
Aus dem Institut und Poliklinik für Arbeits-, Sozial- und Umweltmedizin

Klinik der Ludwig-Maximilians-Universität München

Direktor: Prof. Dr. med. Dennis Nowak

**Emergency departments as complex adaptive systems:
Interrelationships between work system factors, employee well-being and
quality of patient care**

Dissertation

zum Erwerb des Doktorgrades der Humanbiologie

an der Medizinischen Fakultät der

Ludwig-Maximilians-Universität zu München

vorgelegt von

Anna Schneider

aus

Katschar, Kasachstan

2020

Mit Genehmigung der Medizinischen Fakultät
der Universität München

Berichterstatterin: PD Dr. phil. Britta Herbig

Mitberichterstatter: Prof. Dr. med. Markus Wörnle
Prof. Dr. med. Matthias Klein
Prof. Dr. med. Karl-Georg Kanz

Dekan: Prof. Dr. med. dent. Reinhard Hickel

Tag der mündlichen Prüfung: 24.09.2020

Eidesstattliche Versicherung

Schneider, Anna

Name, Vorname

Ich erkläre hiermit an Eides statt,
dass ich die vorliegende Dissertation mit dem Thema

Emergency departments as complex adaptive systems:
Interrelationships between work system factors, employee well-being and quality of
patient care

selbständig verfasst, mich außer der angegebenen keiner weiteren Hilfsmittel bedient und alle Erkenntnisse, die aus dem Schrifttum ganz oder annähernd übernommen sind, als solche kenntlich gemacht und nach ihrer Herkunft unter Bezeichnung der Fundstelle einzeln nachgewiesen habe.

Ich erkläre des Weiteren, dass die hier vorgelegte Dissertation nicht in gleicher oder in ähnlicher Form bei einer anderen Stelle zur Erlangung eines akademischen Grades eingereicht wurde.

Berlin, 20.01.2020

Ort, Datum

Anna Schneider

Unterschrift Doktorandin

Table of contents

Abbreviations.....	v
Summary.....	1
Zusammenfassung	2
1. Introduction.....	3
1.1 Rising demand for in-hospital emergency care services	3
1.2 Emergency departments as an example of complex adaptive systems.....	4
1.3 Implementation of interventions in emergency department work systems	7
1.4 Overview of the project	9
1.4.1 Study objectives and preparation	9
1.4.2 Study design and methods	10
1.4.2.1 Study setting and population.....	10
1.4.2.2 Study design.....	11
1.4.2.3 Study methods.....	11
1.4.2.4 Participative health circle intervention	13
1.4.3 Study results.....	14
1.5 Thesis publications	17
1.5.1 Thesis objectives	17
1.5.2 Summary of publications included in this thesis	17
2. Publication 1: Systematic review of psychosocial work factors and provider mental well-being in emergency departments	21
3. Publication 2: Effects of work conditions on provider mental well-being and quality of care in emergency departments	43
4. Publication 3: Provider interruptions and quality of care in emergency departments.....	56
5. Publication 4: Cross-national comparison of provider time allocation and workflow interruptions in emergency departments	66
6. Further manuscripts	73
6.1 Publication 5: Workflow interruptions and ED provider stress.....	73
6.2 Publication 6: ED psychosocial work characteristics, employee strain and quality of care.....	82
7 Conclusions and outlook.....	88
8 References.....	90
9 Addendum zur Dissertation	98

Abbreviations

CAS complex adaptive system

ED emergency department

EM emergency medicine

GP general practitioner

ITS interrupted time-series

NA Notaufnahme

USA United States of America

Summary

Introduction

Globally, emergency departments (ED) are confronted with yearly rises in visit numbers and an increasingly older and multimorbid patient population. Several work system factors were associated with employee well-being and patient safety in previous literature. This thesis reports results of a mixed-methods intervention study investigating interrelationships between psychosocial ED work system factors, employee well-being and quality of patient care under consideration of the concept of resilient health care and complex adaptive systems (CAS).

Methods

A before and after study including an interrupted time-series (ITS) design was established in the multidisciplinary ED of a tertiary referral hospital in Southern Germany between 2015 and 2017. Applied methods and data sources included (1) standardized employee surveys, (2) structured work observations, (3) patient surveys, (4) register data, and (5) qualitative interviews. Additional data on employees' activity and interruption patterns was collected in one US-American ED in 2016.

Results

Assessment of psychosocial work factors indicated considerable work demands for ED employees before and after the participative intervention comprising ten health circles. Inconsistent longitudinal intervention effects were found for changes in psychosocial work factors and employee mental well-being, e.g., increase in job control but decline in job satisfaction. Improvements in patient satisfaction were observed over time. Interviews revealed facilitators (e.g., comprehensive approach, employee participation) and barriers (e.g., understaffing, organizational constraints) for intervention implementation. Further associations between work interruptions and ED patient satisfaction as well as cross-national differences in ED work activity patterns were observed.

Conclusions

Reasons for inconsistent intervention results stem from the complexity of the ED work system including profession- and institution-specific challenges and individual stress experiences of employees. Studies should further consider employee health as a concurrent determinant as well as outcome in the theoretical concepts of CAS and resilient health care.

Zusammenfassung

Einleitung

Notaufnahmen (NA) sind mit jährlich steigenden Besuchszahlen und einer älter werdenden und multimorbiden Patientenpopulation konfrontiert. Psychosoziale Arbeitsbedingungen wurden in der Literatur mit der Gesundheit von Beschäftigten und der Qualität der Versorgung assoziiert. Diese Dissertation berichtet die Ergebnisse einer Mixed-Methods-Interventionsstudie, die diese Zusammenhänge unter Berücksichtigung der Theorie komplexer adaptiver Systeme adressiert.

Methode

In der interdisziplinären NA eines süddeutschen Maximalversorgers wurde zwischen 2015 und 2017 eine Vorher-Nachher-Studie mit einem sog. Interrupted Time-Series Design durchgeführt. Methoden und Datenquellen umfassten (1) standardisierte Mitarbeiterbefragungen, (2) strukturierte Arbeitsbeobachtungen, (3) Patientenbefragungen, (4) Sekundärdaten und (5) qualitative Interviews. Ergänzende Daten zu Arbeitsbedingungen wurden 2016 in einer US-amerikanischen NA erhoben.

Ergebnisse

Vor und nach der partizipativen Intervention – bestehend aus 10 Gesundheitszirkeln – wurden erhebliche psychosoziale Arbeitsbelastungen für in der NA Beschäftigte identifiziert. Inkonsistente Längsschnitteffekte zeigten Veränderungen in psychosozialen Arbeitsbedingungen und im psychischen Wohlbefinden, z.B. Zunahme der Autonomie jedoch verringerte Arbeitszufriedenheit. Die Patientenzufriedenheit verbesserte sich im Laufe der Zeit. Unterstützende Faktoren für die Implementierung der Intervention waren ihr umfassender Ansatz und die Mitarbeiterbeteiligung wohingegen personelle Unterbesetzung und organisatorische Einschränkungen Barrieren darstellten. Weitere Zusammenhänge zwischen Arbeitsunterbrechungen und der Patientenzufriedenheit sowie länderübergreifende Unterschiede in NA-Arbeitsabläufen wurden beobachtet.

Schlussfolgerungen

Gründe für inkonsistente Interventionsergebnisse liegen in der Komplexität des NA-Arbeitssystems einschließlich berufs- und institutionsspezifischer Herausforderungen und individueller Beanspruchungserfahrungen der Beschäftigten begründet, welche in zukünftigen Studien zur arbeitsbezogenen Gesundheit im Rahmen der CAS-Theorie berücksichtigt werden sollten.

1. Introduction

1.1 Rising demand for in-hospital emergency care services

Between 2009 and 2014, emergency departments (ED) in Germany faced a significant surge in patient numbers amounting to a 42% increase (Wahlster, Czihal, Gibis, & Henschke, 2019). Furthermore, the patient population presenting to EDs is subject to change. Elderly patients represent a group with high probability for longer ED stays, higher resource utilization, as well as higher rates of inpatient admission after emergency treatment (Fuchs, Çelik, Brouns, Kaymak, & Haak, 2019; Wahlster et al., 2019). Otherwise, young adults between the age of 20 and 34 years increasingly rely on emergency services for ambulatory care (Wahlster et al., 2019). Especially in urban areas in Germany, around 66% of patients are discharged home after ED treatment (Trentzsch et al., 2019) pointing to rather minor ambulatory healthcare needs of the respective patients. Low urgency is prevalent in around half of cases treated in EDs, however, most presentations require a comprehensive work-up which consumes considerable time, personnel and instrumental resources (Scherer, Lühmann, Kazek, Hansen, & Schäfer, 2017; Trentzsch et al., 2019). Reasons for increasing ED visit rates are manifold. Although patients generally give positive ratings on the relationship with their general practitioners (GP) and specialists in ambulatory care (Tille et al., 2019), EDs remain the ‘last resort’ for many patients offering instant differentiated diagnostic and care opportunities 24 hours a day (Morganti et al., 2013). Perceived acuity of patient’s medical condition, barriers in accessing primary care services, amenities of in-hospital emergency care including technical equipment and temporal availability, and presumed higher quality of care standards in EDs are patient-reported reasons for seeking care in the emergency setting instead of the ambulatory care sector (Vogel et al., 2019; Schuettig & Sundmacher, 2019).

In this thesis, the United States of America (USA) serve as a comparative country with a longstanding history of emergency medicine (EM) research and EM as a recognized specialist discipline (Williams 2018). As in Germany, recent annual numbers from the US Census Bureau on ED utilization indicate rising demands for ED care. In urban areas, ED visits of the civilian noninstitutionalized population increased from 40.2 to 42.8 visits per 100 persons while ED visits in rural areas even increased from 36.5 to 64.5 visits per 100 persons from 2005 to 2016 (Greenwood-

Ericksen & Kocher, 2019). Complementary to the above-described challenges in German EDs with respect to the patient population, US EDs are also confronted with vulnerable populations including Medicaid beneficiaries, uninsured individuals as well as persons with multiple chronic conditions (Greenwood-Ericksen & Kocher, 2019; Powell, Yu, Isehunwa, & Chang, 2018).

Emergency care, and medical care in general, is becoming more complex due to several technological, diagnostic and therapeutic advances in healthcare organization and delivery as well as a growing share of older and multimorbid patients (National Academies of Sciences, 2019). These ‘transformational forces’ pose new challenges for healthcare provision in general and emergency medicine in specific (Widmer, Swanson, Zink, & Pines, 2018). Each national healthcare system faces particular challenges which pertain to the distinctive features of these systems, e.g., the opioid epidemic and rising healthcare costs in the USA, or transformation of the organization of the pre- and hospital emergency medical system which is currently discussed in Germany (Brokmann, Pin, Bernhard, Walcher, & Gries, 2019). Concomitants of these developments, e.g., ED crowding and maladapted care processes within hospitals, are long-known threats to safe care provision and pose significant burdens on ED employees (Morley, Unwin, Peterson, Stankovich, & Kinsman, 2018). Most of the above-described societal and economic developments are current global challenges for the majority of healthcare institutions and their individual organizational units. However, this thesis concentrates on the inspection of in-hospital emergency care with EDs being independent hospital entities with several interfaces between the in-patient and ambulatory healthcare sectors.

1.2 Emergency departments as an example of complex adaptive systems

Dynamic ED work environments are fast-paced and resources are often scarce, e.g., regarding adequate staffing levels, ED and inpatient bed capacities as well as turnaround times of laboratory samples and radiology findings (Handel, French, Nichol, Momberger, & Fu, 2014; Son, Sasangohar, Rao, Larsen, & Neville, 2019). EDs are thus characterized by several potentially conflicting goals, i.e., optimally caring for all patients according to their individual preferences and needs while adhering to predefined waiting time targets and accommodating an unpredictable amount of potentially critically ill patients. These manifold and at times mutually exclusive tasks lead to stressful work environments

and place considerable burden on ED employees working in these environments as well as patients being treated in these environments (Wears & Vincent, 2015).

To better understand recurrent challenges in care provision and assurance of quality of care in EM, EDs are subsequently described and investigated using different explanatory approaches of systems theories. Systems are generally characterized by a configuration of different components, e.g., people and technical equipment, which combine their activities in an orderly manner to produce certain outcomes. Further, systems are dynamic over time and demonstrate different characteristics regarding their size, flexibility, effectiveness and inclusion of other incorporated sub-systems (Braithwaite, Clay-Williams, Nugus, & Plumb, 2015). Complexity in these systems stems from the diversity, interactivity and hierarchy as well as heterarchy in the system's organization of individual system components (Braithwaite et al., 2015). To describe the regular operating mode of complex work systems, concepts of resilient engineering and human factors principles are applied (National Academies of Sciences, 2019; Son et al., 2019): Resilient systems are thus distinguished by their ability to adjust their performance before, during and after foreseeable as well as unforeseeable minor and major system changes and disturbances in order to achieve required outcomes (Hollnagel, Braithwaite, & Wears, 2015). In healthcare, changes and disturbances mostly stem from a combination of different technological and human factors in the work environment, ranging from staff shortfalls, technical breakdowns, unexpectedly high patient volumes up to mass casualty events. Resilient health care systems thus perform continuous performance adjustments to adapt to varying circumstances and conditions in the internal and external environment (Hollnagel, Wears, & Braithwaite, 2015). Although different methods exist to graphically or procedurally depict systems, complexity can only be described "for a given representation of a system, not for the system itself" (Rasmussen & Lind, 1981, p. 8). This means that only certain states of systems offer themselves for description, but no universal complex system model can be created since sociotechnical systems elude the logic of technological or mechanical blueprints (Rasmussen & Lind, 1981).

Each ED represents a burning lens of a complex adaptive system (CAS) featuring various interfaces to inpatient and outpatient healthcare services and institutions. Furthermore, EDs serve as platforms and culmination points for a variety of different professional groups, e.g., physicians,

nurses, emergency medical technicians, diagnostic services personnel, GPs, as well as patients and other stakeholders. ED employees are responsible for the guidance of patients through different organizational and clinical processes during their care, starting with ED registration and triage and ending with the discharge process or ward transfer (Braithwaite et al., 2015). Safe and efficient ED care thus relies on functioning multi-professional teams which are composed of individuals with different knowledge levels, skills, and values (Hacker, 2003). EDs further serve as examples for small-scale resilient systems since they maintain their performance most of the time, i.e., patients receive safe care despite a number of adversities pertaining to the above-described resource limitations and unpredictable workloads. A number of different models has been proposed to conceptualize the adaptation process of ED systems where ED operations are upheld or recovered after expected or unexpected disturbances (Son et al., 2019). Considering the concept of resilience, ED employees operate as central stakeholders in the work environment by planning, exerting and adapting strategies to deal with patient load and other (un)predictable circumstances. Thus, ED employees play a pivotal role in the upholding of resilient systems, and in return, system performance can be compromised by physically or mentally impaired ED providers.

Employees' work environment encompasses interacting factors pertaining to the physical environment, task, tools, technologies and persons (Carayon, 2009; Carayon & Smith, 2000). Different work characteristics affect psychological states in employees and work outcomes, e.g., regarding behavioral outcomes, e.g., absenteeism, attitudinal outcomes, e.g., job satisfaction, work motivation, role perception outcomes, and well-being outcomes, e.g., anxiety, stress (Hall, Johnson, Watt, Tsipa, & O'Connor, 2016; Schneider & Weigl, 2018). In a meta-analytical literature review, work characteristics were found to explain on average 43% of variance in attitudinal and behavioral outcomes and between 20% and 64% of variance in different well-being outcomes of employees (Humphrey, Nahrgang, & Morgeson, 2007). Work characteristics will be mainly termed work system factors in the remaining thesis in order to illustrate their link with the concept of complex adaptive systems and resilience engineering. Thus, work system factors, such as an extensive and overwhelming workload, time pressure, work-home conflicts and cognitive demands affect the physical and mental well-being of healthcare employees in the short- and long-term (Basu, Qayyum,

& Mason, 2017; Wallace, Lemaire, & Ghali, 2009). In combination with individual predispositions, e.g., specific personality traits (Alarcon, Eschleman, & Bowling, 2009), as well as professional codes, e.g., regarding the handling of mental health issues by colleagues and supervisors, work system factors may not only affect individual employee health outcomes but also quality of patient care (Carayon, 2009; Nielsen, Pedersen, Rasmussen, Pape, & Mikkelsen, 2013). Reduced standards of care, e.g., risks for medical errors, medication errors, and near misses, may result both from overburdening work system factors as well as employees' mental and physical ill health (Hall et al., 2016). Consequently, work-related mental health and well-being of ED employees emerge as multifactorial constructs which are further influenced by factors outside the work environment. Specific risk groups have been identified as being prone to suffer from work-related mental ill health: Young physicians starting specialty training and medical students are especially affected by burnout and depression (Thomas, 2004). Furthermore, EDs pose high-risk environments for impaired mental well-being with up to 26% of emergency nurses (Adriaenssens, de Gucht, & Maes, 2015) and up to 51% of emergency physicians reporting symptoms of burnout (Bragard, Dupuis, & Fleet, 2015). Implications of mental ill health are exacerbated by the risk for concomitant physical and other mental diseases, e.g., sleep disorders, anxiety disorders, reduced immune defense, and decreased productivity, e.g., increase in sick days and decrease of work ability (Ganster & Rosen, 2013; Wallace et al., 2009).

Regular assessment of meaningful work system factors and healthcare employees' well-being is a first step to create awareness for and act upon dysfunctional developments in work systems (Wallace et al., 2009). By addressing shortcomings in work system factors and their consequences for employees acting within these systems, the resilience of CAS might be strengthened. Thus, interventions targeting systemic work factors might improve the well-being of employees and quality of care outcomes.

1.3 Implementation of interventions in emergency department work systems

Numerous measures on how to participatively improve work systems in order to enhance employee well-being and quality of care have been proposed (e.g., Montano, Hoven, & Siegrist, 2014). Underlying frameworks propose a multi-tiered approach which usually involves some form of plan-do-study-act cycles for improvement of a given challenge or problem in the work environment

(e.g., Leis & Shojania, 2017; Pronovost, Cleeman, Wright, & Srinivasan, 2016). Thus, indicators concerning problematic work system factors and the current status of employees' mental and physical well-being have to be systematically identified through suitable risk assessments, e.g., in the form of employee surveys or audits of existing management and support systems (Nielsen, Randall, Holten, & González, 2010). These assessments might point to "symbols of the internal state" (Rasmussen & Lind, 1981, p. 9) of the work system and serve as tools to describe the complexity of the work environment from the employees' point of view. Second, risk assessment results are used in order to establish a base for the development and outline of interventions. Possible interventions might address the individual employee level, e.g., self-care or stress management techniques to personally compensate stressful work experiences, or they adopt the systemic approach aimed at the improvement of the work system as a whole including inherent work processes (Ruotsalainen, Serra, Marine, & Verbeek, 2008). Finally, selected interventions have to be implemented and an appropriate infrastructure for change opportunities has to be developed. Continuing employee engagement with intervention measures and problem awareness have to be strengthened. Thus, resources have to be provided to employees in order to engage with change activities and intervention measures. Regular evaluations of goal achievement have to be conducted to monitor intervention success and potential needs for adjustment. In this context it should be noted that organizational interventions might contribute to system complexity since employees have to adapt to new routines which might encourage errors and disturbances of other work processes. Returning to the concept of resilience, changes to the work system induced by interventions further might be quickly reversed such that the system returns to its flawed baseline position. Thus, work arounds and ignorance of intervention measures by employees may lead to a point where new and potentially beneficial interventions are not implemented in everyday practice and the system returns to its status quo (Sutcliffe & Weick, 2015; Wears & Vincent, 2015).

