ORIGINAL ARTICLE

Competency in chest X-ray interpretation: Variations across medical experiences and training levels

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ABSTRACT

Introduction: Chest X-ray (CXR) remains one of the most commonly used diagnostic imaging tools in clinical practice. However, the accuracy and competency in reading and interpreting CXRs can vary significantly across different levels of medical practitioners, ranging from house officers to senior specialists. The purpose of this study was to assess competency in CXR interpretation among doctors at different stages of their medical careers.

Material and Methods: This is a cross-sectional study conducted using CXRs, which were displayed digitally. A total of 305 participants were recruited, including house officers, medical officers, and registrars in specialty training. A standard set of ten radiographs was chosen, and the participants were required to interpret the CXR in multiple-choice format. Data analysis was performed via IBM SPSS Statistics software, version 25.

Results: Clinical history improved the ability to accurately interpret CXR, with the percentage of participants who accurately interpreted CXRs increasing from 21% of participants who achieved high scores without clinical history to 63.6% of participants who achieved high scores with clinical history. The participants' field of interest and confidence level when reporting a CXR without history were associated with higher accuracy ($p<0.05$) when interpreting a CXR. However, when the clinical history was given to the participant, only the confidence level of the participant affected the final score of the CXR. There is no significant difference in the ability of doctors to interpret CXR despite the difference in seniority in practice; moreover, undergraduate exposure does not play a significant role.

Conclusion: Structured teaching, continuous practice, feedback and integration into clinical decision-making are the keys that translate to greater competency in CXR interpretation. Future researches should emphasize on multicenter approach as it enhances the generalizability of findings to a broader national context.

KEYWORDS:
Chest X-ray; accurate interpretation; clinical history

INTRODUCTION

Chest X-ray (CXR) remains one of the most commonly used diagnostic imaging tools in clinical practice, offering crucial insights into a wide array of medical conditions affecting the lungs, heart, and surrounding structures. Accurate interpretation of CXRs is essential for timely diagnosis, proper treatment, and effective patient care. However, the accuracy and competency in reading and interpreting CXRs can vary significantly across different levels of medical practitioners, ranging from medical students to senior specialists.[1]

This variation in competency may stem from several factors, including the level of formal training, clinical experience, and individual expertise.[1-4] While junior doctors typically possess limited exposure and experience in interpreting chest X-rays, more experienced clinicians, such as senior doctors or radiologists, are often more proficient because of their specialized training and years of practice.

pneumonia, tuberculosis, pulmonary edema, and lung cancer, studies exploring competency differences across various levels of medical practitioners remain limited. This gap highlights the need for a comprehensive understanding of how medical experience and training influence diagnostic accuracy, as well as the potential consequences of such variations on patient outcomes.

The purpose of this study was to assess competency in CXR interpretation among doctors at different stages of their medical careers. By evaluating the performance of medical students, junior doctors, residents, and senior clinicians, this research aims to identify areas of strength and improvement as well as to explore the educational implications for improving training curricula in radiology and clinical diagnostics.

This research contributes to a better understanding of training needs at various levels of medical education, highlighting the importance of targeted interventions and continuing education to improve the overall quality of CXR interpretation in clinical practice. Ultimately, the findings may provide evidence for enhancing medical education programs and improving patient Despite the pivotal role of CXR interpretation in diagnosing conditions such as care outcomes through more accurate and consistent diagnostic practices.

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MATERIALS AND METHODS

Study population

This was a cross-sectional study conducted using CXRs, which were displayed digitally. The inclusion criteria were house officers, medical officers and registrars who were in specialty training. Radiology trainees were excluded from this study. Radiology trainees were excluded from this study because they received formal and focused training in radiograph interpretation, which would give them significantly greater baseline competence than would general medical officers or other non-radiologist doctors. Furthermore, this study aimed to assess competency among doctors with varying levels of general clinical experience. Radiology trainees are not a fair comparator group because of their specialized training.

The sample size calculation is based on a confidence level of 95%, a confidence interval of 5%, and a margin of error of 5% with a standard deviation (SD) of 0.5. The ideal sample size on the basis of the calculation is 278 participants.

A total of 309 participants were recruited however four were excluded because of incomplete data, resulting in a final number of participants of 305.

