

Work conditions, mental workload and patient care quality: a multisource study in the emergency department

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ABSTRACT

Background Workflow interruptions, multitasking and workload demands are inherent to emergency departments (ED) work systems. Potential effects of ED providers' work on care quality and patient safety have, however, been rarely addressed. We aimed to investigate the prevalence and associations of ED staff's workflow interruptions, multitasking and workload with patient care quality outcomes.

Methods We applied a mixed-methods design in a two-step procedure. First, we conducted a time-motion study to observe the rate of interruptions and multitasking activities. Second, during 20-day shifts we assessed ED staff's reports on workflow interruptions, multitasking activities and mental workload. Additionally, we assessed two care quality indicators with standardised questionnaires: first, ED patients' evaluations of perceived care quality; second, patient intrahospital transfers evaluated by ward staff. The study was conducted in a medium-sized community ED (16 600 annual visits).

Results ED personnel's workflow was disrupted on average 5.63 times per hour. 30% of time was spent on multitasking activities. During 20 observations days, data were gathered from 76 ED professionals, 239 patients and 205 patient transfers. After aggregating daywise data and controlling for staffing levels, prospective associations revealed significant negative associations between ED personnel's mental workload and patients' perceived quality of care. Conversely, workflow interruptions were positively associated with patient-related information on discharge and overall quality of transfer.

Conclusions Our investigation indicated that ED staff's capability to cope with demanding work conditions was associated with patient care quality. Our findings contribute to an improved understanding of the complex effects of interruptions and multitasking in the ED environment for creating safe and efficient ED work and care systems.

INTRODUCTION

Emergency departments (ED) are complex and challenging work systems that impose significant demands and stress for ED professionals. In regard to care quality and patient safety, emergency care has been noted as being particularly problematic.¹ Although several human factor issues important to ED work design and care quality have been raised, very few have addressed the interplay of ED work system, mental workload of ED staff and care quality outcomes.^{1 2}

We focus on the relationships between ED work demands, specifically workflow interruptions and multitasking, ED staff's mental workload and patient care outcomes. The current literature base on EDs shows that workflow interruptions and multitasking activities belong to the most prevalent work demands in this context.^{2–7} ED staff are frequently interrupted with additional task demands.^{8 9} Observational research of ED professionals showed wide variations between 5.1¹⁰ and 15.5 interruptions per hour.^{4 8 9 11 12} A study in an Australian teaching hospital revealed that ED physicians failed to return to an interrupted task nearly 20% of the time.¹³ In addition, interruptions are likely to cause ED providers to compensate through task shortcuts or failure to return to the task.¹³ In regard to multitasking, ED staff frequently manage multiple cases and demands simultaneously, which increases the risk for errors.^{1 2} Studies in EDs revealed that a substantial amount of time is dedicated to multitasking demands: ranging from 10.66%⁹ up to 30.6% of the work time.^{3 6 12 14} Although this wide variation of interruption and multitasking rates can be attributed to the changing and dynamic nature

of ED work and context, a considerable proportion of the apparent variation is due to the different definitions used in each study. Thus, the specific use of these terms in each investigation limits comparability and validity across study and settings, respectively. Notwithstanding, the combination of interruptions and multitasking may contribute to failures, errors and quality losses.^{1 13 15} Additionally, interrupt-driven ED environments also contribute to increased workload and stress in ED personnel.^{3 8} Thus, identifying factors that contribute to mental workload in ED professionals is important for improving efficiency and safety in emergency care.

In order to understand the complex, dynamic and unpredictable nature of ED environments, it is necessary to conduct studies that comprehensively address the multiple characteristics of ED work demands as well as relevant patient outcomes.^{1 2 16} Although previous studies have demonstrated the occurrence of intense demands in emergency care, potential effects of these on patient care quality and provider outcomes in emergency care have been investigated less frequently.^{2 17} Moreover, studies are needed that address the effects of interruptive and demanding ED environments on patient care quality.^{12 15 16 18} Despite striving to accomplish efficient care in the ED, workflow interruptions and multitasking demands may be inherent to the complex, cognitive system in the ED.¹ Workflow interruptions and multitasking may be purposeful to ensure efficient delivery of care, immediate communication and information transmission in the ED.^{5 10 15 18}

Applying a two-stage study, we aimed to answer the following questions concerning associations between staff's work demands, mental workload and quality of care outcomes in the ED at stage 1 and then test the hypothesis at stage 2.

First, what is the prevalence of workflow interruptions and multitasking in the ED (stage 1: observational study)?

Second, we hypothesised that higher rates of mental workload, interruptions and multitasking will be associated with lower care quality—indicated through patients' perceived quality of care and quality of patient transfer (stage 2: multisource investigation).

MATERIALS AND METHODS

We conducted this study in a central ED of a community hospital with 16 600 visits per year. This is a typical county hospital ED staffed with surgical and internal clinicians on 24 h duty. In regard to size, patient census, work organisation, staffing levels and technological provisions, the interdisciplinary ED is similar to the majority of German EDs.^{19 20}

Expert observation (stage 1): design, measures and procedure

A time-motion study on ED staff workflow interruptions and multitasking was conducted prior to the

main study for the following reasons: first, interruption rates and multitasking demands can vary across ED settings. Therefore, stage 1 aimed to provide a reliable baseline assessment on the number and content of those specific work demands in this particular ED. This enabled us to draw conclusions about the comparability and external validity of findings in stage 2. Second, the number of studies that use expert observations on multitasking in ED settings is limited.^{3 9 12} Thus, our stage 1 investigation contributes further information on the rate as well as the nature of concurrent task activities in the ED. Third, findings from stage 1 on the prevalence of certain, observed disruption sources in the ED allowed further insight and interpretation concerning the effect of specific ED staff's self-reported interruption events on patient-related quality outcomes (surveyed at stage 2).

