Knowledge of family medicine residents regarding the interpretation of chest X-rays in Jeddah, Saudi Arabia

Ahmed M Sheikh

Specialist Family Physician, Ministry of Health, Jeddah, Saudi Arabia

Correspondence to: Ahmed M Sheikh, E-mail: ma-mzs@hotmail.com

ABSTRACT

Background: Despite the widespread use of chest X-ray and the absence of radiologists in primary healthcare centers in Saudi Arabia, studies have shown that the competence of in-training residents in the interpretation of chest X-rays is poor. Misinterpretation of chest X-rays adversely affects the diagnosis and management plan of physicians, making competence in this skill even more crucial. Despite it being a required skill to attain by the Saudi Council for Health Specialties in most residency programs, no such evaluative study has been carried out on Saudi medical physicians. **Objectives**: The objective of this study is to assess the knowledge of residents in the Saudi Family Medicine Program in Jeddah with regard to their interpretation of X-rays of common chest conditions within the context of their training and experience, to contribute to the enhancement of their radiological skills and consequently improve their radiological diagnosis of common chest conditions. **Materials and Methods:** *A cross-sectional study was conducted on 74 of 88 registered residents – across the four levels – training in the Family Medicine program in Jeddah at the time of the study.* Ten standardized chest X-ray images were presented. For each image, residents filled a multiple-choice form consisting of two parts; pathological radiographic findings and diagnosis. **Results:** The residents correctly established 38.1% of the radiographic findings and 47.7% of the diagnosis. The overall performance of the residents in consideration with their training level, completion of in-training radiology rotation, attendance of extracurricular radiological courses, or prior work experience in the field was statistically insignificant–be it in identifying the findings or selecting a possible diagnosis for each image. **Conclusion:** Based on the results of this study, we conclude that the radiological skills of the family medicine residents–in Jeddah–do not meet the curricular requirements of the training program in identifying pathological findings in chest X-rays nor in correlating them to chest conditions to reach a possible diagnosis. Moreover, the residents' ability to correctly diagnose chest radiographs decline further by their final training year (R4). It is recommended that family medicine residents be exposed to a wider range of chest X-rays during their rotation in the radiology department and to improve the quality of their rotation. Training activities on chest X-ray interpretation should also be introduced throughout the residency program.

KEY WORDS: Chest X-ray Interpretation; Primary Healthcare; In-Training Residents; Family Physicians

INTRODUCTION

Chest X-ray is a noninvasive, inexpensive, prompt, and easily attainable diagnostic tool, especially in the primary healthcare settings of Jeddah, Saudi Arabia. It is one of the most commonly ordered radiographic examinations.[1] In addition, chest X-ray is an essential tool for the diagnosis of many chest conditions.[2]

However, studies elsewhere have shown that the chest X-ray interpretation skills of medical students and resident doctors are insufficient.[3-6] Primary care physicians are the first in the health line to evaluate, diagnose and manage patients. Hence, their radiological skills should meet the standards needed to be able to do so effectively.

The importance of the chest X-ray coupled with the lack of radiologists in primary healthcare settings makes it crucial upon family physicians to become proficient in the interpretation of X-rays of common chest conditions.[7]

Despite these facts and to the researcher's knowledge, studies to assess the knowledge of doctors in the field of chest X-ray have not been performed in Saudi Arabia.

This study aimed to determine whether family medicine residents met the minimum standards of radiological skills set by the Saudi Council for Health Specialties. This was done by assessing their knowledge regarding the interpretation of common chest conditions while taking into consideration factors that may affect their competency.

MATERIALS AND METHODS

This study followed a cross-sectional design, a type of observational study that analyzes data from a population, or a representative subset, at a specific point in time. In this study, the interpretational skills of the family medicine residents in the different training levels of the program was observed and analyzed during December 2015.

It was conducted at the Joint Program of Family and Community Medicine building within the King Faisal Compound in Jeddah, Saudi Arabia. This center hosts the academic activities of the residents enrolled in the Family Medicine Training Program of Jeddah.

All 88 registered residents of all four training levels (R1-R4) were invited to participate in the study. Of these, the 74 residents who participated in this study had various backgrounds of experience and were currently in different training levels within the residency program. Of these residents, some had completed their rotation in radiology – which is a mandatory rotation as per the family medicine curriculum of the SCFHS. Participants comprised both male and female residents; however, their age and sex were not registered.

