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Title

Factors associated with junior doctor plain trauma X-ray interpretation accuracy and strategies for improvement: A scoping review

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Abstract

Background: Plain radiography is a key diagnostic tool for trauma patients in emergency departments, often requiring immediate interpretation so that urgent care is not delayed. Due to difficulty in accessing timely radiologist reports and the demand for rapid decision-making, emergency department doctors, including junior doctors, have, over the years, been involved in the initial interpretation of plain trauma X-rays. However, concerns remain about the accuracy of these junior doctors, which may impact patient safety. Despite its significance, there's a notable gap in knowledge on the factors that influence their accuracy and strategies to improve their accuracy. This review explored these specific factors and strategies.

Method: A scoping review was conducted following the framework by Arksey and O'Malley as updated by Levac, Colquhoun, and O'Brien. Searches were performed in PubMed, SCOPUS, Embase, Cochrane Library, Google Scholar and through reference list search of eligible studies from a timeframe of 1985 to August 2025. A narrative approach was employed to describe findings after content analysis of eligible studies.

Results: Nine articles were ultimately included. The factors identified were emergency department clinical experience, anatomical site-specific interpretation, radiographic image-related factors, time and mechanism of traumatic injury. Further, plain trauma X-ray interpretation training, emergency department clinical experience with a teaching programme and collaboration with radiographers were identified as potential accuracy improvement strategies.

Conclusion: Junior doctors' plain trauma X-ray interpretation accuracy was influenced by several factors. Strategies like training, increased exposure to trauma X-rays in the emergency department with structured teaching programmes, and enhanced collaboration with radiographers can help mitigate the risk of misinterpretations among junior doctors. Future studies should not only validate these findings and investigate additional influencing factors and strategies, but also examine potential barriers to implementing such strategies.

Clinical trial number: Not applicable

Keywords: Junior doctor, Emergency department, trauma, X-ray interpretation, scoping review

Background

Trauma is one of the leading causes of emergency department visits worldwide.[1] In many emergency departments, trauma cases often require diagnostic decisions based on plain trauma X-rays, which are commonly used as an initial assessment tool due to their wide availability and accessibility.[2,3] Hence, accurate interpretation of plain trauma radiographs is foundational to safe and timely decision-making in emergency departments.[4]

While emergency department doctors are responsible for requesting plain X-ray, radiologists and more recently, in certain countries, advanced practice radiographers (reporting radiographers) shoulder the responsibility of providing immediate and accurate interpretations, which aids the decision-making of referring doctors.[4,5] However, the demand for out-of-hours coverage, the global shortage of radiologists, and some jurisdictions' lack of reporting radiographers have increasingly encouraged emergency department doctors to take on the role of initially interpreting plain trauma radiographs to ensure timely patient management.[6,7,8,9] By far, junior doctors defined here as fully qualified early-career doctors who work in, have an ongoing clinical tenure in, or rotate through emergency departments, are also involved in this initial interpretation role. This is particularly common in emergency departments where trauma presentations are high and low-resource settings, including many countries in Africa.[7,8]

Although advantageous, concerns about junior doctors' plain trauma X-ray interpretation competence exist due to their inexperience. For decades, studies have shown that junior doctors are prone to interpretation errors with common issues including missed fractures and misclassified normal variants, among others.[9,10,11] These limitations are concerning because important decisions, such as whether to treat or discharge a patient, often depend on these initial X-ray interpretations. Inaccurate assessments not only risk compromising patient outcomes but may also have significant medico-legal implications, particularly in cases of misdiagnosis or delayed treatment.[12]

Due to this, it is necessary to understand the factors associated with junior doctors' plain trauma X-ray interpretation accuracy to inform the development of interventions necessary to improve their accuracy. Likewise, identifying evidence-based strategies to improve their interpretation accuracy could be beneficial towards enhancing trauma care. However, these factors and strategies specific to junior doctors' plain trauma X-ray interpretation are unclear. Studies have identified factors such as academic qualification or training, age, number of years since qualification, reading volume (quantity of radiographs to interpret), sleeping patterns, time of day (particular shift when interpretation is done), training programmes, types of abnormalities, social networking, availability of prior images, fatigue and even gender as influences on image interpretation performance. [13,14,15]

This scoping review therefore explored the specific factors associated with junior doctors' interpretation accuracy of plain trauma X-rays and identified strategies to inform recommendations towards improving their diagnostic accuracy, education, and future research.

Method

A scoping review[15,17] following Arksey and O'Malley's framework[18] as updated by Levac et al.[19] was employed. This methodological framework has key components which include identification of research question, search for relevant evidence, charting of evidence, data collation, summarising of results and reporting.[20] Through this approach, the mapping of the evidence regarding the topic in terms of regional distribution, its nature, features, and volume was possible. Evidence reporting followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Extension for Scoping Reviews (PRISMA-ScR) checklist.[21] Notably, a review protocol was not prospectively registered to maintain confidentiality of the study concept and prevent premature disclosure of the research idea. Nonetheless, the review adhered to established scoping review methodological frameworks to ensure rigor, transparency, and reproducibility.

Sources searched, search strategy, and article screening

In accordance with the three-step search framework[22] recommended by the Joanna Briggs Institute (JBI), searches were conducted across electronic databases including SCOPUS, PubMed, Embase, and Cochrane Library. Further searches were conducted on Google Scholar and through checking the reference list of eligible articles. The search strategy employed was systematic and was developed in consultation with an expert librarian to ensure the appropriateness and robustness of the search protocol. The search strategy was utilised by GA and ICA-K to conduct the electronic search between January 2025 and February 2025. An additional search was carried out by the same authors in August 2025 to update the results. Boolean operators (OR/AND), truncators (*/?) and keywords: [(factor OR determinant OR driver OR contributor OR indicator OR influence OR strategy OR approach OR intervention OR solution) AND ((junior doctor) OR (house officer) OR houseman OR (casualty officer) OR intern OR (foundation doctor) OR (medical officer) OR doctor)) AND ((radiographic interpretation) OR (image interpretation) OR (X-ray interpretation) OR misinterpretation)) AND (trauma OR fracture)] were used for the search. A sample of full data base search strings (with field tags and truncations) can be found in the supplementary material. The result of the search was managed with EndNote reference manager (version 21). During the screening process, two independent reviewers (GA and ICA-K) were involved in both the title/abstract screening and the full-text review stages. Disagreements between the two reviewers were resolved through discussion and consensus. In instances where consensus could not be reached, a third reviewer (MJN or PCB) was consulted to make the final decision.

