Factors Affecting Radiographers' Compliance with Radiation Protection on All Areas of Hospital Settings Worldwide - A Meta-Analysis

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Abstract

Aim: This study analyzed factors affecting radiographers' compliance to radiation protection in all areas of hospital settings worldwide. Methods: The PICO guide helped put focus on this meta-analysis. Of the 27studies published from search engines and/or databases from 2009 to 2016, only four were selected. A PRISMA guideline was also used to eliminate other studies. Critique framework helped in analyzing the studies selected. Outcomes: Four significant factors affected radiographers and dental professional compliance with the practice of RPs – knowledge, work site, years in practice, and inspection. Of the 100 radiographer in the radiologic department, 98% complied; of the 1500 radiologic technologists, 77,1% complied by patient safety practices and 70,5% complied by personal safety practices; of the 60 radiation workers – 25 radiographers, 21 dentists, 6 oral hygienists, 8 dental therapists – 59% radiographers, 38% dentists and 17% of OH&DT complied wearing protection clothing, 29% radiographers complied protecting patient, 11% all participant never repeat procedures, and 79% radiographers complied radiation safety protocols; of the 31 radiographers, only 1(12,9%) radiographer complied radiation protection. A total of 59.26% compliance was found among radiographers and health care professionals from the four selected studies.

Keywords: Applied Science, Literature, Meta-Analysis, Radiation Protection, Radiography

I. INTRODUCTION

This meta-analysis aims to analyze worldwide factors significantly affecting radiographers' compliance with the Radiation Protection (RP) to reduce radiation effects on hospitals in worldwide setting. Four studies were selected to be analyzed.

RP requires compliance of radiographers because the radiographer plays a central role, as she/he cares for the patient before, during and after the radiographic examination and/or radiological intervention Andersson, et al. [1]. Radiographer is the key person involved in radiation exposure [2]. With the introduction of ALARA principle (As low as reasonably achievable) each examination is expected to be optimized to obtain a quality diagnostic image while keeping the patient dose as low as possible [3].Radiographers need to be more aware of their roles in ensuring total compliance to standard radiation safety in their institution [4]. Compliance levels should be higher to protect the technologist and patient [5].

The purpose of this study is to pave the way for new strategies in reducing ill effects of unnecessary medical exposure on patients and radiation workers by compliance to radiation protection.

A. Concept

According to Mojiri and Moghimbeigi [6]RP has the potential to limit hazardous effects from ionizing radiations. Awareness and knowledge on application protection guidelines and instruments among radiology technicians has an important role to safe working. According to Okeji, et al. [3] RP is described as activities directed towards minimizing radiation exposure of both patient and personnel during x-ray exposure. These RP devices include lead aprons, lead glasses, lead gloves, gonad shields, thyroid shields, patient immobilization devices, and radiation area signs [7].

According to [8], in addition, the use of shielding tools and X-ray beam collimator has extensively been advocated during radiological procedures. The absorbed radiation dose can be reduced as much as 99.4% following the use of (1 mm) lead shield Collimation reduces the overall integral dose to the patient and minimizes the radiation risks.

Fatahi-Asl, et al. [9]mentioned that the proper use of personal protective equipment and observing the instructions and regulations for protection against ionizing radiation can greatly reduce unnecessary exposure. Therefore, factors affecting radiation dose during radiographic examinations include the knowledge on the use of personal protective equipment, the applied tube voltage (kVp), tube current (mA), exposure time (s), filtration, focal spot to skin distance (FFD), film–screen speed, collimation and patient size ([3].Excessive beam size has been identified as the principal cause of unnecessary patient exposure to radiation [3]. Furthermore, to promote the level of RPs, some devices and instruments in the worksite should be properly controlled during radiographic processes. Figure 1 illustrates the conceptual framework of this meta-analysis.

