QUALITY CONTROL AND ENVIRONMENTAL ASSESSMENT OF EQUIPMENT USED IN DIAGNOSTIC RADIOLOGY

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ABSTRACT

Availability and the use of X-ray equipment in both private and government hospitals is on the increase today in developed and developing countries. Quality control of such equipment is of particular importance to prevent avoidable high doses, radiation leakages and to ensure dose optimization. The results of quality control in this study indicate that the output measured in GHL (m2) ranged between 0.0318 and 0.1192 mGy $(mAs)^{-1}$, while relatively higher values which ranged from 0.0762 to 0.2156 mGy $(mAs)^{-1}$ was found in four other hospitals. The tube voltage accuracy measured indicates variation among the hospitals investigated. The deviation in voltage accuracy ranged between 0.9 and 10.9% in the two units of GHL (m1 and m2). In the three other hospitals the range of deviations are 0.2 to 0.5% (PSH), 45.5 to 72.7% (NOH, the highest) 22.9 to 23.3% (NARH). Both GHL (m1) and PSH complied with the requirement of ± 5%. As regard timer accuracy, linearity of the tube current and beam alignment; NOH and NARH exceeded the acceptable limits of ±5%, ±10% and ±3% respectively. The consequence of non-compliance in most part include: repeat exposures, more expenses and more importantly, excess dose to the patient.

Keywords: *Quality assurance, quality control, environmental monitoring, radiation, X-ray output*

1. INTRODUCTION

In Nigeria, X-rays is the most frequently used ionizing radiation in medicine despite advances in magnetic resonance imaging and ultrasound techniques. It has maintained a key role in diagnosis of diseases, injury and in X-ray therapy. In effect it is the largest manmade source of ionizing radiation to the world population (ICRP, 1991; UNSCEAR, 1993; Muhogora and Nyanda, 2001). X-ray is the major contributor to the effective dose of both the patient and the personnel. Because of the radiological risks involved, it is usually recommended that dose to patient from X-ray be kept as low as reasonably achievable (ALARA) with adequate image quality (IAEA, 1996). In addition, programmes for diagnostic imaging departments, regardless of the size, should at least contain the following components: equipment quality control, administrative responsibilities, risk management and radiation safety programme. Equipment quality control unit carries out evaluation of equipment performance to ensure proper image quality, as well as patient and operator safety (Papp, 2002). Moreover, radiation safety unit is to ensure that patient exposure is kept as low as reasonably achievable and that departmental personnel, medical staff and members of the general public are protected from overexposure to ionizing radiation.

Currently, there are far above 4000 X-ray machines in Nigeria (Elegba, 2006) out of which less than 5% are under regulatory control. These thereby pose a great hazard to the patient, personnel and challenges to the regulatory body in Nigeria. As a result of availability of X-ray facilities, some new while others are second hand (known locally as *Tokunbo*), there has been a constant increase in the number and frequency of X-ray examinations in recent times. In Northwestern region of Nigeria for example, a survey of 124 institutions with sources of ionizing radiation indicates that 203 X-ray installations were found with only 90 sealed radiation sources (Mallam et al., 2004). In the same report, Ahmadu Bello University Teaching Hospital (ABUTH) complex on average carries out over 250 diagnostic X-ray examinations per day in the three hospital facilities located in Zaria, Kaduna and Malunfasi. The population of the exposed individuals and the frequency of exposure is an indication that annual collective dose to patient can be quite significant.

The quality control (QC) programme comprises the regular testing that must be carried out on each major component of the system to ensure optimum performance within the system (West,1993). In diagnostic radiology QC test is carried out to ensure that a high quality diagnostic image is produced for a minimum radiation dose to the patient (NRPB, 1988). The major equipment in diagnostic radiology to which quality control can be applied include

X-ray production, detection, image processing and image viewing equipment among others. The equipment testing is coupled with routine environmental monitoring and assessment of image quality (Oluwafisoye et al., 2009).

