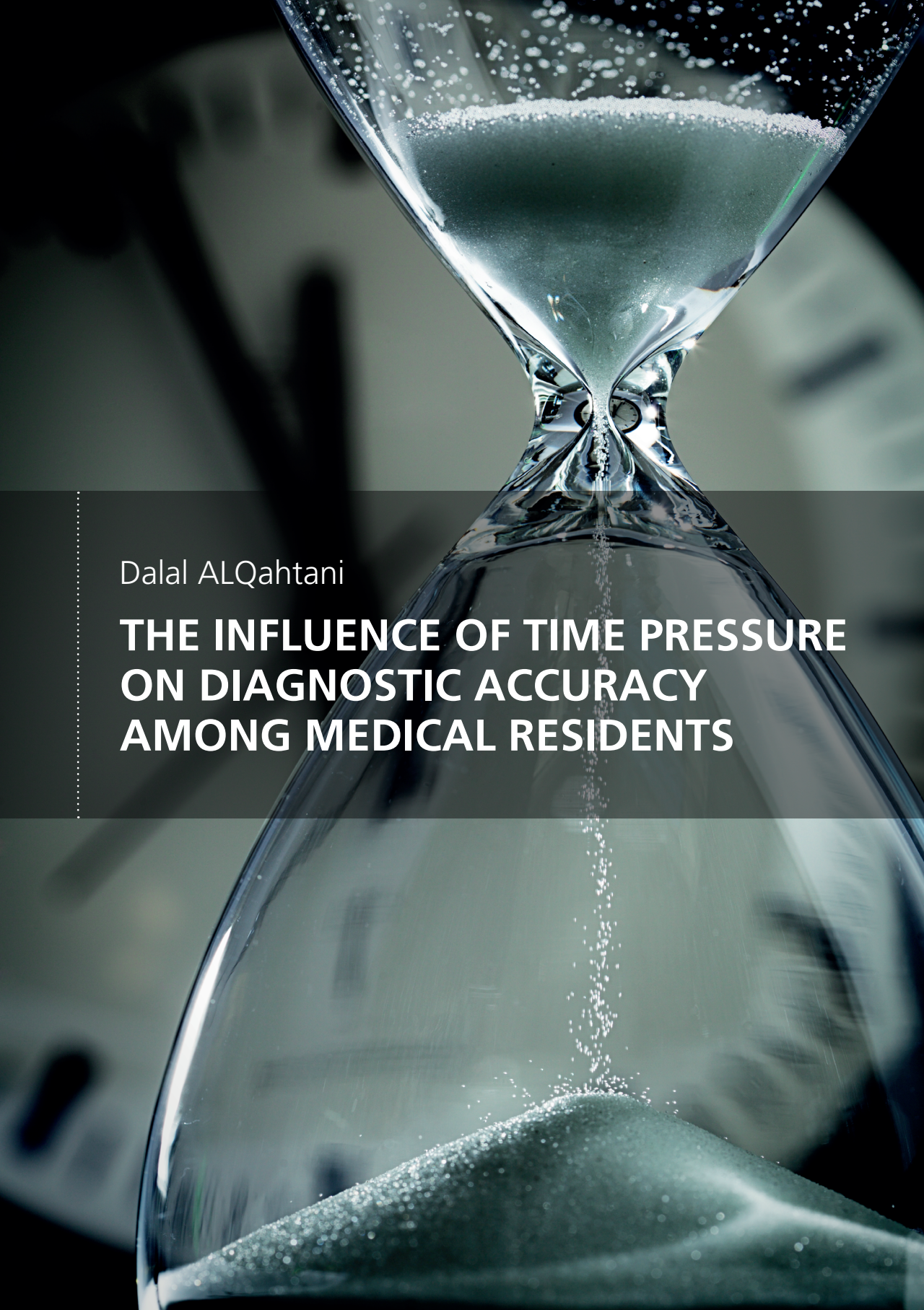

Dalal ALQahtani

THE INFLUENCE OF TIME PRESSURE ON DIAGNOSTIC ACCURACY AMONG MEDICAL RESIDENTS

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The Influence of Time Pressure on Diagnostic Accuracy among Medical Residents

De invloed van tijdsdruk op diagnostische accuratesse van specialiserende artsen

Thesis

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Introduction

Primum non nocere, a Latin phrase that means *"first, do no harm,"* is often quoted from Hippocrates.[1] It highlights a fundamental concept of patient safety and optimal patient care regardless of healthcare system issues. In other words, the system that should provide healing and relief to patients must not expose them to harm.

The report by the U.S. Institute of Medicine (IOM) titled *To Err is Human: Building a Safer Health System* considers patient safety as a major issue facing health care system.[2] The report was a milestone for patient safety and raised a red flag against medical errors in the health care system. In this publication, patient safety was defined from patients' perspective as 'freedom from accidental injury' while an error was described as the 'failure of planned action' or 'using a faulty plan'.[2] These errors can happen in all the stages of patient care, from formulating a medical diagnosis to the provision of treatment. Under optimal health care conditions, they can be preventable.[3] However, when the system faces many challenges, such as too many patients, poor working conditions, limited resources, and others, errors can happen and lead to negative consequences for the patients and the health care system.[2] Medical errors distinguished in the literature include medication errors, diagnostic errors, clinical insufficiency, and surgical mistakes. Although studies have tried to explore factors that contribute to these incidents and the ways in which they could be prevented, their number is still limited.

This thesis aimed to investigate one type of medical error (i.e., diagnostic error) in four studies. These studies focused on time pressure as a causal factor that can hamper physicians' diagnostic accuracy. Through four studies, I explored the issue of time pressure in the workplace and its effects on the diagnostic performance of physicians. More specifically, I investigated (1) the perception of time pressure in the workplace among internal medicine residents, (2) the effects of time pressure and case complexity on the physicians' diagnostic performance, (3) the nature of the negative effect of time pressure (if any) on the diagnostic accuracy of physicians using a larger sample and modified intervention, and (4) the mediating pathways of the time pressure's negative effects on diagnostic accuracy by measuring stress and the number of plausible diagnoses generated during diagnosing the clinical case. The four studies were carried out using both qualitative and experimental approaches. These studies (1 to 4) are presented as Chapters 2 to 4 of this thesis.

To present the rationale for this research project, this chapter introduces the thesis, including an overview of time pressure effects on physicians' health and performance, summarizes the proposed research questions, and outlines the four studies.

MEDICAL ERROR

Two classical studies of medical malpractice published in 1991 in the New England Journal of Medicine are considered as a benchmark for estimating the extent of medical errors. The first one, the 'Harvard Medical Practice Study I,' reviewed 30121 medical records of patients admitted to 51 acute care hospitals in New York State in 1984. They found adverse events in 3.7% of hospitalizations, of which 2.6% caused permanent disability, and 13.6% led to death.[4] Using the same data, the 'Harvard Medical Practice Study II' classified medical errors based on their origin[5] into prevention, performance, drug treatment, diagnosis, system, or unclassified categories. They found that performance errors (35%) are the most common, followed by prevention errors (22%) and then misdiagnosis (14%). However, they reported that 'errors in diagnosis and prevention were most likely to be considered negligent. Moreover, a systematic review analyzed the types of incidents in primary health care and found that medication and diagnostic errors are the most frequently reported incidents.[6]

DIAGNOSTIC ERROR

Medical diagnosis is a clinical judgment that reflects the clinician's expertise, knowledge, and problem-solving skills. It is a step-based process of formulating a clinical decision by examining the nature of a diseased condition.[7] A clinician arrives at a specific diagnosis based on the patient's history and clinical and laboratory information. The clinician must decide what is relevant for diagnosing the case accurately from a potentially large amount of data. However, this is not always a straightforward process, especially when the case is atypical and has complicated signs and symptoms.

Therefore, a diagnostic error is a misjudgment that can have serious effects on patient management, leading to death. It was estimated that the death rate caused by incorrect diagnosis is higher than any other types of medical errors.[5,8] In 2008, Berner and Graber published an extensive review of studies on diagnostic error.[9] They recognized that the diagnostic error rate in clinical specialties is higher (up to 10% to 15%) compared to perceptual specialties, such as radiology, dermatology, and pathology (less than 5%). Moreover, it has been reported that in emergency medicine, the rate of diagnostic errors is high (up to 12%), consistent with excessive stress and added demands of uncertainty and complex decision making in that particular field.[10,11]

A large-scale retrospective study reviewed 15000 medical records from Colorado and Utah hospitals and found that diagnostic errors accounted for 6.9% of adverse events.[8] Another large study in New Zealand assessed 6579 inpatient medical charts and found that errors in

diagnosis contributed to 8% of adverse events, and 11.4% of those errors were evaluated to be preventable.[3] Similarly, a Canadian study reported the incidence of adverse events across hospitals and found that 10.5% of adverse events were related to diagnostic errors.[12]

Diagnostic errors are common, and measures have to be taken to prevent them. To minimize diagnostic errors, it is important to understand their etiology in clinical practice, which is not an easy task because the underlying causes of diagnostic errors involve multiple components of environmental and cognitive factors.[13]

TIME PRESSURE IN CLINICAL PRACTICE

Numerous stressors are persistently affecting physicians. These factors can strain physicians to the point of depression, burnout, substance abuse, suicide, or a mixture of these.[14,15] With the limited amount of time in a day and the many expectations and responsibilities, whether self-imposed or not, stress has become a prevalent phenomenon among physicians and serious problem in the medical field.

Multiple studies have studied the sources of stress in the workplace. Basu et al. conducted a systematic review of the studies investigating sources of stress among physicians and found that long working hours and high work volume and intensity are common predictors of job stress in medical practice.[16] Furthermore, in another study, time pressure and the responsibility for crucial decisions about critically ill patients have been identified as the main stressors among physicians.[17]

Physicians can feel pressed for time for many different reasons. They often see many patients with different severities of disease that may need prompt diagnosis and treatment. Linzer et al. found that 53% of physicians indicated that they felt pressed for time during office visits, which was linked to several negative effects, including stress, burnout, low job satisfaction, and intent to leave the practice.[18] In fact, it was also found that it adversely affected patient safety and led to suboptimal patient care.[18] Moreover, DiMatteo et al. found that physicians who scored low on satisfaction had a negative influence on patient medication adherence.[19]

In addition to treating patients, physicians are also involved in administrative duties, teaching, and community responsibilities. These duties may put physicians under time pressure and unfavorable working conditions. Particularly, using electronic health records has increased administrative duties and led to the reduced direct physician-patient interaction. It has been shown that physicians spend, on average, approximately half of their workday and an additional 28h each month completing electronic patient files.[20] Moreover, time pressure in

the workplace has been linked to staff shortage, lack of teamwork, and the burden to meet certain standards set by the administration.[21]

Effects of time pressure and other stressors on physicians' health

Time pressure in the workplace is a serious issue affecting medical professionals and the healthcare system because of its effects on physician well-being and quality of care. It can lead to low job satisfaction and worsened physicians' health.[18,19]

In 2009, a systematic review found that nine studies out of 10 have established a significant association between work demands and a low level of satisfaction.[22] This was expected, as the organizational environment can have a profound effect on physician well-being. Physicians face long working hours, stress, sleep deprivation, fatigue, exhaustion and burnout.[23] Especially in internal medicine, doctors spend extensive hours in the workplace and experience excessive stress.[24] In fact, higher stress levels were also more common in health care workers compared to other professions.[25] Physicians were found to have higher rates of anxiety, job stress-related depression, substance abuse, and suicide compared to workers in other sectors.[26,27] Moreover, it has been shown that burnout is more likely to affect 45-54 years old physicians, the age group in which work productivity peaks and responsibilities are high.[28] Furthermore, one study showed that out of 35,922 physicians surveyed, 6880 (19.2%) had suffered at least one symptom of burnout.[29] This was found to be associated with long working hours, physicians who worked more than 80 hours/week reported higher rates of burnout (69.2%) compared with physicians who have reduced working hours (38.5%).[30]

It has also been seen that these negative effects of stress in the workplace extend to the physical health of physicians. Abnormal markers of glucose metabolism have been observed in physicians with symptoms of stress.[31] Moreover, a study of more than 40,000 employees found that the risk of work disability was higher among individuals with a higher number of work stressors such as high levels of work demands.[32]

Effects of time pressure on physicians' performance

Based on the above review, an important question is how such time pressure affects physicians' handling of patients' problems. The literature has not yet provided an unequivocal answer; thus, solving this question might have significant consequences for the quality of patient care.

Time pressure in the workplace can have negative repercussions on patients' safety. It can lead to poorer patient care, lower productivity, and reduced professionalism. A study based on doctors' subjective opinions using a questionnaire linked incidents affecting patient care

(suboptimal patient care, expression of anger with patients, serious errors, and even death) to stress symptoms, such as fatigue, high workload, and depression.[33] In a quantitative study, Manwell et al. recognized time pressure as a major source of poor patient care, especially in communicating with patients.[34] Moreover, time pressure can delay reaching a provisional diagnosis, which may put patients' health at risk, particularly in critical cases.[25]

In sum, these studies suggest that stressful working conditions, such as time pressure, have negative effects on patient safety and may lead to diagnostic errors. However, although the current literature seems to implicate time pressure as a source of suboptimal diagnostic performance, the extent to which it directly leads to diagnostic errors is unknown. In the first studies that attempted to assess the influence of time pressure experimentally, it was demonstrated that time pressure not necessarily affects the physician's ability to reach an accurate diagnosis.[35,36] The present thesis attempts to clarify this issue.

When investigating the relationship between time pressure and diagnostic accuracy, it is useful to consider the cognitive processes underlying the diagnostic process. Generally, the medical diagnosis begins with collecting patient information (history, signs, and symptoms), generating provisional diagnosis, testing (ordering, analyzing, and acting on test results), and finally reaching a definitive diagnosis. Various theories have been proposed to explain the processes involved in making diagnoses in clinical practice. One of them is the dual-process theory.[37] Although different dual-process theories exist,[38]they share the basic idea that diagnostic decision-making is a function of two different thinking processes. The first one, called 'system 1,' is non-analytical, implicit, automatic, and involves unconscious processes. On the other hand, 'system 2' thinking is analytical, explicit, controlled, and involves primarily conscious processes. In most diagnostic events, physicians would use system-1 thinking to intuitively and rapidly evaluate the case and generate a list of differential diagnoses and treatment options. System-2 analytical processes are then used to examine the rapidly generated diagnostic hypotheses to confirm or disconfirm them.[39] It is assumed that when the case is typical and straightforward, the physician will use predominately system-1 processes. In contrast, when the case is atypical and complex, the physician is likely to use system-2 processes. Thus, in most diagnostic tasks, it is expected that the two reasoning systems are used dynamically.[37]

Nevertheless, despite the efficiency of system-1 reasoning in solving a clinical case, it is vulnerable to errors.[40,41] However, when system-2 reasoning intervenes, the case information is processed more carefully, deliberately, and systematically. This type of reasoning can reduce diagnostic errors generated by system-1 reasoning.[37,41]

Although diagnostic errors can occur for many reasons, for example, cognitive biases, little is known about the role of time pressure in these errors. In situations where time is restricted, physicians have little time to process and reason about the clinical case, which is likely to affect diagnostic accuracy negatively. On the other hand, greater availability of time would give physicians enough time to collect and process information to reach the correct diagnosis.

In non-medical literature, for instance the psychological literature, it has been suggested that time pressure negatively affects decision-making abilities.[42] For instance, Evans et al. found that the participants under time pressure generated fewer plausible diagnostic hypotheses. [43] Accordingly, it is expected that physicians under time pressure would rely more on non-analytical processes to evaluate the diagnostic hypotheses to compensate for the shortage of time. However, non-analytical reasoning is, as stated above, more prone to errors and biases.[37] For example, premature closure (the failure to consider relevant alternatives after the initial diagnosis) and belief bias (the tendency to evaluate a case based on one's initial belief despite being presented with new information that contradicts that belief) have been found to influence clinical reasoning negatively, particularly under time pressure.[41,43] Nevertheless, this bias was diminished when the participants used a more analytical reasoning approach.[44,45]

Based on this psychology literature, we are tempted to conclude that time pressure has indeed detrimental effects on decision making. The reader should bear in mind, however, that these studies were conducted using quite artificial problems far removed from the problems that a physician encounters in professional practice. Moreover, the number of experiments that studied the effects of time pressure on physicians' diagnostic performance is limited. And the experiments that have been conducted suggest that quick processing of a clinical problem does not necessarily lead to diagnostic error, as no significant differences emerged in the diagnostic accuracy between the quick and slow working conditions.[35,36]

RESEARCH QUESTIONS AND OUTLINE OF THE THESIS

In summary, based on the above literature review of the effects of time pressure on physicians' health and performance, the following questions were raised:

- Several studies have reported that physicians are working under time constraints and experience adverse working conditions. What are the sources of time pressure in their workplace? Do they have negative effects on their health and patient safety? How do they cope? In the study reported in Chapter 2, using a qualitative survey method, I sought to answer these questions, focusing on the actual experiences of a group of physicians.

- Does time pressure have a negative effect on diagnostic accuracy, and if so, to what extent? A first attempt to study the issue experimentally is reported in Chapter 3.
- To what extent do case difficulty and experience moderate the negative effect of time pressure on diagnostic accuracy? In Chapter 4, these two moderating variables are the focus of study.
- What possible cognitive pathways could explain the negative effect of time pressure on physicians' diagnostic accuracy? Stress as a result of time pressure may intervene in the decision-making processes thereby shortcutting the number of diagnostic hypotheses the physician considers. The experiment reported in Chapter 5 test this hypothesis.
- Chapter 6 summarizes the main findings and provides suggestions for remediation.

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2

Time Pressure Experienced by Internal Medicine Residents in an Educational Hospital in Saudi Arabia: A Qualitative Study

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ABSTRACT

Purpose: Residents suffer from high workload and extended working hours, which have several negative consequences on their mental health and patients' safety. Similarly, time pressure, which is also part of the clinical training of medical residents, may have adverse effects on their performance. The aim of this study was to explore internal medicine residents' perceptions of time pressure sources in the workplace, its negative effects on them and their patients and finally what strategies they adopt to cope with them.

Method: This was a focus group qualitative study. Seventeen internal medicine residents from all four years of the residency training were recruited. A semi-structured interview approach was used, and data were analyzed using thematic analysis.

Results: Participants perceived their work as stressful and very demanding. Four major themes emerged to explain the sources of time pressure in the workplace: patient-related factors; practice-related factors; training-related factors; and resident-related factors. In addition, two main themes arose to show the negative effects of time pressure on residents: the effects on residents' health and the effects on residents' performance. Data also showed two main coping strategies, which can be summarized as: active adaptive coping and avoidant maladaptive coping.

Conclusions: This in depth-qualitative study highlights the sources and consequences of perceived time pressure in clinical training of internal medicine residents. Residents feel this adverse working condition could have substantial adverse effects on their health and performance.

INTRODUCTION

Medical residents face many challenges during their training. These challenges include long working hours, high workload, stress, sleep deprivation, fatigue, exhaustion, burnout, and work-life imbalance.[1-3,4] Particularly in internal medicine, residents spend long working hours in the workplace and face excessive demands.[5] They have to deal with many patients during their long shifts and as a consequence often experience stress and time pressure to get the job done. These stressful situations are expected to exert negative effects on residents' psychological and physical status. Martini and colleagues found that residents who worked more than 80 hours a week had higher rates of burnout (69.2%) compared with a burnout rate of 38.5% after reducing their work hours.[6] Similarly, another study showed that working more than 80 hours per week is linked to higher rates of occupational stress among residents.[5] In another study, Rosen et al. investigated the residents' change in depression, sleep deprivation, burnout, and empathy during the 1st year of internal medicine residency.[7] Authors found an increase in the chronic sleep deprivation, depression, and burnout and a decrease in empathy levels from the baseline to the end of the year. These results suggested that throughout the first year of residency, high work demands adversely affected the psychological well-being of residents.

Besides the strains on residents' physical and psychological well-being, these adverse working conditions may as well have detrimental effects on patient safety. For instance, a resident who experiences high workload under time pressure and is fatigued may be prone to commit medical errors.[8,9] This may particularly apply to junior residents with less experience. Indeed, there are some studies that reported residents to admit that stressful working conditions and time pressure resulted in suboptimal patient care, increased medical errors, and cognitive impairments related to clinical judgment.[10-13] A three-year longitudinal study examined the frequency of self-reported medical errors made by the internal medicine residents[14] and found that 34% of residents reported making at least one major medical error throughout the course of the study. Perceived medical errors were associated with higher levels of burnout, higher levels of depression, and reduced quality of life. Another prospective study surveyed 380 internal medicine residents during their training from 2003 to 2008.[8] The findings showed that 39% of residents made at least one major medical error during the study period, which was found to be significantly associated with fatigue and sleepiness during work.

Besides fatigue and long working hours being significant factors that resulted in medical errors, it is not clear whether high workload and time pressure have similarly negative effects resulting in medical errors. In addition, since these studies tend to only focus on a narrow band of residents—mostly junior residents in the first year—it is currently not clear if these

stressful working conditions have a similarly decremental effect on more senior residents. It is possible that more experienced residents are able to apply more effective coping strategies when under excessive workload and time pressure.

Coping strategies have been grouped into active and avoidant strategies. Active coping includes positive adaptation to the situation by modifying the stressor or the way of thinking about it while the avoidant coping strategies are negative adaptations to situations, such as denial, self-blame and alcohol/drugs use.[15] It is important to understand how the residents are coping with time pressure during their work, as the type of coping strategies mediates the negative effects of time pressure on residents.[16] It has been shown that avoidant coping is linked to depression, burnout, and reduced work performance.[17-19]

In summary, it is known that residents experience a variety of work-place related challenges, such as long working hours, high work-load, time pressure, sleep deprivation, fatigue and burnout. It is however not clear how these detrimental factors result in medical errors, such as wrong prescribing of medication or diagnostic errors. It appears from the existing literature that time pressure is a prime candidate for causing diagnostic errors, because when under time pressure residents spent less time dealing with a patient which may make them rush to conclusions potentially without considering and processing all relevant factors.[9,11] This may apply even more to junior residents since they lack the necessary expertise to rely on previous encounters with similar patients and thus need more time for processing all the relevant information. From the current literature it is also not clear how residents cope with these challenges and whether there are differences in coping strategies/behaviors between junior and more senior residents.