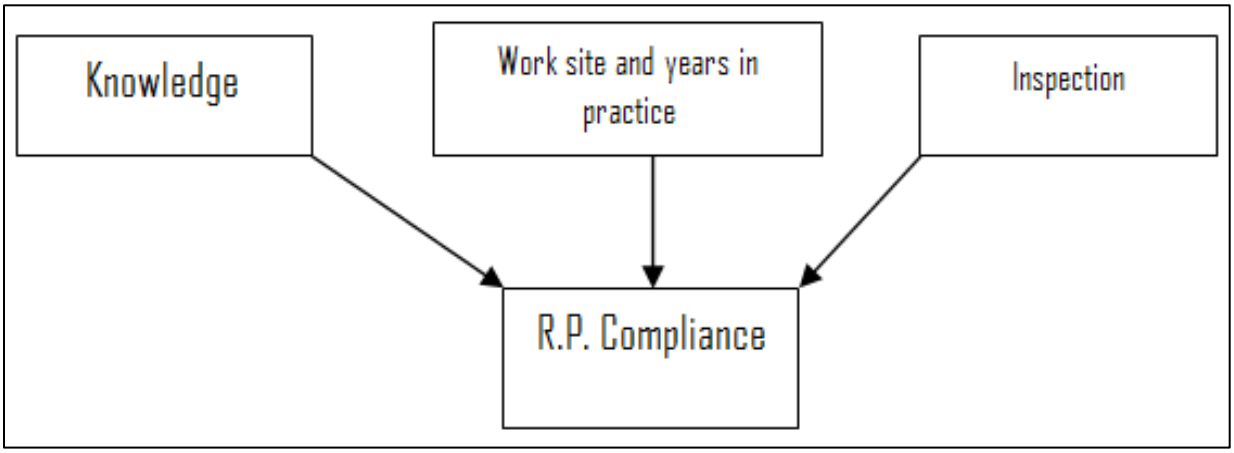

Fig. 1: Concept of the factors affecting RP Compliance

II. BACKGROUND

In 1934, the U.S. Advisory Committee on X-ray radium protection proposed the first formal standard for protecting people from radiation source [10]. By then, the quantitative measurement of ionizing radiation has become standardized in units of roentgens, and therefore, the recommended limit on dose rate was expressed as 0,1 roentgen per day [11]. The limits and the associated risks are listed in table 1, related both to stochastic effects, such as cancer and genetic effect – the deterministic effects. WHO has established a radiation program to protect patients, workers, and the public against the health risk radiation exposure under planned, existing and emergency exposure situations, and has cooperated with 7 other international organizations for the revision and update of the international Basic Safety Standards (BSS) [12].

Table – 1
Current Standards and Associated Estimated of Risk [11]

Category	*Annual Limit*	*Recommended Risk Coefficient*	*Estimated Risk at the Annual Limit*
Occupational annual whole-body limit for stochastic effects	*5rem (stochastic)*	*4×10^{-4} rem^{-1} (for fatal cancer) 8×10^{-5} rem^{-1} (for severe genetic effects)*	*2 in 1,000 per year 4 in 10,000 per year*
Occupational lifetime limit	*1 rem per age (years)*	—	*3 in 100 at age 70*
Occupational lifetime limit for deterministic effects	*15 rem to lens of eye 50 rem to any other organ or tissue system*	—	*no risk if limits not exceeded*
Public annual whole body limit for continuous exposure	*100 mrem*	*5 x10-4 rem-1 (for fatal cancer) 1 x10-4 rem-1 (for severe genetic effects)*	*1 in 10,000 per year 1 in 100,000 per year*
Negligible individual dose (annual whole-body dose per source or practice)	*1 mrem*	—	*no discernable effects (5 in 10,000,000)*

III. METHODOLOGY

Search strategy starts with using keywords entered on search engines on internet as English and Indonesian text words. The databases are the Google Scholar, Pubmed that provided abstract and full text articles. The PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guideline [13] helped eliminate other studies (Figure 2) – using inclusion and exclusion criteria.

