Habilidades em Diagnóstico Radiológico do Interno em Medicina

Radiological Imaging Interpretation Skills of Medical Interns

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KEY-WORDS

– Medical Education.

– Radiology.

– Medical internship.

ABSTRACT

Background: *Medical students' skills in radiographic image interpretation is neither known nor assessed in the case of most medical schools in Brazil.* ***Objective:*** *The purpose of this study was to assess intern students' performance in the interpretation of radiographic images of the chest and abdomen.* ***Methods:*** *A 10-item test was developed using non-contrasted radiological images from the chest and abdomen. Internship students from two public medical schools (Classroom Group, n=50) and doctors (Control Group, n=20) answered the test. A third group (Online Group, n=38) composed of students from different medical schools answered a web-based form with the same 10-item test.* ***Results:*** *Doctors and students were able to accurately interpret only 30% of the radiographic images; 50% of the students and 30% of the doctors performed poorly. The rest produced average levels of performance. There were minimal differences between the Classroom and Online Groups. A point-by-point analysis of their answers has been presented and discussed.* ***Conclusion:*** *Efforts must be made, including the framing of medical curricula interventions, to improve student interns' skills in radiological image interpretation.*

PALAVRAS-CHAVE

– Educação Medica.

– Radiologia.

– Internato médico.

RESUMO

Introdução: *Habilidades de internos em medicina para interpretação de exames radiológicos não são avaliadas nem tampouco conhecidas pela maioria das escolas Médicas.* ***Objetivo:*** *investigar o desempenho de estudantes do internato de medicina para interpretação de exames radiológicos de tórax e abdome.* ***Métodos:*** *um teste com 10 radiografias não contrastadas de tórax e abdome com diagnósticos simples foi respondido por estudantes de internato (grupo Estudantes, n=50) e médicos (grupo Controle, n=20) e enviado a estudantes de internato por via eletrônica (Grupo Online, n=38). As respostas do grupo Estudantes foram comparadas ao Controle e ao Grupo Online separadamente.* ***Resultados:*** *Em apenas 20% casos tanto médicos e estudantes tiveram um rendimento satisfatório, 40% dos casos dos médicos e em 50% dos estudantes o desempenho foi realmente ruim (menos e 40% de respostas corretas) e no restante das respostas o desempenho foi apenas mediano. Os estudantes do grupo Online obtiveram desempenho próximo aos estudantes do grupo Estudantes em 80% das questões. Uma análise ponto a ponto das respostas é cuidadosamente apresentada.* ***Conclusões:*** *O desenvolvimento da competência em diagnóstico radiológico deve ser aprimorado. As escolas médicas devem se preocupar em desenvolver intervenções curriculares efetivas para aperfeiçoá-las.*

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INTRODUCTION

Newly-graduated medics often take on professional commitments, especially in primary health care and emergency services, without having undergone medical residency training. In these services they are challenged to diagnose diseases based on complementary basic exams. Although simple and limited, radiographic imaging of the chest and abdomen remains the essential tool for the diagnosis of several diseases in the clinical setting where recently-graduated physicians work. As general practitioner training requires learning how to interpret these exams so that they can practice their professional duty, it is important to train students to critically assess and associate them to the care of their patients.

Nevertheless, many medical courses do not include formal training of these skills in their curricular programs or teach them in a heterogenous manner with limited class time (1). Rather, this part of their learning is associated to learning of the other clinical areas, often in a segmented and disconnected manner. Even in Europe, where several educational centres reformed their curricula several years ago and are at the forefront of medical education development, there is a great difference between the teaching and evaluation methods and the curricular content in relation to the development of skills in interpreting radiological exams (2).

Although the ability to interpret radiological exams is not formally developed by many medical school curricula in Brazil, this specific skill is tested for admission to medical residency and to perform professional practice from the outset.

Considering the conditions in which the development of these skills is delivered to students, it is only natural to expect a varying range of proficiency in the interpretation of radiological exams, even the simplest ones. In fact, there is a scarcity of studies conducted and published in our area that focus on investigating graduating medical students' competence to interpret and assess radiological imaging. Data relative to studies at Brazilian schools are limited and largely inconclusive. They are often published in regional, non-indexed magazines, with conclusions of only a local extent and sometimes present limited methodologies and objectives.

