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Evaluation of the Medical Imaging Services at Governmental Hospitals-Gaza Governorates

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Dedication

To the greatest man I have in my life, the light of my life... my lovely father

To the biggest heart with the most loving care, who sacrificed a lot for me to become what I am now, my mother

To my wife who supported me through each step of the way and for being the greatest source of inspiration for me...

To the light of my eye…my kids “Miasser, Kateralnada and Daher”

To all those who encouraged, supported, and helped me all the way.

I dedicate this research for all of them …

Maher Daher Suleiman

Declaration

I certify that this thesis submitted for the degree of master is the result of my own research, except where otherwise acknowledged, and that this thesis or any of its parts has not been submitted for higher degree to any other university or institution.

Signed:

Maher D. Suleiman

Date: --------/---------/---------

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Abstract

Medical imaging services are the key tool to diagnose many diseases and have an important role in monitoring treatment and predicting outcome. This field includes many modalities like Conventional Radiology, Fluoroscopy, Computed Tomography, Magnetic Resonance Imaging and Radioscintigraphy...etc. Since the discovery of X-ray by Roentgen in 1985, progressions of international standards seek to improve medical imaging services. Patient convenience and accessibility should be an integral part of the planning and design of departments. Availability of equipment and qualified staff increase safety, outcome and quality of patient's services.

Triangulated study design was used. For the quantitative part; 170 Radiologic Technologists completed questionnaires with 95.5% response rate. The researcher used arbitrated checklist to evaluate medical imaging facilities. Census study conducted on all Radiologic Technologists and medical imaging departments at six main governmental hospitals in the Gaza Strip. In addition, three key informant interviews with Radiologic Technologists manager were conducted.

Researcher have directly interviewed 170 participants (82% Males; 75% younger than 40; 85% have bachelor degree and 86.5% permanent employment). Findings revealed that 143 of Radiologic Technologists having Thermoluminescence Dosimeters, but only 80 holding it. The majority of participants have good training courses. There was shortage in number of radiographic equipment and Radiologic Technologists. Four of sixth of hospitals provided with Computed Radiography. Statistically significant relations between participants years' experience and holding Thermoluminescence Dosimeters (p=0.033); number of exams and patient waiting time in Conventional Radiography (p=0.000). Generally, medical imaging departments that followed standard in structure, occupational safety and reception services were 90%, 70% and 27%, respectively. In Conventional Radiography, 45%, 64% and 83% of structure, occupational safety and essential supplies of imaging rooms were adapted to standard, respectively. Regarding to fluoroscopic rooms, 79%, 82% and 68% of structure, occupational safety and essential supplies were followed the standard, respectively. The Computed Tomography and Magnetic Resonance Imaging departments showed that "60%, 78% and 91%" and "86%, 100% and 90%" followed standard regarding to their structures, occupational safety and essential supplies, respectively.

An improvement in human resources among medical imaging facilities was clearly observed after 1996. There is a good tendency to replace traditional radiography by Computed Radiography. Finally, frequent training courses were conducted in all medical imaging fields except Magnetic Resonance Imaging. On other side, *shortage in number of radiographic machines and Radiologic Technologists at all governmental hospitals was observed. All departments revealed clear defect in structure, design and essential supplies. Critical readings were observed respecting to insufficient radiation protection tools and holding of Thermoluminescence Dosimeters.*

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List of Abbreviations

ALARA	As Low As Reasonably Achievable
ARRT	American Registry of Radiologic Technologists
ASRT	American Society of Radiologic Technologists
AusHFG	Australasian Health Facility Guidelines
BIR	British Institute of Radiology
CD	Compact Disc
CR	Computed Radiography
CT	Computed Tomography
EGH	European Gaza Hospital
ENT	Ear, Nose and Throat
ESWL	Extracorporeal Shock Wave Lithotripsy
GDP	Gross Domestic Product
GS	Gaza Strip
HCPC	Health and Care Professions Council
ICRP	International Commission on Radiological Protection
ICU	Intensive Care Unit
KII	Key Informant Interview
MIA	Medical Imaging Administration
MOH	Ministry of Health

MRI	Magnetic Resonance Imaging
NCRP	National Council on Radiation Protection
NGOs	Non-Governmental Organizations
NHS	National Health Service
OECD	Organisation for Economic Co-operation and Development
OHS	Occupational Health Safety
PCBS	Palestinian Central Bureau of Statistics
PVC	Polyvinyl Chloride
RF coils	Radiofrequency coils
RPII	Radiological Protection Institute of Ireland
RT	Radiologic Technologist
SPSS	Software Statistical Package of Social Science
TLD	Thermoluminescence Dosimeter
UNRWA	United Nations Relief and Works Agency
WB	West Bank
WHO	World Health Organization

Chapter (1): Introduction

1.1 Background

After the discovery of X-ray by Roentgen in 1895, immersive growth was realized in medical imaging modalities. This progress facilitates detection and characterization of different diseases inside human body (Krupinski and Jiang, 2008). Medical imaging or radiography is a photographic process used to image anatomic structures. Instead of visible light, radiography utilizes X-ray energies, which penetrate the body. These energies are absorbed at different rates by different tissue densities and are particularly effective for imaging bone and dense tissues (Siegel et al, 2008).

New knowledge in radiographic imaging is being developed at an increasingly rapid rate and the medical imaging services have expanded dramatically (European Society of Radiology, 2010). Furthermore, the medical imaging services are now the key tool to diagnose many diseases and have an important role in monitoring treatment and predicting outcome. The medical imaging service can comprise methods relying on both ionizing and non-ionizing radiations, covering Conventional Radiography, Fluoroscopy, Nuclear Medicine, Computed Tomography, Mammography, Interventional Radiology, Bone Densitometry, Ultrasonography and Magnetic Resonance Imaging and others (Pereira et al, 2015).

The medical imaging services may be performed in several hospital areas, dependent upon the type or volume of examination required, and may be used in selected instances for imaging of patients. Patient convenience and accessibility should be an integral part of the planning and design of the medical imaging department. A high percentage of the volume of this service will consist of hospitals/flexibility and adaptability should be a main consideration when planning the facility in order to accommodate constant upgrades in equipment technology (Bowen et al, 2008).

Progressive developments in demands to diagnostic imaging and costs during the past two decades have shown that multiplicity of imaging units has increased worldwide. Qualified Radiologic Technologists and appropriate design for the medical imaging facilities according to international standards, increase safety, outcome and quality of services provided to patients.

MOH in GS has six main large governmental hospitals; Indonesia, Al-Shifa, Shohda Al-Aqsa, European Gaza, Nasser and Abu Yousef Al-Najjar hospitals. These hospitals contain medical imaging departments and cover their own geographical areas. Al-Shifa Hospital is the biggest and covers the largest demographic area. Medical imaging departments in Indonesia, Shohda Al-Aqsa, and Nasser hospitals are contain conventional radiography, fluoroscopy and CT. Medical imaging department at Al-Shifa Hospital contains conventional radiography, fluoroscopy, CT, mammography, and dental panorama while at Abu Yousef Al-Najjar Hospital contains only conventional radiography and fluoroscopy. Finally, MRI services are available only in Al-Shifa and European Gaza hospital.

1.2 Justifications of the study

Substantial effect in diagnosis and treatment of different diseases is attributed to the medical imaging services. The medical imaging services are a critical part of health care provision for patients at all of the three levels of health care (primary, secondary, and tertiary) especially in secondary care. MOH is the main provider of the medical imaging services in Palestine, where the number of radiological examinations in the GS reached 519,220. The majority of these exams (81%) were conducted at governmental hospitals in the GS. These services are represented as the following: Conventional Radiography 78.6%, Computed Tomography (CT) 6.2%, Magnetic Resonance Imaging (MRI) 0.7%, Fluoroscopy 0.8%, and others 13.7%. A significant increase in medical imaging services in the GS between 2006-2014 (MOH, 2015c).

No previous study about evaluation of medical imaging services in the GS was reported. Evaluation of medical imaging services is very important particularly in the GS, which is politically unstable, suffering poverty, low health resources and have been exposed to three devastating wars since 2008. All these factors making the evaluation of health care capacities in sector hospitals extremely important, especially medical imaging departments, as they have a significant role in the early and accurate diagnosis. This study conducted to evaluate medical imaging services at governmental hospitals in the GS.

1.3 Problem statement

The medical imaging departments play an effective and important role in the early diagnosis and treatment of diseases. There are international standards and regulations projected to evaluate medical imaging services in terms of RTs number, qualification, machines number and departments design.

Evaluation provides evidence-based information. This type of study is credible, reliable and useful, enabling the timely incorporation of findings, strengthen-weakness points and lessons learned to the decision-making and management processes of the organization (WHO, 2013)

The evaluation of medical imaging services in hospitals is inevitable. So, the evaluation needs to be continually and the clients of these services are at urgent need, where they are needed providing a fast and high quality services. Importance of evaluation is to identify strengths and weaknesses points which make decision makers to improve the quality of medical imaging services provided to patients

GS is one of the largest overcrowded geographical area in the world, this require a doubling of services to adapt population growth (PCBS, 2015). Israeli occupation siege imposed on the GS impact significantly on medical imaging services provided to patients.

Also, significantly increase in breakdowns of radiation equipment resulting from overload work and scarcity of resources. This effect adversely on the quality of services provided to the patients in terms of quality, long waiting time and exam-appointment. There is no known norm for updating programs and human resource skills in the medical imaging departments in the GS. Furthermore, little attention, follow-up and monitoring for medical imaging services compared with the international standards are reported in the GS.

1.4 General objective

The overall aim of this study is to evaluate the medical imaging services at governmental hospitals in Gaza Governorates.

1.4.1 Specific objectives

- To assess the availability of medical imaging equipment exist in governmental hospitals congruent with the international standards.
- To evaluate human resources capabilities exist in medical imaging departments.
- To evaluate the suitability of medical imaging departments design in governmental hospitals.
- To ascertain strengthen and weakness points in the current medical imaging services.

1.5 Context of the study

This study is conducted at the medical imaging departments in the six main governmental hospitals in Gaza Strip. Therefore, it is worthwhile to understand the circumstance that contributes in forming the Palestinian health care system's features and their effect on the Palestinian population. The researcher represented some background information about the demographical context, Palestinian population, political and Palestinian economy that may interact with each other's to influence the health situation and health care services in Palestine.

1.5.1 Demographic context of Palestine

Palestine is an Arabic Country, relatively small one, the total surface area of the historical Palestine is about 27.000 Km². Palestine has been occupied in1948 by Israel and the two remaining parts are separated geographically (West Bank and Gaza Strip) after the war in 1948. Lebanon, Syria, Jordon, Egypt, and Mediterranean Sea are surrounding Palestine (Annex 1) (PCBS, 2015). The total area of the Gaza Strip (365 Km²) and West Bank (5655 Km²) is about 6,020 Km² which represents 22% of historical Palestine area with total population living in is about 4,682,467 individuals (1,819,982 in the GS and 2,862,485 WB) with population density 778 capita per Km^2(MOH, 2015a).

1.5.2 Demographic context of Gaza Strip

GS is a narrow piece of land, located on the south of Palestine on the coast of Mediterranean sea (Annex 2). Its length from Rafah in the south to Beit-Hanoon in the north measures 50 kilometers long and 5-12 kilometer wide. GS is overcrowded area with population number 1,819,982 inhabitant and with population density of 4986 inhabitants/ Km² and about 66.8% of them are refugees as estimated by the year 2015 (Palestinian Central Bureau of Statistics-PCBS, 2015).

GS is divided into five governorates: North Governorate (362,772 inhabitants); Gaza Governorate (625,824 inhabitants); Mid-zone Governorate (264,455 inhabitants); Khan-Younis Governorate (314,393 inhabitants); and Rafah Governorate (225,538 inhabitants) (MOH, 2015b; PCBS, 2015).

1.5.3 Socio-economical context

The economic situation in the GS continued to deteriorate severely due to the siege imposed on the GS. The occupation, siege and closures have left the high densely populated the GS in a state of severe vulnerability (MOH, 2015a).

Preliminary estimates indicated a decrease in Gross domestic product (GDP) in Palestine by 2.5% during 2014 compared with 2013; GDP per capita has decreased by more than 5% during 2014 compared with 2013. The decrease in 2014 was concentrated in the major economic activities that are the biggest contributors to GDP: the agriculture activity, construction activity, services and other items activity and industrial activity.

Additionally, an exceptional level of humanitarian situation due to the intense isolation that has been taken on the GS, with managing mechanisms depleted, popular absolute poverty and an instability of civil society organizations and formal authorities to meet even the basic need of the population (MOH, 2015a)

Unemployment is critical problem in the Palestinian situation, since it has a rate of 29.3% in the year 2014. Unemployment rates in the GS is higher than WB, 40.8 % and 18.2% respectively; this situation resulted due to restrictions on Palestinian movement due to unilateral activities from Israel, and the siege on the Gaza Strip, in addition to the Palestinian Split between the WB and GS. Paid employment is the main source of income in the Palestinian territories (PCBS, 2015).

1.5.4 Palestinian health care system

Health care system in Palestine is complex, because health service delivery in Palestine is divided into five major health care providers: two public providers (the MOH and the Ministry of Interior – Military Health Services) , multiple private providers (hospitals, clinics) and numerous NGOs providers (the United Nations Relief and Works Agency-UNRWA and other local NGOs). The main provider MOH is operating 25 hospitals and 448 PHC facilities, 394 in WB and 54 in GS (PCBS, 2015; MOH, 2015c).

The main roles and responsibilities of the MOH according to the Palestinian Public Health Law is providing, regulating and supervising the provision of health care in Palestine.

Also, MOH is responsible about planning the health care services in coordination with different stakeholders, enhancing health promotion to improve the health status, developing human resources in health sector, managing and disseminating health information, and others (MOH, 2015c).

1.5.5 Governmental hospital service

MOH is the main provider of secondary care in the GS. It is responsible for 13 hospitals across the five governorates and the number of hospital beds in the GS is around 2037. The percent of hospital bed per 1000 capita is about 1.2 (MOH, 2015c). The average occupancy rate at hospitals in the GS is around 88%. The unstable Palestinian political situation increases the load on the health care services in GS and WB.

Six main governmental hospitals provided with radiological departments presenting health care services in GS. Full description about these hospitals (hospital area, employees, RTs and beds number) is given in (annex 3).

1.6 Operational definitions

- **Evaluation:** Evaluation is an assessment, as systematic and impartial as possible, of an activity, project, strategy, policy, topic, theme, sector, operational area, institutional performance. It provides evidence-based information that is credible, reliable and useful, enabling the timely incorporation of findings, recommendations and lessons learned into the decision-making and management processes of the organization (WHO, 2013).
- **Suitability of Medical Imaging Department:** Suitability of medical imaging department was addressed with area, design and structure compared to international standard.

- **Human Resources Capability: Human resources** are a system of activities and strategies that focus on successfully managing employees at all levels of an organization to achieve organizational goals (Byars and Rue, 2006). In this study Human resources capabilities were included RTs in terms of their numbers, gender, qualifications, experiences and training courses.
- **International Standard:** By reviewing several international standards, no sole standard gather all research items (human resource, structure and design, occupational health safety and essential supplies). Accordingly, different international standards (Radiological Protection Institute of Ireland (RPII 09/01), Australasian Health Facility, NHS and WHO) were used to evaluate current research items.
- **Training:** Training as the organized procedure by which people learn knowledge and skills for a definite purpose (Kumar, 2013).
- **Imaging Equipment:** The imaging equipment are the medical machines, which utilized for radiographic imaging (Conventional Radiography, Fluoroscopy, Computed Tomography, Magnetic Resonance Imaging and Radioscintigraphy).
- **Claustrophobia:** Claustrophobia is a morbid fear of enclosed or confined areas, which can result in a panic attack or anxiety hysteria (Karlsson, 2012).
- **Competent Authorities:** Competent Authorities (such the Energy Authority and MOH) are specific bodies that have the right to check medical imaging departments through structure, design, occupational health safety and radiation dose for RTs, staffs and patients.

- **Thermoluminescence Dosimetry (TLD) badge:** Consider as personnel radiation-monitoring system, these badges must be holding all the time by RTs, while they are working in the X-ray department (Palmer et al, 2011).
- **Traditional Processing Machine:** Traditional processing machine used in medical imaging department especially in darkroom. It uses a lot of chemical solution and water to developing X-ray films (Palmer, 2011; Bushong, 2013).

Chapter (2): Conceptual framework and literature review

In this chapter, the researcher illustrates the study‘s conceptual framework which reveals the main domains required for medical imaging services evaluation (as shown in Figure 2.1). It also demonstrates histories of radiology development and differences between medical imaging services in some countries. The chapter provides a comprehensive review of previous related studies.

2.1 Conceptual framework

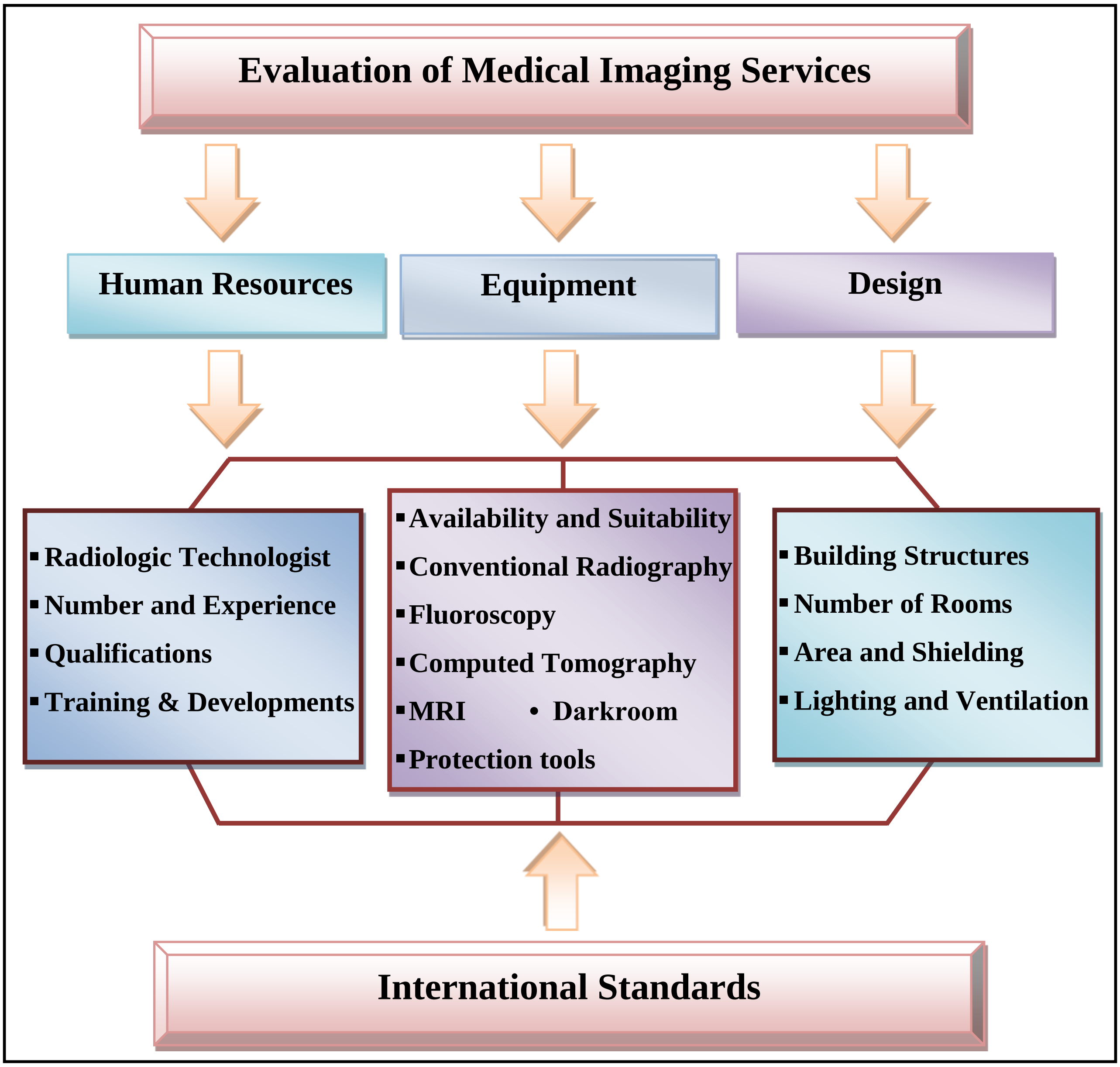

Figure (2.1): Conceptual framework-self developed

Conceptual framework is considered a basic element in the scientific research. It guides the research process, organizes the work and makes the research findings meaningful. The framework of this study was designed by the researcher based on the extensive review of the available literature about the medical imaging service. The review aimed to identify, clarify and establish data based and ascertain strengthen and weakness points in the current medical imaging services.

