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Radiation Safety Assessment of Medical X-Ray Installations at Gazipur District City in Bangladesh

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Abstract: ***The X-ray is an important tool for diagnosis of diseases as well as therapy. The majority of X-ray machines in Bangladesh are of the traditional type at the district level, however technologically advanced X-ray equipment are now on the increasing. Radiation protection and safety challenges are also becoming a major concern in the medical field as the number of X-ray machines increases. In the current study, the radiation safety infrastructure of 40 diagnostic X-ray installations is assessed at Gazipur district city in Bangladesh. The main objective of this study is to ensure that all regulatory requirements are being fulfilled by analyzing data on radiation safety and protection matters. It has been observed that in 41% facilities, radiation doses are within regulatory limit which is a matter of concern from regulatory point of view. Majority of the X-ray room sizes are below the required value (225ft2), it is also a great concern from regulatory perspective.74% installations are used lead and brick as shielding material in control panels of X-ray installations which is satisfactory as per regulatory requirements. Overall performance of all x-ray installations has not been found much more satisfactory level from radiological safety point of view. Most of the facilities the personal protective equipment is found in satisfactory condition but the thermoluminescence dosimeter (TLD) in the facilities are found near satisfactory level. The current study can help Bangladesh in the near future by strengthening the radiation safety infrastructure of all X-ray installations and ensuring efficient regulatory control over the installations.***

Keywords: radiation exposure, competent authority, occupational worker, safety parameters, medical X-ray equipment

1. Introduction

Radiation-generating equipment such as X-ray machines, CT scanners, dental, and C-arms are used for a variety of peaceful reasons in radiological diagnosis and treatment in Bangladesh. However, diagnostic X-ray facilities are still insufficient for Bangladesh's entire population. As a result, X-ray facilities in Bangladesh are consistently growing from city to rural areas in response to public demand. Radiation protection and safety challenges are also becoming a major concern in the medical area as the number of X-ray machines increases. Safety assessment of all radiological installations is an essential part of the regulatory regime. Radiation doses from diagnostic radiology contribute the most to the total dose from all man-made sources of radiation, according to the UNSCEAR. According to national regulations, room design and layout authorization from the competent authority, Bangladesh Atomic Energy Regulatory Authority (BAERA), is required prior to the installation of any kind of radiation generating equipment [1, 2]. However, prior to the installation of the machine, no facility receives such permission from a regulatory authority. As a result, the radiation protection infrastructures at X-ray installations have not been properly developed to ensure radiation safety. In that case radiation safety assessment is very important to develop radiation protection infrastructures. Therefore, significant changes are required to meet national regulatory standards [3]. During the design stage of an X-ray room, it's important to monitor the status of regulatory compliance requirements. In this regard, good quality machine, adequate personal protective equipment, educated and trained manpower, and external shielding arrangement on the present structure can help to keep the radiation dose at a permissible level for both occupational workers and the general public [1, 4]. It has been realized that the radiation protection infrastructure of all X-ray units and installations in the country should be analyzed explicitly in order to ensure effective, efficient, and uniform regulatory control in medical X-ray equipment and installations. Regulatory body in Bangladesh has started a program to conduct regulatory inspections and radiation surveys of all X-ray machines in the country in order to assess the radiation safety and protection infrastructure and its development. Inspection was carried out to collect the regulatory data on X-ray machines in Gazipur district city as a part of the program. The present study could help Bangladesh strengthen its radiation safety and protection infrastructure in the future.

2. Literature Survey

In the current study, a detail radiation safety assessment has been performed in the 40 diagnostic X-ray installations at Gazipur district city in Bangladesh. The majority of X-ray machines used for diagnostic imaging are of the traditional type, and the quality of service provided by the equipment is clearly poor. The primary objective of this study is to ensure that all regulatory requirements are met by analyzing data on radiation safety matters [1, 5]. During the facility's investigation, it was found that a majority of the X-ray operators are not well educated and lack adequate training in the profession. Because to the operator's ignorance, the patient may receive an excessive amount of radiation, putting the patient in a dangerous situation. In this circumstance, medical technologists with training in the relevant field

should be assigned to the diagnostic facility. Radiation dose is being measured in several locations throughout the facilities in this study. Various safety parameters are measured during the assessment of the facilities, including room size, shielding material at the entrance door, control panel, dark room door, and X-ray room wall thickness. The personal protective equipment particularly availability of the lead apron is observed in satisfactory condition in most of the facilities and the thermoluminescence dosimeter (TLD) badge in the facilities are also found near satisfactory level. Lead has been found mostly at the entrance door and control panel barrier of the facilities as a shielding material; however its thickness and homogeneity are a concern from a regulatory perspective. As a result, regulatory oversight is essential to ensure that X-ray machines are utilized safely.

