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ASSESSMENT OF RADIATION PROTECTION STATUS OF THE RADIOLOGY DEPARTMENTS OF TWO SELECTED SECONDARY HOSPITALS IN KANO METROPOLIS, KANO STATE, NIGERIA

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ABSTRACT

Background: During the operation of X-ray machines, radiology personnel and individuals in adjacent areas may inadvertently be exposed to harmful doses of ionizing radiation.

Objective: This study examines the levels of secondary radiation in two busy radiology departments of secondary health facilities in Kano metropolis.

Methods: Radiation doses were measured using a Radiation Alert Ranger Multi-Purpose Digital Survey Meter at various locations by taken first the background radiation, including the control panel, changing room, patient waiting area, protected cubicle, dark room/digitizer, and radiographer's office.

Results: The highest measurement was 22.653 µSv/h in the changing room at Hospital 'B', and the lowest was 0.011 µSv/h in the patient waiting area at Hospital 'A'. Background radiation levels ranged from 0.077 to 0.203 µSv/h, with the highest levels recorded in the CT unit at Hospital 'B'.

Conclusion: The study emphasizes the need for continuous monitoring and stringent control of radiation exposure to ensure the safety of medical staff and the general public.

Keywords: Patient, Ionizing radiation, secondary radiation, Kano metropolis, Survey meter.

Introduction

The utilization of ionizing radiation in medicine has significantly enhanced the preservation of human health by enabling the diagnosis and treatment of various diseases. Beyond medicine, ionizing radiation finds extensive applications in industries, agriculture, environmental monitoring, and water resources management, thereby constituting a vital tool for humanity's advancement [1]. The primary source of irradiation exposure for the general population stems from diagnostic X-rays. While individual exposures are typically minimal, there is a concern regarding the potential elevated risk of cancer when large populations are exposed to radiation. The reduction of unnecessary irradiation to patients during radiological procedures can be achieved with minimal or no compromise on the quality of medical diagnostic information [2]. This is attainable through the utilization of well-designed X-ray equipment operated and maintained by trained personnel, along with the adoption of standardized procedures [3]. It's essential to acknowledge that diagnostic X-ray procedures contribute the most to the population's overall radiation exposure when compared to other man-made sources. Consequently, it's imperative to confine the X-ray beam to areas outside both controlled and uncontrolled zones of X-ray departments, safeguarding them with robust shielding materials like lead [4].

Since its discovery over a century, radiation research has provided profound insights into the biological mechanisms through which radiation impacts health. It's established that radiation can induce effects at the cellular level, leading to cell death or alteration primarily due to direct damage to DNA strands within chromosomes. These health effects resulting from radiation exposure are categorized based on their timing as either early or delayed health effects, as observed through empirical evidence [5]. Over several years, regular inspections of x-ray tubes, diaphragm assemblies, and cones have consistently uncovered significant radiation leaks. These leaks have stemmed from various issues such as the absence or displacement of lead shielding within the tube housing, improper alignment of the diaphragm and cone assembly, or the utilization of materials lacking sufficient protective capabilities [6]. Monitoring the radiation doses absorbed by personnel in the radiology department holds significant importance. A radiation monitoring program aims to pinpoint every instance of radiation exposure within operations, enabling the prompt detection of alterations in radiation parameters that could potentially elevate exposures. Additionally, such programs generate ample data to facilitate optimization efforts [7].

Following recommendations from the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA), the annual effective dose limit for members of the general public in uncontrolled areas—such as patients, visitors to medical facilities, and employees not routinely handling radiation sources—should not exceed 1 mSv[8]. Shielding designs are thus advised to cap exposure at this level per year. Radiographers experience occupational exposure to ionizing radiation at low levels during routine work. However, their annual dose should not surpass 1 mSv, with an upper limit of 20 mSv per year [9]. Exceeding these thresholds escalates the likelihood of cytogenetic abnormalities and raises the risk of fatal cancer for clinical staff conducting diagnostic procedures [10]. As a result of radiological examinations, the exposure of radiation workers and the public to scattered and leakage radiation is consistently increasing [11]. Presently, no studies have been conducted to assess possible quantum of radiation leakage in the radiology departments of the two largest secondary health facilities in Kano Metropolis. Therefore, there is a pressing need for a survey to ensure that the level of leakage radiation from the x-ray tubes and the annual exposure for both radiation workers and department visitors remain within the permissible limits recommended by the ICRP.

