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Investigation on Radiation Protection Status in Hospitals: A case study of selected hospitals in Kampala Uganda

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Abstract
This article discusses a study into the radiation protection status of Ugandan hospitals. Four hospitals with diagnostic radiological capabilities were selected for this inquiry. This study used a questionnaire. The secondary objective was to increase staff awareness of potential radiation health hazards and concerns. Additionally, it was determined important to ascertain radiation workers' level of understanding on radiation protection in order to initiate the process of drafting Ugandan radiological laws, regulations, and codes of practice in this field. The study consists of 92 radiation workers. The study found an acceptable level of occupational radiation monitoring knowledge among radio-diagnostic staff in Kampala Uganda, as well as an acceptable level of radiation monitoring among radio-diagnostic staff in Kampala Uganda, though much work remains to be done on radiation protection practice, as some radiation workers' attitudes toward wearing personnel monitoring devices (dosimeters) were found to be insufficient. Several participants mentioned that their unit lacked personnel monitoring devices. The current study reveals that radiographer' current strategies for reducing radiation exposure to patients and to themselves are ineffective. As a result, corrective measures should be implemented in a systematic and consistent manner to ensure that radiation safety procedures and standards are followed appropriately in radiology departments.

Abbreviations and Acronyms

ALARA	As Low As Reasonably Achievable
MRI	Magnetic resonance imaging
MRS	Magnetic resonance spectroscopy
SPECT	Single Photon Emission Computed Tomography
TLD	Thermo-luminescent Dosimeter

1.0 Introduction

Radiation happens naturally practically everywhere in the world we live in. Radiation has had a significant role in the evolution of all life on Earth (Carlo et al., 2016; Sethole, 2019; Zagórski & Kornacka, 2012). The two most significant events occurred in the final decade of the nineteenth century: the discovery of X-rays and radium. X-rays were being utilized to aid in the setting of a broken arm in a Vienna hospital, within weeks after the discovery of X-rays (Somayyeh, 2018; Tanzi et al., 2020). Modern radiology and radiation have developed into a very sophisticated and astonishingly sharp imaging system through the use of image intensifiers, computed tomography, and digital subtraction techniques, among other advancements. Both X-ray imaging and radiation have advanced slowly over the previous century, with numerous important breakthroughs interleaved. Mary Curie's (1896) discovery of radium cemented the use of ionizing radiation in cancer therapy and the importance of physicists in this field (Dlamini & Kekana, 2021; Gasinska, 2016).

The development of nuclear reactors and particle accelerators in the mid-20th century enabled the development of a variety of powerful and versatile radiation sources such as 60Co, 137Cs, 192Ir, and 99mTc, while linear accelerators, microtones, and cyclotrons enabled the development of a variety of man-made radioisotopes for cancer treatment, thereby establishing a new branch of medicine called nuclear medicine (or radiation medicine). The addition of gamma cameras, positron emission tomography (PET), single photon emission computed tomography (SPECT), and, more recently, nuclear magnetic resonance imaging (MRI) and magnetic resonance spectroscopy (MRS) has augmented diagnostic capabilities (Abuzaid et al., 2019; Faiz, 2009; Franco et al., 2020). Following the discovery, X-ray imaging of the human body is now frequently utilized to diagnose and treat disease. Different improvements in X-ray imaging technology, such as cross-sectional and digital imaging, as well as advancements in device software technologies, have had a substantial impact on diagnostic radiology application. X-rays can cause injury to healthy cells and biological components. As a result, any medical applications that include the use of X-ray equipment should be operated with caution.

