Assessing the Effects of Radiation on X-ray Workers in Hospitals within Port Harcourt Metropolis, Nigeria

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Abstract: ***The research was based on the assessment of the effects of radiation on x-ray workers in hospitals within Port Harcourt metropolis, Nigeria. The study areas were Military Hospital, University of Port Harcourt Teaching Hospital; Palmars Hospital and Save a life hospital all in Port Harcourt. The population size was 150 and the sample size 110 indicating the number of patients and workers within the hospitals for follow-up care. The sampling method used was the simple random technique, using the Taro Yamene formula to determine the sample size. Instrument for data collection were questionnaire designed to suite the aim of study. The research design adopted was the cross sectional survey design. The result showed that 64% of the respondents have adequate awareness of the radiation phenomenon, 77% accept having done x-ray, 64% also agreed to the wearing of film badges by imaging workers, 91% of the hospitals have Pb-lined x-ray rooms, 91% agreed to have been protected from radiation. Similarly, 82 % also acknowledged been properly handled during x-ray examination, 55% agreed having some negative effects of radiation after x-ray examination but 64% disagreed on being given proper instructions and enlightenment on side effects of the radiation. About 82% agreed to a good and cordial relationship amongst imaging workers but same 82% also agreed to the limiting property of radiation dose on workers. Adherence to radiation protection practice among imaging workers in Port Harcourt metropolis during the study period was however poor but the general perception and awareness on the effect, exposure and practice is relatively high. Therefore, imaging workers in Port Harcourt, 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 ionizing radiation.***

Keywords: X-ray, X-ray workers, Radiation, Pb-lined, film badges, imaging workers, exposure ionizing radiation

1. Introduction

The term radiation is the emission or transmission of energy in the form of waves or particles through space or through a material medium (Weisstein, 2014).Radiation is often categorized as either ionizing or non-ionizing depending on the energy of the radiated particles. Ionizing radiation is radiation that carries sufficient energy to detach electrons from atoms or molecules, thereby ionizing them. Ionizing radiation is made up of energetic subatomic particles, ions or atoms moving at high speeds (usually greater than 1% of the speed of light), and electromagnetic waves on the high-energy end of the electromagnetic spectrum. Gamma rays, X-rays, and the higher ultraviolet part of the electromagnetic spectrum are ionizing, whereas the lower ultraviolet part of the electromagnetic spectrum and the entire spectrum below UV, including visible light (including nearly all types of laser light), infrared, microwaves, and radio waves are considered non-ionizing radiation (Schauer & Linton, 2009).

Natural populations have always been exposed to background levels of ionizing radiation. However, with the event of the nuclear age, studies about the effects of higher-than background levels of ionizing radiation on individuals or populations of organisms became important. Background ionizing radiation arises from various manmade and natural sources present in the environment (Ghiassi-Nejad *et al.*, 2002). Through radiation protection, deterministic effects may be prevented and stochastic effects reduced. Radiation dose from diagnostic procedure is controlled by government agencies because of the risks associated with stochastic effects (Arslanoglu *et al.*, 2007). Examples of deterministic effect (doses are given as absorbed dose) are available such as skin erythema 2.5gray, Irreversible skin damage 20.40 gray, Hair loss 2.5gray, Sterility 2.3gray, Cataracts 5gray, Lethality (whole body) 3.5gray, Fetal abnormality 0.1–0.5ay (Zhou & Whaites, 2010).

Similarly, for stochastic effects there is no threshold dose below which it is relatively certain that an adverse effect cannot occur in addition because stochastic effects can occur in individuals that have not been exposed to radiation above background levels. It can never be determined for certain that an occurrence of cancer or genetic damage was due to a specific exposure.

All modern radiation protection guidelines are based upon the linear dose response model. Without a threshold, this model state that as radiation dose increases. Radiation risk also increases and there is no threshold. Because stochastic effects have no identified threshold, even small doses may cause biological harm, hereditary effects cancer and leukemia are some examples of stochastic effects United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2000). The quality factor for x-radiation is one (therefore 1 RAD of radiation equals 1 RAM of x-radiation ie 1Rad = 1RAM) (Daara *et al*., 2014).

Although exposure to ionizing radiation carries a risk, it is impossible to completely avoid exposure. Radiation has always been presented in the environment and in our bodies. We can however, avoid undue exposure through the following protection principles.

a) Time, Distance and Shielding
b) Containment

c) Necs System of Radiation Protection

Therefore inserting the proper shield between you and a radiation source will greatly reduce or eliminate the dose you received (Simonsen, Wilson, Kim, & Cucinotta, 2000). Rooms have a reduced air pressure so that any leaks occur into the room and not out of it (Gower & Mutyabule, 2004).