In light of the above limitations, the objective of the present study was to shed more light on the issue of perceived workplace time pressure by conducting a focus group study with internal medicine residents. Seventeen residents from all four years of the residency training participated in the study. To our best knowledge this is a first attempt to include all levels of residency training, which is expected to paint a more representative picture of the time pressure sources at different stages of their training are facing. In addition, we tried to explore what the negative effects of time pressure for the residents' psychological well-being and patient safety and finally how they attempt to cope with them.

METHOD

Participants

All residents rotating in Internal Medicine Program in King Khalid University Hospital (KKUH), Riyadh, Saudi Arabia were eligible for the study. The internal medicine training program in KKUH is composed of four years of training where residents are exposed to variety of clinical cases in internal medicine by rotating in different departments such as cardiology, critical care medicine and gastroenterology.

In total, 17 residents participated in the study. Their mean age was 26.5 years (SD = 1.12), and gender was distributed as follows: 10 male and 7 female. See Table 1 for an overview and bread down of the four groups.

Table 1: Profile of the focus groups participated in the study.

Group	Residency level	Number of participants	Gender
FG 1	Year 1	5	3 males, 2 females
FG 2	Year 2	5	3 males, 2 females
FG 3	Year 3	4	2 males, 2 females
FG 4	Year 4	3	2 males, 1 female

Note: FG, focus group.

The residents were divided into four groups according to their level of experience: Residency level 1 (R1); Residency level 2 (R2); Residency level 3 (R3); and Residency level 4 (R4). The institutional review board of the National Guard Health Affairs, Riyadh, Saudi Arabia approved the study (RC10/122).

Procedure

Four focus groups were conducted, each focus group represents one level of training and comprised of 3 to 5 participants. Interviews were conducted in the same hospital over four weeks, with one group each week. Each group was interviewed before the beginning of their weekly teaching activity. Participants received no financial incentives for participation.

A semi-structured approach was adopted for the interviews. See Table 2 for the interview guide with the questions the interviewer asked the participants. The guide consisted of six questions and was pilot tested and amended by two internal medicine residents prior to the study.

Table 2: Interview guide.

Questions 1,2
1. Can you describe the intensity of your workload working hours, number of patients, cases characteristics)? *Prompt: Can you describe atypical working day/week?* *Probe: How do you feel about your work time pressure?*
2. What do you think the factors that influence the time pressure during your clinical work? *Prompt: Do you think cases difficulty, cases number and personal factors increase time pressure?*
Questions 3,4
3. Do you think time pressure has any effects on patient care? *Prompt: Are those effects positive or negative?* *Probe: give examples?*
4. Do you think there is a relation between time pressure and diagnostic errors? *Prompt: (How this relationship operates? examples from your practice, if any?!)* *Probe: Do you think experience affects diagnostic errors? and why?*
Question 5
5. How do you adapt to time pressure? *Prompt: Suggest ways that may help physicians to face time pressure in clinical practice?* *Probe: Do you think educational activities might help physicians to adapt to time pressure?*
Closure
Is there anything else you want to mention about time pressure in medical practice?

The interviews begun with a brief introduction, presenting the aim of the study and the objective of the interview. All participants signed the informed consent form and gave the permission for audio recording of the interviews. Participants were encouraged to express their opinions and deeply explore the underlining causes of time pressure in the workplace, its negative consequences and strategies for coping with it. The average duration of the interviews was 37 minutes (ranging from 30 to 60 minutes). The main researcher (AD) conducted the interviews and guided the discussion, and a researcher (AA) observed the interviews and took notes.

Analysis

All interviews were transcribed verbatim including any grammatical errors made by interviewees. Then anonymized by AA and checked for accuracy by AD and MM. Data were imported into ATLAS.ti 8 Mac, a qualitative data analysis software, for data management and analysis. To analyze the data, verbatim transcripts were coded and thematic analysis was applied based on the model described by Braun and Clarke.[20] Coding started with initial open coding where each sentence in the transcript was read and coded line by line. Then followed by axial and focus coding to find the closely related codes and identify common categories and interrelationships. Emerging themes, subthemes, and key issues were identified and recorded. Then the findings were drafted, debated between authors and then finalized.

RESULTS

The results of the focus-group discussions will be presented in the following order. First, residents' perceptions of the main sources of time pressure in their workplace will be presented. This will be followed by presenting the negative effects of perceived time pressure on their psychological and physiological well-being and their performance. Finally, it will be discussed how residents' cope with these challenges in general and time pressure in particular. Citations are marked with resident training level (R1, R2, R3, R4) to help distinguish between the stage of training, participant number and sex (M/F). For easy comparison, we also refer to junior residents (R1 and R2) and senior residents (R3 and R4).

Main sources of time pressure in the workplace

Coding of the residents' transcripts resulted in four main themes that contained two subthemes each (see Table 3). The four main themes to explain the experienced time pressure by residents were: (1) Patient-related factors; (2) Practice-related factors; (3) Training-related factors; and (4) Resident-related factors. The findings gained for the main themes and their corresponding subthemes will be presented in the next four sections.

Table 3: Sources of time pressure in medical practice as described by internal medicine residents.

Themes	Subthemes	Mentions (%)
Patient-related factors	a. Increased number of patients	26.79% (15.48% J -11.31%S)
	b. Case complexity	11.31% (5.95% J – 5.36%S)
Practice-related factors	a. Working too many hours	14.29% (9.52% J – 4.76%S)
	b. Hospital system	11.31% (6.55% J – 4.76%S)
Training-related factors	a. Difficult consultants	13.10% (11.31% J – 1.79%S)
	b. Preparation for exams and educational activities	6.55% (2.98% J – 3.57%S)
Resident-related factors	a. Experience level	9.52% (4.17% J – 5.36%S)
	b. Roles and responsibilities	7.14% (1.19% J – 5.95%S)

Note: J refers to junior residents (R1 + R2) and S refers to senior residents (R3 + R4).

Patient-related factors

The main sources of time pressure mentioned by the residents were the large number of patients they have to deal with and the level of complexity of the cases.

Subtheme: Increased number of patients

26.79 % of the responses from the residents indicated that when the number of patients they had to see is high, they are more overwhelmed and feel time pressured. There was not large difference between junior residents (15.48%) and their senior counterparts (11.31%). See below for some representative responses:

> 'I totally agree with him, it depends on the rotation and number of patients, if too many patients it will be time consuming, we have to compromise something, if the rotation is light and the number of patients is few, I think we can take our time with every single patient.' (R1, P1, F)

> 'If you have fewer patients it will be less stressful and time pressure than heavier load.' (R2, P5, M)

> 'Load of patients. We used to have 23 patients. So, this might compromise some patient care. If we have a rotation with shortage of staff, sometimes you are the only resident and you are dealing with 10 patients.' (R4, P2, M)

However, some participants also felt that the increased number of patients is dependent on the rotation subspecialty:

> 'It depends on the clinical services because sometimes the services are heavier than the others, for example: the cardiology, nephrology and GI (Gastrointestinal) the turnover of patients is quite a lot, it depends on the rotation but some other services such as for instance endocrinology, I know it's relatively lighter.' (R2, P4, M)

Moreover, some of the 1st year residents raised issues related to rotation organization as the reason they came under time pressure. For example, seeing many patients on their 1st day of the rotation without sufficient guidance:

> 'For example, in my neurology rotation I handled like at start more than10 patients by myself, so, I ended up staying up to 6 or 7 PM every day for the first week.' (R1, P4, M)

> 'Always the 1st day of the rotation, is the most difficult day.' (R1, P5, M)

Shortage of residents was also identified by some participants as a contributing factor to time pressure:

> 'The factors that affect time pressure are the obvious thing, number of residents available, the patients at the floor and the difficulty of the cases.' (R2, P3, M)

> 'Also depends on the number of residents sometimes you are alone only on the floor with 12 to 15 patients.' (R2, p4, M)

Moreover, some participants pointed out that the time of the year is a factor that lead to increased number of patients and associated time pressure. For example, during the summer, an increased number of consultants and residents take vacations, which increases the work schedule. While in winter, the number of patients increase due higher prevalence of diseases outbreaks, such as colds.

> 'For summer months, July, August and September that's usually it's the worse throughout the year while the residents have a shortage, you have only one resident, the resident is asked to see six patients and every patient has a story.' (R2, p4, M)

> 'For example, in October, in November and December when there tends to be outbreaks of certain types of infections or certain types of illnesses that tends to happen during those times, our workload is much heavier and we usually admit 9 to 10 patients a night.' (R3, P3, F)

Subtheme: Case complexity

Some residents expressed their frustration when they are facing difficult cases, since they are usually presented in a complicated manner that require time and effort. In total, 11.31% of the responses mentioned it, with again no substantial difference between junior (5.95%) and senior residents (5.36 %).

> 'As you know nephrology patients most of them are sick patients with end stage renal disease and some other comorbidities, so we faced the problems with these new patients with multiple issues, it was really difficult day, we finished that day almost at 8 or 9 P.M.' (R1, P5, M)

> 'Sometimes the cases are beyond your level.' (R2, P1, F)

In addition, complex cases that present urgent issues, require the full attention from the resident may deviate his/her attention from other patients and in that way result in more time pressure, as one of the participants indicated:

> 'If the patient is very sick or having high blood pressure or some issues, we focus on that patient and forget about other patients, I think he will end up dying if we don't not focus on him 100%.' (R1, P4, M)

Contrary, some participants considered seeing straightforward cases as relaxed and enjoyable experience:

> '…..when you deal with straightforward and simple cases it's really enjoyable and fun and observing the prognosis of it, unlike when you are dealing with one who just sick and sick every single day and there is nothing you can do.'

Practice-related factors

This theme captures practice-related factors, expressed by the residents, as source of their feeling of time pressure. The two subthemes that emerged were working too many hours and issues related to the hospital system. See Table 3 for an overview.

Subtheme: Working too many hours

14.29% of the responses from the residents mentioned that sometimes they have to work for longer shifts, that they are on calls, or have to deal with extended working hours, which made them feel time pressured and exhausted. Junior residents appeared to be most affected since their mentions were more than twice that of senior residents (9.52% vs. 4.76%). See below for some representative responses:

> 'It's not like at 4:15 pm, it is the end of the day, we finish the work and we go home. No, we have to finish all the work even if we stay until 7 or 8 PM. At heavier rotation, we must finish the work and go home, we cannot just excuse our self.' (R2, P2, F)

> 'I think to certain degree, what happens in our institutions is that the time pressure happens mostly on our on-calls because by policy, we are required to see patients as soon as we are consulted. If you get multiple consults, we have the same time limit to be applied for three different cases that you have for one different case.' (R3, P3, F)

Moreover, not only that the residents have to stay for long working hours, they also have to deal with unpredictability in their working schedules, which made them feel more under time pressure:

> 'There is one another factor that will affect time pressure which is there is no fix time for the round, sometimes the attending does the round late like 2:30 or 3 PM with one hour before the ending time to finish everything,…..and that make us stay for late in the hospital like 5 or 6 PM and sometimes 7 PM which make us more vulnerable to make a mistake. In contrast if the round started earlier like 10 or 11 AM you are going to have time to finish the work.' (R2, P5, M)

Subtheme: Hospital system

There was relatively large agreement among the junior and senior residents that the hospital system can be a source of time pressure when it is not functioning well. 11.31% mentioned it in their responses (6.55% junior residents and 4.76% senior residents). Some of the residents mentioned that the unclarity about the rules and regulations of hospital can confuse them and exert pressure on them during being on-call or working hours. As residents from R3 mentioned:

> 'For me personally it's not only the number of cases that I see during my working hours or on-call or the complexity of the cases. It's mainly the unclear rules and criteria about admitting the patients. This is the major factor that contributes to our stress during on-call especially, and also our working hours.' (P2, R3, M)

> 'Yes, sometimes you are referred a case from the ER. It's not clear whether this patient should be admitted and to which service. So, we spend most of our time stressing about whether the patient should be admitted under our team or not. So, if there had been any clear rules, that would have made our job much easier.' (P2, R3, M)

In addition, delayed processes for patient care can cause considerable pressure and unnecessary delayed management for patients. They lengthen the patients' stays in the hospital which put the healthcare system more under pressure:

> 'I would like to add, maybe be the system of the hospital itself, sometimes delayed a process of getting done with stuff like radiologic investigations, lab investigation and interventional procedures.

> You have to do the order, ask the intern, discuss with the radiologist consultant and then he might refuses it. It makes sense to take 2 to 5 min to accomplish it but you finish it in 3 to 4 hours to get that. I am doing thing it's not my job as doctor' (R2, P3, M)

The miscommunication between departments in the hospital, which some participants mentioned, was also an issue of the hospital system that place residents under time pressure.

> 'Handling some difficult cases sometimes require additional involvement of other teams, as well as your own. Sometimes we have other issues regarding delayed management of other departments which are sometimes out of someone's control.' (P1, R3, M)

> 'There could be a miscommunication from the senior to the junior, or the junior to the consultant service. Maybe the system doesn't get our orders through, so some orders are delayed or nurses don't see it or drops out of the system.' (R4, P3, F)

An additional factor that was identified by the participants was the use of paper-based, instead of electronic medical records, that put stress and time pressure on the residents, since the paper-based systems is less time efficient:

> 'When I worked on an institute that is paper-based, I felt more time stressed because I usually have a specific rhythm to work that I lost, and because usually writing the full history by hand is time consuming, also some of us are more adaptive to computers and that is the 1st thing. The 2nd thing is the availability of information, usually we have the consultations from other departments as soon as it is written while in the paper system, sometimes people will come and see the file is used by someone else, so they have to wait to finish to make their note. At the same time, you have difficulty with the hand writing and you don't know what he wrote.' (P1, R3, M)

Several participants also pointed to the importance of the team they are working with such as consultants, other residents, interns and nurses in reducing or increasing the stress:

> 'When you deal with nice team, nice fellow, nice seniors, nice nurses who are willing to do their job properly this will decrease the stress almost immediately.' (P1, R2, M)

'If you have uncooperative team members, difficult residents, not interested or frequent absences then you have to deal with workload, so it gets higher.'(R4, P3, F)

Working night hours was also a source of time pressure, particularly inside the ER, as the resident is the on-call physician to cover the emergency cases:

> '…for me, handling the ER itself or the on-calls; the dayshift or the working hours where everyone is around, the consultant is around, is really different than during the night when you're the face of the whole department. You are the first one who is going to handle the patient, whether he is a critical or an easy case. Handling the ER, taking the decision and you will not have feasible imaging or lab works during the night these may be critical to your diagnosis. So you will have to wait till the morning and just take an impression of the clinical status that the patient is in. So, this is a stressful thing.' (R3, P4, F)

Training-related factors

This theme identified training-related factors of the internal medicine training program as sources of time pressure during their work. Residents mentioned handling difficult consultants, preparing for exams and educational activities as main sources of time pressure.

Subtheme: Difficult consultants

Some residents stated that the manner the consultants deal with them is a source of time pressure. In total, 13.10% of the responses referred to difficult consultants. This was clearly more an issue for junior residents (11.31%) as compared with senior residents (1.79%). See below for some representative responses:

> 'A senior setting unrealistic goal for me in training as junior, they expect me to see 3 to 4 new cases within an hour. These put me in more pressure.' (R2, P3, M)

> 'One more important thing, who are you working with, it is really, really important, sometime you are working with wonderful attending, helpful, encouraging you. On the other hand, you may have a stressful attending, very stressful follow and registrar who are trying to make your life even harder.' (R2, P2, F)

> 'There are levels of stresses, dealing with difficult personalities, it is either a consultant or a team member that's just difficult to handle.

> Especially when you're senior and you have to deal with every situation that you have. Sometimes, the consultant would have strict personality that you would not cope with easily." (R3, P4, F)

Some of the participants complained that some consultants are not good decision makers or are not available for them to help them in dealing with difficult cases:

> 'I think another factor is when the consultants are not that helpful or strong in decision making, so I think the stress is more on us. It affects our clinical day, how we make our decisions.' (R4, P3, F)

> 'Stressed because the fellow doesn't actually participate even the consultant was not around and I am the responsible for anything happen.' (R1, P2, F)

> 'And when you call the consultant he may or may not answer, and you will have to wait for him to wake up and make the decision whether to admit or discharge.' (R3, P4, F)

Other residents also complained that some rounds with consultants take a long time, which put them more under time pressure to finish the assigned tasks with their patients:

> 'Some of consultants will take long time in the round, and after that they are asking us to do a lot of things.' (R1, P5, M)

Subtheme: Preparation for exams and educational activities

A few residents highlighted that preparation for exams in their training program put them under stress and time pressure. This considered 6.55% of the responses (see Table 3) and there was no substantial difference between junior and senior residents. See below for some of these responses:

> 'It is really intense and sometimes you get overwhelmed with studying and trying to compensate for grades and dealing with sick patients on the same time, so you need to have like a clear mind in order to function properly. It's really difficult to describe how intensities are unless you are in the field.' (R2, P2, F).

> 'We also have the stress from the exams. I don't think anyone said that. For me, my daily routine I would be enjoying my work taking

> my time in every case that I see. However, when I have an exam I feel pressured that I have to finish it fast or go study a little bit or be on time to go home and study some more for the exam.' (R3, P4, F)

> 'It varies throughout the year, some months especially before the exam we'll be very, very stressful.' (R2, P5, M)

However, it is not only the preparation for year-end exams, but also the academic requirements throughout the year that put the residents under continuous pressure as one of the participants mentioned:

> 'For example, if I have a presentation to present, and I am required to learn as much as I can during the rotation that I have, if the rotation is four weeks and I have one or two presentations during that rotation, I am required to stop my daily study to focus on the presentation then I go back and I get stressed because I'm not doing my daily reading. At the end of the day, we are both trainees as well as lead physicians. Sometimes taking on both roles is a little bit difficult.' (R3, P3, F)

Resident-related factors

This theme identified factors concerning the residents themselves as the source of time pressure during their practice, such as their experience level, their role and responsibilities and personal factors.

Subtheme: Experience level

A number of participants believed that their experience level and unfamiliarly with clinical cases, was a reason to feel time pressured and stressed when dealing with patients. About 7% of the responses contained references to the perceived level of experience. This was slightly higher for senior residents (4.05%) as compared with junior residents (2.995). See Table 3 for an overview. What follows are some of these responses:

> 'I was more stressed about how to do and deal with everything. Seeing myself with the same cases now as a senior, I am much more relaxed. I know now how to deal with it as I have faced the cases before.' (R4, P2, M)

> 'I think, as mentioned, experience would affect time pressure. The more experienced person would have much tolerant to time pressure.' (R4, P2, M)

> 'One more strong issue that make us really stressed is the lack of information and lack of experience, especially in the on-calls.' (R1, P5, M)

Subtheme: Roles and responsibilities

Some of the residents, in particular senior residents, indicated that being a doctor is a responsibility and demands devotion and working for long hours for their patients. Slightly more than 7% (see Table 3) of the mentions contained references to this and that it sometimes places them under time pressure and stress. This was mentioned by substantially more senior residents (5.95%) as compared with junior residents (1.19%). Some of these responses are provided below:

> 'The bigger responsibility that you have to shoulder, the more stress that you would feel.' (R3, P2, M)

> 'Being a doctor it's not like working in another services, it is not like a paper when you put it on the desk and you come to finish it tomorrow. It is dealing with a patient's life, you have to finish and do everything before you leave.' (R2, P5, F)

The senior residents also mentioned that being seniors put them under pressure, because they have more responsibilities. In addition, they have to embrace multiple roles such as being a teacher, supervisor and role model:

> 'I think the stress in senior years is much higher because being responsible, being on call, you are the most senior and you are the one taking the decision.' (R4, P2, M)

> 'Naturally, you want to be a good role model to juniors, you want to teach them, you want to make them feel welcome in the field and especially being a senior in General Medicine unit…… you are shaping them. Because your shortcomings reflect the whole bulk of medicine. They look at you more than yourself. They see you as the physician they aspire to be or what they don't want to be. So that's an emotional pressure, to be a role model and to teach them as well.' (R3, P1, M)

The Negative effects of working under time pressure

Besides identifying sources of time pressure in the workplace, the participants in our study provided detailed insights in the adverse effects of time pressure. Two main themes emerged,

(1) the effects on residents' health and (2) the effects on residents' performance. For each of the main themes, three subthemes emerged. See Table 4 for a breakdown of subthemes.

Effects on residents' health

This theme summarizes the negative consequences of time pressure on the residents' quality of life and psychological well-being. In particular, factors like stress, fatigue, sleep deprivation were mentioned that affected their personal life.

Subtheme: Stress

Working under time pressure can be a source of emotional stress. More than 16% of the responses contained mentions about stress when they were working extended hours, handling many patients and difficult cases. In particular senior residents mentioned to feel stressed (10.34%) as compared with junior residents (6.03%). See Table 4 and the following quotes:

Table 4: Negative effects of time pressure on internal medicine residents.

Themes	Subthemes	Mentions
Effects on residents' health	a. Stress	16.38% (6.03% J – 10.34%S)
	b. Fatigue and sleep deprivation	6.90% (0.86% J – 4.31%S)
	c. Personal life affected	7.76% (3.45% J – 4.31%S)
Effects on residents' performance	a. Suboptimal patient care	26.72% (18.10% J – 8.62%S)
	b. Medical errors	24.14% (14.66% J – 9.48%S)
	c. Cognitive impairments	18.10% (5.17% J – 12.93%S)

Note: J refers to junior residents (R1 + R2) and S refers to senior residents (R3 + R4).

> 'I think the stress all over the residency just goes up and down, it's never been a stress-free area. Depending on the rotation, stress become less or higher.' (R4, P2, M)

> 'For example, just yesterday I was covering the ER calls. Towards the end of my shift, I have 3 referrals at once so I needed to see them all and review them thoroughly in like half an hour maximum so I can call my consultant and get a decision regarding admission or discharge. Luckily, it didn't affect my patients but I think if it happens several times it can lead to exhaustion, feeling stress and it will produce errors for sure.' (R3, P2, M)

> 'I felt stressed because the fellow didn't actually participate, even the consultant was not around and I am the responsible for anything happen.' (R1, P2, F)

Some participants mentioned that residency should not be a stress-free period; residents need stressful situations where they can learn as much as possible and gain experience. However, there was general agreement that stress should be controlled and monitored:

> 'I think residency should be a stressful program. It should be. If it is a stress-free program, then it is a bad residency program. As a resident, you need to be stressed, you need to be on pressure because these are the things that will lead you to improve.' (R4, P2, M) (chief resident)

'The residency should be stressful. It should be stressful because you are dealing with people lives.' (R4, P1, M)

Subtheme: Fatigue and sleep deprivation

Working long hours and under increased workload, made the residents feel overwhelmed and fatigued. Interestingly, their mentions for this subtheme was relatively low (6.90%) as compared to the other subthemes. However, the mentions where substantially higher for senior residents (6.03%) as compared to junior residents (merely 0.86% mentions). See below for some of the utterances:

> 'There are on-calls where they are tiring and there are on-calls that are light, but if that type of on-call kept happening on a recurrent basis my stress levels would be much higher and there would be much, much higher errors.' (R3, P3, F).