Carneiro et al. (3), assessing the ability of medical students from the Federal University of Rio de Janeiro to diagnose pulmonary tuberculosis from chest x-ray images, concluded that the students' competence in this skill was good, but the authors did not investigate the overall competence of the students in interpreting radiological chest exams and restricted their study to a single medical school in Rio de Janeiro state. It could also be argued that there is little and irrelevant production in Brazil relative to this aspect of medical training.

The objective of this study is to investigate the competence of medical students in the final phase of their undergraduate training in relation to the interpretation of simple radiological exams.

4.0 METHODOLOGY

A test with ten radiological images was prepared from simple, digital, non-contrast enhanced radiographs of the chest and abdomen. The study was conducted in the city of Recife, Pernambuco, Brazil.

The radiographs were chosen with the help of a specialist radiologist who diagnosed each selected case. A second specialist radiologist assessed the same radiographs and in cases of discordant diagnosis, the exam was assessed by a third specialist to determine the expected response. The specialist was asked to establish a "label" or primary diagnosis for each radiograph. The radiographs were made on a high quality digital system (General Electric Discovery XR 656 belonging to the Oswaldo Cruz University Hospital, UPE), and printed on a minimum size frame of 15 x 25 cm.

Simple, everyday general practice cases and cases of prevalent diseases were selected, for which the radiological findings were clearly visible: pleural effusion, pneumoperitoneum, hydropneumothorax, reticulonodular lung infiltrate, normal image, intestinal obstruction, megacolon with fecaloma, ureteral stones, calcified fibroid and mediastinal lymphadenopathy (Figure 1). Each radiograph was presented to the student or doctor for up to two minutes and no clinical details were disclosed to them. Subsequently the primary diagnosis or normal exam were recorded. Any student or doctor unable to provide a diagnosis left the answer blank or answered "don't know". The time needed to reach a conclusion was also noted. The primary diagnosis was considered to be the main clinical finding of the radiograph. The student or doctor could write a brief summary of their diagnostic impression of each image. No choice or alternative was presented to them.

Final year medicine students were invited to participate in the test by a graduate medical student. The objectives and methodology of the test were explained to them, and anonymity of the responses was guaranteed. Those who spontaneously agreed to participate in the study signed a free and informed consent form. The test was applied in a reserved and silent space to avoid external factor interference and in the presence of the researcher. The study sample consisted of interns from the two public medicine schools of Pernambuco: The University of Pernambuco School of Medical Sciences and the Federal University of Pernambuco School of Medicine. For the purposes of the control group, twenty general practi-

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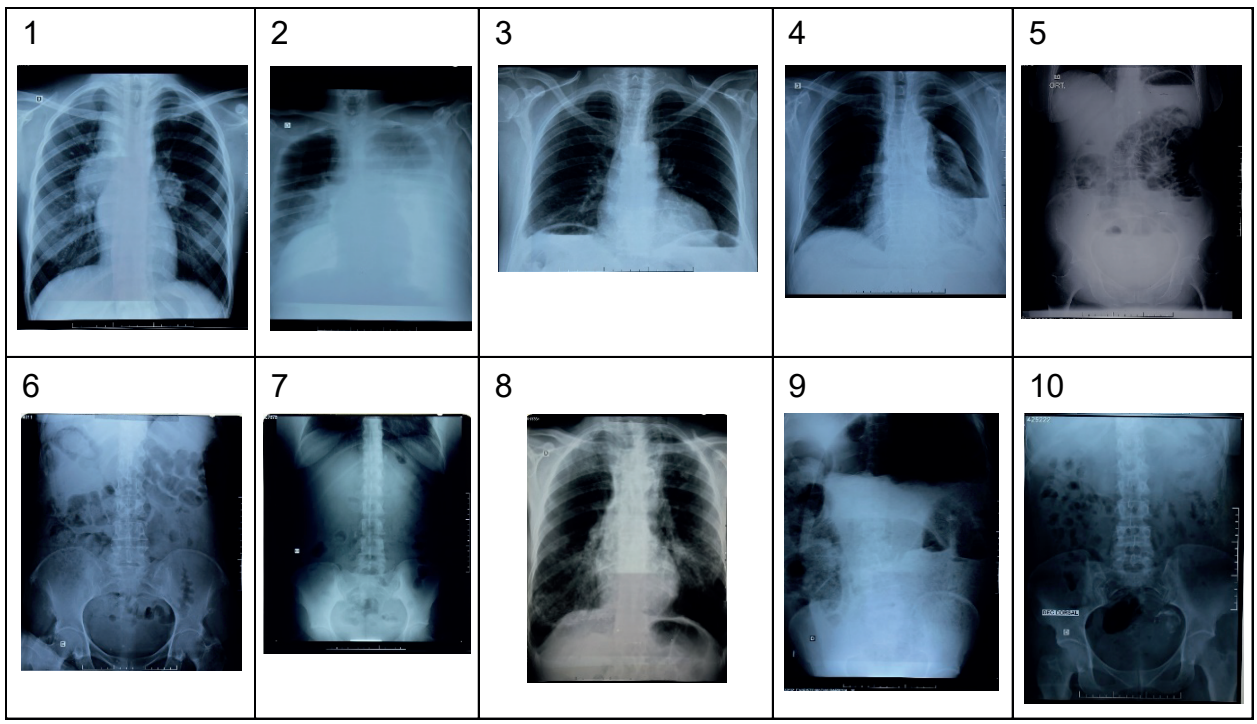
Figure 1
Chest and abdomen radiographs without contrast enhancement. The expected diagnoses according to the specialists consulted were: 1. Mediastinal lymphadenopathy; 2. Pleural effusion; 3. Pneumoperitoneum; 4. Hydropneumothorax; 5. Intestinal obstruction; 6. Normal image; 7. Ureteral stones; 8. Diffuse reticulonodular infiltrate; 9. Megacolon/fecaloma; 10. Pelvic calcification (myoma).