The definitions of key terms are summarised in Table 1.

Table 1. Summary of the key terms and their definitions in the context of this study.

Term	Definition
Junior doctor	fully qualified early-career doctors who work in, have an ongoing clinical tenure in, or rotate through emergency departments. This includes doctor who are: (1) undertaking their two-year post graduate medical internship e.g. house officers and foundation year doctors (2) completed two-year post graduate medical internship and currently practicing in emergency departments e.g. medical officers, senior house officers (3) in early stages of postgraduate training e.g. senior house officers
X-ray interpretation	Initial interpretation of conventional radiographs without any assistance
Trauma	Trauma refers to a physical injury caused by an external force, such as blunt impact, penetrating object, burns, or even explosions
Factor	A variable that influences or affects interpretation accuracy positively or negatively
Strategy	An intervention or action introduced to improve interpretation accuracy

Article selection

Article selection was undertaken by three review authors (GA, ICAK and MJN), each with experience in radiography practice and research, to ensure balanced and informed inclusion decisions. Articles were selected in accordance with predefined inclusion and exclusion criteria (Table 2). For relevance to the research aim, the population, interest, context (PICo) framework[23] further guided the inclusion criteria (Table 3). Briefly, articles published from 1985 to 2025 and in the English language were considered. All articles on junior doctor trauma X-ray interpretation that reported a factor or strategy that influenced accuracy were included. Opinion pieces, commentaries, letters to the editor, editorials, case reports, book chapters and conference papers were excluded.

Table 2. General criteria for article selection and justification for inclusion

Inclusion criteria	Exclusion criteria	Justification
Accessible articles via the various databases searched	-	These databases host several other databases and articles that explore plain trauma X-ray interpretation and related publications.
Articles published from 1985 to 2025	Articles published before 1985	The choice of 1985 was to reflect the inception of digital radiography (although digital systems were not widely adopted until later) as it is in use at present[24,25]
English language	Articles in languages that may require translation into English	To eliminate expenses related to translating non-English materials.
Primary evidence of qualitative, quantitative, and mixed method designs, retrospective and prospective audits.	Opinion pieces, letters to the editor, case reports, commentaries, editorials, book chapters and conference papers.	For factual and credible evidence

Table 3. Summary of the PICo framework further guiding the inclusion and exclusion criteria

PICo	Inclusion	Exclusion

Population	Junior doctors (house officer, houseman, foundation year doctors, casualty officer, medical officer)	Nurses, radiographers, senior resident (specialty trainees), Registrars, senior doctors, and consultants
Interest	Factors and strategies affecting trauma radiograph interpretation accuracy	Factors and strategies influencing non-trauma-related interpretation accuracy Studies about junior doctors' plain trauma X-ray interpretation without influencing factors or strategies
Context	X-ray/conventional radiography	MRI, CT scan, Ultrasound

NB: *MRI= Magnetic Resonance Imaging CT= Computed tomography*

Data extraction

A data extraction table was developed in Excel to record key information relevant to the research aim and objectives. The form captured bibliographic details (author, year, country), study characteristics (aim, design, sample size, setting), participant details (level of training or experience), and key findings related to influencing factors, and strategies for improvement. No quality assessments were done on the included articles in keeping with scoping reviews.

Data synthesis

A narrative approach was employed to describe the study findings after all included studies were imported into NVivo™14 software (QSR International Pty Ltd., Australia) for analysis using a content analysis approach. The content analysis approach allowed for codes and themes to be generated and aided the comparison of the findings of the included studies.[26]

Results

The electronic databases search and search through other means yielded 2,241 articles (Fig. 1). Following this, 2,212 articles were excluded after title and abstract screening. Further, 29 articles were retained for full-text assessment for eligibility. Nine (9) articles were included after the predefined inclusion criteria were applied. The articles identified were studies from the United Kingdom (UK) and Africa, with the majority (n=6) from the UK (Table 4). All the studies included were, by nature, observational studies, specifically diagnostic accuracy studies. The study designs utilised varied across studies, and included prospective (n=2), retrospective (n=1), comparative (n= 5) and cross-sectional (n= 1). The key aims across studies were to explore how accurately junior doctors interpret plain trauma X-rays and how accurately other professionals interpret trauma X-rays compared to junior doctors. Regarding the body area used in the accuracy assessment across studies, four studies (n=4) employed all body parts, four (n=4) only employed the appendicular skeleton, and one study (n=1) employed the axial skeleton. Additionally, the description of the population of interest (junior doctors) per included study has been mapped to the operational definition employed in the review (Table 5). Based on our study's aim, 8 themes were identified, five were factors, and three were strategies. This has been summarised in Figures 2 and 3.

