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Pre-registration UK diagnostic radiography student ability and confidence in interpretation of chest X-rays

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Abstract

Introduction: Chest X-rays are the most frequently requested X-ray imaging in English hospitals. This study aimed to assess final year UK radiography student's confidence and ability in image interpretation of chest X-rays.

Methods: Thirty-three diagnostic radiography students were invited to assess their confidence and ability in interpreting chest x-rays from a bank of *n*=10 cases using multiple choice answers. Data analysis included 2x2 contingency tables, Kappa for inter-rater reliability, a Likert scale of confidence for each case, and questions to assess individual interpretation skills and ways to increase the learning of the subject.

Results: Twenty-three students participated in the study. The pooled accuracy achieved was 61% (95% CI 38.4-77.7; *k*=0.22). The degree of confidence and ability varied depending upon the student and the conditions observed. High confidence was noted with COVID-19 (*n*=12/23; 52%), lung metastasis (*n*=14/23; 61%), and pneumothorax (*n*=13/23; 57%). Low confidence was noted with conditions of consolidation (*n*=8/23; 35%), haemothorax (*n*=8/23; 35%), and surgical emphysema (*n*=8/23; 35%). From the sample *n*=11 (48%),

participants stated they felt they had the knowledge to interpret chest X-rays required for a newly qualified radiographer.

Conclusion: The results demonstrated final year radiography student's confidence and ability in image interpretation of chest X-rays. Student feedback indicated a preference for learning support through university lectures, online study resources, and time spent with reporting radiographers on clinical practice to improve ability and confidence in interpreting chest X-rays.

Introduction

The chest X-ray is the most frequently requested examination in X-ray imaging within England [1], with 192,000 patients being referred from general practitioners alone [2]. Chest X-rays are often used as the initial diagnostic tool to visualise the anatomical structures of the heart, lungs, and bones to detect a range of pathologies from trauma to infection, cardiomegaly, respiratory disease, and lesions [3].

The interpretation of chest X-rays is deemed the most challenging as practitioners must understand the techniques used to obtain the X-ray, assess the image quality, and interpret the basic anatomy within the thoracic cavity [4]. The United Kingdom (UK) Society of Radiographers [5] advise that all UK qualified diagnostic radiographers must have the skills to perform an initial interpretation of their images under the preliminary clinical evaluation (PCE) policy to assist identification of patients with acute abnormalities [6]. The UK Society of Radiographers [5] policy aims to promote the escalation of acute findings to relevant healthcare professionals so they may be reported and actioned in a timely manner [7]. The UK Health and Care Professions Council [8] recommends that all pre-registration students complete sufficient training in image interpretation to be able to practice adequately.

At present, there is limited research on UK student radiographers interpreting chest X-rays outside of eye gaze assessment [9], education [10], or image quality [11]. Research within this area would be beneficial to support student radiographer image interpretation education within their pre-registration degree and provide the foundations for career progression in the future for PCE written commenting of X-ray images and postgraduate reporting qualifications [12].

Research on other healthcare professions interpreting chest X-rays have included final year medical students' accuracy in chest X-ray interpretation by Jeffery et al.[13] who assessed fifty-two students observing ten chest X-rays containing common conditions that they would be expected to recognise. Jeffery et al.[13] concluded that final year medical students struggled to interpret the chest X-rays and lacked confidence in the task. However, it is recognised that medical students receive less chest X-ray teaching than diagnostic radiography students; thus, the results may reflect the disparity in student learning and confidence in ability.

Similarly, Ball et al.[14] observed third-year physiotherapy students' interpretation of six chest X-rays of limited pathologies that physiotherapists would be expected to identify, which resulted in low accuracy scores. Physiotherapy students often gain comparable teaching to radiography students on chest X-ray interpretation as their clinical role will involve assessing chest X-rays, which can influence physiotherapy patient management strategies.

This study aimed to assess final year UK diagnostic radiography student's confidence and ability in image interpretation of chest X-rays. Radiography students within the UK receive more image interpretation education than their fellow healthcare professionals [15]. Thus, the results are expected to differ from other healthcare professions' studies. The results would also have implications for patient safety and the future development of UK radiography undergraduate education.