3. Materials and Methods

The radiation safety and protection infrastructure of diagnostic X-ray installations was studied at 40 facilities at Gazipur district in Bangladesh. Inspections are carried out by the regulating body to ensure that the operator is complying to the specified conditions. The X-ray room layout was drawn using measurements of the room's length and width, wall thickness, door and control panel shielding condition, and its thickness. The layout also included the locations of the X-ray machine, chest stand, control panel, dark room, computed radiography room, and surrounding areas. During inspection the radiation exposure levels were measured using a portable dose rate meter. Two radiation dose rate meters of Geiger Muller (GM) type were used to make the findings more accurately. These instruments were calibrated at secondary standard dosimetry laboratory (SSDL) of Bangladesh Atomic Energy Commission before using in the inspection. Before starting the dose measurement of the X-ray room, the background radiation dose level was measured. After that dose rate was measured at different location of the X-ray room like control panel (CP), entrance door (ED), dark room (DR), computed radiography (CR) room, patient waiting place, reception place, and additional door or other opening space (if any). X-ray machine installation year, X-ray machine type including model, serial number, manufacturer, maximum tube potential (kV), maximum tube current (mA), light beam diaphragm and total tube filtration, number of exposures taken on average in a day, number of workers involved including radiologist, radiographers, operators, and other workers were also recorded during the inspection. According to the investigation personal dosimetry devices are worn on the appropriate part of the body by designated personnel, personal monitoring records are maintained and preserved, all individual annual doses are below the annual dose limits, and appropriate personal protective equipment is available. The surrounding areas of the X-ray room were observed to determine whether or not the surrounding people were exposed to radiation, as well as whether or not the general public was exposed to radiation. It's also assessed to see whether facility employees are following the regulations and completing their regular responsibilities correctly. The presence of a warning sign, a warning notice, and a warning signal at the X-ray room's entrance point was assessed. Based on regulatory data of Gazipur district city in Bangladesh, inspection findings describe the status of X-ray machines, shielding and dose level status, and overall working conditions of X-ray installations. The result also includes an analysis of the current regulatory data in comparison to previous inspection data. The program's findings are being used as a data base or reference document to improve the country's radiation safety feature.

4. Results and Discussion

A total of 40 X-ray units were analyzed in the Bhola district town in Bangladesh. Among all the X-ray machines, the most X-ray machines were found in the 250mA range.

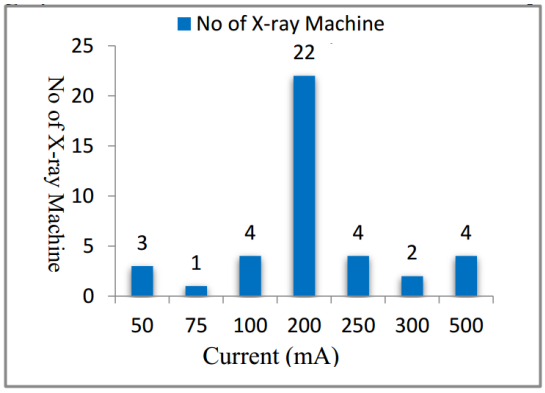

Figure 1: quantity of X-ray machine with mA

Figure 01 shows a graphical illustration of number of X-ray machine with different current level (mA). For the control panel of the X-ray room, the majority of installations use lead and brick as shielding materials. Most of the installations X-ray rooms are smaller than the regulatory requirement of 21sq. m (225ft2), which is a major concern from a shielding standpoint. In the case of X-ray facilities some places require shielding analysis, particularly the control panel, outside the entrance door, where a group of radiation workers may be exposed to a significant amount of radiation [6]. The equipment and workers cannot move around freely during radiological examinations due to insufficient room size. In a number of cases, X-ray rooms are not well-planned and designed with radiation safety regulations in mind. Unwanted exposures of occupational workers, patients, and the general public are unavoidable as a result of this issue.

