Original Article

Radiation protection measures of the radiological facilities in Kano metropolis, Nigeria

Sidi M, England A[1], Mansur U, Muhammad ZI, Garba I, Zira DJ[2], Abubakar U[3], Abubakar AA, Ya'u A, Luntsi G[4]

Department of Medical Radiography, Faculty of Allied Health Sciences, Collage of Health Sciences, Bayero University Kano, [1]Department of Radiography, University Collage Cork, Ireland, [2]Deparment of Radiography, Federal University of Lapia, [3]Deparment of Radiography, Usman Danfodio University Sokoto, [4]Deparment of Radiography, University of Maiduguri, Nigeria

Abstract

Introduction: The medical use of ionizing radiation contributes the largest amount of man-made radiation exposure and ranks second to natural background radiation. Adhering to the standard radiation protection measures minimizes radiation dose to patients, staff, and other public members.

Aim: This study aimed to evaluate radiation protection measures in radiological facilities in the Kano metropolis, Nigeria.

Materials and Methods: This was a cross-sectional study conducted in the Kano metropolis, Nigeria, between February 2021 and May 2021. A structured questionnaire was formulated. The measuring tool was validated by expert and experienced colleagues. The reliability of the measuring tool was tested using a pilot study, and Cronbach's alpha reliability coefficient was found to be 0.815. A total of 101 respondents were recruited. These were the radiographers working in the functional radiological facilities. The obtained data were analyzed using SPSS software version 23.0, and $P < 0.05$ was considered statistically significant.

Results: X-ray room design was sufficient in the majority of radiological facilities 67 (66.7%). Insufficient availability of personnel protective devices in 47 (46.9%) respondents was observed. The majority, 24 (23.9%) of the respondents, indicated poor utilization of personnel protective devices. There was insufficient registration and records of radiation safety measures 26 (26.0%). Only 48 (47.5%) respondents indicated the availability of a QA committee in their facility. Fifty-two (51.5%) of the respondents reported that they have medical physicists/engineers available to provide support within their department, while only 25 (25.7%) had radiation safety officers in their facilities. There was a weak negative correlation between lead aprons and lead rubber gloves with the level of staff training, respectively ($r = -0.254$, $P = 0.010$; $r = -0.214$, $P = 0.031$).

Conclusion: There was sufficient X-ray room design in the Kano metropolis. An insufficient availability of personal protective devices, poor utilization, registration, and records of radiation safety measures was observed. There were inadequate QA committee and QC test in the majority of the radiological facilities. A weak negative correlation was observed between the use of lead aprons and lead rubber gloves with the level of staff training.

Keywords: Ionizing radiation, Kano, radiological facility, safety measures

Address for correspondence: Mr. Mansur U, Department of Medical Radiography, Faculty of Allied Health Sciences, College of Health Sciences, Bayero University, Kano, Nigeria.
E-mail: umansur.radg@buk.edu.ng

Submitted: 06-Feb-2022 **Revised:** 17-May-2022 **Accepted:** 05-Jan-2024 **Published:** 22-Feb-2024

Access this article online	
Quick Response Code:	Website: https://journals.lww.com/wajr
	DOI: 10.4103/wajr.wajr_4_22

How to cite this article: Sidi M, England A, Mansur U, Muhammad ZI, Garba I, Zira DJ, *et al*. Radiation protection measures of the radiological facilities in Kano metropolis, Nigeria. West Afr J Radiol 2022;29:118-24.

INTRODUCTION

The medical use of ionizing radiation contributes the largest amount (>95%) of man-made radiation exposure and ranks second to natural background radiation.[1,2] Studies showed that about 3.6 billion imaging studies per year were carried out worldwide, leading to an increase of about 70% worldwide collective dose for medical diagnostic examinations.[3] A study has shown that about 21% and 10% of the total somatic and genetic effects of ionizing radiation came from medical exposure, with diagnostic radiology being the most important contributor.[4] Exposure to ionizing radiation has been scientifically proven to cause damage to human tissues, like skin burns, skin erythema, epilation, cataracts, sterility, and radiation sickness at high exposure. It also raises the risk of cancers, tumors, and genetic damage at low exposure.[5]

