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ASSESSMENT OF THE APPLICATION OF RADIATION PHYSICS KNOWLEDGE DURING CLINICAL TRAINING AMONG CLINICAL RADIOGRAPHY STUDENTS IN THE UNIVERSITY OF NIGERIA, ENUGU CAMPUS

Idigo Felicitas Ugochinyere *PhD* | **Beatrice Ukamaka Maduka** *PhD* | **Atuoha Ernest** *BSc* | **Chukwu Emmanuel Nnaemeka** *BSc* | **Chiawolam Chiemela** *BSc*

Department of Medical Radiography and Radiation Sciences, Faculty of Health Sciences and Technology, College of Medicine, University of Nigeria, Enugu Campus, Enugu State, Nigeria

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Abstract

Introduction: This study delves into the pivotal role of radiation physics knowledge in shaping the competence of clinical radiography students, with a focus on the challenges they encounter during their training. Despite a reported understanding of basic radiation physics principles, students face barriers that hinder effective translation of this knowledge into clinical practice, potentially leading to suboptimal outcomes.

Materials and methods: The study was conducted among clinical students (4th year and 5th year) of the department of Medical Radiography and Radiological Sciences, University of Nigeria, Enugu Campus, Enugu state. The study design was a prospective, cross-sectional descriptive study which enables to collect data at a specific point in time. The population has a total number of 500 students. Using the statistical formula proposed Taro Yamane a minimum sample size of 220 students was obtained. All clinical radiography students who were willing to participate in this research were included. Ethical approval to carry out the research was obtained from the Health Research and Ethics Committee of University of Nigeria Teaching Hospital, Ituku-Ozalla.

Results: Among 220 participants from the University of Nigeria's Department of Radiography and Radiological Sciences, 180 (81.4%) expressed good level of teaching on radiation physics during pre-clinical training; e 151 (68.3%) reported a good level of understanding of its basic principles. Despite reporting that they were thoroughly taught the basic principles of radiation physics, radiobiology, and radiation protection during pre-clinical training, the majority of student participants struggled to calculate absorbed radiation doses 182 (82.3%) and experienced difficulties in understanding and applying certain radiation physics principles 107 (48.5%). Major challenges that has hindered their appropriate application of radiation physics knowledge were overcrowding during clinical rotations 179 (81.0%), unavailability of radiation physics/protection resources to aid application 117 (52.9%), poor supervision/guidance for students 114 (51.5%) and faulty/non-functional equipment during clinical postings shifts 113 (51.2%).

Recommendations: Recommendations for improvement include a dedicated curriculum for radiography students on radiation physics, increased teaching durations for clinical students during clinical rotations, physicists expert involvement in training clinical students, hands-on training for clinical students, interactive learning methods, and collaborative training approaches that facilitates practical learning.

Keywords: radiation, physics, radiation protection, clinical posting

INTRODUCTION

Since the discovery of X-rays, the use of the principles and methods of physics in medicine has contributed to the improvement of human health. Physics-based techniques have been progressively developed and optimised with the aim to support physicians to formulate prompt diagnoses and to set up the effective treatments of several diseases. Thus, the basic understanding of radiation physics is important when dealing with radiation considering its benefits as well as associated health effects.[1]

Medical physics is a rapidly developing specialty of physics, concerned with the application of radiation to diagnosis and treatment of human disease. In contrast to other physics specialties, such as nuclear physics, solid-state physics, and high-energy physics, studies of modern medical physics attract a much broader base of professionals including graduate medical doctors doing their residency in medical imaging, radiography students in diagnostic imaging and therapeutic radiation oncology, students in biomedical engineering, and students in radiation safety and radiation dosimeter educational programmes.[2] All of these professionals have a common desire to improve their knowledge of the physics that underlies the application of radiation in diagnosis and treatment of disease. They are responsible for the safe and accurate delivery of radiation to patients, as well as the proper use of imaging equipment for diagnostic purposes. Therefore, it is crucial to assess the application of radiation physics knowledge during their clinical training.[2]

