

EFFECTS OF EDUCATIONAL INTERVENTION ON REPETITION RATE OF ROUTINE DIGITAL CHEST RADIOGRAPHY AMONG RADIOGRAPHERS IN TERTIARY HOSPITALS AT MAKKAH, SAUDI ARABIA



Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

June 2019

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EFFECTS OF EDUCATIONAL INTERVENTION ON REPETITION RATE OF ROUTINE DIGITAL CHEST RADIOGRAPHY AMONG RADIOGRAPHERS IN TERTIARY HOSPITALS AT MAKKAH, SAUDI ARABIA

By

ALMALKI ABDULLAH AHMED G

June 2019

Chairman : Associate Professor Rosliza Abdul Manaf, PhD Faculty : Medicine and Health Sciences

Background: Routine digital chest radiography is the common radiological procedure that is performed in a hospital's Radiology Department. Critical issues will arise if this procedure needs to be repeated. Repetition rate is the total number of repeated chest radiography by radiographers divided by total number of chest radiography that performed by the same radiographer, multiply by hundred. High repetition rate increases a patient's exposure to radiation dose. It also increases the workload of radiographers and patient waiting time as well as affects the annual budget of the department. In Saudi Arabia, the repetition of routine digital chest radiography was documented at 14.90%, which is above the acceptable standards.

Objective: The aim of this study is to develop, implement, and determine the effects of educational intervention on the repetition rate of routine digital chest radiography among radiographers in tertiary hospitals within the Makkah Region.

Methods: A quasi-experimental repeated measure was conducted with a control group in tertiary hospitals within the Makkah Region for eight months starting from June 2017. Four out of five tertiary hospitals were selected. Then, two of the four hospitals were combined into an intervention group and the other two combined into the control group. Stratification and a subsequent simple random sampling technique were utilized to select 56 respondents for each group. Pre-post intervention, and follow-up phases were conducted to determine the knowledge, motivation, and skills, and repetition rate among the respondents. The implementation of the educational intervention was after collecting the baseline data. The educational intervention has three objectives which include enhancement of radiographers' knowledge regarding production of high quality of chest radiography, motivating the radiographers to avoid chest radiograph repetition, and increase the level of the skills regarding chest radiograph. Data was analyzed using Chi-Square, one-way MANOVA, and two-way repeated MANOVA and MANCOVA using SPSS 22.

Results: Out of 56 respondents in each group, 47 (83.9%) respondents in the control group and 49 (87.5%) respondents in the intervention group were retained and analyzed. There were no statistically significant differences between the groups with respect to respondent characteristics, knwledge, motivation, skills and repetition rate at baseline p > 0.05. There were statistically significant differences of rknowledge, motivation, skills and repetition rate between groups at the baseline, post-intervention and follow-up after the covariate was controlled where Wilks' $\lambda = 0.301$, p < 0.001. There were statistically significant differences in the primary and secondary outcome between the time of groups, where Wilks' $\lambda = 0.744$, p < 0.001. There were also statistically significant differences in time*groups with respect to knowledge, motivation, skills and repetition rate, where Wilks' $\lambda = 0.317$, p < 0.001. In other words, the behavioral intervention module was effective in reducing the repetition rate.

Conclusion: The educational intervention conducted in this study was found to be effective in reducing the repetition rate among the sample study. The change in repetition rate was attributed to the enhanced knowledge, motivation, and skills of respondents in the intervention group.

Keywords: Repetition rate, educational intervention, radiographers, chest radiography.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN INTERVENSI PENDIDIKAN PADA KADAR PENGULANGAN RADIOGRAFI DADA DIGITAL RADIOGRAFI DI KALANGAN JURU X-RAY DI HOSPITAL TERTIARI DI WILAYAH MAKKAH, SAUDI ARABIA

Oleh

ALMALKI ABDULLAH AHMED G Jun 2019 Pengerusi : Profesor Madya Rosliza Abdul Manaf, PhD Fakulti : Perubatan dan Sains Kesihatan