Methods

Ethical approval for the study was gained from Canterbury Christ Church University Ethics Committee. The participants were recruited from third-year diagnostic radiography students who attended Canterbury Christ Church University. Participant recruitment was conducted by distributing an introductory email with an information sheet to explain the background of the research, what the participants would be required to complete, the eligibility criteria for the study, and a link to the test. A follow-up reminder email was used to reduce non-response bias. The Google Forms online platform [16] was utilised for the data collection. This allowed the responses to be anonymised and automatically returned and compiled into a spreadsheet for analysis (to reduce response bias). The protocols around confidentiality and General Data Protection Regulations (GDPR) were explained following the institution and data protection policies. A consent form was attached to the first page of the electronic test to allow for informed consent and was a requirement to complete consent to proceed to the study. The consent form also included procedures on how participants could withdraw from the study at any stage and who to contact.

Test bank of images

The test contained ten chest X-ray cases with an increasing difficulty level. The disease prevalence was 80% abnormal and 20% normal (including normal variant anatomy). The reference standard applied included two consultant radiologist's agreement on the condition (pathology present) of each chest X-ray case. Two image interpretation lecturers adjudicated the final bank of 10 cases to ensure the suitability of image quality, visibility of the condition, and confirmation the abnormalities were within the scope of learning for third-year student radiographers.

Data collection tool

Each chest X-ray case was presented with the patient's age and gender and four multiple-choice answers (conditions) to choose a correct answer from, similar to UK Royal College of Radiologists [17] assessments.

A 5-point Likert scale question was added after each X-ray case which asked participants to rate the confidence level of their answer, ranging from '1 very unconfident; 2 unconfident; 3 neutral; 4 confident; 5 very confident'. A closed question with forced-choice answers of 'no; yes; not sure', was used at the end of the test for the student radiographers to signify whether they believed their interpretation skills gained from the undergraduate training were sufficient for newly qualified radiographers. If the student answered 'no' or 'not sure' as part of the closed question, they were prompted to answer an open question on what they believed would be most beneficial for their learning to increase confidence in interpreting chest X-rays.

Data analysis

The data analysis used a 2x2 contingency table to calculate accuracy, sensitivity, and specificity, which categorised the responses into true positives (TP), true negatives (TN), false positives (FP) and false negatives (FN); against the known abnormality or normal anatomy as confirmed by the reference standard. A TP score would indicate that the participant correctly identified the case as abnormal in confirmation of the abnormality's reference standard agreement. A FP score would indicate the participant wrongly identified the case as abnormal when confirmed as normal anatomy by the reference standard. A TN score indicates the participant correctly identifying the case as normal compared to the reference standard confirmed normal anatomy. A FN score indicates the participant identified the case as normal when the reference standard agreed that it contained an abnormality. The percentage of accuracy, sensitivity, and specificity can overestimate the true agreement among participants; thus, further statistical analysis included Kappa's interpretation of agreement using each participant's observed TP, TN, FP, FN scores in the 2x2 contingency table to calculate values of Kappa agreement ranging from slight accuracy to almost perfect accuracy (table 1). Kappa measures the consistency (agreement and variability) of inter-rater reliability of the observations among the sample and factors in the possibility of the guessing answers [18,19].

Calculation of the Likert ordinal data used to observe the student’s confidence merged the two unconfident scale responses for each case and the two confident scale responses to calculate percentages between the categories. A mean was not calculated from the non-parametric Likert ordinal data as it would be meaningless as an average to measure central tendency.

Table 1
Kappa statistical interpretation of agreement by Landis and Koch [20].

Kappa	Degree of agreement
Kappa < 0	No agreement
Kappa between 0.00 and 0.20	Slight agreement
Kappa between 0.21 and 0.40	Fair agreement
Kappa between 0.41 and 0.60	Moderate agreement
Kappa between 0.61 and 0.80	Substantial agreement
Kappa between 0.81 and 1.00	Almost perfect agreement

The closed question of forced-choice ('no; yes; not sure') was analysed as a percentage of responses. The open question was assessed by coding the free-text responses into commonly reoccurring themes and words.

Results

Thirty-three final-year students were invited to participate, and twenty-three responses were received, representing a response rate of 69.7%. The participants' answers for the ten chest X-ray cases were assessed against TP, TN, FP, FP categories of each of the four multiple choices (table 2) and provided a breakdown of participants' judgments for each case.

