Assessing and comparing chest radiograph interpretation in the Department of Internal Medicine at the University of the Witwatersrand medical school, according to seniority

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Background. Chest radiographs are a common diagnostic tool in the internal medicine department, and correct interpretation is imperative for adequate patient management.
Objective. To determine the diagnostic accuracy of common pathologies in South Africa that are evident on chest radiographs, and to determine whether there are discrepancies according to different levels of qualification of doctors rotating through the internal medicine department, and which factors contribute to an accurate diagnosis.
Method. Fifteen chest radiographs with common pathologies were given to all doctors rotating through the Department of Internal Medicine at Chris Hani Baragwanath Academic Hospital, and they were asked to interpret them. Information pertaining to their experience, designation and confidence in chest radiograph interpretation was also obtained.
Results. Diagnostic accuracy according to years of experience was as follows: 0 - 5 years 27.0%, 6 - 10 years 43.0%, and >10 years 47.9%. For different designations, accuracy was as follows: consultants 50.5%, registrars 40.9%, medical officers 36.4%, and interns 19.5%. Participants who were confident obtained a mean score of 39.4% and those who were not, a mean score of 31.6%.
Conclusion. Chest radiographs are readily accessible and used daily in clinical practice in numerous facilities. An accurate diagnosis is important to provide quality healthcare. Improved training in interpretation for all, but especially for junior doctors, should be a priority in our training facilities.
Keywords. Chest X-ray, diagnosis, competency, training, education, radiography, radiology, medical.

Afr J Thoracic Crit Care Med 2023;29(1):e265. https://doi.org/10.7196/AJTCCM.2023.v29i1.265

Study synopsis
What the study adds. This study tested the diagnostic accuracy with regard to common pathologies present on chest X ray by doctors rotating through, or stationed at the internal medicine department at an academic hospital.
Implications of the findings. Interpretation of chest X-rays was generally poor but the study did find that this improves with experience and confidence in diagnostic ability. These findings are significant in that they indicate a need to implement improved teaching programs in radiological interpretation, especially at an undergraduate level.

Chest radiographs are the most common radiological investigation requested by the internal medicine department, and are often interpreted by departmental doctors and not radiologists.[1] Accurate diagnosis is of the utmost importance, as clinical decisions are based on interpretation of these radiographs and after-hours interpretation is often left to interns, medical officers or registrars.

Despite being the most commonly requested radiological investigation, chest radiographs remain one of the most difficult to interpret. They play a vital role in diagnosing many diseases, ranging from acute life-threatening conditions such as tension pneumothorax to less critical conditions such as pulmonary tuberculosis or lung cancer, where the chest radiograph is nonetheless an essential component of the work-up.[1] Chest radiographs make up the bulk of radiological investigations reported by non-radiologists and physicians, mainly owing to the sheer numbers performed compared with other modalities. Various factors, often unrelated to the disease, make them difficult to interpret. These include technical factors such as over- or underexposure and projection, overlapping structures and normal variants, to name but a few.[1] Although it is important that non-radiological clinicians receive appropriate training, the extent to which this occurs varies

widely. Overall, medical students in South Africa (SA) receive little formal training in radiology, but despite this, it is expected that all doctors should be able to interpret a chest radiograph.[2] Junior doctors (interns, medical officers and junior registrars) are responsible for most on-site, after-hours duties, where correct interpretation may be critical to further management. Incorrectly interpreted films can have significant adverse consequences, which as well as incorrect diagnoses include over-diagnosis with performance of unnecessary expensive investigations. These negative outcomes can have disastrous effects for the patient, as well as for the clinician's career.[3]

The admission regulations to the Fellowship of the College of Physicians of South Africa (FCP) state under the section on management of patients that the candidate ought 'to select and, where needed, perform appropriate investigations and initiate appropriate treatment based on best available evidence'.[4] This is relevant, in that the portfolio of procedures to be mastered before admission as a Fellow of the College of Physicians also does not specify the interpretation of radiographs, even though specialist physicians are expected to interpret them as part of their day-to-day practice.[5]

In addition to pre- and postgraduation training, clinical experience plays a vital role in the ability to interpret radiographs. However, other factors such as confidence in one's ability, the viewing environment and access to appropriate clinical information also play a role.[6,7] A study performed in the USA, dating as far back as 1993, found that 25% of all radiological procedures were performed by non-radiologists.[8] This included two-thirds of ultrasound scans, half of interventional radiological procedures, including angiography, and 15 - 16% of general radiology. The remainder of the 25% was made up of computed tomography and magnetic resonance imaging.