We may get radiation from medical procedures, consumer products, industrial radiation sources, research activities, etc. Radiation professionals known as radiation worker may get exposure from radiation sources used by them for various applications (Hall, Davis, Demers, Nicole & Peters, 2013). Most common radiation exposure to the professional is from various medical procedures used in Radiology, nuclear medicine, radiotherapy, *etc* (UNSCEAR, 2000). Worldwide, the mean effective dose for medical workers was 1.6 mSv, and for interventional radiology was 3.0 mSv. In the United States, the mean annual effective dose during 2011 for physicians involved in fluoroscopically was 1.6 mSv. The harmful effects of radiation are very well known to us and while working in radiation area we can only minimize the amount of radiation received but we cannot avoid it completely (Hall & Giaccia, 2008; Martin, Harbison, Beach & Col e*l.*, 2012). Therefore, there is need to know the various biological effects of radiation on human beings so that we can use radiation safely. The Radiation protection ordinance and the x-ray ordinance fix the limit values. For occupationally exposed, lower values apply for occupationally exposed pregnant women and apprentices (Schaefer-Prokop *et al.*, 2008). These dose limits shall be observed at the most unfavorable past of effect, taking account of all relevant load paths, and the dietary and lifestyle habits of the reference person in addition to any possible prior contamination by other plants and facilities (Olowookere & Okaro, 2004).

Whenever ionizing radiation falls on human body, it produces ionization and excitation in the tissues and impairs the normal function of the cells. Thus human body will be subjected to biological damage and severity of this damage depends upon various factors mainly, nature and energy of the radiation, total dose & dose rate, the extent and part of the body exposed, age of the person exposed to radiation, radiation sensitivity of the organ exposed, *etc*. The interaction of ionizing radiation with human body could arise either from external radioactive sources or internal contamination leading to biological effects which may later show up as clinical symptoms. Radiobiological data have been derived mostly from micro-organism, cultured mammalian cells and whole animal systems. Human data is derived from the follow-up of the following;

1) Survivors of atomic bomb explosions in Hiroshima and Nagasaki,
2) Inhabitants of Marshall Islands, who were exposed to fallout from thermonuclear devices,
3) uranium miners,
4) radium dial painters,
5) Pionner X-ray technicians and radiologists,
6) Patients exposed to radiation for medical reasons; and
7) Victims of nuclear accidents. A careful analysis of these data has yielded reasonable quantitative estimate of biological effects of radiation in man (Steel, 2002).

The penetration of the human body tissues by the use of ionizing radiation produces damage in the body primarily by ionizing the atoms of which the tissues are composed. Destructive radiation interacting at the atomic level result in molecular change and this in turn can cause cellular damage which may cause abnormal cell function when sufficient cellular damage occurs due to destructive radiation interaction. The living organism may exhibit signs of organic damage (genetic or somatic) change in the organism such as mutation, cataract and leukemia.

Aim and Objectives of the Study

The aim is to assess the effects of radiation on medical imaging workers in hospitals under study.

The specific objectives include the following:

i) To identify the effects of ionizing radiation
ii) To identify various detection equipment
iii) To assess ways and the effects of radiation on medical imaging workers in the studied hospitals.

Diagnostics and interventional radiation are essential parts of present day medical practice. Advance in x-ray imaging technology together with developments in digital technology have had a significant impact on the practice of radiology. This includes improvements in image of available applications resulting in better patient diagnosis and treatment. However the basic principles of x-ray image formation and the risks associated with x-ray exposures remains unchanged. X-ray has the potential damaging healthy cells and tissues, and therefore all medical procedures employing x-ray equipment must be carefully managed. In all facilities and for all equipment types procedure must be in place in order to ensure that exposure to patients, staff and the public are kept as low as reasonable achievable.

All radiological facilities should establish quality assurance programmer whose structure and scope are determined by the needs and complexities of each facility (Jacob *et al.*, 2011).

