Factors affecting diagnostic imaging decision-making in the emergency department during day and night shifts

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ABSTRACT

Background Medical imaging use has increased progressively, prompting discussions about its clinical impact. Interventions to reduce low-value imaging have had varying success, as they generally do not consider the influence of the clinical environment on decision-making. Factors affecting imaging ordering decisions by Emergency Department (ED) medical officers (MOs) and how these factors differ between day and night shifts are poorly understood.

Methodology This mixed methods study was conducted in 2021 at a major tertiary hospital in Western Sydney. Observations and interviews with ED MOs for 20 day-shift and 26 night-shift clinical encounters were analysed to understand how and why imaging decisions were made, along with usage of imaging guidelines. Demographic and clinical patient data (including patient disposition) were obtained retrospectively from medical records to assess the impact of imaging.

Results During night shifts, 18 of the 26 observed clinical encounters used diagnostic imaging, compared with 12 of the 20 observed clinical encounters during day shifts. Factors affecting decision-making during night shifts included limited resources, fatigue, reduced support for junior ED MOs and higher patient load. Interviews suggested CT was more likely to be used during night shifts as a screening tool to expedite decisions and as a substitute for unavailable imaging modalities. In contrast, imaging decisions by day shift junior MOs were influenced by the need to justify their decisions to senior MOs, prompting them to research presenting complaints and imaging indications. Generally, there was minimal reference to imaging decision-making guidelines across both shifts.

Conclusion Differing factors impact imaging decisions by ED MOs during day and night shifts. This needs consideration when designing and implementing targeted physician support strategies and interventions to reduce low-value imaging. Limited resources and MO fatigue should be considered when modifying guidelines/strategies aiming to support MOs during ED night shifts.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Imaging overuse is a global issue, with most interventions focusing on physician education resulting in varying success rates.
⇒ The specific factors impacting ordering of imaging in the ED between day and night shifts are poorly understood, as no studies have examined these to date.

WHAT THIS STUDY ADDS

⇒ In this mixed methods study, fewer ED medical officers (MOs) and a higher patient load were observed during night shifts. MOs during both shifts were observed to make minimal use of diagnostic imaging guidelines, and most reported having no awareness of the guidelines.
⇒ When interviewed, night-shift MOs generally reported less clinical support and lower availability of diagnostic imaging services such as ultrasound, leading to increased use of CT scans. Junior day-shift MOs reported that their primary concern was demonstrating their competence to their supervisors to satisfy the requirements of their clinical rotation.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Use of clinical guidelines was minimal, suggesting that on their own, these are not an effective means of reducing low-value imaging. Interventions to improve the effective and appropriate use of diagnostic imaging in the ED may need to consider differences in clinician behaviour between day and night shifts.

INTRODUCTION

In the emergency department (ED), diagnostic imaging is crucial for patient care.[1] The increasing use of complex imaging has been driven by rising clinical workloads and time pressures, which can lead to ordering of low-value imaging that does not benefit patient care.[1–6] Such imaging increases costs and unnecessary radiation exposure without clinical benefit.[4–6]

Previous research has identified several factors contributing to imaging overuse, including unnecessary repeat scans, fear of litigation, patient expectations, poor communication and increased likelihood of overuse during evening shifts.[5 7] While clinical decision rules and imaging guidelines, for example, American College of Radiology (ACR) and European Society of Radiology (ESR) guidelines, have been developed to improve decision-making, they do not cover all clinical scenarios and their adoption varies among physicians.[5 7 8]

Interventions focused on clinician education have had mixed success in reducing imaging overuse, possibly because they do not address key factors influencing physician behaviour. A conference paper by Bai *et al*[9] had shown that resource availability and influence of senior clinicians were two major factors impacting general diagnostic test ordering within an Australian ED. The study emphasised that there is a need for novel clinical decision support within the ED.[9] However, no study examined whether specific factors impacting ordering of imaging in the ED varied between day and night shifts. In many settings, during night shifts, less experienced clinicians are on duty who face greater uncertainty and resource limitations. Understanding these factors will help improve the design and implementation of interventions aimed at reducing low-value imaging.

This study aims to examine and compare factors impacting imaging decisions during day and night shifts in the ED and their impact on patient care.