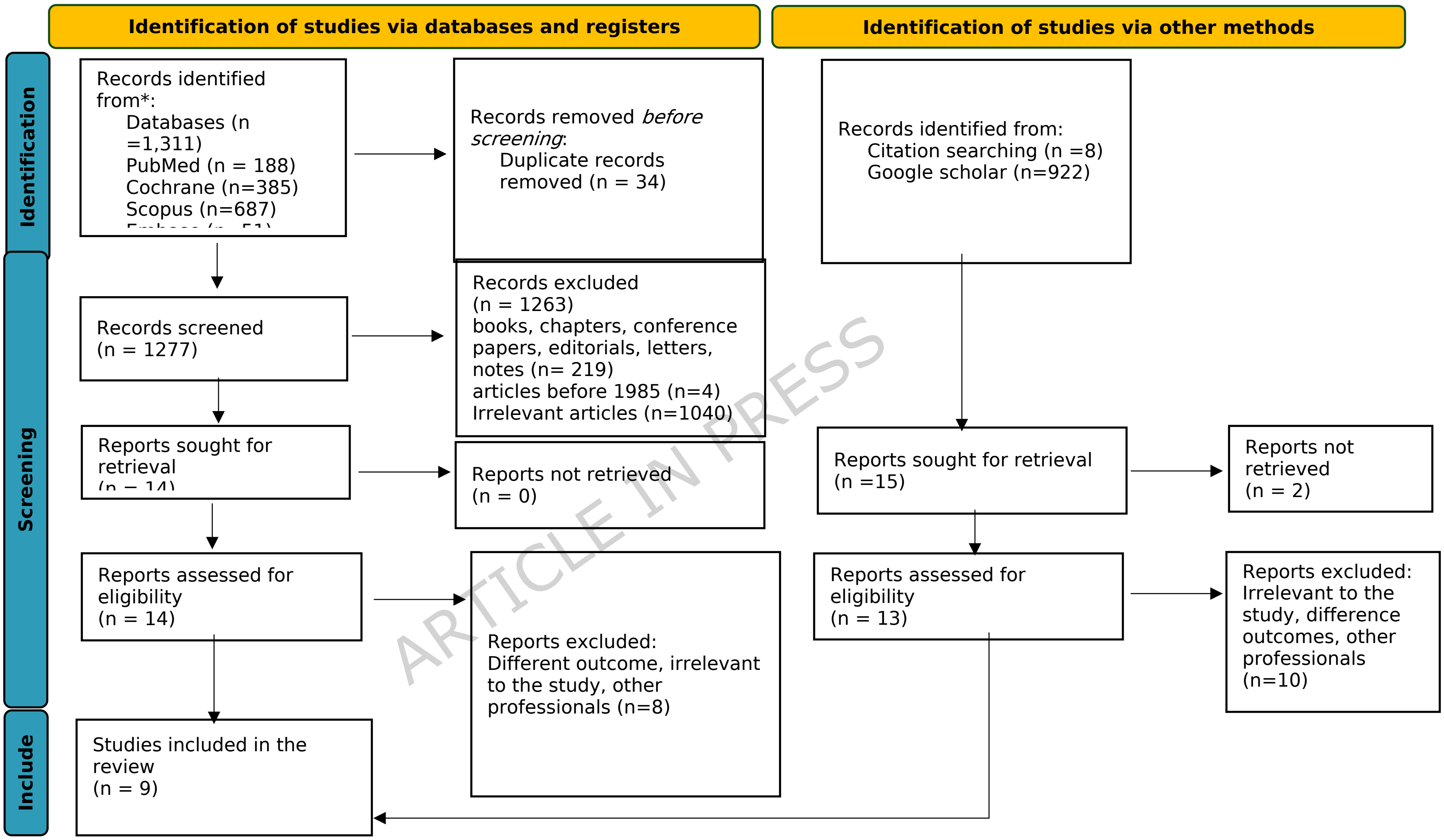

Fig 1. PRISMA Flow diagram of included searches of databases and other sources.

Table 4. Summary of studies included in this review.

Study reference	Study aim	Study design	Professional/ Sample size	Body area	Key finding	Outcome (Statistical significance ? Y/N)	Reference standard
Gleadhill et al. 1987 [27] UK	To determine whether the selection of patients for X-ray examination and the radiological skills of casualty officers alter during tenure of post	Prospective	12 casualty officers	All body parts	Overall, 4.9% of trauma radiographs were misinterpreted (clinically important false negative + all false positive), but this fell from 7.1% (all false positives + all false negatives) to 2.9% during one unit of experience to 7 units, respectively ($p<0.005$).	Strategy for improving accuracy (Y)	Radiologist's report
Vincent et al. 1988 [28] UK	This study assessed the ability of junior doctors in Accident and Emergency (A&E) to detect radiographic abnormalities.	Prospective	32 Senior House Officers (SHOs) with 18 being regular	All body parts	Regarding anatomical sites, junior doctors interpreted X-rays of the limb significantly better than other sites ($p< 0.04$)	Factor influencing accuracy (Y)	Radiologist's report

McLauchlan et al. 1997 [11] UK	To investigate how well junior doctors in A&E were able to diagnose significant X-ray abnormalities after trauma and to compare their results with those of more senior doctors.	Comparative	49 SHOs, 39 had under 5 months of A&E experience, and 10 had over 5 months of experience	All body parts	Experienced SHOs scored higher than inexperienced SHOs for both abnormal (48% against 28%, $p<0.001$) and normal (58% against 39%, $p = 0.01$) x-rays.	Factor influencing accuracy (Y)	Pre-determined answers
Meek et al. 1998 [29] UK	To assess the ability of nurse practitioners to identify a range of subtle but clinically important radiographic abnormalities by comparison with A&E SHOs and to assess the effect of this skill of training for radiograph interpretation.	Comparative	84 SHOs, 41 inexperienced, were in the first two months of their first A&E post. 43 experienced were in their sixth and final month in A&E	Appendicular	The experienced SHOs performed better than the inexperienced SHOs (mean score 25.1/40 CI= 23.4 – 26.7 against mean score 19.9/40 CI= 17.7 – 22.1).	Factor influencing accuracy (N)	Consus report from three trauma radiologists and three A&E senior registrars.
Overton-Brown and	To determine how accurate nurses'	Comparative	14 casualty officers, 7 experienced	Appendicular	After Receiver Operating Characteristic	Factor influencing accuracy (N)	Radiologist's report

