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A Study of the Contextual Factors Influencing Emergency Department Clinician's Diagnostic Test Ordering Decision Making

Full research paper

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Abstract

Australia's total number of pathology tests and imaging services covered by the Medicare Benefits Schedule has increased by over 50% in the last decade. Given that 20-25% of the common pathology tests were considered inappropriate nationwide, an increasing burden is placed on the whole healthcare system by unnecessary diagnostic tests (UDTs). The objective of this exploratory study is to identify the contextual factors that could influence a clinician's diagnostic test ordering decision-making (DTODM) in an Emergency Department (ED). Semi-structured interviews were conducted with 19 ED clinicians. Four factors have been identified to impact clinicians' DTODM: organizational context, patient/family preferences, resource availability, and influences by senior clinicians. The study offers new lenses in clinical reasoning for emergency medicine teaching and training through the eyes of ED clinicians. It outlines an opportunity to introduce novel clinical decision support to assist with clinicians' test ordering without causing alert fatigue or bringing stress.

Keywords Clinical decision making, diagnostic test ordering, emergency department

1 Introduction

In recent decades, many countries have seen increasingly frequent diagnostic test utilization, including pathology and medical imaging. According to Services Australia, the total number of pathology tests covered by Medicare Benefits Schedule in 2020-2021 nationwide has increased 53.8% to over 167 million (Services Australia 2022d), compared to more than 108 million in 2010-2011 (Services Australia 2022c). The same trend in diagnostic imaging services is also observed. Over 29 million (Services Australia 2022b) imaging tests were administered in 2020-2021, a 56.4% increase from over 19 million (Services Australia 2022a) in 2010-2011. A previous report has discovered that 20-25% of the frequently ordered pathology tests were considered inappropriate or unnecessary nationwide (NCOPP 2012), as these tests do not bring any extra value to clinical decision-making (Bindraban et al. 2018) in the sense that the results of such tests do not change clinicians' management plan for patients. Even though the figure is now somewhat dated, continued growth in raw medical test ordering suggests that an increasing burden is being placed on the whole healthcare system by unnecessary diagnostic tests (UDTs). From patients' perspective, UDTs could lead to harm like iatrogenic anemia (Sadowski et al. 2017), infection of the vascular access (Kotecha et al. 2017), or unnecessary exposure to radiation (Jennings et al. 2017).

This research is an exploratory study and aims to identify the contextual factors that could influence a clinician's diagnostic test ordering decision-making (DTODM) in an Emergency Department (ED) setting, as an initial step in understanding a clinician's DTODM behavior and exploring ways to reduce UDTs through clinical decision support (CDS) interventions informed by behavioral change theories. Exploratory interviews were conducted with ED clinicians to achieve the objective.

The rest of the paper is organized as follows: Literature Review discusses previous studies that reported reasons or factors that influence clinician's diagnostic test ordering decisions; Methodology outlines the study setting and the methods adopted for research design, data collection and data analysis; Contextual Factors Influencing DTODM presents the identified contextual factors that could affect DTODM; Discussion explains how these factors would influence DTODM and research limitations; Conclusion highlights the study contributions and future research paths.

2 Literature Review

To date, a limited number of studies have focused on the factors of DTODM, and no study has been identified that reports the contextual factors that could impact DTODM in ED. The studies did discuss DTODM also have different perspectives. Whiting et al. (2007) conducted a review targeting studies examining any factors that could affect a clinician's DTODM. In the study, five high-level factors were identified, including diagnostic factors, therapeutic and prognostic factors, patient-related factors, doctor-related factors, and policy and organization-related factors, with various aspects under each factor, also outlined. The diagnostic factors mainly discussed the medical reasons for test ordering, such as modifying disease pre-test probability (Pewsnar et al. 2004; Price 2000), to rule in or rule out (Feinstein 2002). In different healthcare settings, the diagnostic factors were also different. For example, in primary care, tests were often ordered to rule out or to make referral decisions to secondary care (Espeland and Baerheim 2003), whereas, in secondary care, tests were mainly ordered to diagnose. Following diagnosis factors, therapeutic and prognostic factors were summarized as the decision on treatment, prediction for a subsequent clinical course, and monitoring intervention effects. The diagnostic factors, as well as therapeutic and prognostic factors, are highly dependent on the patient's presentations. Thus, clinicians' DTODM based on these two factors would be influenced by clinical reasoning rather than contextual elements. Patient-related factors included patient's preference, acceptability, and demographics. But the classification of patient acceptability and preference is somewhat overlapped, given that a patient's acceptability of a test could determine one's choice. For example, a patient's concern about exposure to radiation could result in the refusal to receive an imaging test. Doctor-related factors mainly covered their training and practice experience, personal traits, and specialty. Policy and organization-related factors considered the organization's size, resources, and referral processes. The study also suggested several areas where interventions could be introduced to improve test ordering practice.

