statistically significant different n workers with chronic exposure as compared to controls. Relative concentrations of T-helper were also not statistically significant different between workers of radiation and controls. For the cytokines, there were a statistically significant difference of IL-8 concentration ($P<0.05$) of Mayak workers as compared to control groups. Finally, the alterations in T and B components of immunity system in cytokine status revealed in this study sustain chronic inflammation and partially contribute to cardiovascular, malignant and other diseases (Kusunoki, 2010). The study on changes in expression of the immune system proteins allows a better understanding of the mechanisms of late radiation effects.

Chapter (3) Methodology

3.1 Study Design

A case control study aimed to investigate the effects of ionizing radiation on the immunity system of Medical Radiographers (MRs) working in the main governmental hospitals of Gaza Governorates (GG) compared with matched control group of Medical Laboratory Technologists (MLTs).

3.2 Study Population

The target population was all Medical Radiographers who work in main governmental hospitals- Gaza Governorates and meet the inclusion criteria**,** compared with Medical Laboratory Technologists as control group (MRs=92, MLs, 97).

3.4 Study settings

The study was conducted in the six main governmental hospitals-Gaza governorates; Al Shifa Medical complex, Nasser Medical Complex, European Gaza Hospital (EGH), Abu Yousef Al Najjar hospital, Kamal Edwan Martyr hospital, Al Aqsa Mrtyrs hospital.

3.2.1 Eligibility criteria for cases

3.2.1.1 Inclusion criteria

Any MR who is working at radiology departments of governmental hospitals of the GG with 5 years' experience and more, and does not suffer from previous health problems was included.

3.2.1.2 Exclusion criteria

Any MR who is working at radiology departments of governmental hospitals at GG have been excluded if he has less than 5 years working experience. Also, participants with Health diseases such as diabetes mellitus, gross anemia, hepatitis, malignancies, and auto immune disease are excluded from this study.

3.3 Eligibility criteria for controls

3.3.1 Inclusion criteria

Any medical laboratory technician who is working at laboratory departments of governmental hospitals of the GG with 5 years' experience and more, and does not suffer from chronic health problems was included.

3.3.2 Exclusion criteria

Any medical laboratory technician working at the laboratory departments of governmental hospitals of Gaza Strip was excluded if he has less than 5 years of working experience, pregnant or suffers from any chronic health problems.

To study the relationship between independent and dependent variables, the controls were matched to cases on four different variables (age, gender, smoking status, and years of experience).

3.4 Census sample

The sample of this study was 189 participants (92 MRs and 97 MLs). Because the population of the current study was small we applied census sample.

3.5 Study tools

The researcher used two tools in this research. A questionnaire together with complete blood count (CBC) and determination of serum immunoglobulin (IgG, IgA) levels were the main tools of this study.

3.6 Case Definition

Medical radiographers (MRs) working in radiology departments at governmental hospitals which exposed to chronic low doses of ionizing radiation due to occupation.

3.7 Control Definition

Medical laboratories (MLs) working in laboratory departments at governmental hospitals- and have never exposed to chronic ionizing radiation.

3.6 Data collection and processing

Data collection of this study was consisted of two stages; the first stage is collecting the questionnaire data from the study participants in all hospitals. After three weeks of collecting the questionnaire the researcher collecting the blood samples from the study participants who agreed for blood collection in the second stage.

3.6.1 Blood collection and analysis

The collection of blood samples from study participants done by the researcher and some of qualified and professional persons in laboratory. The analysis of the blood samples was carried out using full computerized systems made by diagnostic systems (diaSys) that considered the best systems in analyses because of its high sensitivity and accuracy and easily calibrated. Because no reagent material available in the MOH lab centers, the blood analysis applied in Bakeer private lab center in Rafah. The cost of the analysis was carried on the personal researcher budget.

3.6.1.1 Complete Blood Count

Complete blood count was determined for all subjects who agreed to provide venous blood sample. Venous blood samples were collected by qualified lab technicians. It collected in k3-EDTA tubes and transported in ice box. The analysis of the CBC parameters was carried out using ABX Micros 60, made in France. Calibration was done before used.

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3.6.1.2 Serum immunoglobulin

Venous blood samples were collected from all agreed subjects to determine the total serum immunoglobulin (IgG, IgA). The blood samples collected in plain tubes and transported in ice box. Serum was carried out using immunoturbidimetry methods (Turbi Timer) using Response 910 analyzer made by DiaSys Company, Germany and applying reagent obtained from the same company.

3.6.1.3 Steps of blood samples collection and lab analysis

1- The collection of sample from participants was done from 7 to 9 o'clock in the morning before breakfast. Five milliliters of venous blood samples were obtained from each subject from both cases and controls who agreed for the blood test. 3 out of 5 milliliters of blood sample were put in plain tube to determine the IgG and IgA. The other 2 milliliters put in k3-EDTA tubes for CBC.

2- The researcher had written the serial number of the case and control on the blood tubes. The blood samples put on ice box and then sent to the lab.

3- Blood samples of IgG and IgA were put in centrifuge to get the serum. The blood samples centrifugation at 5,000 rounds per minute (rpm) for 10 minutes to obtain the serum.

4- The serum for each sample put in special tube and then put in the analyzer.

5- The analyzer used for analysis is response 910 from DiaSys company-Germany. This system is full computerized and makes sure the room temperature. It consumes 1 liter of water per hour.

6- Serum analyzed by immuneturbidimetry technique within the system.

7- Calibration and controls were done for the immunoglobulin kit before use.

8- The data such as name and ID are entered on computer and then choose the required blood test.

9- The time for analysis in response 910 is 12 minutes for each test.

10- The analyzer repeats the results of the test one more time in case of abnormal results in order to make sure and to get accurate results.

3.6.2 Questionnaire collection

The researcher himself was collected the data from every participant in this study. A meeting interview was used for filling in a questionnaire which designated for matching the study need. All interviews were conducted face to face by the researcher himself. The researcher started the interview by identifying himself to the participants, and then he explained the title and main objectives of the study. Before filling in the questionnaire the researcher orally asked the participants about the conditions to participate in the study and meet the eligibility criteria. All participants were consented orally to participate in the study. Also, the researcher explained verbally that the participation is voluntary and the information obtained will be used only for scientific research. During the survey the researcher explains and clarifies any of the questions that were not clear. The interview was taken from 5-10 minutes to fill in the questionnaire.

3.7 Validity and Reliability

The questionnaire was validated by eight experts in the fields of radiology, immunology, public heath, microbiology, nutrition, and radiation physics to ensure that the content is highly valid and reliable. The researcher tested the questionnaire on the SPSS and applied the cronbach alpha (0.831). (Annex, 7).

3.8 Pilot Study

Ten participants (five exposed and five non-exposed) worked in European Gaza Hospital (EGH) were the researcher was working were assigned for the piloting stage of the current study. The ten participants were included in the study sample because the entire population of cases is relatively small. The participant in the pilot has 5 years and more in employment and don't have had chronic diseases. They were asked freely to answer the questionnaire. Ethically, venous blood sampling is neither recommended nor appreciated for piloting purposes. A pilot study was conducted to assess the validity of the questionnaire. Therefore, a pilot study is a pre-test of the tool and the results of it let the researcher to modify, add, delete and rephrase on the tool. Also, it examined clarity, ambiguity, length and suitability of questions before the beginning of data collection (Polit, 2004).

3.9 Data management and statistical analysis

The researcher was used the SPSS version 20 in analysis data. The data from questionnaire, CBC and Serum Immunoglobulin (IgG, IgA) quantitation was collected, entered, data cleaning, summarized, tabulated, encoded and statistically analyzed using the Statistical Package program for the Social Sciences (SPSS) version 20. In addition, the measurements and tests (chi square test, independent sample t-test) were performed aiming at the description, identification of the significant relationship, correlation and differences between the MRs and MLs of the present variables and parameters.