Diagnostic imaging processing should be in place for all X-ray applications and equipment in diagnostic radiology facilities to guarantee that public, employee, and patient exposures are maintained as low as reasonably achievable (ALARA) (Adejumo et al., 2012; Eze et al., 2013; Okaro et al., 2010). In diagnostic radiology applications, four critical radiation safety goals must be considered. The first is to safeguard those who should not be subjected to unnecessary radiography procedures. This regulation's word is "justification of examination" (Miller et al., 2021; Mukherji et al., 2020; Tae et al., 2021). Second, if an imaging procedure is absolutely necessary, the patient should be covered against exposure to ultra-radiation during the imaging operation (Abdulkadir et al., 2021; Kargar et al., 2017). Thirdly, radiation protection is essential for hospital personnel and the general people who congregate near such medical radiation equipment (Miller et al., 2021; Okaro et al., 2010). Finally, radiology specialists employed in medical radiation facilities must be protected from excessive radiation exposure on the job (Abuzaid et al., 2019; Somayyeh, 2018). On the other hand, the third and fourth guidelines are predefined and require the optimal selection of radiation shielding materials in and around medical radiation facilities.

Numerous hospitals in Uganda make use of a variety of medical equipment, including X-ray/fluoroscopy machines, Co-60 teletherapy machines, HDR brachytherapy, high energy linear accelerators, and simulators. All of this equipment generates ionizing radiation that can have a variety of biological consequences on people and the general public. Thus, in order to reap the benefits of such ionizing radiation with the least amount of risk, it is critical to conduct a radiation level survey in various locations and around the rooms that have radiation facilities installed. Radiation survey and quality control are not mandated in Uganda, and only a few organizations conduct them voluntarily. After the installations in therapy departments, only the radiotherapy departments are surveyed, and certain medical physicists have taken care of some other facilities, primarily on a voluntary basis. A radiation survey of hospitals is a critical task that must be performed on a regular basis. Until date, Uganda has lacked a comprehensive assessment of radiation protection. Thus, the findings of this study may assist government policymakers as well as newly formed regulatory bodies, such as the Uganda National Atomic Energy Council (UNAEC), in sensitizing the general public about the dangers of inappropriate practices syndromes and in establishing health standards to be followed by practitioners, thereby safeguarding, alleviating, and mitigating the public against the likely undesirable consequences.

2.0 Materials and Methods

A descriptive design was adopted in this study. The survey technique was shown to be effective in determining the hospital's present radiation protection status. It is a useful technique for eliciting data about the features of a population sample, current practices, conditions, or needs (Chandran et al., 2004). This design was selected because it enables the summarization of statistics collections and the condensing of data into an understandable format (Sekaran, 2003). Additionally, the study included a qualitative methodology. The phrase "qualitative method" was historically used to refer to a data collection instrument (such as a questionnaire) or a data analysis approach (such as graphs or statistics) that generates or uses numerical data (Creswell, 2008). The study was conducted in four hospitals in Kampala Uganda, two public hospitals and two private hospitals. The hospitals are labelled, A, B, C, and D. Hospitals A and B are public hospitals and hospitals C and D are private hospitals. The category for selection was based on the understanding that these hospitals and medical institutions may present the greatest risk of radiation exposure to employees and the general public. Standardized and open-ended questionnaires were developed and circulated, to elicit respondents' candid comments about the study. It was processed for analysis using IBM SPSS version 22.0 software, following the retrieval of the questionnaire and collection of essential data.

2.1 Ethical Considerations

The following ethical guidelines were adhered to:

- The researchers maintained the highest standards of quality and integrity by reporting just what they discovered in the field and following a rigorous and systematic report writing approach for academic research.
- The researchers obtained the respondents' informed consent. This was accomplished by requiring respondents to sign an informed consent form prior to participating in the study.
- By involving research respondents on their own terms and at their comfort, and by coding their identities in the final report, the researchers maintained the respondents' privacy and confidentiality.
- The researchers made it abundantly apparent that participation was purely optional. Nobody was coerced, forced, or enticed into participating in the study. If a respondent's opinion changed, the researchers told him or her that they may withdraw from the study without penalty. The researchers took precautions to ensure that no harm would come to the subjects.
- Finally, the researchers ensured that the final report was objective and free of their own bias by relying on the respondents' perspectives in the final analysis.

