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Assessment of Regulatory Compliances in Diagnostic X-ray Facilities in Tangail District, Bangladesh

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Abstract

Due to increasing public demand, diagnostic x-ray facilities are expanding from the city to district even at rural areas faster than ever before in Bangladesh. At the same time radiological safety issues are also becoming the matter of great concern in this area of medical sector. In the present study, a comprehensive investigation is carried out on radiological safety matters in the 34 diagnostic x-ray facilities at Tangail districts in Bangladesh. The main objective of this study is to verify the compliance of regulatory requirements with respect to the radiation safety. The safety parameters are assessed emphasizing particularly on the room size, shielding material at entrance door and control panel and thickness of side walls of x-ray installations. It is very important to investigate the status of regulatory compliance requirements at the stage of designing of an x-ray room. It has been found that 62% facilities maintain the shielding properly and 26% have no shield at all against the radiation. Nearly acceptable room size was found only in the two facilities. Among the facilities few of them use old and non-calibrated x-ray machine. To some extent unexpected dose variation with room size is also observed. The present study on radiological safety status of diagnostic x-ray installations may be a reasonably good presentation of the situation in the country as a whole. The study can contribute significantly to the improvement of radiological safety in near future.

Keywords: *Radiological safety, Compliance requirements, Shielding material, Safety parameters, Dose variation, Safety status.*

1. Introduction

The x-ray machines as medical diagnostic tools are widely used all over the world because of the simplicity and cost effectiveness even though many powerful imaging techniques e.g. Ultra-sonography, magnetic resonance imaging (MRI), gamma scanning etc. are available in these days [1,2]. These practices are the largest contributor of manmade ionizing radiation dose to the occupational workers, patients, and public. About 80% of the total dose to the population is estimated to be caused by medical diagnostic x-ray imaging [3]. The estimation of average annual doses to the environment from diagnostic medical x-ray ranges from 0.3 to 2.2 mSv [3]. Currently more than 4000 medical diagnostic x-ray units are functioning all over the country [4]. However, use of x-ray for radiological diagnosis is associated with a certain amount of risk to the patients, professionals' and persons in the vicinity of the x-ray facility [5]. So, it is very important to ensure that adequate safety infrastructure [6]. According to national standard, the shielding required for entrance door 2 mm of lead/3 mm stainless steel, for control panel barrier the recommended shielding is 10 inch brick wall/2mm lead/3mm stainless steel and for the wall 10 inch brick shielding is required [1]. The Bangladesh Atomic Energy Regulatory Authority (BAERA) is the competent authority for enforcing regulatory provisions for radiation protection in the country [7,8]. BAERA is responsible for monitoring the national standards that the requirements for safe handling of radiation sources including medical diagnostic x-ray installations by implementing the Bangladesh Atomic Energy Regulatory (BAER) Act 2012 and Nuclear Safety and Radiation Control Rules-1997 which are based on International Basic Safety Standards [9]. In this regard BAERA (former NSRC Division of Bangladesh Atomic Energy Commission) has also published the regulatory guide on radiation protection in medical diagnostic x-ray to provide guidance on safety in the design, installation and operation of medical diagnostic x-ray facilities as required by the Act and the Rules [1]. The implementation of the provisions of the guide ensures the protection of occupational workers, patients, general public as well as the environment. One of the main objectives of the guidance is to focus on safety in the design of diagnostic x-ray installations. It is generally presumed that the users take a due note of the provisions of the guide and the x-ray room is therefore designed accordingly. The aim of the present work is to carry out a complete assessment on radiation safety features and to this effect make some recommendations in order to enhance the existing infrastructure of facilities in the light of regulatory demands.

2. Materials and Methods

34 medical diagnostic x-ray installations of Tangail district are preferred arbitrarily for the present study. The study includes the assessment of room size, its surroundings, dark room, control panel position, shielding materials. The radiation dose at control panel, outside the control panel barrier, at the entrance doors, outside the walls of the x-ray room for each x-ray installation was measured. For dose measurement GSM-525 dose rate meters used which were calibrated against gamma ray in Secondary Standard Dosimetry Laboratory of Atomic Energy Research Establishment, Savar, Dhaka. This meters work well within temperature range -28^{0}C to 60^{0}C. The dose measurement range is 0-2000 mR/h equivalent to 0-17.39 mSv/h [11]. Another dose rate meter of model FH40F1, measuring range from 3µSv/h to 999 mSv/h named "Everline" was also used to verify the measured dose by the first instrument. The cross-checking helps to remove confusion. The impact of design and size of the x-ray room on radiation dose to the environment was compared. For collection of all these data, a standard checklist was developed and followed.