In an ideal world where staffing and funding are not limited, all radiological investigations should be reported by a radiologist, especially in the acute care setting, as their interpretation is more accurate than that of emergency department physicians, and subtle radiological abnormalities are less likely to be missed.[9,10] However, even in a developed country such as Japan, an increase of 2.5 times their current number of radiologists (an extra 8 612 radiologists) would be required to provide quality healthcare and reporting.[11] In contrast, SA is a developing country with limited resources, including limited access to specialist radiologists and pulmonologists able to review every chest radiograph performed, particularly after hours. In SA, selective reporting policies are often implemented even by bigger health centres where more radiologists are available, as is the case for the academic hospitals affiliated to the University of the Witwatersrand's Faculty of Health Sciences. Selective reporting is the process by which the clinician decides which plain films they need assistance with and requests reporting by a radiologist. This is an efficient method to reduce the reporting workload without compromising patient care.[12]

Previous international studies have shown that interpretation of chest radiographs is generally poor, but does improve with level of training and confidence in interpretation.[13-15]

The objective of the present study was to assess the variation in chest radiograph interpretation in the Department of Internal Medicine at the University of the Witwatersrand and to identify contributing factors.

Methods

A cross-sectional, prospective study was conducted at Chris Hani Baragwanath Academic Hospital (CHBAH), which has ~3 400 beds, in Johannesburg, Gauteng Province.

The study population included all levels of doctors (interns, medical officers, registrars and consultants) currently rotating through the Department of Internal Medicine. All the subjects participated voluntarily and provided informed consent. There were no consent refusals, but illegible answer sheets were excluded.

Fifteen chest radiographs that depicted conditions commonly encountered in SA were selected from Radiopaedia (radiopaedia.org). These diagnoses were confirmed by the radiologists who had submitted them to Radiopaedia, and also by an independent SA radiologist, to ascertain whether they were fair and representative.

The chest radiographs were printed on photographic-grade paper and placed in an image atlas, a copy of which was given to each candidate. The chest radiographs used are listed in Table 1, and can be viewed on a supplementary file available online (https://www.samedical.org/file/1971).

A questionnaire recording epidemiological information on the participants and including data such as postgraduation year in categories (0 - 5, 6 - 10 and >10 years), position held in the internal medicine department and confidence in interpretation of chest radiographs was handed to each participant along with the image atlas, during either departmental or radiological meetings. After completing the questionnaire, they were asked to provide a diagnosis for each radiograph. If they were unable to give a diagnosis, they could describe the findings. No time frame was allocated to complete the questionnaire, and no half marks were allocated. Full marks, i.e. 1, was given for the correct diagnosis, and 0 for an incorrect diagnosis. If no diagnosis was given but all the radiological features were described, a full mark was given. If partial findings or a diagnosis that would also have led to the correct management were given (e.g. if a diagnosis of 'pulmonary oedema' was given for the radiograph showing congestive cardiac failure), a mark was allocated. If the wrong side or the wrong lobe was described, the participant scored zero, but where they did not specify the side or lobe, but the diagnosis was correct (e.g. 'lobar pneumonia' instead of right middle lobe pneumonia), they scored a full mark.

Table 1. Chest radiographs and diagnoses

Chest radiograph	Diagnosis
1	Congestive cardiac failure
2	Pneumothorax
3	Right upper lobe atelectasis
4	Right pleural effusion
5	Right middle lobe pneumonia
6	Hyperinflation
7	Left lower lobe atelectasis
8	Misplaced central venous catheter
9	Left upper lobe mass
10	Right main bronchus intubation
11	Normal
12	Bronchiectasis
13	Cannonball lesions/lung metastasis
14	Pulmonary tuberculosis
15	Widened mediastinum

Statistical analysis

Data from the questionnaires were captured electronically by the researcher (RGD) in Excel version 2301 (Microsoft, USA). A correct interpretation of an image was coded as 1 and if incorrect it was coded as 0. Any further analysis was performed by a statistician using SAS version 9.4 (SAS, USA). A total score for each participant was calculated by adding the scores obtained for all 15 images. A percentage for each participant was calculated by dividing the total score by the number of images and multiplying by 100. Descriptive statistics, namely frequencies and percentages, were calculated for categorical data, and means and standard deviations were calculated for numerical data. The Shapiro-Wilk test was used to investigate whether numerical data followed a normal distribution. Analytical statistics, namely the χ^2 test, was used to compare percentages in different groups, the independent *t*-test was used to compare mean values in two different groups, and analysis of variance (ANOVA) was used to compare mean values in three or more different groups. A significance level (α) of 0.05 was used.