Radiation protection measures can be described as all the activities directed toward minimizing unnecessary exposure of ionizing radiation to patients, personnel, other members of the public, and the environment during radiological examinations.[6] As a result of the deleterious effects associated with the use of ionizing radiation, it is important the standard radiation protection principles of justification of practice, optimization, and dose limit are implemented appropriately.[7] Structurally, the X-ray room is designed such that all the occupied regions such as walls, doorways, doorframe, ground, ceiling, window frames, protective viewing glass, and radiographer's cubicle should be well shielded. Furthermore, the emergency switch should be easily located and radiation warning signs and alarms should be put in place and properly working.[8] The diagnostic X-ray rooms should be well equipped with personnel protective devices such as lead aprons, thyroid shields, gonad shields, lead gloves, and protective goggles.[9,10] The utilization of personnel protective devices by radiographers is critical; therefore, it is necessary to make use of it effectively and efficiently. Every radiographer should have a thermoluminescent dosimeter barge while working.[11] Written guidelines for an emergency should be put in place. The records of any notifiable accident should be documented, survey meter readings and personnel monitoring should also be documented.[8,11] All radiological facilities should have effective and efficient quality assurance in place.[9]

A study was conducted by El-Feky *et al*.[11] in Tanta University Hospital Egypt had shown that 54.4% and 50% had insufficient radiation safety measures in diagnostic radiology units and radiotherapy units, respectively. However, sufficient measures were observed in all nuclear medicine units. A prospective study conducted by Joseph *et al*.[8] in Nigeria reported radiation protection measures employed by the single hospital studied were good and complied with the international standard. However, the study was carried out in a single tertiary hospital and with only 11 sample sizes in the north-central region of Nigeria. However, the previous study focused mainly on X-ray room design, which was a subset of radiation protection measures and also a smaller sample size was used. This prompted the researchers to include all the components of radiation protection measures and use a larger sample size. In standard practice, all radio-diagnostic facilities must adhere to standard radiation protection measures. Kano state has more than fifteen functional radiological facilities. Despite the large number, to the best of our knowledge of the researchers, there are no published articles on radiation protection measures of radiological facilities in the northwestern part of | Nigeria. Empirical study has shown that the majority of the radiological facilities in the study area do not have standard radiation protection measures, which could lead to serious health hazards to the staff, patients, and public. The findings of the study could serve as a baseline for making recommendations to the relevant authorities and serve as a guide to radiographers and management in making proper implementation of radiation protection measures. The study aimed to evaluate radiation protection measures of radiological facilities in the Kano metropolis, Nigeria.

MATERIALS AND METHODS

This was a cross-sectional study conducted in Kano metropolis, Nigeria, from February 2021 to May 2021. The human research and ethics committee of the Kano State Ministry of Health has approved this study. All the radiographers in the Kano metropolis working in hospitals with functional X-ray equipment were included. Radiographers working with facilities that use only ultrasound, magnetic resonance imaging (MRI), or ultrasound and MRI were excluded. After an intensive literature review, a structured questionnaire was formulated. The measuring tool was validated by expert and experienced colleagues. The reliability of the measuring tool was tested using a pilot study and Cronbach's alpha reliability coefficient was found to be 0.815.

The questionnaire has five sections: Section A: demographic information, Section B: design of diagnostic X-ray rooms, Section C: availability and utilization of personnel protective devices, Section D: register and records of safety measures, and Section E: quality assurance and quality control. A consent form was attached to each questionnaire to obtain the consent of the respondents. One hundred and ten questionnaires were distributed to the radiographers working in all the hospitals and radio-diagnostic centers within the Kano metropolis. During the 1st week of data collection, data were collected from the respondents working in Federal Government Hospitals (FGHs), the 2nd week from those working in State Government Hospitals (SGHs), and the 3rd week from those working with private radio diagnostic centers (PRDCs). Both descriptive and inferential statistics were employed in the data analysis. Spearman's correlation was used to correlate the conduct with the staff training. The obtained data were analyzed using SPSS software version 23.0 (IBM Corporation, Armonk, United States).