After fulfilling all necessary official and ethical approvals, data were collected by a self-administered questionnaire that had been designed by the researcher. The questionnaire was validated by three community medicine consultants and a consultant radiologist who approved the X-ray images; pathological findings and diagnosis. Of the X-ray images used, four images (Lung abscess, pneumothorax, normal, and pleural effusion) were taken from the research of Christiansen *et al.* with the permission of the author.[4]

A total of 10 X-ray images were displayed by a projector in the lecture hall of the Joint Program of Family and Community Medicine building, and questionnaire sheets were distributed and collected from residents (R1, R2, R3 and R4) after the Monday Scientific Activity session.

The questionnaire consisted of two parts. The first part questioned the participant's background through 4 questions; level of training in the residency program (R1, R2, R3, or R4), whether the resident completed the mandatory curricular rotation in the Department of Radiology, whether the resident attended extracurricular courses in radiology and if the resident had prior work experience in the field of radiology before entering the residency program. The second part consisted of 10 identical multiple-choice questionnaire sheets consisting of 20 pathological findings and 10 diagnosis. Each multiple-choice sheet was filled for each image separately. Pathological findings present in the image were ticked by the participants and a single possible diagnosis for the image selected.

To ensure that the findings in the images could be clearly seen by the residents in the hall, the hall's lights were dimmed during the projection and–for each image–the residents were asked whether the content was clearly visible from their seat. If it was not clear, they were accommodated in different seating angles for better visibility.

The next image would only be displayed after confirmation by all residents that they were done with the first. This was to ensure every resident received sufficient time to interpret each image.

Collected data were entered into a personal computer and were analyzed using the (Statistical Package for the Social sciences version 21, IBM, California, Los Angeles, USA). Descriptive statistics (i.e., frequencies and percentages) were calculated. Frequency, percentages, mean, and standard deviation were calculated. Tests of significance (i.e., Chi-square, *t*-test, and ANOVA) were applied to compare residents' responses according to their characteristics. Differences were considered as statistically significant when a $P < 0.05$.

RESULTS

Of the total 88 residents in the family medicine residency program, 74 residents participated—making the response rate 84%.

More than one-third of the participants were (37.8%) R1 residents, 25.7% were in R2, 16.2% were in R3, and 20.3% were in R4. <½ of residents (41.9%) fulfilled their radiology

rotation, while the great majority (90.5%) did not attend any radiology courses and 87.8% did not have any personal experience in radiology [Table 1].

Table 2 shows that out of the 10 images, the number of radiographs for which a correct diagnosis was selected by each resident ranged from 0 to 9 (Mean±standard deviation [SD]: 4.77±1.91 radiographs). None of the residents could diagnose all the radiographs, while only one (1.4%) could diagnose a maximum of 9 radiographs. Less than one-third (31.1%) of the residents selected the correct diagnosis for more than half the images (5/10).

Moreover, out of the 20 findings within the 10 plain Chest X-ray images, the least number of correctly identified findings was 3, while the highest was 15 findings. The number of findings (Mean±SD) correctly identified by family residents was 7.24±1.87. Only three residents (4.2%) could correctly identify more than 10 findings in the plain chest X-rays [Table 3].

Table 4 shows that lung consolidation in a case of pneumonia was correctly identified by the highest number of family medicine residents (60, 81.1%), followed by cardiomegaly in a case of heart failure (58, 78.4%) and rib fracture (56, 75.7%). On the other hand, none of the residents could correctly identify loss of bronchoalveolar markings in a case of pneumothorax, while only four residents (5.4%) could correctly identify upper mediastinal shift in a case of TB and enlarged left atrial appendage in a case of heart failure. Only 7 residents (9.5%) could identify mild pleural effusion in a case of heart failure. On the other hand, approximately half the residents (54.1%) were able to recognize image number 7 as normal while around one-third of the residents (37.8%)

Table 1: Stats on the background of the family medicine residents who participated (*n*=74)

Residents' background	*n* (%)
Level of training in the family medicine program	
1st year (R1)	28 (37.8)
2nd year (R2)	19 (25.7)
3rd year (R3)	12 (16.2)
4th year (R4)	15 (20.3)
Completed the radiology rotation	
Not completed	43 (58.1)
Completed	31 (41.9)
Attended extracurricular radiology courses	
No	67 (90.5)
Yes	7 (9.5)
Work experience in radiology	
No	65 (87.8)
Yes	9 (12.2)

Table 2: Number of correct diagnoses chosen by each resident (*n*=74)