Latar Belakang: Radiografi dada digital dada yang rutin adalah prosedur radiologi yang paling kerap dilakukan di Jabatan Radiologi dan pengulangannya adalah kritikal. Kadar pengulangan adalah jumlah radiografi dada berulang oleh radiografer yang dibahagikan dengan jumlah radiografi dada yang dilakukan oleh radiografer yang sama dan dikalikan dergan seratus. Kadar pengulangan radiografi yang kerap akan meningkatkan dedahan dos radiasi dan masa menunggu kepada pesakit, meningkatkan beban kerja radiografer, dan menjejaskan pembelanjaan tahunan jabatan. Di Arab Saudi, ia didokumenkan pada 14.90% yang melebihi nilai piawai yang diterima oleh agensi perlindungan sinaran.

Objektif: Matlamat kajian ini adalah untuk membangunkan, melaksanakan dan menentukan kesan intervensi pendidikan ke atas kadar pengulangan radiografi dada digital rutin di kalangan radiografer di hospital tertiari di Makkah.

Kaedah: Satu kajian menggunakan langkah berulang yang dilakukan secara eksperimental dengan kumpulan kawalan telah dijalankan di hospital- tertiari-di Makkah selama lapan bulan bermula dari bulan Jun 2017. Empat hospital tertiari-daripada lima telah dipilih. Kemudian, dua daripada empat hospital digabungkan menjadi kumpulan intervensi dan dua lagi sebagai kumpulan kawalan. Stratifikasi diikuti dengan teknik pensampelan rawak mudah digunakan untuk memilih 56 responden untuk setiap kumpulan. Pra, postdan tindakan susulan dijalankan untuk menentukan pengetahuan, motivasi dan kemahiran responden dan kadar pengulangan radiografi dada. Radiografi dada yang dilakukan oleh responden dikumpulkan selama 10 hari bekerja dalam setiap fasa. Pelaksanaan intervensi pendidikan adalah setelah

mengumpulkan data baseline. Intervensi pendidikan merangkumi tiga objektif, peningkatan pengetahuan radiografer mengenai radiografi dada yang berkualiti tinggi, memotivasi para ahli radiografi untuk mengelakkan pengulangan radiografi dada, dan meningkatkan tahap kemahiran mengenai radiografi dada. Data dianalisis oleh Chi-Square, MANOVA satu hala, dan MANOVA dan MANCOVA berulang kali menggunakan SPSS 22.

Hasil: Daripada 56 responden untuk setiap kumpulan, 47 responden (83.9%) dalam kawalan dan 49 responden (87.5%) dalam kumpulan intervensi dikekalkan dan dianalisis. Tidak terdapat perbezaan yang ketara secara statistik antara kumpulan berkenaan dengan ciri responden, pengetahuan responden, motivasi, kemahiran dan kadar pengulangan radiografi dada digital rutin p > 0.05. Terdapat perbezaan yang ketara secara statistik antara kumpulan di peringkat asas, post dan tindakan sususlan selepas mengawal kovariat berkenaan dengan pengetahuan, motivasi, kemahiran dan kadar pengulangan Wilks ' λ = 0.301, p <0.001. Terdapat perbezaan yang ketara secara statistik dalam masa antara kumpulan berkenaan dengan pengetahuan, motivasi, kemahiran dan kadar pengulangan Wilks ' λ = 0.317 p <0.001. Terdapat juga perbezaan statistik dalam kumpulan Wilks ' λ = 0.317 p <0.001. Dengan kata lain, modul intervensi tingkah laku adalah berkesan untuk mengurangkan kadar pengulangan radiografi dada digital rutin.

Kesimpulan: Intervensi pendidikan didapati berkesan untuk mengurangkan kadar pengulangan radiografi dada digital rutin. Perubahan dalam kadar pengulangan adalah disebabkan oleh peningkatan pengetahuan, motivasi, dan kemahiran responden dalam kumpulan intervensi.

Kata kunci: Kadar pengulangan, campur tangan pendidikan, juru X-ray, radiografi dada.