Clinical training is a fundamental component of undergraduate programs in radiography, radiation therapy, and nuclear medicine. It provides students with the opportunity to apply the theoretical knowledge acquired in the classroom to real-world clinical settings. During clinical training, students work under the supervision of experienced professionals, gaining hands-on experience and refining their skills. It is during this period that the application of radiation physics knowledge becomes crucial for safe and effective patient care.[3]

Radiation is a fact of life: all around us, all the time. Radiation is simply defined as an energy moving in the form of waves or streams of particles. Understanding radiation requires basic knowledge of atomic structure, energy and how radiation may interacts with cells in the human body. There are many kinds of radiation all around us. When people hear the word radiation, they often think of atomic energy, nuclear power and radioactivity, but radiation has many other forms. Sound and visible light are familiar forms of radiation; other types include ultraviolet radiation that produces sun tanning, infrared radiation which is a form of heat energy, and radio and television signals.[4]

All these electromagnetic waves do different things. For example, light waves make things visible to the human eye; heat waves make molecules move and warm up; and x-rays can pass through a person and land on a film, allowing us to take a picture inside someone's body They all travel in waves. This property makes it possible to measure the different kinds by wavelength which enables us to tell the kinds of radiation apart from each other. Furthermore, the way the energy is radiated makes it relatively straightforward to detect and measure and inferences can be made about its source. The properties of the energy emitted determines the way it interacts with matter and therefore its measurement technique and requirements for regulation.[4]

However, the intricateness of radiation medicine is the presence of possible hazards to its users amidst its overwhelming benefits and advances when there are deficiencies in knowledge of proper use. Fear of radioactivity and radiation exists in the larger population in spite of the increased use of radiation significantly in medicine, the military, food preparation, power generation and industries due largely to a lack of knowledge on this subject. This therefore justifies the need to diligently incorporate basic physics and radiation physics into the curriculum of all preclinical medical students in their first year of study and further advanced courses, such as like radiobiology, radiation protection and dosimetry, for preclinical students of medical radiography and radiological sciences in their 2nd and 3rd year of study.

Determining the harmful effects of the typically low doses of radiation received in routine daily activities is a very difficult science field. Further, as new technologies emerge that utilise the physical properties of radiation, the health effect data from exposure can be incomplete which heightens levels of anxiety among a wider population. Electromagnetic radiations are far too small to see directly, even with the most powerful optical microscopes, but atoms do interact with matter and living tissues and under some circumstances emit light in ways that reveal their internal structures in amazingly fine detail. This suggests why its possible hazards are not easily detected before they grow into obvious ailments that overwhelm the users. The invisibility of these particles makes it easy for medical imaging students/staffs to neglect the basic practices of radiation protection towards themselves and their clients (patients) like collimation, use of grid mechanism during exposure of body parts thicker than 10cm, accurate selection of exposure factors that will produce images of diagnostic quality thus avoiding cases of repeats, inverse square law practice for radiation protection, gonadal shielding in examinations where the gonads are not the area of interest, basic quality assurance tests for machines in the department, the measurement of absorbed doses of radiation during work hours and a lot more which assures their safety in the clinical settings.[5]

Radiation physics, though a fundamental component of medical imaging and radiation therapy is largely neglected among clinical students and practitioners. There is a lack of comprehensive evaluation methods to gauge the proficiency and practical implementation of this knowledge among students in real-world clinical scenarios. This deficiency hampers the ability of educators and institutions to accurately assess the competence and preparedness of future healthcare professionals in utilizing radiation physics principles effectively and safely.[6]

Without a comprehensive assessment of the application of radiation physics knowledge during clinical trainings, there is a risk of students lacking the necessary skills to interpret and utilise radiation-related information effectively. This may result in suboptimal image quality, improper radiation dose administration, compromised patient safety, and inefficient treatment planning. Additionally, the absence of standardised evaluation methods may lead to inconsistencies in assessing students' proficiency across different educational institutions, hindering the establishment of a benchmark for competence in this critical area.[6]