Sood et al. (2007) performed a systematic review to identify physicians' non-evidence-based-medicine variables that affected test ordering tendencies. Compared to the previous work, this study categorized the identified variables into two groups: nonmodifiable and modifiable physician factors. The nonmodifiable factors included geographic location, practice setting, age and sex, and specialization. The modifiable factors were experience/knowledge, belief, fear of malpractice, financial incentives, awareness of the cost of testing, and feedback/education. Such classification puts focus on the factors that could be modified through intervention and result in improved test ordering practice.

Miyakis et al. (2006) carried out a retrospective review of outpatient medical records over six months to identify the factors contributing to inappropriate test ordering. The researchers reviewed the appropriateness of 25 laboratory blood tests by examining a patient's medical records and diagnoses, using implicit criteria. The identified risk factors that could lead to inappropriate tests were prolonged hospitalization, unfavorable outcome (deaths or lack of diagnosis), and advanced age, all of which were patient related.

We could not track down any peer-reviewed studies systematically exploring the reasons or factors influencing clinicians' DTODM in the recent decade. The above three reviewed studies reported their results based on existing literature reviews rather than conducting empirical studies. Some of the factors identified in these studies are relevant to this study, but also included other factors like doctors' individual patterns. This presents a need to empirically explore why contextual factors matter (Davison and Martinsons 2016), and how they would influence clinicians' test ordering and build into their decision-making patterns. Furthermore, based on the researchers' previous study (Bai et al. 2020), which examines the effectiveness of information and communications technology interventions on UDTs, it can be established that UDTs are commonly seen in hospital settings, and great efforts have been devoted to improving test ordering practices over the past 20 years. But most of these studies introduced interventions without really identifying the reasons behind UDTs. And only limited studies reported continued test ordering behavior change (Brady et al. 2018). Therefore, it is reasonable to take a step back and uncover the test ordering myths with a refreshed eye before introducing a targeted and adequately designed intervention. And this study attempts to narrow the gap by identifying the contextual factors that could influence clinicians' DTODM in ED. Unlike previous studies, an exploratory qualitative approach is adopted by conducting semi-structured interviews to achieve the research objective.

3 Methodology

3.1 Study Setting

The study is carried out in the ED of a public hospital, referred to hereafter as Hospital A, in Melbourne, Australia. A program was designed and implemented in 2013 to support clinicians' test requests to ensure that the tests patients receive are clinically indicated and to avoid unnecessary test ordering (Leach and Buntine 2018). Under the program, multiple interventions have been introduced across the ED and wards. At the time of this study, the predominant interventions consisted of paper evidence-based Care Pathways in the ED to guide the ordering of CT C-spine and brain in trauma, pathology and medical imaging testing in abdominal pain, and medical imaging in patients with suspected pulmonary embolism. In addition to this, a single-page pathology testing guide was displayed throughout all clinical areas in the ED. Regular teaching sessions for junior and senior doctors in the ED were ongoing. Due to this program, most clinicians already had some awareness of the importance of appropriate test-ordering practice.

3.2 Methods

Exploratory semi-structured interviews were used for data collection. A semi-structured interview is practical and flexible in gathering data and providing a greater understanding of the questions (Dresch et al. 2015) and was considered appropriate for the study because of the exploratory nature. The interview protocol (see Appendix 1) was designed to capture the training experience relevant to diagnostic test ordering, the impact of different working environments on test ordering, routine test ordering practices, and the role of patient-specific factors, which are consistent with the contextual and social factors (organization and patient) identified in Whiting et al. (2007). According to different clinicians' responses, probing questions were asked during the interviews to get deeper and more meaningful insights.

