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Pattern of radiation safety measures and security culture in four major hospitals, Ismailia, Egypt

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Abstract
Background: Radiation safety and radioactive source security constitute an essential part of radiation protection in medicine, and launching them involves cultural interactions.
Aim: To explore the current situation of radiation protection in hospitals in order to improve radiation safety and security culture and measures in Ismailia city hospitals.
Subjects and Methods: A cross sectional study was conducted at 13 units in four hospitals in Ismailia city. Health care workers (292) with potential exposure to radiation (physicians, technicians, nurses and physicists) were included. Safety culture questionnaire, inspection checklist and thermo scientific model survey meter to assess the radiation levels in different units were used.
Results: The results of this study showed moderate radiation safety culture (The mean scores culture was 95.3±12.8). The linear regression analysis showed that working days/week significantly predicts the safety culture of participants. Radiation safety and security measures represented in different departments were insufficient. There was variability among hospitals and departments as regard the level and the efficiency of protection, concerning shields and protection of doors and windows.
Conclusion: Different departments/ units in the investigated hospitals showed an overall inadequacy of radiation safety and security measures and most of them showed inefficiency of protection as well as the design of rooms.

Keywords: Radiation, protection, safety, security, culture

Introduction

It has been universally reported that each year more than 2500 million diagnostic radiological examinations, 32 million nuclear medicine examinations and interventional procedures as well as 5.5 million radiotherapy sessions are performed worldwide. Despite all precautions, inevitable health hazards still occur throughout the world every year [1]. Because of numerous uses of radiological procedures and the growing evidences of medical radiation exposure, there are scientific and public concerns regarding dose reduction and radiation protection [2]. In diagnostic examinations, although the radiation dose is low, there is a great concern usually given to reduce excessive and unnecessary exposure of the public and occupational workers [3]. Interventional radiology on the other hand as well as diagnostic radiology can expose both the patients and health care workers to radiation. For longer procedures such as coronary interventions, peripheral vascular interventions, heart catheter, angiography, etc., the dose received by physicians and attendant staff is almost entirely attributable to radiation scattered from the patient [4]. Radiation safety and protection is thus necessary in order to reduce the levels of that exposure [5]. According to safety regulations, X-ray room must be effectively shielded and personal protective equipment must be available for the staff. All performed X-ray examinations must be justified and optimized [6]. Beside radiation safety, radioactive source security is an essential part of radiation protection. Sources can be unrestricted, lost or stolen. Therefore, there are needs for both global and national security protection systems and enhanced capability to achieve radiation security [7]. One of the security measures is the access control in which only individuals with authorized access are allowed to enter areas where radioactive material or radiation producing devices are present [8]. Several radiological accidents in medical and industrial practices using sources of ionizing radiation were attributed to fragile safety culture in the organizations and human faults were the most significant causes to such events [9].

It is understood that the significance of a strong radiation safety culture for decreasing doses to as low as reasonably practicable (ALARP) and avoiding the occurrence of radiation incidents is clear issue. All our behavior in the workplace is due to safety culture, and good safety culture in an organization will trigger all employees to be motivated to adopt safe behavior and avoid damage. In the region of radiation protection culture, the medical and nuclear industry sectors have substantial prominence due to their effect on real and potential doses to workers and the public [10].

Subjects and Methods

This cross-sectional study was conducted in Ismailia city hospitals, Egypt, between May 2015 to august 2017 to assess the radiation protection measures (safety and security) and safety culture. Confidentiality and anonymity were maintained according to the regulations mandated by Research Ethics Committee of Faculty of Medicine Suez Canal University. This study was conducted at four hospitals in Ismailia city and three hospitals refused to participate in the study. For the confidentiality of results, the included hospitals were coded into hospital A, B, C and D. Among the surveyed hospitals, 13 units were included. All health care workers (292) with potential exposure to radiation at the different hospital departments/units (physicians, technicians, nurses and physicists) were included in our study.

Three methods were applied to assess the current situation of radiation safety and security in hospitals and radiation safety culture among health care workers.

1. A self-administered questionnaire to assess the radiation safety culture among healthcare workers including multiple domains [11]; communication openness, communication about error, frequency of events reported, non-punitive response to error, supervisor/manager expectations and actions promoting safety, teamwork across units and teamwork within units. A scoring system was made for the answers to estimate the positive response of health care providers towards safety culture ranging from zero (strongly disagree) to five (strongly agree).
2. Inspection checklist to assess the actual status of radiation safety and security practices provided in the investigated hospitals including general safety measures, patients' safety measures and radiation security procedures.
3. The radiation level where radiation apparatus or radioisotopes are placed was assessed to detect the more radiation unsafe sites around the occupancy area. The assessment was done on two sessions one week apart and the mean background and mean radiation level (behind the shield, in patient waiting areas and in corridors) were assessed. Thermo scientific model FH 40 GL-10 Survey Meter (ranging from 10 nsv/h to 100 msv/h) was useful for measuring photon radiation (gamma- and X-radiation). It was obtained from Egyptian Nuclear and Radiological Regulatory Authority (ENRRA).