tioners were invited to respond to the same questionnaire and in the same research conditions.

A pilot study was conducted with ten students and three doctors. Adjustments to the training of researcher students and to the research instruments were made after the pilot experiment.

Demographic data were recorded for the group of students and control group. The group of students, the level of academic achievement was recorded, represented by the grade point average of each module or discipline of the course.

An electronic form created on Google Forms containing the same images and the same possible answers, as well as an invitation with explanations about the study and instructions for answering it was sent by email to the final year students of the same public universities and to the students of a private university in Recife, Pernambuco. These students' answers were compared to those of the students who responded to the survey in person.

The study groups were defined as follows:

- Student Group: students who answered the survey in the presence of a researcher.
- Online Group: Students who responded to the form sent electronically via Google Forms.
- Control Group: group of doctors who answered the survey in the presence of a researcher.

Inclusion criteria

- Students: final year students of the medical course of one of the medicine schools included in the study;
- General practitioners, emergency care or family doctors graduated for at least five years.

Exclusion criteria:

- Students who had failed disciplines or academic modules during the medicine course;
- Students with a grade point average of less than 7.0;

- General practitioners with less than five years since graduating or who were not exercising the profession.

Analysis of the answers

The answers were written in few words. Answers were considered correct when congruous with those given by the specialist, called the Expected Response, even when not identical to them. To settle doubts and avoid interpretative errors in the classification of the answer as correct or incorrect, all the answers were revised by one of the authors (LECM). Hence, if the expected answer was "intestinal obstruction", answers such as small bowel obstruction, stack of coins sign or paralytic ileus, but answers such as intestinal volvulus or colon obstruction.

Statistical analysis

The data were tabulated in an Excel 2017 spreadsheet. The Student Group was compared to the Control Group and to the Online Group separately.

Data were presented as mean and standard deviation or proportions (%). P< 0.05 was considered significant in all the analyses.

The proportion of correct answers given by the Student Group was compared to the answers of the Control Group. The proportion of correct answers by the Student Group was also compared to that of the Online Group. The proportion of agreement between the answers of the different groups was calculated using the Kappa index[4]. For the purpose of the calculations, the groups were considered to have produced incorrect answers when the proportion of correct answers was less than 40%, an intermediate result if that proportion was between 41% and 70%, and correct answers when the proportion of correct answers was greater than 70%. The Kappa index and the proportion of agreement was calculated using the mathematical tool available at http://justusrandolph.net/kappa/. The other calculations were made using the software GraphPad Prism version 5.00 for Windows, GraphPad Software, San Diego California USA, www.graphpad.com.

This study was approved by the Research Ethics Committee of the Oswaldo Cruz University Hospital, University of Pernambuco, and registered on the National System of Research Ethics (SISNEP) under number CAAE 83718518.9.0000.5192.

The authors of this article declare no conflicts of interest of any kind.

RESULTS

Between June 2017 and February 2018, 50 students and 20 doctors responded to the survey in person and 38 students responded to the electronic survey form (Table 1).

Of the Student Group, 25 of the students were from UPE, 25 from UFPE, with a school grade point average of 8.46+ 0.25. Thirty (60%) declared themselves white, with an average age of 24.6±18 years, where 14 (28%) had graduated from a public school and only 6 (12%) were quota beneficiaries.