Methods

Participants were recruited on the basis of voluntary participation. To minimize selection bias, we recruited participants from multiple facilities, which included participants from tertiary hospitals, district hospitals, and university settings as well as from health clinics in Kuching and Samarahan Divisions.

Researchers approached each of the participants individually and were present to observe and ensure that the participants completed the questionnaire independently, without external assistance or influence.

The participants were requested to provide their demographic data, years of service, and current postings. A standard set of ten radiographs was chosen. The number of CXRs used to assess the participants was adapted from previous studies and ranged from seven to ten.[1,2,3,4] This number was considered sufficient to evaluate key interpretation skills while minimizing participant fatigue and maintaining focus during the assessment.

The following standards were utilized in the selection of the study's images: (i) only one primary diagnosis on the radiograph with no secondary abnormalities, (ii) two radiologists with more than 10 years of experience independently verified the primary diagnosis, (iii) the findings of the primary diagnosis were clear and not obscured by any structures and (iv) no artifacts were detected.

The final selected CXRs were normal CXR, clavicle/rib fracture, lung mass, metastatic lung lesions, congestive heart failure, pneumomediastinum, pneumothorax, pneumoperitoneum, pulmonary tuberculosis, and lung collapse. The images were exported in JPEG format to maintain the original image quality.

For each image, the participants selected a single primary diagnosis in a multiple-choice format with ten choices given. We choose a multiple-choice question format over free-text responses mainly for standardization purpose as to ensure that all participants are assessed with the same options, thus reducing the variability in the responses and increasing the objectivity of the evaluation. It is also easier to mark consistently, especially in our study with a relatively large sample size, as this approach can minimize scoring bias. In free-text, participants might have the correct idea but are unable to express it clearly. Multiple-choice formats reduce such issues by offering clear choices. Above all, responses from multiple-choice formats are easier to analyze statistically, enabling more accurate comparisons and conclusions.

The participants also documented their confidence level concerning their chosen diagnosis. The confidence level of the participants in interpreting CXR was assessed via a self-reported Likert scale. For each of the 10 radiographs, participants rated their confidence on a scale from 1 (totally not confident) to 5 (highly confident). Each radiograph contributed a maximum of 5 points, resulting in a total possible confidence score of 50. This cumulative score reflected the overall self-perceived confidence of each participant in interpreting CXRs. For the purpose of analysis, the responses were recategorized into three levels: not confident (scores ranging from10-20 points), moderately confident (scores ranging from 21-39 points) and highly confident (scores ranging from 40-50 points). This transformation resulted in categorical variables to facilitate group comparisons in the analysis via Chi-square tests to assess associations with other variables.

Two phases were carried out. In Phase 1, the participants will be given CXR without a clinical history, and in Phase 2, a similar CXR will be given: however they will have an additional clinical history. For each CXR, a single-sentence clinical history was provided to simulate real-world scenarios. The clinical histories were formulated and reviewed by a panel of five consultant radiologists. Among them, three were part of the research team, while two were independent radiologists who were blinded to the final diagnosis and study outcomes to reduce bias. This review process ensured that the clinical history was concise, relevant, and free from leading information that might influence interpretation.

Data analysis was performed via IBM SPSS Statistics software, version 25. Descriptive statistics were used to summarize the demographic data. Categorical variables are presented as frequencies and percentages, and were compared via the Chi-square test. A P-value of < 0.05 was considered statistically significant. All analyses were conducted at the 95% confidence level.

RESULTS

A total of 305 participants were included in this study. The overview of the participants' information and interest is summarized in Table I. The number of correct diagnoses for each participant is summarized in Figure I.

Table I: Demographic & Basic Data of Participants (n=305)

	n (%)
Gender	
Male	117 (38.4)
Female	188 (61.6)
Current level of service	
House Officer	76 (24.9)
Junior Medical Officer (<3 years)	98 (32.1)
Senior Medical Officer (>3 years)	102 (33.4)
Medical Officer in specialty training	29 (9.5)
Graduated from	
Local Public University	134 (43.9)
Oversea/Private University	171 (56.1)
Radiology posting during undergraduate studies	
Yes	138 (45.2)
No	167 (54.8)

Table II: Association between the ability to interpret CXR with presence and absence of clinical history