2.2 Limitations of research

- The researcher's capacity to perform this study was hampered by certain informants' obstructive behavior, as well as by inaccessible informants and those who were hesitant to provide information. On the other side, the researcher convinced informants that the work was conducted simply for academic purposes.
- Instrumentation: The surveys included non-traditional questions that the researchers developed. The results' validity is probably to have been compromised, as a result of the instruments' lack of consistency, to address this, the researcher conducted a reliability test in conjunction with a pilot study to ensure that the questionnaires were applicable in other study scenarios.

3.0 Results

This research was conducted at four notable hospitals in Uganda, it enrolled 92 individuals. There were 81 males (88.4%) and 11 females (11.96%), ranging in age from 20 to 49 years, with an average life expectancy of 27.5 years. There were 14 (15.22%) certificate holders, 61 (66.30%) bachelor's degree holders, 13 (14.13%) master's degree holders, and four (4.35%) doctoral degree holders. The study included 26 (28.26%) radiologists, 47 (51.09%) radiographers, 19 (20.65%) darkroom technicians, and 0 (0.00%) nurses. 34 (36.96 percent) of respondents were from A, 25 (27.17 percent) from B, 21 (22.82 percent) from C, and 12 (13.04 percent) from D. Forty-five (48.91%) participants have less than five years of work experience, 24 (26.09%) participants have between five and ten years of work experience, 19 (20.65%) participants have between ten and twenty years of work experience, and 4 (4.34%) participants have more than twenty years of work experience, as shown in Table 1.

Table 1: Socio-Demographic parameters

Variables	Female frequency (%)	Male Frequency (%)	Total Frequency (%)
Gender	11 (11.96)	81 (88.04)	92 (100.00)
Age (Years)			
20-29	7 (63.64)	42 (51.85)	49 (52.26)
30-39	2 (18.18)	29 (35.80)	31 (33.70)
40-49	2 (18.18)	10 (12.35)	12 (13.04)
50-above	0 (0.00)	0 (0.00)	0 (0.00)
Educational Qualification			
Certificate	3 (27.27)	11 (13.58)	14 (15.22)
Bachelor	8 (72.73)	53 (65.43)	61 (66.30)
Masters	0 (0.00)	13 (16.05)	13 (14.13)
PhD	0 (0.00)	4 (4.94)	4 (4.35)
Designation of respondent			
Radiologist	5 (45.45)	21 (25.93)	26 (28.26)
Radiographer	5 (45.45)	42 (51.85)	47 (51.09)
Dark room technician	1 (9.10)	18 (22.22)	19 (20.65)
Nurse	0 (0.00)	0 (0.00)	0 (0.00)
Place of practice			
A (Public)	4 (36.36)	30 (37.04)	34 (36.96)
B (Public)	3 ((27.27)	22 (27.16)	25 (27.17)
C (Private)	1 (9.10)	20 (24.69)	21 (22.82)
D (Private)	3 (27.27)	9 (11.11)	12 (13.04)
Work experience			

(Years)			
Under 5 years	6 (54.55)	39 (48.15)	45 (48.91)
5-10 years	2 (18.18)	22 (27.16)	24 (26.09)
11-20 years	3 (27.27)	16 (19.75)	19 (20.65)
21 years and above	0 (0.00)	4 (4.93)	4 (4.34)

3.1 Occupational radiation monitoring

Film badges, pocket ionizing chambers, and TLDs are all available for occupational radiation surveillance. The majority of respondents 73 (79.35 percent) have all three possible occupational radiation surveillance devices, while 13 (14.13 percent) have only a film badge, six (6.52 percent) have only a TLD, and none have only a portable ionizing chamber. As stated in Table 2, 29 (31.52 percent) of personnel radiation surveillance systems are read monthly, 39 (42.39 percent) of personnel radiation surveillance systems are read quarterly, and 24 (26.09 percent) of personnel radiation surveillance systems are checked for a period of 6 months or more.

