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*Full Length Research Paper*

# Nurses knowledge of ionizing radiation and radiation protection during mobile radiodiagnostic examinations

**Samuel Anim-Sampong*, Samuel Yaw Opoku, Patience Addo, Benard Ohene Botwe**

Department of Radiography, University of Ghana School of Biomedical and Allied Health Sciences, College of Health Sciences, P.O. Box KB 143, Korle Bu, Accra, Ghana
*Corresponding author's email: tychicus77@gmail.com

**Abstract**

**Ionizing radiation is used extensively in the field of medicine for either diagnosis or treatment. Hence, an understanding of radiation safety principles and how to apply them in practice is critical for nursing practice. The study was performed to assess nurses' knowledge of ionizing radiation and radiation protection during mobile radiodiagnostic examination. A quantitative, descriptive cross-sectional survey was employed for this study to provide better means of investigating and assessing the knowledge, misconceptions and perceptions among 43 nurses assigned to clinical rotations in selected wards of the Korle-Bu Teaching Hospital regarding ionizing radiation and its radiation protection. A purposive sampling method using self-administered questionnaires was used to obtain data in respect of the study. The obtained data was analyzed using SPSS version 16.0. Out of the population of 43 nurses, 25.6% (*n*=11) were of the view that objects in the X-ray room emitted radiation after an x-ray exposure and the same percentage indicated that dangerous radiation is emitted from good quality microwave equipment. Also, 37.2% (*n*= 14) presumed that patients emitted radiation after an x-ray examination, while 60.5% (*n*=26) were of the opinion that magnetic resonance imaging (MRI) procedure was a source of ionizing radiation. The majority of nurses have inadequate knowledge and mistaken beliefs about various aspects of radiation sources and its protection. A course on radiation and radiation safety principles for nurses is thus recommended.**

**Key words:** Nurses, ionizing radiation, radiation protection, exposure, biological effects

## LIST OF ABBREVIATIONS

NICU - Neonatal Intensive Care Unit
MRI - Magnetic resonance imaging
LET - Linear energy transfer
HVL - Half-value layer
ALARA - As low as reasonably acceptable

## INTRODUCTION

Medical imaging is currently one of the routine and developing methods in medical diagnostics using advanced mobile and fixed imaging facilities. It is estimated to constitute about 30% to 50% of critical decisions in medical approaches (Abadi, 2000). Though exposure to scattered ionizing radiations or x-rays is encountered during mobile x-ray examinations, the scattered radiations are of lower intensity than the primary x-ray beam. The associated radiation damage or biological effects, however, of low level exposure to ionizing radiation are of a concern and could be reduced by several approaches including procedural (time/ distance, dose monitoring) and physics and engineering (x - ray shielding, radiation protection, etc) controls

(Soares et al., 2011; Reiman, 2006). According to the physics, the degree of radiation damage suffered by an individual exposed to ionizing radiation during medical imaging is a function of several factors such as type and chemical form of the radiation, intensity of the radiation flux (related to the amount of radiation and distance from the source), energy, and duration of exposure.

The damaging biological effects of radiation to living organisms categorized as stochastic and non-stochastic (deterministic) are principally due to radiation overexposures in work places including hospitals as noted by Wrixon (2008) and Ward (2009). Deterministic effects are dose related for which the severity of the effects increases with radiation dose, and are seen above a baseline threshold dose determined by factors such as type of effect and the developmental stage of the organism. According to the American Council of Radiology (ACR) (2010), they are observed only if relatively large doses are applied and multiple cells are involved. Thus severity of deterministic effects increases with increased radiation dose above the threshold. Stochastic effects can result from induced changes in single cells and can potentially result in neoplasia or in changes to reproductive genes. In contrast to deterministic effects, the severity of a stochastic effect does not increase as the radiation dose increases. Stochastic effects are believed to be possible at any level of radiation exposure, with the likelihood increasing as dose increases (American Council of Radiology (2010). According to the International Commission on Radiological Protection (ICRP) (2007), the probability that stochastic radiation damage will occur differs widely for the irradiated individual organs or tissues.

Radiation protection has been defined by Statkiewiczet et al., (2002) as effective measures employed by radiation workers to safeguard patients, personnel and the general public from unnecessary exposures to ionizing radiation. The ICRP clearly defined the overall objective of radiation protection and stated its purpose as providing an appropriate standard of protection for man without unduly limiting the beneficial practices giving rise to radiation exposure, and further suggested that current standards of protection are intended to avert the occurrence of deterministic effects through procedures such as ALARA (As low as reasonably acceptable) and below relevant thresholds and ensuring that all reasonable steps are engaged to reduce stochastic effects (Holmberg et al., 2010). This is one of two triads of radiation safety to provide guidelines for safe uses of radiation in health care. The second triad of radiation safety generally referred to as the *time-distance-shielding* approach of radiation protection consists primary actions implemented through good practices to provide occupational radiological protection, medical radiation protection (patients), public radiation protection from potential risks of radiation (Bushong, 2001).