Anthony, 1998 [30] UK	interpretative abilities were in comparison to casualty officers		(within their 5th or 6th months A&E training) 7 inexperienced (No A&E experience		(ROC) analysis, experienced doctors had an AUC of 0.834, as against new doctors with an AUC = 0.756.		
Chen et al. 2003 [31] UK	To determine the ability of hospital doctors (1) to assess the technical quality of occipitomenta l (OM) radiographs and (2) to identify facial fractures.	Cross-sectional	13 junior doctors (6-36 months at the A&E).	Axial	There was an inverse relationship between the time taken by participants to view the OM radiographs and their subsequent accuracy in interpreting the radiographs for facial fractures (r=-0.2238, p=0.3167). Thus, the more time the participant took to examine the radiograph, the less likely the response was to be correct.	Factors influencing accuracy (N)	Consus report from two consultant dental and maxillofacial radiologists

					The results of the participants attempting to identify fractures on the technically poor films were excluded from the study, as several participants felt unable to decide because of the film fault(s) present.		
Kelly et al. 2012 **32** UK	To determine whether the performance of junior doctors and radiographers in radiographic image interpretation can be improved by working together.	Comparative	10 junior doctors (2-5 years of experience)	Appendicular	Regarding the trauma X-ray interpretation, junior doctors had a Mean AUC= 0.65, SD= 0.12. Upon Collaboration with radiographers, AUC 0.84, SD= 0.06. The results showed statistically significant	Strategy for improving accuracy (Y)	Radiologist report

					improvements in the AUC for the junior doctors when working with the radiographers for the wrist (p = 0.008).		
Ofori-Manteaw & Dzidzornu 2019 **33** Ghana	The aims of this study were to determine and compare the ability of radiographers and junior doctors in interpreting appendicular trauma radiographs both before and after training.	Comparative	12 junior doctors (6 months-2 years of experience)	Appendicula r	Training has a significant impact on accuracy in image interpretation among junior doctors [sensitivity (77.2% vs 67.8% p = 0.025), specificity (86.7% vs 75.6% p = 0.005) and accuracy (81.9% vs 71.6% p = 0.003).	Strategy for improving accuracy (Y)	Consultant radiologist's report

Liu et al. 2022 [8] South Africa	The aim of this study was an audit of the accuracy of after-hour acute trauma-radiograph reporting by doctors in the emergency centre of a district hospital in Africa.	Retrospective	Junior doctors	All body parts	Higher sensitivity was observed for appendicular skeleton and chest X-rays compared with axial and abdomen (p=0.02). Again, night shift reporting was more accurate than daytime (p=0.04). Images demonstrating one, two and three-or-more abnormalities were interpreted correctly in 48%, 26% and 0% of cases, respectively (p < 0.01). Further, blunt trauma cases were reported with greater sensitivity than more complex injuries like	Factors influencing accuracy (Y)	Consensus report of two radiologists

		penetrating trauma and assault ($p<0.01$).	

NB: UK= United Kingdom A&E= Accident and Emergency SHO= Senior House Officer ROC= Receiver Operating Characteristic AUC= Area under the ROC curve Y= YES N= NO

Table 5. Mapping of participants (professionals) in included studies to operational definition of junior doctors.

Operational definition of junior doctors in this study		
Junior doctors include fully qualified early-career doctors who work in, have an ongoing clinical tenure in, or rotate through emergency departments. This includes doctor who are: (1) undertaking their two-year post graduate medical internship e.g. house officers and foundation year doctors (2) completed two-year post graduate medical internship and currently practicing in emergency departments e.g. medical officers, senior house officers (3) in early stages of postgraduate training e.g. senior house officers		
Study reference	**Description of participants**	**Mapped category (from operational definition)**
Gleadhill et al. 1987 [27] UK	Twelve casualty officers, all SHOs; Six in their first post-registration job, five had completed one year as SHO in specialties in acute wards, one from registrar post in neurosurgery but unfamiliar with A&E. All doctors were considered uniform in experience starting the post at the A&E.	(2) Completed two-year postgraduate medical internship and currently practicing in emergency department (3) in early stages of postgraduate training
Vincent et al. 1988 [28] UK	Thirty-two SHOs working at the A&E within an 8-month period with only 18 being regular members of the department.	(2) Completed two-year postgraduate medical internship and currently practicing in emergency department
McLauchlan et al. 1997 [11]	Forty-nine SHOs working at the emergency department as post-registration job; 39 had less than 5 months A&E experience and 10 had greater than 5 months A&E experience.	(2) Completed two-year postgraduate medical internship

UK		and currently practicing in emergency department
Meek et al. 1998 [29] UK	Eighty-four SHOs on a 6-month post at the A&E. While some were in their first two months at post, others were in their sixth and final month.	(1) undertaking their two-year post graduate medical internship (3) in early stages of postgraduate training
Overton-Brown and Anthony, 1998 [30] UK	Fourteen casualty officers who as part of their training were undertaking 6-month rotating post within the A&E. While some were within their 5th and 6th month of A&E training, others were now beginning.	(1) undertaking their two-year post graduate medical internship (3) in early stages of postgraduate training
Chen et al. 2003 [31] UK	Thirteen doctors holding junior training grade positions (House officer or SHO who had been working in A&E for between 6 months and 36 months.	(1) undertaking their two-year post graduate medical internship (2) Completed two-year postgraduate medical internship and currently practicing in emergency department (3) in early stages of postgraduate training
Kelly et al. 2012 [32] UK	Ten junior doctors working in the emergency department. Eight had between 2- and 3-years' experience including their intern year and 2 had between 3- and 5-years' experience.	(2) Completed two-year postgraduate medical internship and currently practicing in emergency department (3) in early stages of postgraduate training
Ofori-Manteaw & Dzidzornu 2019 [33] Ghana	Junior doctors who had work experience ranging from less than a year to two years.	(1) undertaking their two-year post graduate medical internship
Liu et al. 2022 [8] South Africa	Emergency centre staffed by interns, post-internship "community service" doctor, and medical officers	(1) undertaking their two-year post graduate medical internship (2) Completed two-year postgraduate medical internship

	and currently practicing in emergency department

NB: UK= United Kingdom A&E= Accident and Emergency SHO= Senior House Officer

Factors influencing junior doctors' plain trauma X-ray interpretation accuracy

As presented in Figure 2 and Table 6, five themes were identified from six (n= 6) included studies.