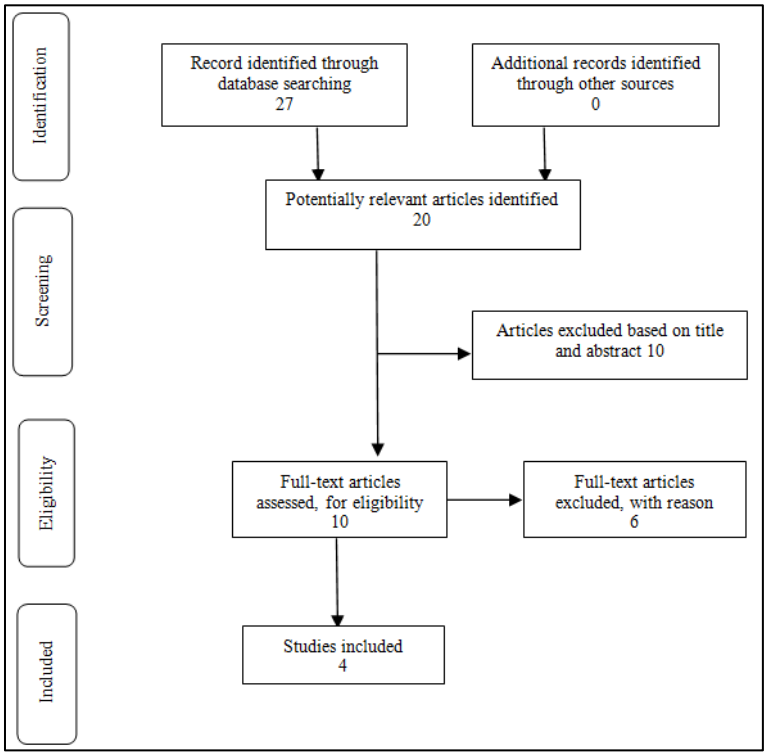

Fig. 2: PRISMA guideline [13]

IV. RESULT

Adejumo, et al. [4] investigated significant compliances with RPs by radiographers affected by knowledge among 100 respondents on questionnaire for years in practice. This study used a simple random sampling method to select the radiographers who were based in radiology centre in south west Nigeria from teaching hospitals (58%), general hospitals (19%), and private diagnostic centre (23%). The ages of respondents were between 20- 60 years. Data collected were analyzed using Epi-info (version3.5.1).

Adejumo, et al. [4] found a 98% of respondents had good academic qualification to practice as qualified radiographer. Almost 99% of respondents believe that radiation safety standard is important and 97% wanted the standard to be compulsory indicating that majority have good knowledge of safety standard. The study showed high rate of awareness and compliance of radiographers in South West, Nigeria to radiation safety standards as stipulated by national and international bodies. The radiation protection devices presented in most centers were impressive indicative of employers' willingness to abide by radiation standards. Clinically all the 23 radiographers in private diagnostic centre were satisfied with the level of safety devices provided for them because it met the standard of protection compared to the satisfaction showed in both government hospitals where a good number 18 showed dissatisfaction in the safety devices provided due to its inability to meet the standard required. Those results showed that larger hospitals were more likely to offer radiation safety than smaller hospitals (83 %and 57%), respectively. The result further showed that knowledge and compliance did not depend on years in practice because out of 97% who had good knowledge on safety standards, 80% had less than 10 years in practice and majority were involved in continuing education.

Reagan and Slechta [5] determined RP compliance by radiologic technologists using the personnel radiation safety practices and patient radiation safety practices. Two independent variables, years of employment in the radiologic sciences and work site, were significantly related to adherence with safety practices ($P < 0.05$). This study used simple random sample from 1500 California radiologic technologists certified by the American Registry of Radiologic technologists, the return rate was 32%. Seven solicited informations about respondent characteristics, including sex, age, years in practice, and primary area of practice, work site, initial radiologic technology education and highest level of education were collected. Data were analyzed using SPSS (SPSS Inc, Chicago, Illinois).