Changes to work processes and other work system factors require that employees are given the time as well as financial and knowledge resources to analyze suboptimal work factors and that they are enabled to search for, implement and evaluate different solutions (Hacker, 2003). Thus, organizational-level occupational health interventions aim to systematically remove or improve

adverse work system factors in order to enhance employees' work-related health and well-being (Nielsen et al., 2010). First, participative approaches might act as an intervention in itself, where employees are empowered to be responsible for their work environment and might experience proud, esteem and a sense of fairness from being in charge for positive changes (Nielsen et al., 2010). Second, participative interventions might serve as an approach to understand system complexity by consulting and learning from affected employees and their everyday experiences. Participative work organization constitutes a preventive effort against system failures by establishing a proactive form of performance adjustment by identifying adverse work system factors potentially leading to failures, patient harm and employee ill health and by taking precautions against these negative outcomes. Effective work systems are developed and sustained through successful interactions between different system components, e.g., persons and technologies (Carayon, 2009; Carayon & Smith, 2000). Employee-oriented work organization offers the opportunity to continuously engage in an advanced form of healthcare quality assurance by analyzing, anticipating and acting upon the premises of complex adaptive systems and their potential threats for system performance.

1.4 Overview of the project

1.4.1 Study objectives and preparation

Aims of the study were threefold. The first aim was to analyze psychosocial work factors of ED employees, i.e., physicians, nurses, and administrative staff members, and their association with employee mental well-being and ED quality of care parameters. The second aim was to prospectively implement a participative organizational-level intervention targeting adverse ED work factors. Finally, the study aimed at the analysis of intervention effects on subsequent changes in ED work factors, employee mental well-being and quality of patient care under consideration of the theoretical concept of complex adaptive systems. In its research design and organization, this study expanded on a similar project in a community hospital ED from 2011 (Weigl, Müller, Holland, Wedel, & Woloshynowych, 2016; Weigl & Schneider, 2017).

In the study preparation phase, the inclusion of two EDs for the implementation of a quasi-randomized controlled study design was planned. Two EDs in the Federal State of Bavaria were approached following recommendation from one ED head physician, and informed about the study.

However, the project was only executed in one ED due to failure to obtain a positive voting by the staff council in time for project start in the second ED. The thesis author further initiated a stay abroad as a visiting researcher in 2016 at the Department of Emergency Medicine, University of Florida, Jacksonville, USA under the supervision of Professor Robert L. Wears (Wears & Perry, 2002; Wears, Woloshynowych, Brown, & Vincent, 2010). The aim of this endeavor was to collect data in an American ED in order to contrast findings from two different settings, i.e., the German ED and the American ED, on selected work activity and work interruption patterns in ED employees' work under consideration of the resilient health care concept. Unless otherwise stated, the following description refers to the main intervention study in the German ED.

1.4.2 Study design and methods

1.4.2.1 Study setting and population

The study setting is a 24-hour interdisciplinary ED of a tertiary referral hospital. The academic hospital provides all major services and medical specialties in 25 medical centers and institutes for an administrative region of almost two million inhabitants. The ED serves adults with a mean yearly patient volume of over 85,000. After study completion in 2016, the hospital passed through major organizational changes including the designation as university hospital and constructional expansion of the ED to accommodate further treatment and short-stay unit capacities. The study was directed at all ED employees including senior and junior physicians from internal medicine, anesthesiology, neurology, and trauma surgery; registered nurses, and administrative personnel regularly working in the ED. Medical students, student nurses, external healthcare providers and on-call consultants were excluded. At baseline, ED staff consisted of 101 nurses (including nursing auxiliary staff), 44 physicians (including rotating residents from different disciplines), and 20 administrative staff members.

The main study obtained a positive voting from the Ethics Committee of the Medical Faculty, Munich University (NR 327-15) as well as the local hospital ethics committee at the study site. For the American study site, the ED academic institutional review board at the University of Florida, Jacksonville gave a positive voting.

1.4.2.2 Study design

A mixed-methods approach was applied to investigate interrelationships between ED psychosocial work factors, employee mental well-being and quality of care. Before data collection at baseline, several meetings with ED management were held including the ED head physician, ED nursing manager, ED administrative head, and the supervisor of ED administrative staff. The study was further presented at different hospital executive board meetings and staff council meetings throughout the project phase. Study contents and study organization were presented in four ED staff meetings before baseline assessment. Study packages including the study information, an informed consent form and the employee survey were distributed in closed envelopes with postpaid return envelopes at baseline and follow-up. Matching of employee surveys across time was conducted with personalized study codes.

For intervention evaluation, a quasi-experimental before and after study design encompassing a 12-month observation period was applied. Data collection for on-site work observations and patient surveys took place on 20 days each at baseline (December 2015 – January 2016) and follow-up (December 2016 – January 2017) between 10 AM and 6 PM at the study site. Prior to start, a stratified sampling procedure for selection of on-site data collection days was prepared to ensure random and equal allocation across all days of the week.

1.4.2.3 Study methods

A multi-methods approach assessed psychosocial work system factors, mental well-being of ED employees and quality of care with a focus on ED patient satisfaction. Applied methods and data sources included (1) standardized employee surveys and daily shift surveys, (2) structured work observations with ED physicians and nurses and concurrent work stress reports, (3) patient surveys, (4) register data, and (5) qualitative interviews, which are briefly described below.

1. Employee surveys and shift surveys: Psychosocial work system factors, i.e., stressors and resources, were measured with different validated self-report tools (e.g., Büssing & Glaser, 2002; Hart & Staveland, 1988; Rödel, Siegrist, Hessel, & Brähler, 2004; Siegrist, Wege, Pühlhofer, & Wahrendorf, 2008) that have been previously applied to the ED setting (Weigl & Schneider, 2017). Mental well-being, i.e., burnout, depressive symptoms and irritation, was

measured with validated survey instruments (Büssing & Perrar, 1992; Kroenke, Spitzer, & Williams, 2003; Mohr, Müller, Rigotti, Aycan, & Tschan, 2006). Conventional cut-off criteria were used to identify participants with elevated levels of emotional exhaustion (Kleijweg, Verbraak, & Van Dijk, 2013) and depressive symptoms (Kroenke et al., 2003). Furthermore, job satisfaction and turnover intentions were surveyed. Employee-reported quality of care was measured with self-perceived frequency of medical errors (Waterman et al., 2007) and overall patient safety in the ED (Pfeiffer & Manser, 2010). Additionally, written shift surveys were available during data collection periods in staff break rooms including questions on daily work stressors and present well-being (Hart & Staveland, 1988).

2. Work observations and subsequent work stress surveys: Observation sessions of ED nurses' and physicians' workflows were allocated randomly across ED sections and professions. Trained observers applied a standardized participant observation approach which has been previously used in ED settings (Weigl, Beck, Wehler, & Schneider, 2017; Weigl et al., 2016; Weigl, Müller, Vincent, Angerer, & Sevdalis, 2012). Distinct activity categories, multitasking incidences and sources as well as reasons of work interruptions were coded. Employees' well-being was surveyed immediately after each observation session with a short survey on current work stress in each observed person (Marteau & Bekker, 1992).
3. Patient survey: All ED patients undergoing consultation or treatment on days of on-site data collection were eligible for participation. Patients incapable to communicate due to illness severity or other physical and mental constraints were not surveyed. Study personnel approached patients and accompanying relatives with a one-page standardized survey on satisfaction with ED quality of care, preferably at the end of patients' ED treatment (Büssing & Glaser, 2003; Weigl, Hoffmann, Müller, Barth, & Angerer, 2014; Weigl, Hornung, Angerer, Siegrist, & Glaser, 2013; Weigl et al., 2016). Translations in English, Russian, and Turkish language were available. Due to data protection legislation, no demographic variables were obtained from participating patients.
4. Register data: Pseudonymised patient information, e.g., demographic characteristics, patient acuity according to the Emergency Severity Index score, and procedural variables, e.g., times

of admission and discharge, were collected from the ED paper file documentation system and hospital electronic medical records for all patients treated during the study period. Furthermore, staff rosters were reviewed to extract data on personnel resources in the study period, e.g., number of physicians and nurses per shift.

5. Qualitative stakeholder interviews were conducted at study half-time and follow-up to complement quantitative methods. A semi-structured interview guideline assessed facilitators and barriers pertaining to intervention implementation as well as employees' mental models (Nielsen & Randall, 2013). Interviewees were recruited through convenience sampling from ED staff.

1.4.2.4 Participative health circle intervention

The description of the preparation, execution and evaluation of the intervention can be found in Publication 2 of this thesis (Schneider, Wehler, & Weigl, 2019a). Fundamental theoretical assumptions during the development of the intervention were loosely based on the solution-oriented approach (Bamberger, 2015; de Shazer, 2004). Guiding principles of the intervention design were that due to system complexity and intertwined relationships between persons and their work environment, employees act as the main experts for work-related problems and corresponding improvement measures. Thus, solutions to workplace problems are constructed by employees in an interactive and inter-professional approach eventually with the support of third parties, e.g., experts or researchers. The health circle intervention focuses on the development of solutions and the strengthening of available resources and competencies of employees in a participative manner (Aust & Ducki, 2004).

Participation in health circles was voluntary and counted as work time for both ED physicians and nurses. However, specific subgroups did not participate in the intervention although they were part of the study population. ED administrative personnel did not participate due to the mostly non-clinical scope of their work and duties and organizational attachment to a hospital unit outside of the ED. Further, the surgery unit of the ED was staffed with senior and junior physicians from the hospitals' trauma surgery ward which did not participate at health circle meetings although they were repeatedly invited. Nonetheless, during the intervention phase, all ED employees were invited to send in solutions

to the coordinating researcher for problem areas discussed in health circles via written handouts to emphasize the participative character of the intervention.

1.4.3 Study results

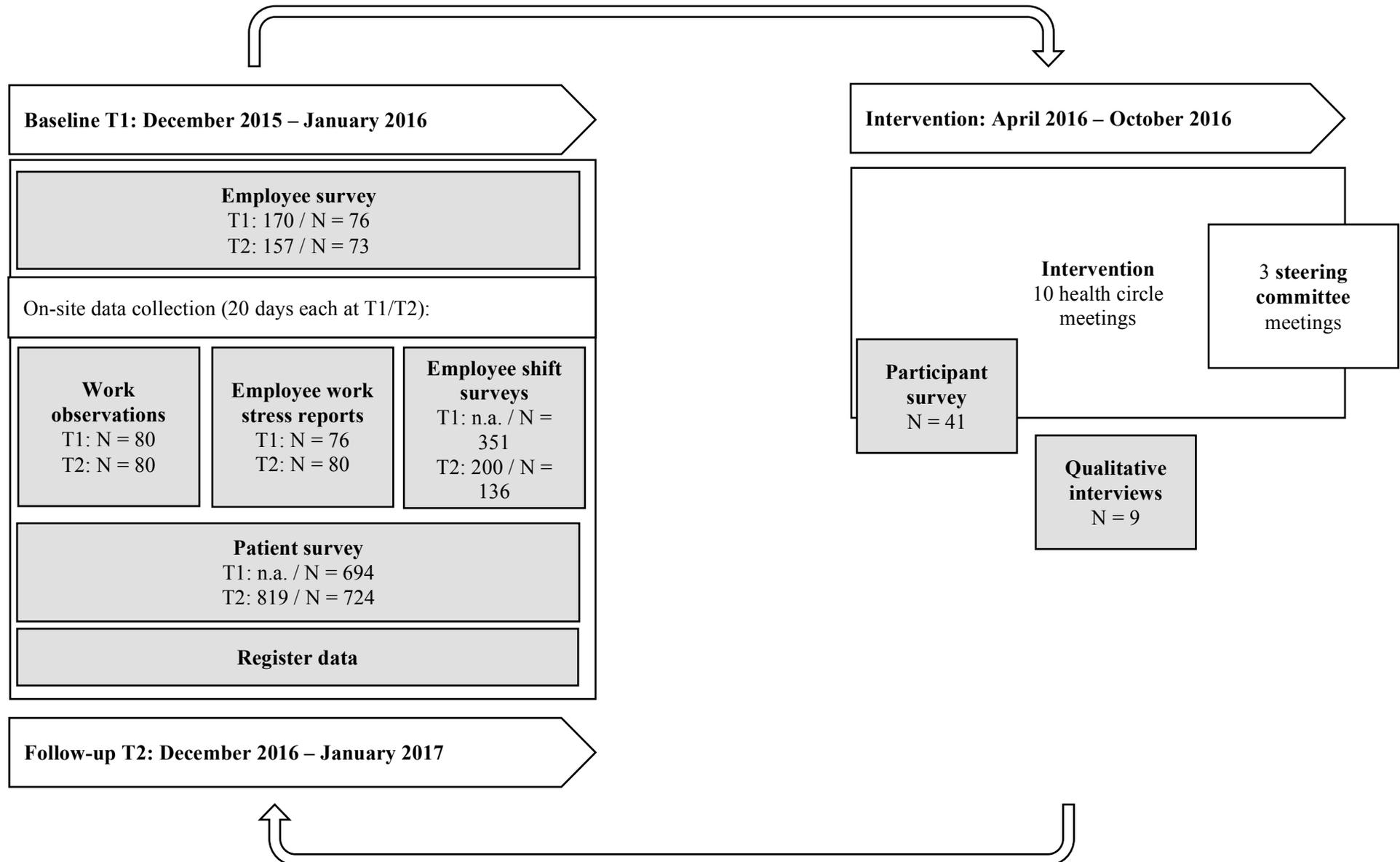
Figure 1 describes the number of returned questionnaires, amount of work observations during baseline and follow-up assessments as well as the number of interviews and intervention meetings. A detailed description of findings pre- and post-intervention can be found in Publication 2 of this thesis (Schneider et al., 2019a).

The initial assessment of psychosocial work factors indicated considerable work demands for ED employees. Baseline results were summarized in a report and presented to ED management and employees, the hospital executive board and the staff council. Ten health circles were conducted on employee-identified problems in routine ED practice and overarching work factors, e.g., regarding lack of personal breaks and the point of triage. Health circles were accompanied by meetings of the steering group with members of ED management and other representatives from relevant hospital departments. Participants of health circles gave positive feedback on meetings especially concerning the possibility for interdisciplinary exchange with colleagues. Overall, thirteen measures were developed by participants to improve respective work factors. Comprehensive written reports were prepared after baseline assessment and follow-up which were made available for members of the steering committee and ED staff upon request. Study results were also disseminated in the staff council's internal newsletters as well as on the hospital's intranet and in-house newspaper.

At follow-up, conflicting results were observed for self-reported changes in psychosocial work factors including profession-specific trends. A decrease in social support and (interprofessional) teamwork among nurses and physicians were reported by participants. Appraisal of the availability of personnel resources and equipment worsened at follow-up. Employees, and especially participating ED nurses, repeatedly criticized insufficient staff resources and spatial shortcomings of the ED. ED-inherent work factors, e.g., time pressure, worsened while self-perceived interruptions decreased. Supervisor feedback improved for nurses and physicians, however, participants criticized a decrease in the trustful relationship with their supervisor and participation opportunities. Nurses' autonomy significantly improved at follow-up. In the free-text comment section of the employee survey, the

following topics were referred to as on-going areas for improvement most frequently: personnel resources, supervisor support, e.g., regarding recognition of work performance, communication with ED-internal and ED-external colleagues, facilities and equipment, ED organization, e.g., interfaces with other wards, distribution of tasks between ED employees, planning of staff rosters, teamwork and social support by colleagues, further training opportunities, and higher financial rewards. As observed with changes in psychosocial work factors, longitudinal outcomes of ED employee mental well-being were mixed and largely differed for professions. An increase in job satisfaction for physicians and a decrease in nurses and administrative employees were observed. Intention to quit was higher in nurses and administrative employees over time while physicians' ratings improved. Physicians reported less irritation, emotional exhaustion, and depersonalization at follow-up, while mental health parameters for nurses and administrative employees mostly decreased. Patients consistently gave higher ratings for ED quality of care on all satisfaction dimensions at follow-up, i.e., ED organization, interaction with ED employees, information and waiting times. Employee-perceived ED patient safety as well as the number of self-reported near misses by ED staff remained stable over time. Qualitative synthesis of stakeholder interviews revealed that ED employees had high expectations before study initiation regarding the possibility to raise awareness for ED workload in other wards and at hospital management level. Most of the surveyed ED work factors were described as relevant, however, ED physicians further expressed high stress potential caused by slow and dysfunctional information technology systems and other technical equipment. They also acknowledged systemic difficulties in ED organization, e.g., problems in handovers to other wards and economical requirements at the hospital management level. Nonetheless, involvement of ED physicians in intervention measures was ambiguous due to selective participation in health circles and improvement measures. ED nurses were described as being more actively involved in intervention activities than ED physicians. Direct rejections of the research study or intervention measures were rarely verbalized.

Figure 1: Overview of the study's data sources and amount of collected data at baseline and follow-up assessments



Notes: n.a. = not available

1.5 Thesis publications

1.5.1 Thesis objectives

The main thesis objective was to analyze intervention effectiveness regarding changes in psychosocial work factors, employee mental well-being and quality of patient care in the ED setting. However, in the course of study implementation and evaluation, system complexity and prevalent particular work characteristics, i.e., work interruptions, emerged as specific points of interest with regard to this setting. Thus, included thesis publications depict the analysis of different ED work system components and their reciprocal associations whilst placing these components in the larger context of work system theory and complex adaptive systems. The goal of this thesis is to exemplify system complexity in a distinct medical setting, i.e., the emergency department, and to identify barriers and facilitators as well as focal points for intervention with regard to potential for improvement of healthcare employees' mental well-being and quality of patient care.

