Radiation Safety at Medical Imaging Departments in Gaza Strip Hospitals, Palestine

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Abstract:

This study is conducted to evaluate radiation safety at governmental hospitals in Gaza Governorates. Triangulated study design (Questionnaire, Checklist and Key Informant Interview) was used for data collection. Census study conducted on all Radiologic Technologists and medical imaging departments at six main governmental hospitals in the Gaza Strip. Findings revealed that there was shortage in number of radiographic equipment and Radiologic Technologists. Statistically significant relations between participants years' experience and holding Thermoluminescence dosimeters (p=0.033); number of exams and patient waiting time (0.000). Generally, medical imaging departments that followed standards in structure, occupational safety and reception were 90%, 70% and 27%, respectively. The study revealed that the reject rate at the department is high and exceed the international standards. The most common causes of film repetition are the processor machine, artifact, exposure factors, and positioning errors. An obvious defect in the radiation safety in radiology department and we recommend that a regular and periodic quality assurance program to be established at all levels of x-ray department to guarantee the provision of effective and sustainable imaging diagnostic services.

Keywords: Radiographer, Gaza, Triangulated study, Darkrooms

Background

Medical radiation becomes significant specialty in medical practice in this day. This type of imaging improved the methods of the healthcare industry and allowed practitioners and scientists to explore more about the human body than ever before. Medical imaging or radiography can also assist in give a decision about tools of treatment, and can illustrate the mysterious problems that clinically fail to diagnosis. Furthermore, the newly advanced machines (i.e., computed tomography, magnetic resonance, nuclear medicine ..etc) success to give detailed information with better resolution and more comprehensive care (Seibert, et al., 1994; WHO, 1982).

It is known that no safe dose of ionizing radiation and large doses can cause measurable increase in biological effect. These effects can cause either somatic or genetic effect. Medical radiation is the major source of exposure from industrial radiation (OMA and OHA, 1984). Standard quality assurance program is strongly recommended as a regulatory requirement in many society and federal institutions (WHO, 1982).

Furthermore, Film reject analysis is a well-established method of quality control (QC) in diagnostic radiology (Peer, et al., 1999). The employment of reject analysis in the evaluation of image quality has quite a long history QC in diagnostic radiology (Zewdeneh, et al., 2008). A rejected film is a film that does not add diagnostic information to clinical analysis because of poor image quality (Peer, et al., 1999; Zewdeneh, et al., 2008; Weather, et al., 1999). Analysis of rejected films yield information about the efficiency of an X- ray department and is the basis for QC and education of the radiographer (Peer, et al., 1999; Mazzaferro et al., 1974; BIR, 1988).

In parallel, the success of any health service depends on the number of health providers, academic degree and efficiency of staffs (Jehanzeb, and Beshir, 2013; Infande, 2015). 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.

This study conducted to evaluate status of radiographic services at Governmental Hospitals in the GS.

Conceptual Framework:

Thermoluminescent dosimetry (TLD) badge considers 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).

Shielding of Medical imaging Department in conventional room walls is 2.9 mm of lead. In 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).

Reject film defined as film of poor diagnostic quality, although it is not repeated (Sadiq, et al., 2017).

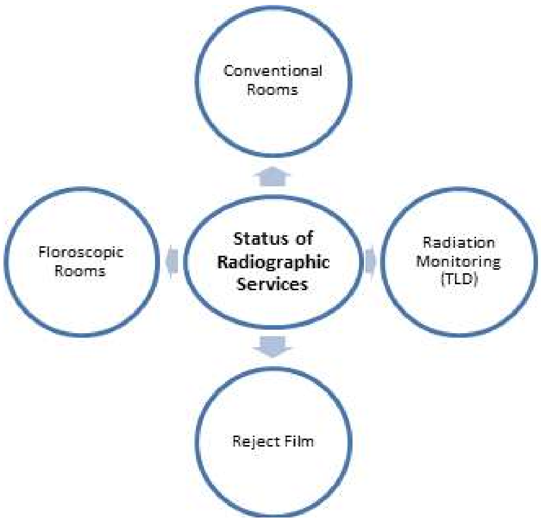

Diagram: Conceptual Framework

2. Methodology

2.1 Study design

A descriptive, analytical cross-sectional study with a triangulated design (quantitative and qualitative) was conducted to evaluate medical imaging services.