In the Online Group, 38 students responded to the invitation, although 96 emails had been sent with the invitation to participate in the study (39.5% response rate). Of those who answered the survey, the average age was 25.05 ± 0.5, 18 (47.4%) from a private school in Recife, 9 (23.7%) from the Federal University of Pernambuco and 11 (28.9%) from the State University of Pernambuco. Only 2 quota beneficiaries were among the respondents. Twenty-six (67.6%) declared themselves to be white, 11 (29.7%) mixed race and only 1, black. Seven students (18.9%) had completed their secondary education at a public school.

Table 1
Demographic data of the group of students

	Total	Face-to-face Survey	Online Survey	P
Answers (n)	88 (100%)	50	38	-
Age (mean ± SD)		24.6±1.8	25.05±0.5	0.40
Declared race				0.5
white	56 (63.3%)	30 (60%)	26 (67%)	
mixed and black	32 (36.7%)	20 (40%)	12 (33%)	
University				0.0001
UFPE	34 (38.6%)	25 (50%)	9 (23.7%)	
UPE	36 (41%)	25 (50%)	11 (28.9%)	
Private	18 (20.4%)	Zero	18 (47.4%)	
Grade point average	-	8.46±0.25	-	-
Graduated from				0.32
public school	21 (23.8%)	14 (28%)	7 (18.9%)	
Private school	67 (76.2%)	36 (72%)	31 (81.1%)	
quota beneficiaries	8 (9.1%)	6 (12%)	2 (5.4%)	0.45

In relation to the doctors, the mean time since graduating was 14.3 ± 9.3 years and 12 (60%) considered themselves white. All the doctors had completed a medical residency, 14 being clinical (70%), 5 surgical (25%) and 1 (5%) as a family doctor. It was found that 9 (45%) had already worked in primary care, and 18 (90%) in emergency care.

Results of the face-to-face survey

The results of the students' and doctors' answers to the face-to-face survey are presented in Table 2.

Analysis of the answers to the survey conducted face-to-face revealed an average response time of 56.04 ± 1.33 seconds among the students and 33.53 ± 1.35 seconds for the doctors. In every instance, the students needed more time than the doctors to arrive at the answer, always with significant statistical difference (p <0.0001). The radiograph of the chest with pneumoperitoneum was the one to which the doctors responded quickest and the radiograph showing intestinal obstruction was the one the students answered quickest.

On average the doctors correctly answered 45% of the questions, and the students 38% (p =0.39). Doctors and students alike had greatest difficulty in identifying ureteral stones, which was correctly answered by none of the doctors and by 2 students. The normal radiograph also posed difficulties, with only 12% of the students and 15% of the doctors correctly identifying the situation. In relation to the radiograph showing mediastinal lymphadenopathy, although the majority of doctors and students could identify alterations in the radiograph, relatively few of them were able to precisely point to the mediastinal disease. The radiograph was more readily interpreted as "vascular congestion" or unspecified infiltrate. A large proportion of the doctors and students were unable to recognise the megacolon or fecaloma in the simple abdominal radiograph, although they could perceive that the radiograph was not normal. Finally, a pulmonary reticular-interstitial infiltrate, common to chronic diseases was easily confused with lobar pneumonia by doctors and students.

On the contrary, intestinal obstruction and pleural effusion were easily diagnosed by the majority of doctors and students, where 20% were unable to identify on the chest radiograph a pleural effusion of large proportions, and the majority of students and half the doctors were unable to perceive the presence of hydroaeric level in a chest radiograph and when they could notice it, were still unable to interpret it correctly.

Only two of the radiographs presented a significantly higher correct answer rate by the doctors. In relation to the pneumoperitoneum radiograph, 75% of the doctors and 44% of the students correctly identified the diagnosis (p= 0.03). Although the radiograph of the calcified fibroid was correctly interpreted by a higher number of doctors, the vast majority of both students and doctors were unable to perceive the radiographic signs of the disease. There were 13 "don't know" answers in the Student Group against 37 "don't knows" in the Online Group, a difference with high statistical significance (P= 0.0001). The UPE students, which school executed a curricular reform 16 years ago, failed to report better performance

Table 2
Proportion of correct answers and average response time per question according to each group studied