The researcher illustrated the evaluation of medical imaging services based on international standards. The evaluation conducted in three domains; human resources; equipment and designs. Each domain consists of various variables that affect the research subject. The study evaluated the situation of medical imaging services compared with the international standards.

2.1.1 Human resources

One of the main steps of medical imaging services evaluation is human resources. The success of any health service depends on the number of health providers, academic degree and efficiency of staffs. There is no doubt that the continuous training and development for staffs affects positively on the type of services, which provided to patients. This increases the ability to deal professionally with a variety of radiation equipment.

2.1.2 Equipment

In the evaluation process of medical imaging services, the equipment (i.e., Conventional Radiography; Fluoroscopy; Computed Tomography and MRI) considered the most important step. The equipment evaluation was conducted through several items (i.e., machine numbers, efficiency, availability, suitability, updating process…etc.).

2.1.3 Design

Design and construction of the medical imaging departments are represented the most important issues inside the hospitals where medical imaging departments need special designs differ from other departments.

Medical imaging departments need specific criteria about location in the hospital. It should be accessible for providing services. In addition, it will be in accordance with international safety standards such as number of rooms, adequate light, ventilation and radiation protective tools. All of these factors effect on medical imaging staff, as well as the quality of service provided to patients.

2.2 Literature review

2.2.1 Introduction

Medical imaging also known as radiology is process of creating visual representations of the interior body for clinical analysis, medical intervention and function of some organs and tissues (physiology). Medical imaging seeks to reveal internal structures to get proper diagnose and treatment. Medical imaging also establishes a database of normal anatomy and physiology to make it possible to identify abnormalities (Vinod and Solanke, 2016).

2.2.2 Human resources

2.2.2.1 Radiologic Technologist

RTs, also known as Medical Radiographers, Diagnostic Radiographers and Medical Radiation Technologists are healthcare professionals who specialize in imaging the human anatomy for diagnosis and treatment of pathology (Bushong, 2013).

RTs are the medical personnel who perform diagnostic imaging examinations and administer radiation therapy treatments. In addition, they perform imaging examinations and they are responsible on accuracy of patients positioning and ensuring quality of diagnostic image. They work closely with radiologists, the physicians who interpret medical images to either diagnose or rule out disease (ASRT, 2015).

2.2.2.2 Experience of Radiologic Technologists

RTs have professional responsibilities in image-production that can be described as a process involving a chain of judgments for attaining a result. This chain needs more experience and qualification. RTs need importance skills of critical reading and assessing the information in the referral before meeting the patient. In CT and MRI, the radiologist chooses the advanced examination methods. In contrast, during Conventional Radiography methods RTs will be liable to decide the appropriate method respecting to the description about patient`s medical problem (Lundvall, Dahlgren and Wirell, 2014).

Judging the patient`s communicative capacity is important. Low communication capacity due to language difficulties or functional impairment, such as hearing loss, is experienced as a challenge for RTs to manage because there is limited examination time. If not taken into account it can result in motion artifacts. Other side need experience for RTs about safety aspects comprise checking the level of radiation for children and fertile women, and ruling out counter indications such as contrast allergy or implants in the body, the latter being a particular safety risk for MRI (Larsson, Lundberg and Hillergard, 2009).

RTs need good experience to choose the appropriate apparatus protocol in relation to the selected method, the specific patient’s condition, capacity, needs, and security risks identified. They explain that their skill lies in their ability to choose the appropriate protocol, and it covers knowledge about the technology beyond button pressing, and gives them the ability to modify the parameters of the modalities when needed (Andersson et al., 2008).

Furthermore, RTs are responsible for communication with the patient during image production. They give the patient advance information about special breathing procedures during image production, and body sensations that may occur when using intravenous contrast (Ford, 2010). Additionally, evaluate the quality of the created images. Therefore, the correct anatomical area has been covered and whether the quality of the images is sufficient for visualization of the pathology. They can identify pathology but only do so in situations where it can facilitate the diagnostic process for the patient (Lundvall, Dahlgren and Wirell, 2014).

2.2.2.3 Certificates of Radiologic Technologists

Three options exist for pursuing a career as a RT: a certificate program that takes one to two years, a two-year associate's degree, or a four-year bachelor's degree. (A certificate program is especially beneficial for an individual with significant experience in medical imaging technology or who is shifting medical fields. This program typically lasts for 21 to 24 months (Vinod and Solanke, 2016).

Certificate programs are available through traditional or online courses, community colleges, technical schools, and some hospitals. (Hospital programs will usually have a condition of employment in order to gain the necessary training.) These institutions often require an intensive coursework schedule. Prerequisites to medical imaging programs may include previous medical experience and medical terminology, office technology or ethics coursework. The foundation of radiology education usually includes anatomy, chemistry, biology, radiology theory, mathematics and patient safety courses (IAEA Safety Standards, 2011). Some universities offer a bachelor's degree in Radiologic Technology. Admission to one of these programs comes with its own criteria specific to the school or country.

In Egypt, RTs graduated from the Institute of Health and Radiology Department and the study is for two years after secondary school. Recently, several private medical science colleges have been established, for which four years of study and one year of excellence have been studied (Saleem and Sabri, 2012). In Saudi Arabia, RTs should successfully undertake a degree level program at a recognized higher level education institution before undertaking further study in radiographic imaging at university for typically 2 to 3 years; this must include a year's experience in a hospital. Upon completion, graduates are qualified RTs and can commence clinical practice (Alaamer, 2012). Similarly, RTs in United States Emirate should have bachelor degree from an accredited university in a radiography, radiology technology or medical/diagnostic Imaging program or diploma in radiology (minimum of three years course duration). Other way by graduated from associate degree in radiography program (not less than 2 years course duration) and registration as radiographer (Dubai health Authority, 2013). RTs in Ireland should study for 4 years on an approved bachelor's degree program; currently, degree programs only available at University College Dublin (Prentakis et al., 2016). In Nigeria, RTs should complete a 5-year undergraduate bachelor degree and a compulsory one-year paid internship program in a hospital after graduation before attaining a full licensing by the Radiographers Registration Board of Nigeria (Ibitoye and Irurhe, 2015). In United Kingdom, there is ambiguity in the use of the term Radiographer, as this does not differentiate between Therapeutic Radiographers (also known as Radiotherapists) and Diagnostic Radiographers. As a result, all of these titles are protected titles within the United Kingdom and cannot be used by any persons who has not undertaken formal study and registered with the Health and Care Professions Council (HCPC). In order to practice Radiography in the United Kingdom candidates must now successfully obtain a pass in a degree level program from an accredited institution. Degrees are offered by universities across the UK and last for at least 3 years in England, Wales and Northern Ireland; and 4 years in Scotland (Shaw, 2004). In United States, these professionals are known as Radiologic Technologists. Formal training programs in radiography range in length that leads to a certificate, an associate or a bachelor's degree. In united states of America, the American Registry of Radiologic Technologists (ARRT) is the primary credentialing organization for Radiologic Technologists in the United States, requires that candidates for ARRT certification Exams must have an associate degree at minimum, effectively ending non-degree granting diploma programs (American Registry of Radiologic Technologists, 2016).

In the GS, before twenty years, there was no institute or university to graduate RTs. The certificates were limited to diplomas from different countries and hospitals. In the last two decades, new and exclusive faculty was established at Al-Azhar University award bachelor degrees in Medical Imaging (Al-Azhar University, 2017).

2.2.2.4 Training and developments

The significance of human resource management depends strongly on training and development. Training and development help RTs to increase their level of performance, which directly leads to increased productivity, and improved profitability to companies. Further, it helps RTs and managers to understand the most effective and efficient way of performing the job (Kumar et al, 2013).

Training and development play an important role in the effectiveness of the medical imaging departments and to the experiences of RT in work. Training is the main reason behind all the success achieved by any activity or discovery or a service, which explains the progress or failure of any society is responsible for the success of any organization or any society (Goldstein and Ford 2002). Training is an important source of preparation human resources for the development of competence to positively affect the development of the institution's performance of all different aspects. Training has implications for productivity, outcomes, health and safety at work and personal development (Goldstein and Ford 2002).

The additional responsibilities of RTs make it necessary to upgrade the educational programs to sufficiently educate students without over whelming them in the process. An ideal training should offer multiple modalities that could be included effectively. The future of the radiologic sciences depends to a large extent on the outcome of its education (Pakarinen and Jussila, 2007).

Internationally, there are recognized programs for the training and qualification of RTs. Some of these schemes may include only a limited amount of training in radiation safety. In this case, they should be supplemented with additional training specifically in protection and safety from MOH or NGOs. RTs should ensure that their knowledge and skills are kept up to date through a program of refresher training. Such training should include a review of the fundamentals of protection and safety, and information on changes to equipment, policies and procedures, and possible changes in regulatory requirements (Espen et al., 2006).

All organizations employing people need to train and develop their staff. Most organizations are cognisant of this requirement and invest effort and other resources in training and development. Such investment can take the form of employing specialist training and development staff and paying salaries to staff undergoing training and development. Investment in training and development entails obtaining and maintaining space and equipment (Goldstein and Ford 2002).

2.2.3 Structure and design

2.2.3.1 Location of medical imaging services

Medical imaging services are organized as one central department, which serves emergency, outpatients, and inpatients. Several factors should be considered when determining the location of medical imaging services within hospital. This service should be strategically located to maximize efficiency in usage. As RTs is constantly changing and creating new methods of medical imaging services are being developed, consideration should also be given to the high probability that the area will require renovation, expansion and equipment replacement in the future. It is frequently more cost effective to expand an existing medical imaging service than to relocate the service completely (Siegel, 2008).

The main medical imaging service should be readily accessible to both inpatients and outpatients, and in proximity to the central vertical transportation system serving other areas of the medical facility. It should be located near ambulatory care, outpatient services, and emergency department (Shoaib, 2013) .

Patient waiting areas should be located near the main entrance to the service and provide direct access to imaging rooms and dressing rooms. Patient holding areas should be located near high volume modalities. For those modalities that require patient preparation, thought should be given to the volume of patients requiring special preparation. Moreover, it should evaluate the advantageous to provide dedicated preparation areas for activities such as starting intravenous medications or inducing anesthesia patients (Siegel, 2008).

The location, structural design and equipment layout of medical imaging department should carefully consider from a radiation protection perspective. This is easier when medical imaging facilities are not designed as stand-alone rooms and are planned as part of an integrated medical imaging department with its supporting areas and services. Planning the room layouts should start as early as possible in the design process and be based on inputs from a team including architects, engineers, hospital management, radiologists, radiographers, other consultant medical staff such as cardiologists or vascular surgeons where relevant, and once identified, the equipment supplier.

2.2.4 Equipment

2.2.4.1 Conventional Radiography

Conventional Radiography is the use of X-rays to visualize the internal structures of a patient. X-Rays are a form of electromagnetic radiation, produced by an X-ray tube. The X-rays passed through the body and captured behind the patient by a detector; film sensitive to X-rays or a digital detector. There is variance in absorption of the X-rays by different tissues within the body, dense bone absorbs more radiation, while soft tissue allows more to pass through. This variance produces contrast within the image to give a 2D representation of all structures within the patient (WHO, 2016).

The advantages of Conventional Radiography are relative inexpensiveness and the possibility to obtain virtual images anywhere by using mobile or portable machines. The disadvantages of this modality are limited such as range of densities that can demonstrate and the use of ionizing radiation (Meštrović, 2016).

2.2.4.2 Fluoroscopy

Fluoroscopy is an imaging modality that uses X-rays to allow real-time visualization of body structures. During Fluoroscopy, X-ray beams continually emitted and captured on a screen to produce real-time and dynamic image. This allows for dynamic evaluation of anatomy and function. High-density contrast agents may be introduced into the patient to allow for greater differentiation between structures (WHO, 2016).

The uses of Fluoroscopy include positioning of orthopedic implants during surgery, catheters and pacemakers, viewing the movement of contrast agents, such as barium, through the body and studying the movement of parts of the body. Through Fluoroscopy, an X-ray beam is passed through the body but instead of being registered on film, the image is displayed on a fluorescent screen. Modern versions digitize the image using ‘flat panel’ detector systems, which reduce the radiation dose required (Jonas, 2011).

2.2.4.3 Computed Tomography

Computed Tomography has been available since the mid-1970s and has revolutionized medical imaging. Today, millions of scans are performed worldwide every year for different clinical questions in a variety of clinical fields. In emergencies for example, CT is widely used as it can provide information very quickly (WHO, 2016).

CT is an imaging modality that utilizes X-ray photons for image production, with digital reconstruction. The CT scanner essentially consists of an X-ray tube and detectors. The X-ray tube produces an X-ray beam that passes through the patient. In this modality, X-ray beam captured by detectors and then reconstructed to create two or three dimension image (WHO, 2016).

CT plays very important role in emergencies when diagnosing strokes, brain injuries, heart disease and internal injuries. In addition, CT considered as one of the very important diagnostic tools that conducted to diagnose cancer and to obtain follow-up examinations for different clinical questions. For a CT scan, the radiation exposure is higher than for a Conventional Radiography examination. On other side, CT scan delivers additional detail and information (Jonas, 2011).

2.2.4.4 Magnetic Resonance Imaging

MRI systems use a powerful magnetic field and radiofrequency pulses to produce detailed images of the body’s structures. The created image is as cross-sectional section or slices without exposing the patient or staff to ionizing radiation (Jonas, 2011).

MRI is considered a medical imaging service that used in radiology to provide real-time, three-dimensional views of body organs with good soft tissue contrast, making visualization of brain, spine, muscles, joints and other structures excellent. It is multi-planar, which means that images can be obtained in multiple body planes without changing positions. When undergoing MRI examination, the patient is asked to remove metallic objects including watches, jewelry and piercings. Surgical implants and other foreign bodies must be carefully evaluated for MRI safety. The patient will hear loud noises and earplugs during time of exam (WHO, 2016).

2.2.4.5 Darkroom

The darkroom is an essential part of medical imaging departments. Room's entrance should be carefully designed to avoid over expose of X-ray films. Lightproof mazes, rotating doors, interlocks, and double entry doors are used to eliminate the possibility of exposing undeveloped film to light. It should have suitable temperature and humidity to avoid artifacts (Fosbinder and Orth, 2012).

It is important that the darkroom be designed to make film processing efficient and precise. Since processing procedures are carried out in near total darkness, every piece of equipment must be in its specific place. For efficiency's sake, the room should be large enough to avoid crowded conditions and the equipment should be arranged to expedite the flow of work and be within arm's reach (Bushong, 2013). Darkrooms do not have to be totally dark, but the light level must be very low (safelight). Safelights provide low-level illumination without exposing and damaging the film.

A safelight contains a low-wattage (7–15 W) light bulb with a special filter to maintain low light intensity. The safelight must be more than one meter from the bench to prevent safelight fogging of the film (Siegel, 2008). Half of a uniformly exposed but undeveloped film is covered with a piece of cardboard, and the film is left on the darkroom table under the safelight for 2 minutes. The film is then developed during processing machines (Bushong, 2013).

2.2.4.6 Protection tools

The exposure for radiation in X-ray procedures must be ALARA with consideration of the expected goals of the procedure, economy, and social factors. Personal radiation protection tools are made of lead and rubber, and is used to cover parts of body that are not in the primary radiation beam, for the patient and the accompanying persons. It includes lead aprons, gonad shields of various sizes, thyroid collars, gloves, and glasses (Goske et al., 2011).

Lead apron

Lead protection tools should always be used during radiographic procedures: the choice of protection depends on the part being examined. It is important not to cover/ obscure the examined part, but all others parts must be protected. Lead protection must be at least 0.25 cm thick for staff and accompanying persons, and there must be at least 0.5 cm of lead shielding for any body part that may enter into the direct radiation beam, which is not under investigation. For gonadal shielding, 1 cm of lead is used (Klavs, Pašagić and Kotar, 2016). Regarding protective lead gloves, shielding gloves like lead apron containing up to 0.33 mm of lead. Wearing gloves reduce dexterity; consequently, if it used inappropriately, will produce significant hand doses and greater body (Fosbinder and Orth, 2012).

Thyroid collar

Minimize risks of X-ray for patients and health operators by using high-quality thyroid shields during imaging procedures. Several common thyroid conditions can have potentially devastating impacts on a patient's health. Lead thyroid collars prevent harmful exposure to this sensitive gland (Romans, 2011).

Gonadal shielding

The same lead-impregnated material used in aprons to fabricate gonadal shields. Gonadal shields should be used with all persons of childbearing age when the gonads are in or near the useful X-ray beam and when use of such shielding will not interfere with the diagnostic value of the examination (Bushong, 2013)..

Thermoluminescence Dosimeter (TLD)

TLD are the most common for radiation monitoring among RTs and other health providers. The badge is comprised of a TLD card, which is placed in a holder that incorporates a filter system. This allows the radiation type and energy to be determined. It is used to determine the whole body exposure of people who may be exposed to radiation (i.e. X-rays or gamma). It can be hold for 4 to 12 week period wearing period depending on the work carried out and the risk to the operator. TLD is used by anyone who may be exposed to significant doses (Holmes, Elkington and harris, 2014).

The monitor consists of a small plastic sachet containing a TLD, which can be chemically disinfected if necessary. The doses are determined by the measurement of the light output from the TLD card. Thermoluminescent materials store energy inside their structure when they are irradiated, as electrons and holes are trapped in trapping centers due to crystalline defects. When that material is heated, electrons and the positive atom recombine, at luminescence centers, and thus light is emitted. The light is measured using a photomultiplier tube inside the reader device. The photons, which emitted are in the visible region and they comprise the TLD signal (Fosbinder and Orth, 2012).

2.2.5 Shielding of medical imaging department

Regarding ionizing radiation, which includes Conventional Radiology, Fluoroscopy and CT. The purpose of Rooms shielding designed are to prevent the transmission of radiation through the room walls. Almost Conventional Radiography, Fluoroscopy, and CT rooms have shielding in at least some of the walls. The required shielding is specified in terms of thickness of lead or concrete. The thickness of the protective barrier depends on the distance from the radiation source, the workload, the use of the space on the other side of the wall, and the amount of time the beam is pointed at the wall (Bushong, 2013).

In conventional room walls is 2.9 mm of lead. Fluoroscopy and CT, required thickness of lead more than 3 mm. The control booth also has a window for viewing the patient during the exposure. This window can either be made of glass or clear plastic that is impregnated with 30% lead by weight (Fosbinder and Orth, 2012).

On other side / non ionizing radiation (MRI); all current MRI rooms requires Radio Frequency (RF) shielding. This shielding prevents incidental RF energies from entering the scan room and disrupting the MR acquisition process. RF shields may be constructed of thin sheets of copper foil, galvanized steel or aluminum. RF shield assemblies must be contiguous on all sides, floor and ceiling. All provided doors and windows in the MRI scanning room must be RF shielded. Similarly, all penetrations into the RF shielded enclosure (including power, air conditioning systems, exhaust, piping, and plumbing) must pass through special RF filters or wave guides. RF shielding typically provides no attenuation of the magnetic fields, which will penetrate standard forms of construction. (Fosbinder and Orth, 2012; Siegel, 2008).

2.2.6 International standards

2.2.6.1 Radiological Protection Institute of Ireland (RPII 09/01)

The Nuclear Energy Board first published the original code design of Diagnostic Medical Facilities Practice the using ionizing radiation in 1988. In the intervening years, the 'Blue Book' as it became known has served the medical community well as the sector has expanded and modernized in Ireland. There have been significant developments since its publication in terms of the underlying radiation protection legislation, regulatory practice as well as developments in new technologies that have given rise to the need for a revision of the Code.