Therefore, it is imperative to address this problem by developing a robust and standardised assessment framework that accurately measures the application of radiation physics knowledge during clinical trainings. This framework should encompass both theoretical understanding and practical skills, providing a comprehensive evaluation of students' abilities to apply radiation physics principles in clinical settings. By doing so, educators and institutions can ensure that undergraduate students receive adequate training and feedback to bridge the gap between theoretical knowledge and its practical implementation, ultimately improving the overall competent of future healthcare professionals in the field of radiation physics.[7]

The specific objectives of the study include to determine the level of radiation physics knowledge among clinical radiography students prior to their clinical training, to evaluate the extent to which undergraduate students are able to apply radiation physics principles in clinical practice, to identify any challenges or barriers faced by undergraduate students in applying radiation physics knowledge during their clinical training and to identify possible methods that can improve the integration of radiation physics knowledge into clinical training programmes.

The aim of this study is to assess the application of radiation physics knowledge during the clinical training of clinical radiography students of University of Nigeria, Enugu campus (UNEC) in the various radiation medicine departments (conventional radiography, computed tomography, radiation therapy, nuclear medicine, etc.).

MATERIALS AND METHODS

The study was conducted among clinical students (4th year and 5th year) of the department of radiography and radiological sciences, UNEC Enugu state. The study design was a cross-sectional descriptive study which enabled us to measure multiple variables (level of knowledge, level of knowledge application, challenges and potential recommendations) at the same time. This design is an effective kick off point to identify gaps in physics knowledge application which may warrant the need for deeper explorations using experimental or longitudinal study designs in the future.

The study population comprised students who were in 4th and 5th year in the department of medical radiography and radiological sciences. Total number of students was 500. The minimum sample size (n) for this study was obtained using the statistical formula proposed by Taro Yamane[8] for a known population, the minimum sample size of 220 students.

Purposive sampling technique was employed to select the participants for this study. Purposive sampling was considered appropriate as it allowed the researchers to select participants who attended their clinical trainings and had knowledge and experience in radiation physics application. This enabled selection of participants who provided rich and meaningful data for the research questions.

Inclusion criteria were 4th year and 5th year students who had participated in clinical training for at least two semesters before the time of this research. Clinical training according to departmental curriculum starts in the second semester of the 3rd year of study. Radiography students who were not in 4th or 5th year of their study were excluded. We also excluded students who consented to not having to attend clinical trainings for at least two semesters.

An online questionnaire was used to collect data from participants. The questionnaire was a combination of structured questions (with close-ended questions) and unstructured questions (with open-ended questions). The closed-ended questions utilised a Likert scale to measure participants' knowledge of radiation physics, their level of application of knowledge and the challenges they experience regarding the application of radiation physics knowledge during their clinical trainings. The open-ended questions provided an opportunity for participants to express their opinions and provide additional insights. Face validity was carried out by the two of the researchers who were expert researchers. A pilot survey with 10% (n=22) of the participants was done. The results were reviewed for feedback in terms of clarity, readability and appropriateness. Following this the questionnaire was distributed to 20% of the participants to test its reliability using Cronbach's Alpha. The overall Cronbach's alpha score of the 30-item scale was 0.74 indicating an acceptable internal consistency.

Data were collected from Tuesday to Friday in the third week of July 2023. An online questionnaire was generated using Google forms and sent to the group chats of the sample group. Responses were immediately received in our email handle as soon as the participants completely filled it online. When our expected responses were achieved, we extracted the Excel spreadsheet of their responses and sent it to the SPSS software.

RESULTS

A total of 222 questionnaires was administered to the clinical students who are in 400L and 500L Medical Radiography, UNEC. A total of 221 out of the 222 questionnaires were successfully filled and returned. The participants ' answers were analysed using descriptive statistics. Demographics of the participants are presented in Table 1. Their responses are presented in Tables 2 to 5. As depicted in Table 1 128 males (57.5%) and 93 females (42.1%) participated in the study. Five (23%) were within the age range less than 20 years, 149 (67.4%) were within 21-25 years, 61 (27.6%) were within 26-30 years, and 5 (2.7%) were above 31 years of age. Eighty-nine (40.3%) were 400 level and 132 (59.7%) were 500 level.