Data were first cleaned, filtered then coded and entered into Microsoft Excel 201.Statistical analyzes were performed by IBM SPSS Statistics Version 22.0 (The Statistical Package for Social Science). Descriptive statistics of the data were presented. Graphs and tables were used as appropriate and according to the type of variables. The percent score will categorize culture into poor, moderate and good according to the study of Alavi *et al*., (2017) where scores less than 50% were considered as poor, between 50% and 75% medium as and greater than 75% were considered as good. Alavi *et al*., (2017) established a score for estimating knowledge, practice and attitude according to the Iranian academic grading (0–20) using the university's common 20-point grade scale. Therefore, the minimum and maximum scores were 0 and 20, respectively, for each set of RP-KAP questions. Scores <10 were categorized as poor; 10–15 as medium, and ≥ 16 were defined as good scores [12]. Regarding the observational checklist, each statement was measured on two points, the properly done procedure was scored (1) and the measures not done was scored (0) with a maximum total scores of (22), (5), (7) and (4) for general safety measures, patient safety measures, radiation producing devices safety measures and security measures respectively. Statistical significance was determined at 95% level of confidence (i.e. differences will be considered significant if $P < 0.05$).

Results

This study included healthcare workers with potential exposure to radiation who agreed to participate in the study (292), with a response rate of 59%. The participants were distributed as follows; nine technicians at Hospital A, 92 health care workers at Hospital B, 167 health care workers at Hospital C and 24 at Hospital D. Regarding the distribution of participants in different departments, the majority of them (32.5%) were obtained from radiology department. As regard to the job characteristics of the study participants, the majority of the participants were physicians (151/292) and mostly young (68 residents and 48 specialists) and the mean workload of participants was 8.4 ± 3.1 hours/day - 4.9 ± 1.2 days a week. (Table 1). The mean total safety culture score among participants was 95.3 ± 12.8 where 58.1% of them correctly answered safety culture questions (Figure 1). There was a significant positive correlation between radiation safety culture scores as regard working days/week ($P<0.0001$) (table 2). The linear regression analysis shows that working days/week significantly predicts the safety culture of participants (table, 3). Regarding radiation general safety measures represented in different departments/units, most of departments (76.9%) did not have a radiation warning sign(s) posted at entrance. Among 13 investigated units, only three units had a radiation Safety Manual. Shielding was used in nine units (69.2%) and eight (88.8%) out of the nine units had shields visibly seen as in proper status. Lead aprons were present in 61.5% (8) of the investigated units in which 37.5% of the aprons were efficient and 75% of them were visibly seen as in proper status. Washing or showering facilities were present in 61.5% of the investigated units. Personal badges were worn only in two units (15.4%) in which only one department that had dosimeter reports (Figure 2). Regarding patients' safety measures provided in the investigated units, almost all the departments assess the patients before the procedure. Health care workers did not explain the procedure to the patients in 61.5% of the investigated units. (Figure 3). Regarding the positive and the negative safety measure undertaken in nuclear medicine unit (linear accelerator part and radioisotope safety measures) undertaken in oncology department in Hospital C, all safety measures are fulfilled except for maintaining knowledge of activities and conducting initial and periodic training of workers by radiation protection officer and some personnel did not wear the dosimeters properly. As regard to radiation producing devices protection measures, it was shown that about 69.2% of the departments did not have any signs bearing the word “CAUTION X-RAY”. The demarcation of controlled area with appropriate warnings was present only in 46.2% of the investigated departments. 23.1% of the units had copies of the manufacturer’s operation/maintenance manuals for reference (Figure 4). Regarding the general radiation security measures, "locks, hinges and interlocks for doors" were present only in 46.2% of the investigated units. The access is limited to only the authorized personnel in 84.6% of the units. Regarding the security measures concerning the nuclear medicine department, measures providing warning of any sabotage, securing stock vials and wastes storage and presence of radioactive material security plan were all present (Figure 5). By assessing radiation levels it was shown that the variability of radiation levels at radiology department of different hospitals. In Hospital A, the mean leakage radiation behind the shield in room 2 (101nsv/h) and in patient waiting place (91.7 nsv/h) was higher than the mean background radiation in these two locations with a statistically significant difference between them ($p<0.05$). Regarding Hospital B, there is a statistically significant difference ($p<0.05$) between the mean background radiation and the mean leakage radiation behind the shield "B" in X- ray room in radiology department. In Hospital C, there is a statistically significant difference ($p<0.05$) between the mean background radiation and the mean leakage radiation behind shield in room 1, room 3, on corridor between X-ray rooms and staff rooms and in patient waiting place in radiology department. In Hospital D, in the interventional radiology room, there is a statistically significant difference ($p<0.05$) between the mean background radiation and the mean leakage radiation on the corridor when the device is "On". In conventional X- ray room, there is a statistically significant difference ($p<0.05$) between the mean background radiation and the mean leakage radiation behind the shield (table, 4). As regard to radiation levels in C.T facilities, it was shown that, in Hospital B, there is no statistically significant difference between the mean background radiation and the mean leakage radiation behind the shield. In Hospital C, there is no statistically significant difference ($p>0.05$) between the mean background radiation and the mean leakage radiation behind shield in room 1 although the mean radiation level behind the shield (709 nsv/h) is higher than that of background radiation (81 nsv/h). In room 2, there is a statistically significant difference ($p<0.05$) between the mean background radiation and the mean leakage radiation behind shield (Table, 5). Regarding linear accelerator unit in nuclear medicine department, there is no statistically significant difference ($p>0.05$) between mean background radiation levels and the mean leakage radiation in control console of accelerator, outside accelerator area, control console of simulator and outside simulator area respectively. Regarding gamma camera room, there is no statistically significant difference ($p>0.05$) between the mean background radiation level and the mean leakage radiation in corridor, patients' waiting place. Also, there is no statistically significant difference ($p>0.05$) between the mean background radiation level and the mean scattered radiation in patient injection place, gamma camera room and controlled area (area between radioisotope preparation place and patient injection place) although exposure level of radiation is high. In addition, there is a high mean scattered radiation level in the radioisotope preparation place (5.2 Usv/h) with a statistically significant difference ($p<0.05$) between it and the mean background radiation of the place (Table, 6).