During the research, the researcher was able to cover Hospitals under the area of study which included Military Hospital Port Harcourt, University of Port Harcourt, Palmars Hospital limited and Save A Life Hospital. Exposure to high level of radiation can be dangerous because radiation is odorless and invisible; those who must work with radioactive materials need special equipment to ensure their safety and safety of those round them. There are different types of radiation detector equipment that is used in x ray radiology department such as Personal Radiation Detector, Dosimeters, Film Badge, Identifiers, Survey Meters *etc*. Before prescribing an x-ray examination the referring physician should be satisfied that the necessary information is not available, either from radiological examinations already done, or from any other medical test or investigations (Davies, 2011).

The radiologist should not allow any person to operate x-ray equipment except they are qualified people as stipulated in the Radiation ordinance, or they are working under direct supervision of radiologists (Quinn *et al.,* 1997).Further protective measures include limiting the time spent by workers in the vicinity of primary and secondary sources, and by wearing appropriate protective clothing. These measure depend on the consistent use of good working practice, they should not form the main basis of protection unless this is necessary for the conduct of the medical procedure or for the case of the patient (Mutyabule & Whaites, 2002).Radiographic units ensure patient safety when operating the unit; the radiographer must use a source-skin distance of at least 12 inches [30cm].This distance limit the effects of the inverse square fall off of radiation intensity with distance (Monfared, Abdi & Saber, 2007).

2. Materials and Methods

This study was achieved using well-structured questionnaires to answer the following research questions;

i) What are the effects of ionizing radiation?
ii) What are the different detection equipment?
iii) How do we assess the ways effects of radiation on medical imaging workers in the studied hospitals?

What are the ways in which workers and patients can be protected in diagnostic radiography?

2.1 Research Design

This study employed a descriptive cross sectional design. This descriptive design is suitable for this study because it describes only the phenomenon without manipulation of variables. This design sought the perception, attitude, feelings and options of respondents about the problem studied in order to provide answers to the research questions.

2.2Area of the Study

Port Harcourt also called Pitakwa is the capital and largest city of Rivers State, Nigeria. It lies along the Bonny River and is located in Niger Delta. As of 2016, the Port Harcourt urban area has an estimated population of 1,865,000 inhabitants, up from 1,382,592 as of 2006. The hospitals having X-ray facility in Port Harcourt include;

a) Military hospital Port Harcourt,
b) University of Port Harcourt Teaching Hospital,
c) PALMARS hospital limited
d) Save A Life Hospital, Port Harcourt

The military hospital Port Harcourt formerly called Delta clinic is an Armed Forces Health facility in new GRA, Port Harcourt LGA, Rivers State. The hospital was originally built by Shell-BP in the early ‘60s to serve as a centre of medical care for the company’s expatriate and local staff but presently owned by the government.

2.3Population of the Study

The population of the study comprises all the adult male and female staff in the hospital in Obio-Akpor. This is about One hundred and fifty (150) population size.

2.4 Sample Size and Sampling Techniques

The sample size of this research is One hundred and ten (110) which comprise all the adult male and female staff in the hospital under study. One hundred and ten (110) respondents were selected to complete the questionnaire. The portion was considered a representation of the entire workforce and this ensures unbiased response from the respondents and employee from all level of management which were selected. This was achieved using the Taro Yamene formula.

2.5 Instrument for Data Collection:

The instrument used for the data in this study was a well-structured questionnaire and the questionnaire is subdivided into two sections (Section A and Section B). The Section A has to do with the socio-demographic characteristics of the respondents while Section B is the research questions.

2.6Validation of the Instrument/ Reliability of the Instrument

This instrument was given to the supervisor and other experts in the field of measurement and evaluation who made necessary corrections which were reflected in the final copy. The test retest method was adopted. Ten percent (10%) of the sample which is eleven (11) copies of the questionnaire was administered to the good staff of the Hospitals under study but entirely outside the area of study setting with similar population characteristics. After two weeks the researcher visited the hospitals under study with the same set of questionnaire. The result was used to calculate the reliability coefficient, using Pearson Product Moment Correlation Coefficient statistic giving a reliability coefficient of 0.65.

2.7 Method of data Collection:

The questionnaires were given to respondents and retrieved immediate to avoid loss and delay in the research process.

2.8 Method of Data Analysis

The main method used in analyzing the data in the study was simple statistical method of percentage differentials.
Percentages of respondents were calculated using the formula below.

$$\%\text{ age of Respondents} = \frac{\text{No of response}}{\text{Total No. of respondents}} \times 100$$

3. Results Presentation

From the questionnaires distributed to the respondents the following data were obtained and as shown below and the result analyzed.