3.10 Ethical and administration considerations

An ethical approval was obtained from Helsinki Committee (Annex, 3)

An administration approval was taken from the ministry of health (MOH) to facilitate sample and data collection (Annex, 2).

An approval obtained from each participant to participate in the study. A verbal consent informs was explained from the researcher himself to each participant.

3.11 Period of study

The study started from May 2015, after approval of the proposal, and completed with the help of God and then everyone in November 2015. Annex (7) describes the activities of the research and expected duration for each activity.

3.12 Limitations of the study

1. The siege on Gaza: there was no reagent for the immunological blood tests available in the MOH. So, the blood tests carried out in a private center and this is took more time, huge efforts and cost a lot of money.
2. The time factor: because the blood reagent not available in MOH the researcher take a lot of time to find out a valid place to apply the blood tests.
3. The researcher took a lot time to find the best laboratory and best method and technique in doing the immunity blood tests (Immunoglobulin). Also, there is a few laboratory centers doing the immunoglobulin tests and also it’s not doing in the routine work like other blood tests such as CBC.

4. The researcher was collected the data on two steps, the first one collected the questionnaire and then goes back another time after 3 weeks to collect the blood samples. This because no reagent and the delay to find the place. The researcher face many obstacles in the second stage of blood collection, this is because the researcher take time between collection of questionnaire and collection of blood sample.
5. At the stage of blood collection, many participants who agreed for blood collection either found sick or travel Gaza and this make the response rates of blood is low and affect the results.
6. In addition, before taking the blood sample, the participants should be completely healthy. This means that participants should not have acute or chronic infection such as flu. This affected the blood sample. Many participants who were agreed for blood collection excluded because they getting sick.
7. The electricity in Gaza was one of the main obstacles; it's responsible of many problems such as the typing mistakes and the interruption of writing the thesis.
8. Difficulties in convincing the volunteers to participate in the study, especially females, because of social considerations and blood samples.
9. There were some difficulties in radiation studies in attempting to investigate effects due to radiation, particularly at the very low exposure levels. Thus any association of a particular biologic effect with an exposure to ionizing radiation must have with it a degree of uncertainty.
10. Another problem that encounter in the study of low level radiation effects is the latent period, for example effects of low dose irradiation on genetic abnormalities, immune system functions and immune system cells (T and B cells).

Chapter (4) Results and Discussion

4.1 Introduction

In this chapter, the researcher presents the main results of the study variables that attained the study objectives. The present study was conducted to determine the effects of exposure to ionizing radiation on the immunity status of MRs at governmental hospitals- Gaza Governorates. Also, it aimed to assess the health status of MRs through complete blood count (CBC) and determination of immunoglobulin G and A, compared to the control group of medical laboratories (MLs).

4.2 Data collection and statistical analysis:

4.2.1 Presentation of the Results

Based on the inclusion criteria, 110 out of 152 MRs working at six main hospitals- Gaza Governorates was included in this study. A hundred and ten questionnaires were distributed to the MRs at their working radiology departments. Appreciatively, 92 of the 110 MRs filled the questionnaire with a response rate of 83.6 %. In addition, 130 out of 197 MLs are included in the study. Therefore, 130 questionnaires were distributed to the MLs at their laboratory departments. Thankfully, 97 of the 130 MLs participated in the study and filled the questionnaire which indicated a response rate of 74.6 %. However, for venous blood sampling the response rates were 58.8 % and 60.2 % for MRs and MLs, respectively. The distribution of the respondent MRs in the different hospitals and governorates is mentioned in Table (4.1) and (4.2). There were 92 MRs participated in this

study from main six hospitals in Gaza Governorates. The main hospitals are Al-Shifa in Gaza city, Naser and European Gaza Hospital (EGH) in Khanyounis, AL-Najjar in Rafah, AL-Aqsa in mid zone, and finally Kamal Edwan hospital in the north governorate.

Table 4.1: Distribution of the Participants According to the Hospitals

Hospitals	Cases (MRs)		Controls(MLs)		Overall	
	N	%	N	%	N	%
Al-Shifa	23	25.0%	24	24.7%	47	24.9%
Naser	18	19.6%	16	16.5%	34	18.0%
EGH	17	18.5%	23	23.7%	40	21.2%
Elnajjar	10	10.9%	8	8.2%	18	9.5%
Alaqsa	11	12.0%	12	12.4%	23	12.2%
Kamal Edwan	13	14.1%	14	14.4%	27	14.3%
Total	**92**	**100.0%**	**97**	**100.0%**	**189**	**100.0%**

The relatively high response rate of the MRs in the study questionnaire reflects a considerable level of awareness and responsiveness to the topic, aims and of the present work. The low response rate of the subjects toward the venous blood sampling is not surprising because great number of people considering venous blood sampling as unfavorable invasive technique (Hartge, 1999; Hansen et al. 2007; Kramer et al. 2008).

Table 4.2: Distribution of the Participants According to Governorate

Governorate	MRs (Cases)		MLs (Controls)		Overall	
	N	%	N	%	N	%
North	12	13.0%	9	9.3%	21	11.1%
Gaza city	17	18.5%	27	27.8%	44	23.3%
Mid Zone	13	14.1%	18	18.5%	31	16.4%
Khan-Younis	34	37.0%	31	32.0%	65	34.4%
Rafah	16	17.4%	12	12.4%	28	14.8%
Total	**92**	**100.0%**	**97**	**100.0%**	**189**	**100.0%**

4.3 Distribution of socio-demographic characteristics of the Participants:

The respondent participants (189) of the study were classified according to their profession into two groups: case group (92 MRs) and control group (97 MLs). The general characteristics of the overall subjects are mentioned in Table (4.3). The mean age of the overall subjects was 36.24 ± 6.65 years, while for the case and control groups it was 35.39± 6.38 and 37.05 ± 6.85 years, respectively. In addition, 43.3% of the participants are in age group from 27-33 years, followed by 41.3% in age group from 34-44. A number of 15.3% participants are in the age group (45-55 y).

Table 4.3: Descriptive Characteristics of the Study Participants:

Characteristics	MRs (Cases)		MLs(Controls)		Overall	
	N	%	N	%	N	%
Age						
27- 33 years	43	52.4%	39	47.6%	82	43.4%
34-44 years	37	47.4%	41	52.6%	78	41.3%
45-55 years	12	41.4%	17	58.6%	29	15.3%
Gender						
Male	76	82.6%	76	78.3%	152	80.4%
Female	16	17.4%	21	21.7%	37	19.6%
Total years of experience						
5-9 years	33	51.6%	31	48.4%	64	33.9%
10-14 years	37	55.2%	30	44.8%	67	35.4%
15-19 years	8	24.2%	25	75.8%	33	17.5%
20 years and more	14	56.0%	11	44.0%	25	13.2%
Marital status						
Single	2	2.2%	10	10.3%	12	6.3%
Married	90	97.8%	87	89.7%	177	93.7%
Geographic location						
Village	3	3.3%	5	5.2%	8	4.3%
City	74	80.4%	75	77.3%	149	78.8%
Camp	15	16.3%	17	17.5%	32	16.9%
House structural material						
Concrete	88	95.7%	92	94.8%	180	95.2%
Asbestos	4	4.3%	5	5.2%	9	4.8%
Smoking status						
Smoker	35	38.0%	36	37.1%	58	30.7%
Non smoker	57	62.0%	61	62.0%	131	69.3%

In addition, the majority of the current participants (cases and controls) are male, which count 152 out of 189 (80.4%). Furthermore, total years of experience are recorded from 5 to 30 years in employment; 35% of study participants had experience from 10 to 14 years, while those who have 5-9 years' of experience are 33.9%, and relatively 17% of them had experience from 15-19 years. The subjects with experience more than 20 years are 13.2%.

