ORIGINAL ARTICLE

Assessment of radiation protection practices among radiographers in Lagos, Nigeria

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ABSTRACT

Background: Use of ionising radiation in diagnostic radiography could lead to hazards such as somatic and genetic damages. Compliance to safe work and radiation protection practices could mitigate such risks. The aim of the study was to assess the knowledge and radiation protection practices among radiographers in Lagos, Nigeria. **Materials and Methods:** The study was a prospective cross sectional survey. Convenience sampling technique was used to select four x-ray diagnostic centres in four tertiary hospitals in Lagos metropolis. Data were analysed with Epi- info software, version 3.5.1. **Results:** Average score on assessment of knowledge was 73%. Most modern radiation protection instruments were lacking in all the centres studied. Application of shielding devices such as gonad shield for protection was neglected mostly in government hospitals. Most x-ray machines were quite old and evidence of quality assurance tests performed on such machines were lacking. **Conclusion:** Radiographers within Lagos metropolis showed an excellent knowledge of radiation protection within the study period. Adherence to radiation protection practices among radiographers in Lagos metropolis during the period studied was, however, poor. Radiographers in Lagos, Nigeria should embrace current trends in radiation protection and make more concerted efforts to apply their knowledge in protecting themselves and patients from harmful effects of ionising radiation.

Key words: Attitude, ionisation, protection, radiation, radiographers

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INTRODUCTION

Radiation protection is the science and art of protecting people and the environment from the harmful effects of ionising radiation. It is also described as all activities directed towards minimising radiation exposure of patients and personnel during x-ray exposure.[1] The objective of radiation protection is to define how one can protect individuals, their descendants and the human race against the potential risks of ionising radiation.[2] Fundamental principles of radiation protection are justification, optimisation and time. Based on the understanding of these fundamental principles, exposing only an individual(s) who should derive maximum benefits from such exposures to ionising radiation (justification), making sure that radiation doses as result of medical exposures are only enough to achieve needed diagnoses (optimisation) and reducing the time of exposure to sources of ionising radiation are means of achieving radiation protection. Consequently, uses of immobilisers, positioning aids, beam size (x-ray field) limiting devices, the type and state of x-ray machines are important factors in radiation protection. Furthermore, availability of installed radiation protection instruments such as area radiation monitors, air borne contamination monitors and personnel exit monitors; and portable instruments such survey meters, lead rubber shields and personnel dosimeters for staff and work place monitoring are also essential.[3] Radiation protection measures also include periodic quality assurance checks on the x-ray machine(s).

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Unbridled exposure to ionising radiation had been scientifically proved to cause damages to living tissue such as skin burns and radiation sickness at high exposures (deterministic effects) and also raises the risks of cancer, tumours and genetic damages (stochastic effects) at low exposures.[4] In spite of this, diagnostic uses of ionising radiation have been on the increase globally since x-ray was discovered in 1895. Medical uses of ionising

radiation now contribute >95% of man made exposure to radiation and now ranks only second to natural background radiation.[5,6] With computed tomography (CT) (a known high dose modality) becoming more available in developing nations such as Nigeria, more recent studies show that about 3.6 billion imaging studies per year are carried out world-wide, leading to an increase of 70% in worldwide collective effective dose for medical diagnostic procedures.[7]

The annual maximum permissible dose (MPD) recommended for designated radiation workers by International Commission on Radiological Protection (ICRP) is 20 mSv per year while that of the public is 1 mSv, whereas effective dose to organs/tissues from a single CT scan examination has been suggested to approach or even exceed doses calculated from epidemiological studies which are known to increase chances of deterministic effects.[8]

Whereas improvements on designs of x-machines and x-ray facilities have lead to drastic reductions in personnel doses in the last two decades, patients' doses within the same period actually increased.[9,10] Should radiographers always adhere to radiation protection/ safety protocols in their daily practices, they could protect themselves and patients from deleterious effects of ionising radiation. Regrettably, unwarranted exposures of patients to ionising radiations due to foreseeable and often avoidable circumstances during diagnostic procedures have been reported.[11,12] Reasons adduced for this include poor knowledge of radiation protection and continued use of obsolete x-ray machines.[13-15] Local legislation in Nigeria has recently given impetus to regularization of radiographic practice to conform to international safety standards. Moreover, since auditing of radiographic practice is an internationally recognized part of radiation protection practices,[16] it is imperative to assess both knowledge and compliance to radiation protection practices among Nigerian radiographers in Lagos metropolis.