METHODS

This mixed methods study was conducted in 2021 at a major tertiary hospital in Western Sydney. Data were collected through observations, interviews of ED medical officers (MOs) and retrospective review of patient clinical records pertaining to the observed clinical encounters. The purpose was to identify factors impacting diagnostic imaging decision-making across day and night shifts in the ED. Day shifts were defined between 8:00 and 22:00. Night shifts at the studied ED are 10 hours in duration, from 22:00 to 8:00. Emergency medicine specialists are onsite between 8:00 and 00:00 only and are available by telephone for indirect supervision between 00:00 and 8:00.

The study was reported in accordance with the Standards for Reporting Qualitative Research checklist.[10]

Study setting

The study was conducted in the ED of an adult tertiary referral hospital in Sydney, Australia. This ED services a multicultural population of approximately 1.5 million people and treats approximately 80 000 adult patients annually. The ED is supported by specialist services for stroke, trauma, cardiology and surgery. Consultant medical officers (CMOs) supervise junior MOs onsite, except between the hours of 00:00 and 8:00, when supervision is provided remotely by on-call CMOs. The radiology department at the studied hospital supplies 24/7 service to the ED. Consultant radiologists are present onsite during business hours and on-call after hours. Radiology registrars are present both in and out of hours. CT radiographers are onsite 24/7. Requests for CT scans can be made by any level of ED doctor. Requests are authorised as appropriate by the radiology department at all hours. One exception is that CT scans for conditions such as suspected acute stroke can proceed with permission from the neurology team and do not require approval from a radiologist to proceed.

ED staffing

During the day shifts, each MO manages seven patients on average, reviewing between two and three patients at any given time. A typical roster during the day shift includes three to five of each type of MO: junior MO (JMO), supervised practitioner with 1–2 years of clinical practice since medical school completion; senior resident MO (SRMO) with 3–5 years of clinical practice since medical school completion; emergency medicine specialist in training/registrar (EMSIT, trainee specialist) with 5–7 years clinical practice since medical school graduation and in accredited specialty training programme; and CMO with 8 years or more of clinical practice since medical school completion and who are accredited specialists in emergency medicine. During the night shifts, each MO manages nine patients on average, reviewing three to four patients simultaneously. There are no CMOs working on the floor, but they are available on call. During night shifts, EMSITs are the most senior staff present on the ED floor, while two to three JMOs, SRMOs and EMSITs are typically rostered.

Apart from CMOs, all other ED MOs are required to have their clinical interactions observed by a senior MO during the shifts. These interactions are graded as clinical training assessments, with feedback given by their seniors. These graded clinical interactions form part of MO's overall ED rotation assessment, which counts towards clinical training requirements.

Availability of the CMO

The primary role of the CMOs is the administrative operation of the ED. This includes facilitating patient flow and providing both direct and indirect supervision to junior medical staff. CMOs provide guidance on the use of guidelines and clinical resources in the studied hospital.

With the exception of CMOs, MOs managing patients in the ED have to balance safe and effective patient care with clinical training requirements. These two priorities can compete, especially when the ED is busy and they need to maintain patient flow. It is reported anecdotally that decision-making in the studied ED is influenced by both clinical context and motivation for career progression, as junior MOs need to balance satisfying rotation requirements as part of their training with effective patient management.

Participants and recruitment

Emergency MOs were employed by the studied hospital and were licensed to practise medicine in Australia. MOs were at various stages of their clinical training, ranging from JMO to EMSIT. The levels of MOs were categorised as described by Klein *et al*,[11] as described above in the 'ED staffing' section.

Convenience sampling was used in this study. All emergency MOs rostered to work on the days/nights when RK was conducting observations and interviews were invited to participate in the study. All consenting MOs were included in the study. Soft and hard copies of participant information and consent forms were distributed to ED physicians at the studied hospital. Interested physicians were advised to approach the researcher (RPK) to volunteer.

We were unable to recruit CMOs into the study cohort as they declined to participate due to high clinical workloads.