Ethics approval had been granted by the Human Research Ethics Committee of Hospital A before contacting any potential participants. Clinicians from the ED in Hospital A were invited to the interviews by an ED research assistant. The researcher then contacted those who agreed to participate in the interview via email, which introduced the research project and the purpose of the interview. A total of 32 clinicians working or rotating in ED were invited to participate between April and December 2021.

Data were analysed using thematic analysis, a technique previously demonstrated to provide an understanding of the salient issues among a particular group or identify typical responses (Braun and Clarke 2006). An inductive approach, applicable where knowledge can be generalized through collected data (Dresch et al. 2015; Saunders 2019), was adopted for formulating the themes. Thematic analysis

with an inductive approach fits the purpose of the study, as we attempt to identify and understand how and why different contextual factors (the salient issues) could influence ED clinicians' (a particular group) DTODM through the responses collected from the semi-structured interviews.

3.3 Participants Characteristics

The interviews were conducted from April to December 2021. Due to the Covid-19 pandemic, the researcher could not visit Hospital A for participant recruitment. A research assistant from ED contacted the clinicians working or rotating in ED and collected the names who showed interest in participating in the interview. These potential candidates were then contacted by the researcher via email. Nursing staff were excluded from the study.

Nineteen out of 32 (response rate 59%) clinicians consented to participate in the interviews. For those clinicians who did not participate, one showed interest but did not set an interview schedule. Among the five refusals, four clinicians replied no because of their busy schedules; one nurse explained that she was not the correct target for the interview. Seven clinicians did not respond to the initial invitations or any follow-up emails.

By the time the interviews were conducted, three clinicians had finished their rotations in ED and started working in other clinical units. All the participants had worked in different hospitals or general practices throughout their medical careers. Table 1 shows the demographics of the participants.

Job Title	Number of Participants	Years of Practice
Intern	1	1 year
Health Medical Officer (HMO)	7	1 to 9 years
Registrar	6	3 to 15 years
Consultant	5	14-31 years
Gender		
Female	6	Male 13

Table 1. Participant Demographics

The length of the clinician's years of practice is mostly relevant to their job titles. Interns and HMOs are relatively junior levels and have shorter years of experience, registrars were at a medium level; whereas consultants are considered as seniors who have usually practised medicine for over a decade and have supervisory responsibilities. Among the six female clinicians, three are HMOs, one registrar and two consultants. The male clinicians include one intern, four HMOs, five registrars and three consultants. The gender distribution of the participating clinicians aligned with the real-world distribution in emergency medicine in Australia, where female accounts for approximately 32% of the emergency workforce and male 68% (Australian Government Department of Health 2016).

3.4 Data Analysis

Eighteen interviews were performed remotely using Zoom and video recorded upon participants' consent. One interview was conducted over Skype, per the clinician's preference, and audio recorded. The interview recordings were transcribed verbatim using NVivo transcription services. The researcher later reviewed and revised the transcripts to ensure the consistency between the interview recordings and the transcripts. Data analysis was performed in NVivo Plus (QSR International). Themes were initially identified based on the different factors in the interview questions. New themes were added when new factors have been discovered and summarized during the analysing process. The last four interviews were conducted two months apart from the previous interviews. From these four interviews, no new themes were identified, suggesting that thematic saturation was achieved. Final themes were discussed among the researchers to ensure they are representative and appropriate to an ED setting.

4 Contextual Factors Influencing DTODM

Four contextual factors were identified as being possible influencers on ED clinicians' DTODM, including organizational context, patient/family preferences, resources availability, and influences by senior clinicians. Sub-themes have also been discovered in organizational context, resource availability and influences by senior clinicians, as seen in Table 2.

- **Organizational context**
 - Overarching ED environment
 - Governance in different hospitals
 - Patient population
 - Patient disposition
- **Patient/Family Preferences**
- **Resource availability**
 - Test resources
 - Evidence-based guidelines
 - Senior clinicians
- **Influences by Senior Clinicians**
 - Supervision style
 - Individual test ordering thresholds

Table 2. Factors Influencing DTODM (reproduced from the thematic codes in NVivo)

4.1 Organizational Context

The overarching ED environment, governance in different hospitals, patient population, and patient disposition were identified as four factors under the organizational context.