1.5.2 Summary of publications included in this thesis

Associations between psychosocial work characteristics and healthcare employees' mental well-being are a well-researched topic in occupational medicine and psychology (de Lange, Taris, Kompier, Houtman, & Bongers, 2003; Ganster & Rosen, 2013). Furthermore, multiple studies analyze the impact of specific work factors on distinct forms of mental well-being in ED physicians and nurses, i.e., burnout (Adriaenssens et al., 2015; Basu et al., 2017). However, reviews quantifying the effects of specific psychosocial work factors on ED employees' mental well-being were lacking. In Publication 1, a systematic review was conducted to identify the most important work stressors and work resources associated with the mental health of ED employees (Schneider & Weigl, 2018). Following a systematic approach, 39 original studies featuring nurse and physician samples mostly from European and (North-)American countries were retrieved in a comprehensive literature search. Overall, included studies were evaluated as weak to moderate regarding methodological quality. To graphically pool information and to synthesize quantitative results, including 367 univariate associations and 370 multivariate associations, harvest plots were used as an innovative approach (Ogilvie et al., 2008). Review results suggest that affective symptoms, e.g., burnout, and positive well-being outcomes, e.g., job satisfaction, are the most frequently studied mental health outcomes in ED

employees. Peer support, well-designed organizational structures, and employee reward systems emerged as the strongest correlates of positive ED employee well-being. This systematic review further (a) identified the need for methodologically more robust studies, i.e., prospective studies with more representative study samples and utilization of standardized instruments, as well as (b) reinforced the importance of work resources as the potentially most effective buffers of the effects of psychological work demands and adverse ED work conditions on ED employees' mental well-being. Most identified associations between psychosocial work factors and mental well-being were weak to moderate in strength. This finding reaffirms the existence of multi-factorial interdependencies between different work system components instead of monocausal effects, emphasizing the need for systems thinking in designing, evaluating and reporting respective research.

Publication 2 focuses on the effects of a multi-professional organizational-level intervention targeting ED employees' work conditions and well-being as primary outcomes and patient-perceived quality of ED care as a secondary outcome (Schneider et al., 2019a). In this publication, a mixed-methods approach including all instruments of the above-described study were used to describe potential long-term effects of the intervention on a variety of outcomes. On the one hand, findings revealed inconsistent intervention effects on psychosocial work factors and mental well-being, i.e., participants reported more job control and less overtime hours at follow-up. However, social support, job satisfaction, and depersonalization deteriorated while respondents' turnover intentions and inter-professional interruptions increased. On the other hand, regarding ED patient satisfaction, study findings suggested consistent improvements in patient-perceived ED organization and waiting times over time. Content analysis of qualitative interviews identified intervention facilitators, e.g., the comprehensive approach of the intervention and focus on employee participation, as well as barriers, e.g., understaffing in the department and organizational constraints for intervention implementation and effectiveness. This study's results underline the difficulties of implementing and evaluating interventions in highly dynamic settings such as EDs. Thus, inconsistent findings of intervention studies targeting the ED work environment may act as indicators for system complexity. Implications for future intervention studies are discussed in the Conclusions section.

Work interruptions are some of the most prevalent work demands in emergency care (Werner & Holden, 2015). Several studies proposed mechanisms for detrimental effects of work interruptions on employee and patient outcomes (Magrabi, Li, Dunn, & Coeira, 2011). However, current perspectives also focus on potentially positive consequences of interruptions on upholding safe patient care in dynamic resilient systems (Westbrook, Raban, & Walter, 2019). Thus, ad hoc exchanges of critical information on a patient's health status or medical history between the interrupted person and the interrupter might be safety-relevant for patients' treatment, especially in ED settings where employees often have to initiate procedures without complete information (Sasangohar, Donmez, Trbovich, & Easty, 2012). Given the importance of work interruptions in ED physicians' and nurses' work, Publication 3 focuses on the prospective effects of ED employees' work interruptions on patient-perceived quality of care using a statistical model to control for temporal effects and clustering (Schneider, Wehler, & Weigl, 2019b). Data from 240 hours of work observations of ED physicians and nurses as well as 1418 patient surveys were analyzed. Study findings reveal the bilateral nature of ED work interruptions by showing that on the one hand the frequency of coordination-related and patient-initiated interruptions was beneficial to patient-perceived efficiency of ED operations, while on the other hand interruptions due to case-irrelevant communication were related to worse patient ratings of ED organization. Under consideration of resilient health care principles, work interruptions might uphold efficient ED operations although effects on individual employees might be detrimental. Important implications of this research include that by designing, implementing and evaluating interventions to address work interruptions in real-world settings, both potentially positive and negative effects of interruptions on employees and patient care have to be taken into account.

Considering the impact of the external environment on work systems, Publication 4 set out to compare work time allocation and interruption rates of ED physicians and nurses in two different national contexts and healthcare systems, i.e., Germany and USA (Schneider, Williams, Kalynych, Wehler, & Weigl, in press). The thesis author collected respective data during a two-month stay in Jacksonville, Florida. A time-motion study comprising standardized expert observations yielded 86 hours of data material. Study results revealed that significant differences were observed in physicians' as well as nurses' time spent in different activities as well as the number of work interruptions.

Differences were mainly attributed to professional roles. Thus, physicians spent more time in verbal interaction with patients, in documentation, and other professional activities while nurses allocated significantly more time to therapeutic and organizational activities. Concerning interruptions, American physicians and German nurses were most often disrupted by colleagues of the same profession while German ED staff were interrupted more often by patients and other sources than American ED staff. Consequently, ED work stressors might be generic across national contexts with prevailing profession-specific demands, i.e., documentation tasks in ED physicians and therapeutic activities in ED nurses. However, observational findings on interruption rates in ED employees partly differed across national settings which warrants careful adoption of interruption rates found in international literature to domestic contexts.

Publication 5 and 6 complement findings of the above-described publications. Publication 5 focuses on the description of relevant interruption sources and contents and their associations with employee-perceived work stress in ED physicians and nurses. In Publication 6, interdependencies between work system factors, employee well-being and patient satisfaction were analyzed in a rural German ED setting.

2. Publication 1: Systematic review of psychosocial work factors and provider mental well-being in emergency departments

Schneider, A., & Weigl, M. (2018). Associations between psychosocial work factors and provider mental well-being in emergency departments: A systematic review. *PLoS One*, 13(6), e0197375.

RESEARCH ARTICLE

Associations between psychosocial work factors and provider mental well-being in emergency departments: A systematic review

Anna Schneider*[‡], Matthias Weigl[‡]

Institute and Outpatient Clinic for Occupational, Social, and Environmental Medicine, Munich University Hospital, Ludwig-Maximilians-University, Munich, Germany

[‡] These authors contributed equally to this work.

* anna.schneider@med.lmu.de



OPEN ACCESS

Citation: Schneider A, Weigl M (2018) Associations between psychosocial work factors and provider mental well-being in emergency departments: A systematic review. PLoS ONE 13 (6): e0197375. <https://doi.org/10.1371/journal.pone.0197375>

Editor: Peter van Bogaert, University Antwerp, BELGIUM

Received: December 20, 2017

Accepted: May 1, 2018

Published: June 4, 2018

Copyright: © 2018 Schneider, Weigl. This is an open access article distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Funding: This work was supported by the Munich Center for Health Sciences (MC-Health). The supporters had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests: The authors have declared that no competing interests exist.

Abstract

Background

Emergency departments (ED) are complex and dynamic work environments with various psychosocial work stressors that increase risks for providers' well-being. Yet, no systematic review is available which synthesizes the current research base as well as quantitatively aggregates data on associations between ED work factors and provider well-being outcomes.

Objective

We aimed at synthesizing the current research base on quantitative associations between psychosocial work factors (classified into patient-/ task-related, organizational, and social factors) and mental well-being of ED providers (classified into positive well-being outcomes, affective symptoms and negative psychological functioning, cognitive-behavioural outcomes, and psychosomatic health complaints).

Methods

A systematic literature search in eight databases was conducted in December 2017. Original studies were extracted following a stepwise procedure and predefined inclusion criteria. A standardized assessment of methodological quality and risk of bias was conducted for each study with the Quality Assessment Tool for Quantitative Studies from the Effective Public Health Practice Project. In addition to a systematic compilation of included studies, frequency and strength of quantitative associations were synthesized by means of harvest plots. Subgroup analyses for ED physicians and nurses were conducted.

Results

N = 1956 records were retrieved. After removal of duplicates, 1473 records were screened for titles and abstracts. 199 studies were eligible for full-text review. Finally, 39 original studies were included whereof 37 reported cross-sectional surveys. Concerning the methodological quality of included studies, the majority was evaluated as weak to moderate with

considerable risk of bias. Most frequently surveyed provider outcomes were affective symptoms (e.g., burnout) and positive well-being outcomes (e.g., job satisfaction). 367 univariate associations and 370 multivariate associations were extracted with the majority being weak to moderate. Strong associations were mostly reported for social and organizational work factors.

Conclusions

To the best of our knowledge, this review is the first to provide a quantitative summary of the research base on associations of psychosocial ED work factors and provider well-being. Conclusive results reveal that peer support, well-designed organizational structures, and employee reward systems balance the negative impact of adverse work factors on ED providers' well-being. This review identifies avenues for future research in this field including methodological advances by using quasi-experimental and prospective designs, representative samples, and adequate confounder control.

Trial registration

Protocol registration number: PROSPERO 2016 [CRD42016037220](https://doi.org/10.1186/1745-6215-16037220)

Introduction

Emergency department (ED) work systems are characterized by various psychosocial risk factors, e.g., high time pressure, varying workloads, and frequent exposure to potentially traumatic events [1, 2]. High rates of occupational stress and significant risks for burnout are reported by ED providers, e.g., by up to 26% of emergency nurses and over 35% of emergency physicians [3, 4]. A growing literature base emphasizes the key role of psychosocial work factors with regard to adverse health outcomes in ED providers [1–6]. Moreover, adverse psychosocial work factors and poor provider health mitigate optimal patient care practices, e.g., by increasing the likelihood of medical errors and near misses, or patient dissatisfaction [7, 8]. So far, no systematic review aimed to quantify this growing research base to determine present methodological study quality in this field, and to inform respective interventions to promote ED physicians' and nurses' well-being in this highly demanding care environment.

According to work system theory, each work system encompasses elements of the physical environment, tasks, tools and technologies, organization, and employee factors [9]. All elements interact and produce physical, psychological, and cognitive stress loads on employees which in turn impact individual outcomes such as health, well-being, and work performance [10]. Persistent exposure to extensive job demands or imbalance between positive and negative work factors lead to psychological distress while well-designed work systems promote positive provider outcomes [9, 11, 12].

ED settings are clinical environments with unique characteristics compared to other hospital units. Available reviews on ED work stress only applied narrative aggregation and, therefore, lack quantitative synthesis of the variety of psychosocial work factors and associated provider outcomes [1–6]. In addition to current qualitative summaries and in order to develop effective prevention measures, we need to systematically gather and pool available information as well as establish systematic evidence to develop a reliable estimate of the influence of psychosocial work factors for ED providers' well-being.

Thus, the main goals of this systematic review are (1) to identify and categorize psychosocial ED work factors associated with the mental well-being of ED providers, (2) to systematically categorize these relationships according to their quantity as well as strength, and (3) to derive recommendations for future research and prevention practice.

Methods

A review protocol was registered and is available on PROSPERO, registration number: CRD42016037220. We followed the guidelines on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (S1 Table) [13]. Searches were run in October 2016 and updated in December 2017.

Search strategy and study selection

We conducted a comprehensive literature search in eight databases: PubMed, MEDLINE, PsycINFO, Academic Search Complete, Business Source Complete, Embase, Scopus, and Web of Science core collection. Keywords were used in a multi-field search describing the study population, psychosocial work factors, and ED providers' mental well-being (S2 Table).

All identified records were screened in consecutive steps (S3 Table). After removing duplicates, both authors independently screened all titles and abstracts of retrieved records based on inclusion and exclusion criteria described in Table 1:

Initial agreement between authors in study selection from abstract screening was 90.8% for 1473 records. Consensus over final inclusion of studies was reached through discussion. Full texts of included records were retrieved. Authors of unavailable articles were contacted. The first author (AS) reviewed all available full texts. N = 100 full texts were further independently assessed for eligibility by the second author (MW). Disagreement over inclusion was resolved through discussion until consensus was achieved. Further eligible studies were searched in references of full texts and in previous reviews on similar topics [1–6]. The first author (AS) extracted data from original studies according to a predefined scheme including information

Table 1. Study inclusion and exclusion criteria.

Criterion	Inclusion	Exclusion
Study design	<ul style="list-style-type: none"> Quantitative observational studies Published in peer-reviewed journals Published between 1996 and December 2017 Published in English or German 	<ul style="list-style-type: none"> Other study types, including case reports, conference abstracts and proceedings, qualitative studies, and experimental studies
Population	<ul style="list-style-type: none"> ED nurses and physicians Other providers regularly employed in EDs (i.e., technicians, administrative staff) 	<ul style="list-style-type: none"> Emergency medical services personnel working in pre-hospital settings Consultants from hospital units outside the ED
Psychosocial work factors	<ul style="list-style-type: none"> Psychosocial work factors and job characteristics derived from ED providers' self-reports or expert observations 	<ul style="list-style-type: none"> Extraordinary work circumstances in ED care, e.g., service during natural disasters Contextual variables of the work environment, e.g., patient numbers, shift work schedule Person-specific variables, e.g., individual working hours, type of contract
ED providers' mental well-being	<ul style="list-style-type: none"> All mental well-being outcomes derived from individual ED providers' self-reports or expert evaluations 	<ul style="list-style-type: none"> Global organizational-level outcomes, e.g., overall staff turnover rates or sick leave rates
Analytic methodology	<ul style="list-style-type: none"> Bi- or multivariate associations between independent measurements of psychosocial work factors and well-being outcomes, i.e., associations between discrete variables 	<ul style="list-style-type: none"> Other descriptive approaches, e.g., frequency of variables which combine determinant and outcomes

ED: emergency department.

<https://doi.org/10.1371/journal.pone.0197375.t001>

on (1) study title, authors, year of publication; (2) ED setting country, ED type and specialty, hospital type, number of annual visits; (3) study design and data collection methods; (4) sample characteristics (ED providers, population size, sample size, response rate, age, gender); (4) determinant and outcome variables (assessment instruments, information on validity and reliability of measures); (5) statistics (statistical methods, power calculation, reported associations, contextual variables); and (6) other relevant information (ethics approval, informed consent, compensation) (S4 Table).

Both authors independently assessed all included studies for methodological quality and risk of bias with the Quality Assessment Tool for Quantitative Studies from the Effective Public Health Practice Project (EPHPP) [14]. EPHPP lists several quality criteria and is suitable for systematic reviews combining original research with different study designs [15]. Inconsistencies in ratings were resolved through discussion until consensus was reached. Studies were not excluded from further analysis and quantitative synthesis on the basis of quality ratings.

Analysis and synthesis

One author (AS) extracted and classified all univariate and multivariate associations into weak, moderate, or strong according to conventional cut-off criteria for correlational effect sizes [16], group differences, and risk estimates [17] (S5 Table). Effect sizes were differentiated into uncontrolled (univariate) and controlled (multivariate) associations, because results from multivariate techniques allow for the assessment of one particular determinant variable while simultaneously taking into account the effects of other potentially relevant determinant factors [18]. Multivariate associations are preferred because they are partly controlled for confounding influences.

Both authors assigned psychosocial work factors to a multi-level taxonomy drawing on the work system model [9]: (a) patients and task-related work factors, e.g., job control, work overload; (b) organizational factors, e.g., personnel resources, rewards; (c) social factors, e.g., support from supervisors or colleagues, interpersonal conflict; and (d) other factors which could not be assigned to (a)–(c), such as general job demands (S5 Table).

ED providers' mental well-being outcomes were classified into (i) positive well-being outcomes, e.g., job satisfaction, work engagement; or (ii) affective symptoms and negative psychological functioning, e.g., emotional exhaustion, post-traumatic stress reactions; or (iii) cognitive-behavioural outcomes, e.g., turnover intention, commitment, and role behaviours; or (iv) health complaints, e.g., somatic symptoms, physical complaints (S5 Table).

In this study, we applied harvest plots to summarize the number and strength of associations between categories of psychosocial work factors and well-being in ED providers (S6 Table). Previous reviews omitted a systematic aggregation of the magnitude of observed associations between psychosocial work factors and ED provider well-being. Yet, in order to identify key risk factors in the ED work environment as well as to develop effective interventions in this field, the distribution of identified associations needs to be collated and illustrated. Thus, in addition to a systematic description of included studies, we applied harvest plots as an innovative approach to graphically pool information and to synthesize quantitative results. Harvest plots are an informative and comprehensive mode of presenting results of systematic reviews and are recommended particularly in case of non-applicability of meta-analysis, i.e., due to substantial heterogeneity of methodological characteristics, populations, study variables, and outcomes [19, 20]. Similar to forest plots, harvest plots display the distribution of evidence for a specific set of hypotheses through a customized and user-friendly structure. Additionally, analyses for ED physicians and nurses were compiled, i.e., harvest plots for each ED profession (S6 Table).

Results

Thirty-nine studies were eligible for inclusion after the screening and selection process (flow chart in Fig 1).

