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Adverse outcomes in the diagnostic reasoning process are related to residents' subjective workload and work experience

This article was submitted as: Zwaan, L; Thijs, A; Wagner, C; Thijs, A; Van der Wal, G; Timmermans, DRM; Adverse outcomes in the diagnostic reasoning process are related to residents' subjective workload and work experience

Abstract

Objective:

To determine the relationship between subjective workload and work experience with the occurrence of adverse outcomes in the diagnostic process. Furthermore, factors influencing subjective workload are explored.

Method:

Data about residents' subjective workload were collected during their first examination of dyspnea patients. Furthermore, they were asked about their work experience. After discharge, the patient records were reviewed to identify adverse outcomes. Using observations, work-related factors were assessed and related to subjective workload which was measured with the NASA-tlx.

Results:

A higher subjective workload was associated with adverse outcomes ($p=0.01$). Less experienced residents encountered more subjective workload ($p=0.006$) and were more often involved in cases with adverse outcomes than more experienced residents ($p=0.017$). There was no significant interaction between subjective workload and work experience on adverse outcomes. The factors that mostly influenced subjective workload involved the presence of a co-worker and the duration of their break, number of patients they saw and the occurrence of unexpected events.

Conclusions:

Subjective workload affected residents' performance irrespective of their work experience. Reducing subjective workload could therefore be a useful intervention to reduce adverse outcomes in the diagnostic process. Since subjective workload was mostly related to the availability of co-workers, suggesting that additional support (e.g. possibility to get assistance) may help reduce the subjective workload.

Introduction

Diagnostic reasoning is an integral part of physicians' work. Failures in the diagnostic process can lead to diagnostic errors and patient harm. Previous research has shown that diagnostic errors occur in a substantial number of cases and that they are considered to be more preventable and to have more severe consequences compared to other error types¹⁻⁴. Besides the occurrence of diagnostic errors, patients can suffer from harm during the diagnostic reasoning process, e.g. due to the application of unnecessary, invasive diagnostic tests. Both diagnostic errors and patient harm in the diagnostic process typically result from cognitive errors,^{5,6} as they are often caused by failures in reasoning of an individual physician.⁷ Previous research in the field of human factors has shown that high workload can severely impair cognitive processing.⁸ There is no general consensus on the definition of workload, but workload is commonly divided in two concepts; objective and subjective (or perceived) workload. Objective workload involves the amount of work assigned to a worker in a specific time period, e.g. the number of patients that a physician sees a day.⁹ Subjective workload is a multidimensional construct that is defined as the amount of cognitive resources required by someone to achieve a certain level of performance.¹⁰ Most of the existing literature about workload in medical practice focused on the effects of objective workload on performance.¹¹⁻¹³ Previous studies have shown that objective workload is different from subjective workload¹⁴ e.g. because objective factors can be experienced differently depending on the person. Since the diagnostic reasoning process is a cognitive process, subjective workload might play a particularly important role. If higher levels of subjective workload do relate to more adverse outcomes in the diagnostic process it is important to study the factors that influence subjective workload. A personal factor that might be of importance to subjective workload is work experience. More experienced physicians may experience a lower cognitive load on the same task than their less experienced co-workers because to them the tasks may be more automatic. Furthermore, factors related to the work environment may lead to an increase or decrease in the needed cognitive resources, for example the number of patients a physician sees, the number of interruptions and whether there are co-workers available to divert tasks to.^{9,13-16}

This study aims to determine whether subjective workload in the diagnostic reasoning process is related to adverse outcomes, i.e. diagnostic errors and patient harm. In addition, the relation between physicians' work experience

and subjective workload is investigated. Furthermore, to be able to develop interventions, we aim to obtain insight into the work-related factors that are associated with the subjective workload of physicians.

Methods

This study consists of two parts. In part one subjective workload of residents during the diagnostic reasoning process and work experience is related to adverse outcomes in the diagnostic process. In part 2 of the study, fourteen residents (who also participated in part 1) were observed to determine which factors are related to subjective workload.