MATERIALS AND METHODS

This evaluative cross-sectional study was carried out between May and August 2011. Convenience sampling method was used to select five hospitals with the largest concentration of radiographers in Lagos metropolis. Forty-three radiographers (n = 43) who gave consents to participate in the study were recruited. The selected hospitals were Lagos university teaching hospital (LUTH), Lagos state university teaching hospital (LASUTH), Eko hospitals plc (EKO), Mecure diagnostic centre and Reddington hospital. LUTH and LASUTH are government owned tertiary health institutions, while the rest are privately owned.

Only radiographers in the five centres who are licensed by radiographers' registration board of Nigeria (RRBN) to practice radiography in Nigeria and who are practicing conventional radiography were included.

Radiographers engaged in ultrasonography, Computed tomography (CT) and magnetic resonance imaging (MRI) were not recruited. Also excluded were students on clinical postings/ attachments and very senior radiographers who are engaged in administrative duties.

Semi-structured, self administered questionnaires were used in collecting data. An inventory was taken of all radiation protection kits such as lead rubber aprons, gonad shields etc and personnel radiation monitors such as film badge dosimeters in all the centres before data collection began. All X-ray machines were visually inspected and test exposures carried out on them by one the authors to ascertain their functional statuses. Year of manufacture of each x-ray tube, statuses of light beam diaphragms, KV and mA selectors as well as availability of automatic exposure controls (AEC) and records of quality assurance tests were all checked and recorded.

To obtain an unbiased assessment of radiation protection practices among radiographers studied, one of the authors posed as a student to conceal his identity so as to be able to observe the radiographers while they worked. The rationale behind the use of an unidentified observer was explained and radiographers consented to that before the study started, although some radiographers gave their consent only when assured that the result of the study shall be made known to them. Observations made in each centre were ticked off in an assessment chart prepared for that purpose.

Knowledge was assessed based on radiographers' understanding of risks associated with diagnostic use of ionising radiation as well as measures to adequately protect themselves, patients and the public from such risks. Radiation protection practices were assessed by observing the availability and use of protective kits such as gonad shields, immobilizers, ray field limiting devices such as light beam diaphragm (LBD), display of x-ray warning signs and exclusion of early cyesis among women of child bearing age prior to exposure of their pelvis to radiation by adhering to the 10-day rule.

Knowledge shall be assumed to be poor if respondents' average score on seven questions used to assess knowledge is <50%. Their radiation protection practices shall be assumed to be poor if basic radiation protection kits such as lead rubber aprons, gonad shields, personnel radiation monitors such as film badges etc are lacking in all the centres. Furthermore, if these basic kits are available but are not adequately utilised, practices shall also be assumed to be poor. Moreover, if modern methods of radiation

protection such as use of pulsed fluoroscopy machines, special paediatric immobilisers and digital radiography machines are not available and if gonads shields are not correctly used when x-raying areas adjacent to the pelvis of women of child bearing age, radiation protection practices shall be assumed to be poor.

Data analysis

Data were tallied and analysed in line with specific objectives of the study. Computer programme-EPI info software version 3.5.1. was used for data analysis. Descriptive statistics such as percentage was used in analysing responses while results were presented in tables.