(1.1) Nigerian Nuclear Regulatory Authority (NNRA)

Due to the deleterious effects of ionizing radiation, the Nigerian Nuclear Regulatory Authority (NNRA) was established by the Nuclear Safety and Radiation Protection Act of 1995. This national regulatory body is charged with primary responsibility of nuclear safety and radiation protection. The Act empowered the NNRA to categorize and license activities involving exposure to ionizing radiation in particular, the possession, production, processing, manufacture, purchase, sale, import, export, handling, use, transformation, transfer, trading, assignment, transport, storage, and disposal of any radioactive materials, nuclear materials, radioactive waste, and any equipment emitting ionizing radiation. In this regard, the NNRA in her document made provision for minimum requirement for the equipment maintenance in line with international regulatory policies.
As part of the effort at enhancing safety in the use of ionizing radiation in Nigeria, the National Institute of Radiation Protection and Research (NIRPR) was established under the guidance of NNRA. The Institute trains personnel in the radiation protection.
The present measurements were conducted to check the suitability of the quality control tests and the stated tolerance levels for various X-ray equipment at four Nigerian hospitals. Additionally, environmental radiation monitoring around the facilities was carried out to ascertain the safety level of both the patient and personnel.

2. MATERIALS AND METHODS

Quality control test (kVp accuracy and reproducibility, mAs linearity) of four government-owned hospitals, one general hospital (GHL), two specialist hospitals [Psychiatric hospital (PSH) and National Orthopaedic hospital (NOH)] and one military hospital (NARH), all located in Lagos were carried out. The GHL has two functional X-ray units depicted as machine 1 (m1) and machine 2 (m 2). The investigation was carried out with the assistance of the staff of the radiology department of each hospital. Meanwhile, each of the X-ray facilities was used for both paediatric and adult examinations. In all the hospitals there was no previous exposure and QC data available. The data manipulation was done using Microsoft Excel, 2003.

(2.1) Measurement of X-ray tube Output and exposure time product

X-ray tube output is the amount of exposure, in millirontgens (mR) delivered to a point in the centre of the useful X-ray beam at a distance of 1 metre from the focal spot for 1 mAs of electron passing through the tube. The output expresses the ability of the tube to convert electronic energy into X-ray exposure. X-ray tube output is the single most important parameter to quantify radiation yield (Zoetelief et al, 2006). The free-in-air exposure, FAE (mR) was measured using factory calibrated KV meter (US made Victoreen X-ray test device, model 4000 M+) obtained from the Department of Physics (DOP) University of Ibadan. The consistency of X-ray tube output with the tube current (mA) or tube current exposure-time product (mAs) was measured for the range of mA or mAs values used in practice. The detector (KV meter) measures the mean, effective and maximum peak tube voltage, power phase, exposure and exposure time. This system determines the tube voltage with accuracy of ± 2% (Victoreen, 1995). The internal ionization chamber that measures exposure has volume of 36 cm^3. The exposure time is measured to an accuracy of ± 2%. The FAE (mR) measured is converted into output in mGy $(mAs)^{-1}$ by multiplying by a factor 0.00877/ mAs (Chang Jong and Hui- Yu, 1999) where mAs in the denominator is the product of the tube current and exposure time set at the time of measurement of the output.

(2.2) Environmental Monitoring and General Observations

The guiding principle used in all regulatory documents is that, radiation doses to the public and to the people who work with radiation must be kept as low as reasonably achievable (ALARA principle). In essence, radiation workers and the patient should be monitored at all times when working. The reason for this monitoring is to ensure that the practice being followed by the workers in their daily routine are safe and do not result in high doses being received. In the present study, the dose rate at different points of interest (the console, entrance door behind the wall, patient waiting seats) was measured with radiation detector (radiation monitor 4 minirad 1000+). This device measures radiation dose rate in μSv/ hr.