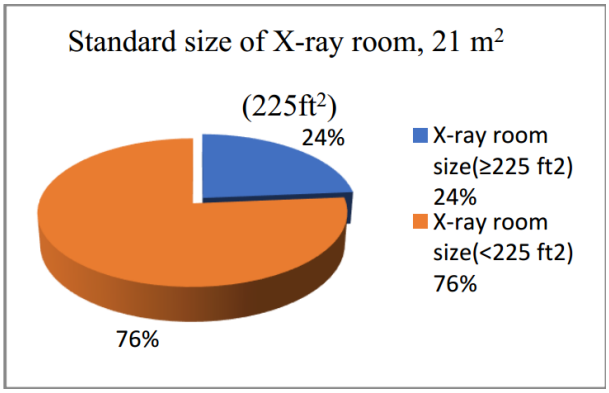

Figure 2: X-ray room size status at Gazipur district city

Figure 2 illustrates the X-ray room size condition in Gazipur district city, showing that just 24% are standard size and 76% are below standard, indicating that a significant improvement is required to meet regulatory demands. Except for two, all X-ray rooms feature has a 10" brick wall that fulfill regulatory requirement and effectively protects X-rays. More than half of the inspected installations radiation dose level was out of regulatory limit (10µSv/hr for occupational worker) because the shielding was not adequate in entrance door and control panel.

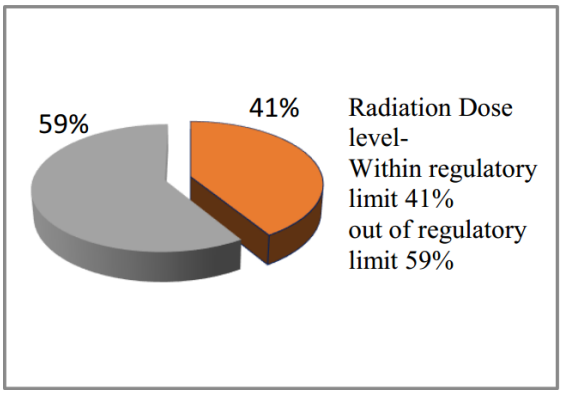

Figure 3: Dose level status of X-ray installations at Gazipur district city

Figure 3 shows in 41% facilities radiation doses are within regulatory limit where 59% are out of regulatory limit.

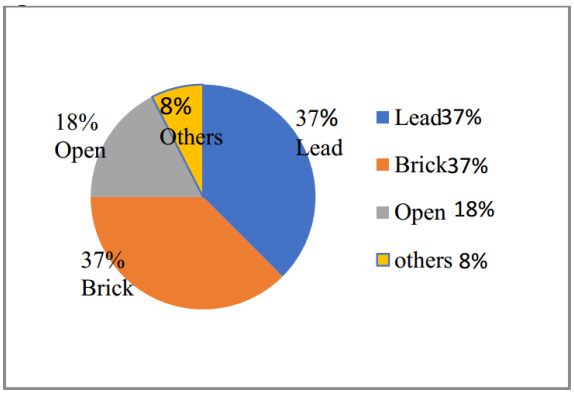

Figure 4: Shielding status of control panels (%) of x-ray machines at Gazipur district city

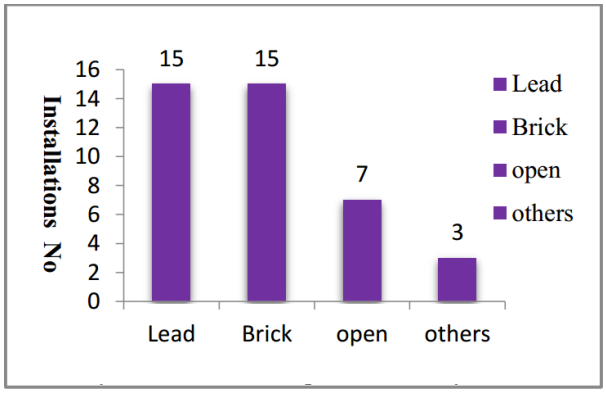

Figure 5: Shilding status of control panels (Number) of X-ray machines at Gazipur district city

Figure 4 and 5 indicate the shielding condition of the secondary barrier (Control Panel); lead and brick are most commonly used shielding material in control panels, covering 74% of all installations, where other materials are used as shielding in 8% control panel and 18% are in open condition.

As 18% of the control panels are found in open condition, high amount dose is observed at operator place in this situation. It is a matter of concern from regulatory point of view. The chest stand is sometimes positioned in such a way that the primary beam is directed towards occupied areas or the dark room, which also contains undeveloped films. Many cases, adequate patient waiting places are not provided. During exposures, patients and their relatives are sometimes required to wait near the X-ray room which may harmful for patient as well as relatives. Radiation warning signals are rarely observed, although radiation caution signs are commonly displayed. The lead Goggles and lead hand gloves for the operators were found in only one X-ray facilities but lead apron was available in 34 installations among the total of 40 installations for the protection of radiation worker. Among the 40 installations, only 25 installations have TLD-Badge for personal radiation monitoring. In terms of radiation safety and protection, the majority of radiation workers are unqualified. Among all inspected installations in Gazipur district city, 33% installations have been found satisfactory performance from radiological safety point of view (Table.1 and Figure 6).