Table 1: Occupational radiation monitoring

Variables	Female frequency (%)	Male Frequency (%)	Total Frequency (%)
Occupational radiation monitoring instruments available for use			
Film badge only	0 (0.00)	13 (100.00)	13 (14.13)
Pocket ionizing chamber	0 (0.00)	0 (00.00)	0 (0.00)
TLD only	0 (0.00)	6 (100.00)	6 (6.52)
All of the above	11 (15.07)	62 (84.93)	73 (79.35)
How frequently do personnel radiation monitoring instruments get readouts?			
Monthly	6 (20.69)	23 (79.31)	29 (31.52)
Quarterly	5 (12.82)	34 (87.18)	39 (42.39)
Six months and above	0 (0.00)	24 (100.00)	24 (26.09)

3.2 Personnel radiation monitoring

Personnel radiation monitoring is used in 79 (85.87 percent) of departments, while it is not used in 13 (14.13 percent) of departments. TLD is used by 54 (58.70%) of respondents, Film badge is used by 32 (41.30%) of respondents, and Pocket ionizing chamber is used by 6 (6.52%) of respondents. The majority of respondents, 59 (64.13 percent), wear their personnel radiation surveillance equipment all of the time at work, 20 (21.74 percent) wear their people radiation surveillance device twice a week, and 13 (14.13 percent) wear it once a week. There is a gender preference in the issuing of the personnel radiation measuring system, according to 28 (30.43 percent), and there is no gender preference in the issuance of the employee radiation monitoring device, according to 64 (69.57 percent). The female gender is most addressed by 18 (64.28 percent), while the male gender is most addressed by 10 (35.71 percent). Two (2.60 percent) said they don't have lead prone in their department, 41 (53.24 percent) said they don't have Gonad shield, 11 (14.28 percent) said they don't have lead screen, and 23 (29.87 percent) said they don't have lead gloves. Six (6.52%) have one to three lead aprons in their department, 26 (28.26%) have three to six lead aprons in their department, and 60 (65.22%) have six to nine lead aprons in their department. Quality assurance tests are performed in 33 (35.87 percent) of departments on a regular basis, 49 (53.26 percent) on an as-needed basis, and 10 (10.86 percent) of departments do not do quality control tests.

Table 2: Radiation monitoring of personnel

Variables	Female frequenc y (%)	Male Frequency (%)	Total Freque ncy (%)
Do you use any of the staff radiation monitoring services in your department?			
No	6 (46.15)	7 (53. 85)	13 (14.13)
Yes	5 (6.33)	74 (93.67)	79 (85.87)
If you answered yes to the above question, what kind of radiation monitoring instrument do you have in your department?			
TLD	8 (14.81)	46 (85.19)	54 (58.70)
Film badge	3 (9.38)	29 (90.62)	32 (41.30)
Pocket ionizing chamber	0 (00.00)	6 (100.00)	6 (6.52)
How often do you put on your personnel radiation monitoring device?			
Always when at work	7 (11.86)	52 (88.14)	59 (64.13)
Twice in a week	2 (10.00)	18 (90.00)	20 (21.74)
Once in a week	2 (15.38)	11 (84.62)	13 (14.13)
Is there a preference for men or women when it comes to receiving a personnel radiation monitoring device?			

No	9 (14.06)	55 (85.94)	64 (69.57)
Yes	2 (7.14)	26 (92.86)	28 (30.43)
If yes from above, which gender is most considered?			
	18 (64.28)	10 (35.71)	
Which of the radiation protective devices listed below is not available in your department?			
Lead prone	0 (0.00)	2 (100.00)	2 (2.60)
Gonad shield	5 (12.20)	36 (87.80)	41 (53.24)
Lead screen	0 (0.00)	11 (100.00)	11 (14.28)
Lead gloves	4 (17.39)	19 (82.61)	23 (29.87)
How many lead aprons are available?			
1-3	0 (0.00)	6 (100.00)	6 (6.52)
3-6	5 (19.23)	21 (80.77)	26 (28.26)
6-9	6 (10.00)	54 (90.00)	60 (65.22)
How frequently does your department conduct quality assurance tests?			
Routinely	2 (6.06)	31 (93.94)	33(35.87)
Occasionally	7 (14.29)	42 (85.71)	49 (53.26)
None	2 (20.00)	8 (80.00)	10 (10.86)