Ethical considerations

An application for full ethical approval was made to the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, and ethics consent was received on 10 December 2021 (ref. no. M210707).

Written informed consent was obtained from all individual participants involved in the study.

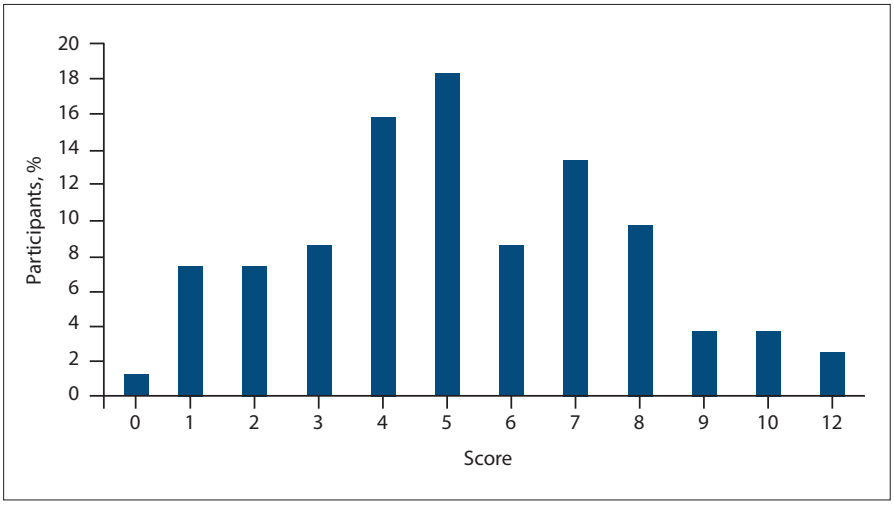

Fig. 1. Frequency distribution of the scores (N=*82*).

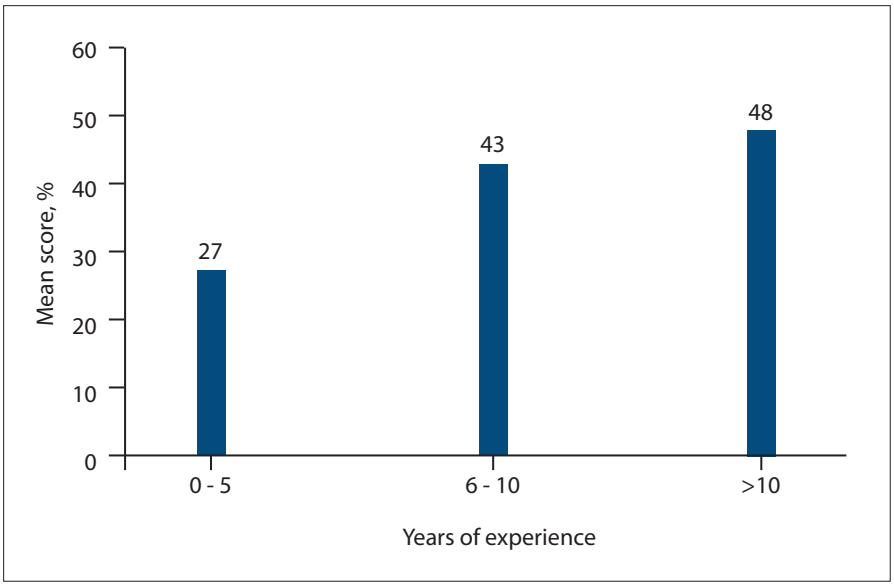

Fig. 2. Mean scores according to number of years of experience (N=*82*)

Results

There were a total of 82 participants in the study, of whom 56.1% were in the 0 - 5 years, 24.4% in the 6 - 10 years and 19.5% in the >10 years postgraduation categories. Consultants comprised 17.1% of the sample, registrars 37.8%, medical officers 12.2% and interns 32.4%. With regard to participants' level of confidence in their ability to interpret chest radiographs, 57.3% were not confident, but the remainder were. In the 0 - 5 years category 26.1% were confident, in the 6 - 10 years category 55.0% were confident, and in the >10 years category 75.0% were confident (p=0.001 between all groups).