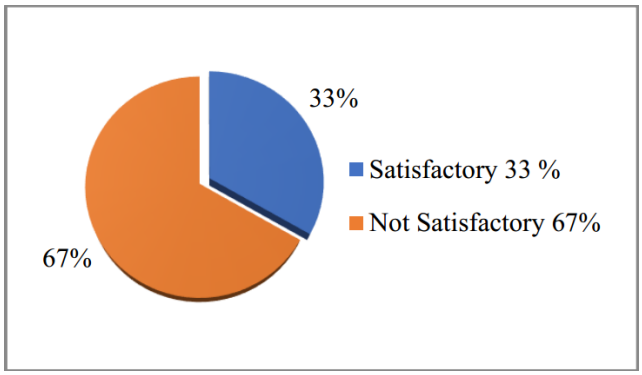

Figure 6: Overall condition of X-ray installations at Gazipur district city

The results indicate that the overall performance of the radiographic X-ray systems is little satisfactory since only 33% of them have satisfactory performance in compliance with the regulatory requirements. Therefore, to improve the equipment performance and operational safety in medical X-ray installations, greater monitoring and surveillance is required. The dose rates observed at several points of interest surrounding the X-ray machines are tabulated in Table 1.

Table 1: Radiation dose levels at some points of interest in and around the X-ray installations at Gazipur district city

Facility Installation Code	Operating condition			Dose rate (µSv/hr)					Overall Assessment
	kV	mA	Time (sec)	Entrance door	Control panel	Additional door	Dark room	Other Location	
GAZ(D)-P-101	70	200	2.5	40	10	NA	NA	Not Applicable	NS
GAZ(D)-P-59	60	150	0.5	0.35	BRL	NA	NA	60 (CR room)	NS
GAZ(D)-P-37	70	100	0.4	BRL	BRL	NA	NA	Not Applicable	SA
GAZ(D)-P-50	60	150	1.6	1.5	80	NA	NA	do	NS
GAZ(D)-P-52	70	200	1.0	0.35	18	NA	NA	do	NS
GAZ(D)-P-118	65	150	2.0	80	50	NA	1.5	do	NS
GAZ(D)-P-117	65	150	0.5	BRL	BRL	NA	NA	do	NS
GAZ(D)-P-32	70	200	0.63	BRL	0.70	NA	NA	35(CR room)	NS
GAZ(D)-P-91	80	100	1.0	BRL	87	NA	NA	Not Applicable	NS
GAZ(D)-P-116	70	100	1.2	25	80	NA	97	do	NS
GAZ(D)-P-79	60	50	1.5	BRL	0.90	NA	NA	do	SA
GAZ(D)-P-115	70	35	2.0	1.0	70	NA	70	do	NS
GAZ(D)-P-93	70	100	1.2	BRL	0.5	NA	0.69	do	SA
GAZ(D)-P-38	63	150	2.0	0.38	50	NA	30	do	NS
GAZ(D)-P-110	80	150	0.4	BRL	BRL	NA	NA	do	NS
GAZ(D)-P-107	65	100	0.4	2.0	90	NA	40	do	NS
GAZ(D)-P-102	62	10	10	BRL	20	NA	1.0	BRL	SA
GAZ(D)-P-103	75	150	1.0	1.0	3.0	NA	NA	do	SA
GAZ(D)-P-105	60	120	0.8	0.38	0.35	NA	NA	BRL	SA
GAZ(D)-P-108	80	100	1	0.46	82	NA	25	BRL	NS
GAZ(D)-P-106	62	50	1.0	0.32	BRL	0.34	NA	do	SA
GAZ(D)-P-111	75	200	1.2	0.40	26	NA	NA	BRL	NS
GAZ(D)-P-109	65	30	1.2	0.35	85	NA	50	BRL	NS
GAZ(D)-P-104	70	100	0.8	1.5	BRL	NA	10	BRL	NS
GAZ(D)-P-119	70	60	1.2	10	BRL	NA	NA	Not Applicable	NS
GAZ(D)-P-122	65	150	0.8	BRL	2.0	NA	BRL	do	SA
GAZ(D)-P-49	80	200	0.32	BRL	0.7	NA	NA	do	SA
GAZ(D)-P-112	60	100	1.0	BRL	35	NA	10	do	NS
GAZ(D)-P-81	70	100	1.6	2.0	BRL	NA	NA	do	NS
GAZ(D)-P-70	81	160	2.0	100	100	NA	1.0	do	NS
GAZ(D)-P-121	60	60	0.6	15	50	NA	1.5	do	NS
GAZ(D)-P-120	60	60	0.6	150	60	NA	NA	do	NS
GAZ(D)-P-114	65	100	0.63	80	BRL	NA	30	do	NS
GAZ(D)-P-76	65	100	2.0	0.7	40	NA	50	do	NS
GAZ(D)-P-57	80	160	1.2	1.5	BRL	NA	NA	do	SA
GAZ(D)-P-113	60	150	2.0	BRL	BRL	NA	BRL	do	SA
GAZ(D)-P-31	65	30	2.0	BRL	0.5	NA	0.5	do	NS
GAZ(D)-P-90	65	150	0.3	1.5	BRL	NA	BRL	do	SA
GAZ(D)-P-67	70	60	2.0	5.0	BRL	NA	NA	do	SA