4.1.1 Overarching ED Environment

The ED has its own features that stand out compared to other wards in a hospital, which makes DTODM in ED different from an in-patient setting. With the increasing number of patients and limited resource capacity (Jarvis 2016), ED clinicians are often under the pressure of time and urgency to order diagnostic tests. One clinician stated that because of the limited time to make test ordering decisions and the pressure to get patients in and out, a much greater culture exists in ED *“to order tests and have results available before you assess the patient or to do a brief initial assessment, order tests and then come back and review later”* [P18] (quotes from the 18th clinician). Therefore, clinicians' need to be able to make DTODM within a short timeframe could lead to *“over order or order lots of tests that aren't necessarily required”* [P18].

4.1.2 Governance in Different Hospitals

Apart from the overarching ED setting, the contexts of different hospitals also play a part in a clinician's DTODM. All the participating clinicians have worked in multiple different hospitals at the time of their interview, some had also worked in hospitals overseas. The differences in various health organizations were recognized as a factor affecting DTODM. In local hospitals where there were more regimented and uniformed test ordering decision-making, clinicians would analyse and think hard to justify why they order certain tests. Contrary to this, in health settings that provided less test ordering governance, clinicians would tend to order more tests:

“[Hospital 1] is a lot more regimented, in terms of ordering structure and what you can and can't order. So [Hospital 1] is a bit more strict on that... whereas at other places like [Hospital 2], [Hospital 3], they're a bit more lenient with what's regularly ordered” [P2]

The differences could also determine the training and education a clinician receives. Therefore, clinicians' DTODM patterns would be affected by the different governance approaches, as well as training and education experiences specifically built upon the governance.

“I think it would depend on whom I'm working with, so sometimes we have doctors that have trained either internationally or [in] different states that don't have the same training that we did. So that potentially approach a differential or a patient's symptoms differently and other separate tests.” [P16]

4.1.3 Patient Population

There was also some recognition of the patient population influencing test ordering. For example, in EDs that were designated as major trauma centers where there is a higher probability of having patients with traumatic injuries, clinicians recognized that a lower threshold for ordering imaging tests, like X-rays or CT scans, might be warranted. But in a non-trauma designated ED like Hospital A, ordering of medical imaging tests required additional justification and were more closely supervised to reduce unnecessary imaging and associated ionizing radiation exposure.

“There were in [Hospital 4] a major trauma centre and for that reason it will be receiving an awful lot more major traumas than [Hospital 1]... And therefore, you would have a higher proportion of scans coming back with genuine concerning results. And then that feeds into the culture of the place” [P4]

Some clinicians stated that these cultural differences would gradually build into their knowledge base and influence their routine test ordering practices. If they move from a previous organization which allows a relatively liberal test ordering practice to a new one that endorses a different and stringent culture, they could undergo “*quite a shock*” [P3] as they need to adjust their ordering practice formed in the previous site to accommodate the new requirements implemented in the new environment.

4.1.4 Patient Disposition

The disposition of patients was also found to be an influencer of initial ED test ordering, with the belief that certain tests had to be ordered prior to admission. On these occasions many ED clinicians stated that they would order those required tests without considering the clinical indications so that the patient could be admitted:

“...Admitting a patient with appendicitis. I know that our surgical department, they want CRP test, for example. That's not a test that we have in evidence now that it's not particularly useful. And so we were moving away from it. But we still get asked of it all the time. So, you know, now we just order them because that's what our colleagues want in their specialty, you know. So, there's an example where we probably do things because, you know, we're going to get asked to do them by either the specialists or by asked to order by the in-patient teams.” [P19]

In the above situation, even though the tests ordered by the ED clinician might not be clinically indicated or useful in diagnosis, they may still be felt to be procedurally necessary so that patients can be admitted to the right clinical unit and receive essential care. This is because the test ordering expectations for admission in inpatient wards could be different from ED. A test that does not have a clear clinical indication in ED might be a routine test that is expected by the inpatient wards prior to admission. It again demonstrates that the context of diagnostic test ordering in ED is complex and influenced not just by patient presentations.