		With history			
Without history		High score	Medium score	Low score	Total
	High score	73	26	11	110
	Medium score	29	30	36	95
	Low score	9	27	64	100
Total		111	83	111	305

Pearson Chi-square value (p-value): 91.906 (p<0.001)

Table III: Chi square test for factors affecting the total scores for CXR without and with history given

	Low Score, n		Moderate score, n		High score, n		Pearson Chi-Square Value (p-value)	
	w/o hx	hx	w/o hx	hx	w/o hx	hx	w/o hx	hx
Gender								
Male	29	34	40	37	48	46	5.564	4.608
Female	71	77	55	46	62	65	(0.062)	(0.100)
Current level of training								
House Officer	31	37	22	20	23	19	10.803	12.222
Junior Medical Officer (<3years)	39	37	26	29	33	32	(0.095)	(0.057)
Senior Medical Officer (>3years)	22	29	37	26	43	47		
Medical Officer in specialty training	8	8	10	8	11	13		
Field of interest								
Medical	15	17	12	10	23	23	17.873	12.826
Surgical	19	20	12	17	15	9	(0.022)	(0.118)
Community/Public Health	19	24	20	19	37	33		
Radiologist	1	3	3	0	0	1		
Undecided	46	47	48	37	35	45		
Graduated from								
Local Public University	48	50	45	39	41	45	3.108	0.889
Oversea/Private University	52	61	50	44	69	66	(0.211)	(0.641)
Radiology Posting in Undergraduate Training								
Yes	47	58	49	39	42	41	3.878	5.394
No	68	53	46	44	53	70	(0.144)	(0.067)
Confidence level when answering								
Not confident	15	16	6	8	7	4	18.399	14.636
Moderate	65	70	85	52	55	61	(0.001)	(0.006)
Confident	20	25	26	23	48	46		