RESULTS

One hundred and one questionnaires were returned, 61 (60%) were from men and 40 (40%) were from women. Ages of the respondents are illustrated in Figure 1. Age group 25–29 had the highest frequency, 47 (46.5%), while 45–49 years had the lowest frequency 1 (1.0%). The majority, 81 (80%) of the respondents had a Bachelor's degree in Radiography, 11 (11%) had a Diploma, and 9 (9%) had a Master's Degree.

Fifty-eight respondents (57%) work in FGH, 29 (29%) within SGH, and 14 (14%) within PRDC. Most (47 [47%]) respondents had between 0 and 4 years of work experience, while only one (1%) had ≥20 years [Figure 2].

Table 1 describes the responses on the design features of the diagnostic X-ray room. Most respondents indicated that there is an appropriate X-ray room design in all the hospitals and radio-diagnostic centers.

Table 2 shows the responses of the respondents on the availability of personnel protective devices. Most respondents indicated poor availability of personnel protective devices.

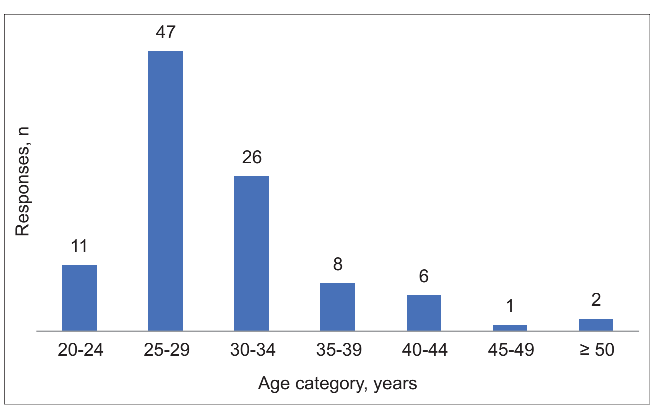

Figure 1: Bar chat illustrating the ages of the respondents

Table 3 shows the responses for the respondents on the utilization of personnel protective devices. Most respondents indicated poor utilization of personnel protective devices.

Table 4 shows the responses of the respondents on training and recording of radiation protection safety. Most respondents indicated that there was poor registration and recording of radiation protection practices.

Table 5 highlights the responses of the respondents on quality assurance and quality control processes. Most respondents indicated that there is poor availability of quality assurance and poor implementation of quality control.

Table 6 shows the correlation of radiation protection measures with staff training. There was a weak negative correlation between lead aprons and lead rubber gloves with the level of staff training respectively ($r = -0.254$, $P = 0.010$; $r = -0.214$, $P = 0.031$).

DISCUSSION

A total of 101 respondents participated in the study, with male respondents having the higher percentage. This was similar to the findings of a study conducted by Sharma *et al*.[6] that reported a higher proportion of 33 (66%) males and 17 (34%) females. Findings from our study, as shown in Figure 1, were similar to the findings of the study conducted by El-Feky *et al*.[11] who reported that the majority of the respondents were between the age range of 20 and 29 years. Figure 2 shows that the majority of the respondents had a Bachelor's degree in radiography and respondents work in an FGH.

The findings of this study, as shown in Table 1, revealed that most radiation safety measures and protection in diagnostic X-ray rooms strictly adhered to IAEA standards