4.2 Patient/Family Preferences

Another common encounter by ED clinicians is patients visiting ED with certain expectations or preferences of what diagnostic tests they should or should not have. All the clinicians responded that they would start by explaining the risk and benefits of the tests required or refused by the patients, based on the “*red flags*” they identified through the patient's presentation and initial examination:

“...It's important to explain to them, one, that it's not necessary in changing their management or health condition [to order the tests they request]. And two, I think a matter of explaining to them that sometimes tests can do more harm than good if we do go out of our way.” [P1]

“But we usually assess the patient to see whether they would benefit or not, and if not, we'll give you our reasoning for not doing the test, explaining what would be the best test to be done to get to the diagnostic part.” [P10]

In the situation where the patients would still insist on their own preferences, several possibilities were discussed. One is that if the tests required by the patients are not invasive, one alternative would be to order “*therapeutic tests*” (Schmalstieg and Goldman 2010) to “*make both of those expectations within reason*” [P2]. This means that even though the tests might not be clinically useful for diagnosis, clinicians would change their normal test ordering threshold to a lower bar and order them to “*allay their (patients') fears or concerns*” [P4].

Two clinicians also explained two cases when patients/families refused to have tests performed. The first case is a senior patient requiring palliative care rather than having diagnostic tests and treatment, even though the presentation already indicated the tests could help with management:

“but you can only do that in this particular circumstance where, you know, the family is saying, you know, please respect her wish to. You know, have, they want to be palliated.” [P6]

In the second case, the guardian (mother) of an adolescent who suffered from a head injury refused a CT scan due to concerns of radiation exposure, even though the attending clinician suggested the investigation was clinically indicated.

“I'm concerned that I haven't explained it properly and I'm worried that this is my failing. It is just my failing, because I have failed to correctly explain this to the patient in terms of appropriateness of this individual. Now, if I have explained it to them and they just choose not to follow my regulation. Well, I'm happy that they're allowed to [refuse tests]. People [referring to the patient and the family] have to make a bad decision.” [P7]

In both cases, clinicians explained their clinical reasoning for why certain tests had to be performed in order to make a clear diagnosis and provide corresponding treatment. They stated that they made sure the patient families understood the explanation. But they also need to respect “*patient autonomy*”, thus, did not order those tests they deemed necessary.

4.3 Resource Availability

The availability of three different resources has been identified as a factor to influence DTODM, namely, test resources, evidence-based guidelines or pathways, and senior clinicians.

4.3.1 Availability of Test Resources

The first resource is test resources. In the occasion when the test resource is not readily available, clinicians need to “make do” with the available tests. On the contrary, with some resources, like CT scan or MRI equipment, becoming more available in hospitals, there is the possibility that these scans would be ordered more often, a trend already observed in the increasing volume of imaging test ordering in the recent decade.

“I also think over time the availability of tests and has become much more than, you know, C.T. scan as well as MRI is a much more readily accessible in hospitals, but also in the community” [P6]

4.3.2 Availability of Evidence-Based Guidelines or Pathways

The availability of evidence-based guidelines or pathways could also affect DTODM. Having easy access to this knowledge base to assist with clinicians', especially junior clinicians' DTODM, would provide more confidence in clinicians' decisions as well as justifications of why or why not certain tests should be ordered. One clinician also mentioned that the guidelines would help to reduce variations among clinicians' test ordering regarding specific types of presentations and diagnoses.

“I got the challenge back then, that every consultant is very variable. So, you end up, it's sort of depending on their own practice more than...because you end up asking them, you know unless it's really obvious because everyone will give you a different answer. In here probably there's a bit more uniformity because of the the C.T. scan pathway.” [P3]

4.3.3 Availability of Senior Clinicians

The availability of senior clinicians would exert influence mostly on junior clinicians. In Hospital A, it is a common practice for junior clinicians to seek approval or discuss their test ordering decisions with a senior. For tests that are not often ordered or imaging with high radiation exposure, it is also mandatory to have a senior clinician sign off in the electronic test ordering system to order these tests.

“For bigger things like, like if you're doing a CT angiogram where you and it's sort of a younger person, then I really wouldn't order that without having a discussion with, with some more senior consultant.” [P11]

One junior clinician also emphasized the difference in his test ordering practice during the night shift. Because there were fewer clinicians on a night shift compared to a day shift, the somewhat senior clinicians could be busy and not always available for discussion, which led to more tests being ordered.

“Night shift would be different...So you can't always ask this one person because normally he's busy. So, I think I end up ordering more scan without discussing with anyone overnight.” [P3]

4.4 Influences by Senior Clinicians

In the situation where senior consultants were available, it was also identified that their supervision exerts a certain influence over junior clinicians (interns, HMOs, and registrars) DTODM, determined on two levels, the supervision style and a consultant's own test ordering thresholds.