Number of radiographs correctly diagnosed	Frequency (%)	Cumulative percent
0	1 (1.4)	1.4
1	2 (2.7)	4.1
2	3 (4.1)	8.1
3	15 (20.3)	28.4
4	11 (14.9)	43.2
5	19 (25.7)	68.9
6	10 (13.5)	82.4
7	4 (5.4)	87.8
8	8 (10.8)	98.6
9	1 (1.4)	100
Total	74 (100)	
Mean±SD	4.77±1.91	

SD: Standard deviation

Table 3: Number of correct radiographic findings identified by each resident (*n*=74)

Number of radiographic findings correctly identified	*n* (%)	Cumulative percent
3	1 (1.4)	1.4
4	2 (2.7)	4.1
5	4 (5.4)	9.5
6	23 (31.1)	40.6
7	16 (21.6)	62.2
8	11 (14.9)	77.1
9	11 (14.9)	92
10	3 (4.1)	96.1
11	1 (1.4)	97.5
12	1 (1.4)	98.6
15	1 (1.4)	100
Total	74 (100)	
Mean±SD	7.24±1.87	

SD: Standard deviation

selected incorrect findings for the Normal X-ray image. In regards of choosing the correct diagnosis, rib fracture could be identified by the highest number of family medicine residents (59, 79.7%), followed by heart failure (58, 78.4%), and pneumonia (57, 77%). On the other hand, only 9 residents (12.2%) could correctly diagnose mitral stenosis while 14 residents (18.9%) could correctly diagnose pneumothorax.

Overall, participants correctly established 38.1% of the findings and 47.7% of the diagnoses.

Table 5 shows that the correctly identified findings, within 10 plain chest X-rays, did not differ among residents irrespective of their training level, their completion of the radiology rotation, their attendance of extracurricular radiological courses or prior work experience in radiology.

Table 4: Number of family medicine residents who correctly identified radiographic findings and diagnosis for each radiograph (*n*=74)

Image number	Radiographic findings and diagnosis	*n* (%)
Lung Abscess	Fibrosis	18 (24.3)
	Air-fluid level	18 (24.3)
	Consolidation	47 (63.5)
	Mediastinal shift	31 (41.9)
	Diagnosis	15 (20.3)
Tuberculosis	Apical cavitation	20 (27.0)
	Apical consolidation	29 (39.2)
	Upper mediastinal shift	4 (5.4)
	Diagnosis	38 (51.4)
Pneumothorax	Partial lung collapse	10 (13.5)
	Loss of bronchoalveolar markings	0 (0.0)
	Diagnosis	14 (18.9)
Heart Failure	Cardiomegaly	58 (78.4)
	Enlarged left atrial appendage	4 (5.4)
	Mild pleural effusion	7 (9.5)
	Pulmonary edema	11 (14.9)
	Diagnosis	58 (78.4)
Pneumonia	Lobar consolidation	60 (81.1)
	Diagnosis	57 (77)
Fracture	Rib fracture	56 (75.7)
	Diagnosis	59 (79.7)
Normal	Incorrect findings selected	28 (37.8)
	Diagnosis	40 (54.1)
COPD/Asthma	Hyperinflated lungs	25 (33.8)
	Diagnosis	30 (40.5)
Mitral Stenosis	Cardiomegaly	34 (45.9)
	Double right heart border	19 (25.7)
	Diagnosis	9 (12.2)
Pleural Effusion	Massive pleural effusion	41 (55.4)
	Pacemaker	44 (59.5)
	Diagnosis	33 (44.6)
Total correct findings (out of 20×74)		564 (38.1)
Total correct diagnoses (out of 10×74)		353 (47.7)

Table 5: Mean performance of the residents in identifying the radiographic findings in context of their background

Residents' background	*n*	Mean±SD of correct answers	*P*
Level of training in the family medicine program			
1st year (R1)	28	6.86±1.58	
2nd year (R2)	19	7.74±1.56	
3rd year (R3)	12	7.58±3.18	
4th year (R4)	15	7.07±1.28	0.391
Total	74		
Completed the radiology rotation			
Not completed	43	7.23±1.67	
Completed	31	7.26±2.14	0.954
Total	74		
Attended extracurricular radiology courses			
No	67	7.27±1.92	
Yes	7	7.00±1.41	0.720
Total	74		
Work experience in radiology			
No	65	7.31±1.96	
Yes	9	6.78±0.97	0.794
Total	74		

DISCUSSION

Family physicians are the first in the health line to evaluate and diagnose patients and hence their radiological skills should meet the standards needed to be able to do so effectively. The minimum standards for chest X-ray interpretation skills for family medicine residents have been set by the Saudi Council for Health Specialties.