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Signatura	
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Committee:	Associate Professor Dr. Rosliza Abdul Manaf
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Committee:	Associate Professor Dr. Muhamad Hanafiah Juni
a	
Signature:	
Name of Member	
Committee:	Dr. Havati Kadir Shahar
Committee.	Di. Hayati Kadii Shahai
Signature:	
Name of Member	
of Supervisory	
Committee:	Dr. Noramaliza Mohd Noor
Signature:	
Name of Member	

of Supervisory Committee:

Professor Dr. Abdelsafi Abbas Mohammed Gabbad

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C

LIST OF ABBREVIATIONS

AAPM	American Association Physicist in Medicine
ACR	American College of Radiology
ALARA	As Low As Reasonably Achievable
AP	Anterior Posterior
CBAHI	Central Board of Accreditation Health Initiation
CD	Compact Disc
CDSI	Central Department of Statistics & Information
CI	Confidence Interval
CON	Conventional Radiography
CONSORT	Consolidated Standards of Reporting Trials
CPU	Central Processing Unit
CR	Computed Radiography
СТ	Computed Tomography
CVI	Content Validity Index
CVR	Content Validity Ratio
DI	Dental Imaging
DR	Digital Radiography
ER	Emergency Radiology
EFA	Explanatory Factor Analysis
FS	Fluoroscopy
GE	General Electric
HIS	Hospital Information System
IAEA	International Atomic Energy Agency
IBM	Information Motivation Behavioral Skills Model
IP	Imaging Plate
IR	Interventional Radiology

	KVp	Kilovoltage peak
	LL	left lateral
	MANOVA	Multivariate Analysis of Variance
	MANCOVA	Multivariate Analysis of Covariate
	MAs	Milliamperage-seconds
	MG	Mammography
	ML	Maximum Likihood
	МОН	Ministry of Health
	MRI	Magnetic Resonance Imaging
	Ng	Total Number of Panelists
	NM	Nuclear Medicine
	PACS	Picture Archiving and Communication Systems
	PA	Posterior Anterior
	PAF	Principal Axis Factoring
	PC	Principal Components
	PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
	RADPEER	Radiology peer review system
	RIS	Radiology Information System
	RL	Right Lateral
	SD	Standard Deviation
	SCFHS	Saudi Commission for Health Specialist
	UK	United of Kingdom
	USA	United States of America
	USD	United State Dollar
	WHO	World Health Organization

CHAPTER 1

INTRODUCTION

This chapter covers the background on routine digital chest radiography and repetition rates worldwide. It also comprises the problem statement, significance of study, research questions, objectives and hypothesis of this work. The definition of the terms used in this study is also included in this chapter.

1.1 Background

Chest radiography is the most common radiological examination performed in radiology departments (Ekpo, Egbe, and Akpan, 2015). In the United States of America (USA), 150 million chest radiographies are performed each year (Brestel and Cohen-sfaty, 2018). In the United Kingdom, radiological chest examination represents more than 19.5% of 39 million radiological examinations performed annually (Hart, Wall, Hillier, and Shrimpton, 2010). In Saudi Arabia, routine chest radiographs also constitute the most common radiological examinations performed in radiology departments (Abdelhalim, 2010; Osman, Elzaki, Abd Elgyoum, Elrahim, and Osman, 2014). Therefore, high-quality chest radiography crucially correlates with a high level of service quality in radiology departments.

A good quality radiograph should provide an acceptable image of the body anatomy. Failure to do so will require the radiograph to be repeated. The term "repetition" refers to the radiograph of patients with clinically unacceptable images, which therefore need to be repeated (Assi, 2018; Benza, Damases-Kasi, Daniels, Amkongo, and Nabasenja, 2018; Little et al., 2017; Sadiq et al., 2017). Mainwhile the repetition rate is the total number of repeated radiorgaphy by radiographer divided by total number of radiography the performed by the same radiographer multiply by hundreds (Zewdu, Kadir, & Berhane, 2017).

The poor of repeated chest radiorgaphy may indicated throughout different criteria such as; cut of one edge of the radioragph, darkness or brighthness of the radiorgaph or artifacts that appears on the part of the radiorgaph due to unvoluntery movement of the lung or patients don't remove the dress the contains metal (Fintelmann et al., 2012; Hlabangana & Andronikou, 2015; Ofori, Antwi, Arthur, Yeboah, & Dzefi-Tettey, 2013). Another indication for the repetition where the radiorgaph when the patients dose not postionned propaply during the imaging process (Assi, 2018; Jones, Polman, Willis, & Shepard, 2011; Sukumar, Yadav, Sahana, David, & Kumari, 2012).