Moreover, 17.4% of the exposed participants were females and 82.6% were males corresponding to 21.7% and 78.3% for control group. About smoking status of the cases (MRs), there were 35(38%) out of 92 smoker subjects. Regarding the control group, 36 smokers and 61 non-smokers were participated to match those in the exposed group.

These findings are similar to some previous studies. Regarding age factor, our study participants were between 27 to 56 years old. This was similar to the most previous studies such as Moghaddam et al. (2004), Serhaliglue et al. (2005); Godekmerdan et al. (2005); Mohammad et al. (2013), and Oskuii et al. (2013). Regarding gender factors, our study revealed that the majority of the study participants (exposed and non-exposed) were males (80.3%) and the others were females. This was matched with Mohammed et al. (2013). However, our study was inconsistent with the study conducted in Poland by Klucinski found that the female participants are more than males. Again, a study conducted in Turkey found the same number of males and females. In addition, our study participants regarding period of employment or years of experience were between 5 to 31 years in employment. This was consistent with a study conducted in Iran in 2013. Other studies were not similar to ours such as Godekmerdan et al. and Klucinski they had participants with 1 to 25 years and 3-31 years of employment respectively.

4.3.1 Descriptive statistics of the study participants (MRs and MLs)

The following table shows descriptive statistics of the study participants regarding the normality of blood. The table shows that the respondents for blood tests are 113 participants (MRs=54 and MLs=57). Tables (4.4.1) and (4.4.2) show distribution of blood test normality among study participants (MRs and MLs). The percentages of abnormal IgG levels among MRs and MLs participants were 24.1% and 3.4% respectively and the others were within the normal ranges. Regarding IgA levels, there were 17.3% and 5.1% for MRs and MRLs. The other parameters of WBCs and its differentials show some abnormality between the two groups.

Table 4.4.1: Descriptive statistics of MRs regarding blood tests

Blood tests	MRs=54			
	Normal		Abnormal	
	N	%	N	%
IgG	41	75.9%	13	24.1%
IgA	45	82.3%	9	17.3%
WBCs	50	93.4%	4	6.6%
Lymphocytes	43	77.8%	10	22.2%
Monocytes	39	72.3%	15	27.7%
Granulocyte	52	96.5%	2	3.5%

Table 4.4.2: Descriptive statistics of control group regarding blood tests

	MLs=57			
Blood tests	**Normal**		**Abnormal**	
	N	**%**	**N**	**%**
IgG	52	92.7%	5	3.4%
IgA	54	94.9%	3	5.1%
WBCs	55	96.7%	2	3.3%
Lymphocyte	50	87.5%	7	12.5%
Monocytes	40	69.2%	14	30.8%
Granulocyte	54	97.1%	3	2.9%

4.3.2 Descriptive statistics for medical radiographers (MRs)

The respondent rate of the exposed participants was 83.6% for the questionnaire, and 58.3% for the blood tests. Table 4.5shows the descriptive of items related to MRs. Relatively, more than half of the MRs mentioned that safety measures in radiographic room are not enough.

Moreover, around 88 % indicates that there is a lack of quality control measures in radiographic rooms, 59.6% irregular maintenance and safeguarding for the radiographic machines. In addition, 65.3% of MRs clarified that their dosimeters have not checked for long time, 68.5% using personnel protective measures during work, while 31.5% go for not use of protective measures.

Table 4.5: Descriptive statistics of items related MRs

Items	MRs = 92			
	Yes		No	
	N	%	N	%
Safety standard in radiographic room	43	46.7%	49	53.3%
Quality control measures on x ray room	11	12.0%	81	88.0%
MRs using protective measures during work	63	68.5%	29	31.5%
Periodic checkup for the film badge	32	34.7%	60	65.3%
Special meals and food for MRs	70	76.1%	22	23.9%
Periodic maintenance to radiographic machines	55	59.8%	37	40.2%

In addition, table 4.6 shows the weekly working hours among MRs inside imaging room and its categorized into three groups; less than 10 hours, from 10 to 20, and more than 20 hours weekly. The majority of MRs (57 out of 92) 62.0% spent from 10-20 hours in the imaging room, while 20.7 and 17.3 of MRs are for group three (>20) and one (<10) respectively.

Table 4.6Weekly working hours inside imaging room for MRs

Groups of weekly working hours of MRs	MRs = 92	
	No	%
Less than 10 hours	16	17.3%
From 10-20 hours	57	62.0%
More than 20 hours	19	20.7%

4.4 Health characteristics of the study participants (MRs and MLs)

Regarding the general health characteristics, the responses to the questionnaire items are mentioned in Table (4.7). As shown by the below table that the current study demonstrated that 40.2 % (37 out of 92) of the exposed (MRs) had previous health problems related to their work conditions such as fatigue, headache, tiredness and others health complaints compared to 16.2% in control group. The difference between two groups was highly statistically significant with p-value =0.000. The odds ratio (OR) was 3.403 which means positive association between MRs having complains regarding the previous problems related work. The confidence interval (CI) was (1.72-6.71). The same results about current health problems related work. OR shows positive association and it was statistically significant with (p=0.000). In addition, 77.5% of exposed group having problems related to work conditions were reduced in holidays. OR was 2.011 which means positive association and statistically significant (p=0.008). Results also reported about 46.7% of exposed participants had headache during their daily life compared to 10.3 % of unexposed control group of MLs, which revealed highly positive association (OR=3.751) and was high statistical significant (p=0.000).

Additionally, the higher number of MRs who have had headache during daily and working life compared to MLs may be attributed to the exposure to ionizing radiation. Similarly, the last item is about intermittent sleep, OR=3.124 and CI 95% was 1.821-6.925, the difference in complaints between MRs and MLs reached the statistically significant level (p.0.00).

In reviewing the literature, regarding symptoms related work condition, the result revealed that the percentage of exposed group suffered from symptoms like headache during the working hours was high (46.7%) with statistically significant compared with the controls

(MLs) (10.2%), Regarding headache complain, the current results are consistent with a study conducted in Egypt which reported that radiographers suffered more from symptoms like headache, tiredness, and dizziness during working hours compared to control group with statistical significant difference (Saleh and et al. 2013).

Table 4.7: General Health status of the study participants (Cases and controls)

Items	(92) MRs		(97) MLTs		Chi- square test		
	No	%	N	%	OR	CI 95%	P-value
Previous health problems							
Yes	37	40.2%	16	16.2%	3.403	1.72 - 6.71	0.000
No	55	59.8%	81	83.8%			
Current health problems							
Yes	35	38.0%	13	13.4%	3.967	1.93 – 8.151	0.000
No	57	62.0%	84	86.6%			
Problems reduce in holidays							
Yes	27	77.5%	8	61.4%	2.011	1.32 – 7.221	0.008
No	8	22.5%	5	38.6%			
Having skin symptoms							
Yes	14	15.2%	7	7.2%	2.308	.887- 6.007	0.064
No	78	84.8%	90	92.8%			
Having eye symptoms							
Yes	31	33.7%	9	9.3%	3.201	1.80- 6.214	0.000
No	61	66.3%	88	90.7%			
Having headache							
Yes	43	46.7%	10	10.3%	3.725	2.02 – 9.02	0.000
No	49	53.3%	87	89.7%			
Having intermittent sleep							
Yes	34	37.0%	7	7.2%	3.124	1.812- 6.925	0.000
No	58	63.0%	90	92.8%			

Other study conducted in India by Prabhakra and Lakshman, (2005) revealed that the total number of symptoms experienced by the radiographers was greater than controls and the difference was highly statistically significant (p=0.000). Similarly, Daoud et al. (2008) identified the impact of radiation on health status and showed that headache was prevailing among exposed workers (52.5%). Meanwhile, it is suggested that the neurovascular

syndrome at low doses of radiation results from localized transient changes in the central nervous system.