(2.3) Optical and Radiation Field Congruence/ Beam Alignment

The beam control system is required for regulating the size of X-ray field area. Therefore, it plays an important role in dose delivered to the patient because it controls the amount of patient surface area exposed to radiation and image contrast (due to scattered radiation). The parameters taken into consideration in beam control system include; beam alignment, optical radiation field congruence, accuracy of the x y scales and illuminator bulb brightness. In this study optical radiation field and beam alignment were examined.

(2.4) Visual inspections

One of the three parts of a quality control programme for a radiographic facility is visual inspection. This part includes checking the main components of the equipment for proper functioning, safety and good mechanical condition. It is expected that they should include; protective lead apparel, lead shield of the cubicle wall, overhead tube crane, radiographic table, control panel and other facilities such as door and automatic light.

3. RESULTS AND DISCUSSION

Five X-ray units in four hospitals were investigated in the study. Both the QC and environmental assessment of the facilities were carried out. Table 1 presents the radiographic equipment information at various hospitals investigated. The years of manufacture of the equipment range from 9 to 31 years, while the year of installation is between 5 and 31 years. The effect of age on the output of an X-ray machine is well documented (Mallam et al., 2004, Ogundare et al. 2004).

Table 1: Specific Data of X- ray machines investigated

Hospital	GHL		PSH	NOH	NARH
Parameter	m1	m2			
Equipment Manufacturer/ model	Genius HF	GEC Medical	Philips Medical	-	General Electric Company
Name of machine	Villa Systemi medicali	Wembley Middlesex	Practix 100	-	Wattson
Year of manufacture	2001	> 30 years	1999	-	1977
Year of installation	2005	> 30 years	2001	-	> 25 years

(3.1) X-ray tube Output

The result of X-ray tube output at a distance of 1m each from the focus of five X-ray units are presented in Table 2. The values of output obtained in GHL (m2) are relatively low, those measured in GHL (m1) are higher than those found in m2. It ranged from 0.0318 to 0.1192 mGy $(mAs)^{-1}$. However, higher outputs are found at the same voltage in PSH and NOH. As an example, at 80kVp the outputs are 0.0796, 0.1676, 0.2156 and 0.0762 mGy $(mAs)^{-1}$ for GHL (m1), PSH, NOH and NARH respectively. The variation in the output could be attributed to the waveform, anode material, filtration, and tube age and anode surface damage. Knowledge of the output value for a given X-ray tube permits the determination of both patient and film exposures. It is also used in the calculation of Entrance Surface Dose (ESD) delivered to the patient at the point where the X-ray beam enters the patient. This dosimetry parameter (ESD) gives the perspective estimation of absorbed dose to the patient. Although the entrance surface dose is a poor risk indicator, it can be used to estimate the effective dose (ED) which better quantifies patient risk (Gkanatsios and Huda,1997). The variation in the output among the hospitals could lead to variation in doses delivered to the patients during the examinations.

Table 2: Measured X-ray Output at different voltages

kVp	Measured Output x 10^{-3} mGy $(mAs)^{-1}$	
	m1(GHL)	**m2 (GHL)**
60	31.80	7.70
80	79.60	13.60
100	125.50	23.90
120	119.20	30.10
	PSH	
65	21.10	
70	41.90	
75	84.20	
80	167.60	
	NOH	
50	26.50	
60	52.70	
70	106.70	
80	215.60	
	NARH	
70	67.10	
80	76.20	
90	85.60	
100	95.7 0	

The consistency of X-ray tube output with mAs was measured for a range of mAs for the five X-ray units at different voltages. The results are presented in figures 1-3. Moreover, results of output measured at different kVp above 80 kVp (GHL and NARH) show strong correlation with mAs, however, the outputs measured at lower voltage of 60 and 75 kVp indicate weak correlation with mAs. The X-ray tube and the anode current are highly stabilized at this point (Suliman and Elshiekh, 2008).

