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Interpretation of radiographs: how good are Nigeria-trained radiographers?

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ABSTRACT

Background. There is a shortage of radiologists in many countries, including Nigeria, which means that many radiographic examinations are unreported. Radiographers may be able therefore provide expert opinions on radiographs in the absence of a radiologist.

Purpose. The study aimed to assess the performance of Nigerian-trained radiographers in the interpretation of radiographic images from a selected range of commonly performed radiographic investigations.

Methods. Ten Nigeria-trained radiographers participated in the study to interpret radiographs (films) from 1189 radiographic examinations. The interpretations of participant were compared with the reports of radiologists, which were regarded as the gold standard. The sensitivity, specificity and accuracy of the participants' interpretations were then determined.

Results. An overall sensitivity of 89.8%, a specificity of 93.5%, and an accuracy of 92.3% were achieved by the participants. Those with post-basic training in radiographic image interpretation performed significantly better than those without post-basic training ($p < 0.0001$).

Conclusion. The performance of the selected Nigeria-trained radiographers in radiographic image interpretation was good when compared with the reports of radiologists. Post-basic training in x-ray film interpretation may result in higher accuracy. It is recommended that Nigerian radiographers with post-basic image interpretation training should assume x-ray film interpretation roles in public hospitals in Nigeria to reduce the number of unreported examinations in view of a shortage of radiologists.

Keywords radiographer reporting, post-basic training, image interpretation

LAY ABSTRACT

A study was done to determine the image interpretation skills of ten radiographers.

INTRODUCTION

There is anecdotal evidence that radiographer reporting of x-ray images is being practised in some hospitals and privately-owned radiology clinics in Nigeria, albeit on an informal basis. A radiographer is a member of the diagnostic radiology workforce and has the required training to provide expert opinion on radiographs.^[1] A radiographer is the first healthcare professional to view every acquired diagnostic image.^[2] A radiographer is therefore in a unique position to communicate professional observations directly to a referring clinician promptly; this could have a significant positive influence on patient care.

^[2] Radiographer reporting augments the work of radiologists who may be over-

whelmed by too many medical images from digital radiography, computed tomography, magnetic resonance imaging and scintigraphy. This is especially true as advancements in equipment design and manufacture have led to the evolution of modern imaging modalities that produce an avalanche of images per investigation.

In some countries the high workload of radiologists has been lessened by employing the services of radiographers trained in plain axial and appendicular x-ray as well as ultrasound interpretation.^[3] While this approach has been used effectively for over 40 years in the United Kingdom and other industrialised countries,^[4] x-ray interpretation by radiographers remains a contentious issue in Nigeria.^[5] We are

advocating for a formal role for radiographers to interpret radiographs in Nigeria. Our proposal for radiographer reporting in Nigeria is based on the fact that general pathology, radiological anatomy, radiographic pathology, image critique and pattern recognition are all integral parts of the radiography curriculum at both the undergraduate and postgraduate levels.^[6] The Radiographers Registration Board of Nigeria (RRBN) encourages Nigerian radiographers to extend and advance their roles through the opportunities provided by its continuing professional development programmes (CPD) to improve their professional knowledge, competence and skills.^[7] There are three Nigerian universities, namely, University of Nigeria, Nsukka; Nnamdi Azikiwe University,

Awka; and the University of Calabar that offer postgraduate studies in radiography. Of the three, only Nnamdi Azikiwe University offers postgraduate training in film interpretation. The programme combines practical learning of radiological image interpretation and courses covering radiological anatomy, pathology, and pattern recognition.

Diagnostic imaging has continued to undergo rapid technical evolution^[8] and services have had to evolve to keep pace with sustained annual increases in demand.^[9] Although image acquisition strategies have delivered capacity growth, image interpretation remains a challenge^[5] and as a result, new ways of working have developed at local and national levels. Radiographers in Nigeria have contributed to the reporting of radiographs in the private setting; the accuracy of these reports is unclear.^[5] There is also limited evidence of the impact of radiographers working in advanced roles beyond task substitution.^[9] The performance of radiographers in interpreting skeletal radiographs at the end of accredited postgraduate training in Southern England was found to be promising: a sensitivity level of 91.6% - 96.7% and specificity of 92.1% - 94.0%.^[3] Also, a large multi-centre clinical evaluation, consisting of 7179 cases conducted across four sites in the United Kingdom showed that the accuracy was 99.1%; sensitivity 97.6% and specificity 99.3%, for skeletal trauma reports produced by trained reporting radiographers.^[10] A study on radiographer reporting in Nigeria was conducted using a narrow range of chest x-rays.^[5]