Part 1: subjective workload and the relationship with work experience and adverse outcomes

Patient selection

The study focused on dyspnea patients; a homogenous patient group that has not been studied extensively in the field of diagnostic error. Five acute care hospitals in the Netherlands (one university hospital, two tertiary teaching hospitals and two general hospitals) participated in the study, which took place in departments of internal medicine, cardiology and pulmonology. For practical reasons, the start of the study was phased, and every hospital participated 6-8 months between May 2007 and February 2008. All dyspnea patients who were admitted to one of the participating hospitals during the inclusion phase of the study were asked to participate. After receiving their informed consent they were included in the study.

The standard working method in the Netherlands entails that the residents act as the treating physicians and are supervised by staff members. Therefore, the physicians that we studied were residents who had shifts in the emergency department or at the ward of internal medicine, pulmonology and/or cardiology.

Reviewers

Four experienced internists were involved in the record review process. Since we wanted the reviewers to be independent and not closely associated with the care provided in the hospitals, we selected internists who were recently retired. The expert internists had to meet several criteria to participate in the study, they: (1) had at least 10 years of post-graduate work experience in internal medicine, (2) had a good reputation amongst colleagues, (3) were retired for

no longer than 5 years at time of selection as a reviewer and (4) had interest in and experience with patient safety research. The internists who participated as reviewers attended a training program about the study protocol. After having reviewed several records, another training session was organized to discuss questions and difficulties the reviewers experienced.

Subjective workload during diagnostic process

Subjective workload of the residents was assessed after the first examination of the dyspnea patient and the decision to admit the patient to the hospital. The residents answered one question (scale 1 to 20) about the level of subjective workload they experienced during diagnosing the dyspnea patient. The residents were instructed to fill out the subjective workload question. For practical reasons it was not possible for the physicians to fill out the whole NASA-tlx, so they were asked to keep the aspects of the NASA-tlx (mental and physician and temporal demands, performance, effort and frustration level) in mind when indicating their subjective workload.¹⁰ The workload question was answered about the same patients whose records were reviewed, which made it possible to link subjective workload to the results of the subsequent record review.

Work experience measurement

Work experience was assessed by asking the participating residents when they started working after obtaining their medical degree.

Adverse outcomes in the diagnostic process

The record review questionnaire assessed all steps of the diagnostic process: (1) History taking, (2) physical examination, (3) laboratory tests, (4) imaging techniques, (5) outlining a diagnosis, (6) starting the treatment and (7) verification of diagnosis and treatment during the patient's stay. The reviewers inquired whether all aspects that they considered to be relevant based on their expert opinion (e.g. allergies, family history, EKG, D-dimer) were identified or checked by the involved resident. Subsequently, the reviewers determined whether the findings were interpreted correctly by the residents. Based on this review, adverse outcomes (i.e. diagnostic errors and patient harm) were identified. Diagnostic error was defined as: a diagnosis that was unintentionally delayed, wrong or missed as judged from the eventual appreciation of more definitive information.⁵ Patient harm was defined as: any disadvantage for the patient that leads to prolonged or strengthened treatment, temporary or permanent (physical

or mental) impairment or death.¹⁷ It was not always possible to determine with complete certainty whether a diagnostic error occurred (e.g. autopsy reports were lacking or the patient went home and there was no information available on the further well-being of the patient). Therefore, the category 'most likely a diagnostic error' as judged by the experienced internist was considered a diagnostic error and therefore added to the category 'adverse outcome'. An extended version of the method is described in the published study protocol.¹⁸

Part 2: The relationship between subjective workload and work-related factors

Based on existing literature, the work-related factors that may influence subjective workload were determined. We selected factors that could lead to an increase or decrease in the required cognitive resources from the resident. The factors that required an increase in cognitive resources were (1) number of patients that the residents saw during the one hour observation (more patients a physician sees results in more information needing to be processed); (2) unexpected events that use cognitive resources e.g. computer failure, (3) interruptions, e.g. by phone or face-to-face and (4) number of emergencies, which may also use additional cognitive resources of the resident. The factors that lead to a decrease in required cognitive resources were: (1) the number of minutes break that a resident had during an hour (more time for a break means less use of cognitive resources) (2) number of available co-workers for diverting tasks to or asking assistance.^{9,13-16}