The Australian Collage of Radiologists recommend that the repetition rate should start from 2% and not exceed 5% (Rajani, Sajjad, Masroor, Parveen, and Naqvi, 2016). The World Health Organization (WHO) and the Radiological Society of North America also agree that repetition rate should not exceed 5% (Ng, Ong, Koh, and Kok, 2017;

WHO, 1982a). Based on the Diagnostic Imaging Quality Assurance Committee, the acceptable repetition rate for a radiograph should range between 5% to 7% (Winston et al., 2001). The American Association of Medical Physicist (AAPM) recommended keeping the repetition rate below 6% and to not exceed 10% (Jones et al., 2015).

A study conducted in China showed that routine chest radiography performed in the radiology department using fixed digital radiography resulted in a higher repetition rate than other radiological examinations by 13% (Fintelmann et al., 2012). A study conducted in Brazil revealed that the repetition rate of chest radiography was 7.93% (Silva et al., 2013). Another study conducted in the USA documented a 27% repetition rate for chest radiography (Little et al., 2017).

In a study conducted in India, repetition rate was linked to the increase in "cost and ionized radiation dose exposure" (Usha, Bhargava, and Bhatt, 2014). This includes the cost of compact discs (CDs) and the cost of maintenance related to equipment tubes and the cost of a radiographer that has been overloaded with work. In a similar vein, a study conducted in Ghana reported an annual increase of more than USD72,000 for each unit maintenance in the Radiology Departments across the country as a result of radiograph repetition (Ofori, Antwi, Arthur, Yeboah, and Dzefi-Tettey, 2013). A high repetition of radiographs at any hospital also means that there is high consumption of valuable physical resources due to increased load of equipment, which would eventually decrease the equipment's lifetime. In addition, low-quality radiographic images result in other issues such as increased direct and indirect costs and time consumption on behalf of both patients and radiographers (Candido et al., 2013; Teferi, Zewdneh, Admassie, Nigatu, and Kebeta, 2012).

Besides that, a high repetition of radiography examinations will increase the dose absorbed by the patient, which has a biological effect on human body cells. It has been demonstrated that patients who have undergone repeated radiography receive an average 3.23 Gray centimeter (Gy.cm) of radiation (Jabbari, Zeinali, and Rahmatnezhad, 2012). It was estimated that a radiographer has about 5% probability of dying from over exposure. Too much exposure could also reduce the radiographer's life span by about six months (Chabot, 2015). Additionally, this effect may extend to the community due to the increase in medically scattered radiation. Furthermore, some diseases might be caused by the ionizing stochastic effect due to this unnecessary radiation, and could also lead to cancers such as leukemia, thyroid cancer, breast cancer, and lung cancer. These cancers have strongly been associated with exposure to radiation and increased absorption of radiation dose (Faraj, Ali, and Saeed, 2013). Thus, radiography repetition places patients and radiology personnel at risk of high doses of ionization radiation (Usha et al., 2014).

Penetration of the X-ray beam should be based on clinical diagnosis due the different pathologies that may affect the mediastinum or other parts of the chest organ. In addition, the patient's cooperation is essential to obtaining accurate radiographic results (Chiri, Awan, Archibald, and Abbott, 2013). The patient's understanding of the procedure will mainly be conferred via communication with the radiographer and

from the information on the methods of examination. It has been discovered that effective communication skills or soft skills in a radiological examination will affect both image quality and patient satisfaction (Ochonma, Eze, Eze, and Okaro, 2015). Radiographers must have a good understanding of image acquisition when performing the procedure, which includes using ideal radiological factors for the equipment and selecting the proper radiological positions.