Data collection

Observations and interviews

RPK was embedded in the ED for 5 day shifts and six night shifts during February and March 2021. RPK (medical practitioner with >5 years clinical experience) was a passive observer during data collection. Observations captured ED environment and ED MO behaviour related to imaging decision-making. Observations were gathered using an adapted version of a previously published tool by Hahlweg *et al*.[12]

Shortly after each encounter, a brief 2 min, semistructured interview was conducted with the treating MO. The interview guide was modified from an instrument previously published by Balla *et al*.[13] The interview guide explored the decision-making process of the MO, including cardinal features of the presenting

illness and factors that influenced MOs' imaging decisions. The observation tool and the interview guide were tested in a simulated ED environment prior to commencing the study. All observation and interview data were recorded and transcribed following deidentification.

Retrospective medical record review

The patient data for the observed clinical encounters were collected from the hospital's clinical record systems FirstNet and PowerChart (Cerner, Kansas City, Missouri, USA) electronic medical records systems (eMR). Variables collected from the eMR included patient demographics and documented clinical information related to imaging orders and patient disposition (at 1 and 4 weeks post clinical encounter). Presenting complaints were categorised as either medical or surgical.

The purpose of collecting data through medical record review was to identify and compare patient demographics, acuity and compliance of imaging orders with the ACR/ESR guidelines during day and night shifts. Collecting data regarding the patient disposition at 1 and 4 weeks post encounter was undertaken to understand the longer-term impact of imaging decisions on each patient.

Data analysis

Qualitative analysis

46 interview/observation transcripts were analysed using Dedoose V.8.0.35 (2018). Thematic analysis was used as per Braun and Clarke.[14] Data were coded iteratively using inductive coding, codes were then categorised to parent themes and compared with understanding factors that influenced imaging decision-making between the day and night shifts. This process involved discussions between RPK, MM and HR (MM and HR are experienced qualitative researchers) to arrive at consensus regarding theme development. Part of the analysis of diagnostic decision-making included examining how and why MOs had used imaging.

Quantitative analysis

Graphpad Prism (V.9.4.1, 18 July 2022) was used for quantitative data analysis. Descriptive statistics were used to describe quantitative data. χ^2 and Fisher's exact tests were used to compare categories. Statistical significance level was set at $p<0.05$.

Application of ACR and ESR appropriateness criteria

ARC and KL reviewed the de-identified eMR summary for each of the observed cases independently and compared cases against the ACR/ESR guidelines. In case of disagreement, a clinical radiologist, NY, provided a final determination regarding adherence of diagnostic imaging orders to guidelines. The guideline compliance assessment was based on the presenting complaint and provisional diagnosis at the time of imaging ordering.

Patient and public involvement

No patients were involved in this study.

RESULTS

Physician and patient characteristics

Observations and interviews included in the study were from 20 day-shift encounters of 16 MOs and 26 night-shift encounters of 24 MOs. Each encounter was a unique interaction between a shadowed MO and a patient. In some cases, we included encounters with the same consenting MOs treating different patients during the observed shift. However, no crossover occurred between the same MO across day and night shifts. There was a maximum of two encounters observed with each MO during each shift.

Participating MO demographic characteristics and experience are shown for each encounter in table 1.

Characteristics of patients treated by the participating MOs are shown in table 2.

During night shifts, 18 of the 26 observed clinical encounters used diagnostic imaging, compared with 12 of the 20 observed clinical encounters during day shifts.

Table 1 Participating observed physician characteristics from each encounter (patient–physician interaction)

Physician characteristics and clinical experience	Day shift	Night shift
Junior medical officer, 1–2 years post medical school graduation		
Total, n (%)	10 (50%)	13 (50%)
Males, n	5	8
Females, n	5	5
Senior resident medical officer, 3–5 years post medical school graduation		
Total, n (%)	4 (20%)	3 (12%)
Males, n	4	1
Females, n	0	2
Emergency medicine specialist in training (EMSIT), 6–9 years post medical school graduation		
Total, n (%)	6 (30%)	10 (38%)
Males, n	2	4
Females, n	4	6

The patient journey

Three main themes were identified following coding of qualitative data obtained from interviews and observation. These themes represent the patient journey as it related to imaging decisions. This was used as a framework to understand and describe factors that influenced imaging decision-making. The patient journey began when the physician acquired background clinical information and ended when the patient's emergency treatment had been completed, that is, the patient was either discharged from the ED, admitted to the hospital or transferred

Table 2 Characteristics of patients presenting to the ED across day and night shifts