The responses for the *n*=23 participants calculated a pooled accuracy of 61.3% with a 95% confidence interval (95%CI) of 38.4 - 77.7 to observe the range of data, of which a wide variance can be observed from the participants in table 3. The spread of scores across the participants' sample identified the highest accuracy 100%, and the lowest 30%.

The sensitivity pooled estimated of the sample of participants was 81% (95%CI 73.3-87.1), providing a measure of the student radiographers ability to identify abnormalities (with a narrow range of variance). At the same time, the ability to identify normal anatomy as calculated with the pooled specificity of 33% (95%CI 23.6-43.3) provided a lower metric of ability.

The pooled Kappa value for the student radiographer’s inter-rater agreement was low (0.22), categorising the measurement of fair agreement, which was lower than expected.

Table 2
Breakdown of responses within the multiple-choice answers to the ten chest X-ray cases.

Image bank	Choice 1	Choice 2	Choice 3	Choice 4
Case 1	Pneumothorax (FP)	Emphysema (FP)	Haemathorax (FP)	Pleural Effusion (TP)
	n=2	n=1	n=1	n=19
Case 2	Aortic Dissection (FP)	Pneumoperitoneum (FP)	Pneumothorax (TP)	Emphysema (FP)
	n=10	n=0	n=12	n=1
Case 3	Pneumonia (FP)	Pulmonary Oedema (FP)	Lung Metastasis (TP)	COVID-19 (FP)
	n=0	n=0	n=21	n=2
Case 4	Tuberculosis (FP)	Pulmonary Oedema (FP)	Consolidation (TP)	Pneumonia (FP)
	n=7	n=2	n=8	n=6
Case 5	Pneumothorax (FP)	COPD (FP)	Haemothorax (FP)	Normal (TN)
	n=1	n=4	n=0	n=18
Case 6	COVID-19 (TP)	Emphysema (FP)	Pneumoperitoneum (FP)	Tuberculosis (FP)
	n=21	n=2	n=0	n=0
Case 7	COVID-19 (FP)	Pneumothorax (FP)	Normal (FN)	COPD (TP)
	n=0	n=4	n=4	n=15
Case 8	Haemothorax (TP)	Pleural Effusion (FP)	Pneumonia (FP)	Pneumothorax (FP)
	n=7	n=7	n=3	n=6
Case 9	Situs Inversus (FN)	Cardiomegaly (FP)	Dextrocardia (TN)	Lung Metastasis (FP)
	n=10	n=0	n=13	n=0
Case 10	Pleural Effusion (FP)	Pneumonia (FP)	Surgical Emphysema (TP)	Normal (FN)
	n=3	n=1	n=7	n=12

The results demonstrated that the participants could competently identify pathologies that are frequently seen in the hospital setting, such as COVID-19, lung metastasis, and pleural effusions. Pathologies that participants struggled with identifying were consolidation, haemothorax and surgical emphysema. Indicating more emphasis could be placed on these conditions within the undergraduate education curriculum. It is recognised there is a degree of difficulty and knowledge required to identify these conditions by student radiographers. These conditions often mimic the appearance of other respiratory conditions that can affect the clinical judgment of the image appearances.

Table 3

Participant individual and pooled interpretation scores across the bank of ten chest X-rays.