The revised Code includes a brief review of the current legislative framework and its specific impact on the management of building projects, a presentation of the main types of radiological and nuclear medicine facilities, a treatment of the technical aspects of shielding calculations and a discussion of the practical aspects of implementing shielding solutions in a building context.

The primary purpose of the Code is to assist in the design of diagnostic facilities to the highest radiation protection standards. Peer editing on the code to ensure the safety of workers and members of the public and the delivery of a safe service to patients. Diagnostic radiology is a dynamic environment, and the code is intended to be used in consultation with the current literature, an experienced radiation protection adviser and a multidisciplinary project team.

2.2.6.2 Australasian Health Facility (Australasian HFG)

The Australasian Health Facility Guidelines (AusHFG) represent a significant body of freely available intellectual property, contained within practical resources suitable for application to all Australian and New Zealand jurisdictions. The AusHFG:

- A vital starting point for design based on research, clinical and consumer input and other evidence - saving hundreds of hours of effort for designers, managers, constructors and clinicians on all public health infrastructure projects to which they have been applied, since their release eight years ago.
- Provide flexible facility responses to allow the delivery of current and emerging models of care, making health assets fit for current and future purposes.
- Support more consistent understanding of terminology across the industry and is a resource that synthesizes information across the wide spectrum of models of care being applied in Australia and New Zealand
- Provide clarity to industry on issues of Australian and New Zealand significance for example facilities for the care of bariatric patients, Tele-health trends and implications of infection and prevention control policy for all facilities design which include (i.e. medical imaging facilities design).
- Provide robust and practical tools that provide a common language for use in all jurisdictions and can help transform the clinical service delivery landscape for providers
- It is a central resource for all government and non-government bodies that helps to reduce project costs, improve timeliness and importantly expose health facility planners and clinical service providers to new and better ways of approaching problems
- Help disseminate current industry knowledge regarding good health facility design and accepted clinical practice in a format accessible to project design teams on all health projects

Chapter (3): Methodology

3.1 Introduction

This chapter illustrates the methodology used to conduct this study. It includes the study design, study population, period and place of the study, sample size, ethical and administrative consideration. The methods of data collection, tools, data processing and analysis and finally the limitations of the study were also explained in this chapter.

3.2 Study design

The design of this study was descriptive, analytical cross-sectional one with a triangulated design (quantitative and qualitative). This design is chosen because it is the best design to describe and evaluate status of medical imaging services at governmental hospitals. Analytic research generates new knowledge about concepts and identifies relationships between variables (Burns and Grove, 2001). Cross sectional design reflects the existing facts at the same point of time of data collection, it is less expensive and it consumes less time than other longitudinal studies. In this study, methodological triangulation would provide combination between **quantitative** (self-administered questionnaire with RTs in addition to special checklist developed based on international standard) and **qualitative** paradigms (in depth interviews with key RTs managers) to validate findings from one method with another, or to enhance understanding of the facts on the ground (Donovan and Sanders, 2005).

3.3 Study population

Medical imaging departments, RTs and equipment at the six main governmental hospitals were evaluated.

3.4 Sampling method

All Medical imaging departments, RTs and equipment at the six main governmental hospitals were included in the current study (census study).

3.5 Study setting

The study was conducted at the medical imaging departments of six main governmental hospitals in the GS (Al-Shifa, European Gaza, Indonesia, Shohda Al-Aqsa, Nasser and Abu Yousef Al Najjar Hospitals).

3.6 Study period

The study had started immediately after having the university academic approval of the proposal and obtaining the ethical approval from the Helsinki in July 2016. Upon the approval, the researcher prepared the required tools of his study in addition to the demographic questions. The researcher extracted findings, created descriptive tables and performed inferential statistical analysis. After finishing quantitative part, qualitative data collection started in January 2017. The researcher stayed about 3 weeks in collection and analysis of the qualitative data. The final draft for defense was handed by the end of February 2017.

3.7 Eligibility criteria

3.7.1 Inclusion criteria

All medical imaging departments that are already exist and provide medical imaging services for patients at the six main governmental hospitals were included in the current study. In addition, all permanent, contract and volunteer RTs at the selected medical imaging services were included.

3.7.2 Exclusion criteria

In the current study, the researcher excluded some medical imaging modalities (such as mammography, ultrasound and dental panorama). The Mammographic and Panoramic machines have specific limitations and privacies and are not provided in all six main hospitals. The Ultrasound was excluded because is not under RTs duties and responsibilities. Finally, all trainees were excluded from the current study.

3.8 Ethical and administrative considerations

The study approval was received from Al- Quds University, an official letter of approval from the Helsinki committee in Gaza was obtained (Annex 4). Additionally, Formal letters were sent through the university to official MOH directorates mentioning the title of the research and name of researcher (Annex 5). The official MOH directorates were formally contacted to obtain their approvals to conduct the study at MOH hospitals (Annex 6).

Full explanatory form about research was attached to each questionnaire (the title of the study, purpose and other related information). The right to participate or not, confidentiality, anonymity of collected data were completely maintained and respected (Annex 7).

3.9 Study instruments

The researcher used three data collection tools in this study; the first and second were arbitrated questionnaire and checklist that arranged as quantitative part; meanwhile the third tool was face-to-face key informant interviews as a qualitative part. All three tools were prepared to evaluate human resources, medical imaging equipment and medical imaging departments' designs. Both of quantitative and qualitative tools were conducted at the six main governmental hospitals (Indonesia, Al-Shifa, Shohda Al-Aqsa, European Gaza, Nasser, and Abu Yousef Al Najjar Hospital).

The first type of data collection was self-developed questionnaire (Annex 8) designed to be clear and free from complex and leading questions. The questionnaire was validated by a group of experts and was subjected to piloting to ensure credibility of answers. The study questionnaire was divided into two parts:

- The first part contained characteristic data about the participants, which was personal and work related data: age, gender, residency place, qualification, training courses, years of experience, hospital name…etc. (10 questions).
- The second part contained equipment information about Conventional Radiography, Fluoroscopy, CT and MRI. The data was included: machine numbers, machine types, machine status, maintenance checkup, annual breakdown and image types (15 questions).

The second type of data collection was checklist developed by the researcher based on international standards "Australasian Health Facility Guidelines", "radiological protection Institute of Ireland" and "National Health Services. The Arbitrated checklist was included close-ended questions about medical imaging departments (Annex 9).

The questions focused on three main factors (structure, OHS, reception) of medical imaging department in general, Conventional Radiography rooms, Darkrooms, Fluoroscopic rooms, CT and MRI departments, respectively.

The key informant interviews were used as a third data collection method. Semi structured, open-ended statements were performed (Annex 10). Three experts were selected to conduct in-depth interviews to dig beneath of the elicited quantitative data, make deep understanding and generate new ideas, and give more evidence towards their perception. It is worthy to mention that interviews were conducted in Arabic language and then translated to English.

3.10 Pilot study

A pilot study conducted on 17 RTs at Indonesia Hospital to explore the appropriateness of the study instruments and let the researcher train for data collection, the clarity of meanings, scales, and the time taken to fill the questionnaire and for expecting response rate. Based on this stage, further improvement in the study validity and reliability was achieved. The participants of the pilot study were included in the total actual study.

3.11 Response rate

The response rate for this study was 95.5 %, where, the total number of the participants was 170 out of 176 RTs.

3.12 Data collection

The researcher using arbitrated questionnaire and checklist to collect the first part of data (consumed about 2 months). Participants were given complete instructions about the purpose of the study and how they were included in the sample after obtaining the consent form. The questionnaires were collected directly by the researcher through face to face with each RT. The researcher gave the participants enough time to answer the questions and encourage them to be open and virtuous in answering while assuring them that information given will be remained confidential and just used for the purpose of the study. To ensure exact and real answer by the participants, the researcher simplified any vague information. The researcher conducted the checklists during the daily work.

The researcher revised the filled questionnaires and checklist. In average, questionnaire and checklist were filled through 10 and 35 minutes, respectively.

The researcher conducted the key informant interviews. The interviewees were contacted alone, face-to-face and the average period time for each interview ranged from 30-45 minutes. All of them were informed about the purpose and the main features of this study.

The interview was semi-structured and included a series of open-ended questions with follow-up probes. Notes that were taken through the interviews were recorded to allow further capturing of information. The interviews focused on the following domains; status of medical imaging services such as structural design, OHS and essential supplies compared with international standard. The interview's questions compared medical imaging services provided to patients before and after 1996 (this date was selected by the medical imaging managers, and is related to the starting of developing imaging departments by MOH). Finally, the medical imaging departments also compared with international standards.

3.13 Validity and reliability

3.13.1 Face validity

The researcher organized the questionnaire in a way that enables the readers to read it easily. The layout of the questionnaire in addition to its structure and its shape was highly professional.

In addition of being the tools of the questionnaire were tested, ten experts in related fields evaluated all the components and the context of the instrument, in order to ensure that it is highly valid and relevance and their comments were taken in consideration. The questionnaire was nicely formatted in order to ensure face validity, this including appealing layout, and logical sequences of questions and clarity of instructions. Also, a pilot study was conducted before the actual data collection to examine employees' response to the questionnaire and how they understand it.

3.13.2 Content validity

Content validity is a subjective estimation of measurement rather than statistical analysis, in order to validate the instrument used. It was done before data collection, by sending the questionnaire with a covering letter to ten experts from different backgrounds; MOH managers, academics and health experts. They were asked to validate the questionnaire in relation to study objectives. Feedback was obtained from all experts (Annex 11).

The validity of the qualitative key informant interviews data was assured by the following actions: going back to respondents (member check) to make sure that the analyzed data was correctly interpreted and low-inference description by using description phrased closed to respondent's accounts.

3.13.3 Reliability

Reliability signifies the issue of consistency of measures, that is, the ability of a measurement instrument to measure the same thing each time it is used (Singh, 2007). The following steps will be done to assure instruments reliability:

- Standardization of the method of data collection was guarantee.
- Then, the data entry in the same day of data collection would allow possible interventions to check the data quality or to re-fill the questionnaire when required – Re-entry of 5% of the data after finishing data entry will assure correct entry procedure and decrease entry errors.

The trustworthiness of the qualitative part was checked by;

- A peer checks through professional experts to review the analyzed data and assure similarity or appropriateness meaning among the peer.
- A member check was done to assure accuracy and transparency of the transcripts during the interviews. In addition, a description of the interviewees' characteristics (location, position, and experience) was done (Annex 12).

3.14 Data management and analysis

3.14.1 Quantitative part

After data collection, the researcher revised the questionnaires, coded them and entered the data into the computer software Statistical Package of Social Science (SPSS) program version 20. Data entry was done day by day to avoid unexpected problems. Data cleaning was done through checking the frequencies of all variables. The questionnaire was analyzed by the quantitative analysis tests. General frequencies were done to figure the response and missing data for each question. To examine the relationships between independent (categories) and dependent variables (numeric scores), inferential statistical tests were made including chi square to reveal the relationship between RTs experience and holding TLDs. Pearson correlation test was used to detect relationship between patient waiting time and number of examinations at morning shift and other relations. Differences among variables were regarded as statistically significant when the P value was lower than 0.05.

3.14.2 Qualitative part

After completing the analysis of quantitative data, the collected qualitative data was analyzed using the coding and thematic analysis approach. In the current study, three key informants experts were interviewed (each alone) to enrich the evaluation process. The key informants were selected based on their known experiences, knowledge and positions in medical imaging administration of MOH. Before each interview, the researcher gave full explanations about the study objectives and the scope of the questions. The interviews were audio recorded, and data were transcribed verbatim to facilitate analysis. All interview transcripts were read many times to get a sense of the data and to review for emerging themes. A coding list was developed and revised as data were reviewed. Data for each code reviewed and compared with other codes. Finally, the researcher identified the questions related to this study and link with concerned collection data.

3.15 Limitations of the study

The limitations of the current study were:

- The difficulties of data collection related to the daily work overload.
- Recurrent electricity cut off limits the access hours into internet.
- Limited access to scientific resources as textbooks, articles and journals.
- Lack of resources, especially time and budget.

Chapter (4): Results and discussion

4.1 Introduction

This chapter presents the results of the statistical analysis obtained from the collected data and the interpretation of these results. The analyses started with general description about demographic characteristics of RTs. The evaluation of the medical imaging services were involved three main categories. Firstly, the researcher presents the evaluation for human resources related to RTs (i.e., academic degree, training efficiency). Then, the equipment were evaluated through machine numbers, suitability, availability for population and updating process. Finally, results were compared with the international standards in respect to department design, structure, lighting, ventilation and radiation protection. It is worthy to mention that the current chapter displays the analysis of three research tools (questionnaire, checklist and key informant interview).

4.2 Descriptive statistics

4.2.1 Demographic characteristics

Table (4.1): Distribution of RTs by characteristics variables (N=170)

Variables		**Frequency**	**%**
Age groups	< 30 years	34	20
	30- 40	94	55.2
	40- 50	21	12.4
	>50 years	21	12.4
Employment	Permanent	147	86.5
	Contract	17	10
	Volunteer	6	3.5
Experience	<10 years	62	36.5
	10- 17	74	43.5
	17- 24	16	9.4
	> 24 years	18	10.6

The total number of distributed questionnaires was 176 and the number of respondents was 170 with a response rate of 95.5%. The first section is planned to analyze the demographic characteristics of the study sample (Radiologic Technologists) N=170 including (Name of hospital, Age, Gender, Certificate, Employment, Years of experience, Training).

Table 4.1 clarifies that 20 % of RTs aged less than 30 years, 55.2% between 30-40 years, around 12.4% between 40-50 years and the same percentage for those older than 50 years. The current results showed that around 75 % of the RTs aged less than 40 years and around 25% older than 40 years. It is known that medical imaging services need special effort, skill and tolerance (heavy-duty and experience). The current readings presented multiplicity in ages of RTs, which facilitate process of department's management. In addition, around 86.5% of RTs were permanent employees, and 10% of them were contracts, and six (3.5%) were volunteers. Finally, 36.5% of RTs have less than 10 years' experience and 43.5% of them have 10-17 years' experience, while 9.4% of RTs have 17-24 years' experience and 10.6% more than 24 years' experience.

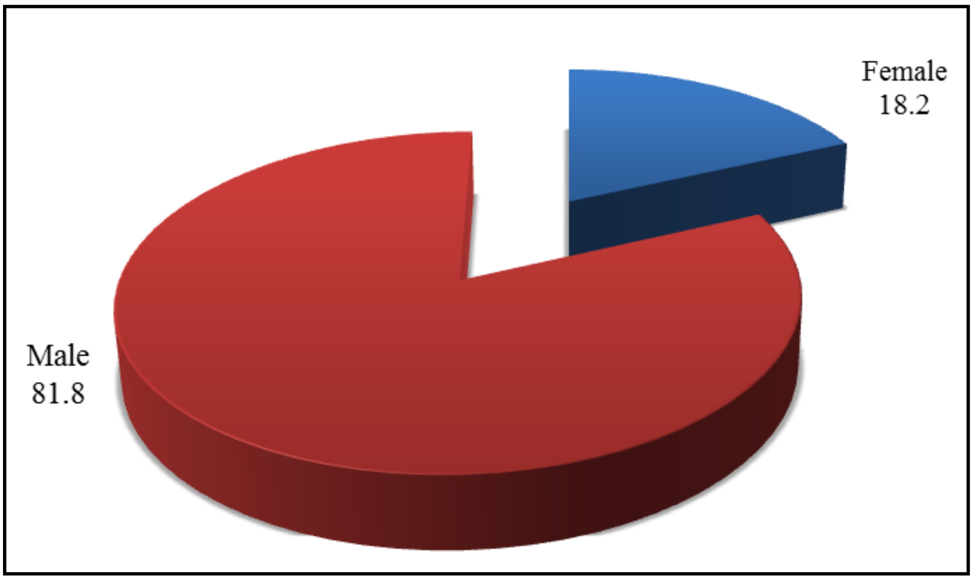

Figure (4.1): Distribution of RTs due to gender

Regarding to participants gender, the majority of RTs were males (81.8%), while 18.2% were females as shown in Figure 4.1. The current results are completely different from the international readings (60-70% female and 30-40% male) (Owen et al, 1995). This may attribute to:

- The decision makers avoiding female recruiting due to the pregnancy implications (maternity and feeding leave)
- Females seeking for morning shift and refused to work at the evening and night shifts.
- Common fear about the negative effect of ionizing radiation on female particularly pregnant.

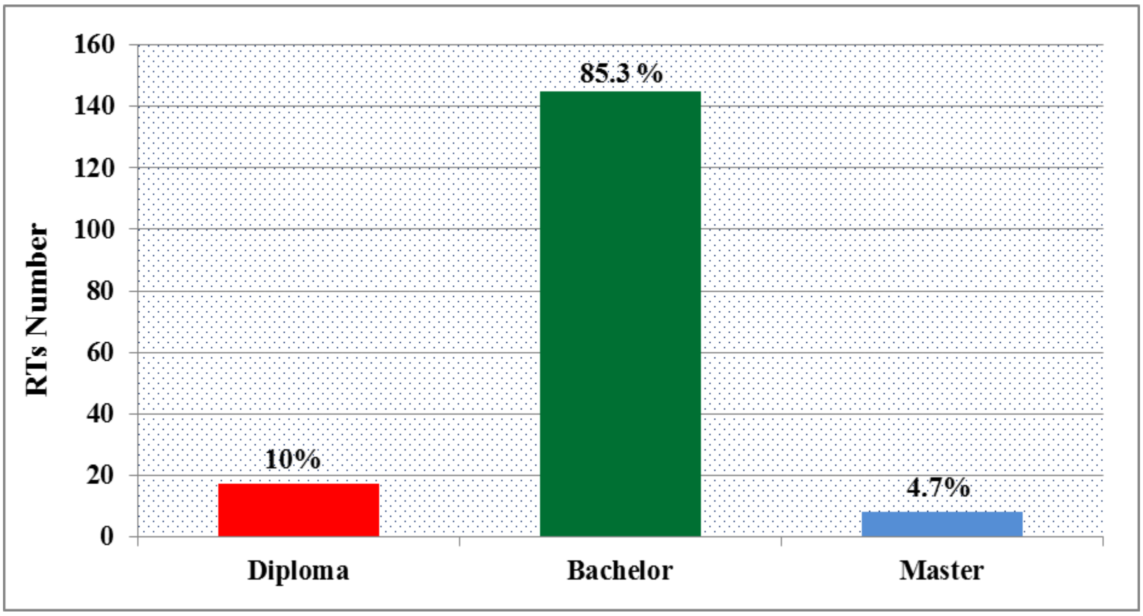

Figure (4.2): Distribution of RTs educational qualifications

Figure 4.2 displays the RTs qualification at the main governmental hospitals. Obviously, the majority of the RTs have bachelor degree (85.3%), 10% have diploma degree and only 4.7% have master degree. The current results are convenient with the interview carried out with Medical Imaging Administration (MIA, 2017). Based on MIA, before 1996 the majority of RTs had diploma degree (more than 95%) and only two RTs had bachelor degree. Nowadays, more than 85% of RTs have bachelor degree (MIA, 2017).

The improvement of RTs qualification may attribute to:

- Many of RTs graduated from different countries with high university degrees.

- The initiation of new faculties in the Palestinian Universities awarding high degrees related to medical imaging.

Table (4.2): RTs distribution among medical imaging departments at governmental hospitals

Hospital name	Frequency	Percent %
Indonesia	20	11.7
Al-Shifa	55	32.4
Shohda Al-Aqsa	21	12.4
European Gaza	28	16.4
Nasser	29	17.1
Abu Yousef Al Najjar	17	10
Total	**170**	**100**

Table 4.2 clarifies that 55 (32.4%) of RTs were worked at Al-Shifa Hospital, which is highly expected as being the biggest hospital in the GS. Consequently, around 16.4% of RTs at Nasser Hospital, 17.1% at European Gaza Hospital, 12.4% at Shohda Al-Aqsa Hospital, 11.7% at Indonesia Hospital, and finally 10% at Abu Yousef Al Najjar Hospital. Based on MIA, before 1996 the total number of RTs at governmental hospitals was 45 and they were distributed in three hospitals as 25, 12 and 8 at Al-Shifa, Nasser and El-Nassr pediatric hospital, respectively. Nowadays, number of RTs became 210 and allocated at eight governmental hospitals (six main, two pediatric and two small hospitals) (MIA, 2017).