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

2.2 Study population and data collection

The current study was conducted on six main hospitals (Table 1) to evaluate; radiation safety, human resources and reject film analysis based on international standards and reports.

Table 1: Distribution of main six governmental hospital in the GS

Hospital name \ Item	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	29	261
Nasser	Khan Younis	1960	25,000	880	6	28	330
Abu Yousef Al Najjar	Rafah	2000	4,000	297	3	17	49

Table 1 shows readings for Gaza-governorates number, hospitals establishment, hospital area, employees, Radiologic Technologists (RTs) and beds number in the six main governmental hospitals (Al-Shifa, European Gaza, Indonesia, Shohda Al-Aqsa, Nasser, and Abu Yousef Al Najjar Hospital).

In the current study, six main targets that provide medical imaging services in Gaza Strip were evaluated. The quantitative part of the current study includes two research tools (questionnaire for radiological technologists in addition to developed checklist attained from "National Health Services, Australasian Health Facility Guidelines and Radiological Protection Institute of Ireland" (NHS, 2001; RPII, 2009; AusHFG, 2016).

Respecting to the qualitative part, in-depth interviews with key informant managers and decision makers were obtained. The interview obtained based on semi structured, open-ended statements.

Reject analysis has been used as a quality indicator for radiology services and has been recommended for radiation safety. In the current study, we determine the rate of reject film in the main hospitals, evaluate the main causes of reject, and repeat imaging process.

Sample Size

Census study included all Radiologic Technologists (176 RTs) and all medical imaging departments at six main governmental hospitals in the Gaza Strip. In addition, three key informant interviews with Radiologic Technologists manager were conducted.

Data Analysis

After data collection, the questionnaires were coded and data were entered into the software Statistical Package of Social Science (SPSS) program version 20. Data cleaning was done through checking the frequencies of all variables. Pearson correlation test was used to detect relationship between patient waiting time and number of examinations. Differences among variables were regarded as statistically significant when the P value was lower than 0.05.

Regarding reject film analysis,

Exposed films = Total number of reject films + total number of repeat films

The total number of films = exposed films + rejected films

$$\text{Reject rate (\%)} = \frac{\text{Number of rejected films}}{\text{Total number of films used}} \times 100 \quad (1)$$

$$\text{Causal reject rate (\%)} = \frac{\text{Number of rejected films for a specific cause in one hospital}}{\text{Total number of films rejects for a specific cause}} \times 100 \qquad (2)$$

3. Results and Discussion

3.1 General Information about existing Radiographic Department

The total number of distributed questionnaires was 176 and the number of respondents was 170 with a response rate of 96.5%. 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).

About 20 % of RTs aged less than 30 years, 55.2% between 30-40 years, around 12.4% between 40-50 years and the same percent 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. This is normal variation in age regarding stopping the recruitment in the last ten years due to the financial situation in Gaza Strip. 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 10.0% 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.

Regarding to participants gender, the majority of RTs were males (81.8%), while 18.2% were females. The current results are complete differ than 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 frightened about the negative effect of ionizing radiation on female particularly pregnant.

3.2 Reasons of Rejected films

Table 2 shows that 13.8 % of films were rejected due to over exposure, while12.4 % of film were rejected due to underexposure. The researchers found that the bad quality films resulted in a high rejected film rate as it is very important for the films to be at appropriate exposure dose in order to enhance its quality and thus enhance its interpretation by the physician.

Table 2: Descriptive analysis of the reasons for reject films

Variable	Categories	Frequencies (%)
Underexposure	No Yes	1681(87.6) 238(12.4)
Artifact	No Yes	1707(89) 212(11)
Position problems	No Yes	1798(93.7) 121(6.3)
Processor problems	No Ye	1613(84.1) 306(15.9)
Patients name printer	No Ye	1919(99.9) 1(0.1)

The study revealed that 11 % of films were rejected due to artifact with various types. It is very important to take attention about the artifact problem and to make the patient wear off their clothes and jewelers especially in the presence of metal artifacts. In addition, the study revealed that 6.3 % of films were rejected due to Position problems. This problem needs an urgent intervention to training the technologists about the positioning especially in case of special views. Moreover, the study revealed that 15.9 % of films were rejected due to processor problems. The researchers noted that the processing machine is an old one and 18 suggest to substitute it with a new one or to use the computed radiography (CR) processing as this will be less radiation dose and less cost at the long run.