3.3 Adherence to radiation protection practice

Forty-six (50.00 percent) reported wearing TLD while at work, 18 (19.56 percent) reported wearing TLD occasionally while at work, and 28 (30.43 percent) reported not wearing TLD while at work. 47(51.08) reported wearing a lead apron during fluoroscopy, 31 (33.69) reported wearing a lead apron occasionally during fluoroscopy, and 14 (15.22) reported not wearing a lead apron during fluoroscopy. 47 (51.08) respondents indicated that they wear a lead apron while performing portable radiography, 31 (33.69) respondents indicated that they wear a lead apron occasionally while performing portable radiography, and 14 (15.22) respondents indicated that they do not wear a lead apron while performing portable radiography.

Eighty-one (88.04) reported wearing lead gloves during fluoroscopy, while 11 (11.96) reported not wearing lead gloves during fluoroscopy. Seventy-five (81.52) respondents said that they wear a thyroid collar in the operating room, 6 (6.52) respondents indicated that they wear a thyroid collar occasionally in the operating room, and 11 (11.96) respondents indicated that they do not use a thyroid collar in the operating room.

Eighty-four (91.30) reported using a light beam diaphragm, 6 (6.52) reported using a light beam diaphragm occasionally, and 2 (2.17) reported not using a light beam diaphragm. Eighty-six (93.48) respondents indicated that they use the cone when necessary, 6 (6.52) respondents indicated that they use the cone occasionally when necessary, and 0 (0.00) respondents indicated that they do not use the cone when necessary. 90 (97.83) stated that they use correct collimation, while 2 (2.17) indicated that they do not. Ninety (97.83) indicated that they utilize marker, while 2 (2.17) said that they do not. Ninety-two (100.00) indicated that they use the right source to image receptor distance (SID), while none indicated that they do not (SID).

Seventy-nine (85.86) respondents answered that they utilize gonad shielding, 5 (5.43) respondents indicated that they use gonad shielding occasionally, and 8 (8.70) respondents indicated that they do not use gonad shielding. Ninety-two (100.00) participants answered that they use lead shield when applicable, and none said that they do not use lead shield when applicable. All participants answered that they employ the shortest possible exposure time.

Forty-nine (53.26) reported wearing a lead apron around all co-patients or staff, 11 (11.96) reported wearing a lead apron around all co-patients or staff on occasion, and 32 (34.78) reported not wearing a lead apron around all co-patients or personnel. Eighty-four (91.30) respondents said that they close the room door during the fluoroscope, 8(8.70) respondents indicated that they close the room door occasionally during the fluoroscope, and 0(0.00) respondents indicated that they do not close the room door during the fluoroscope. This is seen in Table 4

Table 3: Adherence to radiation protection practice

Variables	Female Frequency (%)	Male Frequency (%)	Total Frequency (%)
Personal Protection			
Wearing TLD during the work			
No	6 (21.43)	22 (78.57)	28 (30.43)
Yes	3 (6.52)	43 (93.48)	46 (50.00)
Sometimes	2 (11.11)	16 (88.89)	18 (19.56)
Wearing lead apron during fluoroscopy			
No	1 (7.14)	13 (92.86)	14 (15.22)