Furthermore, the study results demonstrated that the percentage of the exposed (MRs) subjects suffered from skin diseases was two times higher than the percentage of non-exposed subjects as shown in table (4.4). Regarding skin symptoms, similar result was obtained with Prabhakra and Lakshman (2005) and Saleh el al. (2013), which reported that skin problems are remarked with no statistically significant difference between cases and controls. On the other hand, skin lesions (erythema and moist desquamation of the skin) were reported with exposed subjects (Titov et al. 1995). Finally, table (4.4) showed statistical difference between exposed subjects non-exposed regarding to eye infection.

4.4.1 Evaluation of Immunity system of the study participants (MRs and MLs)

The table (4.8) shows the result of questions related to immunity status symptoms and complains that appeared on MRs as compared to MLs. The study revealed large variations among exposed subjects compared to control group regarding the majority of immunity status symptoms (sinusitis, sore throat, gastritis, nausea, anorexia, and repeated infections, pallor, fever, and urinary system). The variations were highly statistical significant as shown in the table below. The OR shows highly positive associations between the different clinical symptoms and MRs exposed to radiation. However, other complains such as bronchitis and ear infections between MRs and MLs showed differences, OR showed no associations and CI 95% contains the value1 with no statistically significant differences.

Comparing our study results with the previous studies, we found that the current results reported repeated infections among MRs more than the control group 25% and 6.8%, respectively. Similar result was revealed by Saleh et al. (2013).

Table 4.8: clinical symptoms and health complains of immunity system among exposed and non-exposed participants

Items	(92) MRs		(97) MLTs		Chi- square		
	No	%	N	%	OR	CI	P-value
Having sinusitis							
Yes	50	54.3%	19	19.6%	4.887	2.557- 9.342	0.000
No	42	45.7%	78	80.4%			
Having sore throat							
Yes	70	76.1%	42	43.3%	4.167	2.220-7.785	0.000
No	22	23.9%	55	56.7%			
Having bronchitis							
Yes	18	19.6%	10	10.3%	2.116	.920 – 4.867	0.073
No	74	80.4%	83	89.7%			
Having gastritis							
Yes	32	34.8%	12	12.4%	3.778	.800 – 5.928	0.098
No	60	65.2%	85	87.6%			
Having nausea, anorexia							
Yes	22	23.9%	2	2.1%	14.777	3.745 – 64.255	0.000
No	70	76.1%	95	97.9%			
Getting ear infection							
Yes	8	8.7%	4	4.1%	1.025	.320 – 3.210	0.198
No	84	91.3%	93	95.9%			
Having urinary infection							
Yes	18	19.6%	5	5.2%	3.111	2.201 -7.235	0.002
No	74	80.4%	92	94.8%			
Having repeated infections							
Yes	24	26.1%	6	6.8%	2.425	1.598 - 6.25	0.001
No	68	73.9%	91	93.2%			
Suffering fever, pallor							
Yes	6	6.5%	1	1.0%	1.225	0.133- 4.255	0.125
No	86	93.6%	96	99.0%			

Saleh and his colleagues showed that 35% of the exposed participants having repeated infection and 15% among non-exposed with significant statistical difference (P=0.02). Our study also was matched with a study conducted in 2002 by Ben and Emelia to test the effect of radiation on the human immune system and they found higher infection rates in people exposed to radiation for long duration at low doses. Additionally, other study conducted in 2003 illustrated the effect of radiation on the human immunity system. The study showed higher infection rates in people exposed to radiation for long duration at low

doses. In the same way, a cross sectional survey carried by Vykhovanets et al. (2000) exhibited an increase in the prevalence of respiratory tract infection among children living around Chernobyl reactor. The scientists attributed this finding to the long term exposing to low radiation doses. On the other hand, a case control study conducted in 2008 by Daoud et al. did not reported repeated infections among exposed workers.

Again, in the present study the percentages of general manifestations such as pallor and hair loss are more among exposed participants than controls but were not statistically significant. Furthermore, the current study exhibited that the exposed person suffered from gastritis greater than non-exposed group (34.4% and 12.8%, respectively), OR showed highly positive association with highly statistical significant level (p=0.000). Comparing our study results we found that these results were close to study conducted in Egypt in 2013 that found gastritis, nausea and anorexia are more among exposed than control group and with statistically significant level (p=0.04) (Saleh et al. 2013). However, a study conducted in Egypt was not matched our results which reported that nausea and anorexia were only in 2.5% among exposed subjects (Daoud et al., 2008). Finally, this study also remarked greater complaints in urinary tract infection among exposed subjects with statistically significant level (p=0.000).

4.4.2 Immunoglobulin A and G and analysis

Table (4.6) shows the immunological (IgG and IgA) blood parameters compared with MRs and MLs using independent t – test. There were 113 participants agreed of the study sample tests. The study results showed that the mean differences of serum IgG levels among the MRs were higher (mean=1279, standard deviation (SD) =359.30) than those in

the control group (mean=1225.21, SD=209.42) but was not reached the statistically significant level (P=0.324). The same result for IgA, no statistically significant differences.

In reviewing the literature, the results of IgG and IgA were close to previous studies conducted in Iran and Egypt which showed no statistically significant difference between the exposed and the non-exposed group (Moghhadam el al. 2005 and Daoud et al. 2008; and Zakeri et al, 2010).

Table 4.9: t-test comparing the means of IgG and IgA among the study participants

Variables Participant	No.	Mean	SD	t-test	P-value
IgG levels					
MRs (Cases)	54	1279.21	359.30	0.990	0.324
MLs (Controls)	57	1225.25	209.42		
IgA levels					
MRs (Cases)	54	215.81	108.42	0.693	0.498
MLs (Controls)	57	202.90	89.32		

Also the results of a study conducted in Poland by Klucinski et al. revealed the same results of our study regarding IgA that found no statistical significant differences between exposed and non-exposed group. In addition, Oskouii et al. found the same results regarding IgG that was no statistical significant differences between exposed and non-exposed group. The results reported that there was no significant influence of low radiation doses on the immunoglobulin concentrations of the medical radiographers. Other study conducted in Russia was matched with our results of IgA that was not statistical (Rybkini et al. 2014). On the other hand, many recent studies conducted in Russia, Turkey, Iran, and Poland revealed abnormal concentrations of IgG and IgA concentrations among exposed subjects compared with control groups (Godekmerdan et al. 2004; Serhatlioglu et al. 2004; Oskouii et al. 2013). These results assumed that occupational exposure to low doses of

ionizing radiation is associated with suppressive influence on the immunoglobulin production, especially with IgG count.

4.4.3 Complete blood count (CBC)

As shown by the table (4.10) that our study results found no statistical significant differences between the MRs and the control group in terms of number of white blood cells (WBCs) and lymphocytes, monocytes, and granulocytes ($p > 0.05$). Table (4.10) showed that the mean difference and SD of lymphocytes and WBCs was higher in exposed subjects compared to control group with no statistically significant levels.