Table 1: Patients and workers knowledge about radiation

Option of Response	No. of Response	Percentage of Response
Yes	70	64%
No	40	36%
Total	110	100%

Table 1 Showed that 70(64%) of respondents have adequate knowledge of radiation concept while 40(36%) respondents lack requisite awareness of the concepts of radiation.

Table 2: Have you undergone an x-ray examination before?

Option of Response	No. of Response	Percentage of Response
Yes	85	77%
No	25	23%
Total	110	100%

Similarly, 85 (77%) of the patients and workers acknowledge having undergone X-ray examination earlier whereas only 25(23%) of the respondents claimed not to having done that before (see Table 2).

Table 3: Where the workers wearing film badge?

Option of Response	No. of Response	Percentage of Response
Yes	70	64%
No	40	36%
Total	110	100%

Table 3 indicates that 70(64%) of the workers wear film badge during X-ray examination while 40(36%) disagreed.

Table 4: Are the X-Ray rooms lead –lined?

Option of Response	No. of Response	Percentage of Response
Yes	100	91%
No	10	9%
Total	110	100%

Source: Field Work (2020)

Result from Table 4 showed that X-ray rooms were load-line according to 100 (91%) respondents whereas 10 (9%) disagreed

Table 5: Did they protect you from radiation?

Option of Response	No. of Response	Percentage of Response
Yes	100	91%
No	10	9%
Total	110	100%

Table 5 showed that 100(91%) of the respondents agreed being shielded during X-ray examination whereas only 10(9%) disagreed.

Table 6: During the X-ray Examination, where you properly handled?

Option of Response	No. of Response	Percentage of Response
Yes	90	82%
No	20	18%
Total	110	100%

From Table 6, respondents agreed that they were properly handled in terms of safety and professional ethics by 90 (82%) of them while 20 (18%) disagreed.

Table 7: After the X-ray Examination, did you notice any negative effect in your body system?

Option of Response	No. of Response	Percentage of Response
Yes	50	45%
No	60	55%
Total	110	100%

Table 7, illustrates to the fact that only 50 (45%) of respondent patients and workers observed any negative effect while 60 (55%) observed some negative effects.

Table 8: After the X-ray Examination, were there instructions given to you by the X-ray worker/s on what to do if there be any side effects?

Option of Response	No. of Response	Percentage of Response
Yes	40	36%
No	70	64%
Total	110	100%

Table 8 showed that 40 (36%) of the patients attested to the fact that instructions on any side effects reported while 70 (64%) claimed no such instructions were issued at all.

Table 9: Did the medical imaging workers cooperate with one another during Examination?

Option of Response	No. of Response	Percentage of Response
Yes	90	82%
No	20	18%
Total	110	100%

Similarly, Table 9 showed that 90 (82%) agreed that there was good professional cooperation by workers even though 20 (18%) still disagreed.

Table 10: Can radiation dose be limited?

Option of Response	No. of Response	Percentage of Response
Yes	90	82%
No	20	18%
Total	110	100%

4. Discussion of Findings

The result showed that adequate knowledge of radiation was 64% (70 respondents) while 36% (40 respondents) lack the awareness as in Table 1. This was lower than the 73% recorded by Eze, Abonye, Njoku, Irurhe and Olowu (2013) in Lagos for radiation protection knowledge. This was also better than that earlier reported in England as it was poor (Mutyabule & Whaites, 2002).

Table 2, indicates the frequency of X-ray examination as 77% (85 respondents) acknowledged having done x-ray while 23% (25 respondents) clam anonymity. According to Gershan, Madjunarova and Stikova (2010), there is the possibility that the number of reported x-ray examinations in top 20 groups were lower than the actual which was similar to the above result. Similarly, the estimated annual number of examination was 326 per 1000 people (32.6%) which were lower than that recorded in this study (Suliman *et al.*, 2015).

According to Kim (2016), when the human body is exposed to radiation (x-rays) cells can die, become malignant or even mutate which can be harmful to tissues and organs. If DNA

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(deoxyribonucleic acid) inside dies, the cell can become cancerous but if DNA damage occurs in a sperm (or egg), can lead to genetic complications (Kim, 2016). Radiology rooms usually have caution signs as instructions but are not found except on request around the study area. These conditions have created high negative percentage responses (64%) as shown in Table 3. Result have also shown that 76% radiologists, 73% emergency department doctors and 100% of patients underestimate the radiation exposure close from CT scans (Kim, 2016).