Similar to previous studies in ED settings, we applied 2 h observation periods.⁴ A trained observer (first author) recorded ED professionals' activities, multitasking and workflow interruptions using an established tool for healthcare professionals.^{11 14 21} The tools' reliability in terms of interobserver agreement was established in earlier studies.^{11 14 21} ED professionals' activities were classified as following: (1) communication with patients; (2) patient evaluation/ diagnostics; (3) care/nursing activities; (4) consultation; (5) documentation/charting activities; (6) communication with ED staff; (7) communication with others; (8) organisation/ coordination; (9) meetings; (10) teaching/supervision; and (11) personal time/breaks. The observer recorded the start and end of each activity.

Multitasking was coded when two activities were observed to be evidently carried out in a timely concurrent manner, that is, simultaneous task performance.^{9 21} The key criterion for the observer was an obvious, directly observable overlay of concurrent activities to code a multitasking incident, for example, writing documentation while talking to a colleague, talking on the phone while simultaneously conducting a diagnostic procedure on the patient.^{14 21}

Workflow interruptions were defined as an event that distracted the observed ED professional from the primary task and caused task switch behaviours.^{9 11 22} This is also referred to as break-in tasks.⁴ The following disruption sources were noted: (1) interruptions by patients, (2) by ED colleagues from the same professions, (3) by ED colleagues from other professions, (3) by telephone/beeper, (4) by patients' relatives, (5) by any other individuals, (6) by technical malfunctions or missing technical provisions, (7) by waiting times and (8) by missing information.

Main study (stage 2): design, procedure and sample selection

At this stage, we aimed to investigate associations between ED staff's workflow interruptions,

multitasking, mental workload and two care quality-related outcomes: patients' evaluations and quality of patient transfer. We applied a multisource design that combined ED staff reports, patients' ratings and external staff evaluations.

Selection of observation dates: Prior to the investigation, all day shifts in a 4-week period were eligible for data collection. A sample of 20 observation days was randomly selected using random number tables from the list of 31 days, resulting in 16 week days and 4 weekend days. Mean daily observation time was 8 h and 39 min (M=8.98 h, SD =2.34 h).

Selection of ED providers

Physicians, nurses and nursing assistants who were designated to the ED on the selected observation days were eligible to take part in the study. During the morning shifts (06:30–14:30), three nurses and two physicians were on ED duty; during the late shift (14:00–22:00), three nurses and two physicians. ED staff were requested to complete the questionnaire at the end of their shifts. Due to confidentiality reasons, we did not collect information on the profession in the questionnaire: it was assured beforehand that analyses for each profession will be only conducted if the number of participants exceeds five nurses or physicians, respectively. This was not the case for the daywise assessments.

Selection of ED patients

All patients who were admitted to the ED during the observation days were eligible. We planned to approach all patients and so no exclusion criteria were established prior to data collection. Patients were given the *Patient Survey Questionnaire* immediately at the end of their ED care by the ED staff or a study assistant (regardless whether they were discharged home or admitted to another hospital unit for further treatment). In some cases (eg, children, dementia patients), accompanying relatives were approached to fill out the survey.

Selection of patient transfers

Regarding the quality of patient transfer from the ED, all patients who were transferred internally from the ED to other units or departments were included, that is, inpatient wards, intensive care unit (ICU) or operating room (OR). In these cases, staff of the admitting unit were requested to evaluate the transfer procedure directly after completion. A study assistant distributed the survey sheet.

Measures

(1a) *ED staff's workflow interruptions:* The daily level of workflow interruptions was assessed with one standardised question from a well-established work analysis survey (KFZA²³). The following question referred to the past shift: "How often were you interrupted during your work?"

(1b) *ED staff's multitasking demands* were assessed with one item from the widely used work analysis tool (ISTA²⁴) as follows: "How often did you have to work on tasks simultaneously?"

(1c) *ED staff's mental workload* was assessed using five items from the NASA-TLX Index (TLX).²⁵ This widely used tool indicates subjective workload and has been shown to be applicable to ED professionals' work.^{17 26} The five items are mental demands ("How mentally demanding was the task?"); temporal demands ("How hurried or rushed was the pace of the task?"); performance ("How successful were you in accomplishing what you were asked to do?"); effort ("How hard did you have to work to accomplish your level of performance?"); and frustration ("How insecure, discouraged, irritated, stressed, and annoyed were you?"). Scale's reliability was good: Cronbach's α , CA=79.

All (1a)–(1c) items' scale range was from 0 'very low' to 10 'very often/high' (using a continuous visual analogue scale).

(2) *Patients' perceived quality of care survey (quality outcome I):* ED patients evaluated the perceived quality of ED care using an established, standardised questionnaire (Munich Patient Inventory²⁷). The following four major aspects of care quality were covered (scale range 1 (not at all) to 5 (yes, very much)): (1) *quality of ED organisation* (two questions; eg, "The ED personnel has enough time for me"); (2) *quality of patient information* (two questions; eg, "ED personnel provided me with detailed information regarding my medical treatment"); (3) *quality of patient interaction* (two questions, eg, "My problems and complaints were taken seriously by the ED staff"); (4) *general satisfaction with ED care* (one question, "Overall, how do evaluate your care in the ED?", scale range 1 (very good) to 6 (very bad)). CA was 0.60 for (1), 0.75 for (2) and 0.72 for (3), indicating consistently acceptable to good reliability.