Table 4.10: t-test comparing the mean of WBCs and it differentials among participants

Variables / Participant	No.	Mean	SD	t-test	P-value
WBCs levels					
MRs (Cases)	54	6835.19	1552.38	0.420	0.674
MLs (Controls)	57	6713.07	1513.55		
Lymphocytes levels					
MRs (Cases)	54	2846.30	837.36	1.524	0.393
MLs (Controls)	57	202.90	89.32		
Monocytes levels					
MRs (Cases)	54	303.70	837.25	-1.224	0.273
MLs (Controls)	57	2700.00	622.35		
Granulocytes levels					
MRs (Cases)	54	3636.19	1077.14	0.771	0.348
MLs (Controls)	57	3475.12	1140.22		

In reviewing the literature, we found that our study results that showed no statistical significant differences between MRs and control group regarding hematological parameters was consistent to some previous studies. Studies conducted in Iraq and Iran Egypt was similar to ours and reported some variations in WBCs and lymphocytes

parameters with no statistically significant levels (Zakeri et al. 2010; Oskouii et al. (2013); Mohammad et al. 2014). However, recent studies conducted in Poland and Pakistan found statistically significant difference between exposed and non-exposed subjects regarding to lymphocytes count (Klucinski et al. (2014); Shahid et al. 2014). These results and variations can be attributed to the performing and practices of protection standards and experience years among exposed participants. In addition, a study conducted in Egypt in 2008 found variations in lymphocytes counts between exposed and no-exposed groups with statistically significant level ($p<0.05$).

4.5 Differences of blood tests of MRs according to the independent variables

The final results of blood tests for MRs were examined statistically according to three factors; years of experience, weekly working hours inside imaging room, and using protecting measures or not among MRs.

Table (4.11): Differences in IgG levels of MRs according to years of experience and protective measures using t-test

IgG levels	N=54	Mean	SD	t-test	P-value
Years of experience					
5-10 years	21	1292.19	325.38	0.320	0.250
>10 years	33	1330.07	345.55		
Protective measures					
Yes	29	1301.30	375.36	.524	0.632
No	25	1258.90	155.32		

T-test results regarding IgG in table (4.11) showed that there were no statistically significant differences of IgG levels between MRs having years of experience below and

above ten years. Also, MRs used protective measure or not showed some variations of IgG between them with no statistically significant level.

Table (4.12): Differences in IgA levels of MRs according to years of experience and protective measures using t-test

IgA Levels	N=54	Mean	SD	t-test	P-value
Years of experience					
5-10 years	21	223.19	207.08	0.921	0.311
>10 years	33	233.07	217.25		
Protective measures					
Yes	29	245.30	222.36	0.524	0.586
No	25	234.90	195.02		

In addition, regarding IgA, table (4.12) showed that there were no statistically significant differences of IgA levels among MRs who used protective measures or not. The same results of MRs with years of experience below and above ten years, showed no statistically significant differences.

Furthermore, table (4.13) and (4.14) regarding WBCs and lymphocytes showed some variations with no statistically significant differences between MRs related years of experience and protective measure.

Table (4.13): Differences in WBCs levels of MRs according to years of experience and protective measures using t-test

WBCs levels	N=54	Mean	SD	t-test	P-value
Years of experience					
5-10 years	21	6835.12	1552.38	0.420	0.352
>10 years	33	6713.32	1513.55		
Protective measures					
Yes	29	7040.35	1116.33	0.973	0.312
No	25	6629.90	1890.04		

Table (4.14): Differences in Lymphocytes levels of MRs according to years of experience and protective measures using t-test

Lymphocytes	N=54	Mean	SD	t-test	P-value
Years of experience					
5-10 years	21	6835.19	1552.38	0.620	0.352
>10 years	33	6713.07	1513.55		
Protective measures					
Yes	29	2915.10	862.30	0.924	0.329
No	25	2790.80	822.1		

Finally, table (4.15) showed the results of anova test comparing the differences of blood tests for MRs with their weekly working hours inside imaging room. The results found some differences between the groups with no statistically significant levels in all blood parameters of MRs.

Table 4.15: Differences in mean of blood parameters of MRs according to the weekly working hours using anova test

Weekly working hours among MRs						
Blood test		**Less than 10 hours**	**10-20 hours**	**>20 hours**	**F-test**	**P-value**
IgG	Mean	1300.23	1207.57	1424.	1.870	0.165
	SD	393.38	298.56	435.07		
IgA	Mean	246.67	216.32	194.36	0.618	0.543
	SD	127.58	101.25	113.25		
WBCs	Mean	6288.36	6858.06	7125.37	0.58	0.449
	SD	7995.33	1614.58	1764.25		
Lymphocytes	Mean	2755.66	2829.32	2945.68	0.147	0.865
	SD	320.58	940.36	859.25		

Chapter (5) Conclusion and Recommendations

5.1 Conclusion

The aim of this study was to determine the effects of the immunity status of medical radiographers exposed to occupational chronic low doses of ionizing radiation at governmental hospitals. Based on case control study, a total of 92 MRs and 97 controls of MLs matched by age, gender, working experience, and smoking status from the main six hospitals—GG (Al-Shifa, Nasser, EGH, Al-Najjar, Al-Aqsa, and Kamal Edwan) were selected. The response rate of MRs regarding the questionnaires and blood tests were 83.6% and 58.8%, respectively, and 74.6% and 60.2%, respectively among MLs.

Data was collected by face to face interview questionnaire and blood tests, which include serum immunoglobulin (IgG and IgA) and complete blood count (CBC). The questionnaire has three main parts: socio demographic variables (age, gender, place of work, years of experience, smoking status, and address) questions corresponding to health and immunity system and finally questions regarding MRs. The blood test performed to identify the immunoglobulin (G and A) along with CBC.

The results of this study revealed that the clinical symptoms and health complains among MRs regarding the immunity system were many times higher compared to the control group with statistically significant levels. However, regarding the immunoglobulin concentrations (IgG and IgA) the mean differences for MRs were higher and showed some variations compared to the control group with no statistically significant levels. In addition, there were no statistically significant levels in the mean differences in WBCs, and lymphocyte counts between the two groups.

The current results supported the evident that the symptoms experienced among medical radiographers (exposed population) are several times higher compared to non-exposed subjects. The most common health complains among MRs were headache, gastritis, sinusitis, nausea and anorexia, and repeated infections with statistical significant levels. Other health complains among exposed subjects such as skin symptoms were higher among cases but did not reach the statistically significant levels.

The serum immunoglobulin concentrations showed some variations between exposed and non-exposed participants. The mean difference of IgG was higher among exposed subjects compared to the non-exposed subjects with no statistical significant. Also, WBCs and its differentials such as lymphocytes showed no statistically significant differences. These results supported the evidence that the symptoms experienced in x-ray department were several times higher compared to non-exposed subjects.

In conclusion, the present study revealed that the continuous exposing to low doses of ionizing radiation causes many health complaints regarding the immunity system. Although the mean differences of immunological parameters (IgG, IgA) were increased among exposed participants than non-exposed group, these differences did not reach the statistically significant levels. The variations of statistical significant differences between clinical symptoms and blood tests may be attributed to the low response of MRs for venous blood sampling (58.8%) compared to the high response obtained from face to face questionnaire.

Finally, medical radiographers are exposed to low doses of radiation, yet significant affection of some basic blood parameters was evident. Thus, personnel monitoring for ionizing radiation and increasing the level of protection for MRs is of utmost importance.

5.2 Recommendations

The current study revealed higher rate of clinical symptoms and health complaints related to immunity system among MRs compared to the control group of MLs. However, there were no statistically significant differences between the two groups regarding the immunoglobulin concentrations (IgG and IgA) and CBC parameters. Therefore, the following points are highly recommended:

1. Periodic medical examination including immunological and hematological blood parameters for all MRs working in governmental hospitals in order to evaluate the health status for them and to early identify any changes and detect any abnormality on their immune response. So, medical examination is considered as a tool for monitoring for MRs exposed to ionizing radiation.

2. Regular film badges (dosimeters) control in order to know the changes on radiation exposures of MRs and to be up to date with their dosimeter readings. This is important in order to take early precautions with any abnormal readings, therefore protect MRs from any danger. Also, it should be mentioned that monitoring for personnel occupationally exposed to ionizing radiation consists of regular film dosimeters control and periodic health examination.

3. Medical radiographers have to adopt technical preventive measures during work such as wearing appropriate protective equipments, lead apron, lead goggles etc. Also, they should regularly use appropriate personal protective equipment's during working hours. These measures will prevent the hazards of radiation.