The lack of sleep was also described by some of the participants as being the result of their day and night shifts. They reported an average of 4 to 5 hours of sleep per day:

> 'Usually we sleep late, average of 5 hours maximum.' (R2, P2, F)

> 'Sometimes you get sleep-deprived during specific kinds of rotations. So usually you try to sleep when you can.' (R3, P1, M)

Subtheme: Personal life affected

Finally, some of the residents were concerned that the increased time pressure during their work affected their personal life, such as family and friends. About 8% of the responses contained reference to it (see Table 4), without a substantial difference between junior and senior residents.

> 'We must finish the work and go home. We cannot just excuse our self. Some time we have a plan and we have to cancel everything. We only manage our plans over the weekend. It's stressful.' (R2, P2, F)

> 'It will affect your personal life no matter of your sleeping. Personal life, personal relationships with your family, and your friends, they will be affected.' (R2, P5, M)

> 'I had to compromise on my personal life so that I can be a good physician at the same time a chief resident.' (R4, P2, M) (chief resident)

> 'Sometimes you get off from work and you sleep and come back to work the next day and that is your social life for the time being.' (R3, P1, M)

Effects on residents' performance

The second theme that emerged describes the negative effects of time pressure on residents' performance. In particular, how time pressure may negatively impact the quality of care given to patients. Our participants highlighted the following adverse effects: suboptimal patient care, medical errors and cognitive impairments.

Subtheme: Suboptimal patient care

A large number of mentions (26.72%) by the residents suggest that they perceived their performance with patients as suboptimal when they are working under time pressure. This was mentioned substantially more by the junior residents (18.10%) as compared with the senior residents (8.62%). For example, delaying admitting or discharging patients until the next shift as one participant prescribed:

> 'like when you have 5 patients and you order to discharge them and you forgot to tell the patient to go home, or forgetting one step in the management.' (R3, P3, F).

Moreover, many participants complained rushing from one patient to the other without giving them sufficient time, which adversely impacted the quality of care provided:

> 'I think time pressure has negative effect on me thus my performance will be less. The patient will not be receiving the full care.' (R4, P1, M)

> 'If we're dealing with patient care, patient treatment or patient management as a whole, and we're dealing with a large number, it would be stressful and hard for me accommodate them all.' (R4, P3, F)

> 'If I have less time I will focus on sick patient and less on stable patient and this in fact affect negatively on patient care because the next day I discover some errors in the stable patient which I have to do in the previous day.' (R1, P5, M)

> 'I think we did our best to give what they need from us, but definitely some of them did not get their optimal attention.' (R1, P2, F)

> 'It's more of delaying in the management of the patient because of the time pressure.' (R1, P1, F)

Participants also believed that when they are under time pressure they are less thorough in information seeking and examination of their patients:

> 'Sometimes I don't have time to do the assessment of the pain, so, I just prescribe paracetamol even if the pain is serious and need more investigation.' (R2, P1, F)

> 'Yes. We try to treat him as soon as possible and when he gets better we discharge him. I think we can interfere and control these things if we have more time.' (R4, P1, M)

> 'We might be exhausted and then by the end of the day, some patients that we didn't see, we'd postpone until the next day because we think they're not that critical' (R4, P3, F)

Subtheme: Medical errors

Similar to the previous subtheme, a large number of mentions (24.14%) referred to medical errors. Again, this was mentioned substantially more among junior residents when compared with their senior counterparts (14.66 vs. 9.48%). In particular, time-constraint conditions appear to make them more prone to medical errors:

> 'I think it all depends on the person, some people may use it as a drive to excel but to certain limits but after that point, it may consciously or subconsciously make errors.' (R3, P1, M)

In addition, medication errors were mentioned by many participants, in light of prescribe inappropriate medication or give the wrong dose:

> 'With time pressure we forgot to renew medication or check if the patient on the proper medication or not.' (R1, P4, M)

> 'Actually, the mistake was the previous resident forget to renew the heparin for more than 2 days because he was stressed almost with a lot of patients almost 7 patients, I handled this patient with DVT from the previous resident because he was overwhelmed, he is good but overwhelmed.' (R1, P5, M)

Also, errors related to insufficient assessment of patient's data was mentioned by the participants:

> 'With time pressure, it may lead to that at the end of the day you may miss something trivial, something small because you are being pressured to finish. Something that would lead to a higher complication the next day.' (R4, P2, M)

> '…because you are focusing on something, you missed the tiny thing….that turns out to be later as serious thing that should have been taken into consideration when the patient got in the hospital.' (R2, P4, M)

Subtheme: Cognitive impairments

Finally, a relatively large number of residents mentioned that time pressure diminished their diagnostic performance and threatened the quality of care provided to their patients (18.1%). By being disorganized and not able to carefully collect, analyze and diagnose their patients correctly as the following quotes exemplify. This was more an issue with the senior residents (12.93%) than with junior residents (5.17%):

> 'Usually you just try to go to the most common and the most dangerous or deadly diagnosis. If you can manage those and just keep your patient alive till the morning, I would consider it a job well done.' (R3, P1, M)

> 'Yes, having limited time to review patient and see them thoroughly will affect your judgment.' (R3, P2, M)

> 'At the same time push you not to press an issue because you're pressed for time. Sometimes you'll not go for that second or third time to ask the patient that same question. When usually you have to get that final answer that might change the picture.' (R3, P1, M)

> '….depending on time pressure and difficulty of cases or the consultant himself, all those factors will be stressors for us and make us confused, or unorganized and we cannot focus on each patient, so we may forget something (maybe something important) so it will end up by diagnostic errors or complication of the patient.' (R1, P4, M)

Moreover, time pressure affected the reasoning process negatively, leading to insufficient hypothesis generation as some participants described:

> 'When we deal with difficult cases with time pressure, this will affect how to deal totally with patient from A to Z, because you want to listen to the patient, you want to understand what the problem, you want to reach the diagnosis, to reach the management, and I have one hour with 3 to 4 patients (you will take the 1st two differential diagnosis.' (R2, P1, F)

> 'We missed simple things in the patient; we only focus on the big picture we don't have time to take the details of the patient. We just take the big picture and then we carry the plan we don't have our own plan as a resident only the consultant and the senior. That's it when we carry on. We do not have the time to plan but only to carry it on.' (R2, P2, F)

> 'From my experience, I noticed that the shorter time I have, the less differential diagnosis. …Common is common and that's the rule to go by. At the end of the day, just keeping them alive is sometimes the only thing you can do.' (R3, P3, F)

The negative cognitive effects of time pressure also extend to residents' learning process from their clinical experiences:

> 'When get physically abused your mind just shut up, you can't think you are overwhelmed, tired and exhausted after a long day of going

back and forth to the patients to arrange images so you do not have time to read or learn about it.' (R2, P1, F)

'I have just 15 min to read about it and provide provisional and initial plan' (R2, P4, M)

Coping strategies with time pressure

The interview data obtained from our participants provided also insights in how residents cope with time pressure. Analysis of the data suggest that there are two main coping strategies, which can be summarized as: (1) active adaptive coping and (2) avoidant maladaptive coping.

Active adaptive coping

A large number of the responses (87.14%) referred to active adaptation strategies that were helping residents to enhance their performance while reducing time pressure. They mentioned that time management, supportive working environment, improving knowledge and skills, seeking social support, humor, accepting the reality, exercising and relaxation are helpful techniques. There were not big differences between junior and senior residents in the frequency with which these active adaptive coping strategies were mentioned (40% junior residents vs. 47.14% senior residents). Below are some representative quotes that included these coping strategies:

'Making priorities in my work for each patient to finish the work and communicate with each other, stuff and nurses, and make sure they understand their patient, understand his job, so the work flow will go smoothly.' (R1, P4, M)

'Try to study more and get experience from my work and my seniors, second thing being happy because a lot of stress will make you depressed.' (R1, P5, M)

'At home, the family support makes a huge difference knowing that at the end of the day, your family is gonna be accepting of you no matter what you did at your work and how you feel and that they'll accept you in whatever shape you come into the home with. That's a huge, huge help. Also, yoga, deep breathing does a lot of help.' (R3, P3, F)

'Seeking support. Support comes from your own self resolve, your determination, also come from external sources like your family, your

colleagues, your friend and your seniors. The support of your seniors is very important.' (R3, P2, M)

'When you see the patient getting better, you would not mind the hours that you spent in the case or in the hospital.' (R3, P4, F)

'You need to be relaxed some people they are really affected by time pressure and they are very stressful and this stress make you more stressful and doing mistakes. So, relaxing technique and just laughing with your colleagues and try to relax yourself, destress yourself it's really important things that helping to adapt time pressure (R2, P5, M)

'Organizing is very important. You have to be organized. if you are coming and start your day without clear plan what going to do today it's going to be time pressure for you.' (R2, P5, M)

'Another thing is the support of environment, sometimes a kind word being said to you or you saying it to someone else really does relieve a lot of pressure.' (P3, p3, F)

Avoidant maladaptive coping

On the other hand, some participants described avoidant maladaptive strategies that do not improve their performance. These mentions were however much less than the mentions of the active adaptive coping strategies (total 12.86%; junior residents 7.14%, senior residents 5.71%). These avoidant maladaptive coping strategies temporarily alleviate the symptoms while the stressor (increased time pressure) maintains its strength or becomes even more stressful. Among the maladaptive strategies mentioned by the participants, self-distraction, like watching TV or movies, unhealthy eating habits and behavioral disengagement, such as giving up to deal with stressful situation, were often the result. See below for some representative quotes:

'By far, my most coping mechanism is eating, and you can tell by weight that is increasing, I'm now in my least fit shape.' (R3, P2, M)

'If you know that you can't do it then there's no point in stressing it out in being unable to do it.' (R3, P3, F)

'I watch movies. Movies is one way to escape from the stress and hospital life.' (R4, P2, M)

DISCUSSION AND CONCLUSIONS

The objective of the present study was to shed more light on the issue of workplace time pressure by conducting a focus group study with internal medicine residents. Unlike many exiting quantitative studies,[8,21-23] we managed to run an in-depth qualitative focus group study from all four years of the residency training, which was expected to result in a more complete picture of the time pressure they are facing at different stages in their training. Besides exploring what are the sources of time pressure in workplace, we tried to find out what the negative effects of perceived time pressure for the residents' psychological well-being and patient safety and what kind of coping strategies they apply. Structured interviews were conducted with seventeen residents.

Thematic coding analysis of the transcribed responses of the participants revealed that there were four main themes that emerged as main sources of time pressure for internal medicine residents. These were (1) patient-related factors, (2) practice-related factors, (3) training-related factors and (4) resident-related factors. All of these four main themes generated each two subthemes. Based on the frequencies of utterances (mentions), the data suggest that the increased number of patients constituted the main source of perceived time pressure; most of the responses (26.79%) referred to this as a source of time pressure. The second most pertinent source of perceived time pressure was long working hours (14.29%). Judging by the number of mentions, particularly junior residents perceived this as a significant source of time pressure. Since senior residents mentioned it substantially less frequent, it appears that senior residents become more used to the long working hours as they progress with their training. The third most mentioned source of perceived time pressure was dealing with difficult consultants. Close to 13% of the responses referred to this as a source of time pressure. Most mentions came from the junior residents (i.e., 11.31%).

Our data also demonstrate that there are sizable differences between junior and senior residents with respect to perceived time pressure. The level of experience and roles and responsibilities were the largest sources of perceived time pressure that were most dominant for senior residents and less so for junior residents. This suggests that as the residents progress their training, their responsibilities as a doctor increase which results in feeling more (time) pressured.

As a next step we focused our attention to the negative consequences of perceived time pressure. Interestingly, time pressure affected more residents' performance rather than their health. The three most negative effects were suboptimal patient care (26.72% of mentions), medical errors (24.14% of mentions) and cognitive impairments (18.1% of mentions). Judging by the number of mentions, suboptimal patient care and medical errors were mentioned

twice as much by junior residents, whereas cognitive impairments were mentioned almost three times as much by senior residents.

Finally, our data also provide insights in how residents cope with the negative consequences of perceived time pressure. It is encouraging to see that the residents mentioned using more adapting active coping strategies (87.14%) rather than avoidant maladaptive coping strategies (12.86%). There were no noteworthy differences between junior and senior residents with regard to the use of active coping strategies. Most of the active coping strategies entailed prioritizing tasks and relying on a social/family support network.

What are the implications of these findings? To our best knowledge, this research is one of the first qualitative studies that investigated the perceived time pressure at a broader spectrum of the residency program, ranging from first to fourth year of residency. The study elaborated on the sources of time pressure, its negative effects and how internal medicine resident is coping with it?

Covering four years of the residency program provided significant insights in potential differences between junior and senior residents. From our study it appears that junior residents struggle more with workload-load related factors (number of patients, working hours and how to deal with consultants), which results in suboptimal patient care and more medical errors. These issues seem to be largely resolved when becoming a senior resident, but they make way for new challenges. Senior residents seem to struggle more dealing with their newly acquired roles and responsibilities often feeling disorganized and not able to carefully collect, analyze and diagnose their patients correctly.

In conclusion, this largely qualitative study unearthed a number of influences in the residents' workplace that negatively affected their work satisfaction, health, and performance. While having pleasure in one's work and living a life without too much stress are characteristics worth pursuing, one outcome is particularly worrisome: the fact that residents believe that the conditions of the workplace affect their performance, leading to increased medical error. It is this threat to patient safety that deserves further scrutiny.

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The Influence of Time Pressure and Case Complexity on Physicians' Diagnostic performance

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ABSTRACT

Purpose: Practicing medicine is a cognitively demanding task that consists of the ability to assess the patient, judge the nature of his or her complaints, and make an appropriate diagnosis. A number of factors have the potential to affect the physician's diagnostic performance negatively. Two of these factors are time pressure and case complexity. However, the empirical evidence that supports this negative influence is scant. This study experimentally investigated the effect of time pressure and the complexity of clinical cases on diagnostic accuracy.

Method: Thirty-seven senior internal medicine residents participated in this study. These residents were randomly allocated to two experimental groups (with time pressure vs. without time pressure). These residents were instructed to diagnose 8 case scenarios (4 straightforward and 4 complex cases) presented on a computer by using E-Prime® 2.0. The time pressure group received feedback after each case that they were behind schedule, whereas the control group did not receive such information. The dependent variables were the mean diagnostic accuracy and the mean processing time spent on each case during diagnosis.

Results: Participants under time pressure spent nearly the same time as the group without time pressure in diagnosing the clinical cases. The diagnostic accuracy scores did not differ significantly between the experimental and control group ($F(1,35) = 0.07$, $P = 0.79$, and $\eta^2 = 0.002$). Conversely, a main effect of case complexity was found ($F(1,35) = 203.19$, $P < 0.001$, and $\eta^2 = 0.85$). Participants processed straightforward cases faster and more accurately compared with complex cases. No interaction was found between time pressure and case complexity on diagnostic accuracy ($F(1,35) = 0.003$, $P = .96$, and $\eta^2 < .001$).

Conclusions: Time pressure did not impact the diagnostic performance, whereas the complexity of the clinical case negatively influenced the diagnostic accuracy. Further studies with the enhanced experimental manipulation of time pressure are needed to reveal the effect of time pressure, if any, on a physician's diagnostic performance.

INTRODUCTION

Physicians can make mistakes. According to a report by the Institute of Medicine (IOM), 44,000 – 98,000 people die each year in the United States alone as a result of medical errors.[1] These errors include medication mistakes, surgical errors, the neglect of serious conditions, and diagnostic errors which form a large part of such mistakes. It is estimated that the death rate caused by incorrect diagnosis is higher than for any other type of medical error.[2,3] A Canadian study [4] reported the incidence of adverse events among hospitals and reported that 10.5% of adverse events were related to diagnostic errors. In 2008, Berner and Graber [5] published an extensive review of studies that focus on diagnostic error. The researchers recognized that the diagnostic error rate in clinical specialties is higher (a maximum of 10% to 15%) compared with perceptual specialties such as radiology, dermatology, and pathology (less than 5%). Understanding the etiology of diagnostic error in clinical practice is important because the causes of diagnostic errors involve both environmental influences and cognitive factors.[6]

Practicing medicine is a cognitively demanding task that requires the ability to assess a patient, to judge the significance of signs and symptoms, and to arrive at the appropriate diagnosis. In certain clinical situations, these tasks are not easily performed, particularly when under time pressure. Physicians usually see, per visit, a high volume of cases of varying difficulty level that need diagnosis and treatment planning. Having to deal with many cases, in a limited amount of time, exerts time pressure on the physicians, which may eventually affect the quality of care provided.[7,8] Given that time pressure is a reality in medical practice, and has been linked to stress, fatigue, low job satisfaction, and suboptimal patient care,[9,10] it is important to investigate whether it also has a negative effect on the diagnostic performance of a physician.

Besides time pressure, the nature of the case has also an important influence on the diagnostic reasoning process. Studies have shown that the level of case difficulty influences diagnostic reasoning and accuracy.[11,12] It has been found that complex cases often result in medical error.[13] Combining both conditions, time pressure may hypothetically interact with case difficulty, exacerbating the probability of error. This assumption has, however, not been subjected to detailed investigation and requires further testing.

In addition to the above, it is important to realize that the diagnostic process involves a complex form of thinking, referred to as clinical reasoning, which involves multiple levels of cognition and metacognition.[14] According to Schmidt et al,[15] 'illness scripts' play an important role, which are mental representations of a disease and develop from continuous exposure to similar cases. Once an illness script is formed, it can be applied, rather effortlessly, to

treating new patients. This heuristic process has been coined "non-analytical reasoning," whereas the diagnostic process involving systematic, effortful analysis of a case is referred to as "analytical reasoning" (or system 1 and system 2).[16]

It can be argued that when a physician is under time pressure, he or she has to rely more on non-analytical thinking because there is limited time for slow analytical reasoning. This is particularly a problem if the case is perceived as complex, that is, the physician does not have a well-developed illness script and needs to fall back on systematic analysis of the case.[17] But even if the physician has a developed illness script regarding the case at hand, heuristics are sometimes prone to result in cognitive biases and errors.[18,19]

To examine the extent of the potential issue of time pressure and case complexity on the accuracy of medical diagnoses, more studies are needed. The objective of the present study is to explore the effect of time pressure and case complexity, while diagnosing a clinical case, on physicians' diagnostic accuracy. We hypothesized that physicians under time pressure would spend less time in diagnosing the cases than physicians without time pressure, both for straightforward and for complex cases. Moreover, we hypothesized that the more non-analytical diagnostic mode would reduce the diagnostic accuracy scores obtained by physicians under time pressure in complex cases (but not in straightforward cases) in comparison with physicians who do not experience time pressure.

METHOD

Design

The experiment employed a 2 x 2 experimental study, with 'time pressure' ('under time pressure vs 'without time pressure') as a between-subjects factor, and 'case complexity' (straightforward cases vs complex cases) as within subject factor. The dependent variables were the mean diagnostic accuracy scores and the mean response time for each case. The ethical approval to conduct the study was granted by the Institutional Review Board (IRB) of the National Guard Health Affairs Riyadh, Saudi Arabia.

Setting

An internal medicine residency training program in Riyadh was chosen to recruit the research project's participants. This program is considered as one of the largest programs in Saudi Arabia for training physicians. This program is accredited and operated by the Saudi Commission for Health Specialties (SCFHS), which was established in 1992.[20] The program is divided into two stages: junior residency of two years, named R1 and R2, and two years of senior residency, called R3 and R4. Through the program, the residents are exposed to a

wide range of cases that cover general internal medicine and all subspecialties. The program also provides the residents with the chance to be introduced to the related specialties of dermatology, neurology, and diagnostic medical specialties.[21]

Participants

Thirty-seven senior residents specializing in the internal medicine training program offered by SCFHS (2011-2012) in Riyadh were enrolled in this study. To maximize the homogeneity of the study's population, the inclusion criteria were: a) level of training: the residents were at stage R3 or R4 of their training; and b) age: less than 35 years old. Repeater residents were excluded from the study. The estimated size of the population was 100 residents. The sample was recruited from three main hospitals (King Abdulaziz Medical City, King Khalid University Hospital, and King Saud Medical City). The participants' involvement was voluntary, and informed consent was obtained from each resident. At the beginning of the study, we did not disclose the full purpose of the study because this may cause participants to think or act in ways 'during solving cases' that would yield inaccurate data. However, at the end of the study, both experimental and control participants were debriefed regarding the true objective of the experiment. Participants who completed the required task received a small financial incentive, which is equivalent to one working hour in the local context.

Materials

Eight written clinical cases, four straightforward cases and four complex cases were used for this research (see Table1). Each case consists of a brief description of a patient's medical history, signs and symptoms, and the results of the investigations. The cases were designated into two categories based on their level of complexity: A) Four straightforward cases, in that they represented problems frequently encountered by internal medicine residents. B) Four complex cases, in that they were characterized by their uncommonness and rarely seen by residents or may show an atypical presentation of diseases. The cases were written by experts in internal medicine and were used in previous research of which the data demonstrated that the eight selected cases were indeed complex or straightforward respectively.[22,23]

Procedure

This study was conducted over two months in a computer lab with residents in hospitals. Each session was 60 minutes long. The cases were presented to the participants using E-Prime 2.0 (Psychology Software Tools, Inc. Pittsburgh, Pennsylvania). E-Prime is a programming package for designing and running psychological experiments.[24] Upon arriving at the lab, residents were randomly allocated, either to the "with time pressure" experimental group or to the "without time pressure" control group. This allocation was performed by assigning participants alternatively to either group.

Table 1: Diagnosis of the clinical cases used in the experiment.