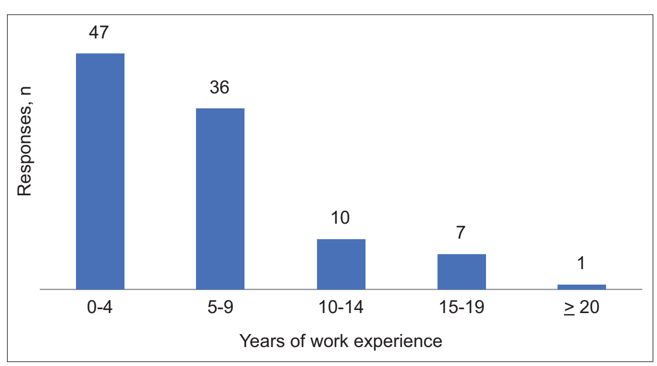

Figure 2: Bar chat illustrating the years of work experience of the respondents

Table 1: Design of diagnostic X-ray rooms

Questions	Compliance, frequency (%)		
	FGH	SGH	PRDC
Does the X-ray room area in your institution is at least 24 m^2?	43 (74.1)	24 (82.8)	11 (78.6)
Do the windows inside the X-ray room is at least 1.6 m from the floor level?	47 (81.0)	23 (79.3)	11 (78.3)
Do the walls, doorframe, ground, ceiling, and window frame of the X-ray room shielded at it should be?	51 (87.9)	26 (89.7)	13 (92.9)
Do the protective viewing glass and radiographer's cubicle well shielded at it should be?	51 (87.9)	21 (72.4)	13 (92.9)
Does the emergency switch easily locate?	37 (63.8)	17 (58.6)	9 (64.3)
Does the radiation warning/caution sign put in place and written in the local language?	49 (84.5)	17 (58.6)	11 (78.6)
Are automatically energized audible warning devices and alarms present and properly working?	17 (29.3)	7 (24.1)	11 (78.6)
Does a copy of the ionizing radiation standard been posted and easily located by the workers?	23 (39.7)	6 (20.7)	8 (57.1)
Is the main beam of X-ray normally directed away from the doors, the control?	43 (74.1)	17 (58.6)	14 (100)
Is the darkroom centrally placed within the department?	31 (53.4)	18 (62.1)	6 (42.9)

FGH – Federal Government hospital, SGH – State Government hospital, PRDC – Private radio-diagnostic center

Table 2: Availability of personnel protective devices

Questions	Compliance, frequency (%)		
	FGH	SGH	PRDC
Do you have a lead apron in your institution?	53 (91.4)	18 (16.2)	14 (100)
Do you have lead rubber gloves in your institution?	14 (24.1)	5 (17.2)	6 (42.9)
Do you have thyroid and gonadal shields in your institution?	14 (24.1)	4 (13.8)	8 (57.1)
Do you have protective goggles in your institution?	12 (20.7)	5 (17.2)	7 (50.0)
Do you have a personnel protective dosimeter?	49 (84.5)	19 (65.5)	9 (64.3)

FGH – Federal Government hospital, SGH – State government hospital, PRDC – Private radio-diagnostic center

Table 3: Utilization of personnel protective devices

Questions	Compliance, frequency (%)		
	FGN	SGH	PRDC
Do you use lead apron when justified and appropriate?	31 (53.4)	11 (37.9)	7 (50.0)
Do you use lead rubber gloves when justified and appropriate?	10 (17.2)	3 (10.3)	5 (35.7)
Do you use thyroid and gonadal shield when justified and appropriate?	11 (19.0)	2 (6.9)	6 (42.9)
Do you use protective goggles when justified and appropriate?	14 (24.1)	5 (17.2)	2 (14.3)
Do you use dosimeter when justified and appropriate?	5 (8.6)	4 (13.8)	5 (35.7)

FGH – Federal Government hospital, SGH – State Government hospital, PRDC – Private radio-diagnostic center

Table 4: Registers and records of safety measures

Questions	Compliance, frequency (%)		
	FGH	SGH	PRDC
Do you have written a guideline for an emergency?	15 (25.9)	9 (31.0)	7 (50.0)
Do you have a record of any notifiable accidents?	11 (19.0)	2 (6.9)	3 (21.4)
Do you keep the records of survey meter readings?	14 (24.1)	5 (17.2)	5 (35.7)
Do you have a record of your personnel monitoring record?	12 (20.7)	5 (17.2)	5 (35.7)
Have you undergone a medical examination on your initial appointment?	33 (56.9)	10 (34.5)	10 (71.4)
Have you ever undergone medical examination when exposure levels indicated by the personnel monitoring device is sufficiently high?	10 (17.2)	3 (10.3)	3 (21.4)
Have you undergone additional training courses on radiation protection?	14 (24.1)	6 (20.7)	2 (14.3)

FGH – Federal Government hospital, SGH – State Government hospital, PRDC – Private radio-diagnostic center

Table 5: Quality assurance and quality control

Questions	Compliance, frequency (%)		
	FGH	SGH	PRDC
Do you have quality assurance in your institution?	31 (53.4)	8 (27.6)	9 (64.3)
Do you have a medical physicist/medical engineer in your institution?	34 (58.6)	9 (31.0)	9 (64.3)
Do you have a radiation safety officer in your institution?	18 (31.0)	2 (6.9)	6 (42.9)