	Expected answer	Students	Doctors	P	Students' response time in s	Doctors' response time in s	P (time)
1	Mediastinal lymphadenopathy	48%	45%	1.0	62.50 ± 4.511	40.25 ± 6.457	0.01
2	Pleural effusion	80%	80%	1.0	51.88 ± 4.086	34.00 ± 3.261	0.01
3	Pneumoperitoneum	44%	75%	0.03	50.12 ± 4.160	23.50 ± 3.640	0.0003
4	Hydropneumothorax	28%	50%	0.09	49.04 ± 3.539	29.15 ± 3.431	0.0015
5	Intestinal obstruction	78%	70%	0.54	44.94 ± 3.407	32.15 ± 3.142	0.03
6	Normal	12%	15%	0.71	55.06 ± 4.065	30.85 ± 3.775	0.0008
7	Urolithiasis	4%	0	0.32	52.02 ± 3.678	30.35 ± 3.948	0.0011
8	Diffuse reticulonodular lung infiltrate	44%	45%	1.0	55.36 ± 3.312	39.95 ± 5.262	0.0155
9	Megacolon fecaloma	36%	40%	0.79	53.64 ± 4.114	34.40 ± 3.412	0.0067
10	Pelvic calcification (myoma)	6%	25%	0.03	85.80 ± 4.571	40.70 ± 4.330	<0.0001

than those from UFPE, which has a traditional curriculum. The students of the University of Pernambuco correctly answered 38.4% (96) of the questions, whereas those from UFPE only 32.8% (82) (p= 0.23). For students from both universities, the greatest difficulty was observed in the interpretation of urolithiasis, for which UPE had no correct answers and UFPE just two (p=0.49) and interpretation of the left-side pelvic calcification, where UPE obtained only one correct answer and UFPE two.

The UPE students reported the best performance for the pleural effusion radiograph, with 20 correct answers, where the UFPE students only had 10 (p = 0.009). It was also found that 85% of the doctors were unable to identify the normal chest x-ray.

The (non-adjusted) Kappa agreement coefficient considering the face-to-face and online answers revealed a value of 0.53± 0.23, where 0.84 is the maximum possible non-adjusted Kappa coefficient, considering the limit frequencies observed, only moderate agreement according to Landis & Koch[4].

Result of the Online Survey

With the aim of comparing students' answers to the survey answered face-to-face or electronically, the results of the 50 students who answered face-to-face were compared to those of 38 students who participated online (Table 3).

The results show that in only two cases (mediastinal lymphadenopathy and reticular lung infiltrate) the performance of the students in the online group was inferior with statistical significance. In these cases, the proportion of correct answers was pitiful. Just as in the face-to-face survey, the most correctly identified diagnoses were those of left pleural effusion and intestinal obstruction. There was clear difficult encountered in identifying ureteral stones, and calcified pelvic mass, as well as a high error level for the megacolon/fecaloma diagnosis and unacceptable difficulty in perceiving a clear case of pneumoperitoneum.

Analysis of the students' answers to the survey applied online, when discounting students from the private Medicine school, showed no significant differences to the analysis made for the entire Online group. This finding suggests that the inclusion of a third medicine school in the online analysis did not radically modify the performance in the survey conducted electronically.

The (non-adjusted) Kappa agreement coefficient considering the face-to-face and online answers revealed a value of 0.47± 0.25, where 0.65 is the maximum possible non-adjusted Kappa coefficient, considering the limit frequencies observed, only moderate agreement according to Landis & Koch[4].

DISCUSSION

Although general practitioner training requires the ability to adequately interpret radiological imaging for appropriate patient care, many of the medical school curricula fail to include formal training and teaching of these skills, despite well-conducted studies having demonstrated that training students in radiological imaging interpretation significantly improves those skills [5,6,7]. To assess the imaging interpretation skills of medical interns, we investigated the performance of students who are nearing the conclusion of their medical course by means of a test containing ten simple, digital radiograph images without contrast enhancement of the chest and abdomen, with a group of graduated physicians as the control group.