Theme 1: Emergency department clinical experience

It was identified in three studies[11,29,30] that junior doctors with emergency department experience performed better at interpreting trauma-related radiographs than inexperienced junior doctors. However, while one study[11] achieved statistical significance, the other two studies[29,30] could only speculate. Quotes from these studies were as follows:

"*[regarding trauma X-ray abnormality identification] The mean score for the 39 inexperienced SHOs was 6.58 (28%) compared to a mean score of 11.25 (48%) for the 10 experienced SHOs. The difference between the two subgroups was statistically highly significant (p < 0.001)*" (McLauchlan et al., 1997, p. 296).[11]

*"[**Although not statistically significant**] The experienced group [SHOs in their sixth and final months in A&E] performed better than the inexperienced [SHOs in the first two months of their first A&E post] group"* (Meek et al., 1998, p. 107).[29]

*"[**Although not statistically significant**] The differences [in AUC] between experienced [completed their 6 months A&E tenure] and inexperienced doctors [starting their A&E tenure] is larger..., indicating that experience... may be the more relevant factor"* (Overton-Brown & Anthony, 1998, p. 893).[30]

Theme 2: Anatomical site examined

It was identified in two studies[8,28] that junior doctors were more likely to interpret appendicular trauma-related radiographs more accurately than other anatomical regions. In both studies, these findings were statistically significant. Selected quotes from these studies were as follows:

... "*X-rays of limbs are significantly better interpreted than other X-rays (p<0.04)"* ... (Vincent et al., 1988, p.104).[28]

... "*Reporting sensitivity and specificity tended to be associated with the site of injury. Performance was best for abnormalities of the appendicular* *skeleton, decreasing sequentially for the chest, axial skeleton and abdomen (p = 0.02)"* (Liu et al., 2022, p. 202).[8]

Theme 3: Radiographic image-related factors

While one study[31] reported that there was a high chance for junior doctors to misinterpret plain trauma X-rays when the radiographic image quality was poor, another study[8] also reported that junior doctors were more likely to accurately interpret trauma-related radiographs with only one abnormality than two abnormalities or more. Selected quotes from these studies were as follows:

*"[**Although not statistically significant**] The results of the participants [junior doctors] attempting to identify fractures on the technically poor films were excluded from the study as several participants felt unable to make a decision because of the film fault(s) present"* (Chen et al., 2003, p. 170).[31]

"*Images demonstrating one, two and three-or-more abnormalities were interpreted correctly in 48%, 26% and 0% of cases, respectively (p < 0.01)*" (Liu et al., 2022, p. 202).[8]

Theme 4: Time

Two studies reported the influence of time on junior doctors' trauma X-ray interpretation accuracy. While one study reported that the longer it took junior doctors to interpret plain trauma X-rays, the less likely they were to be accurate although the finding was statistically insignificant[31], the other study[8] reported that junior doctors on night shift were more likely to interpret trauma-related radiographs accurately than their colleagues on day shift. Selected quotes from these studies were as follows:

*"[**Although not statistically significant]** There was an inverse relationship between the time taken by participants to view the OM radiographs and their subsequent accuracy in interpreting the radiographs for facial fractures"* (Chen et al., 2003, p.169).[31]

… *"Night shift reporting tended to be more accurate than day shift (p = 0.04)"* … (Liu et al., 2022, p.202).[8]

Theme 5: Mechanism of traumatic injury

One study reported that junior doctors were more likely to interpret blunt trauma-related plain X-ray examinations accurately compared to plain trauma X-ray examinations because of complex mechanisms. A quote from the study was:

"[Junior doctors'] performance tended to be associated with the mechanism of injury, with blunt trauma achieving the highest, and community assault the lowest sensitivity and specificity, respectively (p < 0.01)" (Liu et al., 2022, p. 202).[8]