(3) *Quality of patients' intrahospital transfer (quality outcome II):* Concerning the quality of hand-over and transfer of ED patients admitted to inpatient wards, ICU or OR. Three quality indicators were rated by the admitting hospital nurses or physicians from the external units, that is, ICU, OR and inpatient wards. They were requested to evaluate the patient transfer as soon as it was completed. Three questions referred to the following quality indicators during the transfer: (1) *patient-related information* ("General information about the patient?"); (2) *infection-related information* ("Information about any infections that the patient has?"); and (3) *overall transfer process* ("Transfer process in general?"). All three questions were rated through the admitting staff immediately after the handover on a five-point Likert scale (1 (very bad) to 5 (very good)).

(4) *Control variables:* Additionally, using administrative records, the number of patients admitted as well

as number of ED staff present was recorded (including physicians, nurses and nursing assistants, but not administrative staff). The duration of individual patients' ED care was obtained from administrative records.

Data analysis

Data were checked for correctness and implausible values. Descriptive analyses were then computed. At stage 2, for each of the 20 observation days, mean scores of all study variables were aggregated. Then, Spearman's rank correlation tests were used to determine the association of patient load (number of ED patients, average duration of ED care) with ED staff reports and quality outcomes. Next, linear regression analyses were conducted to identify the strength of prospective associations between ED staff's reports and care quality outcomes. Regression models estimated the associations between ED staff reports (ie, disruption and multitasking as independent variables) and the care quality outcomes (ie, patients' perceived quality of care and their intrahospital transfer). In all regression analyses, we adjusted for the number of ED staff because this variable varied across the 20 observation days (mainly due to sickness-related absenteeism). Finally, we computed multivariate regression analyses in which we estimated the single and shared effects of ED staff's reports on the quality outcomes in one regression model. A probability value of $p < 0.05$ was considered statistically significant. Due to the exploratory nature of our study, we did not apply significance adjustment for multiple comparisons.

RESULTS

Stage 1: expert observations on workflow interruptions and multitasking

Six observations were conducted with six different ED professionals (physicians and nurses). Overall observation time was 11 h, 35 min and 50 s with a mean duration of 1 h, 58 min and 58 s (range 1:05:40 to 2:48:53). Overall, 269 activity episodes were observed with the following distribution: communication with ED staff (n=68; 25.3%); care/nursing activities (66; 22.7%); documentation/charting (59; 21.9%); organisation/coordination (26; 9.7%); communication with patients (20; 7.4%); patient evaluation/diagnostics (18; 6.7%); teaching/supervision (9; 3.3%); communication with others (7; 2.6%); and breaks/personal time (1; 0.4%). In 30% of the observed time, staff was observed concurrently conducting more than one activity or 'multitasking'. The most frequent secondary activities were communication with patients (n=29; 10.8%), or colleagues (29; 10.8%), documentation (8; 3.0%) and care/nursing activities (5; 1.9%).

Sixty-seven disruption events were observed in total, and this is equivalent to 5.63 workflow interruptions per hour. Most frequent interruption sources were as follows: by colleagues from the same

profession (n=25; 37.3%), by telephone/beeper (16; 23.9%), from other ED personnel (12; 17.9%), missing information (3; 4.5%) and by a patient (1; 1.5%).

Stage 2: main study

Overall, 565 patients received care during the 20 observed day shifts (mean 28.25 patients/day, SD=5.76, range 15–39). The average time for patients' stay in the ED was 2 h and 17 min (M=2.29 h, SD=0.53, range 1.32–3.27).

In total, 195 patients were excluded from the survey due to the following reasons: dementia, trauma room care, lost consciousness after stroke or alcohol/drug overdose. Also, 370 (65.49%) patients were eligible and of these 304 (82.16%) gave consent to the patient survey. A total of 241 questionnaires (a response rate of 65.14%) were returned to the study team; two questionnaires were excluded from further analyses because of invalid responses. And 239 patient questionnaires were obtained, with a daily average of 11.95 patient responses (SD=2.71, range 7–17).

During the study, 210 (37.2%) ED patients were admitted to referring hospital units (ICU, OR, inpatient wards; mean 10.5 patients/day, SD=2.7, range 7–16). Concerning the evaluations of patient transfers (quality outcome II), we received 205 (97.6%) evaluations. The mean number of evaluated transfers per day was 10.25 (SD=2.05, range 6–14).

In regard to ED staff's survey, 200 ratings were potentially possible. However, we registered 31 absences (sick days) during the observations, so that 169 questionnaires were handed out to ED staff. We obtained finally 76 ratings from ED professionals (this resulted in a response rate of 45.0%)—on average, 3.8 self-reports per day (SD=0.60, range 3–5).

The descriptive statistics of variables for stage 2 are depicted in [table 1](#).

Since we aggregated staff and patient ratings into daily averages, we checked for agreement within the observation days respectively. We computed the internal and temporal agreement using the intracorrelation coefficients (ICCs). Online supplementary table E-1 shows that we obtained average ICCs between 0.59 and 0.67 for our scales, which is considered to be good inter-rater agreement. This inter-rater variance across the observation days shows that 59–67% variance in the scale measures can be attributed to a common source what justifies aggregation to average scores.