As shown in Table 2 the majority of participants (n=180/81.4%) stated that they were thoroughly taught the basic principles of radiation physics, radiobiology and radiation protection during their pre-clinical training. The majority (n=119/53.8%) reported that they had good un-

Table 1. Socio-demographic information of the participants (n=221)

Sex	Frequency	Percentage %
Male	128	57.5
Female	93	42.1
Age		
<20 years	05	2.3
21-25 years	149	67.4
26-30 years	61	27.6
31 and above	06	2.7
Year of study		
400 level	89	40.3
500 level	132	59.7

derstanding of these basic principles above taught during your pre-clinical training, with associated good performance during various assessment tests taken on them. In terms of their current knowledge of radiation physics, radiobiology and radiation protection providing them with the necessary skills and safety in the clinic the majority responded in the affirmative (n=165/74.7%). More than half (n=126/57.0%) responded that they were familiar with the basic principles of radiation physics, radiobiology and radiation protection in all the modalities of medical imaging (CT, MRI, radiotherapy, USS, fluoro, nuclear medicine, etc.). The majority (n=170/76.9%) reported that they appreciated this knowledge in the diagnosis and treatment of diseases. Almost all (n=213/96.3%) reported that they were aware of the potential biological effects of ionising radiation on staffs and patients.

As shown in Table 3. The majority (n=187/84.6%) stated they did apply knowledge of radiation physics in selection of exposure factors during clinical trainings 187 (84.6%). In terms of applying the ALARA principles of radiation safety during all examination protocols and procedures in the clinic the majority (n=205/92.7%) reported that their knowledge of radiation physics helps them to accurately justify the use of grid mechanism In terms of considering patient habitus the majority (n=199/90.0%) confirmed that they did take this into consideration in the use of a grid. The response for the question on standing at a safe distance from the patient during every radiation exposure undertaken in the clinic was n=203 (91.8%). The majority (n-157/71.1%) confirmed that they did communicate the importance of immobility and compliance to the patient in order to avoid repeats. Poor patient-radiographer communication/poor compliance was reported (n=157/71.1%) as a major cause of repeats. Just of half (n=115/52.0%) indicated that their knowledge of radiation physics was not limited to conventional X-ray . However, it was noted that majority (n=182/82.3%) could not calculate the absorbed radiation dose they received over a period of going for postings.

Table 4 demonstrates barriers faced by the participant undergraduate students in applying radiation physics knowledge during their clinical training in frequencies and percentages. The results are as follows: had an interest in radiation physics (n=142/64.3%); did not experience a wide gap between what they were taught in class and what is applicable in clinical postings (n=93/42.0%);did not avoid clinical postings because of fear of the biological effects of radiation to their health (n=187/84.6%); had limited clinical posting experiences because of over population of students

Table 2. Participants/students opinion of radiation physics knowledge among clinical radiography students prior to their clinical training (n=221)

S/N	Variables	n (%)	n (%)	n (%)	n (%)
1.	Were you thoroughly taught the basic principles of radiation physics, radiobiology and radiation protection during your pre-clinical training?	YES 180 (81.4)	NO 24 (10.9)	NOT SURE 17 (7.7)	
2.	Rate your understanding of these basic principles above taught during your pre-clinical training?	POOR 16 (7.2)	FAIR 54 (24.4)	GOOD 119 (53.8)	EXCELLENT 32 (14.5)
3.	Rate your performance during various assessment tests taken on the principles of radiation physics, radiobiology and radiation protection.	POOR 16 (7.2)	FAIR 54 (24.4)	GOOD 119 (53.8)	EXCELLENT 32 (14.5)
4.	Do you believe that your current knowledge of radiation physics, radiobiology and radiation protection is capable of giving you the necessary skills and safety in the clinic?	YES 165 (74.7)	NO 23 (10.4)	NOT SURE 33 (14.9)	
5.	Are you familiar with the basic principles of radiation physics, radiobiology and radiation protection in all the modalities of medical imaging (CT, MRI, Radiotherapy, USS, FLUORO, Nuclear Medicine, etc)?	YES 126 (57.0)	NO 57 (25.8)	NOT SURE 38 (17.2)	
6.	Can you now appreciate this knowledge in the diagnosis and treatment of diseases?	YES 170 (76.9)	NO 20 (9.0)	NOT SURE 31 (14.0)	
7.	Are you aware of the potential biological effects of ionising radiation on staffs and patients?	YES 213 (96.4)	NO 5 (2.3)	NOT SURE 3 (1.4)	