Reagan and Slechta [5] found a 98.9% low compliance with safety practices, 72.2%. Knowledge on safety practices was higher than compliance with safety practices, 82.2% and 72.2%, respectively. The National and California Study was highlighted in this study and informs that the compliance was higher for patient safety practices than for personnel safety practices, 77.1% and 70.5%, Although compliance in this study may have increased since the current study was completed, there was no notable improvement in compliance scores in the 3 years between the national study and the current study. In addition, the type of initial education and highest level of education were related to level of compliance. However, the relationships between type of work site and years in practice to compliance are complex. This is because performance on individual items ranged from 95.6% to 27.4% compliance which was affected by their years in practice.

Modiba [14]determined the compliance to radiation protection protocols also with the years in practice, as demonstrated by radiographers and dental professionals. A quantitative descriptive study methodology was the preferred due to its rigid style of categorizing responses to questions and having the numerical data analyzed statistically. The study was conducted among the eight hospitalsin the Waterberg District of the Limpopo Province, namely Mokopane Regional, Voortrekker, George Masebe, F.H Odendaal, Warmbath, Thabazimbi, Ellisras and Witpoort hospitals at Limpopo Province South Africa. The population consisted of 25 Radiographers, 21 Dentists, 6 Oral Hygienists and 8 Dental Therapists. In this study the SPSS (Statistical Product Service Solutions) was used to analyze data. Descriptive statistics of frequencies mean and standard deviations were displayed. In the analysis of variables, ANOVA was used. The questionnaire was designed in such a way that it addressed the research questions. The questions attempted to find out the level of awareness with regard to long term radiation exposure effects and compliance to radiation safety protocols by radiographers and dental professionals.

[14]asked the participants to present their demographic data in terms of gender, age, level of education, length of service and designation. The total number of participants was 45. They consisted of Radiographers and Dental Professionals (Oral Hygienists, Dental Therapists and Dentists) of ages ranging from 22 to 60 years. Revealed that Shows that the majority (67%) of the participants in the study were females. It is also searching the Radiographers (37%) are in the majority, which was understandable as for them, X-rays is their key function whereas for dental professionals, it is just one of their special investigative tool. Most of the participants (67%) hold at least a Bachelors Degree and 58% of participants had a short duration of service (1-5 years). Questions were also asked on how to establish their knowledge on radiation and its ill-effects. Results revealed an impressive indication of a good understanding of x-rays being a source of ionizing radiation by the majority of respondents (100% for both radiographers, OH&DT and 95% of Dentists) who had number of years in experience.

Hendra, et al. [15] investigated on the Explanatory Research compliance RPs by radiographers with personal radiation protection equipment with probability value of (p) <0.05 as a result (95%), with cross sectional approach methods usedobservation and interview.The population was radiographers from four hospitals in Semarang Indonesia, simple random sampling was used.

The results from the study of Hendra et al (2011) showed that there were, radiographer aged under 30 years (51.6%) over 30 years (48.4%) and their education, level was 24 people (77.4%) with Diploma and 7 people (22.6%) with bachelor's degree which made a significant effect on the compliance with RP. The massive amount of training received by as many as 20 (64.5%) radiographers gave a significant result. Significant results were also obtained from19 (61.3%) radiographers who had less than10 years working experience.

Hendra, et al. [15] found a 3.20% confidence interval that radiographers comply with RPs. This meant that only <96,8% of the 30 radiographers did not comply with RP. There is a significant relationship between age and practician the use of PPE with p = 0.484 (> 0.05); education and in the practice of use of PPE with p = 0.301 (> 0.05); between training and practice the use of PPE with p = 1.000 (> 0.05); between tenure with the practice of the use of PPE with p = 0.387 (> 0.05).