**Basic Physics**

X-rays are very penetrating electromagnetic (EM) radiation with a capacity to cause low ionization rates/cm travel in matter, and do not readily give up energy. They are low linear energy transfer (LET) ionizing radiation and hence are less damaging to human tissues. From the physics, the interaction of a beam of x-ray photons with human tissues is described by the Beer-Lambert exponential relationship which defines the number of incident x-ray photons *(No)* and those that are transmitted *(N)* through a tissue of thickness *x* without interaction (Bushong, 2008; Mattews and Brennan, 2008)

$$N = N_o e^{-\mu x} \qquad (1)$$

where $\mu$ is the linear attenuation coefficient for a type of physics interaction. Since the x-rays interact with tissues under different physics interaction (reactions) mechanisms, the linear attenuation coefficient also called macroscopic cross section is defined for each interaction type *i*. In particular, $\mu$ is a statistical quantity and is the probability per unit differential path length of travel that an x-ray photon undergoes a type of physics interaction, in the limit of small path lengths.Hence the probability per unit path length $\mu_t$, that a neutral x-ray photon undergoes a physics interaction with a tissue in the body during imaging is the sum of the energy-dependent probabilities per unit path length of travel for each type of possible interaction (Rayleigh scattering, photoelectric effect, Compton scattering, pair production).

$$\mu_t(E) = \sum_i \mu_i(E) \qquad (2)$$

i.e,

$$\mu_t = \mu_{Rayleigh} + \mu_{photoelectric} + \mu_{Compton} + \mu_{pair\ production} \qquad (3)$$

The interaction probability *P(x)* that a particle interacts along a depth (path length) *x* is

$$P(x) = 1 - \frac{N(x)}{N_o(x)} = 1 - e^{-\mu_t x} \qquad (4)$$

From this, the probability distribution for estimating the distance of travel for the x-ray photon in the tissue can be calculated via

$$p(x)dx = e^{-\mu_t x}(1 - \mu_t dx) = \mu_t e^{-\mu_t x} dx \qquad (5)$$

Invoking on the requirement for proper probability distribution functions (Eqn. 6),

$$\int_0^\infty p(x)dx = 1 \qquad (6)$$

The mean free path or average distance $\bar{x}$ traveled by the neutrally-charged x-ray photon beam to the tissue sites before interaction is

$$\bar{x} = \int_0^\infty xp(x)dx = \mu_t \int_0^\infty e^{-\mu_t x} dx = \frac{1}{\mu_t} \qquad (7)$$

In the diagnostic energy range, the linear attenuation coefficient decreases with increasing energy except at absorption edges. For a given thickness of tissue, the probability of x-ray interaction depends on the number of atoms encountered per unit distance which is related to the tissue density (*ρ*) the material affects this number. The Beer-Lambert formalism then changes in terms of the tissue's mass attenuation coefficient (*m*), density (*ρ*) and radiological depth (*ρx*) as

$$N = N_o e^{-\mu x} = N_o e^{-\left(\frac{\mu}{\rho}\right)\rho x} = N_o e^{-m\rho x} \qquad (8)$$

The x-ray beams applied in radiodiagnostic imaging of anatomical regions of the body are typically poly energetic, consisting of a spectrum of energies. The effective energy of the poly energetic x-ray beam is basically an estimate of the penetration power of the x-ray beam, as if it were a monoenergetic beam that had the same penetrating ability or half-value layer (HVL) as the spectrum of photons. In particular, the HVL is determined to characterize the hardness of the x-ray beam and can be calculated in respect of the mean free path as

$$\bar{x} = \frac{1}{\mu_t} = \frac{1}{\left(\frac{\ln 2}{HVL}\right)} = 1.44HVL \qquad (9)$$

The x-ray photon flux (*Φ*) or flue cerate is an important and particularly useful physics quantity in imaging modalities such as areas as fluoroscopy where the photon beam is available for extended periods of time.

The energy fluence (*Ψ*) is the amount of radiation energy passing through a unit cross-sectional area of tissue and is the product of the fluence (*Γ*) and the energy per photon (*E*) for a monoenergetic beam of photons, i.e.

$$\Psi = \Gamma E = \Phi E t \qquad (10)$$

During the interaction of a beam of indirectly ionizing radiation x-rays in tissue, radiation energy is deposited in a two-stage process which involves the transformation of photon energy into kinetic energy of charged particles (such as electrons) via the photoelectric effect, Compton effect, and, for very high energy photons, pair production. In the second stage, the energy of the directly ionizing charged particles is deposited in the tissue by excitation and ionization. In particular, x-ray energies employed in diagnostic radiology for absorbers of low atomic number such as tissues, the energy deposited (*dE*) per unit mass (*dm*) of the tissue which is the absorbed dose ($D_{abs}$) is quantitatively estimated as

$$D_{abs} = \frac{dE}{dm} = \Psi\left(\frac{\mu_{en}}{\rho_t}\right)_E \qquad (11)$$

where $\mu_{en}$ and $\rho_t$ are the mass energy absorption coefficient and mass density of the tissue. The product of the absorbed dose ($D_{abs}$) and the radiation weighing factor is the equivalent dose *(H):*

$$H = D_{abs} W_R = D_{abs} Q_f N \qquad (12)$$

where $Q_f$ and *N* are the quality factor and a number of representing the product of all modification factors respectively.The sum of the products of the equivalent dose to each organ or tissue irradiated ($H_T$) and the corresponding factor ($W_T$) for that organ or tissue is called the *effective dose (E) and* expressed mathematically as

$$D_{eff} = \sum W_T H_T \qquad (13)$$

From the physics, the intensity or exposure rate (*I*) of imaging equipment such as an x-ray mobile machine applied in imaging procedures in a hospital and the radiation exposure (*X*) are functions of the imaging parameters and governed by the inverse square respectively, i.e

$$I \propto \frac{V^2 Zi}{d^2} \qquad (14)$$

$$X = \frac{V^2 Zti}{d^2} = \frac{dQ}{dm} \qquad (15)$$

where *V, i, Z, t and d* are the applied tube voltage, tube current, target atomic number, exposure time and distance of the target material, and *dQ* is the electrical charge produced by ionizing radiation per mass *dm* of air. Shielding involves the use of radiation attenuating materials of high absorption cross sections and is a major factor in reducing the risk of radiation exposure. The amount of shielding required for radiation protection is dependent on the x-ray beam energy.