Applying correlation tests, we then checked for associations between clinical load during the 20 days (ie, number of patients admitted) and the study variables: The daily number of patients admitted to the ED correlated significantly with patients' average duration of ED care ($r=0.52$, $p=0.02$). Furthermore, we found a significant negative correlation between number of patients and patients' reported quality of

Table 1 Descriptive statistics for emergency department (ED) staff workflow interruptions, multitasking, mental workload and patient care quality outcomes

Source	Study variables	Scale range	N	Descriptive statistics			
				Mean	Median	SD	Range
ED staff reports	Workflow interruptions	1 (very low) to 10 (very often)	76	5.46	5.50	2.40	0.63; 9.50
	Multitasking demands	1 (very low) to 10 (very often)	76	5.85	6.03	2.24	0.38; 9.38
	Mental workload	1 (very low) to 10 (very high)	76	5.66	5.68	1.45	2.43; 8.41
Quality outcome I: patients' perceived quality of care	Quality of ED organisation	1 (not at all) to 5 (yes, very much)	239	3.40	3.50	0.91	1; 5
	Quality of patient information	1 (not at all) to 5 (yes, very much)	237	4.00	4.00	0.72	2; 5
	Quality of patient interaction	1 (not at all) to 5 (yes, very much)	239	4.11	4.00	0.67	1; 5
	General satisfaction with ED care	1 (very good) to 6 (very bad)	233	2.21	2.00	0.84	1; 5
Quality outcome II: patient intrahospital transfer	Patient-related information	1 (very bad) to 5 (very good)	205	3.59	4.00	0.75	2; 5
	Infection-related information	1 (very bad) to 5 (very good)	205	3.12	3.00	0.71	2; 5
	Overall transfer process	1 (very bad) to 5 (very good)	203	3.38	3.00	0.67	2; 5

N, number of ratings; range (min; max); scale for ED staff reports: continuous visual analogue scale. Scales for patient and transfer evaluations: five-point Likert scale.

information ($r=-0.53$, $p=0.02$). Concerning the duration of ED care, patients who received longer treatment reported decreased quality of patient information ($r=-0.46$, $p=0.04$).

ED staff's reported workflow interruptions per day were highly associated with multitasking demands ($r=0.74$, $p<0.01$) as well as mental workload ($r=0.64$, $p<0.01$). Multitasking demands were also correlated to mental workload ($r=0.65$, $p<0.01$).

To answer our research questions, we related ED staff's reports to both quality outcomes under study on a daily level. The results of the regression analyses (adjusted for the number of ED staff present) are depicted in tables 2 and 3.

Regarding patients' perceived quality of care (quality outcome I), we observed significant associations between ED staff's mental workload and three care outcomes of the patient survey (quality outcome I): ED patients reported decreased quality of ED organisation ($\beta=-0.56$, $p=0.01$) as well as decreased

quality of patient interaction ($\beta=-0.46$, $p=0.05$) if ED staff's workload was high (cf. table 2). Similarly, a negative association was observed between ED staff's mental workload and patients' general satisfaction with ED care ($\beta=-0.45$, $p=0.05$). A potential but insignificant association was found between staff's workflow interruptions and patient information: there was trend that more frequent workflow interruptions were associated with better patients' ratings concerning the quality of information ($\beta=0.39$, $p=0.10$).

When including the three ED staff reports on workflow interruptions, multitasking and mental workload simultaneously in one regression model (adjusting for ED staff present), we found that ED staff's mental workload predicted significantly lower quality of ED organisation ($\beta=-0.34$, $p<0.01$); and ED staff's workflow interruptions significantly predicted quality of patient information ($\beta=0.56$, $p=0.04$). We observed no significant associations with quality of patient interaction or with general satisfaction.

Table 2 Prospective associations between workflow interruptions, multitasking and emergency department (ED) staff's mental workload on patients' perceived quality of care

Predictors: ED staff reports	Quality outcome I: patients' perceived quality of care			
	Quality of ED organisation	Quality of patient information	Quality of patient interaction	General satisfaction with ED care
	β	β	β	β
Workflow interruptions	0.02	0.39	0.19	0.17
Multitasking	-0.25	-0.08	-0.28	-0.38
Mental workload	-0.56*	-0.18	-0.46*	-0.45*

n=20 observation days; β , standardised regression coefficient, controlled for number of staff present per day.

* $p<0.05$. Scale range for ED staff reports (1 (very low) to 10 (very often)); the first three indicators of patients' perceived quality of care were assessed with a five-point Likert scale (1 (very bad) to 5 (very good)), and overall satisfaction was scaled from 1 (very good) to 6 (very bad).

Table 3 Associations between workflow interruptions, multitasking and emergency department (ED) staff's workload on three outcome measures of patient intrahospital transfer

Predictors: ED staff reports	Quality outcome II: patient intrahospital transfer		
	Patient-related information	Infection-related information	Overall transfer process
	β	β	β
Workflow interruptions	0.56*	-0.22	0.47*
Multitasking	0.40	-0.35	0.36
Mental workload	0.32	-0.38	0.37

n=20 observation days; β , standardised regression coefficient, controlled for number of present staff per day.

* $p<0.05$. Scale range for ED staff reports (1 (very low) to 10 (very often)); all aspects of patient intrahospital transfer were evaluated on a five-point Likert scale (1 (very bad) to 5 (very good)).