in the clinic (n=179/81.0%); experienced difficulties in understanding certain radiation physics principles and applying them after being taught (n=107/48.5%); and that there was an unavailability of radiation physics/protection resources to aid application (n=117/52.9%). Just of half agreed there was s poor supervision/guidance for students by practicing radiographers who ought to ensure that students apply their preclinical knowledge (n=114/51.5%); they often expe-

Table 3. Extent to which undergraduate radiography students/participants were able to apply radiation physics principles in clinical practice (n=221)

Variables	Negative Responses (SD & D) (%)	Undecided (%)	Positive Responses (SA & A) (%)
I apply my knowledge of radiation physics in selection of exposure factors during clinical training	20 (9.1)	14 (6.3)	187 (84.6)
I apply the ALARA principles of radiation safety during all examination protocols and procedures in the clinic	10 (4.5)	6 (2.7)	205 (92.7)
I can calculate the absorbed radiation dose I receive over a period of going for postings	127 (57.5)	45 (20.4)	49 (22.1)
My knowledge of radiation physics helps me to accurately justify the use of grid mechanism while considering patient habitus	19 (8.6)	20 (9.0)	199 (90.0)
I stand at a safe distance from the patient during every radiation exposure undertaken in the clinic	13 (5.9)	9 (4.1)	203 (91.8)
I communicate the importance of immobility and compliance to my patient to avoid repeats	11 (5.0)	7 (3.2)	157 (71.1)
The major cause of repeat I experienced in the clinic results from poor patient-radiographer communication/poor compliance	35 (15.8)	29 (13.1)	157 (71.1)
My knowledge of radiation physics is limited only to X-ray (conventional radiography)	115 (52.0)	30 (13.6)	76 (34.4)

SD = strongly disagree, D = disagree, U = undecided, A = agree, SA = strongly agree

Table 4. Barriers faced by the participant undergraduate radiography students/ in applying radiation physics knowledge during their clinical training (n=221)

Variables	Negative Responses (SD & D) (%)	Undecided (%)	Positive Responses (SA & A) (%)
I have no interest in radiation physics because I perceive it as a hard course with abstract applications	142 (64.3)	36 (16.3)	43 (19.5)
I experience a wide gap between what's been taught in class and what is applicable in clinical postings	94 (42.6)	37 (16.7)	90 (40.7)
I avoid clinical postings because of fear of the biological effects of radiation to my health	187 (84.6)	16 (7.2)	18 (8.2)
I have limited clinical posting experiences because of over population of students in the clinic	27 (12.3)	15 (6.8)	179 (81.0)
I experience difficulties in understanding certain radiation physics principles and applying them after being taught	76 (34.4)	38 (17.2)	107 (48.5)
There is unavailability of radiation physics/protection resources to aid applicability	66 (29.8)	38 (17.2)	117 (52.9)
There's poor supervision/guidance for students by practicing radiographers who ought to ensure that students apply their pre-clinical knowledge of radiation	73 (33.1)	34 (15.4)	114 (51.5)
I often experience faulty/non-functional equipment during clinical postings shifts	75 (33.9)	33 (14.9)	113 (51.2)
There are limited opportunities for students to ask questions, seek clarification or engage in discussion related to radiation physics	76 (34.3)	34 (15.4)	111 (50.3)

SD = strongly disagree, D = disagree, U = undecided, A = agree, SA = strongly agree

Table 5. Methods for improving the integration of radiation physics knowledge in clinical postings (n=221)