RESULTS

Forty (n = 40) radiographers of whom 15 (n = 15) were males and 25 (n = 25) were females completed and returned the questionnaires distributed to them (93.0% return rate). The average working experience of the respondents ranged between 1 year and 17 years. Thirty-five percent (35%) of the respondents work at the Lagos university teaching hospital [Table 1]. Thirty-seven respondents (92.5%) in the five centres indicated that they know that increase in KV increased the energy of the x-ray beam and thus reduces both skin and absorbed doses [Table 2], while 28 respondents (70%) agree that uses of light beam diaphragm (LBD) to reduce field size and positioning aids such as immobilisers and straps, especially in paediatric radiography,[16] are indispensable in radiographic practice. Thirty-four respondents (85%) know that justification and optimization are essential principles in radiation protection, while 30 respondents (62.5%) believe there is a need for diagnostic x-ray facilities to have written 'operating procedures and local rules to serve as guides for radiographers. Thirty respondents (63%) said that a radiologist is statutorily responsible for ordering the repeat of radiographs adjudged to be of sub-optimal diagnostic quality whereas 34 respondents (85%) believe that quality assurance tests on x-ray machines and accessories are essential parts of radiation protection practices. Twenty-one respondents (53%) said that all designated personnel must wear radiation monitoring badges while working.

Respondents reported availability of high output x-machines, conventional fluoroscopy machines and of such kits as lead rubber aprons, gonad shields, thyroid shield shields, mobile lead screens in all five centres. Special paediatric straps were, however, not available in all the centres [Table 3].

On independent observation, it was found that radiographers in both LUTH and LASUTH do not wear dosimeters while those in Eko, Mecure and Reddington (all privately owned) hospitals did wear their dosimeters [Table 4]. The 10-day rule was used in all the centres as a guide in booking appoints for x-ray investigations of pelvis of women of child bearing ages. However, only radiographers at Eko, Mecure and Reddington made use of

Table 1: Distribution of respondents by hospital

Hospital	Frequency	Percentage
LUTH	14	35.0
LASUTH	8	20.0
Eko PLC	5	12.50
Mecure	5	12.50
Reddington	8	20.0
Total	40	100.0

LUTH – Lagos university teaching hospital; LASUTH – Lagos state university teaching hospital

Table 2: Evaluation of knowledge in radiation protection

	Luth	Lasuth	Eko	Mecure	Reddington	Total (%)
Use of high KV reduces skin/absorbed dose	13	7	4	5	8	35 (87.5)
Use of immobilisers is indispensable	10	7	3	3	7	30 (75)
Knowledge of justification and optimisation	12	8	5	4	5	34 (85)
Operating procedures and local rules must be written down	6	4	2	3	3	18 (45)
Repeat of paediatric and complex X-ray procedures at the instance of the radiologist only	11	4	3	5	5	30 (75)
QA is an essential part of radiation protection	10	8	3	5	8	34 (85)
Personnel and environmental radiation monitoring are indispensable	4	3	3	3	8	22 (55)

Table 3: X-ray equipment and radiation protection devices in the five centres

	Luth	Lasuth	Eko	Mecure	Reddington
High output units (static and mobile)	Available	Available	Available	Available	Available
Digital Radiography	Not available	Not available	Not available	Not available	Not available
Pulsed Fluoroscopy	Not available	Not available	Not available	Not available	Not available
Conventional Fluoroscopy	Available	Available	Available	Available	Available
Protective lead barriers	Available	Available	Available	Available	Available
Special paediatric immobilisers	Not available	Not available	Not available	Not available	Not available

Table 4: Observed radiation protection practices

	Luth	Lasuth	Eko	Mecure	Reddington
Radiation dosimeters are worn	No	No	Yes	Yes	Yes
Cyesis always ruled out among women	Yes	Yes	Yes	Yes	Yes
Gonads always protected	No	No	Yes	Yes	Yes
QA tests routinely done	No	No	No	No	No
Radiation safety officer available	No	No	No	No	No
Radiation warning signs available	Yes	Yes	Yes	Yes	Yes
Radiation warning written in local languages	No	No	No	No	No

gonad shields when examining anatomical areas adjacent to the pelvis of women in the above category.

There was neither a quality assurance regime nor a designated trained radiation safety officer in any of the five centres. While there are radiation warning signs and red lights to indicate when exposures are in progress in all the centres, there were no written warnings in the local languages of the people [Table 4].