5.3 Further research recommendations

Further studies for definitive statement with regard to the appropriateness of periodic checks of immune function and the most efficient and cost-effective methods for monitoring immune function in radiology workers for detection of early changes in the immune system. Therefore, further studies to evaluate immunity status of medical radiographers using other immunological parameters such as peripheral blood lymphocytes that considered also as accurate indicators of immunity system.

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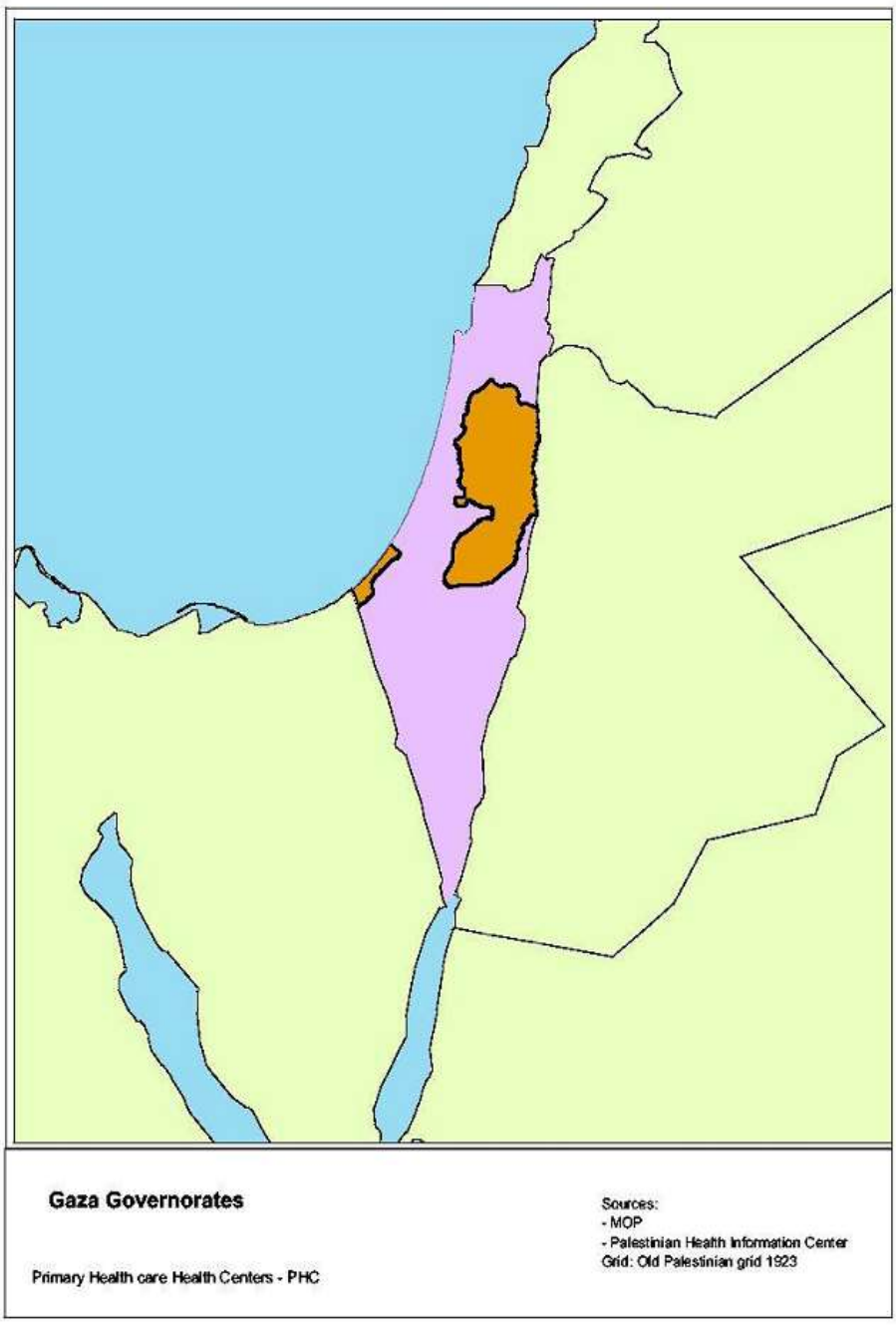
ANNEXES

Annex (1): Palestine Map

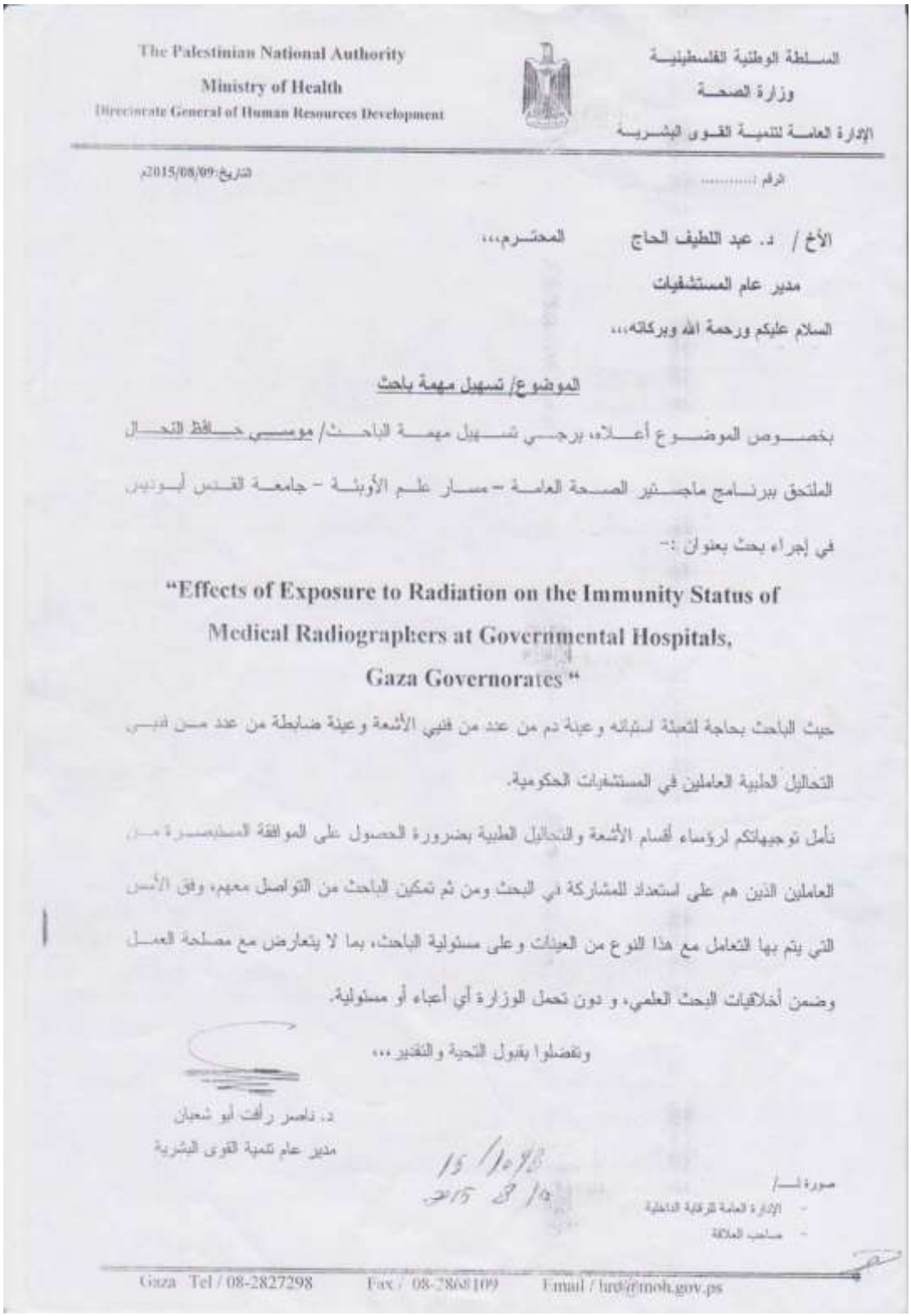


(MOH, 2010c).