A radiographer's role in the working process and the quality of services received are pertinent, making them important individuals that ensure the quality of the radiograph or radiography services (Khafaji and Hagi, 2014). One study showed that radiographers are the main causes of repeat radiography (Akintomide, Egbe, Bassey, Eduwem, and Oyama, 2011). Moreover, various factors relating to radiographers and their influence on the quality of chest radiographs have been investigated. Another study revealed that male radiographers often have a higher repetition rate than female radiographers (Khoshinani, Khoshinani, and Heidari, 2014). Differences in repetition rate as a result of radiographer's experience has also been found in a study conducted in Saudi Arabia (Khafaji and Hagi, 2014). Based on the above evidence, it is recommended that radiographers be included in the process of problem solving and quality improvement to increase their attention and knowledge on the subject matter (Joint Commission International, 2013; Siverbo, Eriksson, Raharjo, and Moonen, 2014). This involvement will enhance their understanding and behavior of imaging phases.

Several studies have also stressed on the necessity of educating radiographers in routine digital radiography in order to change their daily routine at work (Ahmed and Suliman, 2013; Candido et al., 2013; Farajollahi, Fouladi, Ghojazadeh, and Movafaghi, 2014). Thus, the planned education of radiographers is a routine step in producing high-quality chest images, and could provide direction for practitioners to deal with their daily work, and thus reduce repetition rate. This education incorporates different factors that affect the imaging process to ensure image quality is enhanced. It helps enhance the radiographers' knowledge, motivation, and skill by making them understand the implication and burden arising from such an issue, which can assist in service improvement and reduce issue implications such as cost, radiation overdose, and time management.

Annual education of radiographers in Saudi Arabia is similar to that of other healthcare practitioners, in which one of the requirements is the Saudi Commission for Health Specialist (SCFHS). Radiographers should attend training amounting to at least 10–20 credit hours per year (SCFHS, 2017). These training hours include training sessions, lectures, workshops, and conferences. Despite their abundance, the aim of these programs is only to update radiographers about the latest information in imaging and technology.

The structure of a radiographer's profession in Saudi Arabia is based on four professional classifications following the Saudi Commission for Health Specialist license (SCFHS, 2017). The first classification is the radiographer, who possesses a

Diploma in Radiography with no working experience. The second classification is the specialist radiographer, who possesses a Bachelor's degree in Radiography with a one-year experience. The third classification is the senior specialist radiographer, who possesses a Master's degree in Medical Imaging with two years of experience. Meanwhile, the consultant specialist radiographer classification is conferred to those with a Doctoral degree in Radiography with four years of experience.

The hospitals in Saudi Arabia are classified into three categories: Public hospitals supervised by the Saudi Ministry of Health (MOH); other health sectors such are education hospitals; and Private hospitals, which are profit-based. Specifically, MOH has 282 hospitals distributed in the country's cities, which provide primary, secondary, and tertiary healthcare services (MOH, 2015; WHO, 2017a). These hospitals are distributed across the 13 Regions in Saudi Arabia. Riyadh and Makkah Region are the biggest regions in terms of population, distance, and healthcare centers. In the Makkah Region, general and specialist hospitals distributed in the cities have a 8023-bed capacity (General Authority for Statistics, 2013). These bed capacities also come with a definite demand for diagnostic services, in which radiographers play an important role.

1.2 Problem Statement

In Saudi Arabia, one study reported high repetition rates of radiography in tertiary hospitals, whereby a repetition rate of 14.9% was documented. This rate is higher than the mean benchmark of 5% (Khafaji and Hagi, 2014; Ng et al., 2017; WHO, 1982b). Another study reported the repetition rate in two tertiary MOH hospitals in Saudi Arabia amounting to 7.84% and 7.44%. The study also revealed that chest radiography had a higher repetition rate than other radiological examinations (Al-Malki, Abulfaraj, Bhuiyan, and Kinsara, 2003).

There are three factors that may contribute in the high repetition rate which are related to radiorgaphers, patients and machines (Akintomide et al., 2011; Owusu-Banahene, Darko, Hasford, Addison, & Asirifi, 2014). However, repetition of radiography is strongly associated with the radiographers, whereby the issue is described as highly critical in the radiology department (Akintomide et al., 2011). It is estimated that the working hours of the radiographer could increase by as much as 135 hours per month due to this high repetition rate (Ofori et al., 2013). Hence, high repetition rate would lead to increased daily workload. In addition, a high repetition rate increases the waiting time of the patient and delays their treatment plan and clinical decision set by the referring physician (Lin et al., 2016; Zewdu, Kadir, and Berhane, 2017). A high repetition rate could also leads to reduced patient satisfaction and negatively impacts the patient's experience of the healthcare organization.