FGH – Federal Government hospital, SGH – State Government hospital, PRDC – Private radio-diagnostic center

and guidelines. However, PRDCs have more radiation safety measures, followed by FGHs and then SGHs, as shown in Table 1. This is contrary to the findings of the studies conducted by El-Feky *et al.*,[11] Eze *et al.*,[12] Mohamed,[13] and Eze *et al.*,[9] who reported inadequate radiation protection safety measures in most of the X-ray facilities. Furthermore, this study found poorly functioning audible warning devices and alarms in the majority of FGHs and SGHs; however, adequate equipment was reported in the PRDCs [Table 1]. This is in line with what was reported by El-Feky *et al.*,[11]

Table 6: Correlation of radiation protection measures with staff training

Radiation protection practices	Correlates	
	r	ρ
Do you use lead apron when justified and appropriate?	−0.254*	0.010
Do you use lead rubber gloves when justified and appropriate?	−0.214*	0.031
Do you use thyroid and gonadal shield when justified and appropriate?	−0.179	0.074
Do you use protective goggles when justified and appropriate?	−0.080	0.426
Do you use dosimeter when justified and appropriate?	−0.108	0.284

r – Correlation coefficient, ρ – Statistical significance

El-Hady *et al.*,[14] Mohamed,[13] Tamijidi,[15] and Rahimi *et al.*,[16] who also indicated that most X-ray facilities did not have functioning audible warning devices and alarms. However, this is contrary to the studies conducted by Farzaneh *et al.*,[17] and Rostamzadeh *et al.*[18] who reported that this was not a problem in their study centers. Radiation devices and alarms remain a key component of radiation protection measures as they indicate when the X-ray room is active; therefore, their lack may contribute to unnecessary exposure to the staff and those visiting the department. Furthermore, this study revealed that a copy of the ionizing radiation safety standards was not posted in the majority of FGHs and SGHs; however, it was present in the majority of PRDCs, as shown in Table 1. This was similar to studies conducted by El-Feky *et al.*[11] and Mohamed[13] who also reported that ionizing radiation standards were not always available. However, this is contrary to what was reported by Abdellah *et al.*[19] who found that a copy of the ionizing radiation safety standard was posted and easily understood in most studied hospitals. The IAEA recommends that each radiological facility should have a copy of the ionizing radiation safety standards clearly visible and accessible.

This study showed that lead rubber aprons were present in the majority of the X-ray room, as indicated in Table 2. The PRDCs had greater availability of lead rubber aprons, followed by FGHs and then SGHs. This is in line with the studies conducted by El-Feky *et al.*[11] and Salama *et al.*[20] who found that most hospitals had access to lead rubber aprons. However, this is contrary to the findings of the studies conducted by Eze *et al.*[12] and Bhatt *et al.*[21] who reported poor availability of lead aprons. Furthermore, the findings of this study, as shown in Table 2, revealed that there was poor availability of lead rubber gloves, thyroid and gonadal shields, and protective goggles in the majority of FGHs and SGHs. However, PRDCs indicated sufficient availability of thyroid, gonadal shields, and protective goggles. This was supported by the study conducted by El-Feky *et al.*[11] who also reported insufficient availability of lead rubber gloves, thyroid/gonadal shields, and protective goggles. The use of protective goggles, thyroid, and gonad shields reduces the radiation dose to the eyes, thyroid, and gonads by 70%–98% based on various studies.[22] This study found that the majority of the respondents had personal dosimeters, as shown in Table 2. However, the FGHs had greater availability of personnel dosimeters, followed by SGHs, and then PRDCs. These findings were in line with the study conducted by Eze *et al.*,[12] who reported that 62% of the private and only 20% of the public X-ray units provided personal dosimeters. On the contrary, there was poor availability of personal dosimeters in the majority of the health-care facilities reported in the previous studies conducted by Bhatt *et al.*[21] and Mohamed.[13]