To measure the occurrence of these work-related factors, an observation scheme was developed on which observers indicated the work-related factors for each observation hour, i.e. they indicated the start and end time of minutes break and they scored the occurrence of the other factors such as interruptions. The observations took place in one of the participating hospitals, but were a separate part of the study and therefore not related to the record review in part 1. Two medical interns observed 14 internal medicine residents (who also participated in part 1 of this study) during their shift on the ward or their consultant shift. Each resident was observed for at least four hours during one shift. We choose both of the shift types in order to have a larger variety in our measurements of the work-related factors. After each hour, the residents filled out the subjective workload that they experienced over the last hour. This subjective workload was measured by the NASA tlx, which is a well-known subjective workload scale, existing of six factors, i.e. mental demands, physical demands, temporal

demands, performance, effort and frustration.^{10,19,20} In this part of the study all 6 factors were indicated by the resident. The factors of subjective workload each have a scale of 1-20 and therefore add up to a total workload score which ranges from 1-120 (no weighing factor was used so all scales were represented equally).

Statistical analysis

Logistic regression was used to determine the effect of subjective workload and work experience on the occurrence of adverse outcomes. Since most residents included more than one patient in the study, we corrected for confounding of the residents who included the patients. Specifically, we performed tests using a random effects logistic regression model and checked for significance of the random effects of the residents. The levels of work experience and subjective workload are presented in quartiles due to the large variety among the residents for these factors. The predicted probability is used to present the occurrence of adverse outcomes in figure 1.

The relationship between work-related factors and subjective workload was determined using correlations. Subsequently, the factors with a significant correlation were used in a multiple regression analysis.

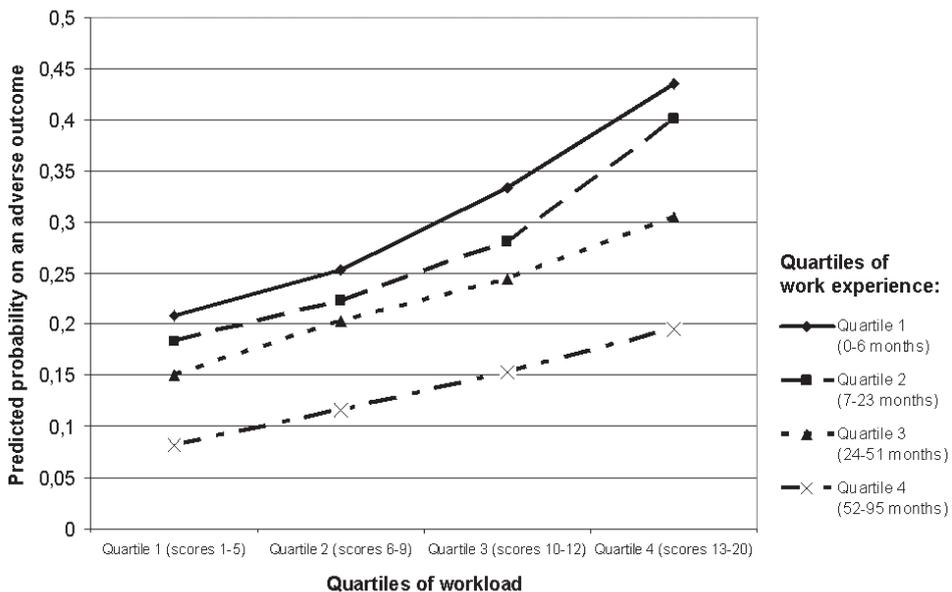


Figure 1. The predicted probability of adverse outcomes for the quartiles of workload and the quartiles of work experience

Confidentiality and ethical approval

The review board of the VU medical center approved of the research protocol. All participating hospitals granted approval to participate. The internist reviewers and researchers involved in the data collection signed a confidentiality agreement to maintain the secrecy of the data. Patients who were included in the study gave informed consent to review their patient record.

Results

Part 1: Subjective workload, work experience and adverse outcomes

Included cases

A total of 261 patients were included in the study. Of 14 patients the patient record could not be obtained. Thus the patient records of 247 patients were reviewed by the expert internists. See Table 1 for patient characteristics. The subjective workload measure of the residents was available in 230 included patients. Sometimes, the resident who included the patient in the study was not able to indicate the experienced workload since he/she was not involved in the examination of the patient at the emergency department (but saw the patient at the ward). Of the 247 included patients, the work experience of the resident was obtained for 210 included patients. For 37 patient cases the resident could, after several attempts, not be contacted to obtain information about their work experience. Of 195 included patients we obtained the resident's work experience, their subjective workload and the patient record was reviewed. For the analyses of subjective workload and adverse outcomes 230 patient cases were used, for work experience and adverse outcomes 210 patient cases were used in the analyses. For the relationship between the three factors (i.e. subjective workload, work experience and adverse outcomes) 195 patient cases were used in the analyses.