Table 3 presents the single associations of workflow interruptions, multitasking and ED staff's mental workload with the three outcome measures of patient intrahospital transfer (quality outcome II). Workflow interruptions were positively associated with quality of patient-related information ($\beta=0.56$, $p<0.01$) and with the overall quality of intrahospital transfer ($\beta=0.47$, $p=0.04$). We observed further associations that were all, however, not significant: increased multitasking demands were moderately associated with higher quality of patient-related information during transfer ($\beta=0.40$, $p=0.06$) as well as with decreased infection-related information ($\beta=-0.38$, $p=0.11$); ED staff's mental workload was negatively related to infection-related information ($\beta=-0.38$, $p=0.08$).

We also computed a regression model that simultaneously assessed the effects of all three predictors on the transfer outcomes respectively. Interruptions significantly predicted quality of patient information during transfer ($\beta=0.49$, $p=0.03$). For the two other outcome measures, no significant associations were detected in the multivariate analyses.

After adjusting for number of patients, we obtained similar results. However, two associations changed: ED staff's multitasking was significantly related to patient information during transfer ($\beta=0.52$, $p=0.01$); and the relationship between ED staff's mental workload and quality of patient interaction turned out slightly weaker and insignificant ($\beta=-0.38$, $p=0.08$).

DISCUSSION

To the best of our knowledge, our study represents the first comprehensive attempt to elucidate relationships between ED staff's work conditions, mental workload and respective care quality outcomes. Drawing on a multisource design, we first observed workflow interruptions and multitasking of ED staff (stage 1) and then used this information to explore the relationship of these factors to patients' and external departmental staff's evaluations of various patient care quality outcomes (stage 2). This study's most novel contribution is the investigation of associations between ED staff's workflow interruptions, multitasking, mental workload and two different sets of patient care quality outcomes. Several findings deserve closer attention, careful interpretation and discussion.

First, we found that ED professionals' mental workload was mainly negatively related to patients' perceived quality of care. When ED professionals experienced an increase of mental workload, their cognitive capacity to deal effectively with patients' requests and demands is stretched. This in turn can be detrimental to performance and patient care.²⁸ This effect occurred irrespective of the staffing level in the ED, which has been shown to be linked to patient care outcomes.²⁹ Research shows that ED personnel apply behavioural strategies to cope with increased

work and patient load such that they focus on patient transfer (to inpatient beds) and discharge.^{30 31} Eventually they may lose sight of patient requests that may be less urgent and relevant to immediate task completion. A second explanation may be that due to increased mental workload the quality of patient-related communication suffered. EDs encompass a large number of human interactions, for example, up >30/h in US EDs.⁴ This puts demands on ED professionals, especially in times of overcrowding and lengthy patient evaluation when the efficiency of their communication skills is tested. Many of these interactions directly influence patient satisfaction or dissatisfaction (and may lead to complaints), or poor patient outcomes.

Second, we observed a trend that increased workflow disruptions were related to increased patients' perceived quality of information. However, this association was not statistically significant and thus needs to be interpreted with caution. We deem the direction of this trend remarkable since transfer ratings were also increased if ED staff reported increased workflow interruptions (cf. table 3). This counterintuitive and contradictive finding deserves careful consideration. There is evidence that highly interruptive and distractive clinical work environments contribute to mental workload, suboptimal clinical performance, and detrimental safety and quality practices in healthcare delivery.^{5 12 13 32-34} Notwithstanding, our results suggest that workflow interruptions may have a particular benefit for care recipients or coworkers: patients who interrupt ED staff may gain more or detailed information and external staff may receive quicker or comprehensive information on ED patients to be transferred to their own unit. This corroborates previous work that interruptions in clinical work have different effects and safety implications.^{22 34-37} Apart from individual hazards (eg, picking up the wrong syringe), interruptions can be purposeful, ensuring a quick and successful function of healthcare delivery or providing timely critical information.^{10 18 22 34} However, our results from the stage 1 observations show that disruptions caused by patients occurred comparatively seldom. Another, alternative interpretation could be that as patients see how busy ED staff are they allow for this when reporting their perception of the quality of information they receive.

Third, we found modest associations between multitasking, which tended to be negatively associated with patients' overall satisfaction with care as well as with infection-related information during patient handover (see table 2). There was an insignificant though a potential trend that ED professionals' multitasking was related to improved patient-related information during transfer. Since a similar result pattern was found between mental workload and the patient transfer quality ratings (quality outcome II, see table 3), we assume that ED staff dealing with enhanced

load tend to focus on particular aspects of the transfer process (ie, general information about patient conditions) while other information may be neglected or forgotten (ie, infection-related information).

Our stage 1 observations enabled us to gain insights into the actual prevalence of ED staff's workflow interruptions. The observed rate was just over five interruption events per hour. This is similar to previous studies in EM.^{4 10 11} However, due to the dynamic and unpredictable nature of ED work, disruptions vary substantially over time, depending on patient load, acuity, as well as staffing.^{8 9} Furthermore, our distribution of interruption sources resembles other ED-based study findings and points to the large percentage of interruptions caused by colleagues and other professionals.⁵ There is an inherent demand to coordinate multiple clinical professionals, particularly in the ED,³⁷ with a larger number of calls and associated disruptions occurring when more complex patients are treated.