Straightforward cases
1- Community acquired pneumonia
2- Acute pericarditis
3- Liver cirrhosis
4- Addison's disease
Complex cases
1- Thyrotoxicosis
2- Septic shock secondary to pneumonia with abdominal aortic aneurysm rupture
3- Inflammatory bowel disease
4- Cushing syndrome secondary to small cell carcinoma

Each resident was seated in front of a computer screen and signed the informed consent form. Then, the participants were instructed to log into the computer program and work in silence without interruption. Upon logging in, the program provided further instructions. The group under time pressure was informed of the following by the initial instructions provided by the computer program:

1. You have a set of clinical cases to diagnose,
2. The available time for diagnosis is short, and
3. You will be informed after each case is diagnosed, how much time remains and what proportion of the complete task remains to be done.

Time pressure perception was manipulated in this experiment by providing the participants with feedback after each case, which was composed of two bars in different color: a green bar indicated the amount of time remaining, and a red bar indicated the number of the cases yet to be diagnosed. This feedback was independent of the participants' performance and gave them the impression that they are always behind schedule. Conversely, the group without time pressure was informed that they had a set of cases to be diagnosed and that the time allocated for the task has been proved to be sufficient.

Prior to the experiment, both groups were given two example cases to get familiarized with the procedure. The actual cases were presented to the participants in random order. The software recorded the response time for each case in seconds.

Analysis

The diagnoses provided by the participants were scored by two experts in internal medicine in a blind (i.e., without knowing the experimental condition under which the responses were given) and independent (i.e., without discussing with each other during the scoring) manner. By following a standardized procedure,[25,26] the diagnosis was judged as accurately correct,

partially correct/partially incorrect or incorrect, receiving scores of 1, 0.5, and 0, respectively. A diagnosis was considered correct when the main component of the diagnosis (i.e., the main/core diagnosis) appears in the diagnosis indicated by the participant, for example: writing "Endocarditis" in the case of acute bacterial endocarditis or "hepatitis" in the case of acute viral hepatitis. A diagnosis was considered partially correct/partially incorrect when one of the constituent elements of the diagnosis appears in the diagnosis written by the participant; however, the main diagnosis was not cited. For example: writing "Sepsis" as the diagnosis in the case of "Pneumonia with sepsis" or "Myopathy" as the diagnosis in the case of "Hyperthyroidism". A diagnosis was considered incorrect when it did not correspond to the main diagnosis, and none of its constituent elements appears in the diagnosis written by the participant (that means, it did not fall into one of the previously noted categories). For example: writing "Acute myocardial infarction" in the case of "Aortic dissection". . All statistical analyses were performed using IBM SPSS version 20.0 (Armonk, NY: IBM Corp.).

A 2x2 repeated-measures ANOVA (significance level: P = 0.05) with the experimental condition (time pressure vs. without time pressure) as a between-subjects factor and case complexity (complex cases vs. straightforward cases) as a within-subjects factor was conducted on the mean diagnostic accuracy scores and the mean response time obtained in the two experimental conditions. This analysis tested the hypothesis that the time pressure would reduce the diagnostic accuracy scores obtained by the group under time pressure in complex cases (but probably not in straightforward cases) in comparison to the group without time pressure.

RESULTS

Thirty-nine residents participated in this study. The descriptive statistics revealed that there were two outliers for which the response time was significantly longer. One outlier was from the experimental group during the solving of difficult cases (mean response time = 520s) and one from the control group during the solving of easy cases (mean response time = 343s). These data points are more than 1.5 interquartile ranges (IQRs) above the third quartile. We believe these values are considered as unusual response times, which may affect the mean response time. Thus, we decided to exclude them.

The remaining 37 participants (18 experimental and 19 control) exhibited the demographics presented in Table 2. After randomization, both the experimental and control groups did not show any significant differences in age or clinical practice.

Table 2: Demographic information for both groups.

Conditions	Demographic features	Values
Experimental group (Under time pressure)	Number of subjects	18
	Age mean in years (range) *Missing data:3*	29.3 (26-40)
	Gender M F	 12 6
	Clinical practice mean in years , (range)	3.9 (1-12)
Control group (Without time pressure)	Number of subjects	19
	Age mean in years (range) *Missing data:1*	28.6 (27-33)
	Gender M F	 14 5
	Clinical practice mean in years (range)	3.6 (2-7)

Response time

Table 3 shows the means and standard deviations of the response time of the straightforward and complex cases for both experimental conditions.

Table 3: Means and standard deviations obtained for response time (in seconds) during diagnosis of the clinical cases as a function of case complexity and experimental condition.

	Under time pressure (Experimental)			Without time pressure (Control)		
	n	***mean***	***SD***	***n***	***mean***	***SD***
Straightforward	18	97.24	33.71	19	107.62	35.17
Complex	18	191.2	69.11	19	205.02	58.09

A 2x2 repeated-measures ANOVA was performed to test the effect of the time pressure (time pressure vs. without time pressure) as between-subject factor and the case complexity (complex vs. straightforward) as within-subject factor and their interaction on response time. The test revealed non-significant differences of time pressure on response time ($F(1, 35) = 0.72$, $P = .40$, $\eta^2 = 0.02$). However, a large significant effect was found for case complexity on response time ($F(1,35) = 114.36$, $P < 0.001$, and $\eta^2 = 0.77$). Straightforward cases were diagnosed more rapidly than complex ones. This outcome constitutes supportive evidence for the validity of the difficulty level of the chosen cases. There was no significant interaction effect of time pressure and case complexity on response time ($F(1, 35) = 0.04$, $P = .85$, $\eta^2 = 0.001$). Participants under time pressure diagnosed the cases with nearly the same speed as the group that was not under time pressure for both the straightforward and complex cases.

Diagnostic accuracy scores

Table 4 shows the means and standard deviations of the accurate diagnosis generated for the straightforward and complex cases under the two experimental conditions.

Table 4: Means and standard deviations obtained for means of accurate diagnosis as a function of case complexity and experimental condition.

	Under time pressure (Experimental)			Without time pressure (Control)		
	n	***mean***	***SD***	***n***	***mean***	***SD***
Straightforward	18	0.80	0.16	19	0.81	0.11
Complex	18	0.25	0.18	19	0.26	0.21

A 2x2 repeated-measures ANOVA was performed to test the effect of the time pressure (time pressure vs. without time pressure) as between-subject factor and the case complexity (complex vs. straightforward) as within-subject factor and their interaction on diagnostic accuracy. The results revealed that there was no significant between-subjects effect of time pressure on diagnostic accuracy ($F(1,35) = 0.07$, $P < 0.79$ and $\eta^2 = 0.002$). However, the results also revealed a significant within-subject effect of case complexity on the diagnostic accuracy ($F(1,35) = 203.19$, $P < 0.001$, $\eta^2 = 0.85$); which suggests that case difficulty significantly affected the diagnostic accuracy. Finally, there was no significant interaction effect of time pressure and case complexity on diagnostic accuracy ($F(1, 35) = 0.003$, $P = .96$, $\eta^2 < 0.001$).

DISCUSSION AND CONCLUSIONS

In this study, we investigated the effect of time pressure and case complexity on the diagnostic performance of physicians. We hypothesized that, when doctors perform under time pressure, their diagnostic skills would be negatively affected when dealing with complex cases but not when dealing with straightforward cases. The assumption is that the induced time pressure would limit the time available to process information through deliberate analytical reasoning,[27] making the participant more depend on non-analytical, heuristic reasoning to process the case. Thus, physicians would spend less time and commit more diagnostic errors, particularly with complex cases. To test these assumptions, we conducted an experiment involving senior internal medicine residents. Straightforward and complex cases were diagnosed under time pressure or without time pressure.

Contrary to our prediction, the results suggest that doctors produced similar diagnostic accuracy scores under time pressure and without time pressure. Although there was not a significant difference between the two groups in terms of diagnostic accuracy, our results

revealed large significant differences in terms of the complexity of the case. Participants spent more time—nearly twice as much—on diagnosing complex cases compared with straightforward ones. Apparently, complex problems presented uncommon features, which needed more exploration and elaboration associated with reflective practice (analytical reasoning) in medicine.[28] Conversely, straightforward cases were processed faster because they presented familiar features. This finding is consistent with those of Mamede et al,[22] who found that case ambiguity affected the diagnostic reasoning of internal medicine residents. Another study found that task difficulty activated reflection and therefore has an influence on the reasoning strategies used.[29] Interestingly, although complex cases took a longer time to diagnose compared with the straightforward ones, it did not necessarily improve the diagnostic accuracy. Most of the complex cases were not diagnosed accurately by the participants. For instance, the "septic shock secondary to pneumonia" case was only diagnosed correctly by one participant. This was despite the fact that our residents were senior; some were even eligible to take the certifying board exam. This result suggests that the time available to generate a diagnosis is not the only factor that may have impacted the diagnostic reasoning process. It appears that the level of expertise, and thus knowledge (i.e., availability of illness scripts) is a crucial factor in generating a correct diagnosis.[6,27] In other words, if cases are complex and thus knowledge is lacking, no matter how much more time was spent on reasoning about them, it did not result in a correct diagnosis because the knowledge is missing to deal with the cases.[13,23,30]

Overall, our finding that there was no significant effect of the treatment on response time nor diagnostic accuracy can mean two things. First, it is possible that time pressure has no significant effect on diagnostic reasoning. This would be in line with the conclusions by Norman and colleagues. Norman et al. divided second year internal medicine participants into two groups and requested that they diagnose 20 clinical cases; one group was requested to be fast but accurate, and the second group was requested to be slow and carful.[31] The researchers found no difference in diagnostic accuracy between the two groups.

A second possibility is that the experimental manipulation was too subtle to cause any significant effect of time pressure on diagnostic performance. The mean difference in response time between both conditions was non-significant and a meager 12 seconds. This may be too little to cause sufficient "damage" to the diagnostic reasoning process. As such, the instructions may have been not sufficiently clear with regard to the limited time available for the entire session and the emphasis on being quick. Although we used two colored bars to visually convey the message that the participants were behind schedule, this visual cue may have been insufficient to result in working faster. This is a limitation of the study. For future studies, it may be more effective to provide additional negative feedback to help the participants interpret the status of the time and progress bars. Providing additional nega-

tive feedback, which is independent of the actual progress, is something that needs further investigation.

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4

Does Time Pressure Have a Negative Effect on Diagnostic Accuracy?

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ABSTRACT

Purpose: Studies suggest that time pressure has negative effects on physicians' working conditions and may lead to suboptimal patient care and medical errors. Experimental evidence supporting this is lacking, however. The present study investigated the effect of time pressure on diagnostic accuracy.

*Method***:** In 2013, third- and fourth-year internal medicine residents at three hospitals in Saudi Arabia were divided randomly into two groups: a time-pressure condition and a control condition without time pressure. Both groups diagnosed eight written clinical cases presented on computers. In the time-pressure condition, after completing each case, participants received information that they were behind schedule. Response time was recorded and diagnostic accuracy was scored.

*Results***:** The 23 participants in the time-pressure condition spent significantly less time diagnosing the cases (mean = 96.00 seconds) than the 19 control participants (mean = 151.97 seconds) ($P < .001$). Participants under time pressure had a significantly lower diagnostic accuracy score (mean = 0.33; 95% CI, 0.23-0.43) than participants without time pressure (mean = 0.51; 95%, CI 0.42-0.60) ($P = .012$). The latter result suggests participants in the time-pressure condition made on average 37% more errors than control participants.

*Conclusions***:** Time pressure has a negative impact on diagnostic performance. The authors propose that the effect of time pressure on diagnostic accuracy is moderated by both the case difficulty level and the physician's level of experience. Post-hoc analyses demonstrated that time pressure affects diagnostic accuracy only if cases are not too difficult and physicians' expertise level is intermediate.

INTRODUCTION

How do physicians perform under conditions of time pressure? The answer to this question has potentially significant consequences for the quality of health care. Presently, no unequivocal answer is available, mainly because direct experimental evidence is lacking. However, the broader literature on the working conditions of physicians suggests that time pressure may have negative effects on performance.

Physicians report that they often work under time constraints and experience stressful working conditions. In a study of working conditions in primary care, Linzer et al[1] found that 53% of physicians complained about time pressure during office visits. The pressure experienced was in turn associated with low job satisfaction, stress, burnout, and intent to leave the practice. A study of 115 internal medicine residents found that 75% of them showed signs of burnout, and those residents were more likely to self-report suboptimal patient care compared with residents without signs of burnout.[2] DiMatteo et al[3] found that dissatisfied physicians negatively influenced patient medication adherence. Moreover, physicians in another study attributed a large number of incidents affecting patient care (e.g., sloppy care, angry communication with patients, serious medical errors, and even death) to stress symptoms such as tiredness, high workload, and anxiety.[4] In a qualitative study, Manwell et al[5] identified time pressure as a major factor affecting the quality of patient care, particularly communication with patients.

Taken together, studies such as these suggest that stressful working conditions have negative effects on patient care and may lead to medical errors. Yet, although time pressure seems to have negative effects on working conditions, the extent to which it directly negatively influences *diagnostic accuracy* is not known. Indeed, it may be possible that being subjected to severe time constraints makes a physician's working life stressful without affecting his or her ability to arrive at an accurate diagnosis. The present study attempts to clarify this issue.

When investigating the relationship between time pressure and diagnostic error, one must consider the cognitive processes involved in making a diagnosis. It is generally assumed that early in an encounter with a patient, and based on limited data, the physician forms a few diagnostic hypotheses that are tested against information gathered subsequently.[6] The emergence of these early diagnostic hypotheses is thought to be a spontaneous and automatic process without the conscious intervention of the physician, whereas searching for evidence in support of these hypotheses is supposed to be a more conscious and analytic process. Deciding which information is needed or relevant is not always a straightforward task, especially when the case is atypical and presents ambiguous and sometimes misleading signs and symptoms.

This description of the process of clinical reasoning fits with current dual-process theories of decision making, which suggest that two distinct psychological processes are at work when a clinician is diagnosing a case: System 1 non-analytical reasoning and System 2 analytical reasoning. Non-analytical reasoning, also called heuristic reasoning, depends on rapid, unconscious pattern recognition during which prior examples or illness scripts stored in long-term memory are retrieved.[7] This type of reasoning is quick, intuitive, implicit, contextualized, and typically efficient in diagnosing routine cases.[8] Despite its efficiency, however, System 1 reasoning is thought to be vulnerable to errors.[9] On the other hand, System 2 reasoning is slow, reflective, sequential, effortful, and particularly used by physicians to diagnose complex cases.[7] This is because under System 2, the available information is processed in a more deliberate and systematic manner. System 2 reasoning may eventually fail, but because of the systematic processing involved, it has been suggested that this type of reasoning minimizes errors generated through System 1 reasoning. As Evans and Curtis-Holmes put it:

> Biases can arise because the heuristic system fails to represent logically relevant features of the problem or represents features that are logically irrelevant to the problem. The evidence suggests that such heuristically generated biases can be inhibited, at least to some extent, by analytic system intervention.[10(p.383)]

Although diagnostic errors have typically been attributed to cognitive biases when using heuristics in rapid System 1 reasoning,[9,11] little is known about how time pressure contributes to such errors. It seems reasonable to assume that having limited time to think and reason about a medical case will have adverse effects on diagnostic accuracy, as compared with a situation in which there is sufficient time to consider all the available information and to systematically evaluate possible hypotheses to eventually reach the most accurate diagnosis.

There is some evidence in the literature (although not the medical literature) suggesting that this is indeed the case.[12] Svenson and Maule[13] found that individuals under time pressure reported feeling impaired in their decision-making ability. In addition, the results of a study by Evans et al suggest that time pressure restricts the generation of inferences based on initial diagnostic hypotheses, as compared with a situation without time pressure.[14] As a consequence, if there is limited time to evaluate diagnostic hypotheses in an analytical manner, the physician would tend to rely more on non-analytical processing to compensate for the lack of time available. Non-analytical reasoning is more vulnerable and prone to bias.[12] One of the most common cognitive biases affecting non-analytical reasoning is premature closure, that is, the failure to consider relevant alternatives after the initial diagnosis,[7] such as when the clinician formulates a diagnosis based on pattern recognition or existing illness scripts without considering other possibilities. Although premature closure is suggested to be

the most common bias, it is only one of more than 40 types of bias that have been identified as affecting clinical reasoning.[9] For instance, belief bias appears to be a likely candidate when a physician is experiencing time pressure.[14] Belief bias is the tendency to evaluate a case based on one's initial belief despite being presented with new information that contradicts that belief. In one study, belief bias was found to increase with rapid responding, which ultimately reduced decision accuracy.[10] Results of similar studies suggest that belief bias can be counteracted by using an analytic-reasoning approach.[15,16] Recently, new neuroscientific evidence has emerged which suggests that the right inferior frontal cortex (IFC) plays a role in minimizing belief bias.[17] However, activation of the right IFC takes time. The researchers found that when activation of the right IFC was restricted by time pressure, the heuristic system could not be inhibited, which resulted in mistakes.

Other studies support the notion that people adapt their thinking strategies to deal with the limited time available. Mandler found that when individuals were put under stress during decision making, the number of alternative solutions they produced was limited compared with those produced by a control group.[18] Likewise, Evans et al found that when individuals were put under time pressure, there was a decrease in the number of generated inferences.[14]

Although the studies reviewed here suggest that time pressure has potentially detrimental effects on diagnostic accuracy, it should be noted that many of these studies were carried out with rather artificial types of problems that people hardly encounter in everyday life. In addition, the number of experimental studies examining the effects of time pressure on the actual diagnostic performance of physicians is limited. Only recently, two studies have been published that examined the issue, involving residents and physicians diagnosing medical cases.[19,20] These studies, though, seem to suggest that time pressure has no particular effect on diagnostic accuracy. For instance, Norman et al conducted a prospective controlled study involving residents, in which one cohort was requested to diagnose 20 medical cases as quickly as possible without making errors, and their performance was compared with the performance of another cohort that was instructed to be careful and slow.[19] The results suggest there was no significant difference in diagnostic accuracy between the quick and slow conditions, although the residents in the slow condition spent more time on diagnosing. In a follow-up study by Monteiro et al, using emergency physicians and residents, the results were replicated, suggesting there was no significant difference between the fast and slow conditions in diagnosing medical cases accurately.[20]

The objective of the present study was to investigate the effect of time pressure on diagnostic accuracy. To that end, we presented to two groups of residents eight clinical cases to diagnose. The experimental group received instructions to be fast and, after diagnosing each case, received feedback on how much time was left and how far they were behind

schedule. This feedback was intended to encourage them to work faster. The control group diagnosed the same cases without any reference to time pressure. We hypothesized that the group under time pressure would spend less time diagnosing the cases than the control group. In addition, we hypothesized that the diagnostic accuracy score of the group under time pressure would be significantly lower than that of the control group. Possible discrepancies between our findings and those of the studies described above are considered in the Discussion section.

METHOD

Design

The study was a randomized controlled experiment conducted in a six-week period during April–May 2014. The independent variable was time pressure (time pressure vs. no time pressure) and the dependent variables were mean response time and mean diagnostic accuracy score. Ethical approval to conduct the study was granted by the institutional review board of the National Guard Health Affairs, Riyadh, Saudi Arabia.

Setting and participants

The internal medicine residency program in Saudi Arabia lasts four years and covers general internal medicine as well as the subspecialties. It consists of two stages, with junior (first- and second-year) and senior (third- and fourth-year) residents.

Forty-four senior internal medicine residents were included in this study. They were recruited from three main hospitals in the Riyadh region (King Abdulaziz Medical City, King Khalid University Hospital, King Saud Medical City). Subsequently, they were randomly assigned to either the experimental (time pressure) or control (no time pressure) condition. After randomization, no significant differences emerged in terms of years of training or age.

Participation was voluntary and informed consent was obtained from those who participated. Due to the nature of the hypotheses, the specific purpose of the study was not disclosed to the participants, because this potentially would influence the validity of the data. Participants were debriefed about the true aim of the study after the experiment.

Materials

Eight written clinical cases were used for this study, with the following diagnoses: Hyperthyroidism, liver cirrhosis, inflammatory bowel disease, Addison disease, aortic dissection, acute viral hepatitis, pseudomembranous colitis, and acute appendicitis. The cases were written by internal medicine experts and had been used in previous studies.[21,22] Each case was presented

in English and was composed of a brief description of a patient's medical history, complaints, signs, and symptoms; physical examination findings; and laboratory test results. See Box 1 for an example case.

Box 1: Example Case from the Eight Written Cases Used in the Study*

A 38-year-old man with a 12-year history of ulcerative colitis was brought to the hospital with diarrhea containing blood, and abdominal pains. He felt fine until 2 weeks ago. Then he had a respiratory infection, influenza-like, and he was prescribed with erythromycin for 10-days. After 6 days of erythromycin he began having severe diarrhea with blood and mucus. The patient had travelled for holidays three months ago, and several fellow travelers had complaints of fever, nausea and watery diarrhea.

Physical examination:
BP: 115/75 mmHg; pulse: 100 / min; temperature: 38° C
Abdomen: distended, diffusely painful on palpation, no audible peristaltic sounds, no signs of peritoneal irritation.

Lab tests:
White cell count: 7200/mm^3, with 60% segmented cells and 19% bands

Imaging tests:
Abdominal X-ray: dilated ascending colon; the transverse colon shows an aneurysm-like dilatation of the splenic flexure and there are visible fluid levels.
Rectosigmoidoscopy: diffusely erythematous and friable mucous membrane.

*The diagnosis for this case is pseudomembranous colitis. Study participants were senior (third- and fourth-year) internal medicine residents recruited from main hospitals in Riyadh region of Saudi Arabia (King Abdulaziz Medical City, King Khalid University Hospital, King Saud Medical City). Residents were randomly assigned to the experimental group (time pressure; n = 23) or the control condition (without time pressure; n = 19).

Procedure

The experiment was conducted in computer labs at the participating hospitals. The cases were presented and data were collected using E-Prime 2.0 (Psychology Software Tools, Inc. Pittsburgh, Pennsylvania). Upon arrival at the computer lab, participants were randomly allocated to either condition and seated separately, so that each participant could only see his or her own computer screen. Participants were asked to work silently without interruptions (no phone calls, talking, etc.). They were informed about the broad purpose of the study—to understand the nature of clinical problem solving—and then were asked to log in into the computer program. The computer program provided all further instructions regarding the task.