Observed patient characteristics	Day shift	Night shift	P value
Patient under 65 years of age, n (%)	11 (55%)	20 (77%)	0.12
Patient 65+ years of age, n (%)	9 (45%)	6 (23%)	
Acute illness, n (%)	14 (70%)	15 (58%)	0.39
Chronic illness, n (%)	6 (30%)	11 (42%)	
Medicine presentations, n (%)	9 (45%)	16 (62%)	0.26
Surgery presentations, n (%)	11 (55%)	10 (38%)	
Triage category (ATS)			
ATS 1, n (%)	2 (10%)	2 (8%)	0.80
ATS 2, n (%)	9 (45%)	10 (38%)	
ATS 3, n (%)	2 (10%)	6 (25%)	
ATS 4, n (%)	5 (25%)	4 (15%)	
ATS 5, n (%)	2 (10%)	4 (15%)	

ATS1 is assessed as the most urgent category, ATS5 is assessed the least urgent category.
$p<0.05$ was considered significant.
ATS, Australian Triage Scale.

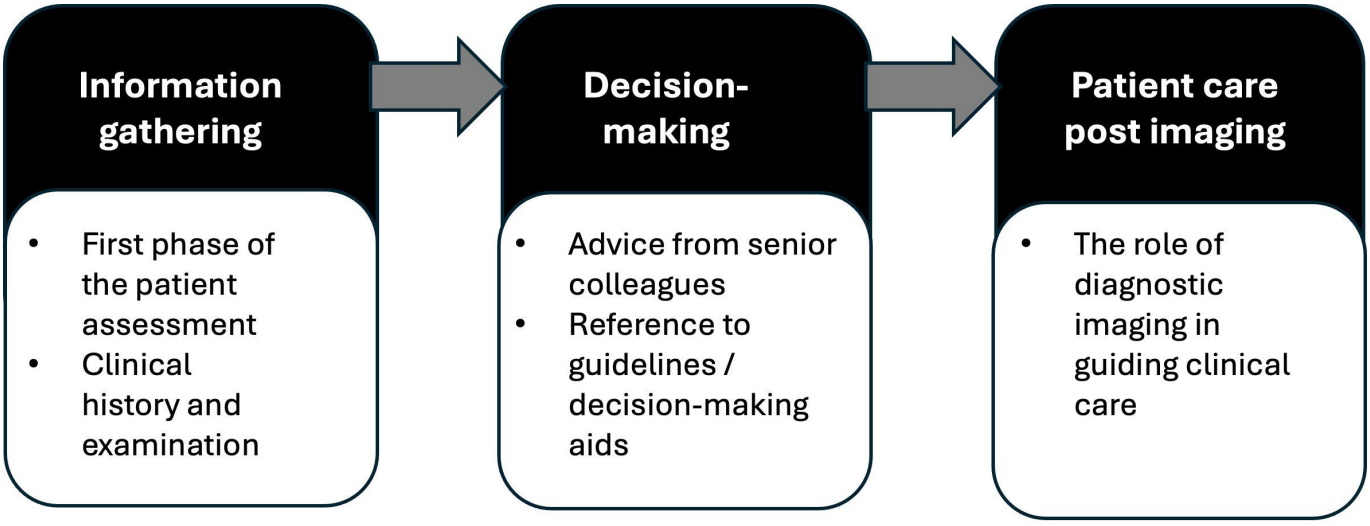

Figure 1 Steps of the patient journey used by emergency medical officers (MOs) to make imaging decisions. The patient journey starts with information gathering (consisting of the first phase of the patient assessment, clinical history and examination) where the MO obtains the information necessary to progress to decision-making. Decision-making occurs when MOs have sufficient information and are ready to decide whether the patient requires imaging and the type of imaging required. It may involve advice from a senior MO, or reference to other decision-making aids. The final stage includes post-imaging patient care, which describes whether and how imaging influences clinical care and management of the patient.

to another facility. We classified components of the patient journey as follows (figure 1):

1. Information gathering.
2. Decision-making.
3. Patient care post imaging.

Imaging decision-making behaviours during the patient journey were compared between the day and night shifts (table 3). The main themes identified within this behavioural analysis were explored.

Two themes identified factors influencing imaging decision-making that were not specific to one stage of the patient journey, but occurred throughout:

1. Resource availability.
2. Fatigue.

These factors were also compared between the day and night shifts.