Table 1: The demographic and job characteristics of study participants

Characteristics	Mean ± SD	Median (range)
Hospital		
Hospital A	9	3.1
Hospital B	92	31.5
Hospital C	167	57.2
Hospital D	24	8.2
Job Category		
Resident	68	23.3
Specialist	48	16.4
Consultant	35	12.0
Nurse	73	25.0
Technician	66	22.6
Physicist	2	0.7
Specialty		
Radiologist	38	13.0
Cardiologist	29	9.9
Gastroenterologist	8	2.7
Oncologist	9	3.1
Anesthesiologist	34	11.6
Orthopedic	33	11.3
Technician	66	22.6
Nurse	73	25.0
Physicist	2	0.7
Work load	Mean ± SD	Median (range)
Working hours/day	8.4 ± 3.1	7 (6-12)
Working days/week	4.9 ± 1.2	5 (2-7)

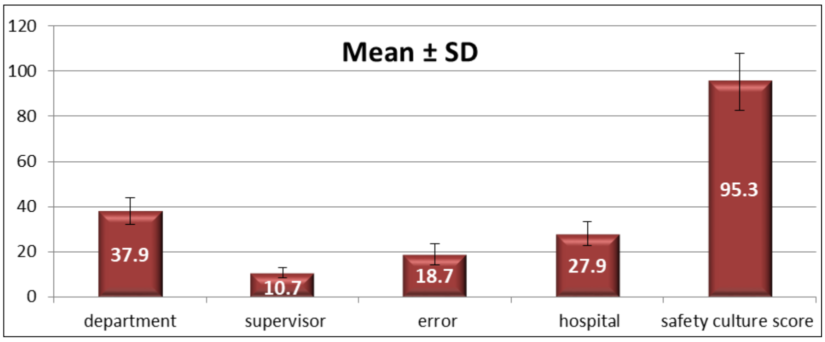

Fig 1: The scores of different aspects of culture

Table 2: Correlation between radiation safety culture scores and different variables.

	safety culture score	
	r	P-value
Age	0.037	0.5
Working hours/day	0.022	0.7
Working days/week	0.200	0.001*

*spearman correlation coefficient is statistically significant at level of confidence at 95% ($p < 0.05$).

Table 3: Multiple linear regression analysis of independent risk factors affecting radiation safety culture.