For the time-pressure (experimental) group, the on-screen instructions stated that during daily practice all physicians experience lack of time because there are usually more patients to be seen than there is time available. In addition, the instructions stated:

> With the present study we are interested in exploring whether providing feedback about the pace of your work (relative to what remains

to be done) would help you deal with time constraints. Therefore, you will receive after each case you have diagnosed, information about how much work still needs to be done and how much time is left for doing so. If time is running short, you can adapt by working your way faster through the next cases. It helps if you actively imagine yourself in a busy emergency room. There is a large number of patients to be seen during the rest of your shift and only very limited time is left. You will probably not be able to see all the cases, but try to work quickly, without compromising accuracy. Do your best to diagnose as many cases as possible.

To manipulate the perception of time pressure in the experimental condition, a visual cue using two bars was provided on the screen after each case. The number of cases still to be seen was represented by a green bar, whereas the time remaining was shown by means of a red bar (see Figure 1).

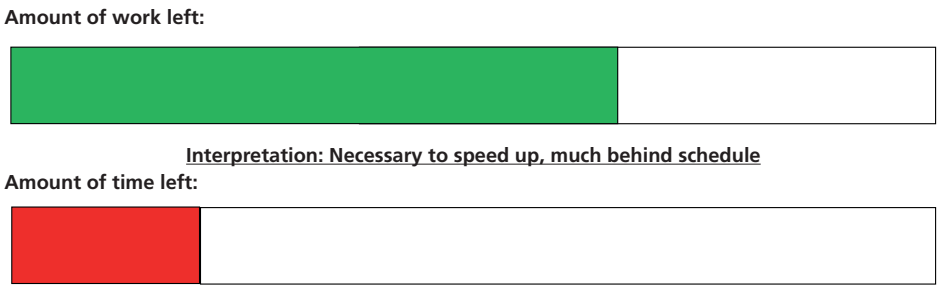

Figure 1: An example of the on-screen visual cues and textual feedback seen by internal medicine residents in the time-pressure condition after entering a diagnosis. This screen appeared after the diagnosis was entered for the seventh of eight cases. The upper bar represents the green bar used to depict the number of cases still to be seen, and the lower bar represents the red bar used to depict time remaining. This feedback was independent of the actual performance of the participant; it was designed to create the impression that the participant was permanently lagging behind schedule.

This information was independent of the actual performance of the participant; it was designed to create the impression that the participant was permanently lagging behind schedule. In addition, text was generated between the two bars to provide feedback about progress. The textual feedback, which was also independent of the participant's actual performance, was intended to be stressful, suggesting that the participant was increasingly falling behind schedule and had to hurry to catch up. In reality, there was no time restriction for responding to individual cases or for the overall experiment. The following are examples of sentences used to induce stress-related time pressure:

> You are on track, but please try to work a bit faster!
> Fast, but still spent more time than what was available for the first two cases
> Necessary to speed up, much behind schedule

For the control group, the on-screen instructions did not contain any reference to time. Participants were merely informed that they had a set of cases to diagnose:

> A clinical case will appear in each screen. Please read the case and type the most likely diagnosis. Type only one complete and precise diagnosis which you find to be the most accurate for the case presented.

Participants in the control group did not receive visual cues or textual feedback on their progress as they worked through the cases.

In both conditions, after receiving the initial instructions, participants were given two example cases to practice on before diagnosing the eight actual cases. Cases were presented in random order and participants typed in their diagnosis for each. Response time was recorded in seconds for each case.

Analysis

Two general practitioners (F.T., M.M.), who were blinded to the experimental condition, independently scored diagnostic accuracy using the following scale: 0 = incorrect, .5 = partially correct, and 1 = correct. A diagnosis was considered correct when it included the main component of the diagnosis or the core diagnosis (e.g., "acute hepatitis A infection" in the case of acute viral hepatitis). A diagnosis was considered partially correct when one of the constituent elements of the diagnosis appeared, but the main diagnosis was not cited (e.g., "hepatitis" in the case of liver cirrhosis). A diagnosis was considered incorrect when it did not correspond to the main diagnosis and none of the constituent elements of the diagnosis appeared (e.g., "acute myocardial infarction" in the case of aortic dissection). The inter-rater agreement was 90.3%, and disagreements were resolved through discussion.

For each participant, a mean score of diagnostic accuracy and a mean response time were generated for all eight cases. A one-way analysis of variance (ANOVA) was performed to determine differences in diagnostic accuracy and response time between the two conditions. Significance level was set to $P = .05$ for all tests. Data were analyzed using SPSS version 21 (IBM Corp., Armonk, New York).

RESULTS

All participants completed all eight cases. Two of the 44 participants were excluded from the analysis because the descriptive statistics revealed that both individuals constituted significant outliers in terms of response time. One outlier was from the experimental group (mean response time = 327.78 seconds) and one from the control group (mean response time = 348.56 seconds). These values are more than four standard deviations (SDs) above the mean response time for their respective groups, and there are thus reasons to believe that these two participants responded in an atypical manner. The remaining 42 participants included 37 men and 5 women. their mean (SD) age was 29.1 (4.44) years and their mean (SD) clinical experience was 3.79 (2.33) years. There were 23 participants in the experimental condition and 19 in the control condition.

Response time

The mean (SD) response time for the time-pressure group was 96.00 (28.69) seconds (95% CI, 83.60–108.41) and for the control group was 151.97 (54.29) seconds (95% CI, 125.80–178.13). The results of the ANOVA indicated that the response time for participants in the time-pressure condition was significantly lower than the response time for the control condition participants: $F(1, 41) = 18.32$, $P < .001$, $\eta^2 = .31$. This difference in response time between the two groups suggests that the experimental treatment did indeed work; participants in the time-pressure condition diagnosed the cases significantly faster than participants in the control condition.

Diagnostic accuracy

The mean (SD) diagnostic accuracy score for the time-pressure condition was .33 (.23) (95% CI, .23–.43) and for the control condition was .51 (.19) (95% CI, .41–.60). The results of a second one-way ANOVA revealed that the time-pressure group had a significantly lower diagnostic accuracy score as compared with the control group: $F(1, 41) = 6.90$, $P = .012$, $\eta^2 = .15$. This outcome suggests that participants in the time-pressure condition made on average 37% more errors than participants in the control condition.

DISCUSSION AND CONCLUSIONS

This study investigated the effects of time pressure on diagnostic performance. We hypothesized that (a) the participants in the time-pressure condition would spend less time diagnosing the eight medical cases than the participants in the control condition and (b) the diagnostic accuracy score of the participants in the time-pressure condition would be significantly lower than that of the participants in the control condition. We reasoned that participants

in the time-pressure condition would spend less time processing the available information analytically and therefore would have to rely more on initial hypotheses produced through non-analytical reasoning. Under these circumstances, analytical error-correction mechanisms cannot do their work properly.[12] To test our hypotheses, we conducted an experiment in which internal medicine residents diagnosed eight written clinical cases either under time pressure or without time pressure.

The results of our study demonstrate that the experimental treatment was successful in manipulating the perception of time pressure: as we hypothesized, participants in the time-pressure condition spent less time per case (on average 56 seconds less) than did control group participants. Moreover, the participants in the time-pressure condition made significantly more errors (37% more on average) than the control group did. In line with dual-process theory,[12] we interpret these findings as follows: If there is insufficient time to fully process a medical case, clinicians rely more on System 1 than System 2 reasoning, because System 1 reasoning is intuitive, effortless, and fast. However, a tradeoff of this intuitive and faster approach is that it may be prone to errors because not all information will be analytically considered and processed. For instance, the results of several studies suggest that time pressure reduces the quality of decision making,[23] causes switching to simpler strategies,[13] and results in a preference for low-risk judgments.[24] Moreover, decisions made under time pressure tend to be less accurate and more prone to cognitive biases, such as premature closure[7] and belief bias.[10,14]

Throughout this article, we have assumed that time pressure mainly affects System 2 reasoning: The physician simply does not have enough time to systematically and analytically process the evidence supporting or falsifying his or her initial hypotheses. However, an alternative explanation, not suggested by the present formulation of dual-process theory, is also possible. Time constraints may affect non-analytical System 1 reasoning as well--or even exclusively. Perhaps time pressure constrains the number and the quality of initial hypotheses generated. If these initial hypotheses are smaller in number and less relevant to the patient problem at hand, then the diagnostic process as a whole suffers. We were, however, not in a position to test this idea as it would have involved asking participants to indicate *all* diagnostic hypotheses that came to mind as part of the diagnostic process. In the present study, we asked only for the most likely diagnosis.

Our findings regarding the influence of time pressure on diagnostic accuracy are at variance with two recent studies on the effect of time constraints on diagnostic reasoning.[19,20] Norman et al[19] asked groups of residents to process a case either quickly or slowly. The instructions for the Speed cohort emphasized that participants should be as quick but as accurate as possible, whereas the instructions for the Reflect cohort emphasized thoroughness and care.

For the Speed cohort, a red timer button was displayed on screen that showed elapsed time on each case. Although the Speed cohort spent about 30% less time on diagnosing the cases than the Reflect cohort, no differences in diagnostic accuracy emerged, suggesting that time pressure has no effect on diagnostic accuracy. Using a similar design, Monteiro et al replicated these findings.[20]

How can the discrepancies between our findings and theirs be explained? We will discuss this incongruity here at some length, because doing so may clarify why time pressure in some cases negatively affects performance while effects are absent in other cases.

A first and straightforward explanation for the differences is that the amount of pressure put on the participants in the Norman et al study[19] may have been less than in our study. The participants in their Speed condition were asked to be quick but as accurate as possible--accuracy was emphasized twice in the instructions. They also received information about the amount of time that had elapsed. In our study, the instructions to the time-pressure group emphasized time constraints and the importance of working fast six times, while accuracy was mentioned once. More importantly perhaps, the visual and textual feedback provided to our participants on their performance was manipulated such that they were *always* behind schedule. This may explain why we found significant differences in diagnostic accuracy between the time-pressure and control groups whereas the other two studies did not. However, what speaks against this explanation is that Norman et al also found an effect on processing time between the two groups (though their response-time difference was smaller compared with ours). If our findings are to have validity, it must mean that time used for diagnosing a case is a less important indicator of what physicians are doing while processing a case than is often thought.

There are signs that this may be the case. Although another study[25] found that amount of time spent on a case was inversely correlated with diagnostic accuracy (i.e., the more time spent, the more mistakes made), Mamede et al[26] demonstrated that under some conditions spending more time leads to better diagnoses. A similar finding also emerged from a recent large study[27] of residents' responses on an internal medicine certification examination, in which further reflection on initial responses improved diagnostic performance, especially for more complex cases. In addition, in the Norman et al study[19] discussed here, residents in the slow condition did not make more mistakes (but rather slightly fewer) than those in the fast condition. Perhaps time spent on diagnosing a case is a byproduct of the reasoning processes involved rather than a crucial causal determinant of performance.

A second possible explanation takes into account the difficulty level of the cases used in the Norman et al study.[19] Those cases were described as fairly complex and the rather modest

performance of both groups (44-45% accurate diagnoses) attests to this level of difficulty. It may be that these cases on average were so difficult that any possible effect of time pressure was simply masked by the difficulty level: even those participants who spent more time could not make much of it. This hypothesis finds support in our own data. When we selected the four most difficult cases (out of the eight used) and repeated the ANOVA, the difference in performance disappeared: $F(1, 41) = 3.33$, $P = .08$, $\eta^2 = 0.08$. The difference in response time remained intact: $F(1, 41) = 15.37$, $P < .001$, $\eta^2 = 0.28$. This post-hoc analysis replicates the findings presented by Norman et al.[19]

There is still another potential explanation for some of the discrepancies. It involves the level of expertise of the participants. Monteiro et al found no effect of time pressure, both for residents and experienced emergency physicians, although the participants in the fast condition used less time to arrive at diagnoses.[20] However, when comparing diagnostic performance between residents and emergency physicians, their results suggest that the emergency physicians were more accurate. It may therefore be possible that those with more experience are simply less susceptible to attempts to put pressure on them. If time pressure hinders mainly System 2 processes, less experienced physicians, who tend to rely more on this type of reasoning relative to their more experienced colleagues, would be more prone to suffer the effect of time pressure. To examine if there were any interaction effects between time pressure and experience in our study, we divided our sample into less vs. more experienced residents using the median as cutoff point and conducted a one-way ANOVA in which we included only the more experienced participants from the time-pressure and control groups. The results of this post-hoc analysis--$F(1, 20) = 0.21$, $P = .65$, $\eta^2 = 0.01$--are in line with the findings of Monteiro et al,[20] suggesting that time pressure does not influence performance. However, differences in processing time between the participants in the time-pressure and control groups remained intact: $F(1, 20) = 10.82$, $P = .004$, $\eta^2 = 0.36$.

Our study has several limitations. First, the mechanism mediating between the amount of pressure experienced by the participants and the mistakes they made remained largely elusive. Some authors point at the role of emotion, in particular stress, as a mediating factor.[28] Stress would in this view lead to more superficial processing of the information in the case. Our design did not allow for direct measurement of such influence. Second, the participants were not experienced physicians but rather residents in their third and fourth years of training. Our post-hoc analyses suggest that more experienced physicians are less susceptible to the negative effect of time pressure, possibly because they rely more on non-analytical reasoning and require less analytical reasoning.[29] A third limitation is the use of written cases to evaluate the effect of time pressure in diagnostic accuracy, which may be viewed as restricting the generalization of findings to real settings. Conducting experiments such as the one described here in a real setting is not feasible, as unavoidable variability in patient

presentation would add too much noise. In addition, it has been shown that clinical case scenarios compare favorably to other methods used to evaluate quality of clinical practice, such as chart abstraction or standardized patients,[30,31] and are a reliable and valid method to detect differences of performance between groups of physicians.[32]

In summary, it seems that the presence or absence of an effect of time pressure on diagnostic accuracy is moderated by both the difficulty level of the cases and the level of experience of the physicians involved. If a case is difficult, having more time to diagnose it may not help. If the physician is experienced, having limited time may not negatively affect his or her performance. However, there appears to be a window within which time pressure *is* influential. When a case is not too difficult (without being obvious) and the physician is not that experienced (e.g., a resident), time pressure may play a negative role by obstructing System 2 analytical processing, by interfering with System 1 non-analytical processing, or both. If one believes—as we do—–that the health care system is populated with patients presenting not-too-complex problems and with physicians of intermediate experience levels, one may assume that negative effects of time pressure on diagnostic performance are endemic.

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5

Factors underlying suboptimal diagnostic performance of physicians under time pressure

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ABSTRACT

Purpose: Time pressure has been implicated in the suboptimal diagnostic performance of doctors and increased diagnostic errors. However, the reasons underlying these effects are still not clear. The aim of this study was to investigate the influence of time pressure on physicians' diagnostic accuracy as well as the mediating effects of perceived stress (emotional pathway) and the number of plausible diagnostic hypotheses (cognitive pathway) on the proposed relationship.

Methods: We conducted a randomized-controlled experiment. Seventy-five senior internal medicine residents completed 8 written clinical cases either under time pressure condition (n=40) or no time pressure (n=35). They were then (1) asked to rate their experienced overall stress and (2) write down any alternative hypotheses they thought of while diagnosing the cases. In a post hoc analysis, we performed a mediation path analysis to test the causal relationship between time pressure, perceived stress, and number of diagnostic alternatives.

Results: The participants who were under time pressure spent less time diagnosing the cases (85.54s vs 181.81s, $p < .001$) and had lower diagnostic accuracy score (0.44 vs 0.53, $p = .01$). In addition, they reported more stress (5.80 vs 4.69, $p = .01$) and generated fewer plausible tentative hypotheses (0.37 vs 0.51, $p = .01$). Two path coefficients were found statistically significant; the first path coefficient was from time pressure to the perceived stress (standardized $\beta = .25$, $p = .029$), and the second negative path coefficient (standardized $\beta = -.32$, $p < .01$) was from time pressure to the number of plausible alternative hypotheses.

Conclusions: Time pressure adversely influences the physicians' diagnostic accuracy through an increased stress response and a reduced number of plausible hypotheses as mediators.

INTRODUCTION

Medicine is a highly demanding profession. Physicians face daily challenges in a high-pressure environment in which they must make critical decisions and potentially life-changing choices. In most situations, these physicians have long working hours, heavy administrative loads, and restricted time for patient visits.[1, 2] They often feel that they do not have enough time to spend with their patients.[3] This kind of busy practice is having negative effects not only on patients, but also on health care providers. For example, it has been shown that time pressure is associated with fatigue, burnout, and low job satisfaction among physicians.[1, 3-5]

Long working hours and excessive workload could have serious consequences for patients' safety. For example, Linzer at al showed that quality of care was lower among time-pressured physicians.[2] Moreover, the present authors found that the negative effect of time pressure could extend to the physicians' diagnostic performance. Using clinical vignettes, we showed that senior internal medicine residents committed more diagnostic errors when they were put under time pressure compared to a control group.[6] Although these results suggest that time constraints would reduce the quality of diagnosis, other studies did not show this effect.[7 8] They suggested that quick processing would not necessarily lead to diagnostic errors.

The purpose of the present study was therefore to replicate the negative effects of time pressure on diagnostic accuracy in a different sample of physicians. In addition, we were interested in the reasons why these effects arise. In particular, we were interested in finding possible pathways that mediate between being pressured and poor diagnostic performance.

To investigate the mechanisms underlying the effects of time pressure, it is useful to consider the thinking processes underlying a clinical diagnosis. Typically, during diagnostic process, the physician collects patient's information (signs and symptoms), generates likely explanations (i.e., tentative hypotheses), critically evaluates them, and then reaches a final diagnosis. A theory often called upon to provide a framework for understanding diagnostic reasoning is dual-process theory.[9] As the theory postulates, diagnostic decision-making is a function of both heuristic intuitions and analytic deliberation. The former is called System 1 thinking while the latter is called System 2. A key difference between the two systems is the speed of processing. System 1 is fast and implicit and uses heuristics and parallel processes that generate hypotheses automatically from long-term memory with minimal effort. System 2, on the other hand, is slow, explicit, and evaluative, requiring the effortful use of working memory, constrained by its limited capacity. In most diagnostic tasks, System 1 reasoning allows physicians to intuitively and rapidly formulate diagnostic hypotheses and management options. These intuitively produced hypotheses will then be confirmed or ruled out analytically through System 2 processes.[9, 10] It is expected that the intuitive system dominates

the diagnosis of routine cases associated with a higher level of certainty, particularly when time is limited. In contrast, if a case is atypical and difficult, then the processing slows down, engaging analytical processes. As noted, the interaction between the two systems is dynamic.

However, time pressure may disrupt the dynamic interaction between the two reasoning systems in controlling the diagnostic task, leading to diagnostic failure. Yet, the mechanisms underlying this harmful effect are not clear. We argue here that at least two pathways, an emotional and a cognitive pathway, alone or in concert, mediate the effect of time pressure on the diagnostic accuracy. Time pressure may cause increased emotional stress levels, leading to mistakes. Alternatively, time pressure may cause a reduction in the number and relevance of tentative hypotheses, increasing the chance that the correct diagnosis is not generated.

A number of studies have argued that time pressure (i.e., imposing a deadline as stressor) changes a person's emotional state, showing that increasing the urgency of a deadline increases stress levels.[11, 12] This kind of time-related stress may have negative effects on diagnostic accuracy. Several studies (although not in medicine) have suggested that being under stress influences the cognitive functions in different ways. For example, Keinan at al. found that stress adversely affects the decision-making strategies, showing that participants shifted to simpler problem solving strategies, such as heuristics, when they were put under stress.[13] Another study found a correlation between the cortisol stress response and risky choices.[14] Moreover, some studies have suggested that stress creates a state of worry, which affects the individual performance on cognitive tasks.[15, 16] In fact, one study showed that when an individual is under stress, increased attention to the stressor depletes the cognitive capacity, which impairs judgment.[17] Therefore, stress may affect reasoning in potentially deleterious ways.

Time pressure can however also simply restrict the number and the relevance of the tentative diagnostic hypotheses. In a previous study, we have demonstrated that physicians under time pressure spend on average 37% less time on a case than those not under pressure. As tentative hypotheses are retrieved from long-term memory, they are maintained in an active state in working memory. Only hypotheses actively maintained in working memory seem to affect the downstream processes of decision-making.[18] It is therefore likely that, under time pressure, the hypothesis-generation and checking process does not fully unfold and therefore lead to a reduction in the number of tentative hypotheses considered. Some even suggest that, under time pressure, physicians even more rely on heuristics to diagnose patients, which cause them to ignore important hypotheses.[10]

In the present study, we empirically examined the effects of time pressure on physicians' diagnostic accuracy, while measuring the amount of perceived stress and recording the number of plausible tentative hypotheses produced in the process.

METHOD

Design

The study was a randomized-controlled experiment. The study protocol was approved by the Institutional Review Board (IRB) of the National Guard Health Affairs Riyadh, Saudi Arabia after the ethical review. The study was conducted between December 2015 and November 2016. The independent variable was time pressure (i.e., time pressure versus no time-pressure), while the dependent variables were response time, diagnostic accuracy, self-reported stress, and number of plausible alternative hypotheses.

Setting and participants

The participants were senior internal medicine residents, enrolled from two teaching hospitals in Riyadh, Saudi Arabia, namely; King Abdulaziz Medical City and King Khalid University Hospital. The residency program of internal medicine in Saudi Arabia covers general internal medicine and medicine specialties that are taken for an average of four years of training. The program consists of two phases, with the first and second year students categorized under the "junior residents", while the third and fourth year students are categorized under the "senior residents". Initially, the principal investigator recruited all the third- and fourth-year internal medicine residents rotating in these two hospitals by sending them emails. The email included an invitation to join a study aimed at understanding the nature of clinical problem solving. Due to the nature of the study, the real intent of the experiment was not revealed to the participants until they had completed the study. The experiment was conducted in eight sessions in the course of seven months.

The participants were randomly assigned to one of two conditions. The time pressure group comprised of 40 participants and the control group (not subjected to time pressure) comprised 35 participants respectively. Participation was voluntary and written informed consent was given by all participants. None of the participants received any financial incentives.

Materials

Participants diagnosed eight written clinical vignettes with the following diagnoses: hyperthyroidism, pseudomembranous colitis, Addison disease, inflammatory bowel disease, acute viral hepatitis, liver cirrhosis, acute appendicitis, and aortic dissection.