With regard to designation, 71.4% of consultants, 51.6% of registrars, 30.0% of medical officers and 22.2% of interns felt confident of their ability to interpret chest radiographs (p=0.012).

The percentage of correct answers obtained for the 15 chest radiographs for the entire cohort was as follows: radiograph 1, 31.71%; radiograph 2, 15.9%; radiograph 3, 46.3%; radiograph 4, 64.6%; radiograph 5, 42.7%; radiograph 6, 48.8%; radiograph 7, 3.7%; radiograph 8, 1.2%; radiograph 9, 45.1%; radiograph 10, 24.4%; radiograph 11, 22.0%; radiograph 12, 22.0%; radiograph 13, 89.0%; radiograph 14, 25.6%; and radiograph 15, 41.5%.

The lowest score for the entire study was 1/15 and the highest 12/15 (80%), with one participant scoring the former and two the latter, equating to 1.2% and 2.4% of the study population, respectively. The majority of the candidates scored between 4/15 and 7/15 (Fig. 1). The mean total score was 35.0% for the entire study.

According to the Shapiro-Wilk test for normality, the distribution of the total scores followed a normal distribution (W=0.974; p=0.0918), and consequently the mean and standard deviation were reported. Fig. 2 shows mean total percentages obtained according to years of experience (p<0.0001 as per the ANOVA), which demonstrated that years of experience significantly improved interpretation.

Mean percentages obtained according to designation were as follows: consultants 50.5%, registrars 40.9%, medical officers 36.4%, and interns 19.5%. Fig. 3 illustrates the individual radiographs identified correctly by each designation.

Participants who were confident obtained a mean score of 39.4%, v. 31.6% for those who were not (p=0.045).

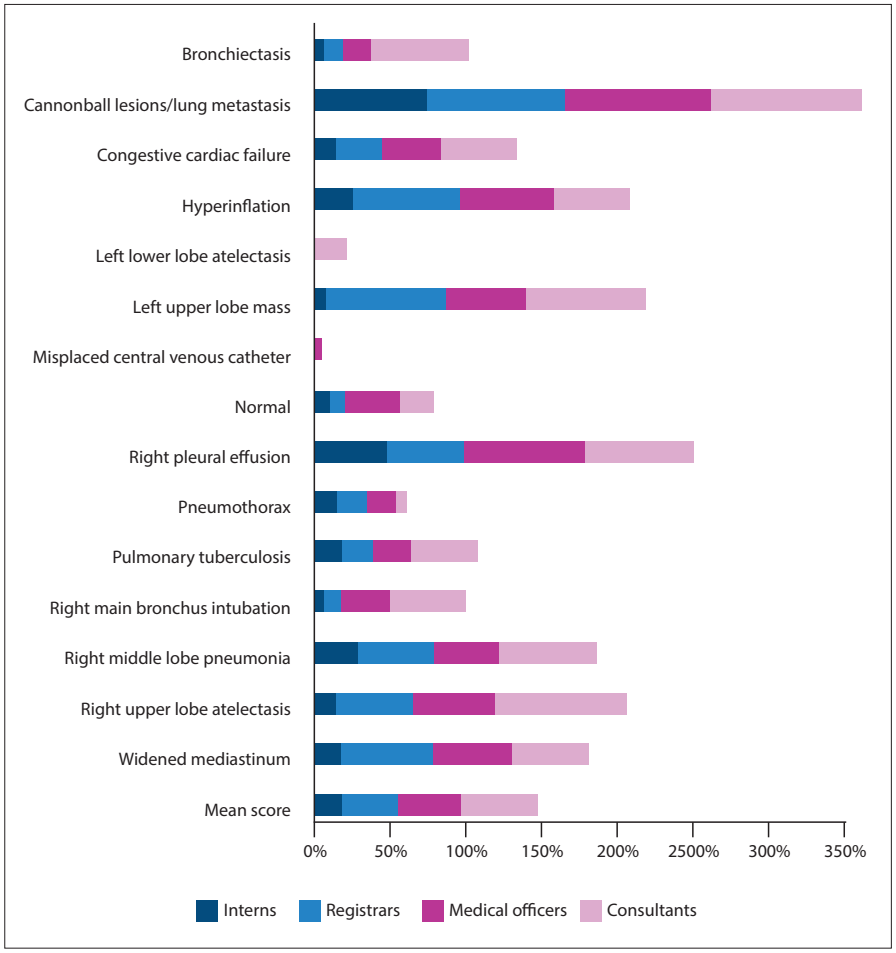

Fig. 3. Frequency distribution of the cases identified correctly by designation (N=82).