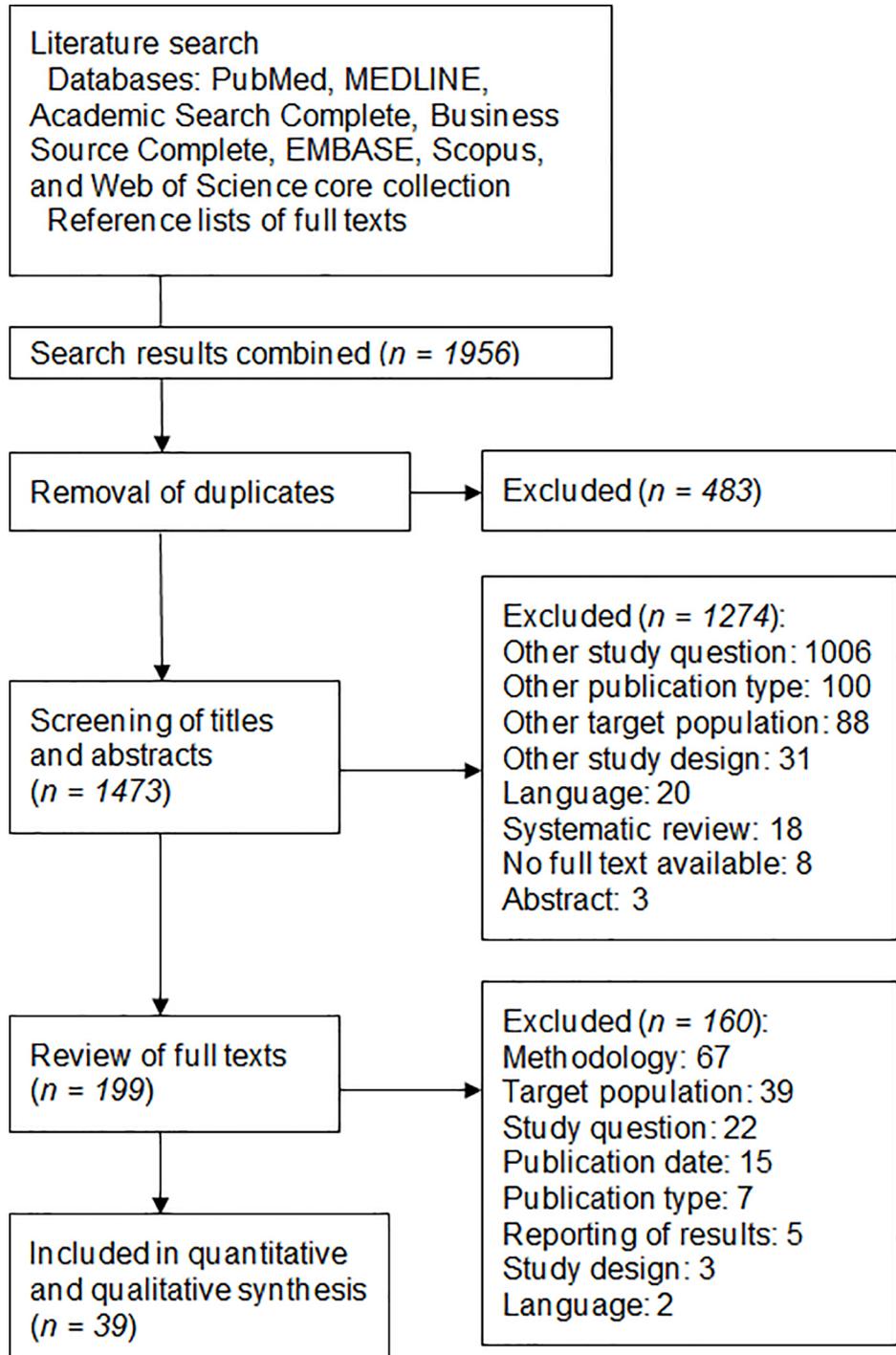


Fig 1. Flow diagram of study selection.

<https://doi.org/10.1371/journal.pone.0197375.g001>

[Table 2](#) describes key characteristics of 39 included studies. Thirty-seven studies used a cross-sectional design, whereas two applied a prospective design [21, 22]. Data collection methods were paper or mail questionnaires (33 studies), online surveys [23–25], combined surveys [26], or structured interviews [27, 28]. Thirteen studies were conducted in European [21, 24, 26, 29–38] and twelve in (primarily North)-American settings [22, 23, 27, 39–47]. Another twelve studies originated in Asia [25, 28, 48–57] and one each in Africa [58] and in Australia [59]. Four studies used a single-centre approach [35, 37, 41, 59]. Multi-centre designs varied in eight studies with 2 to 10 EDs [28, 31, 34, 36, 39, 51, 57, 58], nine studies with 11 to 20 EDs [21, 29, 30, 38, 43, 50, 53, 55, 56], and three studies with 112 to 168 EDs [27, 49, 52]. Fifteen studies did not provide information on the number of surveyed EDs [22–26, 32, 33, 40, 42, 44–48, 54].

Study population

Concerning sampled ED professions, 18 studies explicitly focused on nurses [21, 27–31, 34–36, 38, 40, 41, 43, 45, 47, 50, 58, 59], 12 on physicians [22–26, 42, 44, 46, 48, 51, 53, 54], while three interrogated multi-professional samples [32, 33, 57]. Four studies further involved non-clinical ED professions including administrative and support staff [37, 39, 55, 56]. Two studies used EDs as units of analyses [49, 52]. Ten studies likely used similar samples for different study questions [21, 29, 30, 32, 33, 38, 49, 52, 55, 56].

Median study population size was 465 for physician samples, 378 for nurse samples, and 419 for multi-professional samples. Nine studies did not describe population size characteristics [24, 27, 31, 41, 42, 49, 52, 57, 58]. Median final sample size for physician samples was 225, 242 for nurse samples, and 225 for multi-professional samples. In 11 out of 12 studies on physician samples with specifications of gender, the majority of participants were male. One study included solely female emergency physicians [23]. In contrast, in studies which specified gender in nurse samples, 13 out of 14 included more than 50% female participants; only one study reported a slight surplus of male nurses [38].

Quality ratings

All included studies were evaluated with the EPHPP tool for methodological quality and risk of bias [14]. None of the 39 included studies achieved a strong overall appraisal ([Table 3](#)). Eleven studies attained moderate ratings [21, 24, 30, 32–34, 38, 41, 48, 49, 58]. The remaining twenty-eight studies suggested a heightened risk of bias with overall weak ratings. Concerning individual quality categories, 35 out of 39 included studies received weak or moderate ratings on selection bias, indicating insufficient study sample representativeness or low response rates. Considering control for potential confounders in study design or analyses, 29 out of 39 studies were evaluated as weak or moderate, indicating limited control for potential confounders. However, 25 out of 39 studies obtained a strong rating for data collection due to the application of valid and reliable measurement methods. None of the included studies achieved a strong rating in the remaining three categories, which was mostly due to their cross-sectional design, i.e., concerning study design, withdrawals, and inability to blind outcome assessors and study participants.

Associations between psychosocial work factors and well-being

First, univariate associations of eligible studies were extracted. Overall, 367 univariate associations between psychosocial work factors and provider well-being were identified, whereof 261 associations (71.1%) were reported as statistically significant, indicated with a probability level

Table 2. Key characteristics of included studies on psychosocial work factors and mental well-being in ED providers.

First author, publication year, country, and citation	Participants (P); Response rate (R)	Key study variables and measures	
		Determinant variables: Psychosocial work factors (survey instruments)	Outcome variables: Mental well-being (survey instruments)
1 Adriaenssens, 2015, Belgium [21]	P: 170 nurses, 15 EDs; R: T1: 82.5%; T2: 83.3%	(a) Job demands, job control; (b) Work agreements, material resources, personnel resources, rewards; (c) Social support, social harassment (all LQWQ-N)	(i) Job satisfaction (LQWQ-N), work engagement (UWES); (ii) Emotional exhaustion (MBI), psychosomatic distress (BSI); (iii) Turnover intention (LQWQ-N)
2 Adriaenssens, 2012, Belgium [29]	P: 248 nurses, 15 EDs; R: 80.5%	(a) Frequency of exposure to traumatic events (self); (c) Social support from supervisor, social support from colleagues (both LQWQ-N)	(ii) Posttraumatic stress reactions (IES), psychological distress (BSI); (iv) Fatigue (CIS-20R), somatic complaints (BSI), sleep problems (self)
3 Adriaenssens, 2011, Belgium [30]	P: 254 nurses, 15 EDs; R: 82.5%	(a) Work/time demands, decision authority, skill discretion, physical demands; (b) Personnel resources, work procedures, material resources, rewards; (c) Social support from supervisor, social support from colleagues (all LQWQ-N)	(i) Job satisfaction (LQWQ-N), work engagement (UWES); (ii) Psychosomatic distress (BSI); (iii) Turnover intention (LQWQ-N); (iv) Fatigue (CIS-20R)
4 Ben-Itzhak, 2015, Israel [53]	P: 70 physicians, 16 EDs; R: 35%	(a) Meaningful job; (b) Work/life balance; (c) Social support (all self)	(ii) Burnout (MBI)
5 Blando, 2013, USA [27]	P: 314 nurses, 168 EDs; R: n.d.	(a) Assaults, verbal abuse; (b) Violence-based safety training, security equipment, security guards, security response time, importance of security to management, reports about violence, information about violent events; (c) Security and ED staff working together (all self)	(i) Feelings of safety (self)
6 Bruyneel, 2016, Belgium [38]	P: 294 nurses, 11 EDs; R: 69.7%	(a) Work/time demands, decision authority, skill discretion, physical demands (all LQWQ-N); (b) Nurse foundations for quality of care, nurse participation in hospital affairs, nurse staffing, career development and opportunities, nurse management and leadership (all PES-NWI); (c) Collegial nurse/physician relations (PES-NWI), social support from supervisor and colleagues (LQWQ-N)	(i) Job satisfaction (LQWQ-N); (ii) Emotional exhaustion (MBI-HSS); (iii) Turnover intention (LQWQ-N)
7 Chen, 2017, Taiwan [54]	P: 398 physicians; R: 39%	(a) Workload; (b) Emergency safety, salary and benefit; (d) Supporting environment (all self)	(i) Well-being/ happiness; (iii) Turnover intention (all self)
8 Clem, 2008, USA [23]	P: 1380 female physicians; R: 56%	(b) Compensation, career advancement, recognition, schedule flexibility, equal advancement opportunities and equal compensation for men/women; (c) Interactions with nurses/ non-physicians, appreciation by supervisor, relationship with colleagues (all self)	(i) Career satisfaction (self)
9 Converso, 2015, Italy [31]	P: 95 nurses, 2 EDs; R: n.d.	(a) Job autonomy, psychological demands (both JCQ), gratitude (PGRate) and support from patients (CIS)	(i) Personal accomplishment; (ii) Emotional exhaustion, depersonalization (all MBI-HSS)
10 Crilly, 2017, Australia [59]	P: 34 nurses; R: T1: 33%	(a) Self-realization, workload; (c) Conflict (WES-10)	(ii) Nervousness (WES-10)
11 Cydulka, 2008, USA [22]	P: T1: 945, T2: 823, T3: 771 physicians; R: T1: 94%, T2: 82%, T3: 76%	(a) Energy needed for work, exciting work, control over working conditions, knowing enough, level of patient acuity; (b) Time for personal life, hospital administration, length of shifts, subspecialty support, compensation, job security, personal reward, night shifts, opportunity to attend conferences; (c) Relationship with colleagues (all self)	(i) Career satisfaction; (ii) Burnout (all self)
12 Escriba-Aguir, 2006, Spain [32]	P: 630 physicians and nurses; R: 67.6%	(a) Psychological-emotional demands, job control, physical workload; (c) Social support from supervisor, social support from colleagues (all JCQ)	(i) Personal accomplishment; (ii) Emotional exhaustion, depersonalization (all MBI)
13 Escriba-Aguir, 2007, Spain [33]	P: 630 physicians and nurses; R: 67.6%	(a) Psychological demands, job control, physical workload; (c) Social support from supervisor, social support from colleagues (all JCQ)	(i) Vitality (SF-36); (ii) Emotional exhaustion (MBI), mental health (SF-36)

(Continued)

Table 2. (Continued)

First author, publication year, country, and citation	Participants (P); Response rate (R)	Key study variables and measures	
		Determinant variables: Psychosocial work factors (survey instruments)	Outcome variables: Mental well-being (survey instruments)
14 Estryn-Behar, 2011, France [24]	P: 538 physicians; R: n.d.	(a) Influence at work (DC), quantitative demands (COPSOQ and self), violence from patients/relatives (self); (b) Work/family conflict (WFC); (c) Interpersonal relationships within team, relationships with administration, harassment by superiors, support from colleagues (all self)	(ii) Burnout (CBI); (iii) Intention to leave (self)
15 Garcia-Izquierdo, 2012, Spain [34]	P: 191 nurses, 3 EDs; R: 73%	(a) Excessive workload, death and suffering; (b) Lack of resources; (c) (Interpersonal) conflicts, lack of social and emotional support (all NSS)	(i) Professional efficacy; (ii) Emotional exhaustion, cynicism (all MBI)
16 Gates, Ross, 2006, USA [39]	P: 242 workers, 5 EDs; R: n.d.	(a) Verbal and sexual harassment, threats, assaults (all self)	(i) Feelings of safety (self)
17 Hamdan, 2017, Palestine [56]	P: 444 physicians, nurses, admission personnel; R: 74.5%	(a) Exposure to physical violence, exposure to non-physical violence (self)	(i) Personal accomplishment; (ii) Emotional exhaustion, depersonalization (all MBI)
18 Hamdan, 2015, Palestine [55]	P: 444 physicians, nurses, admission personnel; R: 74.5%	(a) Exposure to physical violence, exposure to non-physical violence (self)	(iii) Intention to quit (self)
19 Hsieh, 2016, Taiwan [28]	P: 159 nurses, 2 EDs; R: 88.3%	(c) Peer support (SSS)	(i) Resilience (RS); (ii) Depression (CES-D)
20 Hunsaker, 2015, USA [40]	P: 284 nurses; R: 28%	(c) Support from manager (self)	(i) Compassion satisfaction; (ii) Burnout, compassion fatigue (all ProQOL 5)
21 Jalili, 2013, Iran [48]	P: 165 physicians; R: 88%	(a) Text needed to be read, patients' economic problems, patient overload, skills, violence, care of old/terminally ill patients; (b) Shortage of equipment, physical environment, problems with other services, economic problems/future of EM career, imbalance of professional/private life, educational issues, image of EM in media, consultant unavailability, new information and technologies; (c) Lack of support and encouragement, communication with colleagues (all self)	(i) Personal accomplishment; (ii) Emotional exhaustion, depersonalization (all MBI)
22 Kogien, 2014, Brazil [41]	P: 189 nurses and technicians, 1 ED; R: n.d.	(a) Intellectual discernment; (c) Social support; (d) Work demands (all JSS)	(iv) Physical domain of quality of life (WHOQOL-BREF)
23 Lin, 2011, Taiwan [49]	P: 385 nurses and physicians, 112 EDs; R: n.d.	(b) Task- and employee-oriented leadership (self)	(i) Satisfaction; (iii) Unit performance (both self)
24 Lin, 2012, Taiwan [52]	P: 442 physicians and nurses, 119 EDs; R: n.d.	(b) Clan culture, adhocracy culture, market culture, hierarchy culture (all OCAI)	(iii) Intent to leave (self)
25 O'Mahony, 2011, Ireland [35]	P: 64 nurses, 1 ED; R: 74%	(a) Time to discuss patient care; (b) Quality assurance program, administration consults, non-punitive management, high standards by administration, administration listens/responds; (c) Nurse/physician collaboration, teamwork (all NWI-PES)	(ii) Emotional exhaustion, depersonalization (all MBI)
26 Revicki, 1997, USA [42]	P: 484 physicians; R: 50% to 55%	(a) Role ambiguity (self, MOAQ); (c) Peer (self) and work-group support (self, MOAQ)	(i) Work satisfaction (self, MOAQ); (ii) Work stress (WRSI), depression (CES-D)
27 Rios-Risquez, 2016, Spain [36]	P: 148 nurses, 2 EDs; R: 73%	(d) Frequency of stress (NSS)	(i) Personal effectiveness; (ii) Emotional exhaustion, cynicism (all MBI-GS)
28 Sawatzky, 2012, Canada [43]	P: 261 nurses, 12 EDs; R: 35%	(a) Competence, professional practice; (c) Work overtime, staffing resources, nursing management; (c) Collaboration with physicians (all PNWE)	(i) Job satisfaction (self), engagement (ECQ), compassion satisfaction (ProQOL); (ii) Compassion fatigue, burnout (both ProQOL); (iii) Intention to leave (nursing) (Price&Mueller)
29 Somville, 2016, Belgium [26]	P: 181 physicians; R: 43.9%	(a) Physical hazards, violence (both Dorevitch et al.), traumatic events (self); (b) Supervisor and colleagues support (both LQWQ-MD)	(i) Job satisfaction (LQWQ-MD); (ii) Posttraumatic stress reactions (IES), psychological distress (BSI); (iv) Somatization (PHQ 15), fatigue (CIS-20R)

(Continued)

Table 2. (Continued)

First author, publication year, country, and citation	Participants (P); Response rate (R)	Key study variables and measures	
		Determinant variables: Psychosocial work factors (survey instruments)	Outcome variables: Mental well-being (survey instruments)
30 Sorour, 2012, Egypt [58]	P: 58 nurses, 2 EDs; R: n.d.	(d) Job demands (JCQ)	(ii) Burnout (MBI)
31 Taylor, 2004, USA [44]	P: 323 physicians; R: 63.5%	(a) Control of activity mix; (b) Control of hours worked (both self)	(i) Work (self) and life satisfaction (SLS); (ii) Work stress (PSS), depression (ZDS), anxiety (ZAS); (iv) Physical symptoms (PSC)
32 Toker, 2015, Turkey [25]	P: 167 physicians; R: 40.7%	(a) Appreciation by patients/ relatives, exposure to violence; (b) Presence of consultant; (c) Compliance with personnel, appreciation by supervisor and co-workers (all self)	(i) Personal accomplishment; (ii) Emotional exhaustion, depersonalization (all MBI)
33 Trautmann, 2015, USA [45]	P: 246 nurse practitioners; R: 31%	(d) Practice independence (DPBS)	(iii) Intention to leave (MDS-R)
34 Weigl, 2016, Germany [37]	P: 53 staff members, 1 ED; R: 61.6%	(a) Autonomy, time pressure, patient-related stressors; (b) Staffing; (c) Supervisor support (WDQ)	(ii) Emotional exhaustion (MBI), irritation (Irri)
35 Williams, 2007, Canada [46]	P: 428 physicians; R: 29.8%	(b) Culture (bureaucratic/ human resources/ entrepreneurial/ rational) (all self)	(iii) Patient commitment, extra-role behaviour (all self)
36 Wilson, 2017, India [57]	Pt: 105 physicians and nurses; R: n.d.	(a) Affected by high mortality, increased load of patients, infection risk; (c) More criticism, departmental activities for staff bonding (all self)	(i) Personal accomplishment; (ii) Emotional exhaustion, depersonalization (all MBI)
37 Wu, 2012, China [50]	P: 510 female nurses, 16 EDs; R: 77.9%	(a) Role overload, role insufficiency, role ambiguity, role boundary, responsibility (all self)	(ii) Occupational stress (PSQ)
38 Young-Ritchie, 2009, Canada [47]	P: 206 nurses; R: 73%	(b) Emotionally intelligent leadership (ECI 2.0), structural empowerment (CWEQ-II)	(iii) Affective commitment (T-C MEC)
39 Zahid, 1999, Kuwait [51]	P: 101 physicians; R: 68.7%	(a) Violence (self)	(ii) Depression, reliving experiences, fearfulness; (iii) Time off; (iv) Sleeplessness (all self)

n.d.: not described; self: self-developed questions; Categorization for psychosocial work factors: (a) patients and tasks, (b) organizational factors, (c) social factors, (d) other factors; Categorization for mental well-being: (i) positive well-being, (ii) affective symptoms and negative psychological functioning, (iii) cognitive-behavioural outcomes, (iv) health complaints; LQWQ-(N or MD): Leiden Quality of Work Questionnaire (for Nurses or for Medical Doctors), UWES: Utrecht Work Engagement Scale, MBI-(HSS or GS): Maslach Burnout Inventory (Human Services Survey or General Survey), BSI: Brief Symptom Inventory, IES: Impact of Event scale, CIS-20R: Checklist Individual Strength, CISS: Customer-initiated Support Scale, JCQ: Job Content Questionnaire, SF-36: SF-36 Health Survey, WFC: Work-family Conflict Scale, COPSOQ: Copenhagen Psychosocial Questionnaire, DCQ: Demand-Control Questionnaire, CBI: Copenhagen Burnout Inventory, NSS: Nursing Stress Scale, SSS: Social Support Scale, RS: Resilience Scale, CES-D: Centre for Epidemiologic Studies Depression, ProQOL 5: Professional Quality of Life Version 5, JSS: Job Stress Scale, WHOQOL-BREF: World Health Organization Quality of Life Short Version, NWIPES: Nursing Work Index Practice Environment Scale, WRSI: Work-Related Strain Inventory, PNWE: Perceived Nurse Working Environment, ECQ: Engagement Composite Questionnaire, PHQ 15: Prime MD Patient Health Questionnaire, ZDA: Zung Depression Scale, ZAS: Zung Anxiety Scale, PSC: Physical Symptoms Checklist, PSS: Perceived Stress Scale, SLS: Satisfaction with Life Scale, JSS: Job Satisfaction Scale, DPBS: Dempster Practice Behavior Scale, MDS-R: Moral Distress Scale-Revised, PSQ: Occupational Stress Inventory, PCL-C: PTSD CheckList-Civilian Version, ECI 2.0: Emotional Competency Inventory, CWEQ-II: Conditions of Work Effectiveness Questionnaire-II, T-CMECS: Three-Component Model Employee Commitment Survey, OCAI: Organizational Culture Assessment Instrument, WDQ-Work-Demand Questionnaire, Irri: Irritation Scale, PES-NWI: Practice Environment Scale of the Nursing Work Index, WES-10: Working Environment Score (10-item version).