Our study, as shown in Table 3, revealed poor utilization of all personal protective devices in the majority of the hospitals. However, respondents in the FGHs and PRDCs used lead rubber aprons only, as shown in Table 3. This is in agreement with the study conducted by El-Feky *et al.*,[11] who reported that only 48 (37.9%) used lead rubber aprons. This disagrees with the studies conducted by Salama *et al.*,[20] Ahmed *et al.*,[23] Rahman *et al.*,[24] and Luntsi *et al.*,[25] who reported that the majority of radiation health workers wear lead rubber aprons. Furthermore, this study showed insufficient use of lead rubber gloves, thyroid/gonadal shields, and protective goggles during radiographic examination by the majority of the respondents. This was similar to the study conducted by Salama *et al.*[20] who found that only 37% used lead glasses and 42% used thyroid shields. Furthermore, El-Feky *et al.*[11] reported that only 41 (33.9%) used thyroid shields and 33 (27.3%) used protective goggles, while none of the participants used lead rubber gloves and gonadal shields. Another study conducted by Ahmed *et al.*[23] revealed that only 22.7% used lead gloves, 25% used gonadal shield and 36% used the gonadal shield. Insufficient utilization of these protective devices might be a result of poor availability of the devices or the attitudes' of the respondents. Furthermore, the current study found that very few respondents used personnel dosimeters during working hours. This is in accordance with the study conducted by El-Feky *et al.*[11] reported that a small proportion of the participants used personal dosimeters during working hours. The use of personal dosimeters during working hours is mandatory. The poor utilization of personal dosimeters may be a result of insufficient availability or due to the attitudes' of the respondents.

The findings of the present study, as shown in Table 4, showed poor documentation of training and records. Table 4 indicates insufficient written guidelines plan for emergencies in most FGHs and SGHs. However, it was sufficient in most PRDCs. This was in accordance with the study conducted by El-Feky *et al.*[11] who found poorly written guidelines plan for emergencies. The current study revealed poor records of notifiable accidents in most facilities. On the contrary, El-Feky *et al.*[11] indicated available records of notifiable accidents. Furthermore, the current study illustrated that there were poor records of survey meter readings, personnel monitoring, and training records in most facilities [Table 4]. However, medical exam records on initial appointments were adequate among respondents working with FGH and radio-diagnostic centers. This agreed with the findings of the studies conducted by Eze *et al.*,[12] and El-Feky *et al.*[11] that reported very poor records keeping in most of the facilitates. However, this is contrary to the findings of the study conducted by Mohamed,[13] who noticed better records for recording personal and environmental monitoring by the hospitals.

The findings of this study, as shown in Table 5, indicated poor availability of quality assurance committees in the majority of the SGHs. However, it was sufficient in FGHs and PRDCs [Table 5]. This agreed with the findings of the previous study conducted by Sidi *et al.*,[26] who found a lack of quality assurance programs for radiological equipment in most centers. The possible reason for the agreement between the two studies might be both studies were conducted in the same state. The lack of QA programs may be a result of a poor attitude toward preventive maintenance culture. The current study [Table 5] revealed that FGHs and PRDCs had medical physicists/medical engineers in their facilities. However, it was insufficient in the SGHs. Medical physicists or medical engineers are the ones responsible for taking corrective maintenance of radiological equipment while preventive maintenance is within the limit of radiographers. Furthermore, as shown in Table 5, poor availability of radiation safety officers was experienced in the majority of radiology departments with SGHs being the least. This is similar to the study conducted by Sidi *et al.*,[26] which found that none of the facilities surveyed has a radiation safety officer. Ideally, a quality assurance program should be led by a radiation safety officer or quality assurance program officer. The findings of the present study, as shown in Figure 3, indicated that the majority of the respondents chose the beam alignment test, darkroom lighting efficiency test, and tube warm-up and air calibration only as quality control tests, followed by tube warm-up and air calibration only. Sidi *et al.*[26] reported that 13 (68%) of the respondents indicated that, beam alignment and collimation test, darkroom lightening efficiency test, and film screen contact were the only quality-control tests being conducted on their equipment. The findings of the current study, as shown in Table 6, showed a weak negative correlation between lead aprons and lead rubber gloves with the level of staff training. None of the previous studies correlate radiation protection practice with the level of staff training.