Nigerian radiographers interpret radiographs and other radiological images in private hospitals and radiodiagnostic centres across Nigeria, but the accuracy of these reports remains undetermined. In view of this we deemed it necessary to assess the performance of Nigeria-trained radiographers in the interpretation of radiographs using a selected range of commonly performed x-ray investigations. Literature does report on the evaluation of radiographers' performance in interpreting chest radiographs only.^[5]

In this current study we assess the performance of two groups of Nigeria-trained radiographers with basic, and post-basic training, respectively in the interpretation of a selected range of commonly performed x-ray investigations using radiologists' reports as the gold standard.

MATERIALS AND METHODS

The radiographs and accompanying radiologists' reports used in this study were obtained from the film archive of a private hospital in Lagos, Nigeria. Ethical approval to conduct the study was obtained from the Research Ethics Committee of Faculty of Health Sciences and Technology, Nnamdi Azikiwe University, Awka. The archived radiographs were from January 2016 to December 2018.

The sample was radiographs obtained from x-ray investigations in the hospital and the radiologists' reports. Ten practising Nigeria-trained radiographers were purposely selected to participate in the study. The x-ray examinations were: skull, thorax, abdomen, pelvis, extremities, gastrointestinal tract, female reproductive tract, and urinary tract.

A total of 1189 x-ray examinations and the corresponding radiologists' reports were selected for the study. A stratified sampling technique was used to select the different examinations. The study sample comprised 150 skull radiographs, 300 chest radiographs, 114 pelvic radiographs, 150 plain abdominal radiographs, 400 examinations of the extremities, 36 hysterosalpingograms (HSG), 19 intravenous urograms (IVU) and 20 barium studies. The inclusion criteria for the x-ray examinations were as follows.

- i. X-ray examinations had to be of patients presenting for the respective x-ray investigation at the hospital where the study was conducted.
- ii. The radiographs had to be a digital copy produced from a computed radiography unit of the hospital.
- iii. Each radiograph had to have satisfactory radiographic technical requirements with regards to the reports issued by each radiologist.
- iv. The radiological reports had to have been issued by the hospital's radiologists.

The inclusion criteria for radiographers that participated in the study were as follows.

- i. A registered Nigeria-trained radiographer practising in Nigeria.
- ii. Voluntarily consented to participate in the study.
- iii. Had to have at least five years experience in x-ray image interpretation before the commencement of the study.

The participants comprised Nigeria-trained radiographers who (i) had undergone post-basic training in x-ray image interpretation, and (ii) those without post-basic training. Each selected radiograph was de-identified and sent to the participants. They were not sent the respective reports of the radiologists. This was achieved by copying the radiographs to a separate folder on the computed radiography unit. Each radiograph was then assigned a unique identification number. The participants were provided with each patient's age, sex, referral source and clinical history. They were requested to write a report indicating (i) normal or abnormal appearances on each radiograph, (ii) key details on abnormal radiographic appearances they observed, and (iii) their impression of what the pathology(ies) might be. Their reports were recorded in a pro forma provided by the researchers. Each participant's level of training in film interpretation was recorded.

To adhere to the principles of confidentiality the data were stored in a secure personal computer. As a precaution to avoid observer bias, the participants were blinded to one another and the reports of the radiologists by sending them images without radiologists' reports using the blind carbon copy (Bcc). The participants received the radiographs and pro forma through e-mails at different locations across Nigeria. They were alerted about the images sent via mobile phones and were asked to send in their reports within 30 minutes of receiving the images.

DATA ANALYSIS

The reports were categorised according to the individual participants. The researchers assessed each report by comparing it with that of its corresponding report by a radiologist. The reports of each participant were assessed for agreement with the reports of radiologists on a case-by-case basis. A correct identification of a normal examination was identified as true negative (TN); a correct identification of an abnormal examination, site of abnormality and diagnosis identified as true positive (TP). If an examination was incorrectly reported as normal, it was identified as false negative (FN); if incorrectly reported as abnormal or the site of abnormality and the diagnosis did not correspond to the respective radiologist's report, it was identified as false positive (FP). The radiologists'

reports were used as the gold standard. The metrics used in the study were calculated as follows.