As ED physicians and nurses interact with many individuals, workflow interruptions create breaks-in tasks⁴ that are responsible for a considerable amount of multitasking demands in emergency care.⁷ Our observations revealed that ED staff performed multitasking in approximately a third of the time in line with previous ED studies.^{3 8 12} Laboratory-based findings in cognitive psychology show that simultaneous task execution contributes to enhanced workload, strain and potential error.^{3 38–40} EDs' dynamic work systems create surges during times with peak patient loads, that is, up to 12–16 simultaneous active patient care responsibilities.⁴ Hence, there is a persistent subjective demand to carry out tasks simultaneously to effectively cope with unpredictable workload.^{7 21} However, the risk for procedural errors and clinical failures increases.^{3 32 38}

LIMITATIONS

Our results need to be interpreted in the light of several limitations. These relate to the time of day of the observations, any effects due to participants being observed, our study setting, the use of self-reporting measures and the design of the study (including sample size) to identify which factors affect patient care. First, our observations included only day shifts. We aimed to increase external validity through observations on a range of weekdays as well as at weekends. Second, inherent to observational studies is the risk of the Hawthorne effect.⁴¹ Although we undertook several measures to minimise observer influence, we cannot exclude that patients or staff may act and respond differently in the presence of investigators. Our interruption measure was defined as obvious task switches in a fairly restrictive definition what might limit comparability to other approaches that applied different definitions. Therefore, comparisons of our interruption rates to other studies that may have used

different definitions for workflow disruptions or multitasking should be made carefully. Furthermore, we acknowledge the small number of observations carried out at stage 1 of this study. Although the response rate in stage 2 among ED professional is similar to participation rates in health provider surveys generally,⁴² we cannot rule out non-response bias. Third, although the ED being studied was comparable to other German ED settings, the findings may not be generalisable for other ED settings in other countries, that is, we were in a county hospital, which was non-academic, with a comparatively low admission rate of highly complex emergency cases. The annual volume of our study ED makes it a fairly small ED compared with larger level 1 trauma centres—in the USA and the UK. Additionally, the primary care system in Germany is much more robust than in the USA where average ED patients tend to be sicker and more in need of admission. Due to confidentiality constraints, we pooled the two ED professions—physicians and nurses—in both stages. This limits the applicability of our findings for individual ED professions. Fourth, the ED relies to a large extent on handwritten patient records that are transferred into computerised electronic medical records. We cannot assume that ED units with different technological and information technology provisions are similar in their extent of workflow interruptions, multitasking and workflow. However, there is evidence to suggest high consistencies in emergency medicine across various ED settings and great similarities between academic and community ED practice environments.⁴

Fourth, we used self-report measures to capture ED staff's work demands as well as patients' perceived care quality. Sole reliance on employees' and patients' experiences can potentially limit the validity of outcome measures and increase the risk for spurious results.^{43 44} Although there are strong reasons that patients' evaluations can provide robust and meaningful indicators of healthcare quality,⁴⁴ we recommend that future studies include objective quality and performance indicators and error metrics to enhance the validity of the associations. Although we applied valid and reliable sets of questions, it needs to be acknowledged that in stage 2 the interruption and multitasking assessments were based on one-item measures. Concerning the handover analyses, we included infection-related information, which is clearly important in some cases but not relevant in all ED patients. Our response rate among ED providers was comparatively modest but was still similar to previous studies. Our study does not allow definite causal inferences, for example, we cannot clearly delineate whether increased workflow interruptions decrease patients' general satisfaction with ED care (cf., table 2) or whether patients who are unsatisfied with treatment and care tend to interrupt staff more frequently. However, based on evidence in other settings we

propose that highly interruptive work environments in the hospital influence clinical performance.^{13 16 33} There may have been confounders present that were not controlled for and that contribute to each of those associations we observed. Therefore, future studies that assume direct effect of work conditions and mental workload on care quality may apply appropriately advanced statistical analyses. Furthermore, in replications with larger sample sizes (ie, observation days) studies may achieve more power to accurately estimate the single as well as the shared effects of interruptions, multitasking and mental workload on care outcomes.

Finally, we acknowledge that our multivariate regression analyses are at risk of inaccurate estimates due to insufficient power and due to multicollinearity, that is, high intercorrelation among the ED staff reports such as workflow interruptions, multitasking demands and mental workload. Applying a larger sample size would also allow for advanced analytical approaches that take account of the nested data structure, for example, hierarchical linear models. Although we obtained high inter-rater agreement for our units of analyses (ie, observation days), a larger sample size would allow for more fined-grained analyses that estimates the nested information within as well as across days. With our approach, it needs a sample of at least 50 observation days to apply multilevel modelling without inaccurate and biased estimations.⁴⁵

IMPLICATIONS FOR ED CARE PRACTICES AND RESEARCH

Operational systems design in the ED departments aims to maximise efficiency, care quality, patient and provider safety and wellness. Our results emphasise that ED systems design should ideally reduce unnecessary workflow interruptions and multitasking demands.¹⁶ Particularly with the objective to manage workload in an efficient and safe manner to create high-quality and efficient front-end operations in the ED. Concerning our finding that mental workload has an immediate effect on patient care, work redesign and training of cognitive strategies to ED providers to reorient themselves after a disruption may be helpful in dealing with interruptive ED work. ED workplace changes should be carefully evaluated for the effect of ED provider interruption and efficiency of communication.^{4 16}

ED professionals' mental workload is critical in providing safe care. Increased subjective workload interferes and degrades vigilance or memory processes and is important in resuming the interrupted tasks, and is therefore related to patient and safety outcomes.²⁸ Thus, our approach permits future assessment of ED system changes. This may assist ED redesign efforts to evaluate intended improvements without creating unintended consequences, in regard to subjective workload or cognitive performance.