In particular, effective shielding generally increases with mass density and attenuates the radiation exposure rate exponentially depending on the thickness of the shield which is often located between a patient or occupational worker and the direction of radiation beam travel. The half-value layer is a standard measure of the effectiveness of a shielding material. Thus, if $I_o$ is the incident x-ray intensity on the shield material, then the intensity $I$ of transmitted radiation through the shielding material of thickness $x$ can be computed from via Eqn. (16):

$$I = I_o\left(\tfrac{1}{2}\right)^{x/HVL} \quad (16)$$

It has been reported in the literature that shielding in medical radiography is often achieved by wearing leaded aprons, leaded thyroid shields, and leaded eyeglasses and are employed for gonadal shielding, personnel shielding, room shielding, and x-ray tube shielding (Ward, 2009; Bushong 2001).

## Role of Nurses

Since radiation is used extensively in the field of medicine for either diagnosis or therapy it is the responsibility of healthcare professionals to provide first hand information to the patients undergoing all radiological procedures and processes (Harrison and Day, 2008). However, despite the extensive use of such radiodiagnostic examinations in healthcare practice in hospitals, most non-radiologic health professionals including nurses are academically uninformed and professionally unaware of the radiological damage and modes of protection associated with the use radiation in medical imaging. Rassin et al., (2010), argued that understanding of radiation and its exposure risks was limited to a selected highly trained population of health professionals excluding nurses.

The role of nurses in mobile imaging procedures is therefore important as they particularly assess, prepare, or monitor patients during and after different radiodiagnostic procedures (Campeau and Fleitz, 2010). Unfortunately, just like all occupational workers, radiology nurses are vulnerable to the damaging effects of radiation (Miracle and Wigginton, 1990; Barr and Schiska, 2005). In the literature, it is suggested that nurses can reduce the risks of radiation by applying the established principles of radiation protection such as ALARA, the 10-day rule, the three cardinal principles (time, distance, and shielding), as well as wearing of protective clothing and dosimeters in their practice (Ward, 2009; Bushong, 2001; Mattews and Brennan, 2008; Saia, 2003).

Radiology nurses are also required to ensure radiation safety and protection to patients by providing a full explanation of the procedure to the prospective patient. Thus, the nurse has a key role to play as the patient's advocate once a radiation procedure is underway as indicated by the Institute of Physics and Engineering in Medicine (IPEM) in association with the Royal College of Nursing (RCN) (2002). Nurses work in the radiation team to care for patients during the course of treatment. They also help in patient evaluation before treatment begins and may talk to the patient about potential side-effects and their management (Australasian Rehabilitation Nurses' Association, 2011).

In Ghana, these observations raise serious concerns and require investigating associated issues such as the extent to which radiation protection are taught in the nurses' training curriculum, existence of in-hospital education and training on radiation protection, whether nurses have any knowledge of radiation damage and risks prior to radiographic examinations, and whether nurses have awareness or a sense of clinical competence with respect to providing assistance during mobile radiodiagnostic imaging of patients. Asmundsdottir and Kaplan (2000) have underscored the importance of such studies and indicated that empowering nurses with sufficient and precise knowledge regarding different aspects of radiation protection was particularly helpful in communicating correct information to the patients undergoing radiological procedures. This study was therefore performed to assess nurses' knowledge and perception about radiation protection measures during mobile radiographic procedures in Ghanaian hospitals.

## METHODS

This study was conducted using indices such as nurses' basic knowledge and understanding of ionizing radiations and associated hazards, investigation of nurses' clinical competence towards responding to radiological procedures, as well as their perception of personal safety and its impact on the willingness to be present during such procedures. Other objectives included examination of the misconceptions held by nurses about exposure risks that could potentially affect health care decisions, and promoting the nurses knowledge about ionizing radiation and instructions in self-protection from exposure to radiation through education.

In accordance with the suggestions of Carter (2000) and Gray (2004) a quantitative, descriptive cross-sectional survey using purposive non-probability sampling method was employed in this study. The study was conducted at the Neonatal Intensive Care Unit (NICU), Surgical Theatres and Surgical Intensive Care Wards of the Korle-Bu Teaching Hospital ( KBTH) in

**Table 1:** Response rate, gender and age distribution of respondents

| Category of respondents | No. of respondents | | % Participation | | | Response rate (%) |
|---|---|---|---|---|---|---|
| Registered (practising) Nurses | 21 | | 48.8 | | | |
| Clinical Nursing Students | 22 | | 51.2 | | | |
| Actual number of respondents | 43 | | 87.8 | | | 87.8 |
| No. of abstaining nurses | 6 | | 12.2 | | | 12.2 |
| **Total** | **49** | | | | | **100** |
| Gender of respondents | **Age of respondents (yrs)** | | | | | **Total** |
| | **18-23** | **24-29** | **30-35** | **36-41** | **>41** | |
| Males (No., %) | 1 (2.3%) | 1(2.3%) | 2 (4.7%) | 1 (2.3%) | 0 (0.00%) | 5 (11.6%) |
| Females (No. %) | 15 (35.0%) | 7 (16.3%) | 8 (18.6%) | 3 (6.9%) | 5 (11.6%) | 38 (88.4%) |
| Total | 16 (37.2%) | 8 (18.6%) | 10 (23.3%) | 4 (9.3%) | 5 (11.6%) | 43 (100%) |
| | | **Professional qualifications of respondents** | | | | |
| Work status of respondents | | **Certificate** | **Diploma** | **Degree** | **Total** | |
| Registered Practitioners | Frequency | 4 (9.3%) | 8 (18.6%) | 9 (20.9%) | 21 (48.8%) | |
| Clinical student nurses | Frequency | 2 (4.7%) | 20 (46.5%) | 0 (0.0%) | 22 (51.2%) | |
| **Total** | Frequency | 6 (14.0%) | 28 (65.1%) | 9 (20.9%) | 43 (100%) | |