In terms of economic burden resulting from this repetition rate, a study by Al-Malki et al. (2003) revealed that repeated radiography in Saudi Arabia costs around USD2,000,000 per year. Financial burden also extends to include operational costs.

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One study stated that the high repetition rate of radiography could consume two months of the equipment lifetime each year, which will finally require the X-ray machine tube to be replaced faster than its intended service life (Khafaji and Hagi, 2014; Khoshinani et al., 2014).

For ionized exposure, if the dose is exceeded, cells and tissue will be adversely affected (Elgazzar and Kazem, 2015). A high repetition of radiographs increases both staff's and patients' exposure to ionized radiation (Al-Malki et al., 2003; Arimie, 2012; Ip, Mortele, Prevedello, and Khorasani, 2012; Jabbari et al., 2012).

According to WHO, radiological practice is influenced by level of knowledge, motivation, and skills (Dieleman and Harnmeijer, 2006). A study conducted in Saudi Arabia by Elsamani, Ahmed, and Elamin (2015) revealed that there is a variation in radiographers' knowledge, where those with poor knowledge constitute 58% of the total radiographers in the country. Another qualitative study also revealed that Saudi radiographers lack the knowledge of quality assurance in Magnetic Resonance Imaging (Alsharif, Mcgee, Rainford, and Davis, 2018). Additionally, it was also revealed that the radiographers lack motivation and this affects the quality of the image produced (Okaro, Eze, and Ohagwu, 2010). Lack of knowledge and motivation dramatically influences the skill level of the radiographer. It has been shown that the increase in repetition rate is due to deficiencies in the radiographers' skills (Waaler and Hofmann, 2010). Competent skills would lead to error prevention in the imaging process phases. Radiographers' skills include the ability to communicate properly with the patient and to handle equipment accurately.

Although this issue has been highlighted by various studies, the repetition rate in routine digital radiography in the Radiology Departments under the MOH of Saudi Arabia has not been consistently measured (MOH, 2016). Also, no specific quality standard has been introduced for repeated radiograph measurements and analyses (CBAHI, 2016). The absence of a quality control that specifically documents repetition rate has led to this issue being ignored. Ignorance of this issue reflects the extent of the radiographers' education.

Education has also been proposed to educate radiographers on how to produce highquality chest radiography images (Hofmann, Rosanowsky, Jensen, and Wah, 2015; Khafaji and Hagi, 2014). A study recommended that education be implemented to reduce repetition rate and improve the radiographers' skills (Silva et al., 2013). It was observed that a radiographer that has not been sufficiently educated will produce poorquality images (Kalondo, 2010). Requiring the radiographer to have a certain level of education will increase the concern and motivation of the radiographer on the subject matter, and improve his or her skills when handling patients and equipment, which will in turn help him or her produce high-quality chest images. Globaly, regular education does not cover different acceptable behaviors for overcoming the issue of radiography repetition. It only concentrates on knowledge enhancement and thus the effect is not retained over a long period of time. Therefore, there is a need to develop an educational intervention based on behavioral theory to overcome the issue of repetition.

1.3 Research Significance

The significance of this study covers three categories: the patient, staff, and organization. For the patient, educating radiographers will help reduce the dose of radiation, decrease waiting time, and increase patient's satisfaction. Meanwhile, for the staff, the radiation dose and workload will be reduced. This intervention study is significant for an organization, as it could reduce the burden of equipment consumption, cost, as well as assist the organization to achieve its vision. In addition, for researchers, who are interested in this field of study, this would help add to the existing body of knowledge on the effect of behavioral intervention modules on the repetition rate of routine digital chest radiography.