Annex (2): Map distribution of population in GS regarding to Governorates

(MOH, 2010c).

Annex (3): Administrative approval from MOH



The Palestinian National Authority
Ministry of Health
Directorate General of Human Resources Development

السلطة الوطنية الفلسطينية
وزارة الصحة
الإدارة العامة لتنمية القوى البشرية

الرقم: ..... التاريخ: 2015/08/09م

الأخ / د. عبد اللطيف الحاج المحترم،،،

مدير عام المستشفيات

السلام عليكم ورحمة الله وبركاته،،،

الموضوع/ تسهيل مهمة باحث

بخصوص الموضوع أعلاه، يرجى تسهيل مهمة الباحث/ موسى حافظ النحال الملتحق ببرنامج ماجستير الصحة العامة – مسار علم الأوبئة – جامعة القدس أبوديس في إجراء بحث بعنوان :-

"Effects of Exposure to Radiation on the Immunity Status of Medical Radiographers at Governmental Hospitals, Gaza Governorates "

حيث الباحث بحاجة لتعبئة استبانه وعينة دم من عدد من فنيي الأشعة وعينة ضابطة من عدد من فنيي التحاليل الطبية العاملين في المستشفيات الحكومية.

نأمل توجيهاتكم لرؤساء أقسام الأشعة والتحاليل الطبية بضرورة الحصول على الموافقة المستنيرة من العاملين الذين هم على استعداد للمشاركة في البحث ومن ثم تمكين الباحث من التواصل معهم، وفق الأسس التي يتم بها التعامل مع هذا النوع من العينات وعلى مسئولية الباحث، بما لا يتعارض مع مصلحة العمل وضمن أخلاقيات البحث العلمي، و دون تحمل الوزارة أي أعباء أو مسئولية.

وتفضلوا بقبول التحية والتقدير،،،

د. ناصر رأفت أبو شعبان
مدير عام تنمية القوى البشرية

15/10/2015

صورة لـ/
- الإدارة العامة للرقابة الداخلية
- صاحب العلاقة

Gaza Tel / 08-2827298 Fax / 08-2868109 Email / hrd@moh.gov.ps

Annex (4): An Ethical approval from Helsinki Committee

المجلس الفلسطيني للبحث الصحي

Palestinian Health Research Council

تعزيز النظام الصحي الفلسطيني من خلال مأسسة استخدام المعلومات البحثية في صنع القرار

Developing the Palestinian health system through institutionalizing the use of information in decision making

Helsinki Committee

For Ethical Approval

Date: 03\08\2015 **Number:** PHRC/HC/50 /15

Name: الاسم: موسى حافظ النحال

We would like to inform you that the committee had discussed the proposal of your study about: نفيدكم علماً بأن اللجنة قد ناقشت مقترح دراستكم حول:-

Effects of Exposure to Radiation on the Immunity Status of Medical Radiographers at Governmental Hospitals- Gaza Governorates

The committee has decided to approve the above mentioned research. Approval number PHRC/HC/50 /15 in its meeting on 03/08/2015

و قد قررت الموافقة على البحث المذكور عاليه بالرقم والتاريخ المذكوران عاليه

Signature

Member Member

Chairman

Genral Conditions:-

١. Valid for 2 years from the date of approval.
٢. It is necessary to notify the committee of any change in the approved study protocol.
٣. The committee appreciates receiving a copy of your final research when completed.

Specific Conditions:-

The subject was approved following the World Medical Association Declaration of Helsinki-Ethical principles for medical research involving human subjects, adopted by the 18th World Medical Association General Assembly, Helsinki, Finland, June 1964 and amended by the 59th WMA General Assembly, Seoul, Korea, October 2008.

E-Mail:pal.phrc@gmail.com

Gaza - Palestine غزة - فلسطين

شارع النصر - مفترق العيون

Annex (5): Questionnaire for study subjects (Arabic version

إقرار بالشهادة

استبيان حول أثار التعرض للأشعة المؤينة على الجهاز المناعي لأخصائيى التصوير الطبى العاملين فى المستشفيات الحكومية–محافظات غزة

يهدف هذا الاستبيان إلى معرفة أثار التعرض للأشعة المؤينة على الجهاز المناعي لأخصائيى التصوير الطبى العاملين في المستشفيات الحكومية–محافظات غزة، من خلال المقابلة المباشرة. علما بأن هذه المعلومات ستستخدم لأهداف البحث العلمي فقط. لذا نرجو الإجابة بصراحة واعطاء اجابة دقيقة. يذكر أن المعلومات التي تقدمها لنا ستكون سرية ومجهولة.

أنا الموقع أدناه أوافق على إجراء الفحوصات التالية :

□ تعبئة الاستبانة □ سحب عينة دم من الوريد

ملاحظة: جميع الفحوصات المخبرية (Venous Blood Sample) ستتم عن طريق مختصين لهم خبرة ودراية كافية لإجراء هذه الفحوصات.

التوقيع / اخوكم الباحث /

موسى حافظ النحال
0599159734

رقم الاستبانة .....

اولا: أسئلة عامة

1-العمر بالسنوات:.....

2-الجنس: O ذكر O أنثى

3-المهنة: O اخصائى تصوير طبى O اخصائى مختبر

4-مكان العمل: O مستشفى الشفاء O مستشفى ناصر O مستشفى الأوروبي

O مستشفى النجار O مستشفى شهداء الاقصى O مستشفى كمال عدوان

5-عدد سنوات الخبرة: O داخل المستشفيات والمراكز الحكومية.....

O خارج المستشفيات والمراكز الحكومية.....

6-الحالة الاجتماعية: O أعزب O متزوج

7-المحافظة : O الشمال Oغزة O الوسطى

O خان يونس O رفح

8- مكان السكن: O قرية O مدينة Oمخيم

9- نوع السكن: O باطون O اسبست

10-التدخين: O مدخن O غير مدخن

ثانيا: أسئلة صحية:

11-هل تعانى من امراض وراثية ؟ O نعم O لا

اذا كانت الاجابة نعم، حدد ما هو المرض.....

12-هل عانيت سابقا من أي مشكلة صحية تعتقد ان لها علاقة بطبيعة عملك؟

O نعم O لا إذا كانت الإجابة نعم، ما هي المشكلة .....

13-هل تعاني حاليا من أي مشكلة صحية تعتقد ان لها علاقة بطبيعة عملك؟

O نعم O لا إذا كانت الإجابة نعم، ما هى المشكلة.....

14- هل تعتقد ان مشكلتك الصحية لها علاقة بمكان سكنك؟ O نعم O لا

15- هل مشكلتك الصحية تخف او تختفي في العطل و الإجازات؟ O نعم O لا

16-هل تعاني من تكرار ظهور الأعراض التالية في الجلد(احمرار، طفح، حكة) خلال الحياه اليومية؟ O نعم O لا

17- هل تعاني من احدى (أو أكثر) الأعراض التالية في العين (حكة، احمرار، دمع، الم، ضبابية الرؤية) خلال الحياه اليومية ؟ O نعم O لا

18- هل تعاني من صداع متكرر خلال الحياه اليومية؟ O نعم O لا

19- هل تعاني من نوم متقطع (بشكل متكرر)؟ O نعم O لا

ثالثا: تقييم الجهاز المناعى

20- هل تصاب بالتهابات الجيوب الأنفية؟ O نعم O لا

اذا كانت الاجابه نعم تكون الاصابة: O مره واحده سنويا O بشكل متكرر(حدد كم مره.....)