Table 1. Characteristics of patients with a diagnostic error or patient harm and patients without a diagnostic error or patient harm.

	Patients with a diagnostic error and/or patient harm (N=54)	Other patients (N=193)
% male patients	48.1%	46.1%
Average age in years (SD)	71.2 (14.0)	69.6 (15.2)
Existing co-morbidity	81.5%	81.3%
Average length of hospital stay in days (SD)	17.4 (22.5)	12.6 (12.0)

Subjective workload and work experience

A total of 72 residents with an average work experience of 29 months included patients in the study. On average each resident included 3.4 patients (range 1 to 18).

The average subjective workload was 9.1 (SD=4.6, range 1 to 20). There were no significant differences in gender, age, existing co-morbidity and median length of hospital stay between the patients for different levels of workload that the residents experienced (see Table 2).

Table 2. Characteristics of patients at different levels of subjective workload of the treating physicians

	1 st quartile	2 nd quartile	3 rd quartile	4 th quartile
Workload range(total 1-20)	1-5	6-9	10-12	13-20
Male patients*	43.6%	52.5%	43.5%	45.1%
Average age in years (SD)*	69.5 (16.1)	70.4 (15.1)	70.5 (13.5)	69.2 (16.3)
Existing co-morbidity *	81.8%	78.7%	82.3%	80.4%
Median length of hospital stay in days**	8	11	10	9

* No significant differences were found for the different quartiles

** The median was used to eliminate the influence of outliers.

Subjective workload and work experience in relation to adverse outcomes

A higher subjective workload was related to more cases with adverse outcomes (OR=1.10, $\beta = 0.099$, $z=2.57$, $p=0.010$, there were no random effects of resident). Patients with adverse outcomes were more often diagnosed by a less experienced resident (OR=0.98, $\beta = -0.02$, $z=2.38$, $p=0.017$, no correction for random effects was needed). Work experience and subjective workload were significantly related ($\beta=-0.2$, $t(193)=2.78$, $p=0.006$), meaning that residents with less work experience experienced a higher subjective workload. Overall, the highest probability of an adverse outcome was for the least experienced residents in a high subjective workload setting (see Figure 1). There was no significant interaction between work experience and subjective workload ($\beta=0.0003$, $z=0.24$, $p=0.81$).

Part 2: relating work-related factors to subjective workload

Residents

14 residents were on average observed for 9.1 hours. Their average work experience was of 40.6 months (SD=24.6). To obtain sufficient variation of

the different work-related aspects different types of shifts were observed. 56 observation-hours took place during the residents shift on the ward, while 71 took place during a consultant shift of the residents.

Work-related factors of subjective workload

The average score of NASA-tlx subjective workload was 38.3. Univariate correlations showed significant correlations for the relationship between subjective workload score and the following work-related factors: number of available co-workers, number of minutes break, number of patients seen and unexpected events. There were no significant correlations for number of interruptions and number of emergencies, which occurred only in 3 observations (see Table 3).

When these factors were included in a multiple regression analyses, the number of available co-workers was significant ($\beta = -6.3$, $t(122) = 2.82$, $p < 0.001$) as well as the number of minutes break ($\beta = -0.33$, $t(122) = 2.08$, $p < 0.05$).

Table 3. The characteristics and correlations of subjective workload and work related factors

	Mean (SD)	Min-max	Correlations						
			2.	3.	4.	5.	6.	7.	
1. Subjective workload score	38.27 (17.10)	3-87	.23*	-.05	-.23**	-.28**	.21*	.14	
2. Number of patients seen	4.41 (2.71)	0-14		-.12	-.20*	-.30**	.10	.14	
3. Number of emergencies	0.02 (0.15)	0-1			.02	.14	-.06	.02	
4. Break duration (minutes)	5.28 (9.44)	0-45				.22*	-.20*	-.17	
5. Number of co-workers	0.76 (0.66)	0-2					-.25**	-.18*	
6. Unexpected events	0.65 (0.84)	0-3						.12	
7. Interruptions	5.09 (3.71)	0-17							