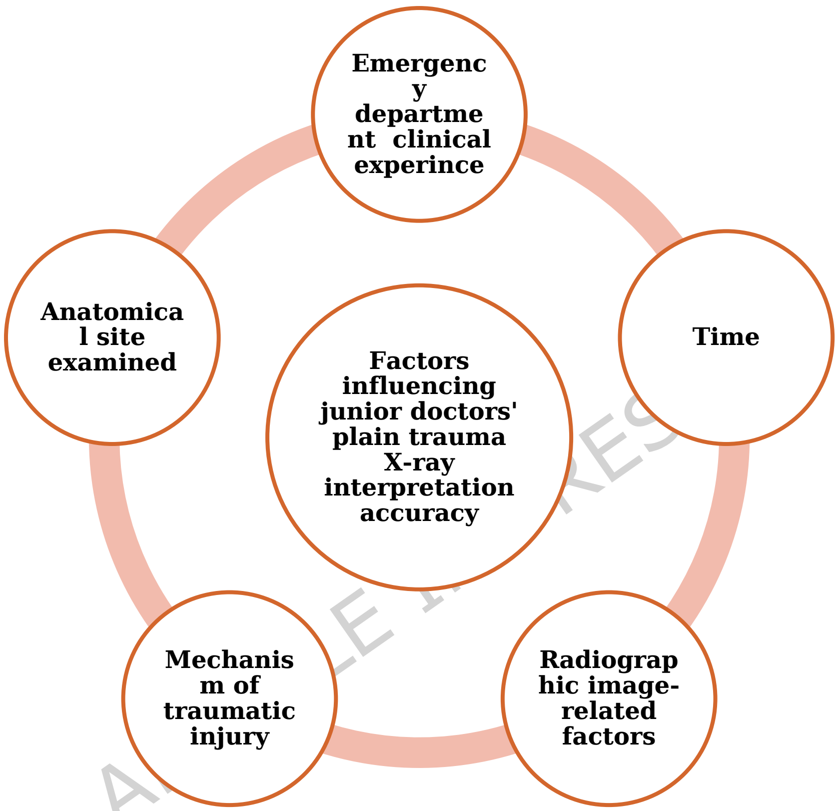

Figure 2. Factors associated with junior doctor plain trauma X-ray interpretation accuracy.

Strategies to improve junior doctors' trauma X-ray interpretation accuracy.

As presented in Figure 3 and Table 6, three themes were identified in three (n= 3) studies

Theme 1: Emergency department clinical experience with a teaching programme

Gleadhill et al.[27] recruited 12 casualty officers (junior doctors) at the start of their 6-month emergency department tenure, supported by a structured teaching programme on plain trauma X-ray interpretation. The study assessed diagnostic performance by analysing the rate of misinterpretation per every 100 radiographs interpreted by each junior doctor, i.e., 1 unit of experience until the 700th radiograph interpretation, i.e., 7 units of experience were achieved. It was identified that the proportion of errors (all false negative errors) decreased with every unit (100 radiograph reviews) of experience, $p<0.005$. They concluded that:

"Clinical experience with trauma, in addition to a teaching programme, positively influenced the ability of doctors to interpret radiographs" (Gleadhill et al., 1987, p. 946).[27]

Theme 2: Collaboration with radiographers

In Kelly et al.'s study,[32] 10 junior doctors and 10 experienced radiographers (approximately 14 years of experience on average, with experience also in the emergency department) were recruited and shown 42 wrist trauma radiographs using ViewDEX software. Junior doctors had a mean AUC of 0.65 when interpreting alone and a mean AUC of 0.84 upon collaboration with radiographers, p= 0.008. They concluded that:

"*Improvement in performance of junior doctors following collaboration strongly suggests changes in the potential to improve accuracy of patient diagnosis and therefore patient care. Decision making of junior doctors was positively impacted on after introducing the opinion of a radiographer. Collaboration exceeds the sum of the parts; the two professions are better together*" (Kelly et al., 2012, p. 90).[32]

Theme 3: Plain trauma X-ray interpretation training

Twelve (12) junior doctors were recruited to interpret 30 trauma X-rays of the appendicular skeleton in a single health facility in Ghana before and after training in trauma X-ray interpretation.[33] It was identified that training had a significant impact on accuracy in trauma X-ray interpretation among junior doctors. [sensitivity (77.2% vs 67.8% p = 0.025), specificity (86.7% vs 75.6% p = 0.005) and accuracy (81.9% vs 71.6% p = 0.003)]. The study concluded that:

… "*with a well-structured training programme, … junior doctors could improve on their accuracies in radiographic abnormality detection and commenting on trauma radiographs*" (Ofori-Manteaw and Dzidzornu et al., 2019, p. 255).[33]

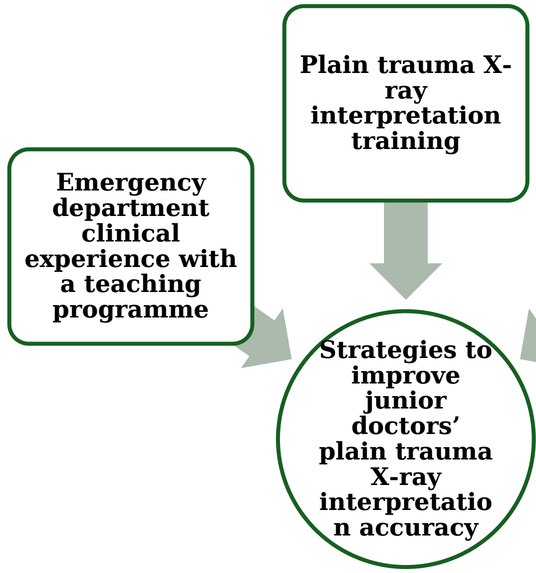

Figure 3. Strategies to improve junior doctor plain trauma X-ray interpretation accuracy.

Level of support for each theme

Given that the evidence presented was identified from only nine studies, we assigned confidence levels to each theme using a pre-specified scoring system to reflect the degree of support from the included studies. This has been summarised in Table 6.

Table 6. Level of support for each theme

Factors influencing junior doctor plain trauma X-ray interpretation accuracy (n= 6 studies)				
Theme	**Number of studies**	**Study reference**	**Statistical significance**	**Level of confidence (Score)**
Emergency department clinical experience	3	McLauchlan et al., 1997[11]	YES	Moderate (3)
		Meek et al., 1998[29]	NO	
		Overton-Brown & Anthony, 1998[30]	NO	
Anatomical site examined	2	Vincent et al., 1988[28]	YES	Moderate (3)
		Liu et al., 2022[8]	YES	
Radiographic image-related factors	2	Chen et al., 2003[31]	NO	Low (2)

		Liu et al., 2022[8]	YES	
Time	2	Chen et al., 2003[31]	NO	Low (2)
		Liu et al., 2022[8]	YES	
Mechanism of traumatic injury	1	Liu et al., 2022[8]	YES	Low (2)
Strategies to improve junior doctor plain trauma X-ray interpretation accuracy (n= 3 studies)				
Emergency department clinical experience with a teaching programme	1	Gleadhill et al., 1987[27]	YES	Moderate (2)
Collaboration with radiographers	1	Kelly et al., 2012[32]	YES	Moderate (2)
Plain trauma X-ray interpretation training	1	Ofori-Manteaw and Dzidzornu et al., 2019[33]	YES	Moderate (2)