<https://doi.org/10.1371/journal.pone.0197375.t002>

of $p < 0.05$. Second, 370 specific multivariate associations from included studies were extracted, whereof 149 associations (40.3%) were significant.

The range and heterogeneity of different constructs and measurement instruments across studies allowed no valid base for meta-analysis. Therefore, two harvest plots for results of univariate and multivariate associations were compiled (Figs 2 and 3). Harvest plots depict the total amount and strength of identified associations between categorized psychosocial work factors and four categories of well-being outcomes, respectively. Due to varying measurement approaches and operationalization of study variables in included studies, harvest plots do not differentiate between positive or negative directions of association. Further, since sample size

Table 3. Quality rating for included studies according to the Quality Assessment Tool for Quantitative Studies (EPHPP).

	Included studies (first author, year)																																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
Selection bias	+	+	+	-	0	0	-	0	-	0	-	0	0	0	0	0	0	0	0	-	+	0	0	0	0	-	0	-	-	-	0	0	-	-	0	-	-	0	0	0
Study design	0	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Confounders	-	-	+	-	-	0	-	0	-	-	+	+	+	+	0	-	-	-	-	-	-	+	0	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Blinding	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Data collection	+	+	+	-	0	+	-	+	+	+	-	+	+	+	+	-	+	+	+	+	0	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Withdrawals	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Global rating	0	-	0	-	-	0	-	-	-	-	-	0	0	0	0	-	-	-	-	-	0	0	0	0	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-

EPHPP: Effective Public Health Practice Project; + strong rating; 0 moderate rating;—weak rating.

<https://doi.org/10.1371/journal.pone.0197375.t003>

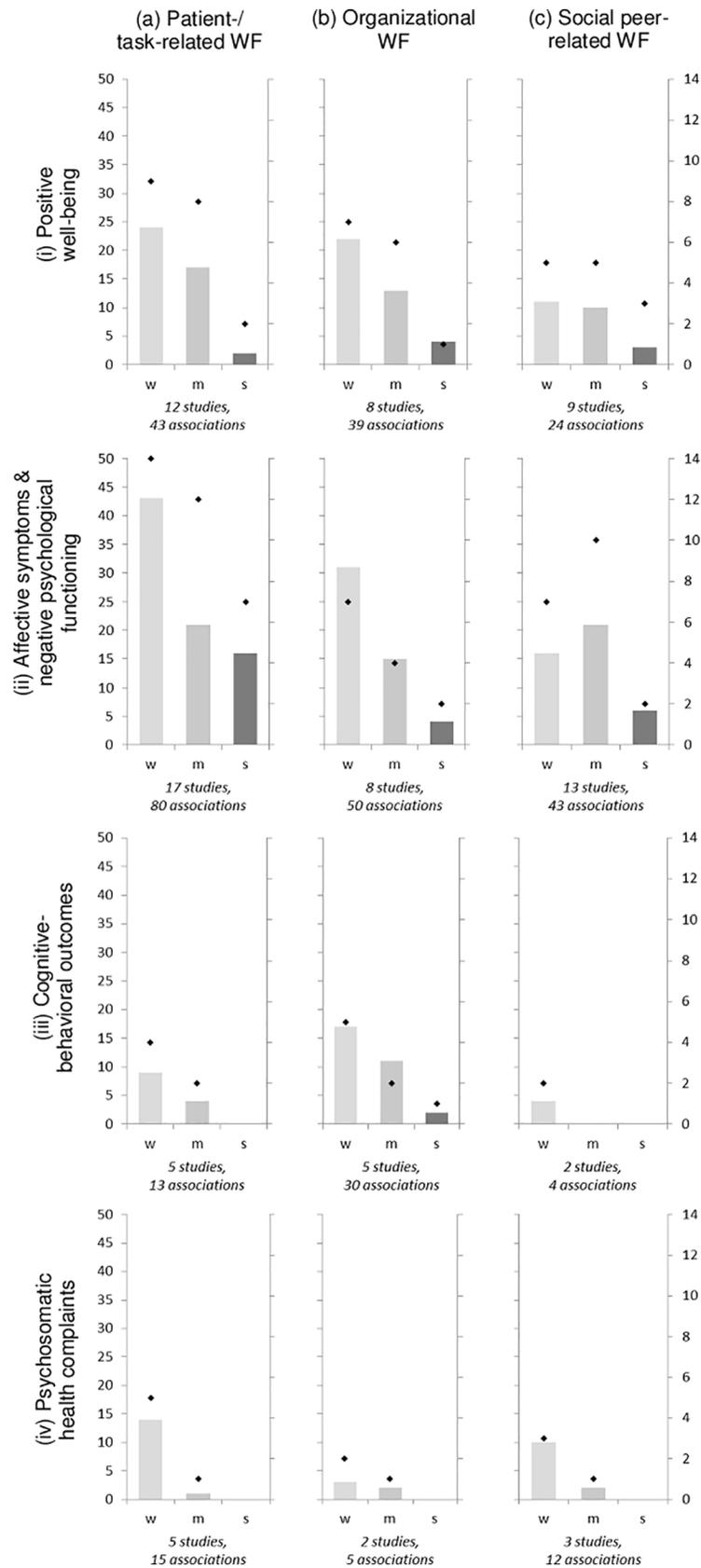


Fig 2. Harvest plot of univariate associations between psychosocial work factors (WF) and ED providers' mental well-being. Left axis (bars) denominates frequency of univariate associations; right axis (diamonds) denominates number of original studies describing these relationships; w: weak, m: moderate, s: strong; Text in italics denominates total number of original studies and total number of univariate associations analysing variables out of the respective categories for psychosocial work factors and mental well-being outcomes.

<https://doi.org/10.1371/journal.pone.0197375.g002>

affects power of statistical tests [60] and biases may influence p values [18], all associations from original studies were included into harvest plots irrespective of their reported level of significance. Category (d) general work factors was omitted from further graphical analyses due to its low allocation status (n = 17 associations). Separate analyses for ED nurse and physicians samples are presented in additional harvest plots (S1–S4 Figs).

Number of identified associations. Across all included studies, ED providers' affective symptoms and negative psychological functioning (n = 26 studies) as well as positive well-being outcomes (n = 21) were most commonly investigated. In contrast, cognitive-behavioural outcomes (n = 12 studies) and psychosomatic health complaints (n = 6) were less often surveyed. Patient- and task-related factors (n = 29 studies) were most frequently analysed in relation to mental well-being, followed by social (n = 23), and organizational factors (n = 19).

Strength of identified associations. The following patterns were observed for all extracted univariate associations (Fig 2): for (i) *positive well-being outcomes*, the highest percentage of strong and moderate associations was found for social work factors (12.5% and 41.7%, respectively). In nursing professionals, however, organizational work factors showed most strong associations (see S1 Fig; 16.7%). For (ii) *affective symptoms and negative psychological functioning*, patient- and task-related work factors had the largest amount of strong associations (see Fig 2; 20%) and social work factors the largest amount of moderate associations (48.8%). In physician samples, social factors held the largest amount of strong associations (see S3 Fig; 25%). For (iii) *cognitive-behavioural outcomes*, organizational work factors had the largest amount of strong and moderate associations (see Fig 2; 6.7% and 36.7%, respectively). However, for physician samples, no strong and moderate associations were observed (see S3 Fig). For (iv) *health complaints*, none of the included work factors were associated strongly (see Fig 2). Organizational work factors showed the largest amount of moderate associations (40%). In physician samples, social work factors were most often associated with moderate strength (see S3 Fig; 50%).

For multivariate associations slightly different patterns were observed (see Fig 3): For (i) *positive well-being outcomes*, the largest amount of strong and moderate associations was found for organizational work factors (14.3% and 18.4%, respectively), comparable to patient- and task-related work factors (12.8% and 19.1%, respectively). For (ii) *affective symptoms and negative psychological functioning*, organizational work factors held the largest amount of strong associations (40.0%) and patient- and task-related (13.5%) as well as social work factors (12.5%) the largest shares of moderate associations. For (iii) *cognitive-behavioural outcomes*, social factors had the largest amount of strong and moderate associations (both 14.3%). However, in nurse samples, organizational (7.1%) and patient-/task-related work factors (9.1%) had the largest share of strong and moderate associations, respectively (S2 Fig). Finally, for (iv) *health complaints*, patient- and task-related work factors were most often associated strongly (see Fig 3; 5.9%), however, social work factors held the largest count of moderate associations (26.7%).

Effects of specific psychosocial work factors on mental well-being

In a final step, we identified all statistically significant associations between psychosocial work factors and ED providers' well-being outcomes (S7 Table). This procedure summarizes the

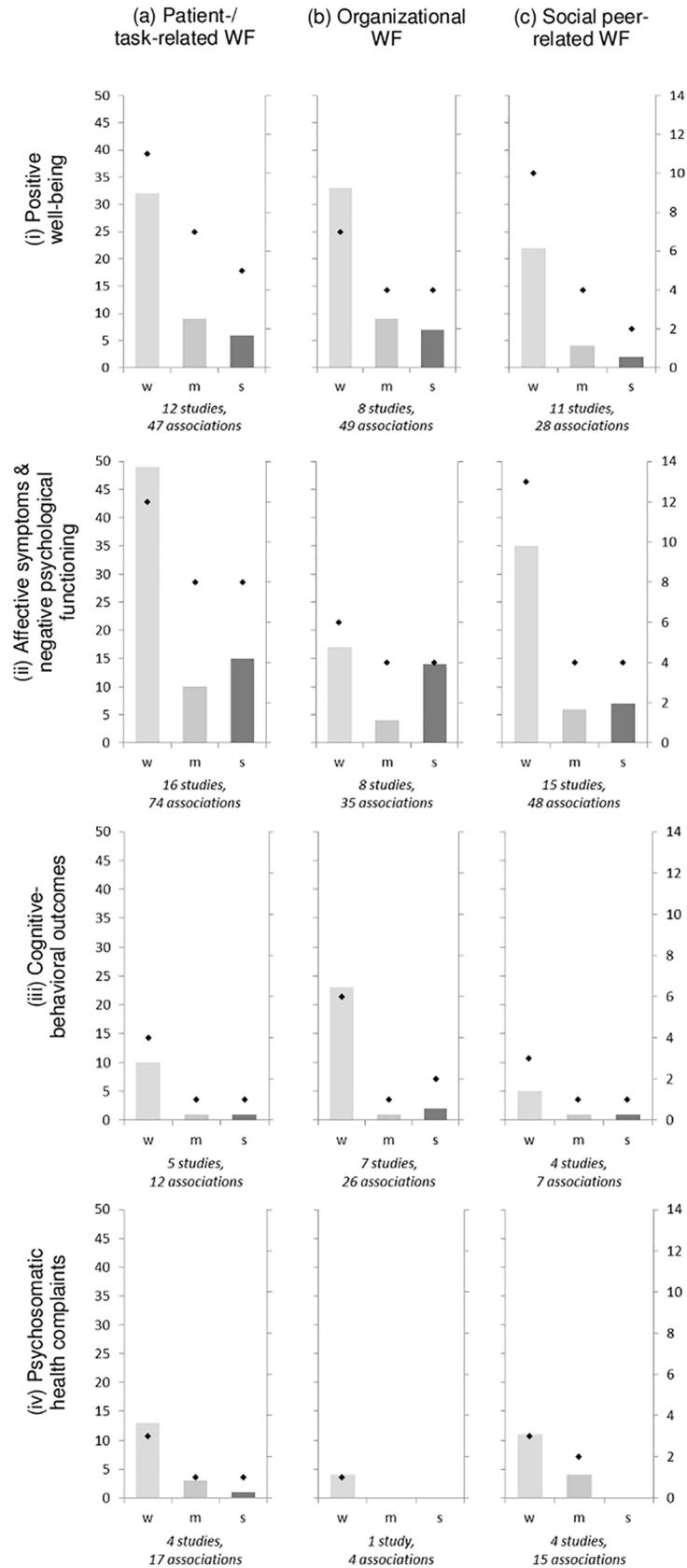


Fig 3. Harvest plot of multivariate associations between psychosocial work factors (WF) and ED providers' mental well-being. Left axis (bars) denominates frequency of multivariate associations; right axis (diamonds) denominates number of original studies describing these relationships. W: weak, m: moderate, s: strong; Text in italics denominates total number of original studies and total number of multivariate associations analysing variables out of the respective categories for psychosocial work factors and mental well-being outcomes.

<https://doi.org/10.1371/journal.pone.0197375.g003>

most important findings stated in included studies and denominates specific psychosocial work factors as starting points for further analyses or interventions. The following associations deserve particular consideration:

Positive mental well-being outcomes. ED providers' job satisfaction was most frequently examined, followed by work engagement, and personal accomplishment. Patient- or task-related factors, e.g., high job autonomy or job control and positive interactions with patients were associated with increased positive well-being [21, 22, 30–32, 38, 44]. In contrast, violence and harassment as well as work overload were detrimental to positive well-being [27, 39, 54, 57]. Organizational factors, e.g., schedule flexibility, participation opportunities, staffing, leadership quality, and adequate salary were positively associated with positive well-being [14, 22, 23, 38, 43, 44, 48, 49, 54]. Social support by colleagues or supervisors, and good teamwork also improved ED providers' wellness [21, 23, 26, 28, 30, 33, 34, 38, 40, 42, 43].

Affective symptoms and negative psychological functioning. Burnout and its components were by far most frequently surveyed, followed by other affective symptoms such as depression, irritation, and psychological distress. PTSD and anxiety were less often examined. Patient- or task-related factors, e.g., workload, time pressure, violence, and traumatic events had adverse effects on affective symptoms and negative psychological functioning [22, 25, 26, 29, 30, 34, 35, 37, 38, 48, 51, 56, 57]. In contrast, job autonomy and positive interactions with patients were associated with less negative well-being [22, 25, 31, 32, 38, 44, 59]. Organizational factors, e.g., staffing problems, difficulties with administration, work-family conflict, unfair compensation or rewards contributed to increased negative affective symptoms [22, 24, 25, 34, 35, 38, 43, 48]. Again, favourable social factors such as good relationships with colleagues, teamwork, appreciation and support from supervisors were associated with fewer negative outcomes [21, 25, 28–30, 32, 33, 35, 37, 38, 40, 42].

Cognitive-behavioural outcomes. Turnover intentions were most frequently analysed [21, 24, 30, 38, 43, 52, 54, 55]. Other outcomes included patient commitment [46, 47] and extra-role behaviour [46]. Favourable psychosocial work factors for positive cognitive behavioural-outcomes such as less turnover intentions, more patient commitment, and extra-role behaviours were job control, influence at work, rewards, encouraging unit culture, leadership, and good relationships with supervisors.

Psychosomatic health complaints. This category included somatic complaints, sleep problems, or fatigue. Predominant predictors of impaired psychosomatic health on the patient- or task-related level were traumatic experiences, violence, and time pressure [26, 29, 30, 51]. Job control improved health complaints [41, 44]. Organizational factors such as rewards and work procedures contributed to fewer health complaints [30]. Beneficial social factors for this outcome category were social support from colleagues and supervisors [26, 29, 41].

Discussion

To the best of our knowledge, this systematic review is the first that quantitatively synthesizes associations between psychosocial work factors and mental well-being in ED providers. A growing research base shows that well-designed ED work systems are fundamental to ED providers' well-being and safe ED care [7, 9]. Yet, the field lacks a systematic appraisal of the

current evidence as well as implications for future research and ED practice. We therefore collated the current research base on psychosocial risk factors and provider well-being outcomes and appraised its methodological quality. Our quality assessment indicated that none of the studies achieved a strong overall appraisal, with the majority evaluated as weak to moderate with considerable risk of bias. Methodological shortcomings of retrieved studies as well as potential methodological advances in the field will be discussed and proposed below. Nonetheless, taking these weak to moderate methodological foundation into account, the following contributions of this review need to be considered:

First, our review reveals a lack of research on psychosocial predictors of cognitive-behavioural outcomes and psychosomatic health complaints in ED providers, e.g., regarding turnover intentions or fatigue. The majority of included research investigated affective symptoms or positive well-being outcomes. Nonetheless, behavioural and health outcomes often result from a chronic exposure and a long-term impact of psychosocial work factors and occupational hazards [10, 61]. In comparison to frequently surveyed affective symptoms and positive well-being outcomes, ED providers' turnover intentions and psychosomatic health complaints represent more distal well-being outcomes. These manifest particularly due to persistent exposure to adverse psychosocial work factors and failure to mitigate these stressors due to limited system or personal resources [38, 62]. Although ED work is often characterized by daily short-term peaks of work stress, prospective effects of chronic stressors and longstanding adverse work factors on ED professionals' well-being need to be interrogated, i.e., in cohort studies. However, EDs are characterized by high staff turnover rates, partially due to high workloads and insufficient resources for providers [3] or rotation schedules during physician training, thus limiting possibilities for long-term follow-up in longitudinal research. This practical impediment remains a widely unaddressed issue of occupational health research in ED settings, which is also reflected in a dearth of longitudinal research identified in our systematic review [21, 22]. Moreover, future studies should test interactive and moderating relationships between psychosocial ED work factors, proximate mental well-being outcomes (i.e., stress, work strain), and, eventually, distal behavioural or health outcomes in ED providers [38].