Overall, participants correctly established 38.1% of the findings and 47.7% of the diagnosis. These are surprisingly lower than the results of the study of Christiansen *et al.*, in which 22 residents (who were not associated in a residency program) established 51% of the diagnosis correctly.[4] Results of this study revealed that out of the 10 radiographs, the average number of radiographs correctly identified by family medicine residents was low (Mean±SD: 4.77 ± 1.91 radiographs). None of the 74 residents could correctly identify all 10 radiographs, while only one resident could correctly identify a maximum of 9 radiographs. Less than one-third (23, 31.1%) of the residents were able to select the correct diagnosis for more than half the images (5/10). Moreover, out of 20 findings within the 10 plain chest X-ray radiographs, the average number of correctly identified findings by family medicine residents was also quite low (Mean ± SD: 7.24 ± 1.87). Only three residents (4.2%) could correctly identify more than half of the findings (10/20) within the plain chest

Table 6 shows that, out of 10 plain chest X-rays, the number of correctly diagnosed images (Mean±SD) by family medicine residents differed significantly according to residents' level of training, with the highest number of correctly diagnosed images among R2 and R3 residents (6.05±2.25 and 5.17±1.95, respectively, *P* < 0.001). However, the number of correctly diagnosed images did not differ significantly irrespective of their completion of the radiology rotation, their attendance of extracurricular radiological courses or prior work experience in radiology.

X-rays. These results may be due to the fact that they were unable to recognize pathological findings, were unfamiliar with the radiological terminologies or were unable to link the findings to their respective conditions.

From among the images, the image of rib fracture (59, 79.7%), heart failure (58, 78.4%), and pneumonia (57, 77%) were the most correctly diagnosed and their findings identified. On the other hand, only 9 residents (12.2%) could correctly diagnose mitral stenosis while 14 residents (18.9%) could correctly diagnose pneumothorax.

Comparing the diagnoses of the four images used in this study and taken from the study carried out in Denmark on 22 residents by Christiansen *et al.*, the results of both studies are shown in Table 7.

This comparison shows that the performance of the participants in this study on these four images was significantly weaker in interpreting the pneumothorax and the normal image while they performed better in interpreting the lung abscess image.

As for the image of pneumothorax in this study, the least correctly identified image, none of the residents were able to point out the loss of bronchoalveolar markings while only 10 (13.5%) residents identified the collapsed lung visible in the image. As a result, only 14 residents (18.9%) selected pneumothorax as the diagnosis for the image. For the normal image, almost one-third of the residents (37.8%) selected

pathological findings which were not present in the image, and approximately only half of the residents (54.1%) were able to recognize the image to be normal.

Results of the present study showed that only a few radiographic findings were correctly identified by most family medicine residents. Lobar consolidation in a case of pneumonia was correctly identified by the highest number of family medicine residents (81.1%), followed by cardiomegaly in a case of heart failure (78.4%) and rib fracture (75.7%). Only 4 residents (5.4%) could correctly identify upper mediastinal shift in a case of TB and enlarged left atrial appendage in a case of heart failure while only 7 residents (9.5%) could identify mild pleural effusion in a case of heart failure.

Comparing the frequency of correct findings with the frequency of correct diagnosis indicates that the residents could not correlate between the findings and their respective medical conditions.

It was assumed, before this research, that the performance of the R4 residents would exceed the other levels due to their experience, but the R2 and R3 residents proved to be slightly more competent in identifying the findings and diagnosing the images than R1 and R4 residents. According to these results, the ability of residents to correctly diagnose chest radiographs decline by their final training level (R4). This may be due to the fact that they spend the entire year in primary care centers, unexposed to teachings in chest X-ray interpretations and perhaps lacking in opportunities to consult seniors for a second reading. In spite of this, this study showed that the overall performance of the residents, in consideration of their training level, happened to be statistically insignificant, whether in identifying the findings or selecting a possible diagnosis. The slightly better performance of the R2 and R3 residents may be due to their recent rotation in radiology or their exposure during hospital rotations which end by the end of the third year of training. Hence, these results show that the competency of the residents is inversely proportional to their level of training which is against the conclusion of Eisen *et al.* that the accuracy in interpretation improved with training.[3]

However, the overall competence of the residents who had completed the radiology rotation was not significantly better

Table 6: Mean performance of the residents in selecting the correct diagnosis in context of their background