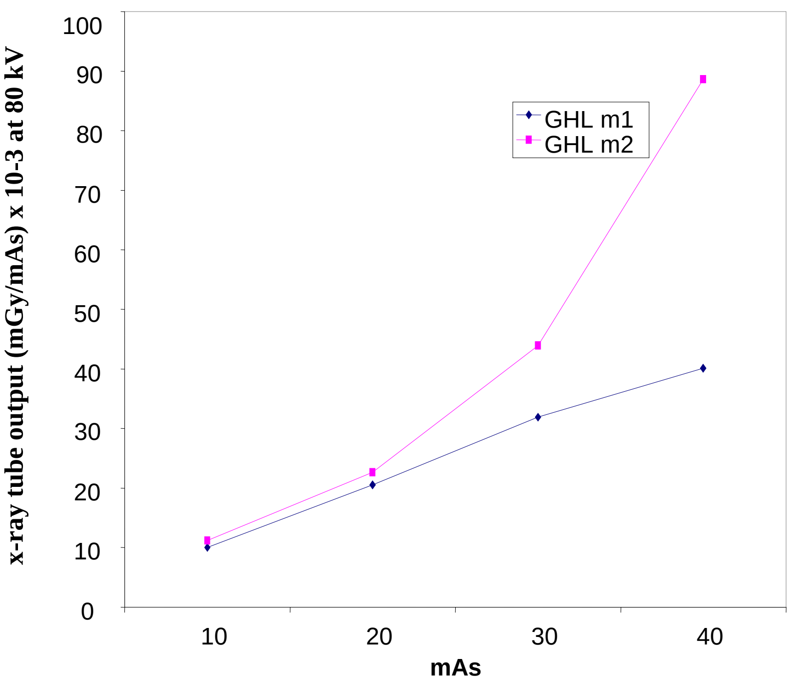

Figure 1: X-ray output as a function of mAs for two X-ray units

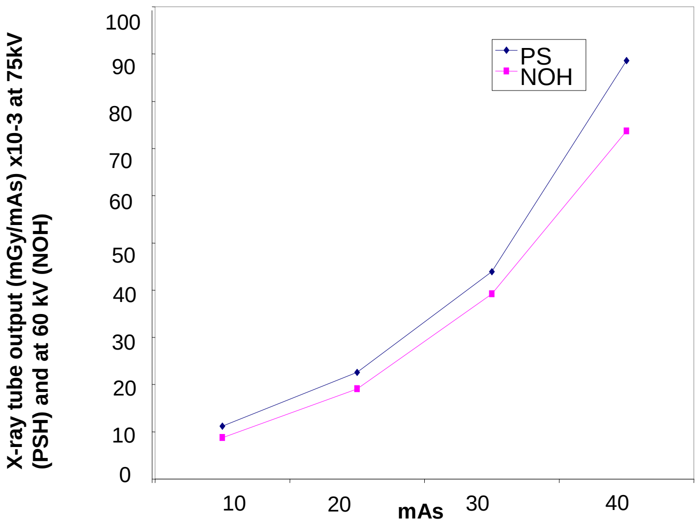

Figure 2: X-ray output as a function of mAs in two X-ray units

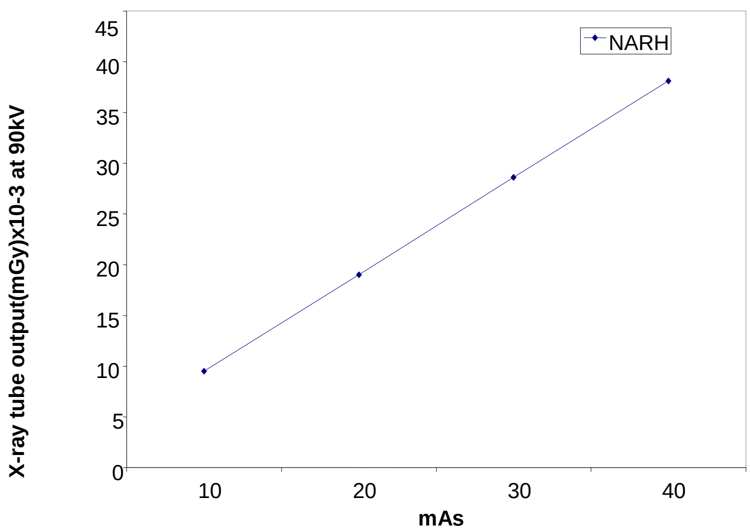

Figure 3: X-ray tube Output as a function of mAs for one X-ray unit

The results of the tube voltage accuracy for five X-ray units investigated are presented in tables 3a-3d. The tables show the tube voltage set, the tube voltage measured and the magnitude of deviation. It should be noted that the magnitude of deviation in kVp vary from hospital to hospital. In GHL, the deviation ranged between 0.9 and10.9 % for the two machines (m1 and m2). The ranges of magnitude of deviation for the three other hospitals are; 0.2 to 0.5 %, 45.5 to 72.7 % (highest in this study) and 22.9 to 23.3 % in PSH, NOH and NARH respectively. Both m1 (GHL) and PSH comply with the requirement of ± 5%, while m2 (GHL), NOH and NARH exceeded the requirement. The reasons for higher deviation in kVp found in NOH and NARH are multifactorial.

The European Commission recommended a high technique of 125 kV IAEA (1995) which probably results in low doses, but the radiologists prefer the higher contrast chest radiograph which results from low kVp. Earlier report indicated that increasing the tube potential (kVp) from 8-13 kV in lumbar and thoracic spine examination resulted in a dose reduction of 26-36% (Martin et al, 1993). The higher deviations outside the tolerance limit as obtained in the present study show discrepancies in kVp between the measured and the set values especially if the tubes are