Accra, Ghana where frequent mobile radiodiagnostic services are required. A sample size of 43 subjects from a population comprising all in-patient staff registered nurses, theatre ward nurses as well as student nurses performing clinical rotations was used. The study was piloted with 5 nurses (excluded from the sample size) to test the reliability, validity and the ambiguity of the questionnaire for purposes of ensuring the clarity of format and adopted designs (McQuillen-Martensen, 2006). An 87.8% response achieved in the pilot did not require modifications as proposed by (Gillies, 2002).

## RESULTS

### Demographics

Forty three out of the initial population of 49 nurses (6 abstentions) recruited for the study 43 agreed (to participation, yielding a net response rate of 87.8%. A main reason for the relatively small sample size is that many nurses working at the study sites at the time of the study expressly indicated lack of relevant knowledge about ionizing radiation and radiation protection and hence declared their unwillingness to participate. The number of practicing nurses (*n*=21, 48.8%) were marginally lower than the clinical nursing students (*n*=22, 51.2%). Expectedly, the majority (*n*=38, 88.4%) of the respondents were females due the higher population of female nurses in Ghana. Over 37.2% (*n*=16) of the respondents were aged 18-23 years. Academically, over 65% (*n*=28) of the population had diploma qualifications while 21% (*n*=9) practiced with higher (degree) qualifications.

Knowledge of radiation and radiation protection is paramount for all occupational radiological workers. Although nurses are professionally are non-occupational healthcare workers, their duties however include handling of patients referred for radiodiagnostic examinations.

Specific to nurses working in these study sites, their lines of duty brings them into contact with mobile diagnostic imaging facilities for which knowledge of radiation protection is required for ensuring effective occupational, medical and public radiation protection. A knowledge assessment of the subject was therefore performed to measure the nurses' ability to explain ionizing radiation terminologies. The results are presented in Table 2.

Basic knowledge in radiation physics is essential to understanding the factors affecting the degree and nature of ionization in respect of radiation safety and protection in radiodiagnostic

**Table 2:** Knowledge assessment index and nurses responses

| Responses on definition of simple/common IR terminologies | Frequency | Percentage |
|---|---|---|
| Use of machines for medical examination purposes that emit harmful rays and have an effect on the body | 4 | 9% |
| Form of electromagnetic radiation that cause ejection of electrons | 2 | 5% |
| Emanation of energy in the form of electromagnetic radiation | 2 | 5% |
| Radiation that is hazardous and cannot be seen | 1 | 2% |
| Energy emitted from a particular source | 4 | 9% |
| Emission of x-rays for diagnostic purposes | 6 | 14% |
| Natural and manufactured radiation containing energy capable of breaking chemical bonds and causing cellular damage | 4 | 9% |
| No response | 20 | 47% |
| Total | 43 | 100% |

| Assessment index | Assessment Value | Frequency | Percentage |
|---|---|---|---|
| Don't know | 0 | 20 | 47% |
| Poor | 1 | 7 | 16% |
| Average | 2 | 10 | 23% |
| Above average | 3 | 0 | 0% |
| Good | 4 | 6 | 14% |
| Very good | 5 | 0 | 0% |
| Total | | 43 | 100% |

**Table 3:** Respondents knowledge on identification and characteristics of ionizing radiation

| Identification of ionizing radiation | Identification of ionizing radiation | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Yes | | No | | No response | | Total | |
| | No. | % | No. | % | No. | % | No. | % |
| Radio waves | 18 | 41.9 | 14 | 32.6 | 11 | 25.6 | 43 | 100.0 |
| Microwaves | 20 | 46.5 | 10 | 23.3 | 13 | 30.2 | 43 | 100.0 |
| Infrared | 26 | 60.5 | 6 | 14.0 | 11 | 25.6 | 43 | 100.0 |
| X-rays | 41 | 95.3 | 0 | 0.0 | 2 | 4.7 | 43 | 100.0 |
| Gamma rays | 36 | 83.7 | 2 | 4.7 | 5 | 11.6 | 43 | 100.0 |
| | **Characteristics of ionizing radiation** | | | | | | | |
| Directly detectable by human senses | 7 | 16.3 | 18 | 41.9 | 18 | 41.9 | 43 | 100.0 |
| Hazardous irrespective of distance from the source | 31 | 72.1 | 4 | 9.3 | 8 | 18.6 | 43 | 100.0 |
| Causes ionization and induces biological effect | 23 | 53.5 | 2 | 4.6 | 18 | 41.9 | 43 | 100.0 |
| Travels in a sinusoidal directions | 16 | 37.2 | 5 | 11.6 | 22 | 51.2 | 43 | 100.0 |
| Influence of radiation energy on degree of ionization and biological damage | 29 | 67.0 | 3 | 7.0 | 11 | 26.0 | 43 | 100.0 |
| Influence of radiation flux on degree of ionization and biological damage | 26 | 61.0 | 7 | 16.0 | 10 | 23.0 | 43 | 100.0 |

imaging procedures. The results of the nurses' knowledge on identification of ionizing radiation, influence of radiation energy and particle flux on degree and nature of ionization are shown in Table 3 above and Figure 1 below. In assessing the nurses' knowledge, 95.3% (*n*=41) identified x-rays as ionizing but were unfamiliar with other types of ionizing radiation while 47% (*n*=20) indicated no knowledge of the subject and hence could not provide any explanation. Whereas 37% (*n*=16) were adjudged to have average knowledge, 16% (*n*=7) were graded poor. No nurse was graded as having very good of the subject Over 16% (*n*=7) of the participants indicated that ionizing