DISCUSSION

The use of ionising radiation for diagnosis could have slight chances of damage to living tissues. Provided protection measures are implemented, risks associated with diagnostic use of ionising radiation could be minimised.[15] Radiographers in Lagos, Nigeria, exhibited a very good understanding of the issues pertaining to radiation protection. They scored an average of 73% in the assessment of their radiation protection knowledge. This is better than what was reported in a similar study in England (United Kingdom) which found knowledge of radiation protection issues among radiographers in that country to be poor.[14] Of particular interest is respondents' understanding that only a consultant radiologist should statutorily request the repeat of all presumably suboptimal radiographs, including paediatric cases. This agrees with international requirement on radiation protection of paediatrics as well as recommendations of Nigeria nuclear regulatory authority (NNRA) on radiation protection.[16]

Optimisation of exposures, for instance, is a function of in-depth knowledge and adherence to written down operating procedures. While it is conceded that most radiographers, by reason of their training, job experience and continuous professional development as highlighted by Davies *et al.,*[17] are usually conversant with optimal exposure factors in their centres, some, especially the newly employed ones may not be. This, therefore, makes availability of written exposure charts indispensable especially in centres where manual selection of exposure factors is still in vogue. Use of exposure charts reduce selection of sub optimal exposures that often result in repeat of exposures and is, therefore, recognised as radiation protection measure. Since only 45% of respondents [Table 3] believe that written guidelines such as exposure charts is necessary in a country where most x-ray machines are obsolete (some x-ray tubes were more than 10 years old while others were more than 25 years old) and where automatic exposure control (AEC) devices are non-existent, it is plausible to infer that patients may have been unnecessarily subjected to avoidable irradiation risks.

X-ray machines in the five centres were high output static and mobile types. High output x- ray units are desirable as they allow selection of both high Kilovolts (KV) from 70 Kv and above and short exposure times (milliseconds) needed to reduce both skin and absorbed doses. Selection of high Kv to produce more energetic beam of x rays, according to Yau Idris (Practice specific Regulations for Medical exposure; National Institute of Radiation protection and research: Training course for Radiation safety officers in diagnostic and interventional Radiology; course material; pp 51-56), is an internationally accepted radiation protection practice. Desirable as use of high KV may appear, a major constraint of such technique is radiation dose creep. This is a gradual build up of dose parameters following sustained preference of high KV over low KV to reduce absorbed and skin doses. According to Schaefer-Prokop *et al.,*[18] consideration of the effect of dose creep is very important if multiple follow-up serial examinations for critically ill patients and vulnerable groups such as children are contemplated.

Radiographers can, however, only be sure of the outcome of any combination of exposure factors selected if x-machines undergo periodic quality assurances checks. This is even more vital if such machines are old such as were found in the study (they were between 10 years and 25 years old in government centres and between 10 years and 15 years old in private centres). Majority (85%) of respondents claimed to have quality assurance programmes included in their *radiation* protection practices whereas no evidence exists to buttress such claims. Furthermore, none of the centres had a resident or consultant medical physicist during the study period. Continued use of obsolete x-ray equipment seems to be a common problem with developing countries as Muhogora *et al.,* also reported the same scenario in Tanzania. In their study, they reported that obsolete x-ray machines with no record of quality assurance tests being carried out on them were still in use in that

country.[15] This situation runs counter to extant national and international requirements.[19] It can, therefore, be said that radiographers in Lagos metropolis neglected an essential aspect in radiation protection practices within the period studied.

Available fluoroscopy machines in all the centres within the study period were of the conventional type, whereas pulsed fluoroscopy enhances radiation protection. Furthermore, none of the centres has acquired digital x-ray machines or adapted their old x-ray machines to digital. During pulsed fluoroscopy, x-rays are delivered in pulses that follow each other in rapid successions with radiation-free gaps that ensure that the dose is significantly reduced. Digitisation, on the other hand, allows for post processing of images during which image contrast could be manipulated to ensure that repeat of exposures due to sub optimal exposures are reduced.[19,20] Why these systems have not been embraced in Lagos metropolis may not be unconnected with paucity of funds which is often the bane of many health systems in developing nations such as Nigeria. However, the situation does imply that a lot still needs to be done to realign radiation protection practices in Lagos metropolis to more current standards.