Each of the cases consisted of a description of a patient's medical history, present complaints, findings of a physical examination and test results. An example is presented in Table 1. All cases were based on real patients with a confirmed diagnosis and had been used in previous studies with internal medicine residents,[6, 19] which allowed us to select cases that had shown to be at an intermediate level of complexity. Cases were presented to the participants online with Qualtrics Software (Qualtrics, Provo, UT, USA), a web-based testing system.

Table 1. Example of case (correct diagnosis: Addison's disease) used in the study with time pressure group (n=40) and no time pressure group (n=35)*

A 45-year-old man presented with complaints of nausea, vomiting and diarrhoea of one-week duration. The patient has had fatigue, malaise, anorexia, and episodes of abdominal cramps over the past six months. He also complains of dizziness and fainting sensation when rising from bed in the morning, and refers decreased sexual interest. He lost 9 kg of weight in the last 4 months. **Physical examination:** The patient is dehydrated and emaciated. His skin is dark in the face, on his hands, the extremities, chest and back. Reduction of axillary hair. BP and pulse lying down: 105/80 mm Hg, 90/min. BP and pulse standing upright: 80/50 mm Hg, 104/min. Heart and lungs: no abnormalities. Abdomen: diffusely painful on palpation, with no signs of peritoneal irritation. Fundoscopic examination: grey-white patches surrounded by areas of dark choroidal pigment. **Lab tests:** Hb: 10.6; Ht: 38%; white cell count: 6600 with 20% eosinophils; sodium: 128; potassium: 5.9; creatinine: 2.0; urea: 39; chloride: 96; calcium: 11.1; bicarbonate: 20. Faeces examination: Strongyloides stercoralis. **EKG**: normal **Imaging tests:** Chest X-ray: no abnormalities Abdominal X-Ray: bilateral calcification in the adrenal glands.

*Participating residents were third and fourth-year internal medicine residents

Procedure

The study took place in the computer labs located within each of the designated hospitals. Participants of both groups were randomly seated and requested to read through the study's instructions provided on their computer screens. All the participants were instructed to work individually in silence avoiding any interruption by phone calls, side-talk, etc. It was not allowed to consult any resources.

Once the participants started, they were asked to enter demographic information including subject number, age, sex, year of graduation, and number of years in clinical practice. Subsequently, they were informed that the experiment comprised of two parts. The first part was to diagnose the electronically-presented clinical cases by entering the most likely diagnosis in the available space. The second part would be explained after finalization of the first part. The on-screen instructions were provided based on the study's condition.

For the first part of the experiment (diagnosis of the clinical cases), the instructions for the time pressure condition read as follows: "This study is concerned with an issue that all doctors face in their daily practice: lack of time. There are usually more patients to be seen than there is time available. We are interested in exploring whether providing feedback about the pace of their work (relative to what remains to be done) would help doctors deal with time constraints. Therefore, you will receive, after each case you have diagnosed, information about how much work still needs to be done and how much time is left for doing so. If time is running short, you can adapt by working your way faster through the next cases. It helps if you actively imagine yourself in a busy emergency room. There is a large number of patients to be seen during the rest of your shift, and only very limited time left. You will probably not be able to see all the cases, but try to work quickly, without compromising accuracy. Please do your best to solve as many cases as possible."

Time-pressure perception was manipulated visually via two bars automatically displayed after each case. A green bar represented the number of cases still to be seen whereas a red bar showed the amount of time left. The two bars were designed not be linked in any way with participant performance but to encourage them to work as fast as they could. Additionally, written feedback was given under the two bars indicating that they were progressively falling behind schedule (regardless of their performance). This procedure was successfully used in a previous study.[6]

After completion of the first part, participants were asked to rate the overall amount of the stress they experienced while they were solving the cases on a nine-point Likert scale ranging from "I felt extremely calm and relaxed" to "I felt extremely stressed".

In the no time pressure condition, participants were requested to diagnose the clinical cases without any time restriction. At the end of the first part of the experiment, they were requested to fill in the same stress Likert scale as the experimental group.

In the second part of the study (reviewing of the diagnosed cases), participants of both experimental and control groups received the same instructions. They were shown the first and second lines of each case (which included the patient age, gender and the main complaint) with the diagnosis they provided during the first part, and requested to write down which, if any, other possible diagnoses crossed their minds while diagnosing the case. Time was not constrained for this part of the experiment.

In both conditions of the experiment, participants were given the chance to practice on one example case before diagnosing the actual cases. All participants diagnosed the same set of cases, but in random order. After completing the session, they were not informed about the

correct diagnosis and were asked not to speak to their colleagues about the cases until the end of the study. Case response time, final diagnosis, tentative hypotheses, and stress were recorded by Qualtrics Survey Software and exported as a data file.

Analysis

Participants' diagnoses and hypotheses for both the first and second parts were scored independently by two board-certified experts in internal medicine (M.M., G.A.), who were blinded to the experimental condition under which they had been given.

For the first part of the experiment, the diagnosis provided by the participants to each case was scored according to its *accuracy* as correct, partially correct or incorrect, receiving scores of 1, 0.5 or 0, respectively. A diagnosis was considered *correct* when the core correct diagnosis was given by the participant (e.g., 'acute hepatitis' in a case of 'acute viral hepatitis'). When the diagnosis was not the correct one but one component of the diagnosis was mentioned, it was classified as *partially correct* (e.g., 'sepsis' as the diagnosis in a case of 'pneumonia with sepsis'). Finally, when the diagnosis written by the participant did not fall into one of these categories, the diagnosis was considered *incorrect* (e.g., 'ectopic pregnancy' in the case of 'acute appendicitis'). Scoring consensus was achieved in 85% of the diagnoses, and discrepancies were resolved through discussion. This procedure was identical to the previous study by ALQahtani et al.[6]

For the second part of the experiment, the generated tentative hypotheses were simply scored by counting the number of possible diagnoses written for each case. Only new plausible diagnoses were counted. Inter-rater agreement was 84% and disagreement was resolved through discussion.

We performed separate one-way ANOVAs to determine differences between experimental conditions in mean response time, mean diagnostic accuracy, mean stress level, and mean number of generated plausible tentative hypotheses. The significance level was set at p= .05 for all the comparisons. SPSS 24.0 for Mac (Armoonk, NY:IBM Corp) was used for the analyses. In a post-hoc analysis, we conducted a mediation path analysis to explore the causal relationship between time pressure, perceived stress, and number of diagnostic alternatives.[20] (It was not possible to include diagnostic accuracy as the dependent variable, because its scores were obtained before stress level and number of diagnostic alternatives were measured.) The model is depicted in Figure 1.

This model allowed us generating path coefficients (standardized regression weights) to explore the extent to which time pressure and stress have an effect on generating plausible alternatives. Thus, there are a number of hypotheses that can be tested. For instance, if

Path B and Path C' are significant and sizable, but Path A is not significant, it would suggest that there is a direct and independent effect of stress level and time pressure on generating plausible alternative hypotheses. Alternatively, it is possible that only time pressure has a direct effect on the generation of plausible alternative hypotheses. If that is the case, it would be signified by a significant and sizable Path C' (and possibly Path A, since time pressure is expected to induce stress), but no significant Path B. Finally, it is also conceivable that stress level is a mediator between time pressure and the number of plausible hypotheses that can be generated. In such a case, on would expect significant and sizable factor loading for Path A and Path B, but not for Path C'. The analysis was conducted using IBM SPSS AMOS 21.0.

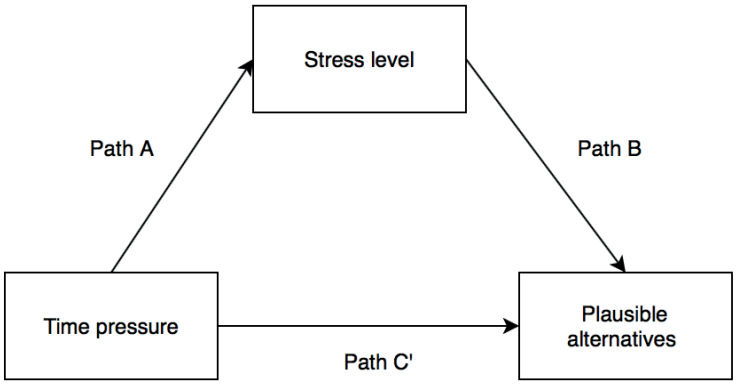


Figure 1. Mediation model of the causal relationships between time pressure, stress, and number of possible diagnoses generated

RESULTS

Seventy-five senior internal medicine residents participated in this study. They were randomly assigned into two groups (time pressure versus no time pressure). Their demographic features presented in Table 2. After randomization, no significant differences emerged between the two groups in terms of age, sex and years of clinical practice. All participants completed the same eight cases.

Table 2: Participants' demographic information as a function of experimental condition

	Time pressure condition (N = 40)	No time pressure condition (N = 35)
Age*	28.13 (1.72)	27.51 (1.76)
Gender (female; male)	14; 26	14; 21
Years of clinical practice*	3.4 (1.2)	3.17 (1.45)

Means (standard deviation into brackets)

Response time

Table 3 shows the mean of the response time for both conditions. There was a highly significant difference between the experimental and control groups as determined by one-way ANOVA ($F(1,73) = 34.89$, $p < .001$). This finding validates our time pressure manipulation; participants in the time-pressure condition diagnosed cases twice as fast as the control group.

Diagnostic accuracy

Table 3 presents the mean scores of participants' diagnostic accuracy performance recorded for each case under both conditions. There was a significant difference between the time-pressure group and control group as shown by one-way ANOVA ($F(1,73) = 5.83$, $p = .01$). These results suggest the participants in the time pressure condition committed more mistakes than the control group.

Table 3: Means and standard deviations of response time and diagnostic accuracy scores generated by 75 internal medicine residents in the time pressure group (experimental condition) or no time pressure group (control condition) diagnosing Eight clinical cases*

	Time pressure condition (N=40)		No time pressure condition (N=35)	
	Mean (SD)	**95% CI**	**Mean (SD)**	**95% CI**
Response time	85.54 (33.85)	74.72 to 96.37	181.81 (96.60)	148.63- 215.00
Diagnostic accuracy score	0.44 (0.18)	0.38-0.50	0.53 (0.15)	0.50- 0.58

Abbreviations: SD: standard deviation; 95% CI: 95% confidence interval.
*Participating residents were third and fourth-year internal medicine residents recruited from two major hospitals in Riyadh region, Saudi Arabia (King Khalid University Hospital and King Abdulaziz Medical City)

Stress level (the emotional pathway)

Table 4 shows the mean scores of stress reported by participants in both conditions. The findings suggest that participants in the time-pressure condition were more stressed than the participants in the control condition ($F(1,73) = 4.701$, $p = .05$).

Tentative hypotheses (the cognitive pathway)

Table 4 presents the mean number of plausible alternative hypotheses generated by the participants for both conditions. One-way ANOVA revealed that the group under time pressure produced fewer plausible differential diagnoses than the control group ($F(1,73) = 6.521$, $p = .01$).

Mediation path model

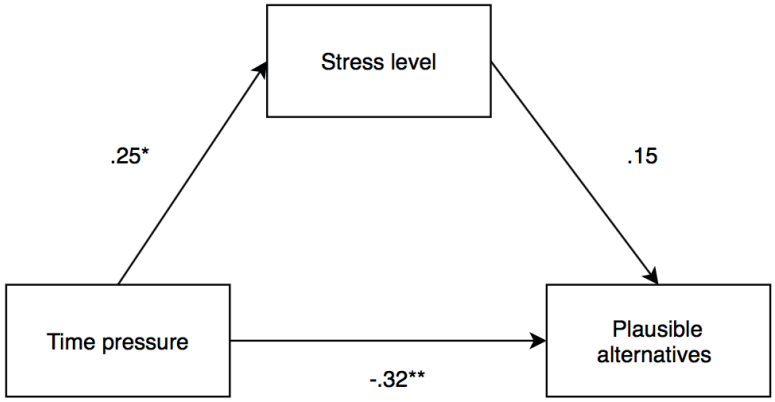
The results of the mediation analysis are depicted in Figure 2. The results suggest that only two path coefficients were statistically significant. The first was the path coefficient from time pressure to the perceived stress (standardized $\beta = .25$, $p = .029$); more time pressure

Table 4: Means and standard deviations of overall stress (the emotional pathway) and number of plausible tentative hypotheses (the cognitive pathway) generated by 75 internal medicine residents in the time pressure group (experimental condition) or no time pressure group (control condition) diagnosing eight clinical cases*

	Time pressure condition (N=40)		No time pressure condition (N=35)	
	Mean (SD)	**95% CI**	**Mean (SD)**	**95% CI**
Overall stress	5.80 (2.26)	5.08-6.52	4.69 (2.18)	3.94- 5.43
Number of plausible tentative hypotheses	0.37 (0.22)	0.30-0.44	0.51 (0.27)	0.42-0.60

Abbreviations: SD: standard deviation; 95% CI: 95% confidence interval.
*Participating residents were third and fourth-year internal medicine residents recruited from two major hospitals in Riyadh region, Saudi Arabia (King Khalid University Hospital and King Abdulaziz Medical City)

let to higher levels of stress. The second significant negative path coefficient (standardized β = -.32, $p < .01$) was from time pressure on the number of plausible alternative hypotheses; more time pressure let to significantly lower number of plausible alternative hypotheses. Finally, there was no significant association between stress and the number of alternative hypotheses (standardized β = .15, $p = .19$).



Note: * $p < .05$ and ** $p < .01$
Figure 2. Mediation model of the causal relationships between time pressure, stress, and number of plausible diagnoses generated

DISCUSSION AND CONCLUSIONS

This study examined the effects of time pressure on physicians' diagnostic accuracy as well as the mechanisms mediating these effects. We hypothesized that the group with time pressure would spend less time diagnosing the cases and make more diagnostic mistakes than the control group. In addition, we argued that time pressure leads to restrictions in the diagnostic

reasoning process, possibly mediated by a stress response (an emotional pathway), the production of fewer and less adequate tentative hypotheses (a cognitive pathway), or both. To test these hypotheses, eight written clinical vignettes were diagnosed following instructions that encouraged time pressure or no time pressure conditions.

Our results are largely consistent with the hypotheses put forward in this study. Participants in the time pressure condition spent less time (less than half) diagnosing the cases than the control group (86 seconds versus 182 seconds, respectively). This result suggests that the time pressure intervention was successful. Furthermore, the diagnostic accuracy was negatively affected under time pressure; participants made more mistakes when faced with time pressure. Therefore, the results of this study provide additional evidence of the negative effects of time pressure on diagnostic accuracy. Some studies have failed to find negative effects of time pressure on diagnostic accuracy.[7, 8, 21] This discrepancy with our results was explained at length in a previous paper.[6]

Although the evidence in the medical literature is contradictory concerning the effects of time pressure on physicians' diagnostic accuracy, converging evidence from the psychology domain is in line with the findings of the current study. Based on dual-process theory,[9] if individuals lack sufficient time to process information fully, they rely more on System 1 (non-analytical, heuristics) than System 2 (analytical, evaluative) reasoning. Time pressure seems to be a context in which an informational overload or a lack of processing opportunity occurs, leading to the automatic non-analytical processing of information. Depending on this kind of System 1 thinking can generate biases that may reduce diagnostic accuracy. For example, it has been shown that, when participants were asked to respond quickly, heuristically generated biases dominated their answers.[22-24] Moreover, several studies have shown that, under time pressure, stereotyping[25] and risky decision making[26] emerge. It should be noted that the cases used in this study were in an intermediate level of difficulty as shown by the mean scores (44%–54% accurate diagnosis); when cases are not straightforward, relying excessively on System 1 tends to decrease accuracy[9] because, when the initial hypothesis is wrong (the likelihood that this happens increases with case difficulty), it cannot be repaired if System 2 is not engaged.

In the current study, we studied possible mediating mechanisms moderating the effects of time pressure. We investigated two possible pathways: an emotional and a cognitive pathway. For the emotional pathway, we explored the role of stress as a mediating factor of time pressure. The results of the mediation analysis demonstrated that participants in the time pressure condition were more stressed while diagnosing the cases compared to the control group. Perhaps this kind of negative emotional state experienced by the time pressure group is the reason underlying their poor diagnostic performance. In fact, these findings direct

our attention to the link between emotional and cognitive functioning. Several studies have shown the effects of stress on memory, knowledge retrieval, and attention.[27-29] For instance, stress-induced cortisol levels have been found to be correlated with reckless decisions and poor memory performance.[14, 30] Furthermore, stress adversely influences decision-making performance, as participants under stress were found to adopt simpler strategies when they were asked to solve problems by shifting to heuristics and relying more on shallower rather than evaluated information.[13]

Interestingly, the path model also demonstrated that the level of experienced stress was not a significant factor in determining how many alternative diagnoses were generated. Only time pressure had a significant negative direct effect on this variable. Thus, stress cannot be seen as a mediator between the relationship of time pressure and the number of alternative diagnostic hypotheses generated. Put simply, if a physician is under time pressure it results in more stress on the one hand, and independent of that, it also results in a reduction of possible alternative hypotheses that can be generated due to lack of available time.

What do these findings signify? Present formulations of dual-process theory[9] seem to suggest that time pressure hinders time-consuming System 2 analysis, thereby preventing thoughtful examination of initial hypotheses that can lead to the recognition of contradictions and the generation of new hypotheses. However, other possible explanation is that time pressure may also influence System 1 processing as well. Time constraints could restrict the number and quality of the initially generated hypotheses. If these premises are fewer in number and less relevant to the patient problem, then the diagnostic process as a whole would be compromised. Supporting this notion, a number of studies have found that time pressure truncates the hypothesis-generation process, leading to fewer hypotheses being retrieved from long-term memory.[31, 32] However, not only the number of initially generated hypotheses may be restricted. The thoughtful analysis part of the clinical reasoning process itself often produces new hypotheses to be tested subsequently. If System 2 is negatively affected, this may in turn restrict the number and quality of System 1 generated hypotheses in the course of the process. We have found evidence that appears to support this idea. Participants who had to process the cases under time constraints, subsequently remembered 14% fewer diagnostic hypotheses. In addition, these hypotheses were of poorer quality. However, due to the nature of interaction between System 1 and System 2 reasoning,[9] either effect cannot be effectively isolated, at least not within the limits of the present study design. In summary, does not only seem to influence System 2 but also System 1, but future research is required to establish this issue.

Some authors believe that stress is an intervening variable here. Mandler for instance, found that, when participants were put under stress, the range of alternatives available

for decision-making and the dimensions considered for each of those decisions becomes significantly restricted.[17] Moreover, research suggests that being under stress affects one's working memory capacity.[33] Apparently, part of the attention is devoted to the stressor, thereby leaving insufficient capacity to deal with the cognitive task at hand. This could lead to inadequate consideration of alternatives, which is suggested to be a defense mechanism against information overload.[17] Another study found that, when participants were exposed to stress, they solved problems in a non-systematic way without scanning all relevant alternatives.[34] These analyses seem to suggest that stress limits the capacity to generate appropriate hypotheses, implying that the more stress the fewer hypotheses are generated. Such state of affairs was represented by the mediation model in our study. We found however no evidence supporting this notion. It appears that emotion and cognition are both independently affected by time pressure.

We mentioned earlier in this paper that the evidence of the adverse effects of time pressure on diagnostic accuracy is inconclusive. In the light of our current findings, we argue that some studies may fail to elicit the stress response in participants under time pressure that would lead to observable effects on diagnostic performance. Research has shown that time perception is subjective and influenced by how individuals experience the passage of time.[35] Time urgent individuals were found to be overestimating the passage of time causing them to experience added pressure.[36] Alternatively, individuals with low time urgency may handle time pressure more effectively, as they do not waste cognitive resources worrying about time. Therefore, exposing participants to time constraints does not necessarily lead to time pressure or stress which may explain the various results reported by different studies.

The present study has some limitations. First, due to the manner the experiment was designed we were not able to directly relate the amount of perceived stress and the number of diagnostic hypotheses produced to final diagnostic accuracy. That would have required testing participants with regard to these variables while they were solving each case and prior to the final diagnosis. We contemplated the idea but eventually rejected it as it would have slowed down the reasoning process and possibly would have interfered with the experimental manipulation. Second, we recruited participants with limited experience; it is unclear whether more experienced physicians would be equally prone to time constraints. In our previous study[6] time pressure did not influence the diagnostic performance of the more experienced residents to the same extent. Therefore, unlike novice doctor, an experienced physician may react differently to time pressure. For example, a physician who is practicing for several years have more reserve of hypotheses stored in their long-term memory that can be readily activated during a case encounter. Weber et al. found a relationship between years of medical experience and hypothesis generation.[37] Further studies may investigate whether time pressure influences to a similar extent the diagnostic performance of experienced physi-

cians during problem solving. Third, the way we measured participants' stress, was indirect. Future research might utilize more authentic measures, such as cortisol levels.[38] Finally, this study was conducted under laboratory settings using written clinical cases, which restricts the generalizability of its findings to real clinical environments, such as busy outpatient clinics. Nevertheless, clinical vignettes were compared favorably to other methods, such as simulated patients and medical record abstraction.[39, 40] They proved to be a valid and reliable approach for measuring physicians' clinical decisions.[41, 42] Moreover, the stress reported by the participants during solving the clinical scenarios under time pressure might be different than the stress during real clinical context. It might be considered, however, that stress induced by real life events would possibly be higher, thereby possibly with stronger effects, than the stress produced by manipulations such as the one we used.

Ultimately, many decisions in the clinical practice must be made under stressful conditions such as time pressure. Therefore, engaging physicians in educational activities to prepare them for situations under time pressure might be useful. Such training can make them more aware of the potential reduction of diagnostic accuracy and hypothesis generation under time pressure, and it is to be investigated if it could help to minimize its negative effects.

In summary, our findings suggest that making diagnoses under time pressure may result in distortions in hypothesis generation, the evaluation of the available alternatives, and the production of an accurate final diagnosis. By highlighting the mediating factors of the observed negative impact of time pressure on the diagnostic accuracy of doctors, the authors hope that health care organizations can seek strategies that would ensure both the optimal performance of their systems and the delivery of high-quality care.

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6

Summary and Conclusions

The purpose of the studies reported in this thesis was to study diagnostic error among physicians, and particular the role of time pressure on the causation of diagnostic error. Chapter 1 reviews the extant literature on the matter.