Further research could discriminate between purposeful and unnecessary workflow interruptions in ED care. Since unnecessary workflow interruptions have a detrimental effect on workload, efficiency of clinical work and patient safety, there is a specific need to reduce hazardous interruptions in ED work. Such interruptions can cause delays, near misses, errors during handovers or phone calls, documentation, reports or nurses obtaining medicine. To reduce inappropriate workflow interruptions, healthcare environments need to be better designed to balance human-human and human-technology interactions, that is, aligning human-oriented redesign efforts with needs for effective and safe functioning of healthcare delivery.^{18 34} Our study suggests that interruptions may also be purposeful, ensuring a quick and successful function of healthcare delivery or providing timely critical information.^{22 34}

A further research avenue exists in regard to technological solutions. Electronic and virtual patient records may have the potential to limit the interruptiveness of ED environments as information transmission and interaction may be conducted asynchronously without frequent mutual interruptions.⁴ Similar effects could be achieved through an electronic message or through whiteboard systems that provide relevant information to internal and external care providers. However, potential pitfalls (eg, misunderstanding of information) need to be investigated carefully in terms of consequences for patient safety and information reliability.⁴

Lastly, in our study we relied on subjective patient outcomes. Future research should investigate objective quality and safety measures, for example, exploring associations between interruptions and medication errors.¹³

CONCLUSIONS

Capturing potential patient-related effects due to workflow interruptions, multitasking and mental workload is an important step in order to create an effective work environment for ED professionals and to increase the quality of care. Our results could suggest that mental workload due to inefficient work practice needs to be constrained because excessive workload can lead to inferior quality of care. Furthermore, our results suggest that workflow interruption and multitasking can be conducive to clinical care. Thus, a rather nuanced standpoint to considerably discuss the appropriateness of workflow interruptions and multitasking is required. Our findings call for further investigations into the complex consequences of interruptions in ED care. Future research should apply triangulation of methods to include objective quality indicators and information on ED staff's work demands such as administrative workload or admission data as well as patient records for case complexities.

Future ED operational system design should promote safe and efficient workflows that promote direct patient interaction, minimise undesired interruptions, promote efficiency in communication and take into consideration the interactive, dynamic and unpredictable nature of ED professionals' work environment.^{1 4 16}

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Competing interests None declared.

Patient consent We informed ED staff before starting, and assured confidentiality and anonymity. In addition, the hospital employee council and all department heads gave their written consent. Participation was voluntary, and we obtained written consent from the ED staff and verbal consent from the ED patients (no personal information was obtained from ED patients).

Ethics approval The Ethics Committee of the Faculty of Medicine from Ludwig-Maximilians-University Munich gave ethical approval for this study (Nr. 406-11).