Table 3
Proportion of correct answers for the Student Group versus the Online Group and for the Student Group versus the Online Group considering only the answers by students from public schools

	Expected answer	Students N = 50	Online N = 38	P	Public (Online) N = 21	p
1	Mediastinal lymphadenopathy	48%	15.8%	0.0017	4%	0.0003*
2	Pleural effusion	80%	76.7%	0.6	71.4%	0.53
3	Pneumoperitoneum	44%	47.4%	0.8	52.4%	0.6
4	Hydropneumothorax	28%	39.4%	0.8	23.9%	0.78
5	Intestinal obstruction	78%	65.8%	0.6	71.4%	1.0
6	Normal	12%	7.9%	0.7	4.7%	0.66
7	Ureteral Lithiasis	4%	0%	0.5	0.0%	1.0
8	Diffuse reticulonodular lung infiltrate	44%	7.9%	0.002	14.3%	0.02*
9	Megacolon or fecaloma	36%	23.3%	0.12	28.5%	1.0
10	Pelvic calcification (myoma)	6%	2.6%	0.5	4.7%	0.55

Simple cases from everyday general practice and of prevalent conditions were selected. Any student or doctor unable to provide a diagnosis left the answer blank or answered "don't know", with the time needed to answer each question being recorded.

The students answered freely what they observed in each radiograph. They were not presented with any clinical information or alternatives from which the answer was to be chosen. Therefore, a pleural effusion could be interpreted as "pleural effusion" or as "hemothorax". Both answers were considered correct, because they indicated that the students were able to note the presence of a large quantity of pleural fluid on the chest radiograph. In the pelvic radiograph, an answer such as "calcified foetus" was considered correct, because the student was capable of perceiving the large pelvic calcification on the radiograph, despite not realizing that it was a mass and not a foetus. The cases in which the answer could cause some doubt were discussed with the research supervisor for the final decision. The flexibility allowed for the answers as shown leads to a greater proportion of answers being considered correct, therefore the results shown here may be overestimated, which is even more worrying.

The methodology used may also have otherwise interfered in the results observed for interpretation of some images, such as for example the radiograph of ureteral stones. The revelation of the patient's clinical symptoms may have led some students to correctly identify the large ureteral stones on the right, which was easily diagnosed by the specialists, even without any clinical history. Although omission of the clinical symptoms may lead to a bias that worsens the results, equally their disclosure could easily have the opposite effect: if it were disclosed that the patient had been treated in emergency care complaining of strong lower back cholic pain to the right and haematuria, a student could indicate the diagnosis of urinary stone even if he or she were only observing a calcified pelvic phlebolith. Also, in relation to the methodology, it must be considered that the answers of the Control group were inevitably subject to the physician's willingness to contribute to the study. Although they had been invited and spontaneously agreed to participate in the research, we are ignorant of the extent to which they felt put out or how willing they really were to take the test. This may have interfered in the quality of the answers in this group. Finally, it must also be considered that a test with only ten radiographs is inherently limited in terms of its extent. With the inclusion of only 10 images, the design of this study is shown to be unassuming. It was not the objective of the authors to extensively study the question, or even to exhaust the subject matter. On the contrary, in view of the scarcity of data in this respect, the intention was merely to demonstrate, through a simple and limited study, the extent of the problem and suggest the need for new and more complex studies. The results of this study should, therefore, be analysed in light of the methodology employed, considering its intrinsic limitations.

The sample of doctors studied included only professionals who had completed medical residency and had been graduated for at least five years, excluding those who were not exercising the profession. We consider this sample to represent an adequate control group for the research as it would be disproportional to compare them to specialists. The assessed students faithfully represented the profile of their schools, since those selected were restricted to those who had not failed any disciplines or academic modules during the medical course and had a grade point average greater than 7.0.

The results demonstrate in a general manner that doctors and students alike are hugely limited in their ability to make radiological diagnoses of simple and commonplace situations. If we consider that a poor performance corresponded to a correct answer rate of less than 40%, an average performance between 40% and 75% and a satisfactory performance to over 75% correct answers, in only 30% of the cases both doctors and students reported a satisfactory performance. In the majority of cases only an average correct answer rate was reported and 30% of the doctors and 50% of the students reported a genuinely poor performance. An example can be made of the inability to diagnose a 1 cm calculus in the mid-ureter which was immediately identified by both specialists who initially interpreted the images, or the inability to perceive a huge calcified myoma in the pelvis. Even more startling is that 20% of the doctors and students are unable to perceive the presence of bilateral pneumoperitoneum in a chest x-ray and that answers such as cardiomegaly, pneumothorax and atelectasis were given by intern students when viewing a chest x-ray with a clear pneumoperitoneum. It is also noted that even in situations in which the doctors displayed better performance than students, the performance of the doctors group was disappointing. The students and doctors presented a poor performance in a radiological imaging interpretation test and in 70% of the times without any statistical differences between the groups. This result suggests that even after the end of the graduation in which this skill was not sufficiently developed, and of years of performing the professional activity, very little improvement of this specific skill was attained. A significant limitation of the doctors in relation to knowledge in the field of radiology was perceived by Borém et al, who investigated physicians at an emergency care unit in Minas Gerais, Brazil[8].