not adequately maintained. Moreover, the excessively high deviation between the set and the measured kVp could reduce the image contrast (Livingstone et al, 2004). The unexpected elevated value of technical parameters which results from faulty machine could affect both patient dose and image quality. The trends found in GHL (m2), NOH and NARH require regular and repeated QC tests.

Table 3: Tube voltage accuracy measured at (a) GHL (m1 and m2), (b) PSH, (c) NOH, (d) NARH

(a)

Tube voltage Set (kV)	Tube voltage Measured (kV)	Magnitude of Deviation (%)	Hospital
M1			
60	59.10	1.5	GHL (m1)
80	78.81	1.5	GHL (m1)
100	98.02	2.0	GHL (m1)
120	115.22	4.0	GHL (m1)
M2			
60	62.50	4.2	GHL (m2)
80	79.30	0.9	GHL (m2)
100	91.00	9.0	GHL (m2)
120	106.90	10.9	GHL (m2)

(b)

Tube voltage Set (kV)	Tube voltage Measured (kV)	Magnitude of Deviation (%)	Hospital
65	65.12	0.2	PSH
70	70.22	0.3	PSH
75	75.39	0.5	PSH
80	81.07	0.1	PSH

(c)

Tube voltage Set (kV)	Tube voltage Measured (kV)	Magnitude of Deviation (%)	Hospital
50	86.34	72.7	NOH
60	96.26	60.4	NOH
70	107.53	53.6	NOH
80	116.43	45.5	NOH

(d)

Tube voltage Set (kV)	Tube voltage Measured (kV)	Magnitude of Deviation (%)	Hospital
70	53.98	22.9	NARH
80	61.53	23.1	NARH
90	69.02	23.3	NARH
100	77.90	23.1	NARH

(3.2) Quality Control (QC) Test

Table 4 is the summary of the QC tests carried out on the equipment at different hospitals. The kVp accuracy tests show compliance with acceptable limit in GHL (m1 and m2) and PSH while NOH and NARH show non-compliance with acceptable limit of 5%. As regards the kVp consistency, similar trend is found in the hospitals as those found in kVp accuracy.