Methods:

This research work has been carried out by the measurement of the secondary radiation from diagnostic X-ray units and CT unit in 2 selected public hospitals in Kano metropolis, Kano state. They remained the largest state-owned facilities within the Kano metropolis and serves not only the teeming Kano populace but also serves as a referral centre to most of the rural and neighbouring states. Radiation dose was monitored by a portable calibrated dosimeter (Radiation Alert Ranger, Multi-purpose digital survey meter). The device has a capability of wide range of digital Geiger counter suitable for nearly all measurement tasks arising in radiation protection through optional plug and play probes available for neutron measurement, alpha and beta contamination reading and even to detect artificial gamma and X-rays. Therefore, it was suitable for the current survey to detect and measure secondary radiation from X-ray at the control area, exact position of working radiographers and uncontrolled area such as patient waiting area, changing room, dark room/digitizer and Radiographer’s office. In the diagnostic X-ray/CT units. The scattered radiation doses at various locations within the radiology departments of Hospital A and Hospital B were measured using a Radiation Alert Ranger Multi-Purpose Digital Survey Meter. Prior to these measurements, the background radiation level was established to ensure accurate assessment. The average background reading, taken with the survey meter, was determined to be 0.146 μSv/h. Background radiation refers to the ubiquitous ionizing radiation present in the environment, originating from natural sources such as cosmic rays, terrestrial sources, and even human-made sources. Establishing this baseline is crucial for distinguishing between normal environmental radiation and additional radiation from medical imaging equipment. Ethical clearance to conduct the study was obtained from the research and ethics committee of the Kano state Government prior to the commencement of the study. All ethical principles before, during and after the study were upheld.

Measurements were performed during the normal working hours of the selected hospitals which were from 8 am to 1 pm and 5 days per week. The survey meter was placed at the chest region of the radiographers, approximately 1 meter from the radiation source during measurements. Each exposure measurement was carried out for a duration of 10 seconds, and three exposures were performed for each measurement to reduce statistical error. Before the machines were switched on, the background radiation was measured in all locations of the radiology units of the selected hospitals. Subsequently, measurement was taken during exposure and immediately after exposure to the radiation. The fallout radiation was measured in control panel, changing room, dark room/digitizer, patient waiting area and the Radiographers office. Machines were operated for a range of energies (70 to 180kVp) and X-ray intensities (12 to 130mAs) which characterises the examination for diagnostic imaging of body parts. Above exposure ranges and types of imaging were selected because they are the most popularly applied in the selected hospitals. Data collected by the utilized dosimeter were measured in nSv/h and μSv/h and are converted into mSv/yr.

Results:

Room 1 in the radiology department of hospital ‘A’ houses a conventional x-ray unit. This unit is a GULFEX F100 (100mA) mobile x-ray unit, installed in 2011. Secondary radiation rates were measured in multiple locations, including the changing room, patient waiting area, protected cubicle, dark room/digitizer, and the radiographer’s office. These measurements were taken at exposure factors of 70 kVp and 30 mAs. Room 2 in Hospital ‘A’ contains an ITALRAY PIXEL HF650 x-ray unit, which was installed in 2006. Secondary radiation rates here were also measured at multiple locations such as the changing room, patient waiting area, protected cubicle, dark room/digitizer, and radiographer’s office, but at different exposure factors of 95 kVp and 12 mAs. At Hospital ‘B’, Room 3 is equipped with a F30III (30mA) mobile x-ray unit, installed in 2013. Measurements in this room, similar to those in Hospital ‘A’, were taken at exposure factors of 70 kVp and 30 mAs across the changing room, patient waiting area, protected cubicle, dark room/digitizer, and the radiographer’s office. Room 4 at Hospital ‘B’ houses a CT-BETJING BRIVO (CT385 ASIR) CT unit, installed in 2017. This unit had the highest exposure factors of 180 kVp and 130 mAs. Secondary radiation measurements were taken in the patient waiting area, protected cubicle, dark room/digitizer, and radiographer’s office.

Table 1: Radiation measurement at various levels of Hospital ‘A’ (room 1 x-ray unit)

LOCATION	EFFECTIVE DOSE RATE /(µSv/h)			AVERAGE EFFECTIVE DOSE RATE /(µSv/h)	AVERAGE EFFECTIVE DOSE RATE /(mSv/yr)
	R1	**R2**	**R3**		
Changing room (CR)	1.864	2.063	0.927	1.618	14.174
Patient waiting area (PWA)	0.014	0.01	0.01	0.011	0.096
Control panel (CP)	11.897	6.465	7.18	8.514	4.583
Dark room /Digitizer	0.059	0.014	0.01	0.028	0.243
Radiographer’s office (RO)	0	0.046	0.006	0.017	0.149

Table 2: Radiation measurement at various levels of Hospital ‘A’ (room 2 x-ray unit)

LOCATION	EFFECTIVE DOSE RATE /(µSv/h)			AVERAGE EFFECTIVE DOSE RATE /(µSv/h)	AVERAGE EFFECTIVE DOSE RATE /(mSv/yr)
	R1	R2	R3		
Changing room (CR)	0.011	0.002	0.04	0.018	0.158
Patient waiting area (PWA)	0.023	0.045	0.032	0.033	0.289
Control panel (CP)	5.229	3.066	14.288	**7.528**	65.945
Dark room /Digitizer	0.072	0.047	0.02	0.046	0.403
Radiographer’s office (RO)	0.023	0.028	0.033	0.028	0.245

Table 3. Radiation measurement at various levels of Hospital 'B' (room 3 x-ray unit)