Figure 2 shows Pareto chart, which exhibits 5 main problems affecting causes the high film rejection rate as in the graph they are as follows: (processor problem, over exposure, under exposure, artifact, position and no patient name).

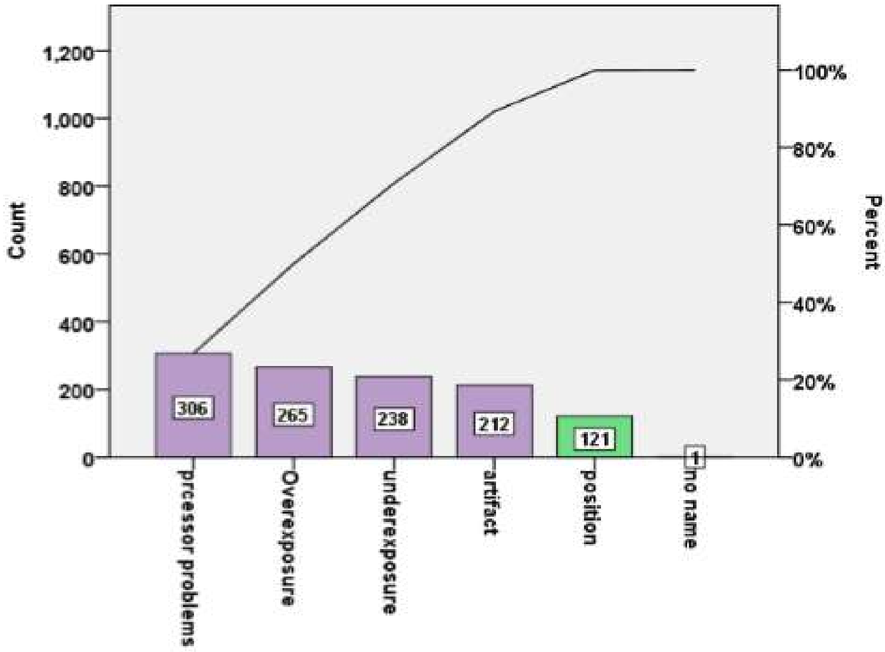

Figure 2: Pareto chart shows the main reasons for reject films

The processing problems is the biggest cause factor of reject film in this study (306 films) ,when solving this problem will reduce 28% of reject film ,the second reason to reject film is over exposure as shown in the chart. As noticed if these two problems were solved, this will reduce of the rejected film by 50%. The third reason for reject films is under exposure which is shown by the chart that the number of rejected film was 238 films. If the three problems were solved, the reject rate will be reduced by 70%.

The fourth reason of reject film is artifact, 212 of films are rejected of this reason. When the problem is solved the reject rate will be reduced by 90%. The final casual factor is positioning errors, the number of reject film due to this reason is 121. The chart shows solving the five problems will resulted in decrease the reject rate by 98%.

3.3 Evaluation designs of existing Radiographic Department

3.3.1 Conventional radiography design checklist

Table 3 clarifies the design and structure of conventional radiography rooms in medical imaging department.

Table 3: Checklist about structure of conventional radiography in governmental hospitals

Item \ Hospital name	Al-Shifa		European Gaza		Nasser		Shohda Al-Aqsa		Indonesia		Abu Yousef Al Najjar		Total	
	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	**Y%**	**N%**
Is control console area suitable? (≥1.5x2 m)	5	1	2		1	2	1	1		1		2	56.3	43.8
Are there windows for room?	3	3		2		3		2		1		2	18.8	81.2
Is there a toilet inside the room?	3	3		2		3		2		1		2	18.8	81.2
Is a room size at least 30 m^2?	3	3	2		2	1	1	1		1		2	50	50
Is there drainage sewage?	6			2	1	2	1	1	1			2	56.3	43.8
Is there a change cubicle?	3	3	2			3		2		1		2	31.3	68.8
The customers/patients door entrance at least 180x150 cm^2?	3	3		2		3	2			1		2	31.3	68.8

Y= yes N=No

The results revealed that all of conventional radiography rooms in medical imaging department have a 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 that 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 exist these windows must be lead shielded. The current check showed that 50 % of imaging rooms have proper size (≥30 m^2) (RPII, 2009; AusHFG, 2016; Bushong, 2013).