Among the benefits of the current study is the increase in level of knowledge, motivation and behavioral skills among radiographers regarding the issue of routine digital chest radiography. This study may also provide empirical evidence for the radiation protection department in MOH to use and generalized behavioral educational material to increase the cognitive perception and modify the behavior of radiographers, and thus minimize the repetition rate in MOH hospitals in the country. Globally, the findings of this research will assist organizations around the world to improve the quality of services offered by the radiology department.

1.4 Research Questions

- i. What are the baseline differences between intervention and control group in :
 - a. Respondents' characteristics?
 - b. Respondents' knowledge, motivation, skills and repetition rate of routine digital chest radiography?
- ii. What are the predictor variables of change in radiographers' knowledge, motivation, skills and repetition rate of routine digital chest radiography?
- iii. What are the differences in the level of radiographers' knowledge, motivation, skills and repetition rate of routine digital chest radiography within and between control and intervention at baseline, post, and follow up in Makkah Region tertiary hospitals?
- iv. What are the differences in the level of radiographers' knowledge, motivation, skills and repetition rate of routine digital chest radiography within and between control and intervention at baseline, post and follow up while controlling possible covariate in Makkah Region tertiary hospitals?

1.5 Research Objectives

1.5.1 General Objective

In general, the aim of this study was to develop, implement and determine the effects of educational intervention on repetition rate of routine digital chest radiography among radiographers in Makkah Region tertiary hospitals.

1.5.2 Specific Objectives

- i. To determine the baseline differences between intervention and control group in:
 - a. Respondents' characteristics
 - b. Respondents' knowledge, motivation skills and repetition rate of routine digital chest radiography.
- ii. To determine the predictor variables in radiographers' knowledge, motivation, skills and repetition rate of routine digital chest radiography.
- iii. To develop and implement the educational intervention among radiographers' at Makkah Region tertiary hospitals.
- iv. To determine the differences in the change of the level of radiographers' knowledge, motivation, skills and repetition rate of routine digital chest radiography within and between intervention and control groups from baseline, post, and follow up at Makkah Region tertiary hospitals.
- v. To determine the differences in the change of the level of radiographers' knowledge, motivation, skills and repetition rate of routine digital chest radiography within and between intervention and control groups at baseline, post and follow up while controlling possible covariate at Makkah Region tertiary hospitals.

1.6 Research Hypothesis

- i. There is no statistically significant differences between control and intervention with respect to respondents' characteristics.
- ii. There is no statistical significant differences in the level of radiographer knowledge, motivation, skills and repetition rate of routine digital chest radiography between intervention and control at baseline at Makkah Region tertiary hospitals.
- iii. There is statistical significant effect of predictors on change of radiographers' Knowledge, motivation, skills and repetition rate of routine digital chest radiography.
- iv. There is a statistical significant differences in the level of radiographers' Knowledge, motivation, skills and repetition rate of routine digital chest radiography within and between intervention and control at baseline, post, and follow up at Makkah Region tertiary hospitals.

v. There is a statistical significant differences in the level of radiographers' Knowledge, motivation, skills and repetition rate of routine digital chest radiography within and between intervention and control at baseline, post, and follow up in while controlling other variables at Makkah Region tertiary hospitals.

1.7 Terms Definition

- vi. Repeat Radiography: Radiograph that perform when the first radiograph does not provide full information to either referring physician or radiologist. It was also defined as "radiological examination output considered useless and waste based on imperfect information that it contains" (Zewdeneh, Teferi, and Admassie, 2008).
- vii. Motivation is individuals' desire to expend effort to benefit themselves and others due to the perception of severity of risk (WHO, 2016; Wright and Christensen, 2013).
- viii. Skills is the ability of an individual to provide and maintain acceptable level of services quality (Snaith and Lancaster, 2008).
- ix. X-ray are "electro-magnetic waves with wavelengths in the region of an Angstrom $(10^{-10}m)$ " (Stohr, 1995). It is used in the medical field to expose the patient by bundle of doses of radiation to see the internal organ of the body.
- x. Tertiary hospital is a health care center with specialized staff and technical equipment, for example cardiology, intensive care unit, and specialized imaging department with average bed capacity of 500 and above (Hensher, Price, and Adomakoh, 2006).

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