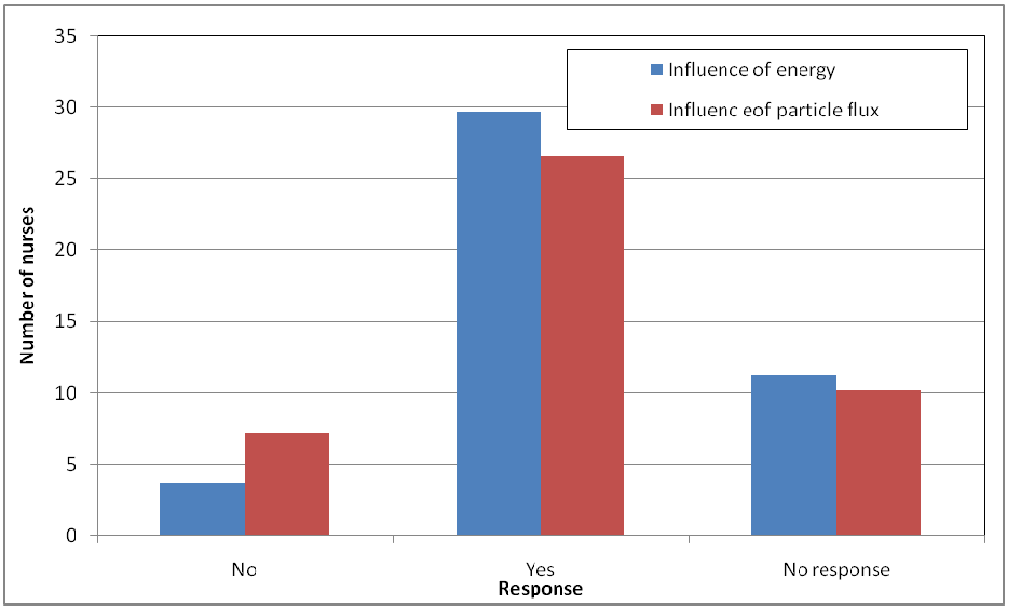


**Figure 1:** Influence of radiation energy and particle flux on degree and nature of ionization

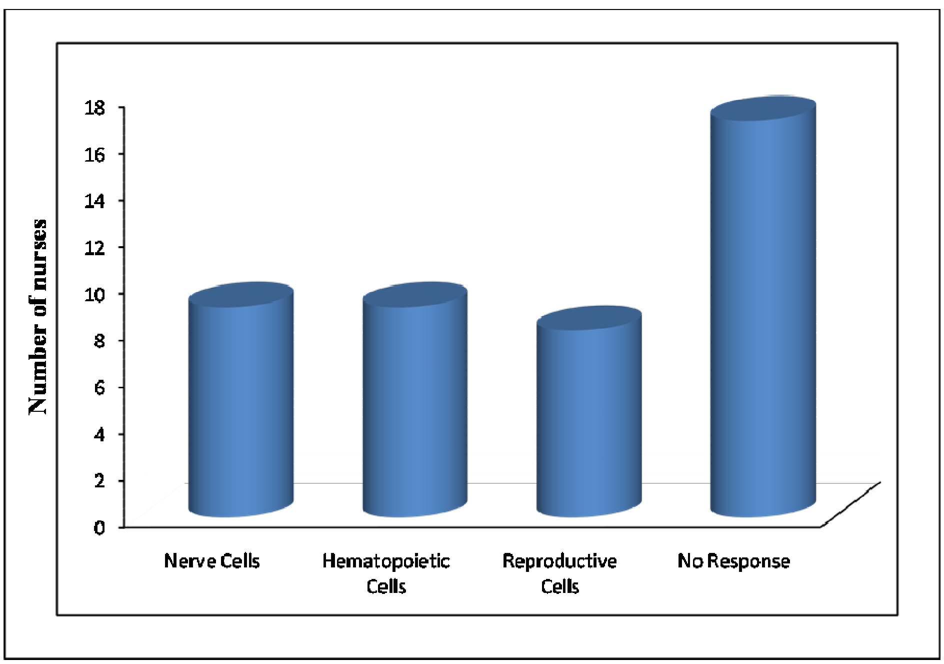


**Figure 2:** Tissues most resistant to ionizing radiation

radiation was directly detectable by human senses, 72.1% (*n*=31) were of the view that it was hazardous irrespective of the distance of the radiation source, and 37.2% (*n*=16) of them specified that ionizing radiation travelled in a sinusoidal directions. However, 53.5% were aware of its property to cause ionization and induce biological effects upon interaction with human tissues. A majority (*n*=26, 61%) of the nurses conceded that the degree and nature of ionization were determined by the radiation flux. A regression coefficient of $R^2$=1.000 was estimated for both indices. The results of the nurses' knowledge regarding resistance of some identified cells to ionizing radiation are illustrated in Figure 2. Majority (*n*=29, 67%) of respondents agreed the degree and