In the present study, no correlation was made between the physician's specific field of work and their correct diagnoses. We sought to ensure that the doctors had professional experience in basic health care or emergency care services, which supposedly require a high level of performance in the skill of interpreting radiological imaging and thus to work with a homogenous and reliable control group. This is an interesting point of investigation for subsequent works and with a broader methodology than the current study.

One relevant aspect of the results presented, and that deserves deep reflection, is in relation to the lack of development of radiograph interpretation skills among the students. Aspects inherent to insufficient training, whether through curricular shortcomings, insufficient class hours, or inherent to a lack of interest in the learning, should be taken into account. Perhaps the students, accustomed to thinking prematurely about a specialization, feel disinterested in the development of this specific skill, perceiving that it will not be missed in the future. In this context, there is a significant number of works published in the pertinent literature that investigate the quality of teaching offered, means of improving and assessing it. They indicate evidence that, despite current efforts, new solutions should be proposed to improve the learning of this skill among intern students and residents, with the aim of enhancing the quality of medical assistance offered by these young professionals.

Despite the importance of this teaching, there are relatively few studies that investigate the curricular interventions required for the development of these skills. O'Brien and colleagues[9] investigating the current teaching and assessment methods for basic radiological imaging interpretation skills in medicine schools in the USA and Canada, with a three-year internship, concluded that the most common assessment methods were written exams and the OSCE. The majority of the schools they investigated spend only two to four hours during the entire internal medical internship to train these skills. The authors concluded that data relative to the development and assessment of radiological imaging interpretation skills in the undergraduate medicine curriculum are insufficient. Linaker[10] examined the literature pertinent to the assessment of radiological diagnosis skills of students and residents and the test results, including the National Board Examination, and concluded that although the assessments were useful tools for teaching radiology, they are not used by many of the training programs. Some programs have inadequate assessments and do not allow their students to review their tests. The author concludes that there is no relation between the proficiency in interpreting radiological imaging and specific tests, results or clinical or pre-professional degree. Lewis Eisen[6] and colleagues evaluated the ability to interpret radiological imaging among medicine students at different levels of training, with the intention of identifying factors associated to the success of this skill. They included students, interns and residents of a single medicine school in the United States and concluded that the level of training, the interest in following a career in pneumology and the area of medical training were factors associated to enhancing the skill of interpreting radiological imaging. For them, although the training is important, relevant diagnoses went unnoticed. Petinaux and colleagues[11] investigated the types of diagnostic mistakes made by doctors attending emergency cases and concluded that 3% of the simple radiological exams presented discrepant diagnosis that were not confirmed by radiologists, where the most discrepant findings were those for bone fractures, dislocations, nodules and pulmonary infiltrates. The authors concluded that continued education actions should be considered to tackle this problem. Joseph Eid and colleagues[12] investigated residents' ability to interpret basic radiological imaging. They used an online base of forms created on the electronic platform ProProfs.com and investigated seven different residency programs of a single medical centre in Michigan, United States. In general, the residents were capable of correctly interpreting only 75% of the exams tested. The authors maintained that residency programs should offer specific training in radiological imaging interpretation as a way of improving patient care. Senra-Portero and colleagues[5] quantified the improvement in medical student performance in interpreting radiological imaging after a training program, comparing students training under different medical curricula in the third and sixth years of the medicine course. An increase in correct responses was found in both groups after the training, but it was far more significant among the sixth-year students, suggesting that the teaching of radiological imaging interpretation is more effective when conducted during the internship.

Reflecting on these results leads us to consider the way in which training skills in radiological diagnosis is delivered to our students. Even at a relatively small centre like the city of Recife, state capital of Pernambuco, and also in Brazil in general, questions like the proportion of the curriculum that focuses on training these skills, the expected competences in this important learning process, evaluation of the development of these skills, as well as the intern's contribution in this construction and the manner in which the intern contributes to it cannot be answered because they are not known. We do not even know the proportion of Medicine schools that can answer these questions in relation to their own competences.

And it is not only in Brazil that it is like this. Elena Kourdioukova[2], studying through an electronic questionnaire distributed to 38 delegate members of the European Educational Committee, found a high number of differences in the curricular content and teaching methods of radiology throughout Europe. Topics such as total curricular hours used in teaching radiological skills through hands-on activities or the study of radiological anatomy or the intern's contribution were very heterogenous. It is likely that should a similar study be conducted in the city of Recife, where the results of this study were found, we would find the causes behind our interns' and doctors' performance being so below the desired standard.