Discussion

Our study took place at a single academic institution, which was similar to a study by Eisen *et al.*[13] in which a number of radiographs requiring emergency interventions were included. These diagnoses were missed more often than not, with pneumothorax being misdiagnosed 95% of the time. The participants also struggled to interpret the normal chest radiograph, even though they had been told that one or more might be normal, unlike in the present study, where the participants were not informed that a normal film might be included. Confidence and seniority were shown to have a positive impact on the accuracy of diagnosis, with worse performance by medical students, interns and registrars.[13]

Mehdipoor *et al.*[14] compared general practitioners and final-year medical students and found that overall interpretation was poor, with no difference noted between the groups. They also stressed the need for more training. In a study similar to ours performed in the UK by Satia *et al.*,[15] the researchers also found improved interpretation with seniority, and concluded that specialist registrars and consultants should review all cases.

The four chest radiographs that were misinterpreted most frequently in the present study were images of a misplaced central venous catheter, left lower lobe atelectasis, a pneumothorax, and the normal film. With the exception of the left lower lobe atelectasis, there was no significant difference between designations as to the correct diagnosis given for these.

Two of the chest radiographs could have represented radiological emergencies or immediately correctable pathologies, namely the pneumothorax (Fig. 4) and the misplaced central venous catheter (Fig. 5). The former was mostly answered as hyperinflation, chronic obstructive pulmonary disease or a normal film, and whereas the latter had multiple catheters and other findings that some participants identified, almost all of them failed to identify the misplaced catheter. Another correctable pathology that was frequently missed by interns, medical officers and registrars was that of a right main bronchus intubation (Fig. 6).

Although the right-sided pneumothorax (Fig. 4) was relatively subtle compared with the contralateral side, it can be seen that there are no clear peripheral lung markings, especially in upper zones. This emphasises the importance of comparing sides. Several participants, especially the consultants and the registrars, thought that the lung fields in the normal radiograph were oligaemic, and some consequently considered that it might represent a pulmonary embolism. Although the image is slightly overexposed, it is nevertheless normal. The independent radiologist who reviewed the films felt that it was fair to use this image, as technical factors such as overexposure are common problems faced daily when assessing printed plain films at the bedside.

Although the diagnosis given for chest radiograph 14 was given as pulmonary tuberculosis (Fig. 7), it is recognised that these findings could be due to other conditions. However, in the SA context these changes are classic for pulmonary tuberculosis, and furthermore no other appropriate alternative diagnoses were given. Some of the juniors, however, did think that this might be miliary tuberculosis.

Plain films remain a key tool in day-to-day clinical practice, and probably will be for the foreseeable future. As can be seen in our small study, diagnostic accuracy does improve with seniority; however, overall it remains poor. Accordingly, the group that performed the worst were the medical interns, which is a reflection of inadequate radiological teaching at undergraduate level. All the pathologies that were demonstrated should form part of a core curriculum for final-year students. The study did not categorise the results according to the university from which the participants graduated, but it seems that it is a country-wide problem that while some training is offered by the various radiology departments, it is generally insufficient and there is a lack of emphasis on its importance.

Although informal training is provided by academic hospitals, there is no clear formal training programme or assessment of radiological interpretation, as stipulated by the Colleges of Medicine of South Africa as a requirement for the FCP (SA).[4] Interpersonal variability was noted in the same groups,