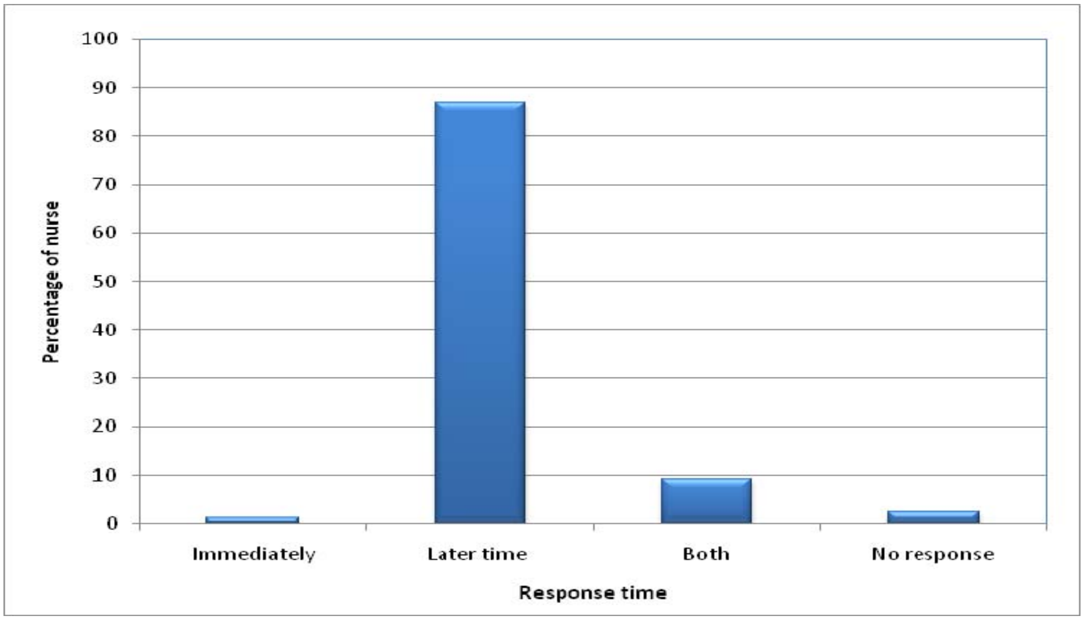


**Figure 3:** Knowledge about post exposure effects ofionizing radiation

**Table 4:** Categories of persons most vulnerable to ionizing radiation

| Professional qualifications, years of working experience | | | Most vulnerable to ionizing radiation | | | Total |
|---|---|---|---|---|---|---|
| | | | Pregnant women | Foetus | Young people | |
| Certificate | Working experience | 1-5yr | 0.0% | 0.0% | 25.0% | 25.0% |
| | | >10yr | 50.0% | 25.0% | 0.0% | 75.0% |
| | Total | | 50.0% | 25.0% | 25.0% | 100.0% |
| Diploma | Working experience | 1-5yr | 23.1% | 38.5% | 0.0% | 61.5% |
| | | 6-0yr | 0.0% | 7.7% | 15.4% | 23.1% |
| | | >10yr | 15.4% | 0.0% | 0.0% | 15.4% |
| | Total | | 38.5% | 46.2% | 15.4% | 100.0% |
| Degree | Working experience | 1-5yr | 22.2% | 33.3% | 0.0% | 55.6% |
| | | 6-10yr | 0.0% | 22.2% | 11.1% | 33.3% |
| | | >10yr | 0.0% | 11.1% | 0.0% | 11.1% |
| | Total | | 22.2% | 66.7% | 11.1% | 100.0% |

Two hypotheses were investigated in respect of registered and student nurses (Table 5):
$H_O$: there is no difference in the level of knowledge on radiation and radiation protection between student nurses and registered nurses.
$H_{1;}$ there is a difference in the level of knowledge on radiation and radiation protection between student nurses and registered nurses.

nature of ionization depended on the energy of the individual particles, while 61% (*n*=26) of respondents agreed that the degree and nature of ionization was determined by the number of radiation particles of flux. A regression coefficient of $R^2$=1.000 was estimated for both indices. Majority of the respondents (*n*=17, 39.5%) were uncertain about which tissues were most resistant to ionizing radiation while 20.9% (*n*=9) indicated nerve and hematopoietic cells as most resistant. A regression coefficient of $R^2$=0.885 was estimated for both indices. The results of the nurses' knowledge on post-exposure effects of radiation and categories of people most vulnerable to ionizing radiation are presented in Figure 3 and Table 4 respectively.

The respondents' knowledge on post-exposure effects of radiation revealed that 72% (*n*=31) of them were aware that radiation effects occurred some years later but were oblivious of the fact that it could also occur immediately as noted by only 1 respondent. The certificate-qualified nurses held the view that pregnant were most vulnerable (50.0%), while the diploma and degree holders indicated lower views of 38.5% and 22.2% respectively. A contrary

**Table 5:** Significant difference between registered and student nurses

| Qualification | *N* | Mean ± δ | *p*-value | Lower Boundary | Upper Boundary |
|---|---|---|---|---|---|
| Student Nurses | 22 | 6.05± 2.32 | 0.343 | -1.970 | 1.210 |
| Registered Nurses | 21 | 6.43 ± 2.83 | | -1.987 | 1.220 |
| **Total ∑** | 43 | | | | |

observation was held in respect of vulnerable of foetus to radiation. In particular, 66.7% of degree nurses indicated that foetuses were more vulnerable compared to 46.2% (diploma) and 25.0% (certificate) nurses.

The statistical inference from the results of the independent *t*-test established no significant difference between the two groups ($p$-value = 0.343 > 0.05).

## DISCUSSION

In this study, the gender ratio of the nursing population was 88.4% (females) against 11.6% (males). This observation, though consistent with the fact that the nursing profession in Ghana is dominated by females, does not disprove the erroneous notion that science-related professions including nursing are best suited for males (Appiah, 2009). The relatively higher ratio (37.2%) of participants aged 18-23 years in the population may be attributed to the higher number of student nurses (*n*=22, 51.2%).