Variable	Culture		
	B	t	P-value
Age	0.198	1.764	0.079
Gender	-1.152	-0.690	0.491
Specialty	0.564	1.856	0.064
Work hours/day	-0.083	-0.324	0.746
Work days/week	2.461	3.542	<0.0001

Fig 2: General safety measures in different departments/units

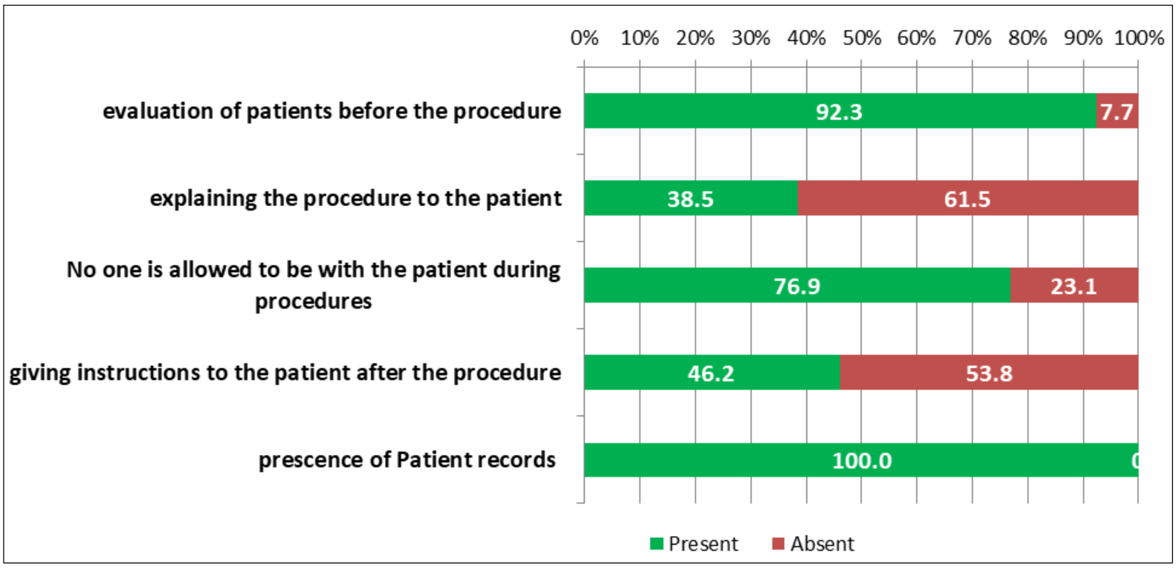

Fig 3: Patients' safety measures in different departments/units

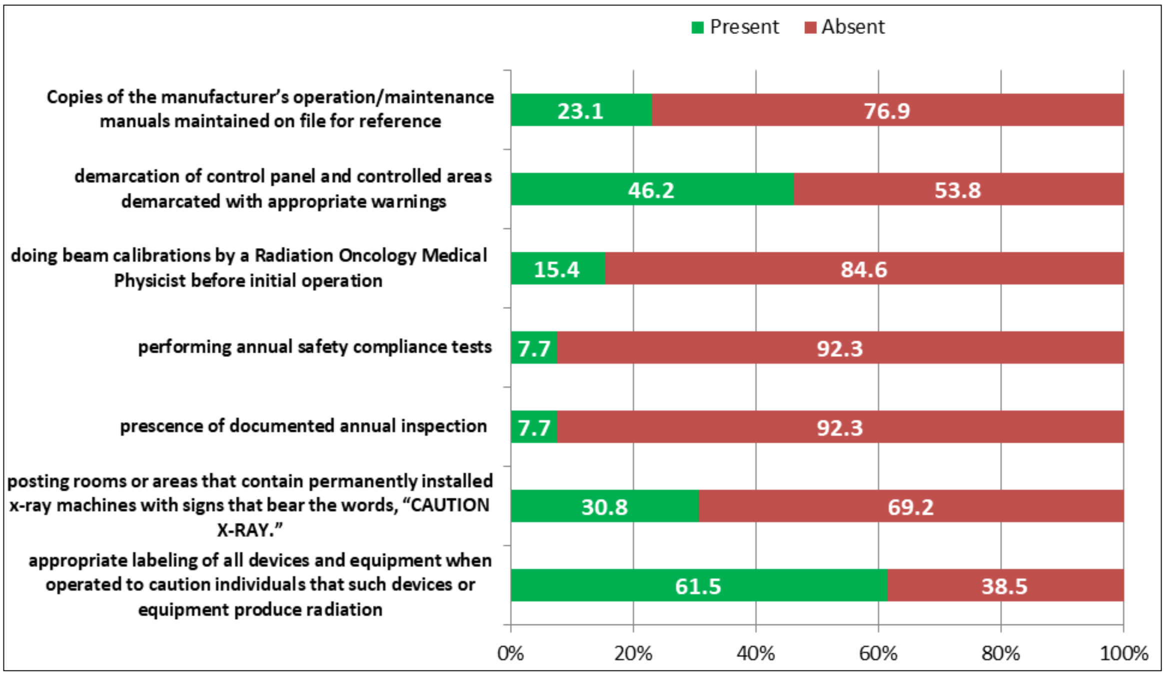

Fig 4: The radiation producing devices protection measures in different departments