*w/o hx = without history given, hx= with history given

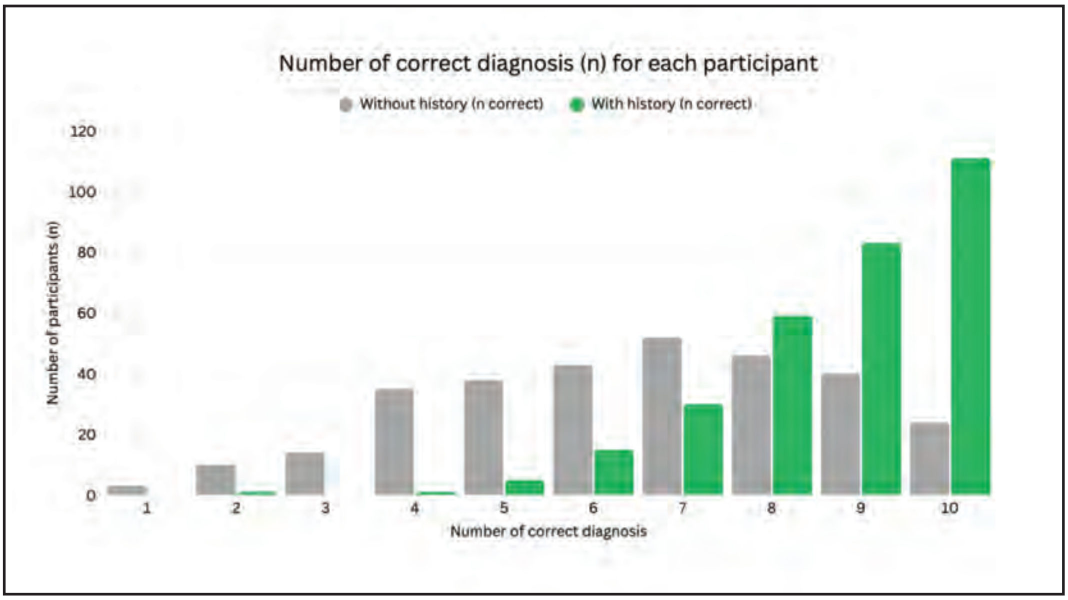

Fig. 1: Bar chart showing number of correct diagnosis for each participant

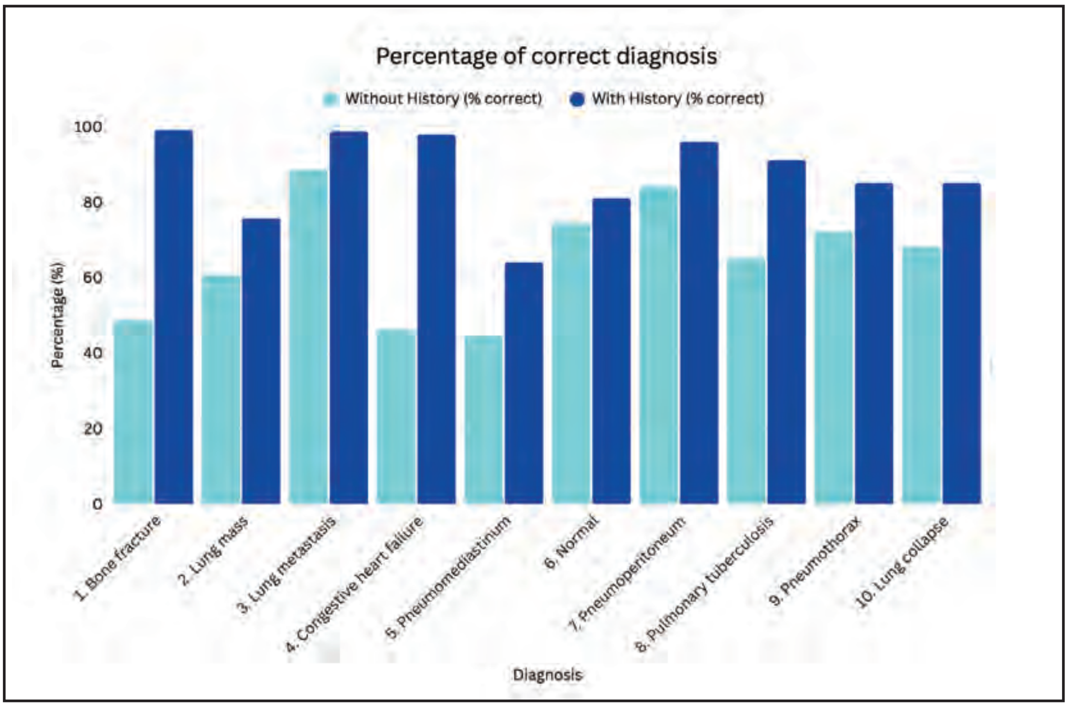

Fig. 2: Bar chart showing percentage of correct diagnosis for each image

The percentage of participants whose CXRs were accurately interpreted improved when clinical history was given; from 7.9% of participants who achieved perfect scores without clinical history to 36.4% of participants who achieved perfect scores with clinical history. Figure I shows a bar chart showing the number of correctly interpreted CXRs for each participant. The chi-square test revealed a statistically significant correlation between the accuracy of CXR interpretation and the presence or absence of a clinical history, as shown in Table II. Patient history during CXR interpretation is significantly related to higher CXR interpretation accuracy scores.

The median score for correctly interpreted CXRs without history was 7.0 out of 10.0, and the median score for correctly interpreted CXRs with history was higher, with a score of 9.0 out of 10.0. The participants were divided into high scorers for those who scored at and above the 75th percentile, which was 8.0 out of 10.0 and low scorers for those who scored at the 25th percentile and below, which was 5.0 out of 10.0 for those without history. For the CXRs with accompanying clinical history, the high score was for those who were at the 75th percentile and above, which was a full score of 10.0 out of 10.0, and the low score was at the 25th percentile and below, which was a score of 8.0 and below.

The percentage of correct diagnoses for each image is summarized in Figure II. Without a clinical history, the majority of the participants could accurately identify CXRs with lung metastasis (88.5%) and pneumoperitoneum (84.2%). The image with the least number of accurate answers is pneumomediastinum.

The chi-square test was performed to analyze the factors affecting the total scores of the participants. The factors that were included as variables include gender, the level of training or years of experience, their field of interest, their undergraduate universities whether from local or overseas universities, whether there is a radiology posting in their undergraduate studies, and their confidence level when interpreting CXRs. Generally, the field of interest and confidence level when reporting a CXR without history were associated with greater accuracy when interpreting a CXR. The results are summarized in Table III. However, if the clinical history was given to the participant, only the confidence level of the participant affected the final score of the CXR interpretation.