Table 4 showed that 91% (100 respondents) of the respondents acknowledged the use of Pb-lined x-ray rooms as opposed to the plate glass (Aldrich & Andrew, 2009). Pb-lined x-ray rooms are the commonest but are replace by more modern plate glasses (Aldrich & Andrew, 2009). Similarly, according to Aldrich and Andrew (2009), certain extra specifications are required when waiting room is near the x-ray room. This is an indication that current technological innovations are not available.

Since radiation is the science and art of protecting people and the environment from harmful effects of ionizing radiation, Eze *et al.* (2013) posited that every patient must be protected using the appropriate tools and materials. Similarly, Eze*et al.*(2013) recorded 73% of respondents having good knowledge of radiation protection and so 91% of the study respondents (90 respondents) agreed to have being protected (see Table5). Lack of protective can lead to both deterministic and stochastic effects (Mallam, Akpa, Oladipupo & Sa'id, 2004). This is a good indication of awareness of adverse implications of the radiations (x-ray).

Table 4.6 showed that during the x-ray examination, 82% (90 respondents) of the respondents agreed they were properly handed as only private hospitals in Lagos wore dosimeters (Eze*et al.*, 2013). Reports also showed that wearing of dosimeters was common amongst the radiographers but not on the patients (Eze & Okaro, 2004). Personnel exposure is low but the likelihood of occupational exposure is possible (Eze & Okaro, 2004; Marshall & Keene, 2007).Though higher percentage 55% of respondents gave a negative response to effect of x-ray on examination, the close range of 45% noticing some effect requires much to be deserved as shown in Table 7. Researches have shown that stochastic effects are mere likely possible (Mallam*et al.*, 2004).

In Table 8, instructions were not given to the x-ray workers and the awareness on side effects were relatively low as 64% supported that no instructions were given to the workers after x-ray diagnosis. About 36% claimed that instructions were given and so adequate awareness of the side effects of x-ray was known. According to the International Atomic Energy Agency, IAEA (1958), most diagnostic investigations will have no adverse effects. The reason for this result can be deduced from the fact that x-ray effects are chromic and latent at the first stages or early years. High dose means high risk hence linear relationship (IAEA, 1958). Similarly, no one becomes radioactive after x-ray procedure (IAEA, 1958).

Results showed in Table 9 indicate that there was adequate understanding amongst the workers around the examination room (82%). This is probably due to the knowledge of workers concerning the dangers, side effects and caution from superior personnel. Team work in radiological reporting occurs amongst the multidisciplinary team of clinical radiologists, radiographers, consultant practitioners and sometimes other members of staff. These professionals have their different functions hence must co-operate to achieve the final result. This was done to achieve the 82% response rate of good working relationship. The outcome of a talk at ECR 2017 emphasized teamwork being the key to ensuring patient safety and hence minimizing the threat of ionizing radiations between radiology professionals. Antoniutti *et al.* (2015) supports the essence of communication and team working in radiology department.

About 90 (82%) respondents supported the limitation availability of radiation though 20 (18%) disagreed as shown in Table 10. This concept was supported by Limchareon, Kaowises and Saerisa was (2018) from their study on the management of radiation dose reduction in hospitals. Similarly, the highest dose reduction technique was for the limited phase creep (52.5%) while the least was decreased tube current (38.6%) (Limchareon *et al.*, 2018). In a similar research, objective data has shown that the use of Infra-Red (IR) reduces noise as against the NO IR with the other identical parameters (Higashigaito *et al.*, 2016). As experts in this filed, majority knew of the need to limit exposure to radiation especially ionizing radiation. Reports have shown the ignorant theft or loss of radioactive materials (Robinson *et al*., 2000). Radiation equipment must be used according to manufacturer's specifications (Alotaibi *et al*., 2014; Jessen *et al.*, 2001).

5. Conclusion

Imaging workers within Port Harcourt metropolis showed an excellent knowledge of radiation protection practice within the study period but poor awareness on the negative effects on man. Adherence to radiation protection practice among imaging workers in Port Harcourt metropolis during the study period was however poor but the general perception and awareness on the effect, exposure and practice is relatively high. There is therefore the ardent need to create more awareness on the likely effects of over-exposure on man and reasons why regular exposure must be checked and controlled. Periodic quality assures tests should become mandatory in all diagnostic x-ray facilities in the country. In workplaces where risk is felt to be present, or at least cannot be ruled out such as medical centres, initiation of medical surveillance is prudent to protect workers' health from nano-materials and lethal radiations (Trout, 2011).

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