LOCATION	EFFECTIVE DOSE RATE /(µSv/h)			AVERAGE EFFECTIVE DOSE RATE /(µSv/h)	AVERAGE EFFECTIVE DOSE RATE /(mSv/yr)
	R1	R2	R3		
Changing room (CR)	34.535	31.596	1.827	22.653	198.440
Patient waiting area (PWA)	4.344	3.164	1.847	3.118	27.314
Control panel (CP)	24.186	18.965	1.115	14.755	129.254
Dark room /Digitizer	0.884	0.846	0.707	0.812	7.113
Radiographer's office (RO)	2.186	3.203	4.239	3.209	28.13

Table 4. Radiation measurement at various levels of Hospital 'B' (room 4 x-ray unit)

LOCATION	EFFECTIVE DOSE RATE /(µSv/h)			AVERAGE EFFECTIVE DOSE RATE /(µSv/h)	AVERAGE EFFECTIVE DOSE RATE /(mSv/yr)
	R1	**R2**	**R3**		
Patient waiting area (PWA)	0.038	0.057	0.031	0.042	0.368
Control panel (CP)	0.046	0.044	0.068	0.053	0.464
Dark room /Digitizer	0.193	0.31	0.193	0.232	2.032
Radiographer's office (RO)	0.003	0.022	0.028	0.018	0.158

Discussion:

The findings of this study reveal significant insights into the radiation protection status of the radiology departments in two selected secondary hospitals in Kano metropolis. The variations in secondary radiation levels across different locations within the radiology departments highlight the importance of adequate shielding and protective measures to ensure the safety of both medical staff and the general public.

In Hospital 'A', Room 1, which houses a GULFEX F100 mobile X-ray unit installed in 2011, the highest radiation measurement was recorded at the control panel (8.514 µSv/h). This elevated level indicates potential deficiencies in shielding around the control area, posing a risk to radiology personnel who spend considerable time in this zone. Conversely, the patient waiting area exhibited the lowest radiation level (0.011 µSv/h), suggesting that the protective measures in place for this area are effective. This finding is in line with a study by Owusu-Banahene *et al.*, 2018.

Room 2 in Hospital 'A', equipped with an ITALRAY PIXEL HF650 X-ray unit installed in 2006, also demonstrated the highest radiation measurement at the control panel (7.528 µSv/h). This consistency in high radiation levels at the control panels across different rooms underscores a recurring issue with shielding effectiveness in these critical areas. The changing room, with a low measurement of 0.018 µSv/h, further indicates variability in protective measures within different locations of the same facility.

At Hospital 'B', Room 3, containing a F30III mobile X-ray unit installed in 2013, the changing room exhibited alarmingly high radiation levels (22.653 µSv/h). This significantly elevated reading suggests inadequate shielding and raises concerns about the exposure risk to patients and staff using this room. The dark room/digitizer, with a much lower measurement of 0.812 µSv/h, indicates better protection in this area, yet the substantial difference between locations within the same room highlights inconsistencies in radiation safety protocols.

Room 4 in Hospital 'B', housing a CT-BETJING BRIVO CT unit installed in 2017, had the highest measurement at the digitizer (0.232 µSv/h). Despite being the highest in this room, it remains considerably lower than the measurements in other rooms, reflecting the more stringent protective measures typically associated with CT units. The radiographer's office, with the lowest measurement of 0.018 µSv/h, indicates that administrative areas benefit from adequate shielding, likely due to less frequent direct exposure to radiation.

The variations in radiation levels observed across different rooms and hospitals emphasize the critical need for regular inspections and stringent control of radiation protection measures. The findings highlight the importance of implementing comprehensive radiation safety protocols, including proper maintenance of X-ray equipment by trained personnel, adherence to standardized procedures, and robust shielding measures. The significant differences in radiation levels between locations within the same room suggest that even minor lapses in protective measures can result in substantial exposure risks. The study underscores the necessity for ongoing vigilance and proactive measures in radiation protection within medical facilities. By addressing the identified issues and implementing the recommended strategies, hospitals can significantly enhance the safety and well-being of both their staff and the public.

CONCLUSION

The study emphasizes the necessity for continuous monitoring and stringent control of radiation exposure in radiology departments. Ensuring that secondary radiation levels remain within safe limits, as recommended by the International Commission on Radiological Protection (ICRP), is crucial for protecting the health and safety of both medical staff and the general public. It is therefore imperative to put in place a well-designed radio-diagnostic room, quality X-ray equipment maintained by trained personnel, along with standardized procedures, is vital for minimizing unnecessary radiation exposure while maintaining high diagnostic quality. Additionally, robust shielding measures, such as the use of lead, are essential to confine the X-ray beam to controlled zones and prevent leakage into uncontrolled areas. The findings from Hospital 'A' and Hospital 'B' underscore the need for regular inspections and improvements in radiation protection protocols to safeguard all individuals within these medical facilities.

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Dataset

Dambele, Musa (2024), "Assessment of Radiation Protection Status of the Radiology Departments of Two Selected Secondary Hospitals in Kano Metropolis, Kano State, Nigeria", Mendeley Data, V1, doi: 10.17632/fntnkpdtrc.1

Conflicts of Interest

The authors would like to declare that, there was no conflict of interest during this research work and the publishing of this article

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