3. Results and Discussions

The measured public dose rates at entrance door and control panel for each facility are shown in the Table-1. This table also shows the existing shielding material and wall thickness of x-ray room. It is observed that first 17 facilities are able to shield the radiation properly where shielding structure has been developed following regulatory guide line except the facilities 14-17 as shown in Figure-1. Then in the facilities 18-34, public and occupational workers exposed with extremely higher dose in the range of 1000 µSv/h as shown in the Figure-2. From the collected data, it is seen that, among these 34 installations, only 2 are in compliance nearly with the regulatory requirement with respect to room size of having 225 ft^2 [1].

The importance of having shielding material is most necessary for the radiation safety. Collected data shows that 59% of faility use lead (Pb), 3% steel and 38% use nothing as shielding material at the entrance door. In case of control panel, 21% use Pb, 44% brick, and 35% do not have any kind shielding for the radiation.

Table 1: Necessary safety parameters of diagnostic x-ray facilities

Facility ID	Room Size in sft	Dose in µSv/h		Shielding Material		Wall Thickness In inch	Facility ID	Room Size in sft	Dose in µSv/h		Shielding Materia		Wall Thickness in Inch
		ED	CP	ED	CP				ED	CP	ED	CP	
FC-01	114.45	0.4	1	LEAD	LEAD	10	FC-18	119.98	20	160	NILL	OPEN	5
FC-02	132	0.25	0.25	LEAD	BRICK	10	FC-19	154	0.25	200	LEAD	OPEM	10
FC-03	147.25	0.25	0.25	LEAD	BRICK	10	FC-20	187	0.25	150	LEAD	OPEN	5
FC-04	130.79	0.25	0.25	LEAD	LEAD	10	FC-21	115.83	160	150	NILL	OPEN	10
FC-05	126	1	0.5	LEAD	BRICK	10	FC-22	179.92	120	1.6	NILL	LEAD	10
FC-06	126	1	0.5	LEAD	BRICK	10	FC-23	112	50	1000	LEAD	OPEN	5
FC-07	168.92	0.25	0.25	LEAD	BRICK	10	FC-24	110	1000	1000	NILL	OPEN	5
FC-08	59.63	0.25	0.25	LEAD	BRICK	10	FC-25	300	120	1000	NILL	OPEN	10
FC-09	158.69	0.25	0.25	LEAD	BRICK	10	FC-26	196.33	1000	1000	NILL	OPEN	10
FC-10	224	0.25	0.25	LEAD	BRICK	10	FC-27	134.67	120	1000	NILL	BRICK	5
FC-11	179.56	0.5	0.5	LEAD	LEAD	10	FC-28	176.25	80	1000	NILL	OPEN	10
FC-12	110.76	0.25	0.25	LEAD	LEAD	10	FC-29	158.12	120	1000	NILL	BRICK	5
FC-13	200	0.5	3	STEEL	LEAD	10	FC-30	124.1	10	1000	NILL	OPEN	10
FC-14	124.52	2	8	LEAD	BRICK	10	FC-31	120.65	0.25	1000	NILL	OPEN	5
FC-15	140	0.25	10	LEAD	BRICK	10	FC-32	107.02	0.25	1000	LEAD	BRICK	10
FC-16	115.83	0.5	20	LEAD	LEAD	10	FC-33	120	20	1000	NILL	OPEN	10
FC-17	182.94	0.25	60	LEAD	BRICK	10	FC-34	58.5	1000	0.25	NILL	BRICK	5