Secondly, we found that the majority of relationships between psychosocial work factors and mental well-being were weak or moderate [16, 17]. However, strong associations were identified for the categories of social and organizational work factors and various well-being outcomes. Occupational health theories emphasize the importance of job resources as buffers in stressor-strain relationships. Thus maintaining good relationships with colleagues and supervisors enhances collaboration, strengthens individual resources, and alleviates the burden of adverse work conditions such as difficult interactions with patients or high workload [11, 61]. Therefore, our results highlight that key resources in EDs such as positive social relations, participation, and financial and non-tangible rewards buffer psychological demands and counteract adverse conditions of the ED work environment [9, 61].

Limitations

According to PRISMA guidelines, review limitations need to be identified on two different levels, i.e., on study as well as the review level [13]:

Concerning the study-level, our review identifies alleys for further efforts to establish high quality studies with reinforced methodological rigour in this specific research field. Overall, the majority of included studies obtained only moderate to weak ratings in regard to methodological quality, with particular deficits regarding selection bias, study design, and control for confounders. The vast majority of studies applied cross-sectional designs that limit inferences concerning causality [18]. Accordingly, reverse or reciprocal causation between mental ill

health and psychosocial work factors may occur over time and requires careful consideration [63]. Thus, different states of mental well-being could act as predictors for the appraisal of work conditions. Furthermore, the observed amount of statistically significant associations reported in included studies is striking and might indicate reporting or publication bias [18]. Future studies should also account for individual person-specific and other factors of the work system, e.g., those relating to contextual factors of the environment such as shift schedule or staffing. These factors were shown to influence providers' mental health and well-being [9, 64]. Furthermore, external validity of our findings needs to be carefully considered since included studies originate from different hospital and national contexts as well as different health-care systems.

At review-level, further limitations apply. We restricted our search to quantitative studies that used separate measures of determinant and outcome variables. This approach facilitates reliable and valid conclusions on effect sizes of associations [65]. We acknowledge that previous reviews included studies with less robust methodological approaches [2–6]. Due to the substantial heterogeneity in populations and study methods as well as ambiguities and incomparability in measures, meta-analyses were not feasible. In this case of insufficient homogeneity to statistically combine data into meta-analyses, user-friendly and graphical summaries of evidence help decision makers and practitioners making sense of available evidence [20]. We thus applied harvest plots as an innovative and comprehensive approach that include the benefits of quantitative summaries without erroneously simplifying or falsely aggregating extracted relationships [19]. Our approach thus expands previous narrative reviews since it facilitates an improved understanding of the diverse and inconsistent research findings through comprehensive and graphical summaries of evidence. We pooled all included studies' information and established different categories for psychosocial work factors and mental well-being. Future reviews in the field may draw upon our taxonomy to elicit a homogenous study and data base for statistical combination into first meta-analyses in the field. Nonetheless, potential misclassification of study variables due to missing or unspecified information in primary studies or plurivalent meanings of reported measures may have occurred. We categorized effect size magnitudes with conventional cut-off criteria that have been subject to scientific discourse [16, 17]. Finally, we applied a recommended and established tool to evaluate studies' methodological quality [15]. However, during the rating process, some quality criteria of the EPHPP instrument were ambiguous with regard to cross-sectional and non-interventional designs, i.e., concerning withdrawals.

Implications for future research and ED practice

This review systematically pooled information on the associations between psychosocial work factors and ED provider well-being and, additionally, appraised the methodological quality of research in this domain. Given the heterogeneity of retrieved studies, our approach is an intermediate but necessary step between existing narrative reviews and upcoming meta-analyses. Future reviews that seek to statistically quantify effects of psychosocial work factors and ED provider outcomes may draw upon our taxonomy for focus as well as to establish a homogenous study and data base. Our findings suggest further (a) to conduct controlled interventions and prospective studies that allow inferences concerning causation; (b) to recruit more representative study samples which enhance external validity; (c) to use standardized and validated questionnaires, objective measures, or expert evaluations; (d) and to apply adequate confounder control in study design or statistical analyses, and finally, (e) to consider effectiveness research on intervention approaches. There is a paucity of interventions that target psychosocial work factors in EDs [2]. Therefore, research on effective interventions to promote ED

provider well-being is imperative and shall take account of our findings, particularly with regard key sources of occupational well-being in ED providers.

Conclusions

This systematic review advances the current knowledge base on associations of psychosocial work factors and ED provider well-being with its quantitative focus, comprehensive aggregation of study findings, and rigorous evaluation of studies' methodological quality. A multitude of different psychosocial risk factors characterizes the ED environment as a challenging and at times overtaxing work system. Especially social support and well-designed organizational systems were found to have a strong to moderate effect on ED providers' well-being. System improvements in health care should be based on comprehensive evidence. However, the methodological foundations of our conclusions need to be considered carefully since methodological quality of included studies was low to moderate. On the one hand, our review informs future research endeavours in this field concerning robust study designs and assessment methods. On the other hand, our findings suggest starting points for work design interventions that address psychosocial work factors in order to promote providers' well-being, retain ED providers in their jobs, and to improve clinical excellence.

Supporting information

S1 Fig. Harvest plot of univariate associations between psychosocial work factors (WF) and ED nurses' mental well-being. Left axis (bars) denominates frequency of univariate associations; right axis (diamonds) denominates number of original studies describing these relationships; w: weak, m: moderate, s: strong; Text in italics denominates total number of original studies and total number of univariate associations analysing variables out of the respective categories for psychosocial work factors and mental well-being outcomes.

(TIF)

S2 Fig. Harvest plot of multivariate associations between psychosocial work factors (WF) and ED nurses' mental well-being. Left axis (bars) denominates frequency of multivariate associations; right axis (diamonds) denominates number of original studies describing these relationships. W: weak, m: moderate, s: strong; Text in italics denominates total number of original studies and total number of multivariate associations analysing variables out of the respective categories for psychosocial work factors and mental well-being outcomes.

(TIF)

S3 Fig. Harvest plot of univariate associations between psychosocial work factors (WF) and ED physicians' mental well-being. Left axis (bars) denominates frequency of univariate associations; right axis (diamonds) denominates number of original studies describing these relationships; w: weak, m: moderate, s: strong; Text in italics denominates total number of original studies and total number of univariate associations analysing variables out of the respective categories for psychosocial work factors and mental well-being outcomes.

(TIF)

S4 Fig. Harvest plot of multivariate associations between psychosocial work factors (WF) and ED physicians' mental well-being. Left axis (bars) denominates frequency of multivariate associations; right axis (diamonds) denominates number of original studies describing these relationships. W: weak, m: moderate, s: strong; Text in italics denominates total number of original studies and total number of multivariate associations analysing variables out of the respective categories for psychosocial work factors and mental well-being outcomes.

(TIF)

S1 Table. PRISMA checklist.

(DOC)

S2 Table. Search strategy.

(DOCX)

S3 Table. Extracted records from literature search in databases and references. N: No; Y: Yes; X: applicable; N/A: not applicable; ft: full-text;?: uncertain.

(XLSX)

S4 Table. Description of included studies. No.: number; ED: emergency department; N/A: not applicable / not available; T1: wave 1; T2: wave 2; SD: standard deviation; CA: Cronbach's Alpha; r: correlation coefficient.

(XLSX)

S5 Table. Extraction of statistical associations in original studies. No.: number; p-value: statistical probability; N: study sample size; T1: wave 1; T2: wave 2; ED: emergency department; UV: univariate association; MV: multivariate association; n.s.: not significant.

(XLSX)

S6 Table. Numerical description of extracted associations for harvest plots. Number before brackets: number of extracted associations; number within brackets: number of studies describing these associations.

(XLSX)

S7 Table. Categorized associations between psychosocial work factors and mental well-being outcomes. First author and year of publication in *italics*; Δ : delta/difference; T2: wave 2; β : standardized regression coefficient/beta; 95%CI: 95% confidence interval; OR: odds ratio; SPC: standardized path coefficient; r: correlation coefficient; SD: standard deviation.

(DOCX)

Acknowledgments

This paper is dedicated to the memory of Professor Robert L. Wears, MD., MS., PhD (Department of Emergency Medicine, University of Florida, College of Medicine—Jacksonville). Prof. Wears substantially contributed to this review and co-authored a preliminary draft of this manuscript. Most sadly, he deceased before final submission of this manuscript.

This work was supported by the Munich Center for Health Sciences (MC-Health).

Author Contributions

Conceptualization: Anna Schneider, Matthias Weigl.**Formal analysis:** Anna Schneider.**Funding acquisition:** Matthias Weigl.**Investigation:** Anna Schneider, Matthias Weigl.**Methodology:** Anna Schneider, Matthias Weigl.**Supervision:** Matthias Weigl.**Validation:** Matthias Weigl.**Visualization:** Anna Schneider.

Writing – original draft: Anna Schneider, Matthias Weigl.

Writing – review & editing: Anna Schneider, Matthias Weigl.

References

1. Johnston A, Abraham L, Greenslade J, Thom O, Carlstrom E, Wallis M, et al. Review article: Staff perception of the emergency department working environment: Integrative review of the literature. *Emergency Medicine Australasia*. 2016; 28(1):7–26. <https://doi.org/10.1111/1742-6723.12522> PMID: 26784282
2. Basu S, Qayyum H, Mason S. Occupational stress in the ED: A systematic literature review. *Emergency Medicine Journal*. 2017; 34:441–447. <https://doi.org/10.1136/emmermed-2016-205827> PMID: 27729392
3. Adriaenssens J, de Gucht V, Maes S. Determinants and prevalence of burnout in emergency nurses: A systematic review of 25 years of research. *International Journal of Nursing Studies*. 2015; 52(2):649–661. <https://doi.org/10.1016/j.ijnurstu.2014.11.004> PMID: 25468279
4. Bragard I, Dupuis G, Fleet R. Quality of work life, burnout, and stress in emergency department physicians: A qualitative review. *European Journal of Emergency Medicine*. 2015; 22(4):227–234. <https://doi.org/10.1097/MEJ.000000000000194> PMID: 25093897
5. Arora M, Asha S, Chinnappa J, Diwan AD. Review article: Burnout in emergency medicine physicians. *Emergency Medicine Australasia*. 2013; 25(6):491–495. <https://doi.org/10.1111/1742-6723.12135> PMID: 24118838
6. Potter C. To what extent do nurses and physicians working within the emergency department experience burnout: A review of the literature. *Australasian Emergency Nursing Journal*. 2006; 9(2):57–64. <https://doi.org/10.1016/j.aenj.2006.03.006>
7. Hall LH, Johnson J, Watt I, Tsipa A, O'Connor DB. Healthcare staff wellbeing, burnout, and patient safety: A systematic review. *PLoS ONE*. 2016; 11(7): e0159015. <https://doi.org/10.1371/journal.pone.0159015> PMID: 27391946
8. Flowerdew L, Brown R, Vincent C, Woloshynowych M. Identifying nontechnical skills associated with safety in the emergency department: A scoping review of the literature. *Annals of Emergency Medicine*. 2012; 59(5):386–394. <https://doi.org/10.1016/j.annemergmed.2011.11.021> PMID: 22424651
9. Carayon P, Smith MJ. Work organization and ergonomics. *Applied Ergonomics*. 2000; 31(6):649–662. [https://doi.org/10.1016/S0003-6870\(00\)00040-5](https://doi.org/10.1016/S0003-6870(00)00040-5) PMID: 11132049
10. Carayon P. The balance theory and the work system model . . . Twenty years later. *International Journal of Human-Computer Interaction*. 2009; 25(5):313–327. <https://doi.org/10.1080/10447310902864928>
11. Stansfeld S, Candy B. Psychosocial work environment and mental health—A meta-analytic review. *Scandinavian Journal of Work, Environment & Health*. 2006; 32(6):443–462.
12. Brand SL, Thompson Coon J, Fleming LE, Carroll L, Bethel A, Wyatt K. Whole-system approaches to improving the health and wellbeing of healthcare workers: A systematic review. *PLoS ONE*. 2017; 12: e0188418. <https://doi.org/10.1371/journal.pone.0188418> PMID: 29200422
13. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Annals of Internal Medicine*. 2009; 151(4):264–269. <https://doi.org/10.7326/0003-4819-151-4-200908180-00135> PMID: 19622511
14. Thomas BH, Ciliska D, Dobbins M, Micucci S. A process for systematically reviewing the literature: Providing the research evidence for public health nursing interventions. *Worldviews on Evidence-Based Nursing*. 2004; 1(3):176–184. <https://doi.org/10.1111/j.1524-475X.2004.04006.x> PMID: 17163895
15. Deeks JJ, Dinnes J, D'Amico R, Sowden AJ, Sakaravitch C, Song F, et al. Evaluating non-randomised intervention studies. *Health Technology Assessment*. 2003; 7(27): 1–173. <https://doi.org/10.3310/hta7270>
16. Cohen J. *Statistical power analysis for the behavioral sciences*. 2nd ed. Hillsdale, NJ: Erlbaum; 1988.
17. Ferguson CJ. An effect size primer: A guide for clinicians and researchers. *Professional Psychology: Research and Practice*. 2009; 40(5):532–538. <https://doi.org/10.1037/a0015808>
18. Grimes DA, Schulz KF. Bias and causal associations in observational research. *Lancet*. 2002; 359(9302):248–252. [https://doi.org/10.1016/S0140-6736\(02\)07451-2](https://doi.org/10.1016/S0140-6736(02)07451-2) PMID: 11812579
19. Ogilvie D, Fayter D, Petticrew M, Sowden A, Thomas S, Whitehead M, et al. The harvest plot: A method for synthesising evidence about the differential effects of interventions. *BMC Medical Research Methodology*. 2008; 8(8). <https://doi.org/10.1186/1471-2288-8-8> PMID: 18298827
20. Burns J, Polus S, Brereton L, Chilcott J, Ward SE, Pfadenhauer LM, et al. Looking beyond the forest: Using harvest plots, gap analysis, and expert consultations to assess effectiveness, engage

- stakeholders, and inform policy. *Research Synthesis Methods*. 2018; 9(1):132–140. <https://doi.org/10.1002/jrsm.1284> PMID: 29106058
21. Adriaenssens J, de Gucht V, Maes S. Causes and consequences of occupational stress in emergency nurses, a longitudinal study. *Journal of Nursing Management*. 2015; 23(3):346–358. <https://doi.org/10.1111/jonm.12138> PMID: 24330154
 22. Cydulka RK, Korte R. Career satisfaction in emergency medicine: The ABEM longitudinal study of emergency physicians. *Annals of Emergency Medicine*. 2008; 51(6):714–722. <https://doi.org/10.1016/j.annemergmed.2008.01.005> PMID: 18395936
 23. Clem KJ, Promes SB, Glickman SW, Shah A, Finkel MA, Pietrobon R, et al. Factors enhancing career satisfaction among female emergency physicians. *Annals of Emergency Medicine*. 2008; 51(6):723–728. <https://doi.org/10.1016/j.annemergmed.2008.01.011> PMID: 18342991
 24. Estryn-Behar M, Doppia MA, Guetarni K, Fry C, Machet G, Pelloux P, et al. Emergency physicians accumulate more stress factors than other physicians—Results from the French SESMAT study. *Emergency Medicine Journal*. 2011; 28(5):397–410. <https://doi.org/10.1136/emj.2009.082594> PMID: 21123828
 25. Toker I, Ayrik C, Bozkurt S. Factors affecting burnout and job satisfaction in Turkish emergency medicine residents. *Open Journal of Emergency Medicine*. 2015; 1(3):64–71. <https://doi.org/10.17140/EMOJ-1-111>
 26. Somville FJ, De Gucht V, Maes S. The impact of occupational hazards and traumatic events among Belgian emergency physicians. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*. 2016; 24(59). <https://doi.org/10.1186/s13049-016-0249-9> PMID: 27121279
 27. Blando JD, O'Hagan E, Casteel C, Nocera M-A, Peek-Asa C. Impact of hospital security programmes and workplace aggression on nurse perceptions of safety. *Journal of Nursing Management*. 2013; 21(3):491–498. <https://doi.org/10.1111/j.1365-2834.2012.01416.x> PMID: 23406321
 28. Hsieh HF, Chen YM, Wang HH, Chang SC, Ma SC. Association among components of resilience and workplace violence-related depression among emergency department nurses in Taiwan: A cross-sectional study. *Journal of Clinical Nursing*. 2016; 25(17–18):2639–2647. <https://doi.org/10.1111/jocn.13309> PMID: 27334990
 29. Adriaenssens J, de Gucht V, Maes S. The impact of traumatic events on emergency room nurses: Findings from a questionnaire survey. *International Journal of Nursing Studies*. 2012; 49(11):1411–1422. <https://doi.org/10.1016/j.ijnurstu.2012.07.003> PMID: 22871313
 30. Adriaenssens J, de Gucht V, van der Doef M, Maes S. Exploring the burden of emergency care: Predictors of stress-health outcomes in emergency nurses. *Journal of Advanced Nursing*. 2011; 67(6):1317–1328. <https://doi.org/10.1111/j.1365-2648.2010.05599.x> PMID: 21371083
 31. Converso D, Loera B, Viotti S, Martini M. Do positive relations with patients play a protective role for healthcare employees? Effects of patients' gratitude and support on nurses' burnout. *Frontiers in Psychology*. 2015; 6(470). <https://doi.org/10.3389/fpsyg.2015.00470> PMID: 25954227
 32. Escriba-Aguir V, Martin-Baena D, Perez-Hoyos S. Psychosocial work environment and burnout among emergency medical and nursing staff. *International Archives of Occupational and Environmental Health*. 2006; 80(2):127–133. <https://doi.org/10.1007/s00420-006-0110-y> PMID: 16710712
 33. Escriba-Aguir V, Perez-Hoyos S. Psychological well-being and psychosocial work environment characteristics among emergency medical and nursing staff. *Stress and Health*. 2007; 23(3):153–160. <https://doi.org/10.1002/smi.1131>
 34. Garcia-Izquierdo M, Rios-Risquez MI. The relationship between psychosocial job stress and burnout in emergency departments: An exploratory study. *Nursing Outlook*. 2012; 60(5):322–329. <https://doi.org/10.1016/j.outlook.2012.02.002> PMID: 22464694
 35. O'Mahony N. Nurse burnout and the working environment. *Emergency Nurse*. 2011; 19(5):30–37. <https://doi.org/10.7748/en2011.09.19.5.30.c8704> PMID: 21977687
 36. Rios-Risquez MI, Garcia-Izquierdo M. Patient satisfaction, stress and burnout in nursing personnel in emergency departments: A cross-sectional study. *International Journal of Nursing Studies*. 2016; 59:60–67. <https://doi.org/10.1016/j.ijnurstu.2016.02.008> PMID: 27222451
 37. Weigl M, Schneider A. Associations of work characteristics, employee strain and self-perceived quality of care in emergency departments: A cross-sectional study. *International Emergency Nursing*. 2017; 30:20–24. <https://doi.org/10.1016/j.ienej.2016.07.002> PMID: 27524107
 38. Bruyneel L, Thoelen T, Adriaenssens J, Sermeus W. Emergency room nurses' pathway to turnover intention: A moderated serial mediation analysis. *Journal of Advanced Nursing*. 2017; 73(4):930–942. <https://doi.org/10.1111/jan.13188> PMID: 27754558
 39. Gates DM, Ross CS, McQueen L. Violence against emergency department workers. *Journal of Emergency Medicine*. 2006; 31(3):331–337. <https://doi.org/10.1016/j.jemermed.2005.12.028> PMID: 16982376