Table 3 Comparison of typical behaviour of clinicians when making imaging decisions between the day and night emergency shifts based on a combination of the common themes derived from the interviews and observations

Typical observed clinician behaviours during the day shift	Typical observed clinician behaviours during the night shift
Information gathering	
► Mostly self-directed information transfer—typically independent, physicians read triage notes and past medical records ► Physicians observed researching the provisional diagnosis and reading medical records in detail ► Longer length of time to complete first phase of patient assessment (average length of time 5–10 min)	► Mostly self-directed information transfer—often hurried, with reference made to the triage notes only, but not past medical records ► Focus on faster and more efficient first phase of patient assessment rather than depth of clinical information ► Shorter length of time to complete first phase of patient assessment (average length of time 1–2 min)
► Patient interaction typically included clinical generalised patient history and targeted clinical examination ► Taking a methodical approach during clinical examination and noting examination findings on paper before continuing with the assessment ► The major focus of the detailed assessments, in addition to patient management, was to satisfy clinical assessment requirements as part of emergency specialist training	► Patient interaction typically included generalised patient history and targeted clinical examination, focusing specifically on exploring the presenting complaint ► Clinical assessments were targeted towards the presenting complaint, and the examination was often rushed, imaging was viewed as safety net if something was missed ► The major focus was efficient patient management, with the aim to rapidly identify the provisional diagnosis and instigate a management plan
Observed decision-making process	
► Greater availability of clinical supervision and services that is, ultrasonography (available 16 hours per day) ► Onsite emergency medicine specialists for 16 hours of the day ► Greater availability of clinical specialist teams if specialist consult was required	► Lesser availability of clinical supervision and services that is, ultrasonography ► Emergency specialists available by phone only; supervision is indirect ► Lesser availability of clinical specialist teams if specialist consult was required ► Imaging was ordered to facilitate faster patient management decisions, sometimes without provisional diagnosis
► Justification of decision-making when ordering imaging, as it was expected that physicians would justify their decision to order a specific investigation as part of their training if challenged by a senior physician	► Fatigue impacted imaging decisions, that is, physicians reaching for coffee cups, yawning, needing to self-correct imaging ordering errors and voicing their exhaustion when working
Observed clinical management post imaging	
► The final management of the patient was largely based on the advice given by a senior physician	► Physicians often instigated management based largely on imaging findings

Information gathering

During interviews, MOs universally viewed information gathering as the foundation of the imaging decision-making process:

> I think about imaging from when I first see the patient, and that is because I consider differential diagnoses in the back of my mind the whole time. I think about the symptom, and what part of the body is being impacted. I start to think, are we going to CT a thick part of the body, like the abdomen or X-ray a thin part of the body, like an extremity? (**JMO working in the day shift**)

First-phase patient assessment

Irrespective of the shift, it was observed that most first-phase patient assessments were self-directed, consisting of MOs reviewing triage notes without involvement of another clinician. This step occurred before the patient was reviewed.

The first-phase patient assessments for day-shift patients were observed to be longer than night-shift assessments, taking around 5–10 min each. This included reviewing the eMR, researching symptoms and generating differential diagnoses. MOs were observed researching imaging modalities for patient presenting complaints using the internet, referring to previous progress notes and comparing justifications for different imaging modalities in order to select the appropriate imaging for the patient.

In contrast, night-shift first-phase assessments were observed to be briefer (1–2 min) with an emphasis only on triage notes. The MOs then moved quickly from reading the notes to assessing the patient, while multitasking (eg, simultaneously reading the notes, writing comments on paper and answering questions from colleagues about other patients). Night shift MOs stated in interviews that they rushed to learn what they could during this phase before a brief (matter of seconds) discussion with a senior doctor. No CMOs were observed to be available in the ED, therefore EMSIT MOs were managing their own patients in addition to supervising junior colleagues during the night shifts.

Clinical history and examination

Most clinical assessments were observed to be similar across both shifts, consisting of a generalised medical history and clinical examination targeted towards the presenting complaint. MOs explained in interviews that this allowed them to efficiently formulate their provisional diagnosis and select an imaging modality.