Yes	7 (14.89)	40 (85.12)	47 (51.08)
Sometimes	3 (9.68)	28 (90.32)	31 (33.69)
Wearing lead apron during portable radiography			
No	1 (7.14)	13 (92.86)	14 (15.22)
Yes	7 (14.89)	40 (85.12)	47 (51.08)
Sometimes	3 (9.68)	28 (90.32)	31 (33.69)
Using of lead gloves during fluoroscopy			
No	1 (9.09)	10 (90.91)	11 (11.96)
Yes	10 (12.35)	71 (87.65)	81 (88.04)
Sometimes	0 (0.00)	0 (0.00)	0 (0.00)
Wearing thyroid collar at the operating theatre			
No	1 (9.09)	10 (90.91)	11 (11.96)
Yes	10 (13.33)	65 (86.67)	75 (81.52)
Sometimes	0 (0.00)	6 (100.00)	6 (6.52)
Patient protection			
Using light beam diaphragm			
No	2 (100.00)	0 (0.00)	2 (2.17)
Yes	9 (10.71)	75 (89.29)	84 (91.30)
Sometimes	0 (0.00)	6 (100.00)	6 (6.52)
Using of the cone when needed			
No	0 (0.00)	0 (0.00)	0 (0.00)
Yes	11 (12.80)	75 (87.20)	86 (93.48)
Sometimes	0 (0.00)	6 (100.00)	6 (6.52)
Using of proper collimation			
No	2 (100.00)	0 (0.00)	2 (2.17)
Yes	9 (10.00)	81 (90.00)	90 (97.83)
Sometimes	0 (0.00)	0 (0.00)	0 (0.00)
Using of marker			
No	2 (100.00)	0 (0.00)	2 (2.17)
Yes	9 (10.00)	81 (90.00)	90 (97.83)
Sometimes	0 (0.00)	0 (0.00)	0 (0.00)
Using of proper source to image receptor distance (SID)			
No	0 (0.00)	0 (0.00)	0 (0.00)
Yes	11 (11.96)	81 (88.04)	92 (100.00)
Sometimes	0 (0.00)	0 (0.00)	0 (0.00)
Using of gonad shielding			
No	1 (12.50)	7 (87.50)	8 (8.70)
Yes	9 (11.39)	70 (88.61)	79 (85.86)
Sometimes	1 (20.00)	4 (80.00)	5 (5.43)
Using of lead shield when applicable			
No	0 (0.00)	0 (0.00)	0 (0.00)
Yes	11 (11.96)	81 (88.04)	92 (100.00)
Sometimes	0 (0.00)	0 (0.00)	0 (0.00)
Using of minimum exposure time			
No	0 (0.00)	0 (0.00)	0 (0.00)
Yes	11 (11.96)	81 (88.04)	92 (100.00)
Sometimes	0 (0.00)	0 (0.00)	0 (0.00)
Protection of the environment			
Using of the lead apron for all co-patient or staff			
No	4 (12.50)	28 (87.50)	32 (34.78)
Yes	4 (8.16)	45 (91.84)	49 (53.26)
Sometimes	3 (27.27)	8 (72.73)	11 (11.96)
Closing the room door			
N0	0 (0.00)	0 (0.00)	0 (0.00)
Yes	11 (13.10)	73 (86.90)	84 (91.30)
Sometimes	0 (0.00)	8 (100.00)	8 (8.70)

3.4 Suggestions from respondents on how to improve staff radiation monitoring

Participants suggested ways to enhance staff radiation monitoring. The vast majority of participants ten (31.30%) suggested providing adequate protection devices, while eight (25.00%) suggested providing adequate personnel surveillance devices to all staff. Two (6.30 percent) to promote low-KVA exposure options through the use of fast film/screen combinations. 1 (3.10 percent) advocated for staff offices to be located away from machine rooms. Two (6.30) proposed that the department appoint a radiation safety officer, 2 (6.30) suggested that the dose be kept low by avoiding repetition, and 2 (6.30) suggested that pertinent rules be enforced. One (3.10) proposed periodic rotation between regions of ionizing radiation and regions of non-ionizing radiation (work schedules), and 4 (12.50) suggested that protective equipment should be regularly examined and quality assurance preserved, as stated in Table 5.