4.2.2 Radiation monitoring

Table (4.3): RTs having TLD badge

TLD badge	Frequency	%
Yes	143	84.1
No	27	15.9
Total	**170**	**100**

TLD badge: dosimeter holds by RTs to determine absorbed radiation dose.

Table 4.3 shows that 143 (84.1%) of RTs have Thermoluminescence Dosimeter (TLD) Badge, and 27 (15.9%) have not. Based on international standard, it is obligatory to provide RTs with at least two TLDs (ICRP, 2007). In the current study, the RTs who did not have TLDs attributed to:

- Some of them lost their TLDs.
- New contracted RTs (after 2008) not provided with TLDs.

Table (4.4): RTs who holding and checking TLDs

Item	Holding TLD		Checking TLD	
	Frequency	Percent	Frequency	Percent
Yes	80	55.9	141	98.6
No	63	44.1	2	1.4
Total	**143**	**100**	**143**	**100**

Table 4.4 describes the practice of RTs toward holding and checking TLDs. The results explored that 80 RTs (~56%) holding TLDs, and 63 (~44%) not holding it. Furthermore, the majority of RTs checked their TLDs (98.6%), but around ~ 43% of RTs checked the TLDs although they did not holding it. This interrupted practice may be attributed to the doubt of RTs toward the precision of TLDs readings.

Table (4.5): Training courses

Training courses	Frequency	%
Conventional Radiography	170	100
Computed Radiography	141	82.9
Fluoroscopy	166	97.6
Computed Tomography	129	75.9
Magnetic Resonance Imaging	31	18.2
Others	3	1.8

Table 4.5 shows that all RTs received training courses in Conventional Radiography, 82.9% received training courses in Computed Radiography, 97.6% received training courses in Fluoroscopy, 75.9% received training courses in CT, 18.2% received training courses in MRI, and only 1.8% received training courses in other modalities (i.e., radiotherapy, isotopes, ESWL…etc.). Based on MIA, before1996 there were no training courses or continuous education programs. However, in the last decade, training courses have conducted in special departments at MOH and Palestinian Universities (MIA, 2017).

4.3 Evaluation of medical imaging equipment in medical imaging departments at governmental hospitals

4.3.1 Availability of medical imaging equipment

Table (4.6): Frequency of functioning medical imaging equipment at governmental hospitals

Medical imaging machine \ Hospital		Indonesia Hospital	Al-Shifa Hospital	Shohda Al-Aqsa Hospital	European Gaza Hospital	Nasser Hospital	Abu Yousef Al Najjar Hospital	Total
Conventional Radiography	Functioning	1	2	5	2	2	2	14
	Not Functioning	0	0	1	0	1	0	2
Fluoroscopy	Functioning	0	0	1	0	1	1	3
	Not Functioning	1	1	1	1	0	0	4
Computed Tomography	Functioning	1	0	3	1	0	0	5
	Not Functioning	0	1	0	0	1	0	2
Magnetic Resonance Imaging	Functioning	0	0	1	1	0	0	2
	Not Functioning	0	0	0	0	0	0	0

Table 4.6 clarifies the availability of the main four imaging equipment (i.e., Conventional Radiography, Fluoroscopy, CT and MRI) at governmental hospitals. Starting with Al-Shifa Hospital, five Conventional Radiography machines are available (the sixth one is used as spare part machine), two Fluoroscopic machines (one is used as spare part machine), three

CT machines and only one MRI. In European Gaza Hospital, there are two Conventional Radiography machines, one Fluoroscopic machine (is not working for long time), one CT machine, in addition to one MRI.

In Nasser Hospital, there are three Conventional Radiography machines (almost two working machines and one is not working), one Fluoroscopic machine, and one CT machine which is not working at time of data collection. In Shohda Al-Aqsa Hospital, two Conventional Radiography machines are available, one fluoroscopic machine and one CT machine but both of them were not working during our data collection. Regarding Indonesia Hospital, only one Conventional Radiography machine, one fluoroscopic machine (not working) and one CT machine are available. Finally, in Abu Yousef Al Najjar Hospital there are two Conventional Radiography machines, and one fluoroscopic machine.

Table (4.7): Clarify image types, machine types and manufacture product of medical imaging machines at governmental hospitals

Item		**Conventional Radiography**	**Fluoroscopy**	**CT**	**MRI**
		No.	No.	No.	No.
Image types	X-ray Film	9	2	0	0
	CD	1	4	7	2
	X-ray Film and CD	6	1	0	0
Total		16	**7**	**7**	**2**
Machine types	New machine	9	6	7	2
	Used machine	7	1	0	0
Manufacture product	General electric			1	
	Care stream	1			
	HITSHI	1			
	SHIMADZU	8	2		
	SIEMNS	4	4	3	1
	PHILPS	2	1	3	1

CD: Compact Disc used to save the created image instead of X-ray film

Table 4.7 describes technical description about available machines at governmental hospitals. Around 56.2% of the recording images in Conventional Radiography use conventional X-ray films, 37.5% mixed X-ray film and CD for imaging and 6.3% use only CD.

During the last decade, MOH introduced Computed Radiography devices. Therefore, there is a tendency to use Computed Radiography instead of traditional radiograph (MIA, 2017). Obviously, the utilizing of CD technique (digitalize system) at governmental hospitals instead of x-ray film was increased. The digitalized system reduces the use of traditional processing machines, which have proved negative health effects on RTs (Alajerami and Sirdah, 2008). Moreover, 56.2% of Conventional Radiography machines installed as new machines, and 43.8% as used ones. Furthermore, half of the Conventional Radiography machines were SHIMADZU product, 25% SIEMNS product, 12.5% PHILPS product and 6.3% CARE STREAM product, and the same percent for HITSHI product.

Regarding the Fluoroscopy, around 57% of image recording were CD, 28.5% film, and 14.2% mixed film and CD. In addition, 85.7% of Fluoroscopy installed as new machines, and 14.2% installed as used ones. Around 57.1% of Fluoroscopic machines were SIEMNS product, 28.5% SHIMADZU product, and 14.2% PHILPS product.

All available CT machines are new and provided with CD recording image. Around 86% of them were SIEMNS and PHILPS product, and 14% are GENERAL ELECTRIC product.

The Forth modality is MRI, and the readings exhibited that images recording were CD, one machine is SIEMNS product and the other is PHILPS product. Based on MIA, there is an enhancement in medical imaging services by providing departments with Computed Radiography. The Computed Radiographies has the ability to reduce patient dose and improve images quality. The computerize systems can transport digitalize images between departments and facilitates (Tele-radiography technique). This system saves the patient's files and images. Furthermore, Computed Radiography is cost-effective compared with the traditional processing machines that use chemical substances, which have health hazards (MIA, 2017).

Table (4.8): X-ray machines existing at governmental hospitals compared to the international standards

Hospital	No. of beds	Required No. of x-ray machines	Existing x-ray machines
Indonesia	110	2.2	1
Al- Shifa	583	11.6	6
Shohda Al-Aqsa	261	5.2	2
European Gaza	261	5.2	2
Nasser	330	6.6	3
Abu Yousef Al Najjar	49	1	2

Table 4.8 demonstrates the status of X-ray machines compared with the international standard. Based on equation 4.1 (Bushong, 2013), the number of X-ray machines is directly proportion with the number of hospital beds.

$$\text{Required number of X- ray machines} = \frac{\text{Number of hospital beds}}{50} \qquad (4\text{-}1)$$

Based on 4-1 equation, it is clear that all hospitals suffer from shortage of X-ray machines except Abu Yousef Al Najjar hospital. Accordingly, the required number of X-ray machines should be at least 2, 11, 5, 5, 6 and 1 in Indonesia, Al- Shifa, Shohda Al-Aqsa, European Gaza, Nasser and Abu Yousef Al Najjar Hospital, respectively. Currently, the existing X-ray machines in medical imaging departments were 1, 6, 2, 2, 3 and 2, respectively. Thus, no medical imaging department fulfills the international standard. In GS, several difficulties and obstacles faced in the developing of medical field particularly the medical imaging field. These obstacles related to high cost of equipment and siege imposed on GS. Finally, the occupation prohibited the import of equipment and related spare parts (MIA, 2017).

4.3.2 Number of daily examinations to the number of Radiologic Technologists

Table (4.9): Number of daily examinations to the number of RTs in Conventional Radiography

Item \ Hospital	Indonesia	Al-Shifa	Shohda Al-Aqsa	European Gaza	Nasser	Abu Yousef Al Najjar
Number of RTs at morning shift	7	12	8	5	7	7
Number of exams at morning shift	150	270	145	120	160	125
Number of exams for each RT in morning shift	21	23	18	24	23	18
Number of RTs at evening and night shift	2	4	4	5	3	2
Number of exams at evening and night shift	100	250	70	80	90	90
Number of exams for each RT in evening shift	50	63	18	16	30	45

Table 4.9 demonstrates number of RTs in Conventional Radiographic rooms at governmental hospitals and number of daily exams. At the morning shift, number of RTs worked at morning shift was 7, 12, 8, 5, 7, and 7 in Indonesia, Al-Shifa, Shohda Al-Aqsa, European Gaza, Nasser and Abu Yousef Al Najjar Hospital, respectively. Based on these values, each RT in the morning shift would carry out 21, 23, 18, 24, 13 and 18, respectively. In parallel, the number of RTs worked at evening shift was 2, 4, 4, 5, 3, 2 in Indonesia, Al-Shifa, Shohda Al-Aqsa, European Gaza, Nasser and Abu Yousef Al Najjar Hospital, respectively. Thus, each RT at the evening shift will carry out 50, 63, 18, 16, 30 and 45, respectively.

In AL-Shifa Hospital, RT conducted 23 and 63 exams at morning and evening shift, consequently. This imaging value considers the largest percentage compared to the other hospitals especially in evening shift. For example, RT at Al-Shifa Hospital is suspected to radiograph four times more than the RT in European Gaza Hospital.

Table (4.10): Number of daily examinations to the number of RTs in Fluoroscopy

Item \ Hospital	Indonesia	Al-Shifa	Shohda Al-	European	Nasser	Abu Yousef AL Najjar
Number of RTs at morning shift	-	1	-	-	1	1
Number of exams at morning shift	-	9	-	-	7	1
Number of exams for each RT in morning shift	-	9	-	-	7	1
Number of RTs at evening and night shift	-	1	-	-	0	0
Number of exams at evening and night shift	-	1	-	-	0	0
Number of exams for each RT in evening shift	-	1	-	-	0	0

Table 4.10 demonstrates the ratio of RTs to the number of daily fluoroscopic exams at governmental hospitals. At the morning shift, each fluoroscopic room, in all hospitals, has only one RT. Based on these readings, each RT at the morning shift will carry out 9, 7, 1 in Al-Shifa, Nasser and Abu Yousef Al Najjar Hospital, respectively. Regarding to evening shift, only Al-Shifa Hospital provides fluoroscopic exams with one suspected case daily.

It is well known that radiation dose of fluoroscopic machine is significant and higher than X-ray machine. A serious problem can be observed at Al-Shifa Hospital. Thus, RT at this hospital is suspected to perform 2 to 8 cases more than Nasser and Abu Yousef Al Najjar Hospital, respectively. Consequently, duplication in radiation dose is highly expected for RTs at Al-Shifa Hospital compared to other hospitals.

Table (4.11): Number of daily examinations to the number of RTs in CT

Item \ Hospital	Indonesia	Al-Shifa	Shohda Al-Aqsa	European Gaza	Nasser	Abu Yousef AL Najjar
Number of RTs at morning shift	3	7	-	2	-	-
Number of exams at morning shift	17	88	-	50	-	-
The number of exams for each RT in morning shift	6	13	-	25	-	-
Number of RTs at evening and night shift	1	1	-	1	-	-
Number of exams at evening and night shift	3	10	-	7	-	-
Number of exams for each RT in evening shift	3	10	-	7	-	-

Table 4.11 shows the number RTs and their daily duties by performing CT machines at governmental hospitals. At the morning shift, number of RTs was 3, 7, 2 in Indonesia, Al-Shifa and European Gaza Hospital, respectively. These readings indicate that each RT carried out 6, 13 and 25, respectively. At evening shift, only one RT is available for CT exam at each hospital. Thus, each RT carried out 3, 10 and 7, respectively.

Undoubtedly, the largest number of CT exams was at Al-Shifa Hospital, but based on the ratio of exams to RTs number, the RT in European Gaza Hospital was suspected to carry out two times more than RT at Al-Shifa Hospital and four times more than RT at Indonesia Hospital. This variation may be attributed to:

- There are three CT machines at AL-Shifa Hospital (one for cardiac and vascular exams, one for oncology and one for general cases). Therefore, it is expected that the largest number of CT exams would be at this hospital. These machines were provided with seven RTs (2 RT for each CT machine). Thus, each RT carried out 13 cases daily.

- The lowest number of CT exams was in Indonesia Hospital and this is attributed to the new installation of CT machine. (Team still under training and the CT does not conduct all exams)

Qualitatively, the first CT machine was installed at private sector in 1994, while the government hospitals offered limited services (Conventional Radiography, Fluoroscopy and Ultrasound). The first CT machine in government sector was introduced in 2000 at Al-Shifa Hospital and then provided to other hospitals (MIA, 2017).

Table (4.12): Number of daily examinations to the number of RTs in MRI

Item \ Hospital	Indonesia	Al-Shifa	Shohda Al-Aqsa	European Gaza	Nasser	Abu Yousef AL Najjar
Number of RTs at morning shift	-	2	-	2	-	-
Number of exams at morning shift	-	20	-	16	-	-
Number of exams for each RT in morning shift	-	10	-	8	-	-
Number of RTs at evening and night shift	-	0	-	1	-	-
Number of exams at evening and night shift	-	0	-	15	-	-
Number of exams for each RT in evening shift	-	0	-	15	-	-

Table 4.12 clarifies the number of RTs in MRI departments at governmental hospitals with their daily exam numbers. For each hospital, two RTs are available at morning shift. Based on that, each RT carried out 10 and 8 exams in Al-Shifa and European Gaza Hospital, respectively. At evening shift, only one RT is accessible in European Gaza hospital and carried out 15 exams with no MRI exam at Al-Shifa Hospital in the evening shift. Qualitatively, MRI machine introduced to the governmental hospitals in 2008. This machine provided services just for one year. In 2012, another MRI machine was

introducing to European Gaza Hospital, and another new machine was fixed in 2016 at Al-Shifa Hospital (MIA, 2017).

4.3.3 Numbers of CT and MRI machines per 1 000,000 inhabitants, 2015

Number of CT and MRI machines per 1000,000 inhabitants in some countries. Starting with CT machines, the number was 56, 35, 15, 14, 10 and 4 in Australia, Germany, France, Turkey, Israel and Gaza Strip, respectively. Actually, obvious dissimilarity in the current readings was recorded between GS and other countries, especially with Australia, Germany and France (OECDa, 2016). On other side, almost two or three of the available CT machines in GS are out of service annually (MIA, 2017).

Regarding MRI machines, the number was 31, 15, 11, 10, 4 and 1 in Germany, Australia, France, Turkey, Israel and Gaza Strip, respectively. Obvious variation was recorded between GS and other compared countries (OECDb, 2016). This figure gives indication about the great shortage of MRI machines in GS. The same result was obtained qualitatively from Key informant interview (MIA, 2017).

4.3.4 Inferential statistical analysis

4.3.4.1 Pearson correlation tests

Table (4.13): The correlation between different variables (Annual breakdowns, Examinations appointments and Patient waiting time) and imaging machines

Annual breakdowns and number of daily examinations		
Variables	**Test Statistic**	**P-value**
Conventional Radiography	-0.426	0.219
Fluoroscopy	0.702	0.504
Computed Tomography	-0.207	0.793
Examinations appointments and number of exams at morning shifts		
Variables	**Test Statistic**	**P-value**
Fluoroscopy	0.971	0.154
Computed Tomography	0.434	0.566
Patient waiting time and No of exams at morning shifts in Conventional Radiography		
Variables	**Test Statistic**	**P-value**
Patient waiting time Vs. number of exams	0.779	0.000*

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

Table 4.13 revealed the relationships between number of annual breakdowns and number of daily examinations in conventional radiography, fluoroscopy and CT. Other relationships between annual breakdowns and number of daily examinations in fluoroscopy and CT machines were tested. Finally, the relationship between patient waiting time and No of exams at morning shifts in Conventional Radiography was also determined.

By using Pearson correlation test, the values of correlation coefficient between annual breakdowns and number of daily examinations in Conventional Radiography, Fluoroscopy and CT were -0.426, 0.702 and -0.207 and p-values were 0.219, 0.504 and 0.793 (>0.05), respectively. These results indicate that there are no significant relationship between annual breakdowns and numbers of daily examinations in Conventional Radiography, Fluoroscopy and CT at significance level $\alpha \leq 0.05$ (Annex 13, 14, 15).

Actually, increase number of daily exams lead to increase probability of breakdown. In the current study, the relationships are not statistically significant and this may be attributed to:

- There is no compatibility between machines' types, capability and specifications and number of cases. In other word, some machines have high specifications appropriate for strong duties, but it is specified for light-duty and vice versa.
- Some machines have been installed recently, these machines tolerate pressure load but this will affect its life expectancy.
- Finally, qualified team was existent in the medical imaging department that can deal professionally with the machines and make good distribution of cases through the working day.

In addition, the relationship between examinations appointments and number of exams at morning shifts. in Fluoroscopy was determined. The value of correlation coefficient was 0.971 and p-value was 0.154 (>0.05). This indicates that there is no significant relationship between examinations appointments and number of exams at morning shifts in Fluoroscopy at significant level $\alpha \leq 0.05$ (Annex 14).

The relationship between exams appointments and number of exams at morning shifts in Fluoroscopy exams was not significant. This may be attributed to:

- Inadequate number of cases due to the high radiation doses in fluoroscopic exams.
- Fluoroscopic machines shortage in the Gaza Governorates hospitals. Hence, most specialists directed patients toward alternative exams (i.e., US, CT and MRI).

The correlation between examinations appointments and number of exams at morning shifts in CT was also tested. The correlation coefficient was 0.434 and p-value was 0.566 (>0.05), which indicates that is no significant relationship between exams appointments and number of exams at morning shifts at significance level $\alpha \leq 0.05$ (Annex 15).

The CT machines were available only in two hospitals (Al-Shifa and European Gaza Hospitals). Recently, Indonesia Hospital was provided with CT machine, and limited cases were allowed to conduct due to the insufficient knowledge and experience of specialists about CT examinations.

Compared CT machines in the European Gaza Hospital and Al-Shifa Hospital, the total number of cases at the morning shift reached to 50 and 88, respectively, while the examinations appointments were 15 and 10 days, respectively. Examinations appointments in European Gaza Hospital take longer time than Al-Shifa Hospital (twice more). This may be attributed to abundance of CT machines in Al Shifa Hospital compared with European Gaza Hospital (3 to 1). This abundance in CT machines allow to specify one machine for advanced techniques (Cardiac and vascular), one for oncology cases and one for remaining cases (without contrast media cases). On other side, only one CT machine is available in European Gaza Hospital, and all cases were queued for this machine.

Finally, the relationship between patient waiting time and number of exams was tested at morning shifts in Conventional Radiography. The value of correlation coefficient was 0.779 and p-value was 0.000 (>0.05). This result indicates that there is statistically significant relationship between the tested variables at significance level $\alpha \leq 0.05$ (Annex 13). When number of exams increase, patient-waiting time will consequently increase. Actually, the patient-waiting time can be reduced by increasing number of radiographic machines.

4.3.4.2 Chi square test

The researcher used Chi- square test to demonstrate the relationship between RTs experience and holding of TLDs.

Table (4.14): The relationship between RTs experience and holding of TLDs

Items		experience of RTs				Total	Chi- square χ^2	P-value (Sig)
		less than 10	10 to less than 17	17 to less than 24	24 to 34 years			
Holding TLD (%)	Yes	57.9	57.5	75	25	56	8.707	0.033
	No	42.1	42.5	25	75	44		

Table 4.14 clarifies the relationship between RTs experience and holding of TLDs at governmental hospitals. The relationship is statistically significant at significance level $\alpha \leq 0.05$. There was a direct relationship between RTs experience and holding of TLDs at all groups except elderly group (24-34). This anomaly may be attributed to: lack of RTs trustiness with TLDs readings in addition to their insufficient knowledge about radiation hazards.