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REFERENCES

- Wears RL, Woloshynowych M, Brown R, *et al.* Reflective analysis of safety research in the hospital accident & emergency departments. *Appl Ergon* 2010;41:695–700.
- Wears RL, Perry SJ. Human factors and ergonomics in the emergency department. *Ann Emerg Med* 2002;40:206–12.
- Laxmisan A, Hakimzada F, Sayan OR, *et al.* The multitasking clinician: decision-making and cognitive demand during and after team handoffs in emergency care. *Int J Med Inform* 2007;76:801–11.
- Chisholm CD, Weaver CS, Whemmouth L, *et al.* A task analysis of emergency physician activities in academic and community settings. *Ann Emerg Med* 2011;58:117–22.
- Brixey JJ, Tang Z, Robinson DJ, *et al.* Interruptions in a level one trauma center: a case study. *Int J Med Inform* 2008;77:235–41.
- Woloshynowych M, Davis R, Brown R, *et al.* Communication patterns in a UK emergency department. *Ann Emerg Med* 2007;50:407–13.
- Walter SR, Li L, Dunsmuir WT, *et al.* Managing competing demands through task-switching and multitasking: a multi-setting observational study of 200 clinicians over 1000 hours. *BMJ Qual Saf* 2014;23:231–41.
- Chisholm CD, Collision EK, Nelson DR, *et al.* Emergency department workplace interruptions: are emergency physicians “interrupt-driven” and “multitasking”? *Acad Emerg Med* 2000;7:1239–43.
- Chisholm CD, Dornfeld AM, Nelson DR, *et al.* Work interrupted: a comparison of workplace interruptions in emergency departments and primary care offices. *Ann Emerg Med* 2001;38:146–51.
- Berg LM, Kallberg AS, Goransson KE, *et al.* Interruptions in emergency department work: an observational and interview study. *BMJ Qual Saf* 2013;22:656–63.
- Weigl M, Müller A, Zupanc A, *et al.* Hospital doctors' workflow interruptions and activities: an observation study. *BMJ Qual Saf* 2011;20:491–7.
- Westbrook JI, Coiera E, Dunsmuir WT, *et al.* The impact of interruptions on clinical task completion. *Qual Saf Health Care* 2010;19:284–9.
- Westbrook JI, Woods A, Rob MI, *et al.* Association of interruptions with an increased risk and severity of medication administration errors. *Arch Intern Med* 2010;170:683–90.
- Weigl M, Müller A, Zupanc A, *et al.* Participant observation of time allocation, direct patient contact, and simultaneous activities in hospital physicians. *BMC Health Serv Res* 2009;9:110.
- Li SY, Magrabi F, Coiera E. A systematic review of the psychological literature on interruption and its patient safety implications. *J Am Med Inform Assoc* 2012;19:6–12.
- Catchpole K, Ley E, Wiegmann D, *et al.* A human factors subsystems approach to trauma care. *JAMA Surg* 2014;149:962–8.
- France DJ, Levin S, Hemphill R, *et al.* Emergency physicians' behaviors and workload in the presence of an electronic whiteboard. *Int J Med Inform* 2005;74:827–37.
- Coiera E. The science of interruption. *BMJ Qual Saf* 2012;21:357–60.
- Fleischmann T, Walter B. Interdisziplinäre Notaufnahmen in Deutschland: Eine Anlaufstelle für alle Notfälle. *Dtsch Arztebl* 2007;104:3164–6.
- Brachmann M. Notaufnahmen in Deutschland [Emergency Units in Germany]. In: Eiff W, von Dodt C, Brachmann M, eds. *Management der Notaufnahme [Management of the emergency unit]*. Kohlhammer: Stuttgart, 2011:42–52.
- Weigl M, Müller A, Sevdalis N, *et al.* Relationships of multitasking, physicians' strain, and performance: an observational study in ward physicians. *J Patient Saf* 2013;9:18–23.
- Brixey JJ, Robinson DJ, Johnson CW, *et al.* A concept analysis of the phenomenon interruption. *ANS Adv Nurs Sci* 2007;30:E26–42.
- Prümper J, Hartmannsgruber K, Frese M. Kurz-Fragebogen zur Arbeitsanalyse (KFZA). *Zeitschrift für Arbeits- und Organisationspsychologie* 1995;39:125–31.
- Semmer N, Zapf D, Dunckel H. Instrument zur stressbezogenen Tätigkeitsanalyse (ISTA). In: Dunckel H, ed. *Handbuch psychologischer Arbeitsanalyseverfahren*. Zürich: vdf, 1999:179–204.
- Hart SG, Staveland LE, Hancock PA, *et al.* Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. *Human mental workload*. Oxford England: North-Holland, 1988:139–83.
- Levin S, France DJ, Hemphill R, *et al.* Tracking workload in the emergency department. *Hum Factors* 2006;48:526–39.
- Bussing A, Glaser R. Employee and client orientation in health care services. *Zeitschrift fuer Arbeits- und Organisationspsychologie [J Work Organ Psychol]* 2003;47:222–8.
- Montgomery VL. Effect of fatigue, workload, and environment on patient safety in the pediatric intensive care unit. *Pediatr Crit Care Med* 2007;8(2 Suppl):S11–16.
- Aiken LH, Clarke SP, Sloane DM, *et al.* Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *Jama* 2002;288:1987–93.
- Flowerdew L, Brown R, Vincent C, *et al.* Identifying nontechnical skills associated with safety in the emergency department: a scoping review of the literature. *Ann Emerg Med* 2012;59:386–94.

- 31 Flowerdew L, Brown R, Russ S, *et al.* Teams under pressure in the emergency department: an interview study. *Emerg Med J* 2012;29:e2.
- 32 Hakimzada AF, Green RA, Sayan OR, *et al.* The nature and occurrence of registration errors in the emergency department. *Int J Med Inform* 2008;77:169–75.
- 33 Wiegmann DA, ElBardissi AW, Dearani JA, *et al.* . Disruptions in surgical flow and their relationship to surgical errors: an exploratory investigation. *Surgery* 2007;142:658–65.
- 34 Rivera-Rodriguez AJ, Karsh BT. Interruptions and distractions in healthcare: review and reappraisal. *Qual Saf Health Care* 2010;19:304–12.
- 35 Kreckler S, Catchpole K, Bottomley M, *et al.* Interruptions during drug rounds: an observational study. *Br J Nurs* 2008;17:1326–30.
- 36 Brixey JJ, Robinson DJ, Turley JP, *et al.* The roles of MDs and RNs as initiators and recipients of interruptions in workflow. *Int J Med Inform* 2010;79:e109–15.
- 37 Westbrook JI. Interruptions and multi-tasking: moving the research agenda in new directions. *BMJ Qual Saf* 2014;23:877–9.
- 38 Zijlstra FRH, Roe RA, Leonora AB, *et al.* Temporal factors in mental work: Effects of interrupted activities. *J Occup Organ Psychol* 1999;72:163–85.
- 39 Monsell S. Task switching. *Trends Cogn Sci* 2003;7:134–40.
- 40 Wickens CD. Multiple resources and mental workload. *Hum Factors* 2008;50:449–55.
- 41 McCambridge J, Witton J, Elbourne DR. Systematic review of the Hawthorne effect: new concepts are needed to study research participation effects. *J Clin Epidemiol* 2014;67:267–77.
- 42 Cho YI, Johnson TP, Vangeest JB. Enhancing surveys of health care professionals: a meta-analysis of techniques to improve response. *Eval Health Prof* 2013;36:382–407.
- 43 Podsakoff PM, MacKenzie SB, Lee JY, *et al.* Common method biases in behavioral research: a critical review of the literature and recommended remedies. *J Appl Psychol* 2003;88:879–903.
- 44 Manary MP, Boulding W, Staelin R, *et al.* The patient experience and health outcomes. *N Engl J Med* 2013;368:201–3.
- 45 Maas CJ, Hox JJ. Sufficient sample sizes for multilevel modeling. *Methodol Eur J Res Methods Behav Soc Sci* 2005;1:86.