21- هل تصاب باحتقان فى الحلق؟ O نعم O لا

اذا كانت الاجابه نعم تكون الاصابة: O مره واحده سنويا O بشكل متكرر(حدد كم مره....)

22- هل تصاب بالتهاب رئوى او التهاب بالشعب الهوائيه ؟ O نعم O لا

اذا كانت الاجابه نعم تكون الاصابة O مره واحده سنويا O بشكل متكرر(حدد كم مره.....)

23- هل تصاب بالتهابات فى المعده مع وجود اضطرابات متكررة (اسهال، امساك....)؟

O نعم O لا

اذا كانت الاجابة نعم تكون الاصابة: O مره واحده سنويا O بشكل متكرر

24- هل تصاب بدوخة وفقدان للشهية (بشكل متكرر)؟ O نعم O لا

25- هل تصاب بالتهابات في الاذن؟ O نعم O لا

اذا كانت الاجابه نعم تكون الاصابة: O مره واحده سنويا O بشكل متكرر

26- هل تصاب بالتهابات في الجهاز البولى؟ O نعم O لا

اذا كانت الاجابه نعم تكون الاصابة: O مره واحده سنويا O بشكل متكرر

27- عند اصابتك بجروح (فى اى منطقه بالجسم) تكون عمليه الالتئام

O سريعة O تستمر لفتره طويلة O تستمر لفترة مع ظهور اعراض مثل

(انتفاخ، احمرار، سخونة)

28- هل تصاب بعدوى متكررة خلال الحياه اليومية؟ O نعم O لا

29-هل تصاب بشحوب بالوجه او حمى متكرره خلال الحياه اليوميه O نعم O لا

30- في حالة كانت اجابتك نعم في احد الاسئلة السابقة (20 الى 28):

فترة الاصابة تكون : O طويلة O قصيره

الاستجابة للعلاج تكون: O سريعة O بطيئه

رابعا: أسئلة خاصة بأخصائيي التصوير الطبي :

31- هل معايير السلامة والأمان مطبقة بغرفة الاشعة؟ O نعم O لا

32- هل هناك إجراءات و مراقبة إدارية لمعايير ضبط الجودة في غرفة الأشعة؟

O نعم O لا

33- هل يوجد صيانة دورية لأجهزة الأشعة ؟ O نعم O لا O بشكل غير منتظم

34- هل يوجد قراءات دورية للجهاز المستخدم لقياس كمية الاشعة لأخصائيى التصوير؟

O نعم O لا O بشكل غير منتظم

35- ما هو نوع جهاز التصوير المستخدم الذى تعمل عليه؟ (يمكنك اختيار اكثر من جهاز)

O جهاز اشعة مقطعية O جهاز اشعة ملونة O جهاز اشعة عادية O جهاز اشعة (C-Arm)

36- كم يبلغ عدد ساعات العمل الأسبوعية في غرفة الأشعة (غرفة التصوير)؟ حدد كم ساعة.....

37- هل يوجد فحوصات دورية لأخصائيى التصوير الطبى (مخبرية وإكلينيكية)؟

O نعم O لا O بشكل غير منتظم

38- هل يتم تزويد اخصائيى التصوير الطبى بوجبات وأطعمة خاصة اثناء عملهم بأقسام الأشعة؟

O نعم O لا O بشكل غير منتظم

39- هل تستخدم أدوات و سبل الوقاية الشخصية من الأشعة اثناء التصوير؟

O نعم O لا

Results of Blood Tests

1. **IgG……..**
2. **IgA…….**
3. **WBCs……**
4. **Lymphocytes……**
5. **Monocytes……..**
6. **Granulocytes……..**

Annex (6) list of arbitrators

List of arbitrators

1- Dr. Yaser Alajeramy

2- Dr. Yehia Abed

3- Dr. Sadi Jaber

4- Dr. Nahed Ellahham

5- Dr. Bassam Abo Hamad

6- Dr. Khitam Abo Hamad

7- Mr. Basel Khamis

8- Mr. Ashraf Shagalae

Annex (7) Time table of the study

Activity	Mar 2015	May 2015	July 2015	Aug 2015	Sep 2015	Oct 2015	Nov 2015
Preparation of proposal							
Seminar and acceptance of proposal (approval)							
Obtaining permission							
Administration approval							
Ethical approval							
Collection of sample and applying test procedures							
Data processing and analysis							
Data interruption and discusses							
Writing and correction the thesis							

عنوان الدراسة: الأثار الناجمة عن التعرض للأشعة على الجهاز المناعي لأخصائيي التصوير الطبي العاملين فى المستشفيات الحكومية– محافظات غزه

اعداد الطالب: موسى حافظ النحال

اشراف: د ياسر العجرمى

ملخص الدراسة

من المعروف ان التعرض المستمر لجرعات صغيره من الأشعة المؤينة على مدى فتره من الزمن قد يؤثر سلبا على خلايا وانسجة واجهزة الجسم وهذا بدوره سيؤدى بعد ذلك الى اثار صحية كبيرة. الجهاز المناعى يعتبر من اكثر اجهزة الجسم حساسية للاشعة، مما يفسر قابليتة للأشعة المؤينة. اخصائي التصوير الطبى العاملين بالأشعة يتعرضوا خلال عملهم الى جرعات من الأشعة بشكل متكرر مما قد يؤثر على الحالة المناعية لهم. هدف الدراسة معرفة الأثار الناتجة عن التعرض الأشعة على الجهاز المناعى لأخصائيى التصوير الطبى العاملين بالمستشفيات الحكومية–محافظات غزة.

لقد اجريت دراسه مقارنة فى ستة مستشفيات رئيسية. عدد العاملين بالأشعه كان 92 مقابل المجموعة المقارنة الذين كان عددهم 97 من العالمين بالمختبرات الذين يعملوا بعيدا عن الأشعة. اخصائيى التصوير والمجموعة المقارنة كان لهم نفس العمر، الجنس، سنوات الخبرة، والتدخين. ادوات الدراسة هى استبانة وتحاليل دم مخبرية. النتائج اظهرت ان نسبه الاستجابه للاستبانه وتحليل الدم للفئة المستهدفه (اخصائيى الاشعه) هى 83.6% و 58.8% على التوالي ، اما بالنسبه لفئه المقارنه (اخصائيى المختبرات) فكانت 74.6% و 60.2% للاستبانه وتحليل الدم على التوالي.

نتائج الدراسة اظهرت ان هناك فروقات كبيره ذات دلاله احصائية فى الشكاوى والاعراض الصحيه مثل الصداع وكان ذات دلاله احصائية كبيرة . كانت نسبة الصداع للأشعة 46.7% مقابل فقط 10.3% للفئة المقارنة. ايضا بالنسبة للأعراض الصحية التى تدل على تأثر الجهاز المناعة مثل التهاب المعدة والعدوات المتكرره لدى العاملين بالأشعة كانت كبيرة وكانت ذات دلاله احصائية مقارنة بالمجموعة المقارنة. بالنسبة لتحاليل الدم كان متوسط الاختلاف للعاملين بالأشعة اعلى من الجهة المقارنة ولكن لم تكن هذه الفروقات ذات دلالة احصائية.

نستنتج من هده الدراسة ان الشكاوى الصحيه التى سجلت من قبل اخصائيى الاشعه اكبر منها بالنسبه للفئه المقارنه وكانت ذات دلاله احصائيه. وبالتالى الفحص الشخصى لجرعه الاشعه المؤينه، كشف طبى للأخصائي التصوير بشكل دورى ومستمر وزياده مستوى الوقايه من الاشعاع لدى اخصائيى الاشعة هو امر فى غاية الاهمية.