Employing a knowledge assessment index based on the correctness of the answers, and per the definition of ionizing radiation (William, 2001), the participants' ability to explain ionizing radiation was assessed as average. In particular, 23% of the respondents obtained an average score rating of 2, while 47% provided no answers to the question and thus scored of 0. However, 14% of the nurses scored good (rated 4) while 16% were inappropriately defined and thus rated 1 as poor scores.

Indeed, 37.2% of the participants' associated sinusoidal waveforms to ionizing radiation contrary to the definition of Dowd and Tonnessen (2011) that emitted energetic particles (ionizing radiation) travelled rectilinearly in all directions, while 16.3% of them thought that ionizing radiation was directly detectable by human senses, and 72.1% associated risk irrespective of source-target distance. This wrong assertion by the respondents is inconsistent with the inverse-square law on radiation exposure and dosimetry (Baker, 1990; Shaw et al., 2011). However, 53.5% were aware of its ability to cause ionization via ejection of an orbital electron upon interaction (William 2001).

Furthermore, 61% of the nurses thought that factors which affected ionization were dependent on the particle flux, contrary to the physics which affirms the fact that ionization is dependent on the energy of the individual interacting particles and not on their number or intensity Responses gathered from the study suggested a poor level of knowledge about ionizing radiation among nurses.

According to Ward (2009), special protection should be provided to radiosensitive organs such as the thyroid and the reproductive organs (gonads). The findings of this study showed that most (*n*=17, 39.5%) of the respondents were uncertain about which human tissues were most resistant to ionizing radiation, while 20.9% (*n*=9) and 18.6% (*n*=8) of the respondents thought the most radiation-resistant tissues were the nerve and hematopoietic cells, and reproductive cells respectively. However, according to the United States Nuclear Regulatory Commission (2004), the hematopoietic cells are the most sensitive, followed by the reproductive cells, concluding that the nerve cells are the most radiation-resistant tissues. The Commission also categorized the biological effects of radiation exposure into those that occurred immediately and later. On the contrary, 72% of the population of this study were aware that radiation effects could occur some years later but were oblivious of the fact that it could also occur immediately. The nurses' contrary indications further indicated a low level of knowledge about the issue

In this study, about 15.4% of the diploma-holding nurses with 6-10 years of working experience believed young people were the most vulnerable, while 50.0% of certificate holders with more than 10 years of working experience, and 33.3% of the degree holders with working experience between 1-5 years held the view that pregnant women and foetuses the most vulnerable respectively. Apart from the degree holding nurses, the indications of the other group of nurses are contrary to the literature. In particular, Martin and Corbert (2003) conducted a number of epidemiological studies and demonstrated that the risks of radiation-induced effects in the foetus were greater than in the adult. The wrong indications by the nurses clearly demonstrated their lack of knowledge on the subject

The independent *t-test* showed a *p-value* of 0.343 < 0.05 and established no significant difference in the level of knowledge about radiation and radiation protection between the registered and student nurses. Using a confidence level of 95%, the results failed to reject the null hypothesis. The mean scores obtained in the knowledge assessment for the various nursing categories (students nurses: 6.05± 2.319, 35.6%; registered nurses: 6.43 ± 2.839, 37.8%) was less than 50% of the total mark, which is indicative of poor knowledge in ionizing radiation and its protection.

The *time-distance-shielding* principles of radiation protection also referred to as the *cardinal principles of radiation protection* by (Bushong, 2001) underscores occupational (health personnel), medical (patients) and public radiation protection. Of the 43 nurses, 60.5% had no knowledge about these basic principles. This observation is not consistent with the report of IPEM and RC (Institute of Physics and Engineering in Medicine in association with The Royal College of Nursing (2002) which recommended that nurses play key role as patient's advocate once a radiodiagnostic procedure was underway.

## CONCLUSION

The research was undertaken to investigate the nurses' perception on ionizing radiation protection during mobile radiographic examination in some selected wards of the Korle-Bu Teaching Hospital in Ghana. The observations made in this study suggested that majority of nurses have limited knowledge about ionizing radiation, associated risks and modes of radiation protection. The study also concludes that misconceptions or wrong perceptions about exposure risks that could potentially affect health care decisions were present among nurses. The absence of curricula in basic radiation protection was conspicuously absent in the nurses training programme, resulting in poor knowledge on the subject among nurses prior to assuming professional duties in radiology departments.

Based on the findings from the study, it is recommended that provision of specific objectives regarding radiation and radiation protection in the curriculum as well as during ward rotation for nurses is essential for enhancing the quality of healthcare service delivery from nurses. This can change behaviours regarding health beliefs and attitudes prevalent within the health sector.

Accordingly, specific training sessions in radiation hazards and radiation protection in the form of seminars should be organized on a regular basis by the hospital's radiation protection board. Additionally, recertification of healthcare practitioners should be linked to successful completion of such seminars. The development of instructional intervention-based programmes for nurses to improve knowledge of the hazards of radiation and the levels of radiation exposure from examinations and procedures is highly recommended.

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### REFERENCES

Abadi NF (2000). *Physics of radiation and radiobiology*. 6th Edn. Tehran, Iran: Jahaddaneshgahi Publishing;; 415-8.