4.4 Medical imaging departments design checklist

4.4.1 General information about departments

All medical imaging departments in hospitals were in ground level except Al-Shifa Hospital in underground. The largest and smallest distance between the emergency and medical imaging departments was 55 and 10 m, respectively.

Table (4.15): General information about structure at medical imaging departments

Item \ Hospital	Indonesia		Al-Shifa		Shohda Al-Aqsa		European Gaza		Nasser		Abu Yousef Al Najjar		Total			
	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	%	N	%
Is there appropriate distribution for imaging rooms?	√		√		√		√		√			√	5	83.3	1	16.7
Are there Special corridors for medical staff?		√	√			√		√		√		√	1	16.7	5	83.3
Are there male/female toilets for staff?		√		√		√	√			√		√	1	16.7	5	83.3
Are there Patient's waiting Area?	√		√		√		√		√		√		6	100	0	0
Are waiting area closed to imaging rooms?	√		√		√		√		√		√		6	100	0	0
Are waiting area spacious based to standard? STD (45 m^2)	√		√		√		√		√		√		6	100	0	0
Is there corridors width for patients? STD ($\geq$2 m).	√		√		√		√		√		√		6	100	0	0
Is there a special store for the department?	√		√		√		√		√		√		6	100	0	0
Is there a patient registration counter?	√		√		√		√		√		√		6	100	0	0
Are there male/female toilets for patients?		√		√		√	√		√			√	2	33.3	4	66.7
Are there recovery rooms?		√		√	√			√	√			√	2	33.3	4	66.7
Is there a reporting room?		√	√		√		√		√			√	4	66.7	2	33.3
Is medical imaging department as one unit?	√			√	√		√		√			√	4	66.7	2	33.3
Are there elevators?	√		√		√		√			√		√	4	66.7	2	33.3
Is there a rest room for the RTs staff?		√		√	√		√		√			√	3	50	3	50

Y= yes N=No

***N.B**: Appropriate means that: the distribution of imaging rooms in medical imaging departments are regular and consistently fit for easy movement for patients. Medical imaging department as one unit means that all medical imaging modalities are available in one department and are not scattered in hospital.*

Table 4.15 clarifies that 83.3% of the governmental medical imaging departments were appropriate. In parallel, neither special corridors for medical staff nor special toilets for staff were available. On other side, all of medical imaging departments in hospitals have patient's waiting area closed to imaging rooms, spacious (based on standard around $45m^2$), corridors width for patients (at least 2 m), a special store for the department, and a patient registration counter (AusHFG, 2016). Around 33.3% of medical imaging departments have male/female toilets for patients, and recovery rooms (AusHFG, 2016). Furthermore, 66.7% of medical imaging departments have a reporting room, elevators, and medical imaging department as one unit. Finally, half of medical imaging departments have a rest room for the RTs staff (AusHFG, 2016).

New facilities design should be conformed to the standard to facilitate imaging services taking into consideration social and economic factors. This means that the facility should be designed to ensure that both of structure and design of imaging department should be properly based to the service presented (RPII, 2009).

Table (4.16): General information about reception services and OHS at medical imaging departments

Item \ Hospital	Indonesia		Al-Shifa		Shohda Al-Aqsa		European Gaza		Nasser		Abu Yousef Al Najjar		Total			
	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	%	N	%
Reception Services																
Is there a queue number system?		√		√		√		√		√		√	0	0	6	100
Is there complaint box?		√		√		√		√		√		√	0	0	6	100
Is there intercom facility?		√		√		√		√		√		√	0	0	6	100
Is there a microphone call system?	√		√			√		√		√		√	2	33.3	4	66.7
Are there comfortable chairs in the waiting area?		√		√		√	√			√		√	1	16.7	5	83.3
Is there a television in the waiting area?		√		√		√	√			√		√	1	16.7	5	83.3
Are there enough chairs in the waiting area? STD (35chairs)		√		√		√	√		√			√	3	50	3	50
Is there telephone access?	√		√		√		√		√		√		6	100	0	0
Occupational Health Safety																
Is there radiation-warning board/ signs?		√	√		√		√			√		√	3	50	3	50
Is there "No Smoking Signs"?		√		√		√	√			√		√	1	16.7	5	83.3
Is there good ventilation for the department?	√		√		√		√		√		√		6	100	0	0
Is there good lighting for the department?	√		√		√		√		√		√		6	100	0	0
Is there fire extinguisher?	√		√		√		√		√			√	5	83.3	1	16.7

Y= yes N=No

Table 4.16 clarifies that none of medical imaging departments have a queue number system, complaint box, and intercom facility. Regarding microphone call system, only Indonesia Hospital has this facility (the newest hospital in Gaza Governorates, 2015). Around 83.3% of departments have no comfortable chairs and television in the waiting area. Based on international standard, half of departments have enough chairs in the waiting area (35 chairs) (AusHFG, 2016). Finally, all medical imaging departments in hospitals have telephone access.

In terms of OHS, half of medical imaging departments at governmental hospitals have radiation-warning board/signs. All departments have good ventilation and lighting (AusHFG, 2016; Bushong, 2013). In addition, 16.7% of departments have No Smoking signs warning and 83.3% of departments have fire extinguisher (AusHFG, 2016).

Radiation-warning signs should position at all access doors to the room and preferably at eye level. The signs should illuminate during the preparation period (if applicable) and continue for the duration of the exposure. In addition, appropriately worded radiation warning signs must posted on access doors to the room (RPII, 2009).

Based on Key Informant Interview (KII), before 1996, no specific standard followed at governmental hospitals regarding medical imaging services and OHS. Nowadays, there is an attempt to arrange workshops and focusing group to develop national medical imaging services seemly to the international standard. Visible improvements in the design, structure and OHS of X-ray rooms, but still other rooms have many defects and shortcomings (MIA, 2017).

4.4.2 Conventional Radiography design checklist

Table (4.17): Checklist about structure and essential supplies of Conventional Radiography at governmental hospitals

Item \ Hospital	Indonesia		Al-Shifa		Shohda Al-Aqsa		European Gaza		Nasser		Abu Yousef Al Najjar		Total			
	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	%	N	%
Structure																
Is there a control console?	1		6		2		2		3		2		16	100	0	0
Is control console area at least 1.5x2 m?		1	5	1	1	1	2		1	2		2	9	56.3	7	43.8
Are there windows for room?		1	3	3		2		2		3		2	3	18.8	13	81.2
Is there a toilet inside the room?		1	3	3		2		2		3		2	3	18.8	13	81.2
Is a room size ≥30 m^2?		1	3	3	1	1	2		2	1		2	8	50	8	50
Is there drainage sewage?	1		6		1	1		2	1	2		2	9	56.3	7	43.8
Is there a change cubicle?		1	3	3		2	2			3		2	5	31.3	11	68.8
Are the patients entry ≥ 180x150 cm?		1	3	3	2			2		3		2	5	31.3	11	68.8
Essential Supplies																
Is there a cupboard / cassette holder?	1		6		2		2		3		2		16	100	0	0
Is there a PVC cover?	1		6		2		2		3		2		16	100	0	0
Is there oxygen supply and suction?		1	3	3	1	1		2		3		2	5	31.3	11	68.7
If yes; is it working?			3		1				1				5	100		

Y= yes N=No

Table 4.17 clarifies that structure of all Conventional Radiography rooms in the medical imaging departments have control console, but only 56.3% of these rooms have proper size (≥1.5x2 m^2) and provided with drainage sewage (AusHFG, 2016). Generally, the operator console area allows observing and communicates the patient during imaging process. This area should be sufficiently large to reduce radiation intensity at the operator's screen and boundaries (RPII, 2009). Around 18.8% of rooms have windows, and toilet inside imaging room. Respecting to rooms which have windows, they are only at Al-Shifa Hospital at different height levels without lead shielding. According to the international standard, no window should be in radiographic room and in case of existence these windows must be lead shielded. The current check showed that 50 % of imaging rooms have proper size (≥30 m^2) (RPII, 2009; Bushong, 2013; AusHFG, 2016). Other international standard exhibited that X-ray room size should be at least 33 m^2 to encompass patient table and the vertical chest bucky stand. The boundaries to all occupied areas (walls, doors, doorframes, floor, ceiling, windows and the protective viewing screens) must be shielded appropriately (BIR, 2000). Finally, 31.3% of the current rooms have changing cubicles and patients door entrance dimension fit with the international standard (≥180x150 cm). The doors should be wide enough and must be shielded against scatter radiation (NHS, 2002; AusHFG, 2016). Changing cubicles should be close to X-ray room and may design as individual changing rooms, which open directly into the X-ray room. This allows for changing arrangements consistent with good radiation protection practice, greater privacy, security and perhaps faster patient throughput (RPII, 2009).

The location, design and equipment layout of X-ray rooms must carefully consider respecting to radiation protection perspective. This is easier when X-ray facilities are not designed as stand-alone rooms and planned as part of an integrated medical imaging department with its supporting areas and services. Planning the room layouts should start as early as possible in the design process. The design of ancillary facilities such as changing cubicles, toilets should be considered (RPII, 2009).

Regarding to essential supplies evaluation, all Conventional Radiography rooms at governmental hospitals have cassette holder. Cassette holder should not be near the wall of the darkroom or on wall of a room or space in which people wait, work, or anywhere near the door of the X-ray room (Palmer et al, 2011). All ground of X-ray rooms should be paved with PVC. Around 31.3% of rooms have active oxygen supply and suction.

Table (4.18): Checklist about occupational health safety Conventional Radiography at governmental hospitals

Item \ Hospital	Indonesia		Al-Shifa		Shohda Al-Aqsa		European Gaza		Nasser		Abu Yousef Al Najjar		Total			
	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	**Y**	**%**	**N**	**%**
Is there adequate light?	1		6		2		2		3		2		16	100	0	0
Is room walls shielded with lead-thickness ≥ 2 mm? (STD)	1		6		2		2		3		2		16	100	0	0
Is the height of lead walls ≥2 m? (STD)	1		6		2		2		3		2		16	100	0	0
Are doors lead shielded?	1		6		2		2		3		2		16	100	0	0
Is the room checking by competent authorities?	1		6		2		2		3		2		16	100	0	0
Is there an air conditioner?	1		6		2		2		3		2		16	100	0	0
Is it working?	1		6		2		2		3			2	14	87.5	2	12.5
Is there good ventilation for room?	1		6		2		2		2	1	1	1	14	87.5	2	12.5
Is X-ray tube direction away from the control console?	1			6	2			2	3		2		8	50	8	50
Is the distance between the X-ray tube and control console ≥3 m? (STD)		1	4	2	2		1	1	2	1		2	9	56.3	7	43.8
Is there a radiation warning signs on the door of the room?		1	3	3		2		2		3		2	3	18.8	13	81.2
If yes, Does it operate in during dose giving?				3												
Is there a lead apron?		1	6		2		2		3		2		15	93.8	1	6.3
Is there a gonadal shielding?		1		6		2	2			3		2	2	12.5	14	87.5
Is there lead protective glasses?		1		6		2		2		3		2	0	0	16	100
Is there a thyroid collar?		1		6	1	1	2			3	1	1	4	25	12	75
Is there lead protective gloves?		1		6		2		2		3		2	0	0	16	100

Y= yes N=No

Table 4.18 clarifies that all of Conventional Radiography rooms at governmental hospitals obey the international standards in terms of an air conditioner, adequate light, walls shielded with lead-thickness (≥2 mm), height of leaded walls (≥ 2 m), lead shielded doors and rooms have checked by competent authorities (RPII, 2009; AusHFG; 2016). Around 87.5% of rooms have good ventilation. In addition to the ionizing radiation, the X-ray room is one of the contaminated area in hospital that need proper ventilation (AusHFG; 2016). Regarding X-ray machines, 50% of X-ray tube properly positioned (direction of X-ray far away from control console). In addition, 56.3% of rooms have adequate distance between X-ray tube and control console (≥ 3 m) (Bushong, 2013). Around 81.2% of rooms have radiation warning signs on the door but did not work. Regarding radiation protection tools, 93.8% of rooms have a lead aprone, 12.5% for gonadal shielding and 25% for thyroid collar. Finally, none of Conventional Radiography rooms have a lead protective glasses or lead protective gloves. Personal protective equipment (lead aprons, thyroid shields, gonad shields) should be available and reinforced hangers should be used for storage of lead aprons (RPII, 2009; Bushong, 2013).

New facilities design should follow the standard to keep the staff and patients doses as low as reasonably achievable (ALARA principle) taking into consideration social and economic factors. This means that the facility should be designed to ensure that radiation exposure is much lower than the legal dose limits (RPII, 2009).

4.4.3 Darkroom design checklist

All Darkrooms in medical imaging departments at governmental hospitals were provided with automatic processing machines except Indonesia Hospital, which has computerized system (Digitalized images). In the current study, 12 processing machines were available in government hospitals. These machines were distributed as 4, 2, 2, 2 and 2 in Al-Shifa, Shohda Al-Aqsa, European Gaza, Nasser and Abu Yousef Al Najjar Hospital, respectively. In terms of product type, four machines were "AGFA product" at Al-Shifa Hospital and eight were "compact product". Finally, four Computed Radiography machines were available at Al-Shifa, European Gaza, Nasser, and Indonesia Hospital.

Table (4.19): Checklist about structure and OHS of Darkrooms at governmental hospitals

Item \ Hospital	Indonesia		Al-Shifa		Shohda Al-Aqsa		European Gaza		Nasser		Abu Yousef Al Najjar		Total			
	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	%	N	%
Structure																
Is the dark room adjacent to imaging rooms?	1		4		2		1		2		2		12	100	0	0.0
Is the room size ≥6 m^2?	1		1	3	1	1	1		1	1	1	1	6	50	6	50
Is there drainage sewage?	1		3	1	2		1		2		2		11	91.7	1	8.3
Is there a space for developing tanks?		1	3	1	2		1		2		2		10	83.3	2	16.7
Occupational Health Safety																
Are there special tanks to collect chemical solutions?		1	1	3	2		1		2		2		8	66.7	4	33.3
Is there adequate light?	1		4		2		1		1	1	2		11	91.7	1	8.3
Are the room well shielded?	1		3	1	2		1		2		2		11	91.7	1	8.3
Is there air suction?	1		2	2	2		1		2		2		10	83.3	2	16.7
Is there good ventilation for room?	1		1	3	2			1	1	1		2	5	41.7	7	58.3
Is the room checking by competent authorities?	1		4		2		1		2		2		12	100	0	0.0

Y= yes N=No

Table 4.19 shows that all Darkrooms in medical imaging departments at governmental hospitals located closed to imaging rooms. In terms of a room size, half of Darkrooms followed the international standard (≥6 m^2) (AusHFG, 2016). Around 91.7% of these rooms have drainage sewage, and 83.3% have enough space for developing tanks.

Regarding OHS evaluation, around 66.7% of Darkrooms have special tanks to collect chemical solution and 91.7% of these rooms have adequate light and lead shielding to prevent radiation leakage. If the X-ray room is adjacent to a Darkroom or a storage facility, shielding to full height is required to protect films located on high-level shelving. The height of the wall must be sufficient to shield to a height of 2 m from the outside ground

(NCRP, 2004; Bushong, 2013; AusHFG, 2016). In addition, 83.3% of rooms have air suction, but only 41.7% of these rooms have good ventilation. Finally, competent authorities have checked the Darkrooms at fixation time, but no regular inspection reported. Based on international standards, checking for Darkrooms should be performed regularly (AusHFG, 2016).

Table (4.20): Checklist about essential supplies in Darkrooms at governmental hospitals

Item \ Hospital	Indonesia		Al-Shifa		Shohda Al-Aqsa		European Gaza		Nasser		Abu Yousef Al Najjar		Total			
	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	%	N	%
Is there a safe light?	1		3	1	2		1		2		2		11	91.7	1	8.3
Is the distance between safe light and bench ≥ 1 m?		1	3	1	1	1	1		2		2		8	66.7	4	33.3
Is there a bench?	1		4		2		1		2		2		12	100	0	0.0
Is there cupboard?	1		4		2		1		2		2		12	100	0	0.0
Is there washbasin?	1		1	3	2			1	2		2		8	66.7	4	33.3
Is there a water filter?		1	3	1		2		1		2		2	3	25	9	75
Is there a PVC cover?		1	1	3		2	1			2	1	1	3	25	9	75

Y= yes N=No

Table 4.20 shows that 91.7% of these rooms have a safe light (red), but only 66.7% were fixed at proper distance above benches (≥1m) (Bushong, 2013). Around 66.7% of these rooms have washbasin. All Darkrooms have benches and cupboard for reloading radiographic cassettes by X-ray films. Finally, 25% of grounds in these rooms paved with PVC and have a water filter for processing machines.

4.4.4 Fluoroscopy design checklist

Table (4.21): Checklist about structure and essential supplies of Fluoroscopy at governmental hospitals

Item \ Hospital	Indonesia		Al-Shifa		Shohda Al-Aqsa		European Gaza		Nasser		Abu Yousef Al Najjar		Total			
	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	%	N	%
Structure																
Is there a control console?	1		2		1		1		1		1		7	100	0	0
Is there a toilet inside the room?	1		2		1		1		1		1		7	100	0	0
Is a room size ≥36 m^2? (include control console) STD	1		2			1	1		1			1	5	71.4	2	28.6
Is there a change cubicle?	1		2			1	1		1			1	5	71.4	2	28.6
Is there a drainage sewage	1		2		1			1	1			1	5	71.4	2	28.6
Are the patients entry ≥ 180x150 cm?	1		2		1			1		1		1	4	57.1	3	42.9
Essential Supplies																
Is there a PVC cover?	1		2		1		1		1		1		7	100	0	0
Is there oxygen supply and suction?		1	2		1			1	1			1	4	57.1	3	42.9
Is it working?			2		1				1							
Is there emergency trolley?		1	2			1		1	1			1	3	42.9	4	57.1
Is emergency trolley ready for use?			2						1							

Y= yes N=No

Table 4.21 clarifies that all of fluoroscopic rooms followed the international standard in terms of control consoles and toilets (AusHFG, 2016). In addition, 71.4% of these rooms obey the standards in terms of room size (≥ 36 m^2), have change cubicle and proper drainage of sewage. Fluoroscopy systems may have large machines operated by remote control, control console and other equipment (BIR, 2000, NHS, 2001). Finally, 57.1% of these rooms have proper patient's door entrance (≥ 180x150cm) (AusHFG, 2016).

Furthermore, all ground in fluoroscopic rooms at governmental hospitals paved with PVC and 57.1% of these rooms have oxygen supply and suction. Around 42.9% of these rooms have emergency trolley ready for use. Invasive techniques and critical cases may be examined in fluoroscopic departments and access to oxygen, suction and emergency trolley are strongly needed (AusHFG, 2016).

Table (4.22): Checklist about occupational health safety of Fluoroscopy at governmental hospitals

Item \ Hospital	Indonesia		Al-Shifa		Shohda Al-Aqsa		European Gaza		Nasser		Abu Yousef Al Najjar		Total			
	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	%	N	%
Is there adequate light?	1		2		1		1		1		1		7	100	0	0
Is room walls shielded with lead-thickness ≥ 3 mm? (STD)	1		2		1		1		1		1		7	100	0	0
Is the height of lead walls ≥2 m? (STD)	1		2		1		1		1		1		7	100	0	0
Are doors lead-shielded?	1		2		1		1		1		1		7	100	0	0
Is there a lead aprone?	1		2		1		1		1		1		7	100	0	0
Is there a thyroid collar?	1		2		1		1		1		1		7	100	0	0
Is the room checking by competent authorities?	1		2		1		1		1		1		7	100	0	0
Is there an air conditioner?	1		2		1		1		1		1		7	100	0	0
Is it working?	1		2		1		1		1			1	6	85.7	1	14.3
Is there ventilation for room?	1		2		1		1		1			1	6	85.7	1	14.3
Is there a gonadal shielding?		1		2		1	1		1			1	2	28.6	5	71.4
Is there a radiation warning signs on the door of the room?	1			2		1	1			1		1	2	28.6	5	71.4
If yes, Does it operate in during dose giving?	1							1								
Is there lead protective glasses?	1		2		1			1	1			1	5	71.4	2	28.6
Is there lead protective gloves?		1	1	1		1	1		1			1	3	42.9	4	57.1

Y= yes N=No

Table 4.22 demonstrates that all of fluoroscopic rooms at governmental hospitals have air conditioner, adequate light, shielded-walls with lead-thickness (≥3 mm), height of leaded walls (≥ 2 m), door lead shielded and rooms have checked by competent authorities at fixation time (RPII, 2009; Bushong, 2013; AusHFG, 2016). Regarding protective tools, all rooms have lead apron and a thyroid collar, 71.4% have lead protective glasses, around

43% have lead protective gloves, but only 28.6% of these rooms have gonadal shielding. Finally, around 86% of these rooms have good ventilation and only 28.6% have radiation-warning signs on the door. Fluoroscopic rooms should be large area for example to contain suitable storage for personal protective equipment (lead aprons and thyroid collars …etc.) should provide and easily accessed in the controlled area (RPII, 2009).