In terms of timer accuracy, it is postulated that exposure time directly affect the total quantity of radiation emitted from an X-ray tube. Therefore, an accurate exposure timer is critical for properly exposed radiographs and reasonable patient radiation exposure. Both GHL and PSH met the the acceptable variability limit. Since the timer accuracy in NOH and NARH are above the limit of acceptability, it is expected that the radiation dose delivered to the patient will be higher than the expected value required to produce the film. Moreover, the linearity of tube current (mA) and beam alignment of both NOH and NARH fell short of the acceptable limit of 10% and 3% respectively. Regulation of X-ray tube filament temperature (along with the exposure time determine the quality of X-rays in the X-ray beam) is done with millampere selector in an X-ray generator. The beam restriction system is required for regulating the size of the X-ray field area. The mechanism controls the amount of patient anatomy exposed to radiation beam (Papp, 2002). This plays a central role in patient dosage and image contrast. The increase in area increases the production of the scattered radiation, hence higher patient dose and health risk.
The non-compliance of optical radiation field and radiation field congruence may stem from the shift in mechanism that moves the shutter, causing improper performance. This leads to higher patient dose and repeat images (result in more films being used and more expenses).

Table 4: Summary of QC tests at different Hospitals

Parameter Tested	Recommended Variability	Results of QC Test				
		GHL m1	GHL m 2	PSH	NOH	NARH
kVp Accuracy	± 5%	Within 5% limit, acceptable	Within 5% limit, acceptable	Within 5% limit, acceptable	>5% limit, Not acceptable	>5% limit, Not acceptable
kVp Consistency	± 10%	Within 10%limit, acceptable	Within 10 % limit, acceptable	Within 10% limit, acceptable	>10% limit, Not acceptable	>10% limit, Not acceptable
Timer Accuracy	±5%for exposure time> 10 ms, ± 20%for exposure time < 10ms	Within 5% limit, acceptable	Within 5% limit, acceptable	Within 5% limit, acceptable	>5% limit, Not acceptable	>5% limit, Not acceptable
Reproducibility of kVp & Timer	± 10%	Within the acceptable limit	Within the acceptable limit	Within the acceptable limit	Outside the acceptable limit	Outside the acceptable limit
Linearity (mA)	± 10%	Within 10%	Within 10%	Within 10%	No linearity observed	No linearity observed
Optical & radiation field/Congruence/ Beam Alignment	3% of source image distance (SID)	Within the acceptable limit of ± 3%	Within the acceptable limit of ± 3%	Within the acceptable limit of ± 3%	Outside the acceptable limit of ± 3%	Outside the acceptable limit of ± 3%

(3.3) Personnel Distribution

The bar chart in figure 4 shows the distribution of personnel. It indicates that two categories of personnel are missing; Radiation Protection Officer/ Medical Physicist and Record Officer. The trend is similar to the earlier work reported elsewhere (Oluwafisoye et al., 2009). The trend shows that radiation protection of the patients, visitors and personnel is not the preoccupation of the management of the hospitals investigated. The absence of the record officers indicate that record keeping at the hospitals is far from being adequate. A record keeping system is necessary to document the quality control procedures, the number of rejects and other activities going on at the X-ray units of the hospital.