It is natural to propose that a similar, yet more extensive and careful test be planned and sent by email to Medical Schools in the whole of Brazil in order to investigate how prepared our students are in relation to these specific skills. Such an investigation would be far-reaching, relatively cheap, repeatable and allow for the planning of valuable actions and guidelines for training radiological skills.

We investigated the results of tests answered by students electronically and in person. In general, the Online respondents demonstrated the same limitations as the students who answered the questionnaire face-to-face, but for two cases (mediastinal lymphadenopathy and reticular pulmonary opacification) the performance of the online respondents were clearly inferior. Furthermore, there were more "don't knows" or answers left blank in this group. Multiple factors explain these findings. Although the instructions sent to the students asked them to answer the test on a computer or tablet and not on a mobile phone due to the size of the display, which can limit some interpretations, it is impossible to know the proportion of students who were unable to overcome the temptation of accessing the test easily on their phones, going against the instruction. In emergency care where newly-graduated medics frequently find job opportunities, the level of training is not the only factor that contributes to radiological imaging interpretation skills. Several strategies have been used to reduce the time between the execution of the radiological exam and the decision making by the doctor. Among such measures, teleradiology through the use of specialized software or the presence of radiologists in the emergency room can interfere in the ability to interpret radiological exams. John Eng and colleagues[7] studied the influence of different factors on the skill to interpret radiographs and conclude that there are important differences when interpreting radiographs on film or shown on a computer screen. Additionally, there are differences of equal or greater magnitude associated to the extent of the doctor training and the specialty of each observer studied. Other factors that influence the results of the online group should be considered, such as: the students who answered the questionnaire in person did so in the presence of a researcher, in a reserved space and were possibly more focused on their task and more willing to collaborate with the research than those who answered the same test remotely. Finally, the way in which the students were approached may have influenced their willingness to collaborate. The participants from the Students group were approached in groups in their hospital internships by one student. They were explained the motives, methods and objectives of the research and invited to take the test spontaneously.

The students from the Online group received an email with explanations, instruction and the invitation, although many of them already knew of the research because they inevitably had colleagues who had participated in the Student group. It is interesting to note that in the first group the students readily agreed to take the test and demonstrated a certain enthusiasm. Nevertheless, in the Online group there was a clear resistance to accepting the invitation. Despite the appeal of their student colleagues, only 39.6% of the emails sent were replied to. These results signalled that an online survey could be employed for a broad investigation in the whole State and even nationwide to specifically assess the radiological diagnosis skills among students or recently-graduated physicians, in order to plan strategies to improve these skills, provided these limitations were considered and some precautions taken: the main one is the selection of images already tested in face-to-face and Online tests and those where the differences in answers between the two groups were minimal. Any images with a rate of incorrect or blank responses of over 90% or correct response rates nearing 100% should also be excluded. An example of this would be the images of mediastinal lymphadenopathy and pulmonary infiltrate, which would be excluded from the test, as well as the images of the ureteral calculus and calcified pelvic myoma.

Finally, it is necessary to bear in mind that the current digital diagnostic imaging technology and technology for distance learning could be considered important tools for the enhancement of radiological imaging interpretation skills, especially during the medical residency or internship. Antonio Pinto and colleagues[13] reviewed 38 articles pertinent to the current use of e-learning in radiology and found that despite the importance of the training and online learning tools and the ongoing technical advances, the quality and reliable of the information found online is highly variable and at times lacking the basic standards for scientific publication. This finding suggests that students who use random bases on the internet for self-learning can find mediocre sources of technical information.

In conclusion, considering the results of the current study, taking into account the limits discussed, we found evidence that the development of this skill should be improved. Medical schools should concern themselves with the development of reliable assessment methods for radiograph interpretation skills and effective curricular interventions should be planned to improve them.

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CONTRIBUTION OF THE AUTHORS

Ana Clara Galindo Miranda, Caio Paes Monteiro and Maria Luíza Câmara Pires contributed equally to the planning of the research, the literature review, preparation of the research project, including the ethical and bureaucratic requirements, field research, tabulation of the results, statistical calculations and composition of the final text for publication.

Luiz Eduardo Correia Miranda: Proponent and coordinator of the research. Revisor of the text for publication.

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