Participant	TP	FP	TN	FN	Accuracy	95% CI	Sensitivity	95% CI	Specificity	95% CI	Kappa	95% CI
1	4	3	2	1	60%	28.6-78.9	80%	48.6-98.9	40%	8-58.9	0.20	0-0.75
2	5	2	1	2	60%	41.1-89.1	71.4%	57.9-92.2	33.3%	01-81.8	0.04	0-0.68
3	6	3	1	0	70%	51.1-70	100%	4.3-100	25%	01-25	0.29	0-0.76
4	3	5	1	1	40%	21-58.9	75%	51.4-98.6	16.7%	0-32.4	0.07	0-0.38
5	6	2	2	0	80%	48.8-80	100%	74-100	50%	11-50	0.55	0.04-1.00
6	6	2	1	1	70%	51.1-88.9	85.7%	72.2-99.2	33.3%	01-64.8	0.21	0-0.85
7	4	4	1	1	50%	31.1-68.9	80%	61.1-98.9	20%	01-38.9	0	0-0.49
8	5	2	1	2	60%	41.1-89.1	71.4%	57.9-92.2	33.3%	01-81.8	0.04	0-0.68
9	6	2	2	0	80%	48.8-80	100%	74-100	50%	11-50	0.55	0.04-1.00
10	6	1	1	2	70%	51.1-88.9	75%	63.2-86.8	50%	02-97.2	0.21	0-0.85
11	6	2	1	1	70%	51.1-88.9	85.7%	72.2-99.2	33.3%	01-64.8	0.21	0-0.85
12	3	6	0	1	30%	30-48.9	75%	75-98.6	0%	0-15.7	0	0-0.18
13	3	4	1	2	40%	21.1-71.4	60%	41.1-91.4	20%	01-51.4	0	0-0.34
14	4	3	2	1	60%	28.6-78.9	80%	48.6-98.9	40%	08-58.9	0.20	0-0.75
15	6	1	1	2	70%	51.1-88.9	75%	63.2-86.8	50%	02-97.2	0.21	0-0.85
16	3	3	2	2	50%	18.9-81.1	60%	28.9-91.1	40%	08-71.1	0	0-0.60
17	6	0	2	2	80%	48.8-80	75%	55.5-75	100%	22-100	0.55	0.04-1.00
18	3	5	1	1	40%	21-58.9	75%	51.4-98.6	16.7%	0-32.4	0.07	0-0.38
19	8	0	2	0	100%	69.3-100	100%	80.8-100	100%	23.4-100	1.00	1.00-1.00
20	3	4	1	2	40%	21.1-71.4	60%	41.1-91.4	20%	01-51.4	0	0-0.34
21	4	4	2	0	60%	28.9-60	100%	61.2-100	33.3%	07-33.3	0.29	0-0.66
22	4	3	2	1	60%	28.6-78.9	80%	48.6-98.9	40%	8-58.9	0.20	0-0.75
23	6	2	1	1	70%	51.1-88.9	85.7%	72.2-99.2	33.3%	01-64.8	0.21	0-0.85
Pooled					61.3%	38.4-77.7	81 %	73.3-87.1	33 %	23.6-43.4	0,22	0-0.85

Correlation of the identified respiratory conditions with the Likert scale confidence scores (table 4) confirms conditions such as COVID-19, lung metastasis, and pneumothorax were confidently identified. Likewise, the conditions students were most unconfident with were consolidation, haemothorax and surgical emphysema.

Table 4

Participant confidence scale responses to the ten chest X-ray cases.

		5-Point Likert confidence scale				
		1	2	3	4	5
Image bank	**Respiratory conditions**	**Very unconfident**	**Unconfident**	**Neutral**	**Confident**	**Very confident**
Case 1	Pleural Effusion	*n*=2 (8.6%)		*n*=12 (52.1%)		*n*=9 (39.1%)
Case 2	Pneumothorax	*n*=3 (13%)		*n*=7 (30.4%)		*n*=13 (56.5%)
Case 3	Lung Metastasis	*n*=2 (8.6%)		*n*=7 (30.4%)		*n*=14 (60.8%)
Case 4	Consolidation	*n*=8 (34.7%)		*n*=10 (43.4%)		*n*=5 (21.7%)
Case 5	Normal	*n*=1 (4.3%)		*n*=13 (56.5%)		*n*=9 (39.1%)
Case 6	COVID-19	n=4 (17.3%)		*n*=7 (30.4%)		*n*=12 (52.1%)
Case 7	COPD	*n*=3 (13%)		*n*=13 (56.5%)		*n*=7 (30.4%)
Case 8	Haemothorax	*n*=8 (34.7%)		*n*=11 (47.8%)		*n*=4 (17.3%)
Case 9	Dextrocardia	*n*=0 (0%)		*n*=7 (30.4%)		*n*=16 (69.5%)
Case 10	Surgical Emphysema	*n*=8 (34.7%)		*n*=10 (43.4%)		*n*=5 (21.7%)

When asked if the student radiographers believed their undergraduate education gave them the necessary skills to interpret chest X-rays, the responses (figure 1) demonstrated 48% of participants felt that they had the knowledge required when interpreting chest x-rays, the level of confidence of 41% (table 4) reflected the results (table 3).