4.4.5 Computed Tomography design checklist

Table (4.23): Checklist about structure and essential supplies of CT at governmental hospitals

Item \ Hospital	Indonesia		Al-Shifa		Shohda Al-Aqsa		European Gaza		Nasser		Abu Yousef Al Najjar	Total			
	Y	N	Y	N	Y	N	Y	N	Y	N	-	**Y**	**%**	**N**	**%**
Structure															
Is control console area ≥ 6 m^2? (STD)	1		3		1			1	1		-	6	85.7	1	14.3
Is a room size ≥42 m^2? (STD)		1		3	1			1	1		-	2	28.6	5	71.4
Is there a toilet inside the room?		1	1	2		1		1		1	-	1	14.3	6	85.7
Is there a recovery room for patients?	1		3		1			1	1		-	6	85.7	1	14.3
Is there a reporting room ≥ 8 m^2?		1	3		1		1		1		-	6	85.7	1	14.3
Is there a change cubicle?	1		3			1		1		1	-	4	57.1	3	42.9
Are the patients entry ≥ 180x150 cm?	1		2	1	1			1		1	-	4	57.1	3	42.9
Is there a drainage sewage	1		3			1	1			1	-	5	71.4	2	28.6
Essential Supplies															
Is there emergency trolley?	1		3		1		1		1		-	7	100	0	0
Is emergency trolley ready for use?	1		3		1		1			1	-	6	85.7	1	14.3
Is there a PVC cover?	1		2	1	1		1		1		-	6	85.7	1	14.3
Is there oxygen supply and suction?		1	3		1		1		1		-	6	85.7	1	14.3
Is it working?			3		1		1		1		-	6	100		

Y= yes N=No

Table 4.23 demonstrates that 85.7% of CT departments have spacious control console size (≥ 6 m^2), but only 28.6% of the departments follow the standard room size (imaging room) (≥ 42 m^2) (AusHFG, 2016). Around 85.7% of these departments have patient recovery rooms and reporting rooms (≥ 8 m^2) (AusHFG, 2016). In addition, 57.1% of departments have changing cubicles and patients' entry (≥180x150 cm). Finally, 71.4% of departments have drainage sewage. According to international standard, imaging departments need essential drainage sewage to ditch waste product of patients and chemicals (NHS, 2001).

Regarding essential supplies evaluation, all departments have emergency trolley and 85.7% of them were ready for use. Around 85.7% of CT departments followed the international standards in terms of ground paved with PVC and availability of oxygen supply and suction (all of them ready for use) (AusHFG, 2016).

Table (4.24): Checklist about occupational health safety of CT at governmental hospitals

Hospital / Item	Indonesia		Al-Shifa		Shohda Al-Aqsa		European Gaza		Nasser		Abu Yousef Al Najjar	Total			
	Y	N	Y	N	Y	N	Y	N	Y	N	-	Y	%	N	%
Is there ventilation in room?	1		3		1		1		1		-	7	100	0	0
Is room walls shielded with lead-thickness ≥ 3 mm? (STD)	1		3		1		1		1		-	7	100	0	0
Is the room checking by competent authorities?	1		3		1		1		1		-	7	100	0	0
Is the height of lead walls ≥2 m? (STD)	1		3		1		1		1		-	7	100	0	0
Are doors lead-shielded?	1		3		1		1		1		-	7	100	0	0
Is there a lead apron?	1		3		1		1		1		-	7	100	0	0
Is there an air conditioner?	1		3		1		1		1		-	7	100	0	0
If yes; is it working?	1		3		1			1	1		-	6	85.7	1	14.3
Is there adequate light?	1		3		1			1	1		-	6	85.7	1	14.3
Is there lead protective glasses?		1	2	1	1		1			1	-	4	57.1	3	42.9
Is there a radiation warning signs on the door?	1		2	1		1	1			1	-	4	57.1	3	42.9
If yes, does it operate during imaging?	1		1	1				1			-				
Is there a gonadal shielding?		1		3		1		1		1	-	0	0	7	100
Is there a thyroid collar?		1	3		1		1			1	-	5	71.4	2	28.6
Is there lead protective gloves?		1	2	1		1		1		1	-	2	28.6	5	71.4

Y= yes N=No

Table 4.24 illustrates that all CT departments at governmental hospitals have good ventilation, air conditioners, lead aprons, walls-shielded (thickness ≥3 mm and height ≥2m), lead shielded doors and existing rooms are checked by competent authorities (NHS, 2002; NCRP, 2004; PRII, 2009; AusHFG, 2016). On other side, none of the CT department has gonadal shielding. Around 85.7% of departments have adequate light while 57.1% of departments have lead protective glasses, and radiation warning signs on the door. Finally, 71.4% of departments have thyroid collar, and only 28.6% have lead protective gloves.

4.4.6 Magnetic Resonance Imaging design checklist

Table (4.25): Checklist about structure, services, OHS and essential supplies of MRI at governmental hospitals

Item	Hospital	Al-Shifa Hospital		European Gaza Hospital	
		Yes	No	Yes	No
Structure	Is a room size ≥ 42 m^2?		√		√
	Is there a control console?	√		√	
	Is control console area ≥10 m^2?	√		√	
	Is there a change cubicle?	√		√	
Services	Is there a headphone for patient?	√		√	
	Is there a communicating system "intercom" between patient and RT?	√		√	
	Is there a special form for procedures?	√		√	
Occupational Health Safety (OHS)	Is there ventilation for room?	√		√	
	Is there an air conditioner?	√		√	
	Is it working?	√		√	
	Is there adequate light?	√		√	
	Are the room walls having a copper shielding?	√		√	
	Is there a safety guidelines Panel before entering scanning room?	√		√	
	Is the room checking by competent authorities?	√		√	
Essential supplies	Is there oxygen supply and suction?	√		√	
	Is it working?	√			√
	Is there a PVC cover?	√		√	
	Is there non-magnetic emergency trolley?	√		√	
	Is emergency trolley ready for use?	√		√	
	Is there an anesthesia machine?	√			√

Table 4.25 describes that both MRI departments at governmental hospitals conform to the international standards in terms of availability of control consoles with size ($\geq$10 m^2) (AusHFG, 2016). Both departments have change cubicles, headphones for patient, special form for procedures, communicating system "intercom" between patient and RTs. Regarding to room size, both of imaging rooms did not follow the standard recommended size ($\geq$ 42 m^2). MRI rooms should have proper size (42 m^2) to contain MRI machines and large cupboard for radiofrequency coils (AusHFG, 2016). Both of existing MRI departments have provided with the standard OHS.

The oxygen supply and suction in European Gaza Hospital are not ready for use. Furthermore, ground of both MRI rooms paved with PVC and provided with non-magnetic emergency trolley (ready for use). The anesthesia machine is available only in the MRI department of Al-Shifa Hospital. Finally, both hospitals have closed MRI machines, magnetic field strength $\geq$1.5 tesla and various types of Radio-Frequency coils.

N.B: *Radio Frequency (RF) coil: is also known as "MRI-antenna", broadcasting the radiofrequency signals to the patient then receiving the returned signals. The RF coil plays significant role in images formation (Schild, 1990).*

In current study, the researcher prepared six arbitrated checklists based on international standards; the first checklist addressed general evaluation about medical imaging departments at the six main governmental hospitals (Conventional Radiography, Darkrooms, Fluoroscopy, CT and MRI checklist). The checklists focused on specific terms; structures, occupational health safety, essential supplies and reception. Almost all obtained results were compared with international standards.

Table (4.26): Summarize the conducted checklists in different sections of Medical Imaging Departments

Items	Structure %	OHS %	Essential Supplies%	Reception %
Departments (generally)	69	70	-	27
Conventional radiography	45	84	83	-
Darkrooms	81	80	68	-
Fluoroscopy	79	82	66	-
CT	60	78	91	-
MRI	86	100	90	-

The main results obtained from the conducted checklists in different sections of medical imaging departments regarding structures, OHS, essential supplies and receptions were summarized in Table 4.26. The results clarifies that the reception and conventional radiography at all medical imaging departments recorded less percentage and did not follow the international standards. On other side, the obtained results about MRI departments gave high percentage and conformed to the standards.

Chapter (5): Conclusion and recommendations

5.1 Conclusion

The medical imaging services are essential for health care provision for patients at all three levels of health care especially in secondary care. Qualified RTs and appropriate design increase safety, productivity and quality of services provided to patients. This study was carried out to evaluate the medical imaging services at governmental hospitals in Gaza Governorates. This study may provide guidance to the decision makers in order to improve the quality of medical imaging services. The study utilized a descriptive, analytical cross sectional design with a triangulated approach. Both self-developed questionnaire and checklist were used as data collection tools for the quantitative part. In addition, key informants interviews were used as qualitative part to enhance and strengthen quantitative results. The high response rate (95.5%) ensured subjects interesting and high validity of the study findings.

The human resources in the current study were evaluated based on several questions through face-to-face interview with the RTs at governmental hospitals, and through personal interview with medical imaging administration. The number of RTs was dramatically increased (~5 times more) compared to their number in 1996. Four-fifths of RTs were males, aged less than 40 years, permanent employees and have a bachelor degree. Furthermore, obvious enhancement and concentration in training courses related to medical imaging fields and especially in CT and MRI. Comparing between medical imaging capacities of hospitals, Al-Shifa Hospital has the largest RTs number and equipment because it covers the largest demographic area in the GS. Significant overload on RTs was remarked in all medical imaging departments at governmental hospitals, especially at evening and night shift. Statistical significant relations were observed between excess number of exams at morning shift and patient waiting time in Conventional Radiography; RTs years' experience and holding TLDs.

The availability of medical imaging equipment was checked based on arbitrated checklist filled in six governmental hospitals, and through personal interview with medical imaging administration. The status of medical imaging department in the Gaza Strip was compared with the WHO in addition to the national standard of three developed countries (Australian, New Zeeland and Britain). Moreover, the researcher compared the availability of advanced imaging modalities with other countries like Ireland, American, Turkish, France and Germany.

Regarding conventional X-ray machines, 16 machines were available and almost all ready for use; five fluoroscopic machines were obtainable, but about half of them were not functioned. Around 70% of CT machines were functioning and both of the available MRI machines functioned. Furthermore, there is a tendency to replace traditional radiography by Computed Radiography (four-sixth of governmental hospitals were provided with CR).

In comparison with the international standards, there is shortage in number of X-ray machines at all medical imaging departments. the CT, MRI and medical imaging departments in GS show clear number deficiency based on standard inhabitant-machine ratio. Overload on imaging machines was observed for the majority of machines (Conventional Radiography, CT and MRI machines).

All medical imaging departments at governmental hospitals are placed in ground level except Al-Shifa Hospital in which it is located underground. Around 83% of the checked departments were appropriate (Regular with consistent distribution of imaging rooms and easy movement for patients). Regarding to departments structure, OHS, reception, the readings showed that around 69%, 70% and 27% of the departments followed the standard, respectively.

Regarding adherence to international standards, around 45% of all Conventional Radiography structure at governmental hospitals adapted the international standard, 64% for OHS and ~83% respecting to the essential supplies at departments. The evaluation of Darkrooms showed that 81% of these rooms followed the structural standards, 80% for OHS and only 68% for essential supplies. The structure, OHS and essential supplies of fluoroscopy rooms revealed that 79%, 82% and 66% followed the standard, respectively.

The final evaluation was conducted on CT and MRI departments. In CT departments, around 60%, 78% and 91% of these departments followed international standards regarding to their structure, OHS and essential supplies, respectively. With regard to MRI departments, distinguish readings were remarked in their structures (86%), OHS (100%) and essential supplies (90%) compared with the international standard.

Finally, several strengthen points are obtained from the current results that may summarize as: All departments (Conventional Radiography, Fluoroscopy, CT and MRI) have spacious patient's waiting rooms, corridors, special store and registration counter and ground paved with PVC. In terms of human resources enhancement and improvement, several training course in Conventional Radiography, Fluoroscopy, Computed Radiography and CT were conducted. Also, all checked departments have adequate light, good ventilation, air conditioner, lead aprons, shielded walls and doors. The majority of medical imaging departments have CD for images recording. Regarding CT and MRI departments, proper structure, high OHS and suitable essential supplies were remarked.

Conversely, one-fifth of RTs have not TLDs and half of those did not holding it. In terms of continuous training and education, there is a shortage in training courses related to MRI machine. In addition, Shortage in RTs number was remarked in evening and night shifts at all medical imaging departments. Regarding equipments availability, big shortage in X-ray, fluoroscopy, CT and MRI machines at all medical imaging departments were reported. Obvious deficiency was observed in the structure and design (special corridors, toilets for staff and warning signs). The results revealed that none of department has queue number system and intercom facility. Almost of checked Conventional Radiography rooms and CT departments have not radiation-warning signs, gonadal shielding, lead protective glasses, thyroid collar and lead protective gloves. In addition, several of Conventional Radiography rooms did not provided with oxygen- suction supply. Improper size and bad ventilation were remarked in 50% of the checked Darkrooms. Finally, all MRI rooms have improper rooms size.

5.2 Recommendations

The current study provided important findings that worth to be studied carefully and responded by decision makers. The researcher strongly recommends that the uptake of the study be considered in the future improvement initiatives. Based on the study analysis, findings and conclusions, the researcher proposes the following recommendations:

- Appropriate management of human resources has an effective role in improving medical imaging services by creating a comfortable work environment, equal employee's distribution, fair workload, stress reduction and training.
- Enrich culture of TLDs practice and develop specific program or training courses to encourage RTs to comply with TLDs standards.
- Increase radiographic machine numbers to be proportional with inhabitant's growth.
- Providing two CT machines for each medical imaging department, one for advanced exams (vascular, oncology) and other for other exams (without contrast).
- Encourage utilization of digitalize imaging modalities instead of traditional imaging machines.
- Regular monitoring and auditing of medical imaging departments in terms of structure, OHS, protective and essential supplies are strongly in need.

5.3 Recommendations for further studies

- Conduct similar study at private and non-governmental organizations sectors.
- Conduct in-depth study about RTs compliance regarding holding of TLDs.
- Conduct action research in similar study to improve medical imaging services.

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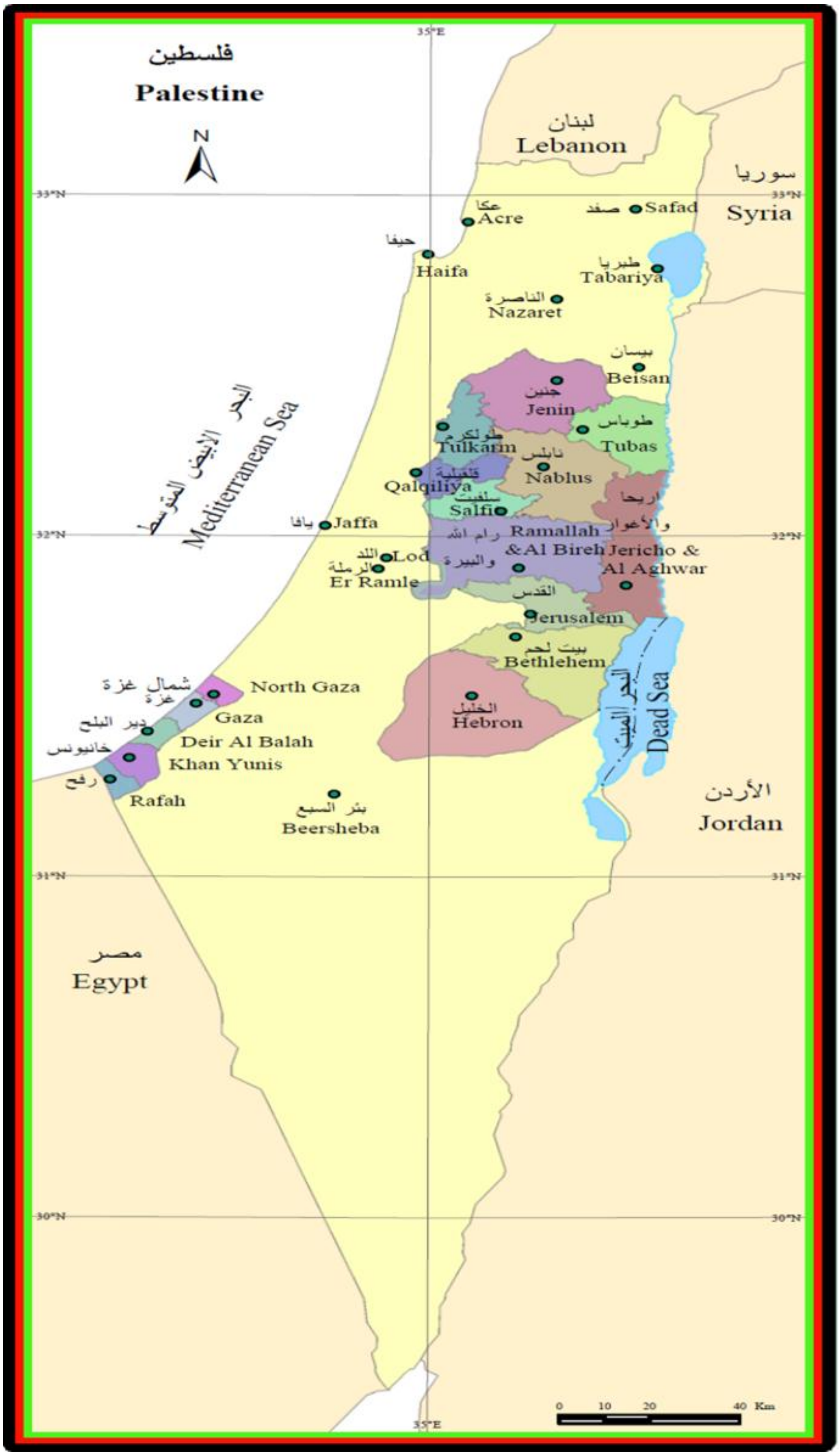
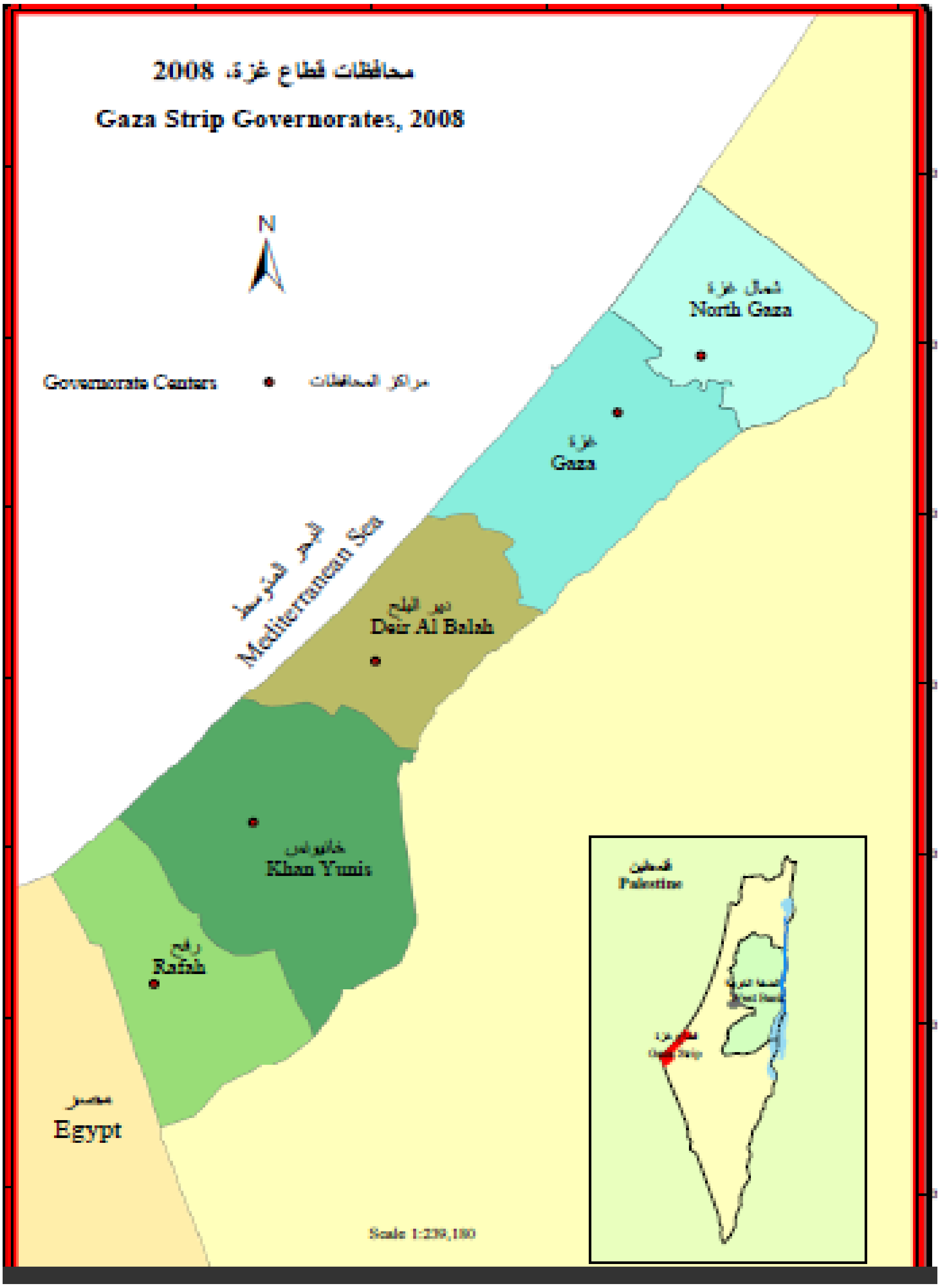
Annexes