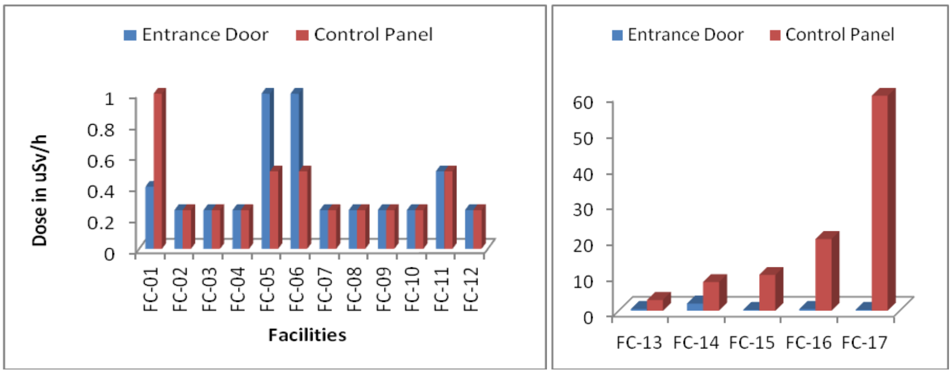

Figure 1: Dose at entrance door and control panel of facilities having shield

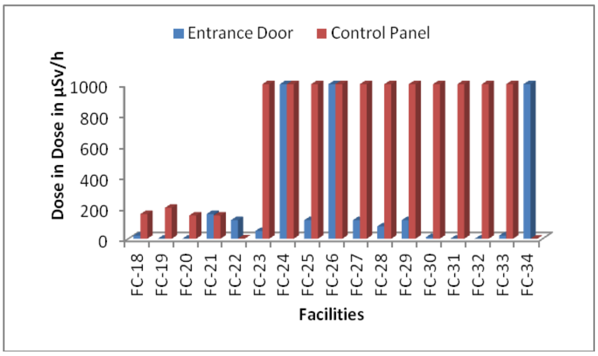

Figure 2: Dose rate without shielding

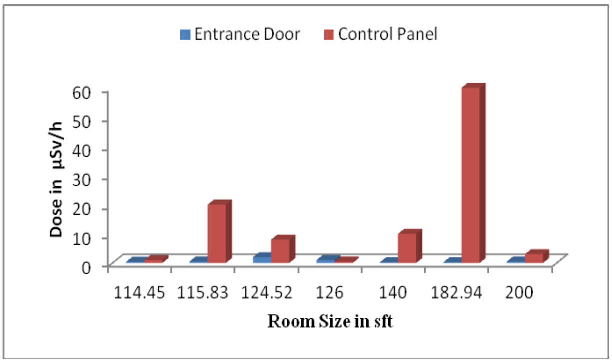

Figure 3: Variation of dose rate with room size

The wall thickness and construction material of the x-ray rooms are also observed in this study. The BAERA rules suggest that every facility should have 10'' brick wall for the x-ray room. From the collected data, it is found that 76% facilities have the required wall thickness whereas 24% cannot fulfill the requirement (Figure-4).

4. Conclusions

The present study reveals several instances of noncompliance with the regulatory requirements. The major noncompliance is the room size. Besides, 62% facilities used the shielding material whereas 12% are partially shielded and 26% facilities have no shield against the radiation as shown in Figure-4. Among the 62% of shielded facilities, five (13-17) facilities have higher dose rate which is due to non-uniformity of shielding material. From Figure-2 it is seen that facilities 18-34 have no shielding. But the dose rate variation is found impractical in the facilities of 18-22. This is because those facilities used old machine and hence operate in lower KVp and mA. The dose rate varies with room size unexpectedly which is presented in Figure-3. This may happen due to positions of machines in the room, beam filtration etc. and non-calibration of the machine as well.

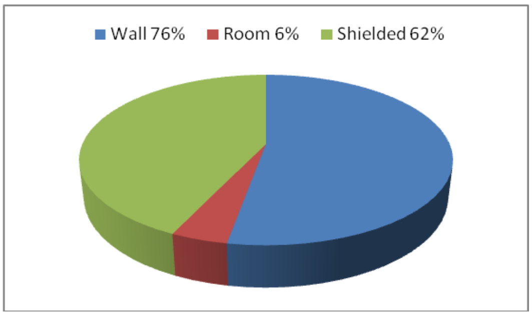

Figure 4: Percentage of facilities compliance with wall thickness, room size and shielding

Again 69% facilities used lead (Pb) as shielding material at entrance door and 29% used this material at control panel. Therefore, remaining facilities are not safe in the view of radiation protection. In these facilities public and workers are being exposed to unwanted radiation regularly. The situation in case of room wall condition is quite satisfactory from regulatory point of view. But the overall situation still requires significant improvement. The main reason behind this is the lack of knowledge and consciousness towards the radiation safety.

As the Government has established a new independent regulatory body "Bangladesh atomic Energy Regulatory Authority (BAERA) which could play a strong role in order to implement the regulatory requirements by organizing periodic safety audit, unannounced inspection, training for public awareness on radiation safety and taking steps to enforce the provisions of the Act and rules through which the radiation safety of occupational, public, patient and the environment will be ensured and hence will be the strongest radiation safety infrastructure throughout the country as it is required by the national and international organizations.

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