Characteristics of residents	*n*	Mean±SD	*P*
Level of training in the family medicine program			
1st year (R1)	28	4.00±1.33	
2nd year (R2)	19	6.05±2.25	
3rd year (R3)	12	5.17±1.95	
4th year (R4)	15	4.27±1.49	0.001
Total	74		
Completed the radiology rotation			
Not completed	43	4.56±1.88	
Completed	31	5.06±1.93	0.262
Total	74		
Attended extracurricular radiology courses			
No	67	4.78±1.90	
Yes	7	4.71±2.14	0.936
Total	74		
Work experience in radiology			
No	65	4.82±1.97	
Yes	9	4.44±1.42	0.588
Total	74		

SD: Standard deviation

Table 7: Comparison of the performance of the participants of this study and that of Christiansen *et al.* on the same radiographic images

Images	This study (%)	Christiansen *et al.*(%)
Lung abscess	20.3	5
Pneumothorax	18.9	59
Normal	54.1	77
Pleural effusion	44.6	41

than those who had not whether in identifying the findings correctly or diagnosing the conditions. These findings could indicate inadequacy of their rotation in radiology.

Furthermore, the performance of the few residents who attended extracurricular radiology courses or had prior work experience in the field did not show to be more competent than those who did not have these experiences. These findings may point to the fact that the residents may benefit more of in-training courses rather than trying to gain these skills individually.

All these findings reflect the weak knowledge and practice of family medicine residents in interpretation of chest X-rays. It is quite evident that their competency in recognizing radiographic findings and reaching the correct diagnosis needs to be improved. This can be due to the inadequate training of the residents in their radiology rotation as well as the absence of continuous training in the interpretation of X-rays in primary healthcare centers, especially for R4 residents who only attend primary care centers throughout the final academic year.

These observed low levels of correct interpretations of chest radiographs by family medicine residents are in accordance with those of Schenkel,[8] who reported that of special concern is the vast number of wrong interpretations of plain X-ray radiographs by non-radiologist clinicians. The results also strengthen the conclusion of Bergus et al.,[9] who noted that family physicians usually find chest radiographs more difficult to interpret than extremity films.

On the other hand, studies elsewhere showed family physicians to be more competent in interpreting radiographs. Walsh-Kelly[10] reported that in-training residents misinterpreted only 16% of their radiographs. Kennedy et al.[11] reported that only 21% of non-radiology physicians incorrectly identified chest radiographs of congestive heart failure patients. Smith et al.[12] have evaluated the frequency of agreement between a primary care physician's reading of radiographs compared with that of a radiologist. Concordance between readings by family physicians and radiologists was found in 72.5–92.4% of all radiographs.

Loy and Irwig[13] emphasized that family physicians have an important privilege in interpreting radiographs correctly since they usually have a more detailed patient's clinical history than any radiologist. Although frequently a family physician may not be fully perfect in interpreting a diagnostic radiograph, his/her misinterpretation rate should be minimal and must not differ from the rates experienced by radiologists.

Training of family medicine residents in X-ray interpretation should be reviewed as it can be the main reason for low competencies among residents. This has been emphasized by several studies. Loy and Irwig[13] stressed that misinterpretation

of radiographs by clinicians is mainly due to their inadequate training in their radiology rotation.

Family physicians are on the frontline of the healthcare system and are the first to make decisions regarding the management of their patients. Such poor skills can have harmful consequences, such as an overlooked pneumothorax. It is recommended in context of the requirements of the SCFHS and in the light of medical ethics that certified physicians be competent in the interpretation of X-rays of common chest conditions. Such competency may be achieved by placing more focused, wider exposure and structured training in radiology as was recommended by Eisen et al.[3]

Study Limitations and Obstacles

This study has been conducted only at the Family Medicine Residency Program of Jeddah. Therefore, generalization of its results is limited exclusively to the study area. To the researcher's knowledge, this study is a first of its kind in Saudi Arabia to assess the competence of family medicine residents regarding the interpretation of chest radiographs. It was quite difficult to compare the results of this study with those of other studies since only a few researches relevant to this study were available.

CONCLUSION

Based on the results of this study, we conclude that the radiological skills of the family medicine residents – in Jeddah – do not meet the curricular requirements of the training program in identifying pathological findings in chest X-rays nor in correlating them to chest conditions to reach a possible diagnosis. Moreover, the residents' ability to correctly diagnose chest radiographs decline further by their final training year (R4). It is recommended that family medicine residents be exposed to a wider range of chest X-rays during their rotation in the radiology department and to improve the quality of their rotation. Training activities on chest X-ray interpretation should also be introduced throughout the residency program.

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