NB: A simple, pre-specified confidence scoring system was applied to each theme under factors and strategies. For factors, confidence in themes were scored on (i) number of supporting studies (1–2 studies = 1; 3 studies = 2; >3 studies = 3) and (ii) number of studies with statistically significant findings (0 = 0; 1 study = 1; ≥2 studies = 2). Scores were summed (maximum = 5) and interpreted as follows: total 1–2 = Low confidence, total = 3 = Moderate confidence, total 4–5 = High confidence. For strategies, confidence in themes were scored on (i) number of supporting studies (1 study = 1; 2-3 studies = 2) and (ii) number of studies with statistically significant findings (0 = 0; 1 study = 1; ≥2 studies = 2). Scores were summed (maximum = 4) and interpreted as follows: total 1 = Low confidence, total = 2 = Moderate confidence, total 3-4 = High confidence.

Discussion

This scoping review explored the evidence on the factors influencing the accuracy of junior doctors in interpreting plain trauma radiographs and strategies that can improve their diagnostic performance. Despite identifying only nine articles, the findings from these published studies provide a synthesised view of the subject in question across the UK and Africa. Given that the practice of junior doctors initially interpreting plain radiographs to harness clinical decisions is predominant in emergency departments, it was unsurprising that all studies were conducted in the emergency department.

Several factors were identified that influence junior doctors' diagnostic performance. Junior doctors who had completed or were in the final month of tenure in the emergency department interpreted plain trauma X-rays more accurately than their less-experienced counterparts highlighting the importance of prolonged exposure to plain trauma X-rays in a clinical setting. McLauchlan et al.[11] argued that although junior doctors in their study had an overall low plain trauma X-ray interpretation accuracy, the significant difference between the experienced and inexperienced junior doctors showed that junior doctors appeared to learn during their emergency department post. Similarly, additional studies echoed this finding, although it was a speculation.[29,30] According to Tachakra and Beckett[34], emergency department clinical experience can build familiarity with normal and abnormal trauma X-ray presentations among junior doctors, which possibly explains this factor. Nonetheless, emergency department clinical experience alone does not improve plain trauma X-ray interpretation accuracy among junior doctors.[27,28]

Again, anatomic site-specific plain trauma X-ray interpretation accuracy varied, with junior doctors demonstrating higher accuracy in interpreting appendicular skeletal trauma X-rays compared with axial skeletal trauma X-rays.[8,28] Notably, trauma to the extremities, often with a suspected fracture, is one of the most common reasons patients present to the emergency department.[35] Hence, junior doctors at the emergency department could build familiarity with such X-ray presentations. This, coupled with the fact that axial trauma cases are complex to interpret, perhaps explains this finding.[8] This factor suggests that junior doctors should not be left alone to manage an axial trauma case where interpreting plain X-rays is critical to aid treatment, but rather, they should be assisted by a senior colleague or, at best, wait for a prompt radiologist's report.

Regarding radiographic image-related factors, studies contend that the quality of a radiographic image has an impact on interpretation accuracy and consequently, the clinical management of patients.[36,37] Specifically, poor image quality can potentially lead to misinterpretations, missed diagnoses, and inaccurate conclusions. For instance, a study found that lower spatial resolution and increased quantum noise affected radiologists' perceived ability to interpret calcification cases in mammography.[38] Although drawing parallels from mammography may be indirect and may not fully generalise to trauma imaging, they highlight the importance of optimal image quality in diagnostic accuracy. Therefore, in Chen et al.[31], complaints from junior doctors regarding poor quality trauma-radiographs, potentially causing uncertainty and inaccuracies leading to exclusion of such radiographs from the accuracy analysis, were unsurprising. At best, plain trauma X-rays must be of optimum quality to ensure correct interpretations. That aside, junior doctors must also be able to recognise poor quality trauma radiographs and where it impacts clinical decision-making, they should consult the radiographer or a senior clinician before taking any action.

Additionally, junior doctors were more likely to interpret blunt injury-related radiographs accurately than plain trauma X-rays from other complex mechanisms of injury. Complex mechanisms of injury may more likely result in multiple pathological findings on a single trauma radiograph, which has been well documented and even revealed in this review (as an image-related factor) to reduce interpretation accuracy.[8,39,40] Again, junior doctors should not be allowed to assess such examinations alone but with a senior colleague.

Time possibly influenced junior doctors' plain trauma X-ray interpretation accuracy in two somewhat counterintuitive ways. Although not statistically significant, Chen et al.[31] found that longer interpretation times among junior doctors were associated with lower accuracy, possibly reflecting diagnostic uncertainty or increased case complexity. Complex plain trauma X-ray may require closer scrutiny and extended analysis, like the axial trauma X-rays involving facial fractures utilised in Chen et al.[31]. Although in the study[31], interpretation times ranged from 5 seconds to 3 minutes, Brady et al.[41] noted that most abnormalities on conventional plain radiographs are detected within the first few seconds, with true positive identification rates declining thereafter, emphasising the importance of pattern recognition efficiency. Nonetheless, balancing speed with careful analysis remains crucial, as over-reliance on rapid, intuitive judgment can lead to misinterpretation. Interestingly, Liu et al.[8] reported higher diagnostic accuracy among junior doctors during night shifts compared to day shifts. While the cause remains unclear, it may relate to workflow dynamics or a higher proportion of normal studies at night, as highlighted in the study[8]. Regardless, these findings related to time highlight the need for further research.