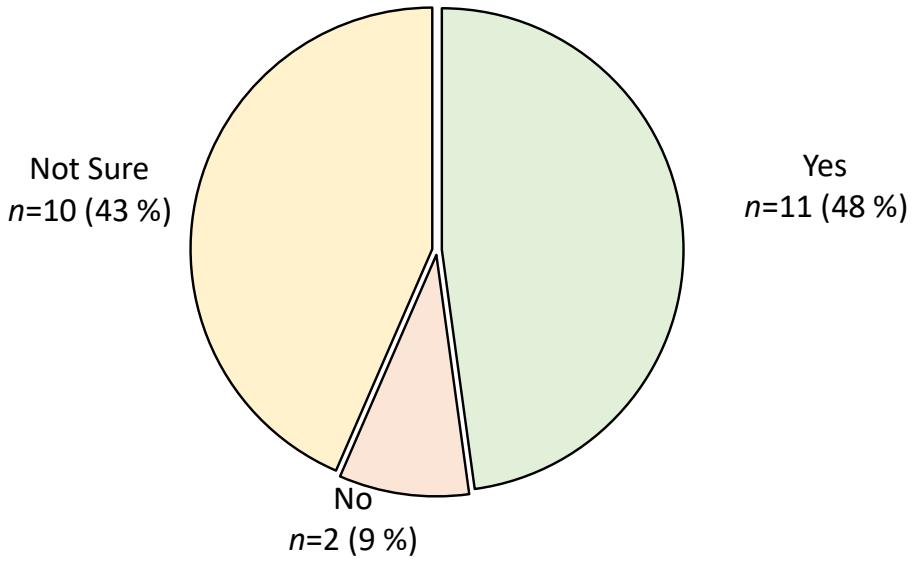

Figure 1. The students were questioned whether they believed they had the necessary skills to interpret chest X-rays effectively

The follow-on question for participants' who responded 'no' or 'not sure' to the previous question were prompted to answer what they believed would be most beneficial for their learning to increase confidence in interpreting chest X-rays. Participants disclosed that more 'repetitive learning' styles would benefit them, such as 'quizzes or online resources' (25%). This learning style provides the ability to connect to previously learned knowledge and has been shown as an effective revision method [21]. A proportion of responses requested 'more lectures' were needed on chest X-rays (41%) and wanted comparable learning hours between the chest and the appendicular skeleton for image interpretation.

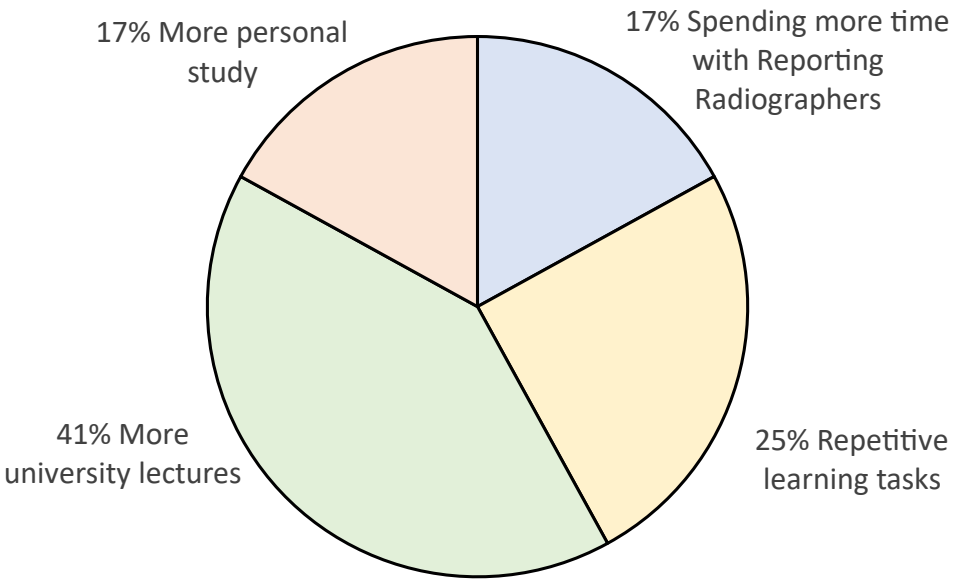

Figure 2
The participant's suggestions to improve learning and confidence in chest X-ray interpretation.