As with the first phase of clinical assessment, MOs working in the day shift were observed taking time to methodically note their findings on paper while they were with the patient before continuing with the assessment. In contrast, the observed MOs working in the night shift rushed the clinical examination (they were observed to move through the tasks quickly, writing very brief notes, not engaging in depth with the task at hand), explaining during interviews that they were under time pressure and that imaging was their safety net if something had been missed:

> … often in ED you are managing many patients and stakeholders simultaneously, such as expectations of patients, clinical supervisors, and other staff such as nurses. We don't always conduct a comprehensive assessment for this reason (sometimes we do), but we also see the imaging as a safety net. (**EMSIT working in the night shift**)

Decision-making

Observations suggested MOs' imaging decisions during both shifts were guided predominantly by advice from senior colleagues, patient clinical history/examination and sometimes published decision-making aids/guidelines available on the hospital intranet.

The MOs working in the day shifts relied to a greater extent on the internet to research established practices, as noted by the observations. In most cases, no imaging guidelines were used by these MOs. In comparison, MOs working in the night shifts relied much more on discussions and guidance from senior MOs.

Table 4 Imaging orders placed by the physicians during the day and night shifts

Imaging and modality used	Day shift	Night shift	P value
Imaging studies ordered by physicians			
No imaging, n (%)	8 (40%)	8 (31%)	0.55
CT only, n (%)	1 (5%)	5 (19 %)	
Radiographs only, n (%)	5 (25%)	8 (31%)	
Radiographs and CT, n (%)	5 (25%)	4 (15%)	
Ultrasound, n (%)	1 (5%)	1 (4%)	
p<0.05 was considered significant			

Placing and justifying imaging orders

JMOs/EMSITs are required to complete clinical training assessments during their rotation for career progression, which is an expectation of Australian medical training. These were typically completed during day shifts when there are more staff available. Consequently, justification of decision-making by junior to senior MOs was commonly observed during the day shifts. During interviews, MOs working in the day shift mentioned that they felt pressure to display their clinical competency to their supervisors by justifying clinical management decisions:

> …you don't want to appear incompetent and not pass your training assessments. Sure, we can access decision-making protocols, but they only partially help. We are responsible at the end for the patient. We have clinical expectations we need to fulfill. (**JMO working in the day shift**)

Patient care post imaging

A greater proportion of cases during the day shifts were managed without use of imaging (table 4), and these cases were typically triaged as less urgent (documented by the medical records). Many of these patients were repeat presenters to the studied hospital's ED, and the staff were often observed to continue managing these patients based on their prior documentation.

For patients who underwent imaging, MOs working in the day shift took 10–15 min to read the imaging reports and review images prior to instigating management. In some cases, MOs referred to departmental management guidelines before discussing their findings and a proposed management plan with senior MOs. During the day shifts, a single provisional diagnosis was typically documented by the MOs in the order form requesting a specific imaging investigation. Typically, the imaging results confirmed the diagnosis suspected by the MOs.

During night shifts, MOs instigated basic management, such as providing intravenous fluids prior to receiving imaging results. Following imaging, MOs typically scanned the report briefly (1–2 min), then altered management accordingly. MOs were observed discussing multiple patients simultaneously with EMSIT, typically without specifically referencing departmental management guidelines. In post encounter interviews, MOs in the night shift explained that they were aware of the guidelines' existence, but not their content; they reported not using these guidelines due to time constraints. MOs working in the night

shift typically considered multiple diagnoses (as they reported in their interviews) that could account for presenting symptoms and multiple potential management plans, depending on what the imaging might show:

> If the CT brain is negative, discharge to nursing home. If positive, for admission under the geriatric medicine team. I think the test will most likely be negative. (**SRMO working in the night shift**)

Compliance with ACR/ESR guidelines

When imaging decisions were reviewed by the research team for compliance with the ACR/ESR guidelines, it was noted that recommendations were not available for over half of the presenting complaints for patents in both shifts. Although we initially intended to evaluate compliance with the guidelines, it became apparent during the interviews that at least in some cases MOs modified their provisional diagnosis to fit the imaging modality they were requesting. As the extent of this behaviour was not known, these data were deemed unreliable and were therefore excluded.