4.4.1 Supervision Style

Some consultants take a more hands-on approach to supervising junior clinicians. They would like to get more involved in the junior's DTODM, whereas other consultants tend to be relatively hands-free, allowing more liberty in the junior clinician's decision making:

"Some consultants like you to run every single thing pass them and others don't." [P1]

There is certainly the risk of missing investigations and nuanced diagnosis by the junior clinicians in cases when they work with hands-free consultants, which has been confirmed by one of the senior clinicians:

"Now, I think there's a danger in the way I've done it. Like there is absolutely the chance that people who appeared simple are going to be missed by my HMOs and stuff that is smaller and potentially dangerous will go through and, and not be got caught." [P4]

4.4.2 Consultant's Test Ordering Thresholds

Some consultants have a higher threshold of test ordering, which indicates that they might order fewer diagnostic tests compared to their peers who have a lower threshold.

"The other factor that influences what you do is ... who your consultant on the floor is. So, you know, for example, there are some consultants that are more aggressive in ordering tests. And conversely, there are some who are far more conservative... And so that affects your practice." [P19]

It could not be established whether the clinicians who would like to get more involved in the junior clinician's DTODM are also those who have a higher test ordering threshold. However, these differences in both the consultant's supervision style and their own test ordering practices could result in variations in test ordering, implying that there could either be test overutilization where unnecessary tests have been ordered or underutilization where certain tests should be ordered to reach an accurate diagnosis and offer appropriate patient management.

5 Discussion

From previous studies and the findings of this study, it can be demonstrated that DTODM is a complex process that considers various contextual factors involved in medical practice. Under certain circumstances, the influence of these contextual factors goes beyond only the patient's symptoms and could override the decisions based on evidence-based medicine. For example, a deep-rooted medical culture of relatively liberal test ordering governance will internalize into the clinician's DTODM and can be challenging to change or modify. This has also been confirmed by Davies et al. (2000) who stated that deeply entrenched values and beliefs underpinning clinical practices were difficult to penetrate. Thus, implementing an intervention on an organizational level to improve DTODM could turn out to be effective as it would target the overarching environment that encompasses clinicians' practice, which has shown to be the case in Hospital A.

A patient's influence on DTODM could be seen as a manifestation of a shared patient-clinician decision making (Stiggelbout 2012), a medical practice that has gained popularity gradually over the decade. Involving patients in the clinician decision making would enable patients to be aware of the benefit, risks and costs of medicine and thus make informed choices. When patients explicitly require or refuse diagnostic tests, clinicians must explain why the test should be considered unnecessary (harm) or essential (benefits over risks and costs) for the diagnosis and treatment. Even though there is still the possibility of a patient's final decision going against the clinician's, their autonomy is at least respected, underpinning the wide-accepted four biomedical ethical principles (Beauchamp 2019). One point that needs to be noted is that during the interview process, none of the clinicians mentioned that they would pro-actively engage the patient in their DTODM, but rather passively if the situation needed them to. In a case when patients have strong expectations of whether to have diagnostic tests, modifying the clinician's DTODM would not make any difference in improving test ordering appropriateness, given that it is the patient that makes the final call.

Resource availability, to be more specific, the availability of senior clinicians, as well as their influences, were mainly reported among junior clinicians. From the results, it could be concluded that junior clinicians' DTODM is greatly impacted by their supervisors. Over-dependence on the supervisors exists where junior clinicians would seek advice without thinking hard enough. This is also when major cognitive bias – confirmation bias (Arnott and Gao 2022) – has been identified in the junior clinician's DTODM. Some junior clinicians mentioned explicitly that they would go to the seniors they knew might share the same thinking pattern as them and avoid those who might give different opinions. Some senior clinicians also observed that junior clinicians DTODM were sometimes “*knee-jerking*” without considering clinical indications carefully. Clinicians' decision making process is imperfect and could be influenced by cognitive biases (Saposnik et al. 2016), regardless of clinicians' experiences and levels. The difference between a senior and a junior clinician is that senior clinicians might be less impacted by the biases because of more experiences and a broader knowledge base accumulated over years of practice. Thus, a junior clinician's DTODM could be affected by their own cognitive biases as well as the senior's, indicating opportunities for major improvement.