	Which of following measures do you believe will further advance the application of radiation physics among clinical students?	YES n (%)	NO n (%)	NOT SURE n (%)
1.	I have no interest in radiation physics because I perceive it as a hard course with abstract applications	199 (90.0)	21 (9.5)	1 (0.5)
2.	I experience a wide gap between what's been taught in class and what is applicable in clinical postings	154 (69.7)	66 (29.9)	1 (0.5)
3.	I avoid clinical postings because of fear of the biological effects of radiation to my health	210 (95.0)	10 (4.5)	1 (0.5)
4.	I have limited clinical posting experiences because of over population of students in the clinic	211 (95.5)	8 (3.6)	2 (0.9)
5.	I experience difficulties in understanding certain radiation physics principles and applying them after being taught	206 (93.2)	13 (5.9)	2 (0.9)
6.	There is unavailability of radiation physics/protection resources to aid applicability	210 (95.0)	10 (4.5)	1 (0.5)

rience faulty/non-functional equipment during clinical postings shifts (n=113/51.2%); and was limited opportunities for students to ask questions, seek clarification or engage in discussion related to radiation physics (n=111/50.3%).

Table 5 demonstrates recommendations for improving the integration of radiation physics knowledge in clinical postings in frequencies and percentages. The results were as follows. Development of a dedicated/achievable radiation physics curriculum with unlimited access to updated textbooks and reference materials (n=199/90.0%); increase in the duration of radiation physics education in pre-clinical classes (n=154/69.7%); employment of radiation physics experts to handle students in radiation physics courses (theory and practical) (n=210/95.10%); provision of hands-on practical trainings in applying radiation physics during clinical postings (n=211/95.5%); incorporate interactive learning methods, such as simulations or virtual reality especially to cushion effects of overpopulation currently experienced (n=206/93.2%); and encourage collaboration between radiation physicists, clinical trainers and clinical students during clinical trainings (n=210/95.0%).

DISCUSSION

In the evaluation of the extent to which clinical radiography students were thoroughly taught prior to their clinical training, it was revealed from the results that majority (81.4%) responded in the affirmative. Over two third (68.3%) stated that they understood what they were being taught in radiation physics and performed well when assessed on what they have learnt. Almost three quarters (74.7%) confirmed they had acquired sufficient knowledge during clinical training to produce the necessary skill they need for their clinical training. This result is in keeping with that of Tejinder et al[9] where the majority of the students in their study possessed variable levels of prior knowledge of the core Einsteinian concepts.

In our study the participants use of this acquired knowledge in the treatment of diseases and the potential biological effects of ionizing radiation on staffs and patients was also rated high among the students: 76.9% and 96.4%, respectively. This significantly is in contrast with the study carried out by Rego et al[10] on the effects of radiation on different organs or living beings, where the awareness among the students did not display a strong opinion, with average scores lying between 3.1 and 3.6 against a ten-point scale.

The result on the application of the acquired knowledge of radiation physical during clinical training revealed that majority of the participants did apply this knowledge in a variety of ways like, in the selection of exposure factors, in employing the ALARA principle for radiation safety of themselves and the patient, and in communicating with or positioning a patient during examinations to avoid repeat cases. The majority affirmed that their application of this acquired knowledge cuts across all the various modalities in medical imaging and not limited to just conventional X-ray imaging.

Our findings highlighted the challenges faced by radiography students in applying their knowledge of radiation physics during clinical rotations. Despite reporting that they were thoroughly taught the basic principles of radiation physics, radiobiology, and radiation protection during pre-clinical training, the majority struggled to calculate absorbed radiation doses and experienced difficulties in understanding and applying certain radiation physics principles. Calculating absorbed radiation doses is a critical skill for radiographers, as it directly impacts patient safety and radiation protection. This finding suggests that the students in our may not be receiving sufficient clinical practical experience or feedback on how absorbed radiation doses are monitored and calculated.

These results are consistent with previous research that identified gaps in the application of theoretical knowledge in clinical settings.[11] The findings also support the notion that clinical training experiences play a crucial role in developing students' competence in applying radiation physics principles.[12] Our findings are in keeping with Rego et al[10] as they reported average scores between 3.2 and 3.5 against a ten-point scale showed that the students cannot measure the difference between doses delivered in diagnostic examinations and doses delivered in therapy.