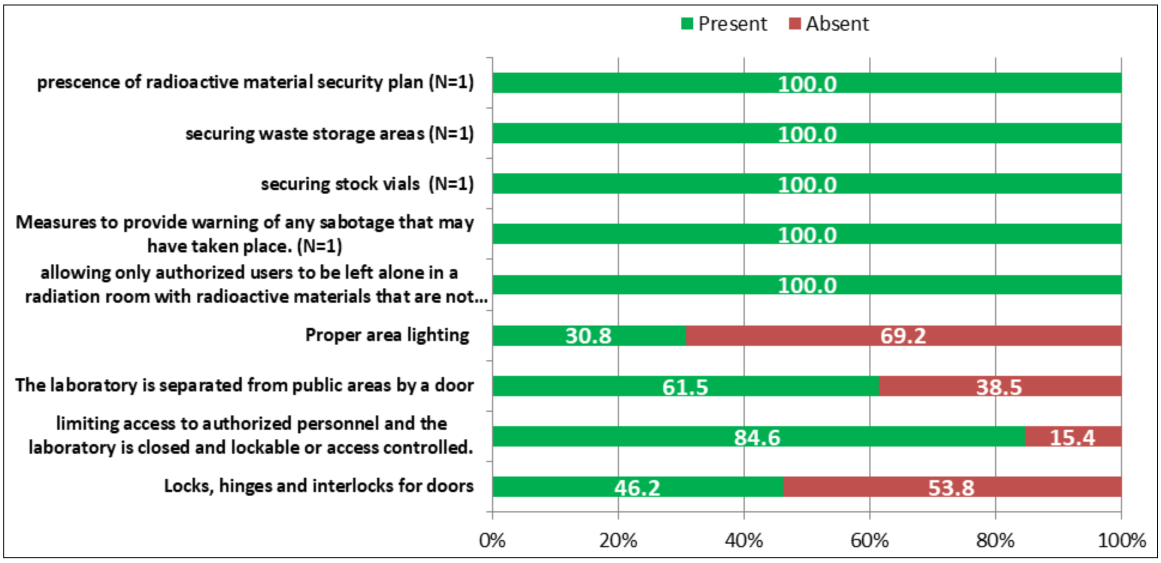

Fig 5: Radiation security measures in different departments/units

Table 4: The radiation levels in radiology department (X ray facilities) of different hospitals

Hospital	Locations	Background radiation (Mean ± SD)	Radiation level (Mean± SD)	P value
Hospital A	Room 1 (behind shield)	80± 1.4	80.5 ± 0.7	0.696
	Room 2 (behind shield)	80.2 ± 0.3	101± 1.4	0.002*
	Patient waiting area	78.7± 0.7	91.7± 2.3	0.012*
Hospital B	Behind shield A	80.6 ± 0.3	81.5 ± 1	0.347
	Behind shield B		227 ± 1.4	<0.0001*
	Patient waiting area	79.6 ± 0.8	80.3 ± 0.1	0.3
Hospital C	Room 1 (behind shield)	85 ± 0.6	13200± 141.4	0.005*
	Room 3 (behind shield)	80.4 ± 0.1	26000± 414.2	0.025*
	Room 4 (behind shield)	80.4 ± 0.1	12654±17742.7	0.6
	On corridor between unit 1 rooms and staff rooms	81.3± 1.1	17800±424.3	0.01*
	patient waiting area	81± 1.4	15800±424.3	0.012*
Hospital D	Room 1 (in corridor at interventional radiology)	79.9 ± 0.4	155 ± 1.4	<0.0001*
	Room 2 (Behind shield of diagnostic radiology)	79.1 ± 0.3	4000± 282.8	0.032*
	Room 2 (In corridor of diagnostic radiology)		80.3 ± 0.1	0.085

*t- test is statistically significant at level of confidence of 95% ($p< 0.05$)

Table 5: The radiation levels in radiology department (C.T facilities) of different hospitals

Hospital	Locations	Background radiation (Mean ± SD)	Radiation level (Mean± SD)	P value
Hospital B	Behind shield (control console)	80.6 ± 0.3	85 ± 0.7	0. 15
Hospital C	Room 1 (Behind shield in control console)	81 ± 0.6	709± 553	0.355
	Room 2 (Behind shield in control console)	80.6 ± 0.8	6400±141.4	0.010*

*t- test is statistically significant at level of confidence of 95% ($p< 0.05$)

Table 6: The radiation levels of radiation in nuclear medicine unit at Hospital C.