While protective barriers such as gonad shields, leaded screens and lead rubber aprons were available in all the centres, none of the centres had any special paediatric immobilisers. Children, by nature, are restless and apprehensive in most hospital environments and so they require special care and immobilisation during radiography to prevent motion blurring of images. Since use of immobilisation devices such as mummy sheet, pig-o-stat and other special paediatric straps, according to Cook, are considered necessities in radiation protection of children.[21] It is, therefore, not out of place to assume that children in Lagos, Nigeria may undoubtedly have received unnecessary exposures to radiation due to possible repeat exposures over the years.

In spite of excellent knowledge found among radiographers in the study, it was observed that only radiographers in the private hospitals appropriately used protection devices such as gonad shields when it is necessary. In particular, gonad shields were available in all the centres studied but were either deliberately or inadvertently ignored in government hospitals. It is mandatory, according to ICRP radiation safety standards,[20] for gonads shields to be used for the protection of the gonads when the pelvis is not part of the anatomical area being examined. Their use is more essential when women of child bearing age in whom early cyesis is suspected come for x-ray examinations. A possible explanation of this rather poor attitude exhibited by radiographers in government hospital may be that since regulatory agencies appear not take supervision of radiation protection practices seriously, then there is no fear of possible sanctions among radiographers who compromise radiation safety standards in the country. Furthermore, discrepancies were noted between the numbers of radiation protection devices such as sand bags, gonad shields, mobile lead screens etc. declared by radiographers in government hospitals compared to such items observed. This was not the case in private centres. We believe that this result could only have been a ploy among radiographers in government hospitals not to expose the dearth of such essential protection kits in their centres. In any case, it points to a better commitment to radiation protection practices by radiographers in private hospitals and that unfortunately, most radiographers in government hospitals in Lagos, Nigeria were rather unmindful of well documented somatic and genetic effects of ionising radiation.[15]

Personnel radiation monitoring is essential to ensure that annual permissible dose limits are not exceeded. There were no area and air borne radiation monitors in any of the centres studied. Furthermore, only 50% of respondents were observed to wear radiation dosimeters during the period studied. This was rather an attitudinal issue as it was found out in the course of this study; dosimeters were supplied to all radiographers in all the centres studied. Eze *et al.,*[2] reported a better attitude to wearing radiation dosimeters among a sample of industrial radiographers in Port-Harcourt, Nigeria. In spite of reported decline in personnel exposures due to improvements on knowledge, departmental and equipment designs,[9,10] possibility of occupational exposure, according to Eze *et al.,*[2] still exists. Since no radiographer should ever lose sight of this fact, radiographers who refuse to wear dosimeters as was found among most radiographers in Lagos, Nigeria, for whatever reason, stand the chance of unwittingly exceeding their recommended annual maximum permissible doses of dose limits of 20 mSv averaged over a 5-year period for designated radiation workers[8] without ever knowing what has happened.

CONCLUSION

Radiographers in Lagos, Nigeria, demonstrated a good knowledge of hazards associated with diagnostic use of ionising radiation and also of protection mechanisms from such hazards. Their knowledge, however, had little impact on radiation protection practices which were found to be poor. Radiographers in government hospitals were generally apathetic to radiation protection practices. Were we able to cite an incidence of radiation induced ailments in the country, it could have improved the quality of the study. Furthermore, the small sample size used in the study may affect its quality. Functional states of obsolete x-ray machines studied were not assessed beyond visual inspection due to dearth of medical physicists in the

country. However, based on our results and on reviewed literature, it is recommended that:

1. All centres working with ionising radiation should ensure a strict adherence to radiation safety practices to protect radiographers, patients and the public from harmful effects ofionising radiation.
2. Periodic quality assurance tests should become mandatory in all diagnostic x-ray facilities in the country.
3. The Nigerian national assembly should amend laws guiding diagnostic use of ionising in Nigeria to make them more effective.
4. Since knowledge alone, though very important, cannot translate to adequate radiation protection, radiographers must, therefore, update their knowledge often to include the most current trends in radiation protection and then make more concerted efforts to follow existing radiation protection protocols in their daily work routine.

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