Patient outcome post encounter

A greater proportion of night-shift patients were admitted to the hospital (n=15, 58%), compared with the day shift (n=6, 30%). Patients admitted during nights predominantly presented due to trauma (eg, stabbings, motor vehicle accidents or falls). According to eMR, very few patients represented to the ED at 4 weeks post clinical encounter (only 5%: n=1 for the day shift; 4%, n=1 for the night shift).

Other factors affecting imaging decisions

Resource availability and fatigue were two identified factors that did not affect a particular part of the patient journey, but were present throughout it. We discussed these factors separately.

Resource availability

The greatest observed difference between the two shifts was limited availability of senior MO support, some imaging services (eg, ultrasound), and limited access to some clinical specialties during night shifts.

Non-ED specialty consulting services were available by phone and not onsite after hours, except for psychiatry, surgery, radiology and internal medicine trainees. This meant MOs working in the night shift had to manage patients more independently compared with their day-shift counterparts. During interviews, junior MOs reported not feeling comfortable calling the CMOs from other specialties without having completed the expected investigations and therefore completing a more extensive clinical workup before making a referral for admission:

> I don't always like calling consultants from other specialties for an admission in the early hours of the morning because I don't want to seem inadequate in my decision-making. If someone needs to be admitted, then I will admit and call the consultant at a reasonable time. (**EMSIT working in the night-shift**)

In some cases, when patients needed an ultrasound during the night shift, junior MOs reported in interviews adjusting the provisional diagnosis to justify use of a CT to their seniors and facilitate patient treatment:

> I feel that sometimes you need to modify your diagnosis a little so that you can use whatever resources are at your disposal. (**EMSIT working in the night-shift**)

In contrast, MOs working in the day shift reported having more clinical support and resources at their disposal:

> I love working the day shifts, because it means I can pick up the phone and call people without being worried about waking them up in the middle of the night. (**SRMO working in the day-shift**).

MOs across both shifts acknowledged during interviews that sometimes a CT was not the appropriate modality, but it was ordered for two reasons: (1) having some form of imaging to decide about patient disposition if another modality was unavailable; (2) ward-based clinicians requested the imaging to facilitate their workup and eventual management of the patient when they are admitted:

> In the emergency department, there are times when we request imaging that we know is not indicated or necessary from an acute perspective, but we are trying to keep the ward doctors happy, and also keeping ourselves satisfied that we have done what we can to work up our patients. (**EMSIT working in the day-shift**)

When interviewed, a small minority of MOs working in the night shift raised concerns about the imaging they requested, feeling that these investigations would not add anything to the diagnosis and management of their patients. Nevertheless, they ordered such imaging to satisfy cultural expectations in the ED:

> Sometimes it's better to have some imaging rather than none. I know that it's not always right to order a chest X-ray on someone who has abdominal pain, or CT for someone who may have cholecystitis. It still needs to be done because it's standard in the ED to order imaging for our patients. (**EMSIT working in the nightshift**)

Fatigue

Fatigue was a factor specific to the night shifts. MOs in night shifts were seen yawning and reaching for coffee cups during their shifts and breaks. Drinking coffee was not encouraged. However there was no restriction on doing so during the ED shifts at the studied hospital, especially when completing clinical reviews. During the day shifts, fatigue was not brought up during postencounter interviews, nor observed as a significant issue. The MOs working in the day shift were generally more animated and explained during interviews that they consumed coffee prior to their shift commencing.

MOs in night shifts reported slowed decision-making, forgetfulness, distractibility and being less perceptive of their surroundings. They described night shifts to be a more stressful environment which overall was much more difficult compared with day shifts:

> Especially later during the night shifts, I find it hard to think and will miss things that I otherwise would have picked up, such as telltale bedside clues in clinical exams that tell me how sick a patient is. Sometimes I forget parts of the workup, such as ordering a specific blood test or getting an X-ray before a CT for evaluating a fracture. Other times, I feel like my mind isn't moving along. (**EMSIT working in the night shift**)

DISCUSSION

This study demonstrated that the ED environment and the constraints MOs experience during day and night shifts influence imaging decisions. Interventions intended to reduce low-value imaging should take environmental factors into account during design and implementation to enhance the chances of success. This study explored contextual factors impacting imaging decision-making. A previous study by Bai *et al*,[9] identified several factors that influenced selection of imaging studies by ED

physicians. These included ED resource availability, including availability of guidelines, patient and family preferences, and senior clinicians' influence. However, that study did not explore the differences in factors influencing imaging decisions between the day and night shifts. The present study demonstrated that while some of these factors are similar to those identified by Bai *et al*, they differ between the day and night shifts.