Soares PFA, Aline Garcia Pereira AG, Flôr RC (2011). Utilization of radiation protection gear for absorbed dose reduction: an integrative literature review. *Radiol Bras* ;44 (2)doi.org/10.1590/S0100-39842011000200009

Reiman RE (2006). *Radiation Protection for Mobile X-ray and CT Procedures*, Radiation Safety Division. Duke University Medical Centre;. Available athttp://www.safety.duke.edu/radsafety/nurses /mobile/index.html. Accessed on 12-30-2010.

Wrixon AD (2008). New ICRP recommendations. *J. Radiol. Prot.* ; 28:161–168.

Ward P (2009). Production of x-rays In: Easton, S. (ed). *An introduction to radiography*. London. Churchill Livingstone;103-109.

American Council of Radiology (2010). ACR Practice Guideline for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation; 2008. Available at http://www.acr.org/SecondaryMainMenuCategories/quality_safety/guidelines/dx/Pregnancy.aspx). Accessed on 12-30.

International Commission on Radiological Protection (2007). *Recommendations of the International Commission on Radiological Protection. Annals of the ICRP* (Publication 103).Elmsford, New York: Pergamon Press..

Statkiewicz SM, Visconti PJ, Ritenour ER (2002). *Radiation protection in medical radiography*. In: Wilker Jeanne (Ed). USA: Andrew Allen.

Holmberg O, Czarawinski R, Mettler F (2010). The importance and unique aspect of radiation protection in medicine. *European Journal of radiology*.:76:6-10

Bushong SC (2001). *Radiologic science for technologists: Physics, biology, and protection*. 7th Edn. St. Louis, MO: Mosby.

Bushong CS (2008). *Radiologic science for Technologists.* 9thedn. St. Louis: Mosby Elsevier.

Johns HE, Cunningham JR: The physics of radiology, 4th ed. Springfield, IL: Charles C Thomas.1983

Preston RJ, Boice JD, Brill AB, Chakraborty R, Conolly R, Hoffman FO, Hornung RW, Kocher DC, Land CE, Shore RE, Woloschak GE (2013). Uncertainties in estimating health risks associated with exposure to ionising radiation. *J Radiol Prot.* ;33(3):573-88. doi: 10.1088/0952-4746/33/3/573.

Mattews K, Brennan PC (2008). Justification of x-ray examinations: General principles and an Irish perspective. *Radiology*.;14(4):349-355

Harrison J, Day P (2008). Radiation doses and risks from internal emitters. *J Radiol Prot*.;28(2):137-59.

Rassin M, Berger M, Silner D (2010). Available at www.radiologynursing.org; 2008. Accessed 24-12-.

Campeau EF, Fleitz J (2010). *Limited Radiography*. 3rdedn. New York: Delmar Cengage Learning.

Miracle VA, Wigginton MA (1990). Nurses and ionizing radiation: a study of two institutions. Critical Care Nursing.:10(5): 58-64.

Barr JMB, Schiska AD (2005). Radiologic safety: Historical perspective and contemporary recommendations. *Journal of Radiology Nursing*.;24: 6-10.

Lima GG, Gomes DG, Gensas CS, Simão FM, Rios MN, Pires LM, Kruse LM, Leiria TLL (2013). Risk of Ionizing Radiation in Women of Childbearing Age undergoing Radiofrequency. *AblationArq Bras Cardiol*:1-5

Mattews K, Brennan PC (2008). Justification of x-ray examinations: General principles and an Irish perspective. *Radiology*;14(4):349-355.

Saia DA (2003). *Appleton & Lange's review for the radiography examination*.5th Edn. Columbus, OH: McGraw-Hill..

Institute of Physics and Engineering in Medicine in association with The Royal College of Nursing (2002). *Ionising radiation safety: a handbook for nurses*. 230 Tadcaster Road, New York: IPEM Publications..

Australasian Rehabilitation Nurses' Association: Chapter reports 2011. Available at www.arna.com. Accessed on 11-05-2011.

Asmundsdottir EE, Kaplan S (2000). Kelandic occupation therapist's attitudes towards professionalism. *Scandinavian Journal of Occupational Therapy.(7):67-75.*

Carter DE (2000). *Descriptive Research*. In: Cormack D.F.S (Ed). *The research process in Nursing*. 4th Edn. Oxford: Blackwell Science.

Gray DE (2004). *Doing research in the real world.* London: Sage Publications.
McQuillen-Martensen K (2006). *Radiographic image analysis*. 2ndedn. Iowa: Elsevier Saunders.
Gillies A (2002). *Using research in nursing*: *a workbook for practitioners*. Oxford: Radcliffe Medical Press.
Appiah E (2009).Occupational health issues among radiographers in the Accra Metropolis. Unpublished Project Work (BSc.), University of Ghana.
William R (2001). Radiation in radiological practice. In: Peter Corr (Ed) Pattern recognition in diagnostic imaging. South Africa: Nelson R Mandela School of Medicine, University Of Natal: 16-20.
Tonnessen BH (2011). Pounds L Radiation physics Journal of Vascular.; 53(1): 6S-8S.
Baker N (1990). Exposure to Ionizing Radiation from x-rays in the intensive care unit.
Shaw P, Duncan A, Vouyouka A, Ozsvath K (2011). Radiation exposure and pregnancy *Journal of Vascular Surgery*;53(1):28S–34S
United States Nuclear Regulatory Commission (2004). Fact sheet on Biological Effects of radiation: Available at http://www.nrc.gw/reading-rm/doc-collection/fact-sheets/bio-effects-radiation.html. Accessed on 4-02-2011.
Martin CJ, Corbert RH (2003). *Interaction of ionizing radiation with matter.* In: Martin, C.J & Sutton, D.G (Eds) *Practical Radiation protection in Health Care*.Oxford: Oxford University Press.