CONCLUSION

Most radiological facilities (FGHs, SGHs and PRDCs) within the Kano metropolis had sufficient diagnostic X-room design. However, insufficient personal protective devices and poor utilization of these personal protective devices, insufficient training and records, and poor-quality assurance programs were observed. A weak negative correlation was observed between lead aprons and lead rubber gloves with the level of staff training.

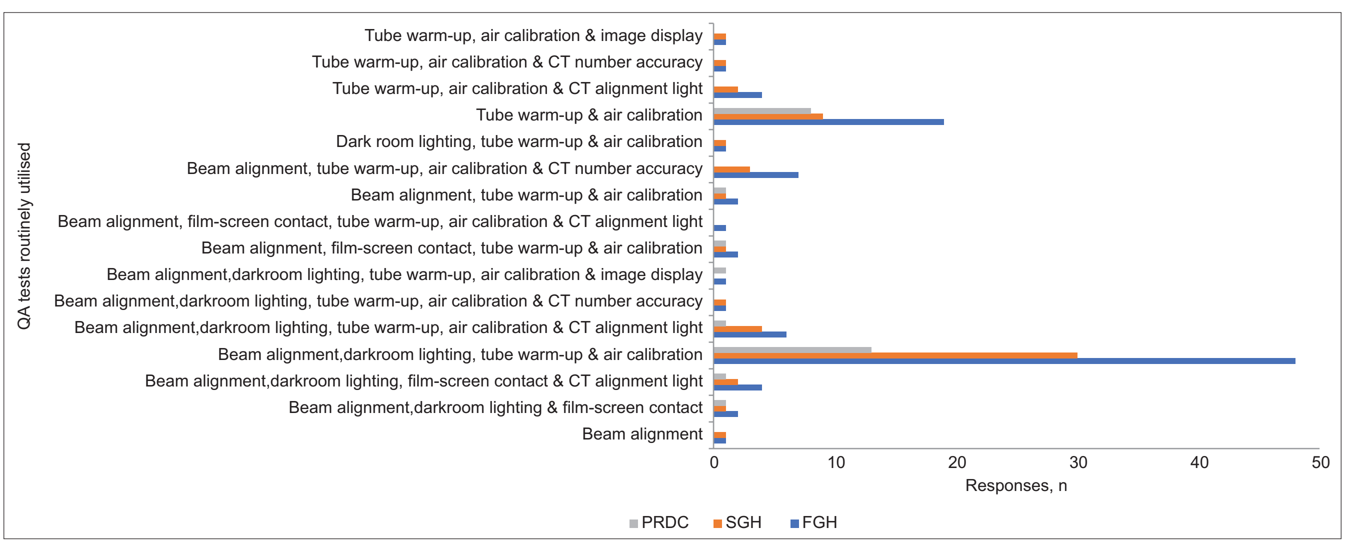

Figure 3: Illustrates the routine quality assurance tests undertaken within the different study centers. FGH – Federal government hospital, SGH – State government hospital, PRDC – Private radio-diagnostic center