Imaging orders and guidelines

Night shifts are characterised by a higher proportion of hospital admissions. Junior MOs typically manage these shifts without specialist input due to the ED culture discouraging consultant contact.[15] Although clinical decision aids may benefit night-shift clinicians, they reported during interviews that time constraints precluded their use. Managing patient flow is a priority during night shifts, so guidelines and decision aids must be time-efficient.[15–17] Interventions to improve imaging decisions during night shifts must consider reduced senior support, limited opportunities for MOs to check information, and the potential unavailability of some imaging modalities, for example, ultrasound. Interventions may include decision support integrated into the eMR and real-time AI-based support.[16 17] Fatigue significantly influences night-shift MOs' decisions, as diurnal sleep–wake cycle interruptions affect their clinical judgement. This should also be considered in design of interventions. Further studies are needed to determine the best interventions to reduce low-value imaging during night-shifts.[16 17]

Compared with night shifts, MOs working in day shifts experience less time pressure due to higher staffing levels. However, their behaviour was influenced by the need to demonstrate their competence to superiors, as their career prospects depend on positive feedback from ED consultants. This presents an opportunity to integrate clinical decision support and interventions to reduce low-value care into routine training and assessment, thus enhancing decision-making and improving the quality of care. Anecdotally, the studied hospital's ED environment encourages learning under supervision.

Patient load per doctor was higher during night shifts at the studied hospital ED. However, some cultural issues also impacted physicians' behaviour. During day shifts, although patient flow remained a concern, junior MOs were focused on satisfying expected clinical training and performance requirements. During night shifts, there is an on-call CMO, but there is a culture of reluctance to contact them, unless absolutely necessary. This is driven in part by the junior staff not wanting to appear incompetent if they call a CMO for what turns out to be a non-urgent matter.

Limitations of the study

This study has several limitations. First, interviews with MOs were brief due to time constraints. Only one hospital ED was included, limiting generalisability. Not all physicians in the ED during the studied shifts participated, reducing the study's comprehensiveness. This study did not observe/interview the same MOs during both day and night shifts, therefore no direct comparison of their decision-making during different shifts could be made. Nevertheless, this study provided valuable insights into factors impacting imaging decisions of more junior staff who represent the majority of the ED MO staff during the day and are the only MOs physically present in the ED during night shifts.

Although we initially intended to assess compliance of imaging decisions with the ACR/ESR guidelines, our ability to assess for guideline compliance was based on the provisional diagnosis listed on the imaging indication. As reported by some MOs during interviews, some of these diagnoses were entered to justify ordering more complex imaging, for example, CT, than was required by the actual provisional diagnosis. We cannot rule out this practice being more widespread, as some MOs may not have disclosed this information during the interviews. Therefore, these data were not considered reliable and were excluded from the study. Moreover, it should be noted that no ACR/ESR guidelines were available for over half the clinical encounters in each shift in this study.

Data were collected during the COVID-19 pandemic, affecting MO behaviour due to increased patient load and restrictive health policies. Concerns about contracting SARS-CoV-2 led some clinicians to decline participation. Additionally, the inability to recruit ED CMOs meant that insights from more experienced MOs on imaging decisions were not obtained. Thus, MO behaviour may not represent typical practice.

FUTURE DIRECTIONS AND CONCLUSION

Imaging decisions were influenced by the different ED environmental factors during day and night shifts. These differences should be considered in the design and implementation of interventions to reduce low-value imaging.[18]

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Contributors All coauthors contributed to the work as follows: substantial contributions to the conception or design of the work, or the acquisition, analysis, or interpretation of data (RPK, GV, HR, ACR, KL, ALS, NY and MM); drafting the work or revising it critically for important intellectual content (RPK, GV, HR, ACR, KL, ALS, NY and MM); final approval of the version to be published (RPK, GV, HR, ACR, KL, ALS, NY and MM); and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved (RPK, GV, HR, ACR, KL, ALS, NY and MM). RPK is the guarantor.

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