- TP = number of true positive cases
- TN = number of true negative cases
- FP = number of false-positive cases
- FN = number of false-negative cases
- P = number of all positive cases
- N = number of all negative cases

$Sensitivity = TP \div P \div (TP + FN)$...Equation 1

$Specificity = TN \div N$ or

$Specificity = TN \div (FP + TN)$...Equation 2

$Accuracy = (TP \div TN) \div (P + N)$...Equation 3

$False\ Positive\ Rate = FP \div N$ or

$False\ Positive\ Rate = FP \div (FP + TN)$ or

$False\ Positive\ Rate = 1 - Specificity$...Equation 4

$False\ Negative\ Rate = FN \div P$ or

$False\ Negative\ Rate = FN \div (FN + TP)$...

Equation 5

The data collected were analysed using MedCalc biomedical statistical soft-

ware version 19.4.1 (Acaciaaan 22 8400 Ostend Belgium). The overall sensitivity, specificity and accuracy of the participants' image interpretation was calculated. The sensitivity, specificity and accuracy of the participants' x-ray interpretation were categorised according to the type of x-ray examination and level of training in x-ray image interpretation. Statistical tests were two-tailed with statistical significance considered at $p < 0.05$.

RESULTS

The majority of participants ($n=8/80\%$) did not have post-basic training in image interpretation. The remainder ($n=2/20\%$) had undergone post-basic training in image interpretation. Table 1 shows the overall performance of the participants across the 10 categories of x-ray investigations used as samples in the study. It shows that the participants achieved a sensitivity of 89.8%, specificity of 93.5% and an accuracy of 92.3% in image interpretation. Table 2 shows the comparative performance of those with post-basic training in image interpretation and those without such training. Table 3 shows the statistical

comparison between the performances of the two groups over the entire range of the investigations that were interpreted. The two participants with post-basic training had significantly better sensitivity (95% vs 84.7%), specificity (96.1% vs 91%) and accuracy (95.7% vs 88.8%) than the eight without post-basic training ($p < 0.0001$).

DISCUSSION

This study aimed at determining the performance of two groups of Nigeria-trained radiographers; those with basic training, and those with post-basic training in image interpretation. Participants in each group were asked to report on a selected range of x-ray investigations. Their reports were compared with those of radiologists, which were used as the gold standard. This was done to determine the performance of the participants in x-ray image interpretation in order to obtain data for motivation of a formal radiographer reporting role in Nigeria's public hospitals, if needed. The study was underpinned by a shortage of radiologists, which results in many examinations not being reported, and published evidence that radiogra-

Table 1. The performance of all the participating Nigeria-trained radiographers in x-ray image interpretation

Outcome of examination	Abnormal	Normal	Total	Sensitivity	Specificity	Accuracy
	True Positive	False Positive		89.8%	93.5%	92.3%
Positive	362	51	413			
Negative	False Negative	True Negative				
	41	735	776			
Total	403	786	1189			

Table 2. The performance of Nigeria-trained in x-ray image interpretation according to the level of training and x-ray investigation

Investigation	Radiographers with post-basic training (n=2)			Radiographers without post-basic training (n=8)		
	Sensitivity (%)	Specificity (%)	Accuracy (%)	Sensitivity (%)	Specificity (%)	Accuracy (%)
Skull X-ray (n=150)	93.1	97.5	96.7	50	89.4	80
Chest X-ray (n=300)	97.8	96.1	96.7	95.5	92.5	93.3
Pelvis (n=114)	96.7	96.3	96.5	89.7	85.7	87.7
Plain abdomen (n=150)	85	94.6	92	76.2	92.6	88
Upper extremity (n=200)	98.1	95.1	97	94.8	88.1	92
Lower extremity (n=200)	89.7	96.9	95.5	73.2	93.7	89.5
HSG (n=36)	87.5	96.4	94.4	55.6	88.9	80.6
IVU (n=19)	100	90.9	94.7	75	72.7	73.7
Barium swallow (n=10)	66.7	100	90	66.7	100	90
Barium meal (n=10)	100	85.7	90	100	85.7	90
All investigations (n=1189)	95	96.1	95.7	84.7	91	88.8

Table 3. Comparison of the performance of radiographers with post-basic training in x-ray image interpretation and radiographers without post-basic training in x-ray image interpretation