Hospital	C.T locations	Background radiation (Mean ± SD)	Radiation level (Mean± SD)	P value
Unit 6	Control console of accelerator	79.3 ± 3.9	365.5± 119.5	0.182
	Outside accelerator area		72.3 ± 1.1	0.135
	Control console of simulator	83.3 ± 1.3	346.1± 387.4	0.513
	Outside simulator area		80.8 ± 0.8	0.147
Unit 7	In radioisotope preparation place	79 ± 0.7	5200 ± 282.8	0.025*
	In patient injection place		2500 ± 565.7	0.104
	In gamma camera room		4500 ± 707.1	0.072
	In controlled area		220 ± 28.3	0.089
	In corridor		79.4 ± 0.1	0.51
	In pt. waiting area		76 ± 1.4	0.113

*t- test is statistically significant at level of confidence of 95% ($p< 0.05$)

Discussion

In this study, there is a moderate safety culture score. Similar to our study findings, Abdellah *et al*., (2015) showed that the mean attitude percent score was 46.9 ± 8.6 and ranged from 22% to 65% [13]. On the other hand, Alavi *et al*., (2017) showed that the mean attitude score was 8.6 ±2.7 representing 43% of total score, that is less than in our study [12]. In the present study, different departments in the investigated hospitals showed a poor radiation general safety measures where 76.9% of departments did not have a radiation warning sign(s) posted at entrance. Emergency procedures and emergency phone numbers were not posted in nearly almost all departments (12/13). Among 13 investigated departments/units, only three departments had a radiation safety manual. Body badges were available only in two departments and lead aprons were present in 61.5% (8/13) of the investigated departments in which 37.5% of the aprons were efficient and 75% of them were visibly seen as in proper status. These findings were inconsistent with the guidelines mentioned by international commission of radiation protection that entails using a radiation warning sign(s) and ensures that clear emergency procedures are critical features of safety features that should be included in the design and construction of diagnostic and interventional radiology equipment [14]. On the other hand, these findings are consistent with a study conducted in the hospitals affiliated to the Iranian Mazandaran University of Medical Sciences that showed that none of the studied hospitals had enough warning signs [15]. Also these findings are consistent with one study by Emi-Reynolds *et al*., (2012) where it was observed that none of the protective measures or equipment was fully present in the diagnostic units except lead aprons [16]. Regarding patients' safety measures provided in the investigated departments, health care workers did not explain the procedure to the patients in 61.5% of the investigated departments. Ten out of 13 departments did not allow anyone to be with the patient during the procedures and patients' records were kept in all departments. This is consistent with the International Basic Safety Standards (BSS) in which ensuring safety of patients requires evaluation of patients during and after treatment, calibration & maintenance of equipment, ensuring protocols for treatment procedures and maintaining records of relevant procedures and results [17, 18]. As presented in our study, about 69.2% of the departments did not have any signs bearing the word "CAUTION X-RAY". Annual inspection was done and documented only in one department (7.7%). The demarcation of controlled area with appropriate warnings was present only in 46.2% of the investigated departments. Only 3 out of 13 departments (23.1%) had copies of the manufacturer's operation/maintenance manuals for reference. These findings were not matching the ICRP and BBS safety standards where it is necessary to restrict access to and demarcate controlled areas, warning lights should be placed at eye level, details of the radiation protection officer and maintaining equipment [14]. In this study, the general radiation security measures showed that locks, for doors were present only in 46.2% of the investigated departments. The access is limited to only the authorized personnel in 84.6% of the departments. The proper area lighting was present only in 30.8% of the departments. Regarding the security measures concerning the nuclear medicine department, measures providing warning of any sabotage, securing stock vials and wastes storage and presence of radioactive material security plan were all present. All of these findings are consistent with study done in Nepal where radiation protection survey for diagnostic radiology was done in twenty-eight different hospitals and five different radiotherapy centers. The observations included: "there is not automatic exposure control in most of the X-ray units; window at the X-ray room and door without lead protection were found at some hospitals outside the Kathmandu region; there is no quality control program in diagnostic radiology but there is a quality control program in radiotherapy facility centers" [19]. In the present study, the survey result showed that nuclear medicine unit was built according to protection criteria. Training of personnel was inadequate except for medical physicist and this is different from the survey done in Nepal in which all radiotherapy centers have medical physicists and radiation protection officers trained and educated [19]. As presented in this study, different departments in the investigated hospitals obtained poor scores of radiation safety and security measures that were observed with no statistically significant difference among the investigated departments and hospitals ($p>0.05$). Nuclear medicine unit had the highest scores followed by cardiac catheterization units in cardiology departments. This can be due to the potential exposure to IR in these departments with high doses that may expose both healthcare workers and patients to risk. This in turn, results in giving these departments/units more interest than other departments. Unlike a study carried