Annex (1) Map of Palestine



From (PCBS, 2015)

Annex (2): Location map of Gaza strip



Annex (3): Distribution of six main governmental hospital in the GS

Item / Hospital	Governorate	Establishment	Area (m^2)	Employees number	Radiologists number	RTs number	Beds number
Indonesia	North	2015	16,000	350	4	20	110
Al- Shifa	Gaza	1946	45,000	1535	20	55	583
Shohda Al-Aqsa	Mid Zone	2001	4,000	474	3	21	261
European Gaza	Khan Younis	2000	56,000	691	11	28	261
Nasser	Khan Younis	1960	25,000	880	6	29	330
Abu Yousef Al Najjar	Rafah	2000	4,000	297	3	17	49

Annex (4): Ethical approval from Helsinki committee - Gaza governorate

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: 01/08/2016 **Number:** PHRC/HC/143/16

Name: MAHER D. SULEIMAN

الاسم: ماهر سليمان

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:

Evaluation of the Medical Imaging Services at Governmental Hospitals-Gaza Governorates

The committee has decided to approve the above mentioned research. Approval number PHRC/HC/143/16 in its meeting on 01/08/2016

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

Signature

Member Chairman Member

Genral Conditions:-

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

Specific Conditions:-

E-Mail:pal.phrc@gmail.com

Gaza - Palestine

غزة - فلسطين
شارع النصر - مفترق العيون

Annex (5): Al-Quds University approval latter

l-Quds University
Jerusalem
chool of Public Health

جامعة القدس
القدس
كلية الصحة العامة

التاريخ: 2016/7/23

حضرة الدكتور/ناصر أبو شعبان المحترم
مدير عام تنمية القوى البشرية–وزارة الصحة

تحية طيبة وبعد،،،

الموضوع: مساعدة الطالب ماهر سليمان

رجو تكرم سيادتكم بالعلم بأن الطالب المذكور أعلاه يقوم بإجراء بحث بعنوان:

"Evaluation of the Medical Imaging Services at Governmental Hospitals-Gaza Governorates"

كمتطلب للحصول على درجة الماجستير في الصحة العامة–مسار علم الأوبئة، وعليه نرجو التكرم بالموافقة والايعاز لمن يلزم للسماح للطالب بجمع البيانات الخاصة لبحثه، حيث تشمل عينة البحث أقسام الإشعة من حيث التصميم وفنيي الأشعة العاملين في مستشفى (الأندونيسي، شهداء الأقصى، غزة الأوروبي، أبو يوسف النجار)، مجمع الشفاء الطبي، ومجمع ناصر التابعة لوزارتكم لموقرة.

علماً بأن المعلومات ستكون متوفرة لدى الباحث والجامعة فقط وسنطلعكم على النتائج في حينها .

و اقبلوا فائق التحية و الاحترام،،،

د. بسام أبو حمد
ـيق عام برامج الصحة العامة
فرع غزة

ـة:
– الملف

Jerusalem Branch/Telefax 02-2799234
Gaza Branch/Telefax 08-2644220 -2644210
P.O. box 51000 Jerusalem

اكس 02-2799234
كس 08-264420-2644210
5 القدس

Annex (6) MOH approval latter

State of Palestine
Ministry of health

دولة فلسطين
وزارة الصحة

التاريخ:10/08/2016

السيد : ناصرالدين رافت مصطفى ابوشعبان المحترم

مدير عام بالوزارة/الإدارة العامة لتنمية القوى البشرية - /وزارة الصحة

السلام عليكم ورحمة الله وبركاته ,,,

الموضوع/ تسهيل مهمة باحث/ ماهر سليمان

التفاصيل //
بخصوص الموضوع أعلاه، يرجي تسهيل مهمة الباحث/ **ماهر ظاهر سليمان** الملتحق ببرنامج ماجستير الصحية العامة – مسار علم الوبائيات- كلية الصحة العامة - جامعة القدس في إجراء بحث بعنوان -:
" Evaluation of the medical imaging services at governmental hospitals – Gaza Governorates "
حيث الباحث بحاجة لبعض المعومات المتعلقة بخدمات الأشعة في المستشفيات ولتعبئة استبانه ونموذج ملاحظة لعدد من غرف الأشعة في مستشفيات قطاع غزة (الاندونيسي- مجمع الشفاء الطبي- مستشفى شهداء الأقصى- مجمع ناصر الطبي- مستشفى غزة الأوروبي - مستشفى الشهيد أبو يوسف النجار)، بما لا يتعارض مع مصلحة العمل وضمن أخلاقيات البحث العلمي، و دون تحمل الوزارة أي أعباء أو مسئولية.

وتفضلوا بقبول التحية والتقدير،،،

محمد ابراهيم محمد السرساوي
مدير دائرة/الإدارة العامة لتنمية القوى البشرية -

التحويلات

▪ مدحت عباس خضر حسن (مدير عام بالوزارة)	← حسن محمد خليل حافظ اللوح(مدير مستشفى)	لعمل اللازم والافادة
▪ عبد اللطيف محمد محمد الحاج(مدير عام بالوزارة)	← مدحت عباس خضر حسن (مدير عام بالوزارة)	إجراءاتكم بالخصوص
▪ محمد خليل محمد زقوت(مدير)	← علاء الدين محمود فايز المصري(طبيب رئيس قسم)	لعمل اللازم
▪ عبد اللطيف محمد محمد الحاج(مدير عام بالوزارة)	← شوقي ابراهيم عبد القادر سالم(مدير مستشفى)	إجراءاتكم بالخصوص
▪ كمال عواد محمد خطاب(مدير مستشفى)	← عبد الكريم كامل حسن الجمل(اشعة)	لعمل اللازم
▪ محمد خليل محمد زقوت(مدير)	← خالد امام ابراهيم ضهير(مدير دائرة)	لعمل اللازم
▪ عبد اللطيف محمد محمد الحاج(مدير عام بالوزارة)	← محمد خليل محمد زقوت(مدير)	إجراءاتكم بالخصوص
▪ عاطف محمد خليل الحوت(مدير مستشفى)	← محمد سلامه علي الهمص(طبيب مدير)	إجراءاتكم بالخصوص
▪ عاطف محمد خليل الحوت(مدير مستشفى)	← محمد عبد الفتاح سعيد صبح(مدير)	إجراءاتكم بالخصوص
▪ محمد ابراهيم محمد السرساوي(مدير دائرة)	← ناصرالدين رافت مصطفى ابوشعبان(مدير عام بالوزارة)	إجراءاتكم بالخصوص

غزة تلفون. 2846949-8 (970+)
فاكس. 2826295-8 (970+)

Gaza Tel. (+970) 8-2846949
Fax. (+970) 8-2826295

Annex (7): Explanation about the study to the participants (English and Arabic)

Evaluation of the Medical Imaging Services at Governmental Hospitals-Gaza Governorates

Dear participant

I am a researcher / **Maher Daher Suleiman;** I highly appreciate your participation in this study.

This research is part of study requirements for a master's degree in health epidemiology from the School of Public Health- Al-Quds University - College of Graduate Studies. This study aims to evaluate of the Medical Imaging Services at Governmental Hospitals in Gaza Governorates. You are kindly requested to answer all the questions of the questionnaire; it takes about 5-10 minutes. Your participation is voluntary and you have the right not answer some of the questions. It is important to point out that your participation in the study is very important, and we assure that your answer will be used for research purposes only, while ensuring strict confidentiality.

Thank you for your cooperation

Maher Daher Suleiman

mdas111@hotmail.com

Mobile- 0598924229

كلـــيـــة الصحـــــة العامـــة

رسالة توضيحية

تقييم خدمات التصوير الطبي لدى المستشفيات الحكومية في محافظات غزة

أخي المشارك/أختي المشاركة

أنا الباحث/ ماهر ظاهر أحمد سليمان ، طالب ماجستير بجامعة القدس كلية الدراسات العليا برنامج الصحة العامة. أقوم بإجراء هذا البحث كمتطلب رئيسي من متطلبات الدراسة لنيل درجة الماجستير في علم الاوبئة حيث تهدف هذه الدراسة إلى تقييم خدمات التصوير الطبي لدى المستشفيات الحكومية محافظات غزة.

أثمن عاليا مشاركتكم في تعبئة هذه الاستبانة والتي قد تستغرق ما بين 5- 10 دقيقة، علما بأن مشاركتكم طوعية ويمكنكم عدم الإجابة على بعض الأسئلة. ومن المهم أن نشير إلى أن مشاركتكم في الدراسة تعتبر بالغة الأهمية، ونؤكد لكم أن إجابتكم ستستخدم لأغراض البحث العلمي فقط مع ضمان السرية التامة.

لذا أرجو تعبئة الاستبانة كاملةً بدقة وواقعية وبما يعبر عن رأيك

شكراً لكم على حسن تعاونكم،،،

الباحث/ ماهر ظاهر أحمد سليمان

mdas111@hotmail.com

جوال/ 8924229059

Annex (8): The Questionnaire

Personal Information

1. Questionnaire code: ☐ ☐ ☐	**2. Date:** …../……../……….	**3. Name of hospital:**……………………………..
4. Code of hospital: ☐	**5. Age by years:** …………….	**6. Gender:** ☐ Male ☐ Female

7. Place of residence: ☐ North Gaza ☐ Gaza City ☐ Mid-zone ☐ Khan-younis ☐ Rafah

8. Certificate: ☐ Doctorate ☐ Master's degree ☐ Bachelor's degree ☐ Diploma ☐ Other: ……………….

9. Employment: ☐ Permanent ☐ Contract ☐ Volunter ☐ Trainee

10. Monthly salary: ☐ NIS	**11. Total years of experience:** ☐

12. Having TLD badge: ☐ Yes ☐ No	**13. Holding TLD :** ☐ Yes ☐ No	**14. Checking TLD:** ☐ Yes ☐ No

15. Training courses: ☐ Conventional Radiography ☐ Computed Radiography ☐ Fluoroscopy ☐ Computed Tomography ☐ Magnetic Resonance Imaging ☐ Others ……………………………….

Equipment Information

First: Conventional Radiography: No. of machines Available: ☐	**Functioning** ☐	**Code:** ☐
Is there a spare machine: ☐ Yes ☐ No	**Image types:** ☐ X-ray film ☐ CD ☐ X-ray filmand CD	
Total No. of RTs: ☐ Male ☐ Female	**No. of RTs at morning shift:** ☐ Male ☐ Female	
No. of RTs at evening and night shift: ☐ Male ☐ Female	**Total No. of daily examinations:** ☐	
No. of exams at morning shift: ☐	**No. of exams at evening and night shift:** ☐	
Machine type: ☐ New machine ☐ Used machine	**Machine Installing:** ☐ year(s)	

Manufacture company: ☐ SIEMNS, Years (………………….) ☐ PHILPS, , Years (……………….) ☐ SHIMADZU,Years (…………….) ☐ Other …………………………………………….

No. of annual breakdowns: ☐	**Breakdowns periods:** ☐ Day(s)

Maintenance checkup: ☐ Yes ☐ No (**If Yes,** ☐ Annual ☐ Monthly ☐ Weekly ☐ Daily)

Second: Fluoroscopy: No. of machines Available: ☐	**Functioning:** ☐	**Code:** ☐
Is there a spare machine: ☐ Yes ☐ No	**Image types:** ☐ X-ray film ☐ CD ☐ X-ray film and CD	
Total No. of RTs: ☐ Male ☐ Female	**No. of RTs at morning shift:** ☐ Male ☐ Female	

No. of RTs at evening and night shift: ☐ Male ☐ Female | **Total No. of daily examinations:** ☐

No. of exams at morning shift: ☐ | **No. of exams at evening and night shift:** ☐

Examination appointment taken after: ☐ Day(s) | **Machine Installing:** ☐ year(s)

Machine type: ☐ New machine ☐ Used machine

Manufacture company: ☐ SIEMNS, Years (…………………) ☐ PHILPS, , Years (………………)
☐ SHIMADZU,Years (…………….) ☐ Other ……………………………………………

No. of annual breakdowns: ☐ | **Breakdowns periods:** ☐ Day(s)

Maintenance checkup: ☐ Yes ☐ No (**If Yes,** ☐ Annual ☐ Monthly ☐ Weekly ☐ Daily)

Third: Computed Tomography: No. of machines Available: ☐ | **Functioning:** ☐ | **Code:** ☐

Is there a spare machine: ☐ Yes ☐ No | **Image types:** ☐ X-ray film ☐ CD ☐ X-ray film and CD

Total No. of RTs: ☐ Male ☐ Female | **No. of RTs at morning shift:** ☐ Male ☐ Female

No. of RTs at evening and night shift: ☐ Male ☐ Female | **Total No. of daily examinations:** ☐

No. of exams at morning shift: ☐ | **No. of exams at evening and night shift:** ☐

Examination appointment taken after: ☐ Day(s) | **Machine Installing:** ☐ year(s)

Machine type: ☐ New machine ☐ Used machine

Manufacture company: ☐ SIEMNS, Years (…………………) ☐ PHILPS, , Years (………………) ☐ Other ……………………

No. of annual breakdowns: ☐ | **Breakdowns periods:** ☐ Day(s)

Maintenance checkup: ☐ Yes ☐ No (**If Yes,** ☐ Annual ☐ Monthly ☐ Weekly ☐ Daily)

Forth: Magnetic Resonance Imaging : No. of machines Available: ☐ | **Functioning:** ☐ | **Code:** ☐

Is there a spare machine: ☐ Yes ☐ No | **Image types:** ☐ X-ray film ☐ CD ☐ X-ray film and CD

Total No. of RTs: ☐ Male ☐ Female | **No. of RTs at morning shift:** ☐ Male ☐ Female

No. of RTs at evening and night shift: ☐ Male ☐ Female | **Total No. of daily examinations:** ☐

No. of exams at morning shift: ☐ | **No. of exams at evening and night shift:** ☐

Examintion appointment taken after: ☐ Day(s) | **Machine Installing:** ☐ year(s)

Machine type: ☐ New machine ☐ Used machine

Manufacture company: ☐ SIEMNS, Years (…………………) ☐ PHILPS, , Years (………………) ☐ Other ……………………

No. of annual breakdowns: ☐ | **Breakdowns periods:** ☐ Day(s)

Maintenance checkup: ☐ Yes ☐ No (**If Yes,** ☐ Annual ☐ Monthly ☐ Weekly ☐ Daily)

Annex (9): Medical imaging department design checklist

Governorate :………………. **Hospital Name:** …………………

General Information about Department:

No.	Item	Yes	No	Note
Structure				
1.	Is the distribution of imaging rooms appropriate?			
2.	Are there Patient's waiting Area?			
3.	Are waiting area closed to imaging rooms?			
4.	Are waiting area spacious based to standard? STD(45 m^2)			
5.	Are there Special corridors for medical staff?			
6.	Is there corridors width for patients? STD (at least 2 m).			
7.	Are there male/female toilets for patients/ clients?			
8.	Are there male/female toilets for staff?			
9.	Is there a special store for the department?			
10.	Are there recovery rooms?			
11.	Is there a patient registration counter?			
12.	Is there a rest room for the RTs staff?			
13.	Is there a reporting room?			
14.	Is medical imaging department as one unit?			
15.	Are there elevators?			
16.	Radiology department location ☐ ground ☐ Underground			
17.	The distance between emergency and medical imaging department ……..…. M			
Reception Services				
18.	Is there a queue number system?			
19.	Is there a microphone call system?			
20.	Are there comfortable chairs in the waiting area?			
21.	Are there enough chairs in the waiting area? STD (35chairs)			
22.	Is there a television in the waiting area?			
23.	Is there complaint box?			
24.	Is there telephone access?			
25.	Is there intercom facility?			
Occupational Health and Safety (OHS)				

26.	Is there radiation-warning board/signs?			
27.	Is there "No Smoking Signs"?			
28.	Is there good ventilation for the department?			
29.	Is there good lighting for the department?			
30.	Is there fire extinguisher?			

1st : Conventional Radiography

Rooms No.:………… **Room Code:………………**

No.	Item	Yes	No	Note
	Structure			
1.	Is a room size at least 30 m^2? (STD)			
2.	Are there windows for room?			
3.	At what height from floor? ..…. m			
4.	Is there a control console?			
5.	Is control console area at least 1.5x2 m? (STD)			
6.	Is there a change cubicle?			
7.	Is there drainage sewage?			
8.	Are the patients door entrance at least 180x150 cm? (STD)			
9.	Is there a toilet inside the room?			
	Services			
10.	Patient waiting time for examination in morning shift ………….. minute(s).			
11.	Patient getting the images and report at the morning shift …………minute(s)			
	Occupational Health and Safety (OHS)			
12.	Is there good ventilation for room?			
13.	Is there an air conditioner?			
14.	Is it working?			
15.	Is the adequate light?			
16.	Is X-ray tube direction away from the control console?			
17.	Is the distance between the X-ray tube and control console at least 3 m? (STD)			
18.	Is room walls shielded with lead-thickness at least 2 mm? (STD)			
19.	Is the height of lead walls at least 2 m? (STD)			
20.	Are doors lead shielded?			
21.	Is there a radiation-warning signs on the door of the room?			
22.	If yes, Does it operate in during dose giving?			
23.	Is there a lead aprone?			
24.	Is there a gonadal shielding?			
25.	Is there lead protective glasses?			

26.	Is there a thyroid collar?			
27.	Is there lead protective gloves?			
28.	Is the room checking by competent authorities?			
	Essential supplies			
29.	Is there a cupboard / cassette holder?			
30.	Is there oxygen supply and suction?			
31.	Is it working?			
32.	Is there a Polyvinyl Chloride (PVC) cover?			