40. Hunsaker S, Chen HC, Maughan D, Heaston S. Factors that influence the development of compassion fatigue, burnout, and compassion satisfaction in emergency department nurses. *Journal of Nursing Scholarship*. 2015; 47(2):186–194. <https://doi.org/10.1111/jnu.12122> PMID: 25644276
41. Kogien M, Cedaro JJ. Public emergency department: The psychosocial impact on the physical domain of quality of life of nursing professionals. *Revista Latino-Americana De Enfermagem*. 2014; 22(1):51–58. <https://doi.org/10.1590/0104-1169.3171.2387> PMID: 24553703
42. Revicki DA, Whitley TW. Organizational characteristics, perceived work stress, and depression in emergency medicine residents. *Hospital Topics*. 1997; 75(1):30–36. <https://doi.org/10.1080/00185869709596473>
43. Sawatzky J-AV, Enns CL. Exploring the key predictors of retention in emergency nurses. *Journal of Nursing Management*. 2012; 20(5):696–707. <https://doi.org/10.1111/j.1365-2834.2012.01355.x> PMID: 22823226
44. Taylor DM, Pallant JF, Crook HD, Cameron PA. The psychological health of emergency physicians in Australasia. *Emergency Medicine Australasia*. 2004; 16(1):21–27. <https://doi.org/10.1111/j.1742-6723.2004.00532.x> PMID: 15239751
45. Trautmann J, Epstein E, Rovnyak V, Snyder A. Relationships among moral distress, level of practice independence, and intent to leave of nurse practitioners in emergency departments. *Advanced Emergency Nursing Journal*. 2015; 37(2):134–145. <https://doi.org/10.1097/TME.000000000000060> PMID: 25929224
46. Williams ES, Rondeau KV, Francescutti LH. Impact of culture on commitment, satisfaction, and extra-role behaviors among Canadian ER physicians. *Leadership in Health Services*. 2007; 20(3):147–158. <https://doi.org/10.1108/17511870710764005> PMID: 20690460
47. Young-Ritchie C, Spence Laschinger HK, Wong C. The effects of emotionally intelligent leadership behaviour on emergency staff nurses' workplace empowerment and organizational commitment. *Nursing Leadership*. 2009; 22(1):70–85. PMID: 19289914
48. Jalili M, Roodsari GS, Nia AB. Burnout and associated factors among Iranian emergency medicine practitioners. *Iranian Journal of Public Health*. 2013; 42(9):1034–1042. PMID: 26060665
49. Lin BYJ, Hsu CPC, Juan CW, Lin CC, Lin HJ, Chen JC. The role of leader behaviors in hospital-based emergency departments' unit performance and employee work satisfaction. *Social Science & Medicine*. 2011; 72(2):238–246. <https://doi.org/10.1016/j.socscimed.2010.10.030> PMID: 21159414
50. Wu H, Sun W, Wang L. Factors associated with occupational stress among Chinese female emergency nurses. *Emergency Medicine Journal*. 2012; 29(7):554–558. <https://doi.org/10.1136/emj.2010.094391> PMID: 21680572
51. Zahid MA, Al-Sahlawi KS, Shahid AA, Awadh JA, Abu-Shammah H. Violence against doctors: 2. Effects of violence on doctors working in accident and emergency departments. *European Journal of Emergency Medicine*. 1999; 6(4):305–309. PMID: 10646918
52. Lin BY, Wan TT, Hsu CP, Hung FR, Juan CW, Lin CC. Relationships of hospital-based emergency department culture to work satisfaction and intent to leave of emergency physicians and nurses. *Health services management research*. 2012; 25(2):68–77. <https://doi.org/10.1258/hsmr.2012.012011> PMID: 22673696
53. Ben-Itzhak S, Dvash J, Maor M, Rosenberg N, Halpern P. Sense of meaning as a predictor of burnout in emergency physicians in Israel: A national survey. *Clinical and Experimental Emergency Medicine*. 2015; 2(4):217–225. <https://doi.org/10.15441/ceem.15.074> PMID: 27752601
54. Chen K-C, Hsieh W-H, Hu S-C, Lai P-F. A survey of the perception of well-being among emergency physicians in Taiwan. *Tzu Chi Medical Journal*. 2017; 29(1):30–36. https://doi.org/10.4103/tcmj.tcmj_12_17 PMID: 28757761
55. Hamdan M, Abu Hamra A. Workplace violence towards workers in the emergency departments of Palestinian hospitals: a cross-sectional study. *Human Resources for Health*. 2015; 13(28). <https://doi.org/10.1186/s12960-015-0018-2> PMID: 25948058
56. Hamdan M, Hamra A. Burnout among workers in emergency Departments in Palestinian hospitals: prevalence and associated factors. *BMC Health Services Research*. 2017; 17(407). <https://doi.org/10.1186/s12913-017-2356-3> PMID: 28619081
57. Wilson W, Raj J, Narayan G, Ghiya M, Murty S, Joseph B. Quantifying burnout among emergency medicine professionals. *Journal of Emergencies, Trauma, and Shock*. 2017; 10(4):199–204. https://doi.org/10.4103/JETS.JETS_36_17 PMID: 29097859
58. Sorour AS, Abd El-Maksoud MM. Relationship between musculoskeletal disorders, job demands, and burnout among emergency nurses. *Advanced Emergency Nursing Journal*. 2012; 34(3):272–282. <https://doi.org/10.1097/TME.0b013e31826211e1> PMID: 22842970

59. Crilly J, Greenslade J, Lincoln C, Timms J, Fisher A. Measuring the impact of the working environment on emergency department nurses: A cross-sectional pilot study. *International Emergency Nursing*. 2017; 31:9–14. <https://doi.org/10.1016/j.ienj.2016.04.005> PMID: 27184408
60. Biau DJ, Kernéis S, Porcher R. Statistics in brief: The importance of sample size in the planning and interpretation of medical research. *Clinical Orthopaedics and Related Research*. 2008; 466(9):2282–2288. <https://doi.org/10.1007/s11999-008-0346-9> PMID: 18566874
61. Bakker AB, Demerouti E. Job demands–resources theory: Taking stock and looking forward. *Journal of Occupational Health Psychology*. 2017; 22(3):273–285. <https://doi.org/10.1037/ocp0000056> PMID: 27732008
62. Ganster DC, Rosen CC. Work stress and employee health: A multidisciplinary review. *Journal of Management*. 2013; 39(5):1085–1122. <https://doi.org/10.1177/0149206313475815>
63. Tang K. A reciprocal interplay between psychosocial job stressors and worker well-being? A systematic review of the "reversed" effect. *Scandinavian Journal of Work, Environment & Health*. 2014; 40(5):441–456. <https://doi.org/10.5271/sjweh.3431> PMID: 24756578
64. Alarcon GM, Eschleman KJ, Bowling NA. Relationships between personality variables and burnout: A meta-analysis. *Work & Stress*. 2009; 23(3):244–263. <https://doi.org/10.1080/02678370903282600>
65. Kasl SV. Measuring job stressors and studying the health impact of the work environment: An epidemiologic commentary. *Journal of Occupational Health Psychology*. 1998; 3(4):390–401. <https://doi.org/10.1037/1076-8998.3.4.390> PMID: 9805283

3. Publication 2: Effects of work conditions on provider mental well-being and quality of care in emergency departments

Schneider, A., Wehler, M., & Weigl, M. (2019). Effects of work conditions on provider mental well-being and quality of care: a mixed-methods intervention study in the emergency department. *BMC Emergency Medicine*, 19, 1.

RESEARCH ARTICLE

Open Access



Effects of work conditions on provider mental well-being and quality of care: a mixed-methods intervention study in the emergency department

Anna Schneider^{1*} , Markus Wehler² and Matthias Weigl¹

Abstract

Background: Emergency departments (EDs) are highly dynamic and stressful care environments that affect provider and patient outcomes. Yet, effective interventions are missing. This study evaluated prospective effects of a multi-professional organizational-level intervention on changes in ED providers' work conditions and well-being (primary outcomes) and patient-perceived quality of ED care (secondary outcome).

Methods: A before and after study including an interrupted time-series (ITS) design over 1 year was established in the multidisciplinary ED of a tertiary referral hospital in Southern Germany. Our mixed-methods approach included standardized provider surveys, expert work observations, patient surveys, and register data. Stakeholder interviews were conducted for qualitative process evaluation. ITS data was available for 20 days pre- and post-intervention (Dec15/Jan16; Dec16/Jan17). The intervention comprised ten multi-professional meetings in which ED physicians and nurses developed solutions to work stressors in a systematic moderated process. Most solutions were consecutively implemented. Changes in study outcomes were assessed with paired t-tests and segmented regression analyses controlling for daily ED workload.

Results: One hundred forty-nine surveys were returned at baseline and follow-up (response at baseline: 76 out of 170; follow-up: 73 out of 157). Forty-one ED providers participated in both waves. One hundred sixty expert work observations comprising 240 observation hours were conducted with 156 subsequent work stress reports. One thousand four hundred eighteen ED patients were surveyed. Considering primary outcomes, respondents reported more job control and less overtime hours at follow-up. Social support, job satisfaction, and depersonalization deteriorated while respondents' turnover intentions and inter-professional interruptions increased. Considering the secondary outcome, patient reports indicated improvements in ED organization and waiting times. Interviews revealed facilitators (e.g., comprehensive approach, employee participation) and barriers (e.g., understaffing, organizational constraints) for intervention implementation.

Conclusions: To the best of our knowledge, this is the first study to report prospective effects of an ED work system intervention on provider well-being and patient-perceived quality of ED care. We found inconsistent results with partial improvements in work conditions and patient perceptions of care. However, aspects of provider mental well-being deteriorated. Given the lack of organizational-level intervention research in EDs, our findings provide valuable insights into the feasibility and effects of participatory interventions in this highly dynamic hospital setting.

Keywords: Work conditions, Emergency department, Nurses, Physicians, Mental well-being, Intervention, Quality of care, Patient survey, Emergency care, Emergency service, Hospital

* Correspondence: Anna.Schneider@med.lmu.de

¹Institute and Clinic for Occupational, Social, and Environmental Medicine, University Hospital, LMU Munich, Munich, Germany

Full list of author information is available at the end of the article



Background

Emergency departments (EDs) are highly dynamic work environments with particular risks for provider well-being and quality of care [1]. Adverse work factors contribute to high work stress among ED providers [2]. Burnout has been reported by 26% of emergency nurses [3] and by up to 51% of emergency physicians [4]. Suboptimal patient care was also linked to adverse ED work factors such as poor teamwork or frequent workflow interruptions [5–7]. Notwithstanding the need for effective interventions concerning ED work conditions, there is a dearth of reported interventions [1, 2, 8]. Thus far, research on prospective interventions targeting psychosocial ED work factors is limited [2, 4, 8, 9]: First, an intervention study with ED nurses in three Chinese emergency care facilities showed that comprehensive management (nurse manager-led meetings on communication skills, conflicts, efficacy elevation, and emotion control) was related to lower burnout levels over 6 months [10]. Second, a teamwork intervention in California at four ED sites was associated with improved perceptions of the ED work environment among ED nurses and physicians [11]. In this study, EDs participated in a teamwork training curriculum (Emergency Team Coordination Course) where teamwork principles such as maintaining team structure and climate, problem solving strategies, team communication, executing plans and managing workload as well as team skills were practiced. Lastly, an 18-month prospective study of nurses in 15 Belgian EDs observed that changes in work conditions, such as job demands, control, social support, reward, social harassment and work agreements, were associated with job satisfaction, work engagement, emotional exhaustion and turnover intentions [12]. These study findings indicate that job demands were relatively stable whereas social support and material resources showed most variation over time; turnover intentions deteriorated [12]. Yet this observational research omitted any specification of actual intervention measures. Overall, available studies have shortcomings such as lack of theoretical foundation, insufficient methodological rigor for identification of prospective effects, and sole focus on specific ED professions [2, 8].

The Systems Engineering Initiative for Patient Safety (SEIPS) framework [13] provides a sociotechnical model of interdependencies between several work factors, provider and patient outcomes in healthcare [13]. The underlying premise is that multiple factors (tasks, technologies, persons, environment, organization) conjointly generate stress loads and affect provider and organizational outcomes, i.e., provider health as well as patient safety [14]. Furthermore, participative interventions apply systematic analyses as well as collaborative improvement of work conditions [15–17]. Thus ‘front-line’ providers, such as ED physicians and nurses, are best suited to identify and solve problems in their work

environment [18, 19]. Although preliminary evidence suggests that organizational-level interventions can be effective in eliciting positive changes in work systems and provider well-being, thorough evaluations concerning intervention effects on quality of care outcomes are scarce [20].

The aim of our study was to investigate the effects of ED work system factors on provider well-being and quality of ED care, using the SEIPS model as a theoretical framework. Second, we set out to evaluate the feasibility and effectiveness of a multi-professional organizational-level intervention with focus on both ED provider and patient outcomes. Third, we used mixed-methods interrupted time-series (ITS) evaluations to determine intervention effects. An ITS paradigm is recommended as a quasi-experimental surrogate for assessing intervention effectiveness when a randomized controlled trial is not feasible [21, 22].

Methods

A prospective intervention study with a mixed-methods ITS design encompassing a 12-month observation period was established. Methods included (1) standardized provider surveys, (2) structured work observation sessions with ED physicians and nurses and concurrent work stress reports, (3) patient surveys, (4) register data, and (5) stakeholder interviews, which are described below. Observation sessions, work stress reports, and patient surveys were conducted on-site on 20 days each at baseline (Dec 15 – Jan 16) and follow-up (Dec 16 – Jan 17), respectively (exact dates are listed in Additional file 1: Table S1). ED providers were informed about the study via presentations and information leaflets. Written informed consent was obtained prior to data collection. The Ethics Committee of the Medical Faculty, Munich University, approved the study (NR 327–15).

Setting and sample

The study setting is a 24-h interdisciplinary ED of a tertiary referral hospital in a major city in Southern Germany. The academic hospital provides major services and medical specialties for an administrative region of almost two million inhabitants. The ED serves adult patients with mean yearly visits of over 85,000. It is organized in three sections according to patient’s chief complaints: i.e., ten separate bays for non-surgical patients, five separate bays for surgical patients, two resuscitation bays, and an observation and clinical decision unit with 24 beds. The ED is regularly staffed with junior and senior physicians from internal medicine, trauma surgery, and neurology, as well as further specialists on call.

The study team approached two hospitals for participation, whereof this ED’s department head, hospital administration, and hospital’s worker council agreed to take part. The study team established first contact directly with the head of the ED. The head discussed the proposal with the

head of nursing and introduced it in two team meetings of ED physicians and nurses, respectively. After positive feedback from ED staff, the study was presented at the hospital board meeting and received approval. The specific motivation and decision for participation were not specified prior to study start. However, the ED was described as a high strain work environment with particular challenges for nurses, physicians, and patient care. All professionals working in the ED, i.e., nurses, physicians, and administrative staff, were eligible for participation. At baseline, ED staff consisted of 101 nurses (including assistant nurses), 44 physicians, and 20 administrators. External providers and on-call consultants were not included.

Methods and study outcomes

Proposed intervention effects on (a) work system factors, (b) provider mental well-being, and (c) quality of care were identified using the following methods:

(1). Provider survey

ED providers received surveys at baseline and follow-up that were distributed through internal mail. Pre-stamped envelopes were provided for direct return of questionnaires to the study team. Deadline for survey completion was four weeks and estimated average time for filling in questionnaires was 25 min. Matching across time was ensured through personalized study codes.

(1a) *Work system factors* were measured with a validated self-report tool for work analysis in hospitals that has been previously applied to ED work settings [23, 24]. Following SEIPS framework, several work factors were surveyed. Task-related factors included scales on patient stressors (i.e., dealing with difficult patients; three items), job control (i.e., autonomous decision making and personal discretion; four items), participation opportunities (i.e., influence on work-related decisions; four items), work overload (i.e., job duties exceeding work time; three items). Organizational factors consisted of personnel resources (i.e., adequate staffing; three items), information problems (i.e., availability and clarity of work-related information; three items), uncertainty (i.e., job insecurity; three items), social support (i.e., support by colleagues and supervisors; three items), and supervisor feedback (i.e., feedback on performance and task behaviors by senior leaders; two items). Self-reported mean weekly overtime (in hours and minutes), profession (ED physician, ED nurse, ED administrator) and professional tenure (in years) were further retrieved.

(1b) *Provider well-being* included two key burnout dimensions, i.e., emotional exhaustion and depersonalization (four items each) [9] and a screening tool for depressive symptoms (two items) [25]. Both tools are validated and have been previously applied in healthcare as well as ED

provider samples [8, 24]. Conventional cut-off criteria were used to determine providers with elevated levels of emotional exhaustion (scale mean > 3.5) [26] and depressive symptoms (scale sum score ≥ 3) [25]. Job satisfaction and turnover intentions were measured with one item, respectively.

(1c) Provider perceptions of *quality of care* were measured with a three-item scale on the frequency of medical errors [27]. Respondents were asked to indicate whether they had experienced a near miss, minor error, or serious error during the past year. For each type of error, a short definition was provided. Additionally, overall patient safety was further assessed with one item ("Please rate the degree of patient safety in your department from your point of view") [28].

(2). Work observation sessions and work stress reports

Observation sessions of ED nurses' and physicians' workflows were allocated randomly across three ED sections and professions. Randomization and sessions were limited to provider day shifts between 10:00 am and 5:00 pm on 40 pre-defined days of data collection. Trained observers shadowed providers for 90-min sessions using a standardized participant observation approach that has been previously applied to ED settings [6, 29].