TIME PRESSURE

Physicians describe their work to be busy and tiring that they often work under time constraints and experience stressful working conditions. For example, Linzer et al found that 53% of physicians reported time pressure during office visits. The pressure was found to associated with stress, burnout, low job satisfaction and intent to leave the practice.[1] Another study by Shanafelt et al, found that in 115 internal medicine residents, 75% of them suffered from burnout, and was associated with self-reported suboptimal patient care practices.[2] Moreover, physicians in another study attributed a large number of incidents affecting patient care (for example: sloppy care, poor communication with patients, serious medical errors, and even death) to stress symptoms such as tiredness, high workload, and anxiety. In a qualitative study, Manwell et al recognized time pressure as one of main factors affecting the quality of patient care, particularly communication with patients.[3] The question however to what extent working under time pressure *causally* affects the quality of diagnostic reasoning, leading to higher levels of diagnostic error, is unresolved. Only two studies (Norman et al; Monteiro et al)[4,5] shine some light on the issue. They asked one group of residents to diagnose 20 clinical cases as quickly as possible without making mistakes, and compared their performance with the performance of the control group that was instructed to be careful and slow. These findings indicate that there was no significant difference in diagnostic accuracy between the quick and slow conditions, though more time was spent by the residents in the slow condition.

DIAGNOSTIC REASONING AND DIAGNOSTIC ERROR

In most situations, during early encounter with a patient and based on few information, the physician generates a few diagnostic hypotheses that are tested against several data gathered subsequently.[6] The process of developing these early diagnostic hypotheses is thought to be an automatic and intuitive process without the conscious involvement from the physician, whereas searching for evidence in support of these hypotheses is supposed to be a more effortful process. In most cases, determining which information is needed is not always an easy task, especially when the case is unusual and presents with vague and confusing signs and symptoms. This process of clinical decision making and involved reasoning can be explained by dual-process theory.[7] The theory suggests that two distinct reasoning processes

are involved when a clinician is diagnosing a case: nonanalytical reasoning (System-1) and analytical reasoning (System-2). Nonanalytical processing is quick, unconscious and depends on pattern recognition during which illness scripts and prior examples are retrieved from long-term memory.[7,8] This type of reasoning is known to be implicit, contextualized, intuitive, and typically efficient in solving routine cases.[9] However, despite its efficiency, System-1 is thought to be prone to errors.[7,10] On the other hand, analytical processing is slow, conscious, sequential, effortful, and particularly used by physicians to diagnose complex cases.[7] This is because by using System-2 reasoning, the available information is processed in a more deliberate and organized manner. Nevertheless, System-2 processing may eventually fail, but because of the systematic controlled reasoning involved, it has been proposed that this type of reasoning reduces diagnostic errors generated through System-1 reasoning.[7]

Based on this theory of diagnostic reasoning we assumed that time pressure would interfere with System-2 reasoning, because analytical thinking takes time, and would force physicians to rely more on System 1 more heavily inducing errors. While dual-process theory guided our research, the specific questions asked were:

- What kind of sources of time pressure do residents perceive in the workplace?
- To what extent does time pressure affect diagnostic performance?
- Do case difficulty and prior experience moderate the effects of time pressure on diagnostic reasoning?
- What are possible cognitive pathways mediating between time pressure and diagnostic performance?

STUDY 1: WHAT ARE POSSIBLE SOURCES OF TIME PRESSURE DURING PRACTICE?

The thesis first study reported in Chapter 2 was qualitative in nature and explored the time pressure experiences in the workplace of the internal medicine residents. It attempted to answer the following questions: What are the sources of time pressure during practice, its negative effects on their patients and the strategies adopted for them to cope? Internal medicine residents (17) undergoing residency training were approached and interviewed using semi-structured approach. Data were recorded and analyzed by thematic analysis. The participating residents found their work to be very demanding and stressful. The major themes developed that explain the sources of time pressure in the workplace: (1) patient-related factors, such as the ever increasing number of patients and the complexity of their problems ; (2) practice-related factors, such as having to work too many hours and poorly functioning hospital admission procedures and organization in general; (3) training-related factors, such as supervisors who are insufficiently supportive and examinations that are a

source of additional pressure; and (4) resident-related factors, such as lack of experience and role confusion. In addition, additional themes arose showing that time pressure negatively affected the residents: the residents' health were affected —many complained of stress, fatigue and sleep deprivation--and how it affected family life. In addition, residents felt that they could not do everything that is necessary in the care of patients. Data also showed the main coping strategies as active adaptive coping and avoidant maladaptive coping. Majority of the respondents referred to active adaptation strategies helped them to improve their performance while lessening time pressure. Resident stated that a supportive working environment, time management, actively improving skills and knowledge, finding social support, reality acceptance, humor, relaxation and exercise were helpful techniques. Avoidant maladaptive coping strategies—less prevalent—focused on alleviating the symptoms. The maladaptive strategies stated by the residents were self-distraction, like unhealthy eating habits, watching movies or TV, and behavioral disengagement, such as rejection to cope with a stressful situation.

STUDY 2: TO WHAT EXTENT DOES TIME PRESSURE AFFECT DIAGNOSTIC PERFORMANCE?

Using an experimental design, Study 2, reported in Chapter 3, explored the effect of time pressure and case complexity on physician's diagnostic accuracy. Senior internal medicine residents (37) were randomly assigned into two conditions (with time pressure vs. without time pressure). Then, they were asked to diagnose 8 written clinical scenarios (4 straightforward cases vs. 4 complex cases, identified as such in previous research)[11,12] shown on a computer using E-Prime 2.0 software. Time pressure perception was manipulated in this experiment. After each case, the group under time pressure received visual feedback in the form of two different colored bars: a green bar indicating the total time remaining, and a red bar indicating the quantity of cases to be diagnosed. The response was independent of the residents' actual performance and made them feel that they were always behind schedule. The control group did not receive such feedback and could deal with the case at their own pace. The dependent variables were the mean diagnostic accuracy scores and the mean processing time spent on each case during diagnosis. The main findings were as follows: residents under time pressure completed almost the same amount of time as the residents not under time pressure in diagnosing their clinical cases. Diagnostic accuracy scores did not differ significantly between the experimental and control group. However, a main effect of case complexity was found. Residents managed the cases straightforward faster and more precisely compared with complex cases. No interaction was however found between time pressure and case complexity on diagnostic accuracy. Based on the fact that the time-pressured group did not spend less time on diagnosing the cases than the control

group, we concluded that the experimental manipulation with the green and red bars in itself was insufficient to cause any significant effect of time pressure on diagnostic accuracy.

STUDY 3: CASE DIFFICULTY AND PRIOR EXPERIENCE AS MODERATORS OF THE EFFECTS OF TIME PRESSURE ON DIAGNOSTIC REASONING

Study 3, reported in Chapter 4, was a second attempt to test the time pressure effect on physicians' diagnostic accuracy. Having learned from Study 2, we increased the amount of time pressure on our experimental subjects. As in this study we provided them with fake visual feedback after each case in the form of two different colored bars: a green bar indicating the total time remaining, and a red bar indicating the quantity of cases to be diagnosed. But we gave them in addition textual feedback, such as: "You are fast, but you still spent more time than was allocated for the first two cases," "Fast, but you are still behind schedule," and "You are not fast enough; there are still three cases to be seen." This feedback was anticipated to be stressful, signifying that the participant was progressively falling behind schedule and had to haste to catch up.

Forty-four senior internal medicine residents were randomly allocated to one of two groups: a time-pressure condition and a control condition without time pressure. Eight clinical cases were presented to both groups to diagnose. Response time was recorded, and diagnostic accuracy was scored. The participants in the time-pressure condition in this experiment completed significantly less time diagnosing the cases than the control participants. Participants under time pressure had a significantly lower diagnostic accuracy score than participants without time pressure. In fact, participants in the time-pressure condition used almost 60% less time and made 37% average more errors than the control participants.

Interestingly, post-hoc analyses demonstrated that the time pressure effect on diagnostic accuracy was moderated by both the physician's level of experience and the case difficulty level. They showed that time pressure affected the diagnostic accuracy only when cases are not too hard and physicians' expertise level is intermediate. It suggests that if a case is problematic, it may not even help to have more time to diagnose it. Even if the physician is proficient, time pressure may not negatively affect his or her performance. However, time pressure may be influential on certain cases. On cases that are not too hard (without being obvious) and the physician or resident on duty may not be experienced, time pressure may negatively play a role by obstructing System 2 analytical processing, by interfering with System 1 non analytical processing, or both. We concluded with the observation that since the health care system is mostly presented with patients having not-too-difficult cases and with physicians'

level of experience is intermediate, time pressure negative effects on diagnostic performance are prevalent.

STUDY 4: WHAT ARE POSSIBLE COGNITIVE PATHWAYS MEDIATING BETWEEN TIME PRESSURE AND PERFORMANCE?

In Study 4, reported in Chapter 5, we entertained the plausible hypothesis that psychological stress is increased by time pressure, and the somewhat less plausible hypothesis that higher levels of stress cause participants to consider fewer diagnostic alternatives to their final diagnosis. So, stress as a result of time pressure may intervene in the decision-making processes thereby shortcutting the number of diagnostic hypotheses the physician considers.

Using the time-pressure methodology developed in Studies 2 and 3, 75 senior internal medicine residents were randomly allocated into two groups: with time pressure or without time pressure. Participants diagnosed eight written clinical cases. Response time was recorded, and diagnostic accuracy was scored.

When the first part of the study was completed, all participants rated the overall amount of stress they experienced on the cases they solved on a 9-point Likert scale ranging from 'I felt extremely calm and relaxed' to 'I felt extremely stressed'. After this, both groups were asked to review the cases diagnosed. The first and second lines of each case were shown (including the patient's gender, age and main complaint) as well as the provided diagnosis during the first part. Participants had to write down other possible diagnoses if any, that they thought of during the case diagnosis.

As in Study 3, under time pressured participants completed lesser time diagnosing the cases and had a lower mean diagnostic accuracy score. Additionally, more stress was reported and generated fewer plausible tentative hypotheses. In an attempt to causally relate time-pressure (yes/no), amount of stress and number of alternative diagnostic hypotheses considered, we conducted path analysis through structural equations modeling. Although the paths between time pressure on the one hand and stress and plausible alternative hypotheses on the other were statistically significant, we failed to find a direct path between stress and the number of alternative hypotheses. Due to restrictions of the experimental design, we were not able to relate stress and plausible alternative hypotheses to diagnostic performance. That would have required us to measure both variables directly after each case, as we did with time and accuracy. Such in-between measurements would no doubt have interfered with the treatment.

DISCUSSION AND CONCLUSIONS

In this final section we would like to return to two issues important to the findings presented in this thesis. The first is: Why did we find effects of interruptions whereas others failed? And the second issue is: Is it possible to frame our findings within the dual-process theory of reasoning?

Why did we find effects of time pressure whereas others failed?

As has been stated before, our findings contradict two prior studies on the effect of time constraints on diagnostic reasoning.[4,5] Norman et al. studied groups of residents who processed their cases either quickly or slowly. The Speed cohort instructions highlighted that residents should be quick but also possibly accurate, whereas the Reflect cohort instructions highlighted care and thoroughness. Although the Speed cohort spent about 30% less time on diagnosing the cases than the Reflect cohort, no differences in diagnostic accuracy emerged. These findings were replicated by Monteiro et al. using a similar design. How can we explain the discrepancies between our findings and their findings?

A forthright explanation of the differences was that the amount of time pressure spent by the participants in Norman et al. study was less than what was reported in our study. The Speed condition participants were requested to be quick but as accurately possible—accuracy was stressed in the instructions twice. Information on the amount of time that elapsed was provided. In our study, the time-pressure group instructions gave emphasis to time constraints and the importance of working faster *six* times, while mentioned accuracy only once. Perhaps more importantly, the textual and visual feedback given to our participants' performance was directed on the basis of always being behind schedule.

Another possible explanation could be the level of difficulty of the cases used in Norman et al. study. The cases described were fairly complex. The average cases could be so difficult that the time pressure effect was merely concealed by the level of difficulty. Participants who even spent more time could only do as much. This hypothesis is supported in 2016 study,[13] here reprinted as Chapter 4. The four most difficult cases selected (from the eight cases used) and after repeating the statistical analysis, the difference in performance disappeared.

The third probable explanation for some of the discrepancies is the involvement of the expertise level of the participants. Maybe the residents in the Norman and Monteiro studies were too experienced already. If time pressure impedes mainly the process of System-2, physicians with less experience, whose relative type of reasoning relies more on their more experienced colleagues, would suffer more the effect of time pressure. We were able to show that indeed more experienced physicians did not suffer while being pressed for time.

Relationship with the dual-process theory of reasoning?

What do these findings signify with regard to the trade-off between System 1 and System 2? Present formulations of dual-process theory locate errors of judgement mainly in the realm of System-1 processing. Think of Daniel Kahneman's influential book 'Thinking fast and slow' in which the author gives many examples of how we tend to jump at conclusions and advises us to slow down and be more analytical. This theory then suggests that time pressure in particular hinders System-2 time consuming analysis, thus prevents the thoughtful examination of initial hypotheses that can lead to the recognition of contradictions and the generation of new hypotheses. System-1 is considered as the source of all evil. Other authors, however, see System-1 type of reasoning as the ultimate expression of expertise, while having to resort to System-2 is a sign of expertise falling short.[14,15] In this view, shortening time for processing would not be such a problem because System-1 is quick and accurate most of the time. However, it is possible that time pressure may also negatively influence System-1 processing. We know that physicians usually generate a few diagnostic hypotheses early in the encounter with a patient.[16] These hypotheses come to them effortlessly. Time constraints may restrict the quality and number of these hypotheses. If these hypotheses are fewer quantitatively and relevantly less problem to the patient, the diagnostic process as a whole will be compromised. In accordance, several studies have found that time pressure abbreviates the generation process of hypothesis, which leads to retrieve fewer hypotheses from long-term memory. However, it may be restricted to only the number of initially generated hypotheses.

New hypotheses that will be tested are produced from analytical parts of the clinical reasoning process itself. If System-2 reasoning is negatively affected, the number and quality of System-1 generated hypotheses may be restricted in the course of the process. Evidence that supported this idea was found. Participants in our 2018 study,[17] here reprinted as Chapter 5, where participants were asked to manage the cases under time constraints subsequently considered 14% fewer diagnostic hypotheses. Additionally, these hypotheses were of inferior quality. Of course, due to the nature of the interaction between System-1 and System-2 reasoning, effects can be easily isolated, at least not within the limits of the present experimental designs. Therefore: time pressure may to interfere, both with System-2 and with System-1 thinking, but further investigation should be researched to verify this.

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Nederlandse samenvatting

Het doel van de studies die in dit proefschrift worden beschreven was het bestuderen van diagnostische fouten onder artsen en in het bijzonder de rol van tijdsdruk op de oorzaak van diagnostische fouten. Hoofdstuk 1 geeft een overzicht van de bestaande literatuur over dit onderwerp.

TIJDSDRUK

Artsen beschrijven hun werk als druk en vermoeiend, omdat ze vaak onder tijdsdruk werken en stressvolle werkomstandigheden ervaren. Linzer et al. ontdekten bijvoorbeeld dat 53% van de artsen tijdsdruk rapporteerde tijdens spreekuurbezoeken. De druk bleek samen te gaan met stress, burn-out, lage werktevredenheid en de intentie om de praktijk te verlaten.[1] Uit een ander onderzoek van Shanafelt et al. bleek dat onder 115 arts-assistenten interne geneeskunde 75% van hen last had van een burn-out, wat samenging met zelfgerapporteerde suboptimale patiëntenzorg.[2] Bovendien schreven artsen in een ander onderzoek een groot aantal incidenten die de patiëntenzorg beïnvloeden (bijvoorbeeld slordige zorg, slechte communicatie met patiënten, ernstige medische fouten en zelfs overlijden) toe aan stresssymptomen zoals vermoeidheid, hoge werkdruk en angst. In een kwalitatief onderzoek wezen Manwell et al. tijdsdruk aan als een van de belangrijkste factoren die de kwaliteit van patiëntenzorg beïnvloeden, met name de communicatie met patiënten.[3] De vraag in hoeverre werken onder tijdsdruk de kwaliteit van diagnostisch redeneren *causaal* beïnvloedt, wat leidt tot meer diagnostische fouten, is echter onbeantwoord. Slechts twee studies (Norman et al; Monteiro et al) [4,5] werpen enig licht op de kwestie. Ze vroegen een groep arts-assistenten om 20 klinische gevallen zo snel mogelijk te diagnosticeren zonder fouten te maken en vergeleken hun prestaties met de prestaties van de controlegroep die de opdracht had gekregen om zorgvuldig en langzaam te zijn. Hun bevindingen geven aan dat er geen significant verschil was in diagnostische nauwkeurigheid tussen de snelle en langzame groepen, hoewel de arts-assistenten in de langzame groep meer tijd besteedden.

DIAGNOSTISCHE REDENERING EN DIAGNOSTISCHE FOUT

In de meeste situaties stelt de arts tijdens een vroege ontmoeting met een patiënt, en op basis van weinig informatie, enkele diagnostische hypothesen en toetst deze aan verschillende gegevens die daarna worden verzameld.[6] Gedacht wordt dat het proces van het ontwikkelen van deze vroege diagnostische hypothesen een automatisch en intuïtief proces is zonder de bewuste betrokkenheid van de arts, terwijl het zoeken naar bewijs ter ondersteuning van deze hypothesen een meer inspannend proces zou zijn. In de meeste gevallen is het niet altijd een gemakkelijke taak om te bepalen welke informatie nodig is, vooral niet wanneer

de casus ongebruikelijk is en de patiënt presenteert met vage en verwarrende symptomen. Dit proces van klinische besluitvorming en betrokken redeneren kan worden verklaard door dual-process theorie.[7] De theorie suggereert dat er twee verschillende redeneerprocessen meespelen wanneer een arts een diagnose stelt: niet-analytisch redeneren (Systeem-1) en analytisch redeneren (Systeem-2). Niet-analytische verwerking is snel, onbewust en afhankelijk van patroonherkenning waarbij ziektescripts en eerdere voorbeelden uit het langetermijngeheugen worden opgehaald.[7,8] Het is bekend dat dit type redenering impliciet, gecontextualiseerd, intuïtief en typisch efficiënt is bij het oplossen van routinezaken.[9] Ondanks zijn efficiëntie wordt echter aangenomen dat System-1 gevoelig is voor fouten.[7,10] De analytische verwerking, aan de andere kant, is traag, bewust, opeenvolgend, inspannend en wordt door artsen vooral gebruikt om complexe gevallen te diagnosticeren.[7] Door systeem-2-redeneringen te gebruiken wordt de beschikbare informatie namelijk bewuster en georganiseerder verwerkt. Desalniettemin kan de verwerking van Systeem-2 uiteindelijk mislukken, maar vanwege de systematische gecontroleerde redenering die erbij betrokken is, is gesteld dat dit type redenering diagnostische fouten als gevolg van systeem-1-redenering vermindert.[7]

Op basis van deze theorie van diagnostisch redeneren gingen we ervan uit dat tijdsdruk Systeem-2-redeneren zou verstoren, omdat analytisch denken tijd kost en artsen zou dwingen meer op Systeem-1 te vertrouwen, wat meer fouten zou veroorzaken. Terwijl de dual-procestheorie de leidraad was voor ons onderzoek, stelden wij de volgende specifieke vragen:

- Welke bronnen van tijdsdruk ervaren arts-assistenten op de werkvloer?
- In hoeverre beïnvloedt tijdsdruk diagnostische prestaties?
- Hebben eerdere ervaring en de moeilijkheidsgraad van casussen een matigende invloed op de effecten van tijdsdruk op diagnostisch redeneren?
- Welke mogelijke cognitieve paden kunnen mediëren tussen tijdsdruk en diagnostische prestaties?

ONDERZOEK 1: WAT ZIJN MOGELIJKE BRONNEN VAN TIJDSDRUK TIJDENS DE PRAKTIJK?

De eerste studie in dit proefschrift, beschreven in Hoofdstuk 2, was kwalitatief van aard en onderzocht de ervaringen met tijdsdruk op de werkplek van de arts-assistenten interne geneeskunde. Het doel was de volgende vragen te beantwoorden: Wat zijn de bronnen van tijdsdruk tijdens de praktijk, de negatieve effecten ervan op hun patiënten en de strategieën die voor hen zijn gebruikt om ermee om te gaan? Arts-assistenten interne geneeskunde (17) in opleiding werden benaderd en geïnterviewd met behulp van een semi-gestructureerde

benadering. De gegevens werden geregistreerd en geanalyseerd door middel van thematische analyse. De deelnemende arts-assistenten vonden hun werk erg veeleisend en stressvol. Ter verklaring van de bronnen van tijdsdruk op de werkvloer kwamen als belangrijkste thema's naar voren: (1) patiëntgebonden factoren, zoals het steeds groeiende aantal patiënten en de complexiteit van hun problemen; (2) praktijkgerelateerde factoren, zoals te veel uren moeten werken en slecht functionerende ziekenhuisopnameprocedures en -organisatie in het algemeen; (3) opleidingsgerelateerde factoren, zoals onvoldoende ondersteuning door supervisoren en extra druk door examens; en (4) arts-assistentgerelateerde factoren, zoals gebrek aan ervaring en rolverwarring. Daarnaast kwamen aanvullende thema's naar voren die lieten zien dat tijdsdruk een negatief effect had op de arts-assistenten: hun gezondheid werd aangetast - velen klaagden over stress, vermoeidheid en slaapgebrek - en hoe dit het gezinsleven beïnvloedde. Daarnaast hadden bewoners het gevoel dat ze niet alles konden doen wat nodig is in de zorg voor patiënten. Gegevens lieten ook zien dat actieve adaptieve coping en vermijdende onaangepaste coping de belangrijkste copingstrategieën waren. De meerderheid van de respondenten verwees naar actieve aanpassingsstrategieën die hen hielpen om hun prestaties te verbeteren en tegelijkertijd de tijdsdruk te verminderen. Arts-assistenten verklaarden dat een ondersteunende werkomgeving, time management, het actief verbeteren van vaardigheden en kennis, het vinden van sociale steun, acceptatie van de realiteit, humor, ontspanning en beweging nuttige technieken waren. Vermijdende, onaangepaste copingstrategieën - minder gangbaar - waren gericht op het verlichten van de symptomen. De onaangepaste strategieën die door de arts-assistenten werden genoemd waren zelfafleiding, zoals ongezonde eetgewoonten, films of tv kijken, en terugtrekkend gedrag, zoals weigering om met een stressvolle situatie om te gaan.