The mean confidence level when reporting a CXR increased from 37.05 +/-6.814 with no history to 42.93 +/-6.024 with a given history.

DISCUSSION

CXR is one of the most widely utilized imaging modalities in clinical practice because of its accessibility, affordability, and diagnostic utility. Proficiency in interpreting CXR is crucial for health practitioners to ensure prompt and precise diagnosis, especially in emergency, respiratory, and cardiovascular disorders.

A lack of proficiency in interpreting CXR could result in incorrect diagnosis, which can lead to delayed treatment; jeopardizing patient safety. Thus, it is essential to incorporate systemic radiology interpretation classes early in medical school and reinforce them during clinical rotations.

Among the 305 participants in our study, the majority (54.8%) did not have a formal radiology posting during their undergraduate years. Their radiograph interpretation skills are derived mainly from the incorporation of radiograph interpretation from other major postings. Several studies have concluded that those with formal training in radiology early in their medical school course have greater competency in interpreting CXRs. [3,5,6] However, our study showed that the ability to interpret a CXR successfully is independent of whether there is a formal radiology posting in their undergraduate years. Most undergraduate radiology postings are short, observational, and lack hands-on interpretation experience. Without regular practice, students may be unable to develop the skills needed to accurately interpret CXRs. Furthermore, even if the students have radiology exposure during their undergraduate years, their skills will decline over time without reinforcement. By the time they are practicing, especially if they are not regularly involved in radiology, their retained knowledge may be minimal.

Interpreting CXR without any clinical information poses a notable challenge for clinicians. However, this is one of the many challenges faced by clinicians, especially in emergency settings. Our study revealed a significant increase in the ability to accurately interpret CXR if a patient's clinical history was given, as shown in Figure I and Table II. This is in tandem with all the major studies performed before, and it stresses that understanding the patient's symptoms, medical history, and clinical presentation is crucial and essential for guiding an accurate diagnosis. This finding shows that while chest radiographs can reveal important pathology on their own, interpretation is significantly more accurate and precise when coupled with the patient's clinical history. We therefore stress again the importance of proper clinical information given to any clinician when they are interpreting a CXR, which can eventually lead to better accuracy, fewer errors, and safer decisions when interpreting a CXR. Current radiologic training should highlight both technical reading skills and the importance of incorporating clinical information for the best outcome.

Our study revealed that, with respect to a patient's clinical history, the ability of any clinician to interpret CXR accurately is independent of gender, working experience, field of interest, which university the clinician graduated from, and whether the clinician had a formal radiology posting in their undergraduate studies.

The independence of CXR interpretation skills from different levels of work experience may seem unexpected, but this phenomenon has been echoed in several international studies.[7,8] One of the suggested reasons is due to inadequate radiology exposure during their undergraduate training. Most of the medical curricula provide limited structured exposure to radiology, particularly CXR interpretation. Another possible explanation for why clinical experience does not guarantee interpretation skill is that clinical exposure may only increase familiarity with disease patterns; however, it does not necessarily equate to improved image interpretation unless there is formal feedback and guided training. Studies have shown that feedback is a crucial element in improving educational programs in radiology.[9] However, several studies have shown improved overall median scores with increased level of training.[1,7,10]

This study also does not show a significant difference in the total scores between those who graduated from the local public or from overseas/private universities. In contrast, one of the studies in Jordan showed that the successful interpretation of CXR is closely related to the universities from which they graduated, which is mostly attributed to the curricula of the radiology postings at each of their respective universities.[3]

The confidence level plays a vital role in the accuracy of CXR interpretation, as proven in this study. Our study revealed that higher self-reported confidence is associated with greater diagnostic accuracy. Confident practitioners are more decisive and less likely to second-guess correct interpretations. A higher confidence level comes from greater experience and familiarity with radiological patterns as well as stronger visual recognition skills.[11] The confidence level is the only common factor that affects the accuracy of CXR interpretation in both circumstances, with and without the patient's clinical history. Studies have indicated that both regular exposure to CXRs and systematic training have positive effects on the confidence level of a clinician when interpreting a CXR.[12,13] Additionally, there is a positive correlation between students' self-confidence levels and their interest in learning.[14] Moreover, self-confidence emerged as a strong predictor of learning interest which underscores the importance of self-confidence among students to increase their learning interest and overall academic engagement.[14] Our findings, supported by global studies, highlight the need for educational strategies that can increase confidence through structured exposure and feedback which can ultimately improve diagnostic accuracy in interpreting CXR.