Dark Room

Rooms No.:………… **Room Code:……………………**

No.	Item	Yes	No	Note
	Structure			
1.	Is a room size at least 6 m^2? (STD)			
2.	Is the dark room adjacent to imaging rooms?			
3.	Is there drainage sewage?			
4.	Is there a space for developing tanks?			
	Services			
5.	Processing machine types			
6.	Developer procesing ☐ manual ☐ automatic			
	Occupational Health and Safety (OHS)			
7.	Is there good ventilation for room?			
8.	Is there an air suction?			
9.	Is the adequate light?			
10.	Are there special tanks to collect chemical solutions?			
11.	Are the room well shielded?			
12.	Is the room checking by competent authorities?			
	Essential supplies			
13.	Is there a safe light?			
14.	Is the distance between safe light and bench at least 1 m?			
15.	Is there a bench?			
16.	Is there cupboard?			
17.	Is there washbasin?			
18.	Is there a water filter?			
19.	Is there a Polyvinyl Chloride (PVC) cover?			

2nd : Fluoroscopy (Screening)

Rooms No.:…………　　　　Room Code:…………………

No.	Item	Yes	No	Note
Structure				
1.	Is a room size at least 36 m^2? (include control console) STD			
2.	Is there a control console?			
3.	Is there a change cubicle?			
4.	Is there a drainage sewage?			
5.	Are the patients entry at least 180x150 cm? (STD)			
6.	Is there a toilet inside the room?			
Occupational Health and Safety (OHS)				
7.	Is there ventilation for room?			
8.	Is there an air conditioner?			
9.	Is it working?			
10.	Is the adequate light?			
11.	Is room walls shielded with lead-thickness at least 3 mm?(STD)			
12.	Is the height of lead walls at least 2 m? (STD)			
13.	Are doors lead-shielded?			
14.	Is there a radiation-warning signs on the door of the room?			
15.	If yes, Does it operate in during dose giving?			
16.	Is there a lead aprone?			
17.	Is there a gonadal shielding?			
18.	Is there lead protective glasses?			
19.	Is there a thyroid collar?			
20.	Is there lead protective gloves?			
21.	Is the room checking by competent authorities?			
Essential supplies				
22.	Is there oxygen supply and suction?			
23.	Is it working?			
24.	Is there a Polyvinyl Chloride (PVC) cover?			
25.	Is there emergency trolley?			
26.	Is emergency trolley ready for use?			

3rd : Computed Tomography

Rooms No.:………… **Room Code:…………………**

No.	Item	Yes	No	Note
	Structure			
1.	Is a room size at least 42 m^2? (STD)			
2.	Is control console area at least 6 m^2? (STD)			
3.	Is there a recovery room for patients?			
4.	Is there a change cubicle?			
5.	Is there a drainage sewage			
6.	Are the patients entry ≥ 180x150 cm?			
7.	Is there a toilet inside the room?			
8.	Is there a reporting room at least 8 m^2?			
	Occupational Health and Safety (OHS)			
9.	Is there ventilation for room?			
10.	Is there an air conditioner?			
11.	Is it working?			
12.	Is the lighting adequate?			
13.	Are the room walls having a lead-thickness at least 3 mm?			
14.	Are the high of room lead walls at least 2 m?			
15.	Are doors protected by lead?			
16.	Is there a radiation warning signs on the door of the room?			
17.	If yes, Does it operate in during dose giving?			
18.	Is there a lead apron?			
19.	Is there a gonadal shielding?			
20.	Is there lead protective glasses?			
21.	Is there a thyroid collar?			
22.	Is there lead protective gloves?			
23.	Is the room checking by competent authorities?			
	Essential supplies			
24.	Is there oxygen supply and suction?			
25.	Is it working?			
26.	Is there a Polyvinyl Chloride (PVC) cover?			
27.	Is there emergency trolley?			
28.	Is emergency trolley ready for use?			

4th : Magnetic Resonance Imaging

Rooms No.:………… **Room Code:……………**

No.	Item	Yes	No	Note
Structure				
1.	Is a room size at least 42 m^2? (STD)			
2.	Is control console area at least 6 m^2? (STD)			
3.	Is there a recovery room for patients?			
4.	Is there a change cubicle?			
5.	Is there a drainage sewage			
Services				
6.	Is there a headphone for patient?			
7.	Is there a communicating system "intercom" between patient and RT?			
8.	Is there a special form for procedures?			
Occupational Health and Safety (OHS)				
9.	Is there ventilation for room?			
10.	Is there an air conditioner?			
11.	Is it working?			
12.	Is the adequate light?			
13.	Are the room walls having a copper shielding?			
14.	Is there a safety guidelines Panel before entering scanning room?			
15.	Is the room checking by competent authorities?			
Essential supplies				
16.	Is there oxygen supply and suction?			
17.	Is it working?			
18.	Is there a Polyvinyl Chloride (PVC) cover?			
19.	Is there non-magnetic emergency trolley?			
20.	Is emergency trolley ready for use?			
21.	Is there an anesthesia machine?			
Machine				
22.	MRI machine: ☐ Opened ☐ Closed			
23.	RF coils types: ☐ Head ☐ Cervical ☐ Spine ☐ Body ☐ Exterimty ☐ Breast ☐ Lower limbs ☐ Others			
24.	MRI machine: ☐ Less than 1.5 Tesla ☐ 1.5 Tesla and more ☐ Others…………………….….			

Annex (10): Key informant interview- English

1. What were the medical imaging services that offered to patients/clients before 1996?
2. What were medical imaging devices types before 1996? How much was their number?
3. Before 1996, what are the hospitals that provided medical imaging services? How many RTs were? What are types of certificates for RTs?
4. Have there been training course continuously for RTS?
5. Is there a standard for medical imaging services before 1996?

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6. After 1996, what is new in the medical imaging services? What are the hospitals that provide medical imaging services? How many RTs were? What are types of certificates for RTs?
7. When CT scan service was introduced to Gaza Strip?
8. When MRI service was introduced to Gaza Strip?
9. When fluoroscopy service was introduced to Gaza Strip?
10. Is there a standard for medical imaging services after 1996?
11. Were imaging rooms according to international standards before 1996?
12. What is the medical imaging services that offered to patients/Clients now?

Annex (10): Key informant interview- Arabic

مقدمة وشرح الغرض من البحث وسيناريو المقابلة

تقييم خدمات التصوير الطبي لدى المستشفيات الحكومية في قطاع غزة

1- ما هي خدمات التصوير الطبي التي كانت تقدم للمرضى قبل عام 1996؟

2- ماهي أنواع معدات التصوير الطبي قبل عام 1996؟ وكم كان عددها؟

3- قبل عام 1996 ماهي المستشفيات التي كانت تقدم خدمات التصوير الطبي؟ وكم كان عدد فنيي الأشعة؟ وما هي أنواع شهاداتهم؟

4- هل كان هناك دورات تدريبيه للفنيين قبل عام ؟

5- قبل عام 1996 هل كان هناك معايير لخدمات التصوير الطبي؟

6- بعد عام 1996 ما هو الجديد في خدمات التصوير الطبي؟ وما هي المستشفيات التي تقدم خدمات التصوير الطبي؟ وكم عدد الفنيين؟ و ما هي أنواع الشهادات لديهم؟

7- متى تم إدخال خدمة الأشعة المقطعية قطاع غزة؟

8- متى تم إدخال خدمة تصوير الرنين المغناطيسي قطاع غزة؟

9- متى تم إدخال خدمة الفلور وسكوبي قطاع غزة؟

10- بعد عام 1996 هل كان هناك معايير لخدمات التصوير الطبي؟

11- بعد عام 1996 هل غرف التصوير الطبي مطابقة للمعايير الدولية؟

12- ما هي خدمات التصوير الطبي المقدمة للمرضى الان؟

Annex (11): Questionnaire review experts

No.	Name	Location
1	Dr. Yehia Abed	Al-Quds University
2	Dr. Sammy Al-agha	Al- Azhar university
3	Dr. Khalid aboushab	Al- Azhar university
4	Dr. Nahed Al-Laham	Al- Azhar university
5	Dr. Ahmed Najim	Al- Azhar university
6	Mr. Ibrahim Abbas	MOH
7	Mr. Mousa Al-nahal	MOH
8	Mr. Ziad Al awor	MOH
9	Mr. Rafat Ahmed	MOH
10	Mr. Basel Khamis	Al-Quds Open University

Annex (12): Characteristics of the key informants

No.	Name	Location	Position	Experiences
1	Mr. Ibrahim Abbas	MOH	Medical Imaging manager	More than 20 years
2	Mr. Ziad Alawuor	MOH	Medical imaging director	More than 20 years
3	Mr. Rafat Ahmed	MOH	Medical imaging director	More than 30 years

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Annex (13): Evaluation of Conventional Radiography in governmental hospitals

Name of hospital	No. of a spare machine	Image types	Total No. of RTs (daily)		No. of RTs at morning shift		No. of RTs at evening & night shift		No. of exams at morning shift	No. of exams at evening and night	Machine type	Machine Installing	Manufacture company	Total No. of annual breakdowns	Breakdowns periods (days)	Maintenance checkup	If Yes
			M	F	M	F	M	F									
Al-Shifa	1	X-ray Film	0	0	0	0	0	0	0	0	Used	2008	SHIMADZU	1	400	Yes	annual
		X-ray Film	3	2	1	2	2	0	50	50	Used	2008	HITSHI	1	7	Yes	annual
		Film & CD	1	0	1	0	0	0	10	0	Used	1996	SHIMADZU	0	0	Yes	annual
		X-ray Film	3	0	3	0	0	0	90	0	New	2010	SHIMADZU	1	5	Yes	monthly
		X-ray Film	2	0	2	0	0	0	70	0	New	2011	SHIMADZU	4	7	Yes	monthly
		Film & CD	5	0	3	0	2	0	50	200	New	2013	SIEMNS	1	30	Yes	annual
European Gaza	0	Film & CD	4	1	1	1	3	0	70	50	New	2015	SHIMADZU	1	2	Yes	monthly
		Film & CD	4	1	2	1	2	0	50	30	New	2007	PHILPS	2	2	Yes	monthly
Nasser Hospital	0	Film & CD	0	0	0	0	0	0	0	0	New	2005	SIEMNS	0	0	No	
		Film & CD	5	2	2	2	3	0	90	90	New	2014	SIEMNS	1	7	Yes	monthly
		X-ray Film	2	1	2	1	0	0	70	0	New	2013	PHILPS	0	0	Yes	monthly
Shohda Al-Aqsa	1	X-ray Film	5	3	3	3	2	0	120	20	New	2015	Care stream	1	10	Yes	monthly
		X-ray Film	4	0	2	0	2	0	25	50	Used	2000	SHIMADZU	1	10	Yes	monthly
Indonesia	0	CD	6	3	4	3	2	0	150	100	Used	2016	SIEMNS	0	0	Yes	annual
Abu Yousef' Al Najjar	0	X-ray Film	3	2	3	2	0	0	100	0	Used	2008	SHIMADZU	3	4	Yes	monthly
		X-ray Film	4	0	2	0	2	0	25	60	Used	2000	SHIMADZU	0	0	Yes	annual

M=Male F=Female

Annex (14): Evaluation of Fluoroscopy in governmental hospitals

Hospital	No. of a spare machine	Image types	Total No. of RTs		No. of RTs at morning shift		No. of RTs at evening & night shift		No. of exams at morning shift	No. of exams at evening & night	Examination appointment taken after	Machine type	Machine Installing	Manufacture company	Total No. of annual breakdowns	Breakdowns periods (days)	Maintenance checkup	If Yes
			M	F	M	F	M	F										
Al-Shifa	1	CD	2	0	1	0	1	0	9	1	7	New	2007	SIEMNS	24	4	Yes	monthly
		CD	0	0	0	0	0	0	0	0	0	New	2011	SIEMNS	3	7	Yes	annual
European Gaza	0	CD	0	0	0	0	0	0	0	0	0	New	2000	SIEMNS	0	0	No	
Nasser	0	Film & CD	1	0	1	0	0	0	7	0	7	New	2011	PHILIPS	1	40	No	
Shohda Al-Aqsa	0	X-ray Film	0	0	0	0	0	0	0	0	0	New	2006	SHIMADZU	0	0	No	
Indonesia	0	CD	0	0	0	0	0	0	0	0	0	New	2015	SIEMNS	0	0	Yes	annual
Abu Yousef Al Najjar	0	X-ray Film	1	0	1	0	0	0	1	0	2	Used	2008	SHIMADZU	3	4	Yes	annual

M=Male F=Female

Annex (15): Evaluation of Computed Tomography in governmental hospitals

Hospital	No. of a spare machine	Image types	Total No. of RTs		No. of RTs at morning shift		No. of RTs at evening & night shift		No. of exams at morning shift	No. of exams at evening & night	Examination appointment taken after	Machine type	Machine Installing	Manufacture company	Total No. of annual breakdowns	Breakdowns periods (days)	Maintenance checkup	If Yes
			M	F	M	F	M	F										
Al-Shifa	1	CD	2	0	2	0	0	0	30	0	10	New	2015	PHILIPS	2	30	Yes	annual
		CD	3	0	3	0	0	0	3	0	0	New	2004	SIEMNS	1	60	Yes	monthly
		CD	3	0	2	0	1	0	55	10	7	New	2008	PHILIPS	1	30	Yes	monthly
European Gaza	0	CD	3	0	2	0	1	0	50	7	15	New	2012	PHILIPS	1	90	Yes	monthly
Nasser	0	CD	0	0	0	0	0	0	0	0	0	New	2005	SIEMNS	0	0	No	
Shohda Al-Aqsa	0	CD	0	0	0	0	0	0	0	0	0	New	2016	General electric	0	0	No	
Indonesia	0	CD	3	1	2	1	1	0	17	3	6	New	2015	SIEMNS	0	0	Yes	monthly

M=Male F=Female

Annex (16): Evaluation of Magnetic Resonance Imaging in governmental hospitals

Hospital	No. of a spare machine	Image types	Total No. of RTs		No. of RTs at morning shift		No. of RTs at evening & night shift		No. of exams at morning shift	No. of exams at evening & night	Examination appointment taken after	Machine type	Machine Installing	Manufacture company	Total No. of annual breakdowns	Breakdowns periods (days)	Maintenance checkup	If Yes
			M	F	M	F	M	F										
Al-Shifa Hospital	0	CD	2	0	2	0	0	0	20	0	10	New	2016	SIEMNS	1	45	Yes	monthly
European Gaza Hospital	0	CD	2	1	1	1	1	0	15	15	10	New	2012	PHILIPS	1	7	Yes	monthly

M=Male F=Female

Summary in Arabic

ملخص الدراسة

تقييم خدمات التصوير الطبي لدى المستشفيات الحكومية في محافظات غزة

إعداد: ماهر ظاهر أحمد سليمان

إشراف : د. ياسر صالح العجرمي

مقدمة

تعتبر خدمات التصوير الطبي أحد أهم أركان العملية الطبية التشخيصية والعلاجية, حيث هناك أنواع متعددة من خدمات التصوير الطبي منها (تصوير الأشعة العادية, تصوير الفلور وسكوبي, تصوير الأشعة المقطعية, تصوير الرنين المغناطيسي و المسح الذري ... الخ). هناك طاقم متخصص يعمل في خدمات التصوير الطبي منهم أخصائي التصوير الطبي الذي يقوم بالتعامل المباشر وكذلك تصوير المريض. تعتبر خدمات التصوير الطبي مفتاح التشخيص للعديد من الأمراض بالإضافة إلى الدور المهم في مراقبة العلاج وتوقع النتائج. ينبغي الأخذ في الحسبان راحة المريض وتسهيل إمكانية الوصول إلى خدمة التصوير الطبي عند تخطيط وتصميم أقسام الأشعة. الطاقم المؤهل بالإضافة للتصميم المناسب لأقسام التصوير الطبي وفق المعايير الدولية يزيد من فرص السلامة المهنية, الإنتاجية وجودة الخدمات المقدمة للمرضى.

هدفت هذه الدراسة بشكل عام إلى تقييم خدمات التصوير الطبي لدى المستشفيات الحكومية في محافظات غزة.

تم إجراء دراسة مقطعيه وصفيه تحليلية بتصميم كمي ونوعي في أقسام التصوير الطبي لدى المستشفيات الحكومية بمحافظات غزة. الجزء الأول من المنهجية هو الجزء الكمي: وقد تم

تجهيز إستبانة محكّمه, قام البحث بتعبئتها من خلال مقابلة شخصية وجها لوجه مع أخصائي التصوير الطبي في المستشفيات الحكومية الستة (المستشفى الإندونيسي, الشفاء, شهداء الأقصى, غزة الأوروبي, ناصر و أبو يوسف النجار). وقد وصلت نسبة المشاركة الى 95.5%. بينما كان الجزء الثاني هو جمع البيانات من خلال قائمة مرجعية تم تصميمها من خلال الباحث وقد كانت معتمده علي المعايير الدولية. فيما يتعلق بالجزء النوعي فقد قام الباحث بإجراء ثلاث مقابلات رسمية مع أصحاب القرار من مدراء أخصائي التصوير الطبي.

أظهرت النتائج أن نسبة الاستجابة 95.5%، منهم 82% ذكور، 87% موظفين دائمين، ونسبة أعمار أخصائي التصوير الطبي الأقل من 40 سنة كانت 75%. كما وبينت النتائج أن نسبة الحاصلين على درجة البكالوريوس هم 85%، درجة الدبلوم 10% أما درجة الماجستير فكانوا تقريبا 5%. وقد تبين أن سنوات الخبرة لدي أخصائي التصوير الطبي متفاوتة فكانت نسبة من لديهم سنوات خبرة أقل من 10 سنوات هم 36.5% ومن لديهم سنوات خبرة ما بين 10-17 سنة هم 43%. من النتائج تبين أيضا أن مستشفى الشفاء يحتوي على أكبر عدد من أخصائي التصوير الطبي بنسبة 32% وكذلك أكبر عدد من ناحية توفر الأجهزة وقد أوعز الباحث ذلك لكونها تقوم بتغطية أكبر مساحة ديموغرافية. وقد سجل مستشفى ناصر ثاني أعلى نسبة أخصائي التصوير الطبي 17% من ثم سجل مستشفى أبو يوسف النجار الأقل من حيث عدد أخصائي التصوير الطبي 10%. كما وأضحت الدراسة أن نسبة من لديهم جهاز قياس الجرعة الاشعاعية كانت 84% أما الذين التزموا بحمل الجهاز كانوا 56% وهذا يظهر خلل في امتثال أخصائي التصوير الطبي في استخدام أجهزة القياس والرصد الاشعاعي.

إضافة الى ذلك تم تسجيل فروقات ذات دلالة إحصائية بين سنوات الخبرة لدي أخصائي التصوير الطبي وحمل أجهزة الرصد الإشعاعي.

كما أظهرت الدراسة أن 83% من أقسام التصوير الطبي كانت تتميز بتصاميم مناسبة من خلال توزيع الغرف وسهولة الوصول للقسم. وبصفة عامة كانت نسبة التطابق مع المعايير الدولية في أقسام التصوير الطبي 69% في التركيب والتصميم 70% في معايير الصحة والسلامة المهنية و27% فيما يتعلق باستقبال المرضى.

أما بالنسبة لتصوير الأشعة العادية كان امتثال غرف التصوير للمعايير الدولية هو على التوالي 45%, 64% و83% لكل من معايير التصميم ونسبة الصحة والسلامة المهنية بالإضافة الى جاهزية الغرف بالإمدادات الضرورية خلال عملية التصوير.

أما بالنسبة لغرف التحميض (الغرفة المظلمة) فإن امتثالها للمعايير الدولية كانت على النحو التالي: 81% من خلال التصميم والتركيب, 80% فيما يتعلق بالصحة والسلامة المهنية و68% للإمدادات الضرورية.

أما بالنسبة لغرف الفلوروسكوبي فقد كان امتثال الغرف للمعايير الدولية من ناحية التصميم هي 79%، الصحة والسلامة المهنية 82% و66% للإمدادات الضرورية للغرفة.

أما بالنسبة لأقسام الأشعة المقطعية فقد أظهرت النتائج أن امتثال الغرف للمعايير الدولية هو 60% من ناحية التصميم و78% لأساسيات الصحة والسلامة المهنية و91% للإمدادات الضرورية للغرفة.

أخيرا، كان امتثال أقسام الرنين المغناطيسي للمعايير الدولية من ناحية التصميم هو 86% وكانت نسبة الصحة والسلامة المهنية هي 100% و90% للإمدادات الضرورية.