Category	Sensitivity	Specificity	Accuracy
Nigeria-trained radiographers with post-basic training	95%	96.1%	95.7%
Nigeria-trained radiographers without post-basic training	84.7%	91%	88.8%
Difference	10.3%	5.1%	6.9%
Chi-square	69.129	25.616	39.573
95% Confidence Interval	7.92 - 12.72	3.14 - 7.11	4.78 - 9.07
Remark	$p < 0.0001^*$	$p < 0.0001^*$	$p < 0.0001^*$

Note: Degree of freedom = 1, * = statistically significant difference between pairs of values.

phers can interpret x-ray images. There are thus opportunities for radiographers to expand their scope of practice. The shortage of radiologists in Nigeria was highlighted previously; in 2015 there were between 250 and 300 radiologists and this translates to about one radiologist to 566,000 persons.^[11] Therefore, cold reporting happens in most public hospitals.^[12] Literature does report good levels of performance of radiographers in image interpretation in Nigeria and other parts of Africa.^[5,13,14] The opportunities that exist for radiographer reporting have been highlighted in the literature.^[5,12,15]

The results of this study show a generally high level of performance by Nigeria-trained radiographers in image interpretation when compared with the radiologists' reports used in this study. The performance of the participants (radiographers) without post-basic training in image interpretation was good; those with post-basic training did significantly better. The implication of this is that education and training in image interpretation can potentially improve the accuracy of radiographer reports. The difference in performance between the two groups of Nigerian radiographers can be attributed to skills obtained during formal training. This points to the need for formal training programmes and support for interested Nigerian radiographers to equip them to develop their skills, knowledge, competence, confidence and fully utilise their potentials in the area of x-ray image reporting. Unfortunately, structured training in image interpretation is in short supply. There is only one postgraduate programme in film reporting, which is offered at the Nnamdi Azikiwe University. This programme leads to a Master of Science (M Sc) degree in the speciality after 12 months of full-time study or 18 months on a part-time basis. There are also pattern recognition module courses offered by the

Radiographers Registration Board of Nigeria (RRBN).

The performance of the radiographers in this study with post-basic training in interpretation of radiographs of the skull, chest, pelvis, plain abdomen and extremities was good. These types of radiographic examinations should therefore be included if there were to be phased stages of implementation of radiographer reporting. The participants' performance in the interpretation of HSG, IVU, barium swallow and barium meal examination was good. However, further research should be done because of the limited number of cases included in this study.

In carrying out this study, cognisance was taken of the opinion expressed by Donovan and Manning^[16] and re-echoed by Mubuke.^[17] For successful radiographer reporting to take place it should be task-specific and limited in scope. Their opinions hinged on the limited medical knowledge of radiographers. Previous studies on the subject-matter have been task-specific and limited in scope.^[3,5,13,18,19] The only difference between this current study and previous ones is that the scope of reporting was expanded to include radiological investigations of more body parts. The results in this current study may be viewed as encouraging when compared with previous studies with narrower scopes.

A major limitation of this study was the use of reports written by a team of radiologists as the gold standard to judge the correctness of radiographers' reports. The incidence of false-positive and false-negative diagnoses by the radiologists could not be ruled out. We re-echo the suggestion of Anderson et al^[19] in Australia: radiographer reporting should be considered more seriously in Nigeria despite the limitations of our study. This is especially

important with the increasing growth of radiology and imaging in the country.

The results of this study could be used to argue for a staged (phased) approach to the implementation of widespread acceptance of reporting on x-ray films by Nigerian radiographers. Structured postgraduate education in film interpretation should be developed, encouraged and supported for those Nigerian radiographers who choose to extend their roles in the area of x-ray film reporting. In-house, on-going training of Nigerian radiographers is essential to optimise patients' outcomes, especially in emergency departments.

CONCLUSION

This study provided statistical evidence of the high performance of the Nigeria-trained radiographers in image interpretation. The performance of Nigeria-trained radiographers in image interpretation can be improved by dedicated post-basic training in image interpretation.

CONFLICT OF INTEREST

None to declare.

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ROLE OF AUTHORS

Conceptualisation and design of the study was done by CCO, CEI, and CUE. CEI and RE did the literature search. Data collection and analysis was done by CEI, CCO, and RE. The manuscript was written by CEI, CCO, and RE. It was then checked by KO, CCO, CUE, CEI, RE, UE, and AUG.

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