Table 4: Suggestions from respondents on how to improve staff radiation monitoring

Suggestions	Female frequency (%)	Male Frequency (%)	Total Frequency (%)
All staffs should be provided with adequate personnel monitoring devices.	2 (40.00)	6 (60.00)	8 (25.00)
To encourage low KVA selections during exposure, use fast film/screen combinations.	0 (0.00)	2 (100.00)	2 (6.30)
Locating staff offices far from machine rooms	0 (0.00)	1 (100.00)	1 (3.10)
Hire a radiation safety officer for the department	1 (50.00)	1 (50.00)	2 (6.30)
Keeping the dose low by avoiding repetition	0 (0.00)	2 (100.00)	2 (6.30)
Providing adequate protective devices	0 (0.00)	10 (100.00)	10 (31.30)
Enforce all applicable rules	0 (0.00)	2 (100.00)	2 (6.30)
From time to time, rotate from ionizing radiation to non-ionizing radiation locations (work schedules)	0 (0.00)	1 (100.00)	1 (3.10)
Protective equipment monitored constantly, and quality assurance maintained.	2 (50.00)	2 (50.00)	4 (12.50)

4.0 Discussions

Radiation protection is a critical safety element in the practice of radiography (Okaro et al., 2010). The study involved 81 males (88.04 percent) and 11 females (11.96 percent). This shows that the radiation department employed a greater number of men. Radiographers were the most often surveyed group, with 47 (51.09 percent) responding, followed by radiologists with 26 (28.26 percent) and technicians with 19 percent (20.65 percent). Radiographers were the distributors of ionizing radiation at all of the hospitals included in the study, and hence there were more of them in the study areas. This is consistent with Adejumo et al. (2012)'s recommendation that radiographers be aware of their role in ensuring that established radiation safety rules are applied consistently in their facilities. The study discovered that a substantial proportion of respondents 79 (85.87 percent) had an outstanding awareness of personnel radiation surveillance. This is line with the findings of Eze et al., (2013) and Adejumo et al., (2012), who discovered that radio-diagnostic staff were extremely conscious of and adhered to radiation monitoring procedures. Some respondent, 13 (14.13 percent) of them shown a lack of expertise of staff radiation monitoring. This was comparable to the conclusions of (Okaro et al., 2010), who revealed that certain radiology staff possessed an alarmingly low level of awareness regarding personal radiation surveillance. This is because the radiology department is comprised of individuals with varied levels of education and academic degrees, from technicians to radiographers to radiologists, but no one should be unaware of the risks of ionizing radiation.

A significant number of responder scans employee radiation monitoring equipment on a monthly or quarterly basis, 68 (73.91 percent). This is consistent with (Okaro et al., 2010; Sethole, 2019), who discovered that radiation monitoring equipment are read on a quarterly basis. Although only 24 (26.09 percent) of them indicated that staff radiation surveillance devices were scanned every six months or more frequently in a year. This is consistent with Adejumo et al. (2012), they found out that radiographers in government hospitals are unsatisfied with the frequency with which radiation surveillance devices are read.