[ED=Entrance door; CP=Control panel; DR= Dark room; OR= Other room; BRL= Background Radiation Level (0.20-0.30µSv/hr), NA= Not Available; CR= Computed Radiography; SA=Satisfactory; NS=Not Satisfactory]

Table 1 shows that dose rates for occupational workers are greater than the acceptable dose limit (10 Sv/hr) in a few X-ray installations. The dose rate recorded at the ED were found higher than regulatory limit in seven facilities of Gazipur district city. During data collection the background radiation level was found to be from 0.20 to 0.30 µSv/hr in the X-ray installations. According to the data analysis, about one-third of the installations meet the required standards. The Quality Assurance (QA) program, dosimetry and calibration services were not present in any one of the X-ray installations. In all facilities, there were 59 radiographers and only 15 radiographers of them have Diploma in Medical Technology. It clearly indicates the inadequate academic qualification of medical technicians. The majority of technologists are trained through their professional work. The Bangladesh Atomic Energy Regulatory Authority (BAERA) has provided some of them with basic radiation protection training. The majority of the installations require improvement. In most of the facility, the machine room size needs to be increased and made square and machine should be positioned at the centre of the room. However, if an installation complies with the general operating regulations and makes minor improvements, it may be allowed to operate with the necessary license from the Bangladesh Atomic Energy Regulatory Authority (BAERA).

5. Conclusion

Ionizing radiation, such as X-rays, increases the risk of fatal cancer in those who are exposed to it. Although the diagnostic X-ray is an important part of health care, occupational workers, patients, and the general public may be exposed to unwanted radiation as a result of diagnostic X-ray installations. As a result, adequate safety and protection of X-ray generating equipment is essential to assure good image quality as well as the safety of patients, workers, and the general public. The current radiation

protection infrastructure of the facilities has to be significantly improved in order to meet the requirements of national and international radiation safety regulations. The lack of radiation shielding arrangements has been found in this study, allowing for necessary steps to be taken to develop radiation safety and protection infrastructure in accordance with regulatory guidelines. Facility also should appoint educated and professionally sound manpower and confirm availability of radiation monitoring equipment to assure radiation safety in the facility. It is important to follow BAERA's regulatory requirements in order to avoid undue radiation exposure to radiation workers, patients, and the general public. The facility personnel who are involved with radiological activities are mainly responsible for ensuring radiation safety of diagnostic X-ray. With the proper implementation of the BAER Act-2012 and the NSRC Rules-1997, it will be possible to develop the radiation protection infrastructure in X-ray facilities more in the future. The regulatory authority will provide appropriate guidelines to ensure the radiation safety of X-ray installations, as well as verify that the facility fulfilled the regulatory requirements for radiation safety. Both the regulatory body and the user should work more actively to upgrade the radiation protection infrastructure as well as safety feature of all X-ray facilities and to establish effective regulatory control over all medical X-ray installations.

6. Future Scope

After collecting all regulatory data, inspection reports with some recommendations were produced for improving radiation protection infrastructure and sent to the appropriate facilities for radiation safety infrastructure development in accordance with national legislation. The regulatory body has the authority to re-inspect the facilities in the future to see whether they met the regulatory requirements or if there have been any modifications to the facilities in terms of radiation safety. The findings of the re-inspection could be used to further improvement of the facilities. A comprehensive investigation with a large number of diagnostic X-ray facilities is required to accurately complete all findings related to radiation safety and protection in all areas. However, moving forward with the analysis is somewhat challenging due to a lack of resources and logistical support from the regulatory body.

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