Three strategies were found in this review which could potentially improve junior doctors' plain trauma X-ray interpretation accuracy if implemented. Firstly, Gleadhill et al.[27] found that adding a structured teaching component on plain trauma X-ray interpretation, alongside exposing junior doctors to trauma cases (clinical experience), improved their ability to interpret traumatic abnormalities[27]. Vincent et al.[28] reinforced this strategy, arguing that clinical experience at the emergency department alone is insufficient to improve plain trauma X-ray interpretation accuracy among junior doctors. The study[28] also emphasised that not all teaching methods are equally effective. For instance, introductory lectures alone may not be enough.

Instead, they advocated for structured, formal approaches that provide a comprehensive understanding of trauma radiology. A well-designed teaching programme can complement junior doctors' clinical experience by ensuring that junior doctors develop both pattern recognition skills and an understanding of trauma radiograph interpretation principles. Therefore, this combined approach can be essential for improving the diagnostic accuracy of junior doctors in trauma radiograph interpretation.

Secondly, it is undeniable that training significantly impacts plain X-ray interpretation accuracy. Tachakra and Beckett[34] contended that training casualty officers could reduce the number of missed abnormalities. Findings from this review align with the above, as it was revealed that junior doctors achieved significant improvement in their post-training trauma X-ray interpretation test compared to pre-training.[33] Notably, this substantial improvement among junior doctors was achieved in just two weeks under the guidance of a consultant radiologist, highlighting the effectiveness of even a short, intensive training. Similar findings among radiographers further support that training in trauma radiograph interpretation is a key strategy for improving accuracy.[33,42,43]

Finally, research has consistently shown that radiographers demonstrate high accuracy in interpreting plain trauma X-rays,[32,42,44] sometimes outperforming junior doctors.[7,45] Hence, one can postulate that a collaboration between junior doctors and radiographers in plain trauma X-ray interpretation may be crucial for accurate diagnosis among junior doctors. In fact, such ideas were even reported in the 1980s.[46] Indeed, Kelly et al.[32] found significant improvement in the accuracy of junior doctors' trauma radiograph interpretation upon collaborating with experienced radiographers. Collaboration between clinicians and radiographers in plain X-ray interpretation has taken many forms, documented in the literature. For instance, radiographer abnormality detection system or 'red dots system', open communication, preliminary clinical evaluation, and hot reporting by reporting radiographers.[5,47,48] It is therefore vital that, depending on the setting, any of these be adopted to ensure accuracy among junior doctors in urgent cases to prevent diagnostic errors and improve patient management.

Given that the evidence presented was identified from only nine studies, we assigned confidence levels (Table 6) to each theme using a pre-specified scoring system to reflect the degree of support from the included studies. For factors, emergency department clinical experience was supported by three studies, with one showing statistical significance, resulting in moderate confidence rating. The anatomical site examined had two supporting studies, both significant, also yielding moderate confidence. Radiographic image–related factors and time were each supported by two studies, but only one in each theme was significant, while mechanism of injury was supported by a single significant study; these themes therefore had low confidence ratings. For improvement strategies, each potential intervention thus, emergency department clinical experience with teaching programmes, collaboration with radiographers, and plain trauma X-ray interpretation training, was supported by only one statistically significant study, giving moderate confidence. The above suggests caution when generalising these findings and also emphaise the need for further studies to strengthen understanding of the factors influencing junior doctor X-ray interpretation and effective strategies to improve it.

Limitation

The English language employed as an eligibility criterion has a potential limitation on the generalisability, as relevant articles published in other languages may have been excluded. Nonetheless, the inclusion of studies from different geographic locations increases the generalisability of this review. Finally, some of the findings in this review were identified from single studies with some results not reaching statistical significance, caution should be taken when generalising the results. Nonetheless, similar patterns in findings have been reported in other studies conducted in comparable populations and contexts, which supports the consistency of our findings.

Conclusion

This review identified some key factors that influence junior doctors' plain trauma X-ray interpretation accuracy, including emergency department clinical experience, anatomical site, trauma radiograph-related factors, mechanism of injury and time. Training, increased exposure to plain trauma X-rays at the emergency department with structured teaching programmes and enhanced collaboration with radiographers could potentially help mitigate the risk of misinterpretations among junior doctors at the emergency department. Hence, implementing these deliberate strategies in clinical practice could be essential to enhance the diagnostic performance of junior doctors and consequently, trauma care in emergency departments. Future studies should verify these findings and explore other factors and strategies, as some of the identified findings in this study were from single studies and also since the total number of studies identified were few. Also, factors that may hinder the implementation of these strategies should be explored.

List of abbreviations

A&E Accident and Emergency

SHO Senior House Officer

ROC Receiver Operating Characteristic

AUC Area under the ROC curve

MRI Magnetic Resonance Imaging

CT Computed Tomography

JBI Joanna Briggs Institute

Declarations

Ethical approval

Since this was a review paper, ethical approval was not needed.

Consent for publication

Not applicable

Availability of data and materials

All data generated or analysed during this study are included in this published article.

Competing interest

The authors have no competing interest to declare

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Authors' contributions

GA contributed to the conceptualisation, design, data acquisition, analysis, interpretation of data, final draft and revision. ICA-K contributed to the conceptualisation, design, data acquisition, analysis, interpretation of data, final draft and revision. AD contributed to the conceptualisation, design, data acquisition, analysis, interpretation of data, final draft and revision. YAW contributed to the conceptualisation, design, data acquisition, analysis, interpretation of data, final draft and revision. BOB contributed to the conceptualisation, design, data acquisition, analysis, interpretation of data, final draft and revision. MJN contributed to the conceptualisation, design, data acquisition, analysis, interpretation of data, final draft and revision. IA contributed to the conceptualisation, design, data acquisition, analysis, interpretation of data, final draft and revision. PCB contributed to the conceptualisation, design, data acquisition, analysis, interpretation of data, final draft and revision.

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