Another identified issue is the variation in DTODM among senior clinicians because of their own test ordering style formed over their medical careers. This finding also confirms the result of a previous study (Li et al. 2021), where they explored reasons of why variations among ED test ordering practice exists. The variation implies that there might be potentially helpful tests being ignored or unnecessary tests being ordered (Scowen et al. 2020), both of which were not ideal medical practice since they might not provide the most appropriate patient management or medical resources were wasted. The introduction of evidence-based Care Pathways in Hospital A provided a certain level of uniformity in clinicians' DTODM in ED, but variations still exist, as reported by some clinicians.

The study has several limitations. Even though saturation has been achieved within the existing sample, it is possible that more themes might be discovered, given that a larger sample could be attained. The study was only conducted in one department of a single site, which can limit its generalizability of the factors to be applicable in other contexts. Due to clinicians increased workload and busy schedules caused by the Covid pandemic, the participants explicitly wished to limit the interview time. Given the tight timeframe, it is possible that the participants might not be able to provide in-depth enough thoughts. One last issue is that not all the identified themes in this exploratory study were mentioned by all the clinicians. But these themes have been discussed and identified with the research team as valid. They are insightful and important enough to explain the test ordering decision making from a contextual perspective.

6 Conclusion

Test ordering decision takes various contextual factors into consideration, apart from patient presentations. In an ED setting, it is an even more complex decision process given the urgency and crowd compared to inpatient wards. This study has explored the contextual factors that could influence ED clinicians' DTODM, with four factors being summarized through exploratory semi-structured interviews, including organizational context, patient/family preferences, resource availability, and influences by senior clinicians. The findings contribute to knowledge by providing new insights and explanations regarding the contextual factors that affect clinicians' DTODM in an ED setting. These factors have not been systematically investigated in the extant literature, and also outline an opportunity to introduce novel CDS to assist with clinicians' test ordering decisions and reduce variation (Li et al. 2021).

To design such CDS, behavioral change strategies, such as nudge (Thaler and Sunstein 2009), could be adopted. Nudge focuses on improving people's decision making without limiting choices or affecting incentives, and is “easy and cheap to avoid” (Thaler and Sunstein 2009). It offers new approaches to CDS design that could avoid alert fatigue or electronic health record-related stress among clinicians, which is a common issue in the CDS alerts (Ancker et al. 2021); and has already demonstrated effectiveness in improving public health. This study has identified areas where CDS nudge could be introduced to improve DTODM: focusing on the organizational context and junior clinicians. The next step of the study is to determine how these contextual factors would affect ED clinicians' DTODM on a cognitive level by applying a dual process decision making model for the diagnostic test ordering (Bai et al. 2021). Cognitive biases in the decision making process will also be explored. Lastly, design recommendations for CDS nudge will be proposed. The CDS nudge aims to mitigate the negative impact of cognitive biases by gently guiding clinicians to more clinically appropriate test ordering practice and subsequently reducing UDTs. Future research could also focus on how to address the inconsistent diagnostic test ordering thresholds among ED clinicians, and test ordering expectations in different departments within a health organisation by conducting a noise audit (Kahneman et al. 2021).

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Appendix 1 Semi-Structured Interview Protocol

Topic #1 Interviewee demographics	<ol style="list-style-type: none"> 1. What is your level of experience? (Intern/HMO/Registrar/Consultant) 2. Which clinical unit are you currently working in? 3. How long have you been practicing medicine? 4. Have you worked in other hospitals, either within or outside Hospital A?
Topic #2 Diagnostic test requesting practices	<ol style="list-style-type: none"> 5. Have you received any training regarding diagnostic test requests since you work as a clinician? 6. What would you do if a patient requires to perform a specific test that might not deemed necessary based on your judgements? Or a patient requires not to perform a test that you decide to request? 7. How would different workflows and requirements in different hospitals impact your test ordering decision making? (For physicians who worked in multiple hospitals) 8. Could you give an example of a recent patient case that you have encountered and deemed complex or tricky when you made the test request decision? Please describe the patient presentations and your decision-making process as detailed as you can. <p><i>PROBE a:</i> What information did you use to make the test request decision?</p> <p><i>PROBE b:</i> Can you recall how long it took you to make the decision?</p>

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