out by Dehghani *et al*., (2015) in which the radiation safety status was compared in 18 hospitals and the statistical test has shown the difference of safety statuses among hospitals was significant ($p<0.001$). The inconsistence between the results in our study and the study carried out by Dehghani *et al*. (2015) may be attributed to the bigger number of investigated hospitals in their study [20]. Regarding assessment of radiation levels using survey meter, 13 departments/units were assessed including four radiology departments, two CT scan units, two cardiac catheterization units, two operation theatres, one ERCP unit and one nuclear medicine unit. As shown in our study while surveying hospital A, there were two chest X-ray rooms with two chest X- ray devices placed in both. The mean background radiation in both rooms and in patient waiting area were nearly the same (80, 80.2 and 78.7 nsv/h) which is within the safe limit. While comparing the mean background radiation in room1 with the leakage radiation behind the shield, they were both the same (80 nsv/h and 80.5 nsv/h respectively) and there is no statistically significant difference between them. This can be explained, as the shield is properly leaded and protective. Unlike room1, the mean leakage radiation behind the shield in room 2 (101nsv/h) and in patient waiting place (91.7 nsv/h) was higher than the mean background radiation in these two locations with a statistically significant difference between the mean background radiation and the mean leakage radiation in these two locations. This may be due to the inefficient protection of the shield and the design of the room. While observing room 2, the shield and the X-ray device were visibly old and by asking about them, it was mentioned that it was old device and shield and no maintenance was done. As regard to Hospital B, it was shown that the mean background radiation levels in X-ray room, CT room, operation theatre and patient waiting area in radiology department were within the safe limits. In X-ray rooms, there were two shields and two X-ray devices, one shield was protective, and the other one is inefficient as it was old and not maintained. In CT room, the mean leakage radiation in the control console is as well as the mean background radiation with no statistically significant differences between them. This may be due to efficiency of protection as well as design of this room. In radiology department, patients' waiting area is protected as the mean leakage radiation in it is equal to that of background radiation in the same location. In the operation theatre, where fluoroscopy (C arm) device is used for many surgical procedures, the mean leakage radiation levels while the door opened or closed (455 or 125 nSv/h respectively) are higher than the mean background radiation in the same area. This is attributed to inefficiency of walls or doors of the rooms. By checking the rooms, it was found that the rooms have no leaded walls or doors. As regard to X- ray facilities in Hospital C, there were three working rooms and their mean background radiation levels were within the safe limits. The mean background radiation levels in the corridor and patient waiting area were also within the safe limits. However, there were statistically significant differences between the mean background radiation and the mean leakage radiation behind shields in room 1, in room 3, on corridor between X-ray rooms and staff rooms and in patient waiting area. Although there was no statistically significant difference between the mean background radiation and the mean leakage radiation behind the shield in room 4, this was not a practical difference as the mean leakage radiation behind the shield in this room was higher than that of background radiation in the same location. Therefore, it is concluded that the shields are ineffective and provide insufficient protection to the staff. In addition, it is concluded that there is inefficient protection of doors and walls that may be responsible for exposing patients to harm. As regard to CT facilities in Hospital C, there were two CT rooms and two CT devices in them. The mean background radiation levels were within the safe limits. There was no statistically significant difference between the mean background radiation and the mean leakage radiation behind shield in room 1 although the mean radiation level behind the shield (709 nsv/h) was higher than that of background radiation (81 nsv/h). In room 2, there was a statistically significant difference between the mean background radiation and the mean leakage radiation behind shield. This may be due to inefficiency of protection as well as the design of CT rooms. As presented in this study, there was one ERCP room present in Hospital C. The mean background radiation level in this room was within the safe limits (80 nsv/h). There was a statistically significant difference between the mean background radiation and the mean scattered radiation released on one-meter distance from C arm device where the staff table for administrative work is placed. This in turn entails the importance of strict adherence of any staff present in the room to radiation safety practices as wearing lead aprons and other PPE. On another hand, there was a statistically significant difference between the mean background radiation and the mean leakage radiation outside the room only when the room door was opened and this entails that the room and the door have to be properly and efficiently leaded and protected. In this study, it was shown that in cardiac catheterization unit at Hospital C showed that the control console area and outside of the unit were within the safe limit and it was built according to safety criteria. There was no statistically significant difference between the mean background radiation and the mean leakage radiation in both the