The major barriers in the application of their acquired knowledge during clinical postings was over-crowding of procedure rooms during clinical rotations, unavailability of radiation physics/protection resources, poor supervision/guidance by their superiors in the clinic, and poor/lack of interactive sessions between students and their clinical supervisors. Overcrowding in clinics can limit students' opportunities to engage in hands-on learning, observe procedures, and develop their skills in a real-world setting. This finding raises questions about the capacity of the teaching hospital in our study to accommodate clinical students, as well as the effectiveness of the clinical education programme in providing students with meaningful learning experiences. Lack of resources can limit students' opportunities to engage in self-directed learning, practice problem-solving, and develop their critical thinking skills. Also, lack of supervision can limit students' opportunities to develop their skills, receive feedback, and learn from experienced professionals and faulty or non-functional equipment can limit students' ability to practice procedures, develop their critical thinking skills, and learn from hands-on experiences.

This result contrasts with the study conducted by Young et al[13] where most radiography students reported a positive attitude towards clinical supervision (73.3%), although a significant minority reported not being confident across survey items related to the tasks required in supervising students during their clinical rotations (ranging from 20.7% - 29.1%).

The participants in our study suggested that to increase the application of their acquired knowledge during clinical trainings include the following should be considered. Provision of hands-on practical trainings in applying radiation physics during clinical postings; employ radiation physics experts to handle students in radiation physics courses (theory and practical) and to solve the issue of over-crowding during clinical rotations; incorporating interactive learning methods, such as simulations or virtual reality specially to cushion effects of overpopulation currently experienced; and encourage collaboration between radiation physicists, clinical trainers and clinical students during clinical trainings. These suggestions are in keeping with those of Thea et al[14] because graduating nursing students reported that they have low competence in communication, leadership and delegation skills, which may be due to lack of sufficient opportunities to practice communication/leadership skills such as delegation and supervision during clinical rotations. A near-peer clinical supervision model was done and the result of this study by whom? on twenty-seven first-year (69.2%) and 43 third-year (46.7%) students who completed the questionnaire noted positive experience and would recommend it to other students, Third-year students reported gaining confidence, teaching, delegation and leadership skills.

LIMITATIONS

Some of the limitations of study include sample size as the findings were limited to just clinical radiography students in UNEC, potentially impacting the generalisability of the results. Time constraints were a limitation as the overbearing academic workload did does not balance with time required for learning and project research work. The abnormally short academic session posed limitations in our research work.

RECOMMENDATIONS

The findings of this study have significant implications for radiography education and practice. Firstly, the study highlights the need for radiography programmes to provide students with more opportunities to practice and apply radiation physics principles in clinical settings. This can be achieved by increasing the number of clinical posting hours, providing students with access to simulation software or virtual reality environments, and encouraging instructors to use more interactive and immersive teaching methods. Secondly, the study emphasises the importance of providing students with timely and constructive feedback on their understanding and application of radiation physics principles. Instructors and programme administrators should strive to create a supportive learning environment that encourages students to ask questions, seek clarification, and engage in discussions related to radiation physics. Finally, the study highlights the need for radiography programmes to address the resource gaps and equipment issues that can limit students' opportunities to develop their technical skills. Programme administrators and clinic administrators should work together to ensure that students have access to functional equipment and resources that support their learning and development.

CONCLUSION

Incorporating radiation physics knowledge into clinical rotations for clinical radiography students holds great potential for enhancing their understanding and practical application of this crucial aspect of their profession. By following the recommended strategies, educators can create a more comprehensive and effective learning experience. While there are limitations to the study, such as sample size and external factors, the positive impact on students' ability to apply radiation physics in clinical settings suggests that this approach has significant educational value.