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Discussion

The less experienced residents encountered a higher subjective workload than more experienced residents. Adverse outcomes occurred significantly more often when the subjective workload was high and when the resident had little work experience. However, there was no significant interaction between the subjective workload and work experience of residents on the occurrence of adverse outcomes meaning that an increase in subjective workload revealed a similar negative association with adverse outcomes for all levels of work

experience. The work-related factors that were mostly associated with the subjective workload were the availability of co-workers to divert tasks to and duration of the break, and to a lesser extent the number of patients that a resident had to attend to and the occurrence of unexpected events.

Some limitations of our study should be noted. Subjective workload in part 1 of the study was measured by only one item. Adverse outcomes were determined by patient record reviews which contain limited information and may not reveal all adverse outcomes. Although there were no significant differences in patient characteristics it is still possible that the cases in which subjective workload was high were the more difficult cases, thus the higher subjective workload could be related to the difficulty of the task. Finally, the relationship between work-related factors and subjective measures of workload was determined involving only one hospital and 14 residents, reducing the generalizability of the study.

Previous studies also revealed the association between high workload and performance.^{8,13} A study on objective workload (number of nurses per patient) showed an association with patient harm, i.e. when there were fewer nurses per patient, more patients died.^{11,13} Studies on subjective workload also showed negative effects on health care professionals, specifically health problems such as burnout. These studies, however, did not relate a high subjective workload to performance, i.e. the occurrence of adverse events in an everyday clinical setting.^{21,22} The effect of work experience on cognitive performance, e.g. diagnostic reasoning, has been shown in several studies conducted in a research setting,²³⁻²⁶ Not surprisingly, these studies showed that experts outperformed novices.²⁴ Our findings showed that this difference in performance was also present in an everyday clinical setting.

In general, more experienced residents experienced a lower subjective workload compared to residents with less experience. Although it is possible that their objective workload is lower, it is more likely that more senior residents are more efficient and skilled in performing diagnostic tasks and have more efficient ways to cope with objective workload. As more experience would affect subjective workload as well as the performance of diagnostic tasks, this might explain the absence of an interaction between subjective workload and work experience on adverse outcomes: The relationship between subjective workload and the presence of co-workers could be explained by the fact that the presence of co-workers means that the resident has a lower objective workload, i.e. sees fewer patients and has more time to take a break (as the latter variables significantly correlate). However, it also suggests that the presence of co-workers impacts

subjective workload because this co-worker can share the responsibility for a patient. This implies that the feeling that they can ask for support or to share responsibility is important for residents' experience of workload. This has been shown in a study on time pressure (an important aspect of workload. This study on experienced time-pressure and task performance showed that when people had the feeling they had insufficient time to perform a task, their performance decreased independently of the actual time they had.²⁷ Thus, it might not even be necessary to adjust objective workload, since subjective workload might be reduced by the feeling that assistance is available at all times. In conclusion, although in this present study we could not determine a causal relationship between subjective workload and performance, our findings suggest that a reduction of subjective workload positively affects diagnostic performance and hence the quality of care. In light of this conclusion, some recommendations can be given.

Interventions focused on reducing subjective workload can be helpful to all physicians regardless of their level of experience. When physicians indicate that their subjective workload is high, the availability of assistance might positively affect their performance, particularly the performance of less experienced physicians. In addition having a back-up system might have a similar effect, e.g. presence of an attending physician in the hospital at night or a back-up resident who can assist in situations with a high subjective workload. Thus, a physician who claims to be busy, i.e. with a high subjective workload, should be taken seriously regardless of the objective workload and their work experience.

Conclusions

Adverse outcomes were more likely to occur in the diagnostic reasoning process when the subjective workload was high and when physicians were less experienced. Subjective workload was associated with a decline in performance irrespectively of work experience. Subjective workload was related to the availability of co-workers to assist them, the duration of their break, and to a lesser extent the number of patients they saw and the occurrence of unexpected events. Therefore, we recommend taking a high subjective workload seriously regardless work experience and objective workload. It is recommended that the possibility to ask for additional assistance in high subjective workload settings is organized.

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