Table – 2
Summary of the four selected studies

Comparison	*Intervention*	*Population*	*Outcome*
[4]	*Investigate RP Compliance*	*Radiographers in the hospital N= 100*	*RP compliance: 98%* *Factor: Knowledge*
[5]	*Determine RP Compliance*	*Radiologic Technologist in the hospital N=1500*	*RP Compliance:* – *compliance patient safety : 77.1%* – *compliance personnel safety: 70.5%* *Factor: Work site and years in practice*
[14]	*Investigate RP Compliance*	*25 Radiographers 21 Dentists 6 Oral Hygienists 8 Dental therapists In the hospital N=60*	*RP Compliance :* – *Compliance to Wearing Protective Clothing; 59% Radiographers, 38% of dentists and 17% of OH&DT seem to comply with the wearing of a dosimeter.* – *Compliance to Radiation Protection on Patients; 29% of radiographers agree* – *Protection of patients against radiation exposure;* *1) 100% of all participants comply with the requirement.* *2) 59% of all participants (24% radiographers, 17% OH&DT and 19% Dentists) rarely repeat procedures.* – *Compliance to radiation safety protocols; Radiographers felt exposed to radiation (more at risk, 35% and highly at risk 24%) than other health-care professionals with the majority of dentists (63%) feeling slightly at risk.* *Factor: Knowledge*
[15]	*Investigate RP Compliance*	*Radiographers in the hospital N=31*	– *RP Compliance: 12.9%* – *Factor:* – *Knowledge* – *RP Compliance: 87.1%* – *Factor:* – *Inspection*

V. DISCUSSION

Selecting research studies published on internet search engines mostly have positive results, and researchers must be aware that these are examples of selection biases, since most studies are not published on the internet with negative results [16].

The four selected studies spanned from four different countries to justify that diversities among subjects – radiographers – in hospital settings worldwide must comply with the practice of RPs.

Knowledge, work site and years in practice, and Inspection are implied as factor to make radiographers and other health care professionals autonomously comply with the practice of RP.

A. Implications to Practice

The most important aspect in medical radiation science is the understanding of safe use of ionizing radiation, associated radiation hazards and their consequences on the final outcome in diagnosis and treatment[17]. Radiation exposure over a long period of time (years) produces stochastic effects. There is no threshold level of radiation exposure below which could be said with certainty that cancer or genetic effects will not occur. Doubling the radiation dose doubles the probability that a cancer or genetic effect would occur[18].

Genetic risks among human users are difficult to assess which occur in descendants of exposed individuals. Somatic effect like leukemia and solid tumor has a latent period of few years to 40 years. As these effects are not immediately produced, the radiographer become over confident regarding overexposure to the radiation. In our part of the world, knowledge of radiographers regarding radiation protection is poor. Most radiographers had little knowledge of radiation protection principles and procedures. This lack of knowledge is harmful to themselves and general population [2].

There was generally a lack of in-depth understanding of what ionizing radiation is, in particular, the ill-effects of chronic exposure to low levels. It was worrisome that only 11% of all respondents indicated that they never repeated procedures because repeating procedures subject patients to recurrent exposures. Only 11 respondents (1 radiographer & 10 Dental professionals) mentioned the wearing of a dosimeter, Only 1 radiographer was able to mention a dosimeter as an important safety feature. It was also noted that respondents were not worried much about the lack of information in the community regarding radiation exposure risks [14]. Knowledge of radiographer regarding optimal techniques, radiation dose, radiation protection measures is important for reducing radiation exposure to himself and general population[2].

Although compliance may have increased since the current study was completed, there was no notable improvement in compliance scores in the 3 years between the national study and the current study. Type of initial education and highest level of education were not related to level of compliance. The relationships between type of work site and years in practice to compliance are complex and inconsistent [5].The result further showed that knowledge and compliance did not depend on years in practice because out of 97% who had good knowledge of safety standards, 80% had less than 10 years in practice and majority were involved in continuing education [4].