Continuous dose measurements must be made with proper devices and at monthly intervals, as recommended by the ICRP, to minimize the probability effect of radiation (stochastic) on radiation personnel. Personnel radiation monitoring is used by 59 (64.13 percent) of respondents, while 33 (35.877 percent) of respondents do not use it. This finding is congruent with that of Eze et al., (2013); Abdulkadir et al., (2021); and Dlamini & Kekana, (2021), who discovered that radio-diagnostic staff possessed an exceptional grasp of personnel radiation surveillance but did not practice it. This could be as a result of management's inadequate provision of personnel radiation surveillance systems or radiographers' lack of knowledge of the critical nature of their use during operations; or it could be as a result of radio-diagnostic staff negligence. In this regard, our findings are comparable to those of previous studies (Kargar et al., 2017; Abuzaid et al., 2019; Somayyeh 2018). Fifty-four (58.70 percent) of the institutions surveyed, TLD was the most often used personnel radiation monitoring device, followed by film badges in 32 (41.30 percent) and pocket ionizing chambers in 6. (6.52 percent). Okaro et al. (2010) discovered comparable results in hospitals equipped with personnel radiation monitoring equipment. This is because TLD badges are small and lightweight, have the ability to store radiation exposure over time, are extremely sensitive, and may be reused several times after reading. TLDs are used to quantify and monitor occupational doses during radiation exposure; even modest errors can result in doses that are not reported. As a result, further specific training is required, with an emphasis on the dangers of workplace radiation exposure and the importance of wearing TLDs while working. According to 64 (69.57 percent) of the participants, there was no gender preference in the distribution of staff radiation surveillance equipment. This is consistent with the 2011 Washington Hospital Radiologic Technology program brochure, which stated in item 2 of the student radiation protection criterion that all students, regardless of gender, should be provided with a radiation surveillance device.

Radiation protection items such as lead aprons, gonad shields, lead screens, lead gloves, and lead goggles were also available in the hospitals visited, while lead aprons and screens were most frequently available, while gonad shields, lead goggles, and lead gloves were insufficiently supplied. This is consistent with the findings of Adejumo (2012) and Eze et al. (2010), who discovered that the majority of diagnostic facilities tested were capable of providing the warning light, lead aprons, lead doors, gonad shields, lead line, and lead screens for safety devices inspection. This is because radiation protection for radiation workers is highly dependent on the correct use of radiation protection devices in the radiology department, and management has an obligation to provide suitable radiation protection equipment prior to creating a radiology institute.

In the majority of hospitals visited, quality assurance (QA) tests were performed on the equipment, with 49 (53.26 percent) performing them on an ad hoc basis and 33 (35.87 percent) performing them on a routine basis. Around ten percent (10.86 percent) of participants said that their institution does not practice quality assurance. This is consistent with the findings of Eze et al., (2010), who concluded that overall quality was low in all hospitals surveyed. ALARA is a critical concept in medical radiation protection since its primary objective is to eliminate unnecessary radiation exposure and to optimize radiation doses. ALARA is founded on three fundamental principles: time, separation, and shielding. Radiographers can improve radiation protection by adhering to established global standards and practices, as well as by employing the appropriate instruments and equipment.

5.0 Conclusions

This study found a significant level of occupational radiation surveillance knowledge among radio-diagnostic staff in Kampala, Uganda, as well as a significant level of radiation tracking among radio-diagnostic staff in Kampala, Uganda, though much work remains to be done on radiation protection practice, as some radiation workers' attitudes toward wearing personnel monitoring devices (dosimeters) were found to be inadequately poor, and governance of radiation exposure was found to be insufficient.

The current study reveals that radiographers' current strategies for reducing radiation exposure to patients and to themselves are inadequate. As a result, radiology departments should implement a systematic and coordinated approach in the form of corrective actions to ensure the proper application of radiation safety measures and standards. Additionally, continuous education is critical for radiographers who are less experienced.

6.0 Recommendations

The following recommendations should be considered in light of the findings in order to enhance radiation protection measures and lower radiation doses for radio-diagnostic workers and the general public:

- Stakeholders should fund the installation of radiation protective systems in all radiological diagnostic centers.
- Providing ongoing training to employees, patients, and the general public in order to increase their knowledge of radiation protection concerns.
- Hospitals should provide radiation protection advisers to monitor radiation protection measures, practices, and inspections of radiation dose rate levels in health facilities in Uganda on a daily basis.
- The government should establish a Radiation Regulatory Board or Commission comprised of those involved in the field of radiation.
- All users of radiation producing devices and employees in the immediate region should be expected to wear a TLD, film badge, or other form of dosimetry for personnel monitoring service.

Declaration of conflict of interest

The authors declare there is no conflict of interest.

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