ETHICAL CLEARANCE/INFORMED CONSENT

Ethical approval to carry out the research was obtained from the Health Research and Ethics Committee of University of Nigeria Teaching Hospital, Ituku-Ozalla. An online informed consent form was attached to the electronic questionnaires distributed to the participants during the data collection. Participants give an informed consent before they proceed to other sections of the questionnaire. Participants were assured of their right to withdraw at any time without consequences. To protect participants' confidentiality, no personally identifiable information was collected and the collected data was anonymised before analysis. This study complied with the Nigeria Data Protection Act (2023) (13) in ensuring the confidentiality and security of participant data.

AVAILABILITY OF DATA AND MATERIAL

The data used for this study are available upon reasonable request.

COMPETING INTERESTS

The authors declared no potential competing interest with respect to the research, authorship, and/or publication of this article.

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CONTRIBUTIONS OF THE AUTHORS

IFU conceptualised the idea, BUM developed the methodology, AE, CEN and CC collected the data. AE, CEN analysed the data. IFU wrote the original draft, and BUM reviewed and edited the manuscript. All authors read and agreed to the final draft for publication.

DISCLAIMER

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the views of the publisher and editorial board.

REFERENCES

1. Mehta SR, Suhag V, Semwal M, Sharma N. Radiotherapy: Basic Concepts and Recent Advances. Med J Armed Forces India. 2010 Apr; 66(2):158-62. doi: 10.1016/S0377-1237(10)80132-7. Epub 2011 Jul 21. PMID: 27375326; PMCID: PMC4920949.
2. Lenaerts E, Coucke P. La physique des radiations ionisantes pour les néophytes [Radiation physics for beginners]. Rev Med Liege. 2014; 69 Suppl 1:13-5. French. PMID: 24822299.
3. Matthews EP. Radiation Physics, Biology, and Protection. Radiol Technol. 2019 May; 90(5):471-485. PMID: 31088948.
4. Bortfeld T, Jeraj R. The physical basis and future of radiation therapy. Br J Radiol. 2011 Jun; 84(1002):485-98. doi: 10.1259/bjr/86221320. PMID: 21606068; PMCID: PMC3473639.
5. Donya M, Radford M, ElGuindy A, Firmin D YM. Radiation in medicine: Origins, risks and aspirations. Glob Cardiol Sci Pr. 2014; 4:437-48.
6. Nakashima J, Duong H. Radiology, Image Production and Evaluation. 2023 Jul 31. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan. PMID: 31985938.
7. Feynman, Richard Phillips. "The Relation of Physics to Other Sciences." The Physics Teacher 2 (1964): 111-117.
8. Yamane T. Taro Yamane Method For Sample Size Calculation. Math Assoc Niger. 2021; 46(1):188.
9. Kaur, T. and Blair, D. and Stannard, W. and Treagust, D. and Venville, G. and Zadnik, M. and Mathews, W. et al. 2018. Determining the Intelligibility of Einsteinian Concepts with Middle School Students. Research in Science Education.
10. Rego, Florbela & Peralta, Luis. (2006). Portuguese students' knowledge of radiation physics. Physics Education. 41. 259. 10.1088/0031-9120/41/3/009.
11. Kelly C. Student's perceptions of effective clinical teaching revisited. Nurse Educ Today. 2007 Nov; 27(8):885-92. doi: 10.1016/j.nedt.2006.12.005. Epub 2007 Feb 23. PMID: 17321013.
12. Atwood TF, Brown DW, Juang T, Moore KL, McConnell KA, Steers JM, Murphy JD, Mundt AJ, Pawlicki T. A review of patient questions from physicist-patient consults. J Appl Clin Med Phys. 2020 Aug; 21(8):305-308. doi: 10.1002/acm2.12942. Epub 2020 Jun 9. PMID: 32519450; PMCID: PMC7484844
13. Young, H.D.; Freedman RAS and Z. University Physics with Modern Physics Technology Update. 13th ed. Pearson Education; 2014. 32-44 p.
14. Van de Mortel TF, Needham J, Henderson S. Facilitating learning on clinical placement using near-peer supervision: A mixed methods study. Nurse Educ Today. 2021 Jul;102:104921. doi: 10.1016/j.nedt.2021.104921