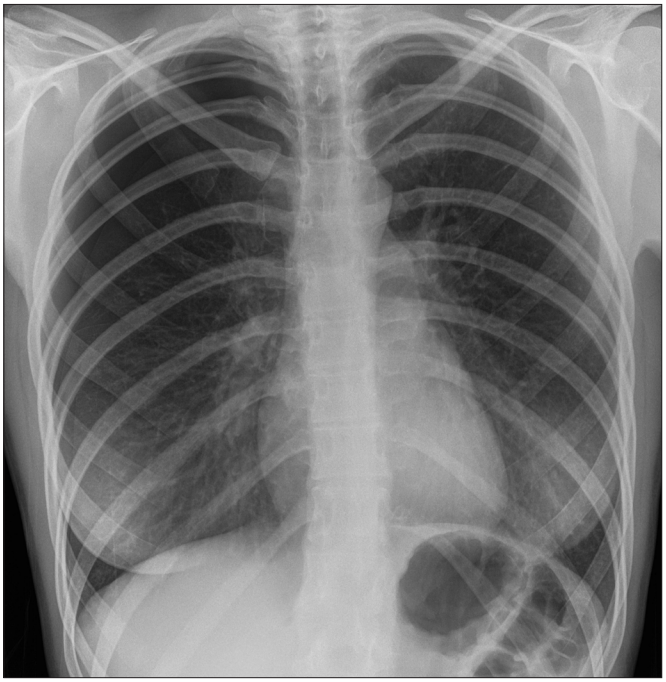

Fig. 4. Pneumothorax (Bickle I. Pneumothorax. Case study, Radiopaedia.org. https://doi.org/10.53347/rID-56429).

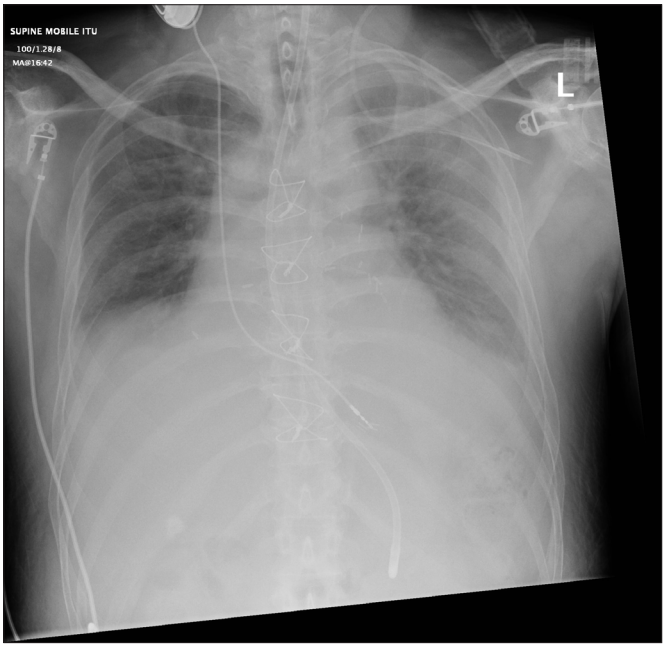

Fig. 5. Misplaced central venous catheter (Basiony M. Central venous catheter inserted into left subclavian vein. Case study, Radiopaedia.org. https://doi.org/10.53347/rID-74441).

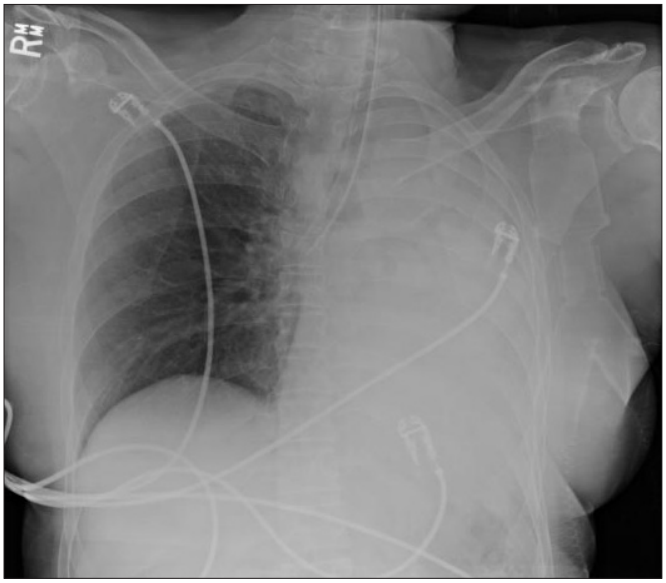

Fig. 6. Right main bronchus intubation (Radswiki T. Misplaced endotracheal tube. Case study, Radiopaedia.org. https://doi.org/10.53347/rID-11634).