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Sources and Effect of Ionizing Radiation, UNSCEAR Report. Vol. I. Annexes A and B. New York, United Nations; 2008.
2. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Sources and Effect of Ionizing Radiation, UNSCEAR Report. Vol. I. Annexes A and B. New York, United Nations; 2010.
3. National Council on Radiation Protection and Measurements. Radiation dose management for fluoroscopically guided interventional medical procedure; 2011. Available from: www.knovel.com/knovel2/Tocv.jsp?BookID=3876. [Last accessed on 2022 Jan 05].
4. Sidi M, Umar M, Ugwu AC, Nwobi C, Dare A. An evaluation of safety culture among radiation health professionals in Kano metropolis. Niger J Med Imaging Radiat Ther 2015;4:10-20.
5. Mallam SP, Akpa MD, Oladipupo MD, Sa'id A. Reappraisal of existing expression for estimating radiation output from diagnostic x-ray machine. Niger J Phys 2004;16:30.
6. Sharma M, Singh A, Goel SH, Satani S. An evaluation of knowledge and practice towards radiation protection among radiographers of Agra city. Sch J App Med Sci 2016;4:2207-10.
7. Do KH. General principles of radiation protection in fields of diagnostic medical exposure. J Korean Med Sci 2016;31 Suppl 1:S6-9.
8. Joseph DZ, Peter E, Adejoh T, Gloria M, Goriya K, Abubakar M. Assessment of radiation protection measures in a Nigerian tertiary health care centre. J Health Med Nurs 2016;31:90-104.
9. Eze CU, Abonyi LC, Njoku J, Irurhe NK, Olowu O. Assessment of radiation protection practices among radiographers in Lagos, Nigeria. Niger Med J 2013;54:386-91.
10. International Commission on Radiological Protection. Managing patient dose in digital radiology. A report of the international commission on radiological protection. Ann ICRP 2004;34:1-73.
11. El-Feky AA, El-Sallamy RM, El-Sherbeni AA, El-Mursi H. Safety measures among workers occupationally exposed to ionizing radiation in Tanta university hospital. Tanta Med J 2017;45:166-74.
12. Eze KC, Nzotta CC, Marchie TT, Okegbunam B, Eze TE. The state of occupational radiation protection and monitoring in public and private X-ray facilities in Edo state, Nigeria. Niger J Clin Pract 2011;14:308-10.
13. Mohamed AT. Radiation safety awareness and practice in Sudanese medical facilities: A descriptive. Int J Sci Res 2015;4:2190-5.
14. El-Hady IM, Alazab RM, Abdel-Wahed A, Ghandour AA, Elsaidy WH. Risk assessment of physical health hazards in Al-Azhar university hospital in new Damietta, Egypt. Egypt J Hosp Med 2013;53:1019-35.
15. Tamijidi AM. Status of principles of radiation protection in radiology center of Bushehr province. Iran South Med J 2014;4:47-52.
16. Rahimi SA, Salar SH, Asadi A. Evaluation of technical, protective and technological operation of radiologists in hospitals of Mazandaran medical sciences universities. J Mazandaran Univ Med Sci 2007;17:131-40.
17. Farzaneh MK, Mehmandoost-Khajeh-Dad AA, Namayeshi B, Varmal ZN, Mesgani M. Condition of observing the principles of radiation protection in radiology centers in Sistan and Baluchestan province of Iran. Int J Cur Res Rev 2013;5:82-5.
18. Rostamzadeh A, Farzizadeh M, Fatehi D. Evaluation of the level of protection in radiology departments of Kermanshah, Iran. Iran J Phys 2015;12:200-8.
19. Abdellah RA, Attia SA, Ahmed MF, Abdel-Halim WA. Assessment of physicians' knowledge attitude and practices of radiation safety as Suez Canal University Hospital, Egypt. Open J Radiol 2015;5:5250-5.
20. Salama KF, AlObireed A, AlBagawi M, AlSufayan Y, AlSerheed M. Assessment of occupational radiation exposure among medical staff in health-care facilities in the Eastern province, kingdom of Saudi Arabia. Indian J Occup Environ Med 2016;20:21-5.
21. Bhatt CR, Widmark A, Shrestha SL, Khanal T, Ween B. Occupational radiation exposure in health care facilities. Kathmandu Univ Med J (KUMJ) 2012;10:48-51.
22. Rose A, Rae WI. Personal protective equipment availability and utilization among interventionalists. Saf Health Work 2019;10:166-71.
23. Ahmed RM, El-Amin MA, El-Samani M, Wisal B, Hassan W. Knowledge and performance of radiographers towards radiation protection, Taif Saudi Arabia. J Dent Med Sci 2015;14:63-8.
24. Rahman N, Dhakam S, Shafqut A, Qadir S, Tipoo FA. Knowledge and practice of radiation safety among invasive cardiologists. J Pak Med Assoc 2008;58:119-22.
25. Luntsi G, Ajikolo AB, Flavious NB, Nelson L, Nwobi C. Assessment of knowledge and attitude of nurses towards ionizing radiation during theatre/ward radiography. J Nurs Care 2016;5:1-5.
26. Sidi M, Abba M, Nwobi C, Dare A. Assessment of quality assurance program for conventional X-ray equipment in Kano metropolis. J Assoc Radiographers Niger 2014;28:19-24.