control room (shield) and the corridor between cardiac catheterization room and patients' care room where their mean leakage radiation was as the same as the mean background radiation in these locations. In operation theatre at Hospital C surveyed in our study, the fluoroscopy device was portable moving from one room to another, the rooms were not leaded, no protective aprons were present and there was a statistically significant difference between the mean background radiation and the mean leakage radiation outside the operation room while the room was either opened or closed (the room may be left open in many situations). Unlike the operation rooms using fluoroscopy, the vascular surgery room was built within the safe criteria where there was no statistically significant difference between the mean background radiation and the mean leakage radiation outside this room. In nuclear medicine unit (linear accelerator and gamma camera room), the survey result and the readings showed that all radiotherapy centers are built according to protection criteria. As presented in this study, survey of cardiac catheterization unit at Hospital D showed that the unit was efficiently protected and the reading in control console and patient recovery compared to background radiation was nearly the same. On the other hand, at the same hospital in radiology department, the interventional radiology room shows a statistically significant difference between the mean background radiation and the mean leakage radiation on the corridor when the device was "On". In conventional X- ray room, there was a statistically significant difference between the mean background radiation and the mean leakage radiation behind the shield. This in turn reflects the inefficiency of walls or doors of the rooms. The aforementioned results of this study go in agreement with the results of Adhikari *et al*., (2012), Bari *et al*., (2015) and Salama *et al*., (2016) [19, 21, 22]. The study of Bari *et al*., (2015) was conducted to assess the radiological leakage and scatter from X-rays machines in radiology departments of seven randomly selected hospitals at Duhok governorate in Iraq, in different locations including both control panel area and the patients waiting or visiting area that are located near the radiography room. From the measurement results, doses were changed from one hospital to another depending on the building design and structure of X-ray rooms. All measurements were equal to background radiation that was approximately the same at all hospitals, that is consistent with the present study. It was noticed that most hospitals barriers (doors and walls) were not appropriate to the standards except in two hospitals [21]. The results of our study were more informative than that of Bari *et al*., (2015) as we covered all departments/units that may poses potential exposure to ionizing radiation as well as the lack of statistical significance testing in their study. The survey of Adhikari *et al*., (2012) was conducted in 28 different hospitals having 44 X-ray machines, 10 CT scanners, 2 mammography units and 2 catheterization laboratory, as well as five radiotherapy centers having three tele-cobalt machines, two HDR brachytherapy, three linear accelerators and two simulators. This study was conducted to measure the radiation level at six specific locations. Regarding radiology units, this study showed that windows and doors at the X-ray room without lead protection were found at some hospitals outside the Kathmandu region and there is a leakage in almost all units. At two-catheterization laboratory, radiation survey results showed that the control console area and the outside of the catheterization-lab were within the safe limit. Radiation surveys at all five different radiotherapy centers showed that they were within safe limits and were built according to protection criteria [19]. The study of Salama *et al*., (2016) was conducted to assess the occupational radiation exposure and safety protection among medical staff in health care facilities in the Eastern Province, Kingdom of Saudi Arabia (KSA) where four health care facilities with radiological services were randomly selected for the study. The measurement of radiation in the x-ray and CT-scan room at different points and waiting rooms of different hospitals were assessed. This study mentioned that the results were surprising and alarming and there were significant associations in radiation exposure levels in all selected hospitals concerning imaging and waiting room in both X-ray and CT rooms. Furthermore, the high level of radiation exposure might be due to the leakage of radiation through imaging room and the lack of radiation safety procedures during and after imaging [22].

Our study has some limitations including that a self-administered questionnaire was used and the correctness of the answers may not be seen in participants' practice. This study involved four hospitals in Ismailia city where other three hospitals refused to participate due to lack of cooperation of these hospitals. The relatively low response rate in this study (59%) is another limitation and more studies with higher populations may afford supplementary visions regarding this topic.

Conclusion

From our study findings, we concluded that the different departments in the investigated hospitals showed an overall inadequacy of radiation safety and security measures except for nuclear medicine unit and cardiac catheterization units. In addition, there is a variation between departments in different hospitals regarding radiation protection and most of them showed inefficiency of protection as well as the design of rooms except for nuclear medicine department, cardiac catheterization units and C.T. room in Hospital B where they built according to safety criteria.

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