Those working in radiation departments, radiographers should also as a matter of urgent importance undergo trainings/ refresher courses in radiation. Hospital Managements should design programs which should emphasize patient education like introductory talks every morning before work begins. Information posters should be displayed throughout the hospital, and brochures that explain safety procedures and common concerns should be made available to all patients. There is also a need for more monitoring of these facilities by the Regulatory bodies[18].The results of this study corroborated those of the national study and indicated the need for educational and organizational interventions to increase compliance with safety practices for patients and personnel[5].

The significance of protection against ionizing radiation, holding more workshops, short-term training courses, preparation and distribution of posters and pamphlets on the effects of radiation on the body and protection and safety against ionizing radiation are recommended to raise staff and patients' knowledge and awareness levels. In addition, more inspection and supervision by health physics authorities seems in order[9]. Respondent usually use personal radiation protection equipment when there is any auditing or inspection from head office or safety team [15].

Heads of radiology departments and hospital managers should provide an atmosphere in which radiographers can optimally use the available facilities, perform their periodic medical check-ups, and participate in annual training courses. Radiographers should be encouraged on this issue and be financially supported; moreover, adequate time should be allocated for training courses. Also, hospital managers should promote the RP level by regular monitoring of radiation safety at radiology departments and adequately follow-up the results. Of course, in some specific cases, adherence to RP principles should be mandatory[7].

The initial concept of radiation protection involved three physical principles: (a) shielding (usually by lead) of unexposed areas, especially radiosensitive organs such as bone marrow, gonads and thyroid; (b) increased distance between the radiation source and radiation workers or patients; and (c) reduction of exposure time(Radiation protection in humans).Radiation protection is described as the activities directed towards minimizing radiation exposure of both patient and personnel during x-ray exposure. Excessive beam size has been identified as the principal cause of unnecessary patient exposure in diagnostic radiology. Factors affecting radiation dose during radiographic examinations include applied tube voltage (kVp), tube current (mA), exposure time (s), filtration, focal spot to skin distance (FFD), film–screen speed, collimation and patient size [3].

In order to improve performance, awareness and attitude of radiographers, increase the efficiency of services and reduce unwanted exposure of patients and personnel, it is recommended: 1) increasing supervision and inspection of authorities, 2) replacing old and worn out devices with new and advanced ones and 3) implementing retraining courses [19].

VI. CONCLUSION

With the practice of RPs in all areas of hospital settings (59.26%) it was analyzed that there are three significant factors affecting radiographers and health care professionals' compliance with RPs: (1) Knowledge (2) Work site (3) Years in practice and (3) Inspection

A. Compliance to Radiation Safety Protocols;

1) *Compliance to Wearing Protective Clothing*

- The importance of complying with the wearing of a dosimeter, (35% radiographers, 25% OH&DT and Dentists respectively), rarely (6% radiographers, 8% OH&DT and 19% Dentists) or never wearing a dosimeter (50% OH&DT and 19% Dentists) only 59% of radiographers, 17% of Oral Hygienists & Dental Therapists and 38% of dentists complied.

2) *Compliance to Radiation Protection on Patients*

- A 29% of radiographers agree to always protect patients before radiological examinations. This was quite peculiar as dental professionals (Dentists, OH & DT), indicated that they protect the patients (93% and 83%, respectively).

3) *Protection of patients against radiation exposure*

- Compliance with radiation safety protocols includes the filing or keeping of X-ray records. A 38% of Dentists indicated to only sometimes keeping patients' records and 19% never keep the patients' records, radiographers seem to be doing well in ensuring patients records are kept, with 100% of all participants indicating that they comply with the requirement.
- The frequencies of repetition of X-ray procedures were about 59% of all participants (24% radiographers, 17% OH&DT and 19% Dentists) rarely repeat procedures whereas 63% of all participants (24% radiographers, 8% OH&DT and 31% Dentists) always repeat procedures.

4) *Compliance to radiation safety protocols*

- The level of radiation risks health-care professionals feel exposed to, as compared to other health-care workers in their institutions. Radiographers felt exposed to radiation (more at risk, 35% and highly at risk 24%) than other health-care professionals with the majority of dentists (63%) feeling slightly at risk.

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