Discussion

The participants made some common errors; for instance, 22% of participants failed to identify the normal chest X-ray and instead interpreted it as either FP cases of pneumothorax or chronic obstructive pulmonary disease (COPD). These errors were further reflected in the student radiographers' 'confidence' ability, with 57% of participants rating themselves as a neutral response for confidence in their decision making on a normal chest X-ray. Whereas 52% of participants wrongly interpreted the surgical emphysema case as a normal chest X-ray, with 43% rating themselves a neutral response for confidence in their decision making.

The results demonstrated the students competently identified pathologies of COVID-19, lung metastasis, and pleural effusions, which might be accounted for due to the specific

imaging appearance of these pathologies on chest X-rays. These may be easier to remember due to common occurrences within the hospital setting (student exposure to them during clinical placement, which is a large portion of the academic curriculum for United Kingdom (UK) universities).

The study results of 61.3% accuracy are comparable to the Jeffery et al.[13] study of a larger sample of final year medical students' interpretation of ten chest X-rays accuracy of 62.5%. Additionally, the study results were higher than the Ball et al.[14] study of a similar sample size of third-year physiotherapy students' interpretation of six chest X-rays with a lower accuracy of 33.3%.

Post-registration radiographers are expected to have the knowledge to identify normal cases and identify when X-rays demonstrate potentially life-threatening conditions, especially when a patient is referred from the primary care setting. Thus, pre-registration education is an important component along with clinical placement learning to gain the skills, abilities, and confidence in image interpretation skills.

Radiographers provide an essential skill as healthcare professionals who are required to identify abnormalities to aid patient triage as set out by the UK Society and College of Radiographers [5] PCE policy. Although these written commentaries are not formal reports, they play an essential role in assisting clinical decision making, especially within the accident and emergency imaging; thus, radiographer confidence and ability is a necessity.

McLaughlin et al.[9] has demonstrated that post-registration radiographer's interpretation skills increase in competence when provided with greater experience in clinical practice, which is reiterated by Ekpo, Egbe and Akpan [22], who demonstrated a correlation between the number of years qualified in clinical practice and the improvement in image interpretation skills. Stevens and White [23] surveyed new post-registration radiographers' increased confidence in image interpretation. They identified a strong connection between pre-registration university and clinical placement training and improved confidence in post-registration ability. The Stevens and White [23] survey also highlighted that from their sample of *n*=85 participants, 77.6% were confident in their ability of image interpretation; 85.9% expressed their university training was sufficient for image interpretation; with 45% stating that on the job training in clinical placement helped image interpretation learning.

Providing image interpretation skills at an undergraduate level will assist future continuing professional development in diagnostic accuracy and confidence of X-ray interpretation, which is a requirement for post-registration radiographers [24]. Due to a lack of published studies assessing student radiographer's chest X-ray interpretation to compare results against, further research involving a larger sample of student radiographers is recommended to evaluate ability and confidence.

Limitations

Although participants were advised the test should take no more than 15 minutes to complete, there was no formal time limit or record of how long participants took to answer the questions, which may influence the results. The participants accessed the study on their personal computers and devices. As such, there is an acknowledgement of the variability of screen resolution of the devices used and the environmental lighting during participant participation in this study, which might affect performance and results. A further limitation of the study is the sample size which may extenuate individual differences among the participants. Future recommendations are for a larger multi-institute or national study to assess a larger cohort of radiography students abilities to confirm the findings.

Conclusion

The study aimed to assess the accuracy and confidence in interpreting chest X-rays by final year diagnostic radiography students. The findings suggest which conditions provide high and low confidence levels, which correlated to the accuracy scores when identifying common respiratory conditions and normal anatomy.

With the volume of chest X-rays referrals increasing in the UK, it is imperative newly qualified radiographers at the start of their career have the knowledge to differentiate normal from abnormal anatomy and pathology to assist the patient treatment and management pathway.

The results of this study can help inform the academic direction of chest X-ray image interpretation education of common respiratory conditions in pre-registration diagnostic radiography programmes. Further research on a wider sample size is recommended.

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