ONDERZOEK 2: IN HOEVERRE BEÏNVLOEDT TIJDSDRUK DIAGNOSTISCHE PRESTATIES?

Gebruikmakend van een experimenteel ontwerp, onderzocht Studie 2, beschreven in Hoofdstuk 3, het effect van tijdsdruk en casuscomplexiteit op de diagnostische nauwkeurigheid van artsen. Senior internisten (37) werden willekeurig ingedeeld in twee groepen (met tijdsdruk versus zonder tijdsdruk). Vervolgens werd hen gevraagd om 8 schriftelijke klinische scenario's te diagnosticeren (4 eenvoudige casussen versus 4 complexe casussen, als zodanig geïdentificeerd in eerder onderzoek).[11,12] De scenario's werden getoond op een computer met behulp van E-Prime 2.0-software. In dit experiment werd tijdsdrukperceptie gemanipuleerd. Na elke casus kreeg de groep onder tijdsdruk visuele feedback in de vorm van twee verschillend gekleurde balkjes: een groene balk die de totale resterende tijd aangeeft en een rode balk die het aantal te diagnosticeren casussen aangeeft. De respons was onafhankelijk van de daadwerkelijke prestaties van de internisten en gaf hen het gevoel altijd achter te

lopen op schema. De controlegroep kreeg dergelijke feedback niet en kon de casus in hun eigen tempo afhandelen. De afhankelijke variabelen waren de gemiddelde diagnostische nauwkeurigheidsscores en de gemiddelde verwerkingstijd die tijdens de diagnose aan elke casus werd besteed. De belangrijkste bevindingen waren als volgt: internisten onder tijdsdruk besteedden bijna evenveel tijd aan het diagnosticeren van hun klinische casussen als de internisten die niet onder tijdsdruk stonden. De diagnostische nauwkeurigheidsscores verschilden niet significant tussen de onderzoeks- en controlegroep. Er werd echter een hoofdeffect van casuscomplexiteit gevonden. Internisten handelden de eenvoudige casussen sneller en nauwkeuriger af dan complexe casussen. Er werd echter geen interactie gevonden tussen tijdsdruk en casuscomplexiteit op diagnostische nauwkeurigheid. Op basis van het feit dat de tijdsdrukgroep niet minder tijd besteedde aan het diagnosticeren van de casussen dan de controlegroep, concludeerden we dat de experimentele manipulatie met de groene en rode balk op zich onvoldoende was om enig significant effect van tijdsdruk op de diagnostische nauwkeurigheid te veroorzaken..

STUDIE 3: MOEILIJKHEIDSGRAAD VAN DE CASUS EN EERDERE ERVARING ALS MODERATORS VAN DE EFFECTEN VAN TIJDSDRUK OP DIAGNOSTISCH REDENEREN

Studie 3, beschreven in Hoofdstuk 4, was een tweede poging om het tijdsdrukeffect op de diagnostische nauwkeurigheid van artsen te testen. Nadat we van Studie 2 hadden geleerd, hebben we de mate van tijdsdruk op onze proefpersonen verhoogd. Net als in Studie 2 hebben we na elke casus valse visuele feedback gegeven in de vorm van twee verschillende gekleurde balken: een groene balk die de totale resterende tijd aangeeft en een rode balk die het aantal te diagnosticeren casussen aangeeft. Maar we hebben ook tekstuele feedback gegeven, zoals: "Je bent snel, maar je hebt nog steeds meer tijd besteed dan was toegewezen voor de eerste twee casussen", "Snel, maar je loopt nog steeds achter op schema" en "Je bent niet snel genoeg; er zijn nog drie casussen om te zien." Verwacht werd dat deze feedback stressvol zou zijn, wat betekent dat de deelnemer steeds verder achter raakte op het schema en zich moest haasten om de achterstand in te halen.

Vierenveertig senior interne geneeskunde-assistenten werden willekeurig toegewezen aan een van twee groepen: een tijdsdrukgroep en een controlegroep zonder tijdsdruk. Aan beide groepen werden acht klinische casussen voorgelegd om te diagnosticeren. De responstijd werd geregistreerd en de diagnostische nauwkeurigheid werd gescoord. De deelnemers in de tijdsdrukgroep in dit experiment hadden significant minder tijd nodig om de casussen te diagnosticeren dan de deelnemers in de controle. Deelnemers onder tijdsdruk hadden een significant lagere diagnostische accuratessescore dan deelnemers zonder tijdsdruk. In feite

gebruikten deelnemers in de tijdsdrukgroep bijna 60% minder tijd en maakten gemiddeld 37% meer fouten dan de controledeelnemers.

Interessant is dat post-hocanalyses aantoonden dat het tijdsdrukeffect op de diagnostische nauwkeurigheid werd gematigd door zowel het ervaringsniveau van de arts als de moeilijkheidsgraad van de casus. Ze lieten zien dat tijdsdruk de diagnostische nauwkeurigheid alleen beïnvloedde als de casussen niet te moeilijk zijn en het expertiseniveau van artsen gemiddeld is. Het suggereert dat als een casus problematisch is, het misschien niet eens helpt om meer tijd te hebben om deze te diagnosticeren. Zelfs als de arts bekwaam is, is het mogelijk dat tijdsdruk zijn of haar prestaties niet negatief beïnvloedt. Bij bepaalde casussen kan tijdsdruk echter van invloed zijn. In casussen die niet te moeilijk zijn (zonder dat dit duidelijk is) en waarin de dienstdoende arts of arts-assistent misschien niet ervaren is, kan tijdsdruk een negatieve rol spelen door de analytische verwerking van Systeem-2 te belemmeren, door de niet-analytische verwerking van Systeem-1 te verstoren, of beide. Onze conclusie bestond uit de observatie dat, aangezien het gezondheidszorgsysteem meestal te maken krijgt met niet al te moeilijke casussen en het ervaringsniveau van artsen gemiddeld is, negatieve effecten van tijdsdruk op de diagnostische prestaties overheersen.

STUDIE 4: WAT ZIJN MOGELIJKE COGNITIEVE PADEN DIE MEDIËREN TUSSEN TIJDSDRUK EN PRESTATIE?

In Studie 4, beschreven in Hoofdstuk 5, hebben we de plausibele hypothese aangenomen dat psychologische stress toeneemt door tijdsdruk, en de iets minder plausibele hypothese dat hogere niveaus van stress ertoe leiden dat deelnemers minder diagnostische alternatieven voor hun uiteindelijke diagnose overwegen. Stress als gevolg van tijdsdruk kan dus interveniëren in de besluitvormingsprocessen, waardoor het aantal diagnostische hypothesen dat de arts in overweging neemt wordt verminderd.

Met behulp van de tijdsdrukmethodologie die is ontwikkeld in onderzoeken 2 en 3, werden 75 senior interne geneeskunde-assistenten willekeurig verdeeld in twee groepen: met of zonder tijdsdruk. Deelnemers diagnosticeerden acht schriftelijke klinische casussen. De responstijd werd geregistreerd en de diagnostische nauwkeurigheid werd gescoord.

Toen het eerste deel van het onderzoek was voltooid, beoordeelden alle deelnemers de totale hoeveelheid stress die ze ervoeren bij de casussen die ze hadden opgelost op een 9-punts Likertschaal, variërend van ‘Ik voelde me extreem kalm en ontspannen’ tot ‘Ik voelde me extreem gestrest’. Hierna werden beide groepen gevraagd om de gediagnosticeerde casussen te beoordelen. De eerste en tweede regel van elke casus werden getoond (inclusief

het geslacht, de leeftijd en de belangrijkste klacht van de patiënt), evenals de tijdens het eerste deel verstrekte diagnose. Deelnemers moesten eventuele andere mogelijke diagnoses waar ze tijdens de casusdiagnose aan dachten opschrijven.

Net als in onderzoek 3 besteedden deelnemers onder tijdsdruk minder tijd om de casussen te diagnosticeren en hadden ze een lagere gemiddelde diagnostische nauwkeurigheidsscore. Bovendien werd meer stress gerapporteerd en werden minder plausibele voorlopige hypothesen gegenereerd. In een poging om tijdsdruk (ja/nee), hoeveelheid stress en het aantal overwogen alternatieve diagnostische hypothesen causaal met elkaar in verband te brengen, hebben we padanalyse uitgevoerd door middel van modellering van structurele vergelijkingen. Hoewel de paden tussen tijdsdruk enerzijds en stress en plausibele alternatieve hypothesen anderzijds statistisch significant waren, konden we geen direct pad vinden tussen stress en het aantal alternatieve hypothesen. Vanwege beperkingen van het experimentele ontwerp waren we niet in staat om stress en plausibele alternatieve hypothesen te relateren aan diagnostische prestaties. Dat zou vereisen dat we beide variabelen direct na elke casus moesten meten, zoals we dat met tijd en nauwkeurigheid hebben gedaan. Dergelijke tussenmetingen zouden ongetwijfeld de behandeling hebben verstoord.

DISCUSSIE EN CONCLUSIES

In deze laatste paragraaf willen we terugkomen op twee zaken die belangrijk zijn voor de bevindingen in dit proefschrift. De eerste is: waarom vonden we effecten van onderbrekingen terwijl anderen deze niet vonden? En de tweede kwestie luidt: is het mogelijk onze bevindingen in het kader te plaatsen van de dual-process-theorie van redeneren?

Waarom vonden we effecten van tijdsdruk terwijl anderen deze niet vonden?
Zoals eerder vermeld, zijn onze bevindingen in tegenspraak met twee eerdere onderzoeken naar het effect van tijdsdruk op diagnostisch redeneren.[4,5] Norman et al. bestudeerden groepen arts-assistenten die hun casussen snel dan wel langzaam afhandelden. De instructies van het Speed-cohort benadrukten dat arts-assistenten snel maar mogelijk ook nauwkeurig moesten zijn, terwijl de instructies van het Reflect-cohort zorg en grondigheid benadrukten. Hoewel het Speed-cohort ongeveer 30% minder tijd besteedde aan het diagnosticeren van de casussen dan het Reflect-cohort, kwamen er geen verschillen in diagnostische nauwkeurigheid naar voren. Deze bevindingen werden gerepliceerd door Monteiro et al. een soortgelijk ontwerp gebruiken. Hoe kunnen we de discrepanties tussen onze en hun bevindingen verklaren?

Een duidelijke verklaring voor de verschillen was dat de hoeveelheid tijdsdruk besteed door de deelnemers aan Norman et al. studie minder was dan wat werd gerapporteerd in onze studie. De deelnemers aan de Speed-conditie werden verzocht snel maar zo nauwkeurig mogelijk te zijn - nauwkeurigheid werd twee keer benadrukt in de instructies. Informatie over de verstreken tijd is verstrekt. In onze studie legden de instructies van de tijdsdrukgroep de nadruk op tijdsdruk en het belang van *zes* keer sneller werken , terwijl nauwkeurigheid slechts één keer werd genoemd. Misschien nog belangrijker is dat de tekstuele en visuele feedback op de prestaties van onze deelnemers was gericht op het feit dat ze altijd achterliepen op schema.

Een andere mogelijke verklaring zou de moeilijkheidsgraad kunnen zijn van de casussen die werden gebruikt in de Norman et al. studie. De beschreven casussen waren vrij complex. De gemiddelde gevallen konden zo moeilijk zijn dat het tijdsdrukeffect alleen maar werd verhuld door de moeilijkheidsgraad. Deelnemers die zelfs meer tijd besteedden, konden maar zoveel doen. Deze hypothese wordt ondersteund in een studie uit 2016,[13] hier overgenomen als hoofdstuk 4. De vier moeilijkste gevallen waren geselecteerd (uit de acht gebruikte gevallen) en na het herhalen van de statistische analyse verdween het verschil in prestatie.

De derde mogelijke verklaring voor een deel van de discrepanties is de rol van het expertiseniveau van de deelnemers. Misschien waren de arts-assistenten van de Norman- en Monteiro-studies al te ervaren. Als tijdsdruk vooral het proces van Systeem-2 belemmert, zouden artsen met minder ervaring, wier soort redenering meer op hun meer ervaren collega's steunt, meer last hebben van tijdsdruk. We konden aantonen dat inderdaad meer ervaren artsen geen last hadden van tijdsdruk.

Relatie met de dual-process theorie van redeneren?

Wat betekenen deze bevindingen met het oog op de afweging tussen Systeem-1 en Systeem-2? De huidige formuleringen van de duale-procestheorie lokaliseren beoordelingsfouten voornamelijk op het gebied van Systeem-1-verwerking. Denk aan Daniel Kahneman's invloedrijke boek 'Thinking fast and slow', waarin de auteur veel voorbeelden geeft van hoe we geneigd zijn om overhaaste conclusies te trekken en ons adviseert om het rustiger aan te doen en meer analytisch te zijn. Deze theorie suggereert vervolgens dat vooral tijdsdruk de tijdrovende analyse van Systeem 2 belemmert en dus het bedachtzame onderzoek van initiële hypothesen verhindert dat kan leiden tot de herkenning van tegenstrijdigheden en het genereren van nieuwe hypothesen. Systeem-1 wordt beschouwd als de bron van alle kwaad. Andere auteurs zien Systeem-1 redeneren echter als de ultieme uitdrukking van expertise, terwijl het terugvallen op Systeem-2 een teken is dat expertise tekortschiet.[14,15] In deze visie zou het verkorten van de verwerkingstijd niet zo'n probleem zijn, omdat Systeem-1 meestal snel en nauwkeurig is. Het is echter mogelijk dat tijdsdruk ook de System-1 verwerk-

ing negatief kan beïnvloeden. We weten dat artsen meestal vroeg in het contact met een patiënt een paar diagnostische hypothesen genereren.[16] Deze hypothesen komen moeiteloos bij hen op. Tijdgebrek kan de kwaliteit en het aantal van deze hypothesen beperken. Als deze hypothesen minder in aantal zijn en relatief minder problematisch voor de patiënt, komt het diagnostisch proces als geheel in gevaar. Verschillende onderzoeken hebben in overeenstemming aangetoond dat tijdsdruk het proces van hypothesen genereren verkort, wat ertoe leidt dat er minder hypothesen uit het langetermijngeheugen worden opgehaald. Het kan echter worden beperkt tot alleen het aantal initieel gegenereerde hypothesen.

Nieuwe hypothesen die zullen worden getest, worden geproduceerd op basis van analytische gedeelten van het klinisch redeneerproces zelf. Als de Systeem-2-redenering negatief wordt beïnvloed, kan het aantal en de kwaliteit van de door Systeem-1 gegenereerde hypothesen in de loop van het proces worden beperkt. Er werd bewijs gevonden dat dit idee ondersteunde. Deelnemers aan onze studie uit 2018,[17] hier overgenomen als hoofdstuk 5, waar deelnemers werd gevraagd om de casussen onder tijdsdruk te behandelen, namen vervolgens 14% minder diagnostische hypothesen in overweging. Bovendien waren deze hypothesen van inferieure kwaliteit. Natuurlijk kunnen effecten, vanwege de aard van de interactie tussen Systeem-1 en Systeem-2-redeneringen, gemakkelijk worden geïsoleerd, althans niet binnen de grenzen van de huidige experimentele ontwerpen. Daarom kan tijdsdruk interfereren, zowel met Systeem-2 als met Systeem-1-denken, maar nader onderzoek moet worden gedaan om dit te verifiëren.

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PhD portfolio

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Courses	Year	Workload
– Problem based Education and Study Skills	2011	4.00
– Learning and Cognition	2011	4.00
– Curriculum and Instruction	2011	4.00
– Program and Faculty Evaluation	2011	5.00
– Organization, Management and Leadership	2011	6.00
– Design of Authentic Learning Environment	2012	3.00
– Basics of Research in Education: Basics and Techniques	2012	5.00
– Student Assessment	2012	4.00
– Faculty Development	2012	3.00
Total workload (ECTS)		38

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Curriculum vitae

Dalal ALQahtani from Saudi Arabia earned her Bachelor degree in dental surgery (BDS) from College of Dentistry - king Saud University (KSU) in Saudi Arabia in 2007. In 2010, she received her Master of Science in Dentistry (MSc) in the specialty of Oral Diagnostic Sciences; and completed clinical residency in Oral and Maxillofacial Pathology from College of Dentistry-KSU.

Dalal ALQahtani started working in College of Dentistry-KSU as demonstrator in Oral Pathology, Department of Oral Medicine and Diagnostic Sciences in 2007. Then in 2010, she was appointed as lecturer in oral pathology. In 2015, she was promoted to assistant professor. In addition, she established oral pathology laboratory for diagnostic services in Dental University Hospital-KSU, and she is the current Head of the lab.

Inspired by the changes in education in Saudi Arabia and the interest in improving medical education, she persuaded a degree in Medical Education. In 2013, she earned a Master degree in Medical Education from King Saud bin Abdulaziz University for Health Sciences in Saudi Arabia. She worked on projects related to the themes of clinical reasoning and diagnostic errors.

From 2007 to date, she has been involved in teaching undergraduate and postgraduate courses in oral pathology. Also, she collaborated with Minster of Health in Saudi Arabia in giving workshops in clinical teaching and professionalism for health professionals.

In 2014, she worked with team from College of Dentistry in updating the curriculum of undergraduate dental program in KSU. In 2017, she became the head of the curriculum reform project. She worked in developing professional competencies of general dentist.

Dalal ALQahtani, received Rector Award and the Golden Medal for Excellence in teaching in the health sciences colleges in 2013. On the same year, she also received Excellence in Learning and Teaching Grant from Center of Excellence in Learning and Teaching, KSU. In 2014, she was selected as E-Leraning Pioneer Among Universities of Saudi Arabia to join program: Female e-Learning Pioneers in Saudi Universities for The Year 2015 (Teaching Track). In 2015, she was also nominated by the College of Dentistry-KSU for Early Career Educator Excellence in Dental Education Award from the Association for Dental Education in Europe (ADEE).

Dalal ALQahtani worked in several research projects related to topics of oral pathology and medical education. Her research interests are about oral cancer, clinical reasoning, diagnostic errors and dental education.

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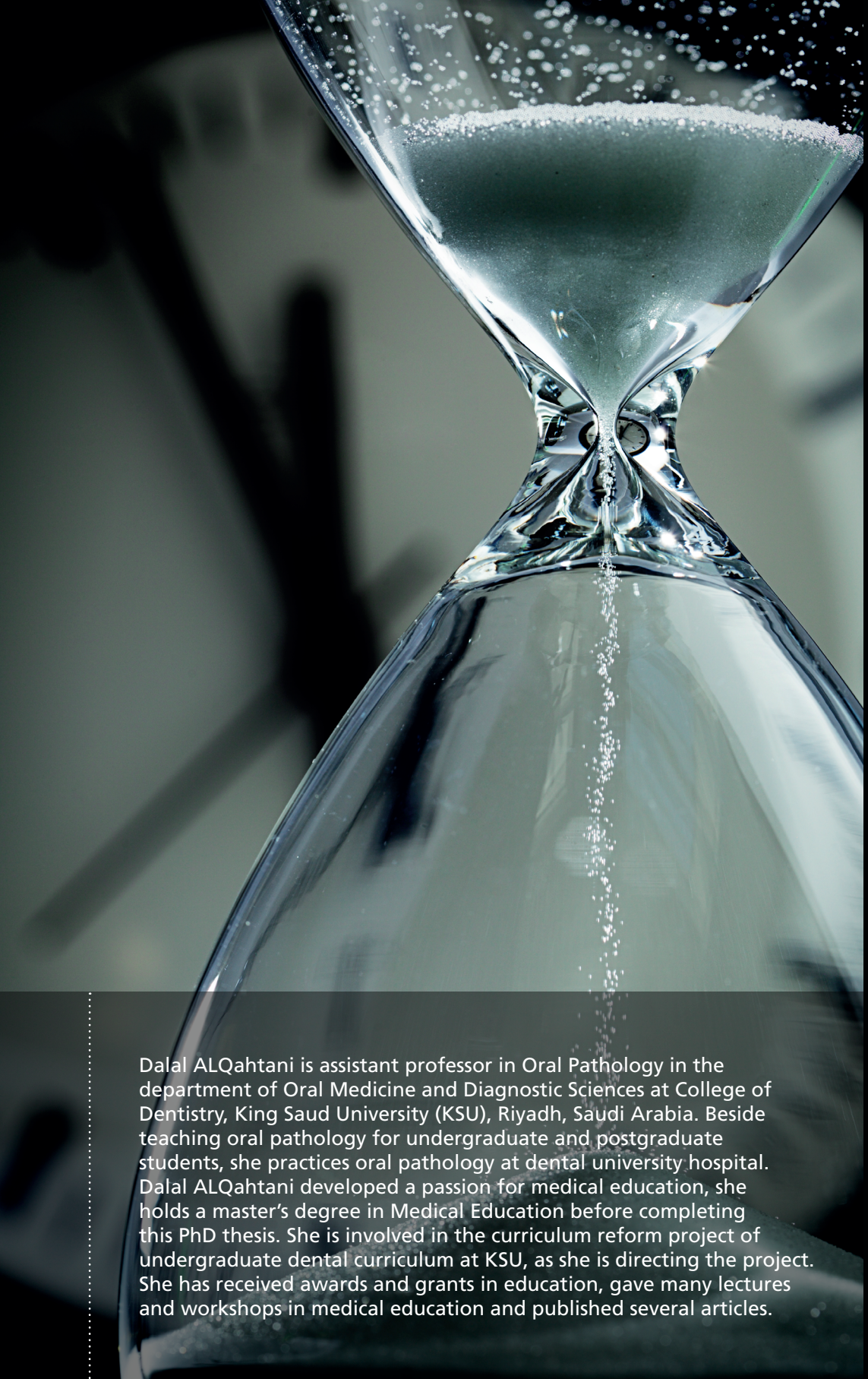

Dalal ALQahtani is assistant professor in Oral Pathology in the department of Oral Medicine and Diagnostic Sciences at College of Dentistry, King Saud University (KSU), Riyadh, Saudi Arabia. Beside teaching oral pathology for undergraduate and postgraduate students, she practices oral pathology at dental university hospital. Dalal ALQahtani developed a passion for medical education, she holds a master's degree in Medical Education before completing this PhD thesis. She is involved in the curriculum reform project of undergraduate dental curriculum at KSU, as she is directing the project. She has received awards and grants in education, gave many lectures and workshops in medical education and published several articles.