Other international standard exhibited that X-ray room size should be 33 m^2 to contain patient table and the vertical chest bucky stand. The boundaries to all occupied areas (walls, doors, doorframes, floor, ceiling, window and the protective viewing screen) must shield appropriately (BIR, 2000). Finally, 31.3% of the current rooms have a change cubicle and patients door entrance dimension fit with the international standard (≥180x150 cm). The door should be wide enough and must be shield against scatter radiation (AusHFG, 2016; NHS, 2002). Change cubicle should be close to X-ray room and may design as individual changing rooms, which open directly into the X-ray room. This will allow 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 dose not designed as stand-alone rooms and planned as part of an integrated radiology/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).

3.3.2 Fluoroscopy design checklist

Fluoroscopy systems may have large machines operated by remote control, control console and much equipment (BIR, 2000; NHS, 2002). Table 4 clarifies the design and structure of fluoroscopic rooms in medical imaging department.

Table 4: Checklist about structure of fluoroscopy at governmental hospitals

Hospital name / Item	Al-Shifa		European Gaza		Nasser		Shohda Al-Aqsa		Indonesia		Abu Yousef Al Najjar		Total	
	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y%	N%
Is there a control console?	2		1		1		1		1		1		100	0
Is there a toilet inside the room?	2		1		1		1		1		1		100	0
Is a room size at least 36 m^2?	2		1		1			1	1			1	71.4	28.6
Is there a change cubicle?	2		1		1			1	1			1	71.4	28.6
Is there a drainage sewage	2			1	1		1		1			1	71.4	28.6
Are the patient's door entrance at least 180x150 cm? (STD)	2			1		1	1		1			1	57.1	42.9

Y= yes N=No

The results clarify 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. Finally, 57.1% of these rooms have proper patient's door entrance (≥ 180x150cm) (AusHFG, 2016).

3.4 Radiation Monitoring

3.4.1 Adequacy of Thermoluminescence Dosimeter (TLD) among RTs

Table 5 clarify the adequacy of thermoluminescence dosimeter among RTs in the six main hospitals.

Table 5: RTs having TLD Badge

TLD Badge	Frequency	Percent
Yes	143	84.1
No	27	15.9
Total	170	100

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

The table reveals 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 (MIA, 2017).

3.4.2 Holding and Checking of TLDs

Table 6 describe the practice of holding and checking process of TLDs by RTs in the six main hospitals.

Table 6: RTs who holding and checking TLDs

	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**

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 attribute to the doubt of RTs toward the precision of TLDs readings.

3.4.3 The relationship between RTs experience and holding of TLDs

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

Table 4. 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	22	42	12	4	80	8.707	0.033
	No	16	31	4	12	63		
Total		38	73	16	16	143		

Table 4. 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 attribute to: RTs trustiness with TLDs readings in addition to their insufficiently knowledge about radiation hazards.

4. Conclusion

Radiation status of radiographic departments in the governmental hospitals were evaluated based on international standards. Generally, the design of all radiographic departments full fill the minimum requirement for radiation safety. Big shortage in the number of TLDs, and awareness courses are strongly in need to improve concepts of radiation protection among RTs.

Regarding reject film analysis, the most common factors causes the high reject rate are processing machine, type of examinations, positioning errors and the exposure factors. The study also revealed that the type of examination is the most important factor affecting the repeated rate had the most repeated rate. The results of this study suggest that rejection analysis is a useful tool in monitoring and improving diagnostic imaging services and can be used to assess and control the future cost effectiveness of diagnostic imaging departments.

All Authors declare that:

Declarations of interest: none

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