Interestingly, the accuracy of the interpretation of pneumomediastinum was low despite the patient's clinical history. The diagnosis of pneumomediastinum can be made with CXR in 70-90% of cases[15,16,17], with computed tomography (CT) scans being more definitive in the diagnosis. However, the accuracy varies depending on the quality of the radiograph and the interpreter's experience. A study assessing the competency of family medicine residents in interpreting CXR revealed that only 48.5% correctly identified pneumomediastinum cases.18 Consistent with this finding, our study also demonstrated near similar results with 44.4% of participants accurately diagnosed with pneumomediastinum without a clinical history and which slightly improved with added history to 64.3% accuracy. The lower diagnostic accuracy for pneumomediastinum may be attributed to its rarity in clinical practice, which leads to less exposure and limited familiarity among clinicians, especially non-radiologists. Additionally, pneumomediastinum presents with subtle radiographic signs, which can be easily overlooked on CXR.

The skill of CXR interpretation remains crucial despite the rise of artificial intelligence (AI), as AI can detect patterns, but lacks a the clinical context, whereas clinicians interpret CXR by integrating patient history, physical findings and laboratory results.[19] In addition, the performance of AI might vary with image quality or uncommon cases. On top of that, especially in our country, some hospitals, especially those in rural or lower resource areas, the AI tools are not easily assessable. We strongly believe that AI enhances, but does not replace, the skill of chest X-ray interpretation. A well-trained clinician can apply human reasoning, clinical insight, and ethical judgment, all of which are critical for safe, accurate patient care.

This study is most likely the first study of CXR interpretation in Malaysia involving a variety of doctors working in different fields and with different working experiences. Most importantly, the significance of clinical history in medical practice, particularly in CXR interpretation, was explicitly confirmed by this study's comparison of participant performance in two distinct circumstances in which the clinical history was initially withheld and subsequently given to the participants.

This small-scale study has several limitations despite the significance of the study. First, each diagnosis may present with a range of clinical manifestations on CXR. The ability of the participants to accurately recognize the radiographic pattern in this study does not reflect the ability of the participants to recognize the different manifestations of a similar disease. Second, the gold standard used in our study can also be questioned. Research has demonstrated that even seasoned radiologists may read a CXR differently.[20] However, to minimize this effect, our study recruited two experienced radiologists, and both needed to have a complete consensus on all of our CXRs. Third, the use of voluntary sampling introduces several limitations, as those who volunteer may have a particular interest or confidence in CXR interpretation, which may not represent the general population of doctors. This may lead to an overestimation of competence. Furthermore, voluntary participation leads to an imbalance in the number of participants across different training levels, affecting the statistical power of comparisons. Future studies should consider stratified sampling to better represent the target population and reduce bias.

CONCLUSION

Assessing healthcare professionals' CXR interpretation skills is essential for assessing their readiness to face their daily workloads. However, there is a paucity of literature regarding their ability to interpret CXR. Therefore, this study was carried out to look at the degree of competency among doctors in interpreting CXR and also to explore the best teaching strategy that could support curriculum improvement.

The confidence level plays a vital role in the accuracy of CXR interpretation; thus, we conclude that the key to accurately interpreting a CXR depends heavily on continuous learning and constant practice, as these are essential elements in building higher confidence levels when interpreting CXR. Structured teaching, continuous practice, feedback and integration into clinical decision-making are the keys that translate to greater competency in CXR interpretation. Future researches should emphasize on multicenter approach as it enhances the generalizability of findings to a broader national context. We recommend curriculum reforms or standardized training modules to address this skill gap.

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ETHICS

Ethical approval was provided by the Ethics Committee, Faculty Medicine and Health Sciences, Universiti Malaysia Sarawak UNIMAS (Rujukan Etika: FME/24/127 dated 23 February 2024) and the National Medical Research Register (NMRR ID-23-03359-TZZ).

CONFLICT OF INTEREST

None.

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