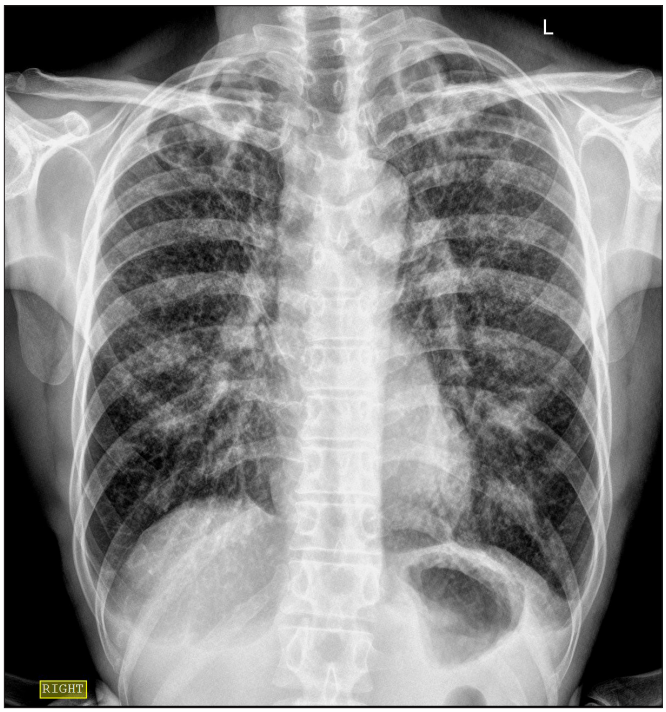

Fig. 7. Pulmonary tuberculosis (Yonso M. Pulmonary tuberculosis. Case study, Radiopaedia.org. https://doi.org/10.53347/rID-96212).

probably related to self-study, or to having a specific interest in pulmonology or radiology, but this was not investigated.

SA is a resource-limited country in terms of both equipment and staff. A number of regional and district hospitals have X-ray facilities and radiographers, but no radiologists or specialist pulmonologists to review the chest radiographs. The deficiency in training will therefore affect future service provision, as many interns will go on to become community service medical officers or general practitioners, and some registrars may do sessional or outreach work in these more peripheral hospitals.

There are two possible solutions to the current deficiency:[13] (*i*) all films could be reported by a radiologist or reviewed by a pulmonologist; or (*ii*) interpretative skills could be improved. The former remains unrealistic in our setting, particularly in the smaller, more peripheral and rural centres. Teleradiology may represent a solution, but again resources in terms of access to quality computer technology are scarce, and the shortage of radiologists would be a limiting factor.

Training still represents the most reasonable objective. This is achievable only by implementing more robust, goal-directed radiological training programmes at SA universities for undergraduate students, as well as for medical officers and internal medicine registrars in training. Such programmes have been shown to improve chest radiograph interpretation dramatically.[13,16,17] Other studies indicate that improved interpretation may possibly be achieved by using a picture archiving and communication system (PACS) rather than plain films, owing to better resolution and the ability to modify the images by altering the grey scale to reduce the effect of technical factors such as incorrect exposure. Although the larger, metropolitan and academic centres in SA do have PACS, it is unlikely that the smaller, district and rural hospitals would have the budgets to incorporate this, given our resource constraints.

There are some limitations to this study. No histories or clinical information were provided to the participants, and this may well have improved interpretation if it had been available.[13,18,19] The images were printed on paper, which although it was photographic grade, will always result in some loss of resolution. The images chosen were, however, classic examples of the pathology depicted, and both the primary investigator and the independent radiologist felt that use of paper images would be fair. The consultant group may have been slightly skewed, as some were from subspecialties such as rheumatology or haematology that do not have as much exposure to chest radiograph interpretation as the pulmonologists and the general ward staff would have.

Conclusion

Although improved chest radiograph interpretation was noted with increasing seniority, overall interpretation was poor. The practical implications of this situation are that service delivery across all hospitals will be compromised. It is imperative that radiological training is improved at all levels, but especially at an undergraduate and intern level.

Declaration. The research for this study was done in partial fulfilment of the requirements for RGD's MMed (Diagnostic Radiology) degree at the University of the Witwatersrand.

Acknowledgements. The authors acknowledge the Division of Radiology and Internal Medicine, CHBAH and University of the Witwatersrand. We further acknowledge Mrs M Viljoen, who conducted the statistical analysis, and Radiopaedia as a platform for supplying us with the images used.

Author contributions. RGD was the main author and was responsible for the idea, the protocol, data collection and compilation of the article. GAR was the principal supervisor and assisted with project design, review, analysis and editorial review. CMvdM made conceptual and editorial contributions. MAN made conceptual and editorial contributions.

Funding. None.

Conflicts of interest. None.

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Accepted 17 January 2023.