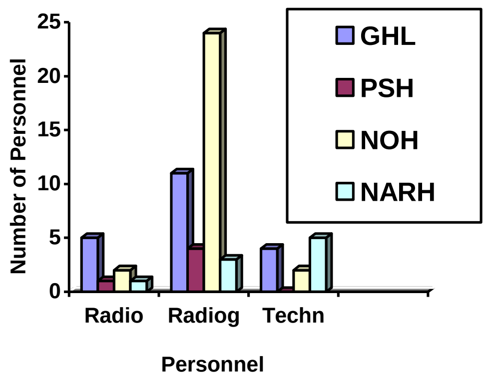

Figure 4: Distribution of Personnel at each centre

(3.4) Visual/ General Observations

The result of visual observations is presented in table 5. It shows that all the basic components inspected were functional except LED indicator on the control panel found in GHL (m2). Table 6 shows the general observations carried out at various hospitals investigated. Columns 1 and 2 show that the main door leading to the X-ray room is not lead-lined. Columns 3 and 4 indicate that only NOH has efficient second door and lead-lined. The cubicles of the four hospitals are efficient. This indicates that the designer of the console put in place adequate measures that prevent the technicians from extraneous rays during exposures. The doors to the units lack automatic control, implying that during the exposure the doors do not close automatically as a result, controlled access to the area where radiation exposure may be taking place is not ensured. Lead apron was not provided in NARH. Nevertheless, the lead apron provided in GHL was not efficient. Regulation for good practice stipulates that lead aprons and gloves should be available in the radiographic room and have a minimum of 0.5 mm of lead equivalent thickness (Papp,2002). It is also evident that technique charts were missing in all the units, an indication that technique parameters are chosen at random by the radiographers responsible for the exposure of the patient. This could lead to poor matching of patient size and technique parameters.

Table 5: Information on visual inspection of x-ray machines

S/N		Inspection	GHL		PSH	NOH	NARH
			m1	m2			
1	a	Stability, stiffness of hanger	F	F	F	F	F
	b	Stability of chest stand	F	F	F	F	F
	c	Image receptor	F	F	F	F	F
2		Working of movement locks of tube	F	F	F	F	F
3		Control panel switches (moveable energizing switches)	F	F	F	F	F
4		Checks of indicator & meter on control panel	F	NF	F	F	F
5		Tube lamp	F	F	F	F	F
6		Control switches	F	F	F	F	F

F= Functional NF = Not Functional

Table 6: General observations of immediate surroundings of X-ray facilities investigated

S/N	Observations	GHL		PSH		NOH		NARH	
		Y	N	Y	N	Y	N	Y	N
1	Main door to x-ray room (Lead lined)	-	N	A	-	A	-	A	-
2	Main door to x-ray room (Lead efficient)	-	N	A	-	A	-	A	-
3	Second door x-ray room (lead lined)	NA	-	NA	-	A	-	NA	-
4	Second door to x-ray room lead lined (efficient)	NA	-	NA	-	A	-	NA	-
5	Cubicle type (wood)	NA	-	A	-	NA	-	NA	-
6	Cubicle type (lead)	A	-	-	-	A	-	A	-
7	Cubicle efficient	A	-	A	-	A	-	A	-
8	Cubicle window (efficient)	-	N	A	-	A	-	A	-
9	Door interlock provided	-	N	-	N	-	N	-	N
10	Door (close automatically)	-	N	-	N	-	N	-	N
11	Provision of lead apron	A	-	A	-	A	--	-	N
12	Lead apron efficient	-	N	A	-	A	-	-	N
13	Hazard warning light provided	-	N	-	N	-	N	-	N
14	Hazard warning light functional	-	N	-	N	-	N	-	N
15	Hazard warning sign (Displayed)	-	N	-	N	-	N	-	N
16	Functional air-conditioner	A	-	A	-	A	-	A	-
17	Personnel monitoring (TLD badges) available	-	N	-	N	A	-	A	-
18	Qualified Radiographers Available	A	-	A	-	N	-	A	-
19	Dark room & x-ray room connected	-	N	-	N	A	-	A	-
20	Darkroom temperature controlled	-	N	-	N	A	-	-	N
21	Thoroughfare (Prohibited)	A	-	A	-	A	-	A	-
22	Log book available	-	N	-	N	-	N	-	N
23	X-ray machine over 10 years	A	-	A	-	A	-	A	-
24	Space of x-ray room adequate	A	-	A	-	-	N	A	-
25	Collimator light adequate	A	-	A	-	-	N	A	-

A (Y) = Yes N (N) = NO NA (Y) = Not Available

Moreover, warning light was not provided in any of the units to warn visitors or other personnel of the exposure going on in the X-ray room. The personnel monitoring badge was only available in NOH, indicating that personnel dose monitoring in GHL, PSH and NARH are non-existent.

(3.5) Dose level

Result of environmental dose monitoring at the chosen locations within and in the immediate environment of each of the X-ray units investigated is presented in table 7. The results in all the five units indicate that the dose rate measured at the couch are generally very high. At the edge of the cubicle the dose rates recorded are greater than the background dose rate by a factor of 7, 20, and 10 in GHL (m1), PSH and NARH, respectively. The dose rate measured within the cubicle is comparable to the background. This condition is safe for the radiographer; however, the dose rate is high within the entrance door in GHL (m1) and NARH, it is greater than the background dose rate by a factor of 6 and 7.5 each. In addition, the dose rate measured at the waiting lobby of the patients is comparable with the background dose rate in PSH and NARH, but higher than the background dose rate by a factor of 10 in NOH. The high dose rate experienced in NOH could be attributed to damaged door of the X-ray units. Another possible explanation for the high dose rate at the waiting lobby is the direct link between the lobby and the X-ray machine. It is interesting to note that there were no leakages experienced in the five X-ray units investigated as reported in the earlier study carried out in Nigeria (Oluwafisoye et al., 2009).

Table 7: Radiation Dose Rate level of X-ray units (measured)

S/N	Description of location	Dose rate level measured μSv/hr				
		GHL (m1)	GHL (m2)	PSH	NOH	NARH
1	Couch	Very high	Very high	Very high	Very high	Very high
2	Edge of cubicle	1.4	0.3 [1 m from the edge of cubicle- 0.5]	4.0	-	2.0
3	Glass of cubicle	0.8	-	0.2	0.2	0.2
4	Within cubicle	-	0.2	0.3	0.2	0.2
5	Behind wall (outside the X-ray room)	BK [Outside window-0.4]	0.2	BK	-	-
6	Behind Entrance door	1.0 [Outside the locked door- 0.4]	0.4	-	0.3 Second door opened- 1.0, Outside damaged door-0.5	-
7	Inside the entrance door	1.2	0.6	-	-	1.5
8	Patient waiting door	-	-	BK	2.0	0.3

Background (BK) dose rate 0.1 – 0.2 μSv /hr

Apparently, this present study is the first QC test and environmental monitoring efforts carried out in the five X-ray units in four hospitals investigated. This is an indication that the results are preliminary against which future measurements could be compared. Besides, the use of thermoluminescent dosimeters (TLD) for the personnel monitoring has never been undertaken in the five units. Personnel monitoring is essential, since there is a link between the ionizing radiation and generation of reactive oxygen series [ROS] (Cohen, 2002). These ROS have been implicated in the etiology of over hundred diseases. Radiation is one of the major exogenous sources of free radicals in man and it has been proved that ionizing radiation produces ROS in biological system capable of destroying biomolecules such as DNA, lipids, proteins and carbohydrate (Olisekodiaka et al., 2009). Workers operating X-ray equipment are exposed to long term low doses of ionizing radiation which may affect their antioxidant status.
Results of the QC tests and monitoring were sent to the management of the four hospitals investigated. In Addition, recommendations on the necessity of regular QC test were forwarded to each hospital for necessary actions.

4. CONCLUSION

Quality control tests of five X-ray units are undertaken with purpose of safety and dose optimization in the X-rays centres investigated. The ages of three out of five machines are well over 10 years. In addition, the deviation of the measured kVp from set value on the control panel varied among the hospitals. Two out of the five machines complied with the required standard of practice, while three exceeded the requirement. The QC test carried out on kVp accuracy and consistency show non- compliance in two hospitals. The distribution of personnel show that, the preoccupation of the authority of the X-ray unit investigated was the quality of the radiograph produced at the expense of safety of the patient. The variation in the output of the various tube is an indication that doses among the hospitals differ. In each of the X-ray units investigated there was no specialized facility to perform paediatric examinations and film viewing.

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