(2a) *Work system factors* were represented by observed interruption rates. An established tool to identify workflow interruptions was applied [6, 29]. Referencing the SEIPS model, we distinguished between interruptions initiated by patients and their relatives (task-related factors), and those by ED colleagues of the same or another profession (organizational factors). Furthermore, duration of personal breaks (e.g., time for personal rests, short respites from work, or regular pauses during the shift) during observation sessions was coded (in % of observed time) [30].

(2b) *Provider well-being* was surveyed immediately after each observation session with a short survey on current cognitive, emotional, and physical aspects of work stress in each observed provider [31].

(3). Patient survey

All ED patients undergoing consultation or treatment on days of on-site data collection were eligible. After information and verbal consent, patients filled in the survey. Patients' relatives were allowed to fill in the survey by proxy if they accompanied patients throughout their ED stay. Patients with incapability to communicate due to illness severity or other physical and mental constraints were not surveyed. The patient questionnaire was handed out by members of the study team, preferably at the end of patients' ED treatment. All study team

members received prior training in how to approach and interview ED patients.

(3c) Patient perceptions of ED *quality of care* were obtained with a standardized patient survey (Munich Patient Inventory) with additional translations in English, Russian, and Turkish language. This questionnaire assesses patient-perceived quality of care [32] and has been tested for reliability and validity in different clinical settings [33, 34], including the ED setting [6]. It contains scales on the quality of interaction (example item: “My problems and complaints are taken seriously by ED providers”), patient information (e.g., “I am comprehensively informed about the course of therapy and treatment”), ED organization (e.g., “I know who of the ED providers is responsible for me”), and waiting time (e.g., “My waiting time until the first consultation with an ED physician was adequate”). Additionally, patients’ overall satisfaction with care was obtained with one question (“Overall, how do you evaluate care in this ED?”).

(4). Register data on ED workload

An approximate measure for daily ED workload was computed with day-level data on patient numbers, patient acuity (ESI, Emergency Severity Index score), and staffing levels. Data was extracted from ED administrative records and staff rosters.

(5). Stakeholder interviews

To complement quantitative results, we used ED stakeholder interviews for qualitative process evaluation [35, 36]. Nine stakeholder interviews were conducted at study half-time and follow-up. A semi-structured interview guideline assessed intervention implementation, facilitators and barriers, and providers’ mental models [35]. Questions were derived from Nielsen & Randell (2013)’s framework for comprehensive process evaluation of organizational-level interventions [35]. The German interview guideline can be obtained from the corresponding author. Interviewees were recruited through convenience sampling. All interviewed stakeholders had a job tenure > 5 years in the ED, except one junior physician. Four physicians (three with leadership responsibilities), four nurses (one in leadership position) and one ED administrator were interviewed. Overall, there were four female and five male interviewees. The department head, nursing supervisor, and administration head were interviewed twice to comprise intervention implementation at ED management level at half-time as well as follow-up. Interviews lasted between 30 and 60 min. We did not apply a prior estimate of expected sample size for data saturation since project resources did not allow for more stakeholder interviews.

Intervention

The intervention started after feedback of baseline survey results to ED staff during regular internal meetings as well as through internal mail. Ten 90-min meetings, termed health circles [15], were held at three-week intervals over a period of seven months. Three to seven ED nurses and physicians participated in each meeting. Principally, all ED providers were invited to take part. Decision for participation was completely at the discretion of each ED provider. Practically, the majority of participants consisted of staff members who were on duty on days of respective meetings; for nurses, usually before or after their shift; for physicians, mostly in breaks during their shift. Therefore, participants varied considerably across individual meetings. Participation in health circles was considered work time. Additionally, ED nursing management and the hospitals’ workers council (German: ‘Personalrat’; employee representatives being elected by hospital employees) attended. All meetings were moderated by the study team. In the first meeting, the concept of health circles was introduced. Potential advantages of this approach (i.e., tailored to local needs, employee involvement, intervention process adapted to context) as well as potential problems (e.g., insufficient implementation of solutions, organizational constraints, time-consuming and long-lasting process of structural re-organization) were discussed. Afterwards, participants identified adverse ED work conditions in a systematic process facilitated by moderators: Participants classified problematic work conditions according to their practical importance and potential for change and formed an agenda of issues for improvement for subsequent meetings. Each of the following meetings focused on the development of measures for one of the identified work problems. In these guided health circles, participants collectively analyzed and discussed potential solutions for work problems and defined an action plan with concrete measures, persons responsible, and deadlines [19]. Two meetings were designated to evaluate implementation status of measures and to discuss potential adjustments. Each health circle meeting was documented in written form and made available to the entire ED staff through the intranet information system. Additionally, participating nurses and physicians were assigned to report on health circle meeting outcomes in their regular team meetings.

After each health circle meeting, participants provided short feedback on their satisfaction with and effectiveness of the respective meeting. We used a self-developed tool that measured five aspects: (1) participant’s satisfaction with meeting outputs (“I am satisfied with the results of today’s health circle”), (2) meeting atmosphere (“I am satisfied with today’s group atmosphere”), (3) opportunities to actively develop solutions for work problems (“In this health circle I can actively contribute to improvements of our work situation”), (4) motivation to

improve work conditions (“Today’s health circle meeting motivates me to improve processes and contents of my work”), and (5) participant’s expectations of actual implementation of developed solutions in everyday work (“The developed solutions can be implemented in our daily workflow”). All questions were answered on five-point Likert-Scale ranging from 1=“no, not at all” to “5 = yes, exactly”.

In addition to health circles, three meetings of a steering committee were held during the intervention period. These meetings comprised ED management (ED head, head nurse), the hospitals’ work council and health promotion department, and head of ED administration. The steering committee discussed measures developed by ED staff which could not be implemented immediately, needed approval from ED management, or affected inter-departmental or hospital-wide coordination and decisions [15]. In each meeting, the committee reviewed the action plan, monitored project status, and discussed measures developed in health circle meetings with regard to their implementation in routine work organization and processes.

Analyses

First, to identify proposed intervention effects, changes in provider survey results between baseline and follow-up were calculated using paired t-tests. To assess strength of changes, Cohen’s effect sizes were calculated and classified as weak (0.2–0.4), moderate (0.5–0.7), or strong effects (> 0.8) [37]. Second, ITS data of hourly interruption rates from work observation sessions, work stress reports, and patient perceptions of care were aggregated to mean scores at the day-level. Data was analyzed with segmented regression analysis with 40 available data points, i.e., 20 each pre- and post-intervention [21]. A daily ED workload measure was calculated from mean daily staffing levels and number and acuity of patients as indicated by ESI scores [38]. Autoregressive integrated moving average (ARIMA) models were estimated and controlled for ED workload [39]. In all steps, listwise deletion was used for missing data. All quantitative analyses were conducted with SPSS 24 (IBM, Chicago). Interview data was analyzed applying content analysis. All nine interviews were audio-taped and transcribed verbatim to cluster recurrent main themes [40].

Results

Intervention implementation

In the first health circle meeting, participants identified six adverse ED work conditions: (1) lack of personal breaks (i.e., regular work breaks and personal pauses were often omitted due to high workload); (2) work agreements (i.e., unspecified agreements on patient care and tasks that hinder fast and efficient care); (3) high work pressure environment: point of triage (i.e., ED’s location where incoming

patients are assessed for the severity of their symptoms based on a standardized process), (4) leadership, (5) staff information (i.e., insufficient information on current reorganizational projects), and (6) staff shortages (i.e., sustained understaffing of ED personnel). Thirteen respective measures were developed focusing on improvements in task-related and organizational work factors (see Table 1). Implementation fidelity varied by the time of follow-up: Eight solutions were implemented or in progress. Five were deemed unfeasible by the steering committee due to financial constraints and personnel shortages and were not pursued.

Sample description

At baseline, 170 provider surveys were distributed whereof 76 were returned (response rate: 44.7%). At follow-up, 73 out of 157 surveys were returned (46.5%). Forty-one ED providers participated at both waves (29 ED nurses, 5 ED physicians, 7 ED administrators). Tests for panel attrition (between those who returned a complete survey both times and those who only answered at baseline or follow-up) indicated that the final sample reported higher professional tenure, higher ratings of work overload, and higher depersonalization (see Additional file 1: Table S2).

Overall, 160 observation sessions (80 each at baseline and follow-up) were conducted, resulting in 240 observation hours: 99 with ED nurses and 61 with ED physicians. One hundred fifty-six work stress reports were collected after observations (76 at baseline, 80 at follow-up).

Altogether, 1418 ED patients were surveyed; 694 at baseline (survey response rate: 69.2%) and 724 at follow-up (81.2%).

Changes in work system factors

At baseline, respondents reported high levels of patient stressors, work overload, information problems, and uncertainty. Participation opportunities, personnel resources, and supervisor feedback were rated as below average (see Table 2). Considering mean changes over time, job control significantly increased ($p = 0.01$). Mean weekly overtime significantly decreased from 7.3 to 5.8 h ($p = 0.01$). Supervisor feedback improved although this change was not significant ($p = .058$). However, social support deteriorated at follow-up ($p < 0.01$). Considering Cohen’s delta, effect sizes for changes in work factors were rather weak ranging from $\Delta = .31$ (social support) to $\Delta = .42$ (overtime) (see Table 2).

No significant changes were observed in mean daily ED workload, workflow interruptions by patients, and respondents’ time spent in personal breaks (see Table 3). Intra-professional interruptions (e.g., nurse interrupts nurse) decreased before the intervention ($\beta = -0.1$, $p = 0.04$), whereas inter-professional interruptions (e.g., nurse interrupts physician) significantly increased after the intervention ($\beta = 0.1$, $p = 0.03$). Mean interruptions by relatives decreased after the intervention ($\beta = -0.7$, $p = 0.03$).

Table 1 Action plan of ED providers' identified issues for improvement, respective measures, and implementation status at follow-up

Work system factor (SEIPS)	Identified problems and issues for improvement	Solutions and respective improvement measures	#HCM / #SCM	Implementation status at follow-up
Organization	Lack of personal breaks during work time (i.e., limited opportunities to take breaks while on duty; short duration of breaks; multiple short breaks instead of longer pauses)	Schedule additional nursing staff for short-term replacement of nurses taking breaks	HCM#2 / SCM#2, SCM#4	Not feasible and declined after discussion in steering committee
		Short-term rotation across ED units to replace nursing staff in breaks	HCM#2/ SCM#2, SCM#4	Partially completed
		Supervising physicians coordinate residents' breaks	HCM#2/ SCM#2	Fully completed
		Shift supervisor coordinates temporary replacement of nursing staff in breaks on a daily basis	HCM#2/ SCM#2, SCM#4	Declined after discussion in steering committee
Task	Unclear work agreements (i.e., lack of mutual agreement between ED units concerning patient transfers and admissions; unclear agreements with ICU and adjacent care units concerning specific care obligations, e.g., timing of transfusions)	Revise agreements for interdisciplinary occupancy of ED observation unit	HCM#3 / SCM#2, SCM#4	Discussed with consulting physicians and head nurses; not implemented
		Agreement on transfusion process in ED observation unit	HCM#3 / SCM#2	Discussed among attending physicians; completed
Organization		Meeting with ICU representatives and revision of patient transfer agreements from ED observation unit	HCM#3 / SCM#2	Not implemented
Organization	High pressure environment - point of triage (i.e., poor and narrow design of triage area; understaffing; lack of qualified personnel for triage; ongoing project on redesign of triage process and assisting technology)	Repeated discussion of various solutions for point of triage in ED management meeting (with the objective to manage exceeding work load during triage)	HCM#4, HCM#5, HCM#7 / SCM#3, SCM#4	Few completed (e.g., blocking of external phone calls); but most solutions considered not feasible (e.g., separate room, free of distractions, permanent staffing of two qualified nurses at triage)
		Leadership (e.g., staff's need for enhanced participation in meetings and ongoing reorganization)	External moderator for ED nursing staff meetings to allow for enhanced discussion and opportunities to ask questions	HCM#6 / SCM#3, SCM#4
		Ad hoc meeting for ED providers concerning reorganization of triage process	HCM#6 / SCM#3, SCM#4	Completed
	Lack of staff information (i.e., lack of status information concerning ongoing projects and reorganization activities in the ED)	Provision of Q&A sheet on reorganization of triage process for nurses in intranet	HCM#6 / SCM#3, SCM#4	Completed
	Staff shortages (i.e., permanent understaffing, particularly during times of high patient load)	Schedule additional nursing and medical providers in shifts	HCM#8 / SCM#4	Not implemented
	Realistic HR planning of ED personnel and shift staffing levels of ED nurses and physicians	HCM#8 / SCM#4	Not started at follow-up	

Legend. ED emergency department, SEIPS Systems Engineering Initiative for Patient Safety model, ICU intensive care unit. #HCM / #SCM: Number of health circle meeting (HCM) or steering committee meeting (SCM), issue being discussed, analyzed, or reconsidered (HCM#1: feedback session of baseline results and development of action plan; SCM#1: feedback session of baseline results)

Changes in respondents' well-being

At baseline, 61% of respondents reported high emotional exhaustion and 22% depressive symptoms above cut-off. At follow-up, the proportion of ED respondents with reported emotional exhaustion (75.6%) and depressive symptoms increased (34.1%). Both trends were not statistically significant. Depersonalization significantly increased over time ($p = 0.01$; see Table 2). Respondents further reported less job

satisfaction ($p = 0.01$) and higher turnover intentions at follow-up ($p < 0.01$). However, mean daily work stress did not change significantly (see Table 3).

Changes in quality of care

Respondents' reports of the frequency of medical errors and overall ED patient safety remained stable over time (see Table 2).

Table 2 Descriptive statistics and changes in work factors, respondent well-being, and quality of care (provider survey)

Study outcomes	Scale range	No. of items	Baseline (T1)		Follow-Up (T2)		Effect size (Cohen's d)	t-test		
			Mean	SD	Mean	SD		t	df	p
Work system factors										
Patient stressors	1–5	3	4.10	.63	4.11	.71	.02	−.10	.40	.921
Job control	1–5	4	2.63	.76	2.90	.74	.36	−2.57	39	.014
Participation opportunities	1–5	4	1.81	.70	1.83	.70	.03	−.24	39	.813
Work overload	1–5	3	4.37	.61	4.37	.48	–	.08	40	.937
Personnel resources	1–5	2	1.93	.70	1.76	.75	.23	1.13	39	.265
Information problems	1–5	3	3.20	.79	3.26	.80	.08	−.55	40	.583
Uncertainty	1–5	4	3.46	.65	3.64	.61	.29	−1.73	39	.091
Overtime (in hours)	–	1	7.79	3.93	5.93	4.92	.42	3.00	13	.010
Social support	1–5	2	3.15	.87	2.88	.89	.31	3.27	40	.002
Supervisor feedback	1–5	2	2.05	.90	2.30	.93	.27	−1.96	39	.058
Provider well-being										
Emotional exhaustion	1–6	4	4.19	.94	4.21	1.03	.02	−.18	40	.855
Depersonalization	1–6	4	3.18	1.23	3.54	1.22	.29	−2.29	40	.027
Depressive symptoms	1–4	2	1.90	1.48	2.22	1.53	.21	−1.59	40	.119
Job satisfaction	1–7	1	4.42	1.24	3.79	1.49	.46	2.60	37	.013
Turnover intentions	1–5	1	2.29	1.01	2.72	1.28	.37	−3.12	40	.003
Quality of care (ED provider reports)										
Frequency of errors	1–5	3	1.98	.74	2.05	.75	.09	−.54	40	.591
Patient safety	1–5	1	2.71	.78	2.50	.71	.28	1.90	40	.064

Legend. N = 41 participants; ED: emergency department, SD: standard deviation, d: delta, t: t-test statistic, df: degrees of freedom, p: probability level; bold if $p < .05$

Table 3 Changes in day-level work factors, provider well-being, and patient reports of ED care (segmented regression analyses)

Study outcomes	ARIMA parameters										Goodness of fit (Rsq)
	Intercept		Trend pre-intervention		Level change		Trend post-intervention		Workload		
	β	p	β	p	β	p	β	p	β	p	
Work system factors											
Time spent in breaks (in %)	2.64	.060	−.01	.834	−.67	.635	.04	.522	−.14	.181	.12
Interruption rates by patients	.46	.607	−.01	.588	−.31	.686	.04	.210	.02	.732	.29
Interruption rates by relatives	.26	.434	−.02	.067	−.67	.029	.02	.062	.03	.285	.37
Interruption rates by colleagues of the same profession	3.84	.007	−.07	.041	1.04	.334	.06	.181	−.11	.291	.41
Interruption rates by colleagues of other ED professions	2.36	.047	−.05	.103	−.98	.318	.095	.026	.02	.821	.31
Provider well-being											
Work stress	1.36	.002	.01	.288	.57	.127	−.02	.155	.03	.369	.15
Quality of ED care (Patient reports)											
Overall satisfaction with ED care	1.66	<.001	.01	.205	.08	.781	−.02	.197	.056	.016	.33
Patient-oriented organization	3.24	<.001	−.01	.132	.08	.658	.02	.022	.000	.980	.67
Patient-oriented interaction	4.63	<.001	−.01	.045	.16	.443	.01	.304	−.03	.093	.30
Patient-oriented information	4.03	<.001	.00	.727	.03	.866	.01	.545	−.01	.553	.40
Satisfaction with waiting time	4.09	<.001	−.02	.011	−.06	.778	.03	.011	−.04	.072	.48

Legend. ARIMA: Autoregressive integrated moving average, Rsq: R-square, β : standardized regression coefficient, bolded if $p < .05$

However, significant changes in patient-perceived quality of care were observed (see Table 3). At follow-up, patient evaluations of ED organization improved ($\beta = 0.02$, $p = 0.02$). Further, ratings of waiting time declined before the intervention ($\beta = -0.02$, $p = 0.01$), but improved significantly after the intervention ($\beta = 0.03$, $p = 0.01$). Concerning interaction with ED providers, a negative pre-intervention trend was observed ($\beta = -0.01$, $p = 0.045$), however, no significant subsequent changes were identified. Patient's overall satisfaction with ED care remained stable at a high level. Daily ED workload negatively predicted overall patient satisfaction ($\beta = 0.1$, $p = 0.02$), such that patients were less satisfied with overall quality of care on days with less favorable patient/provider-ratios.

Evaluation of intervention fidelity and implementation process

Forty-one surveys were collected after health circle meetings. Participants indicated high satisfaction with meeting outputs (mean, $M = 4.2$; standard deviation, $SD = 1.0$), meeting atmosphere ($M = 4.7$, $SD = 0.5$), and opportunities to actively develop solutions for work problems ($M = 4.1$, $SD = 0.7$). Participants also reported high motivation to improve work conditions ($M = 4.0$, $SD = 1.0$). However, developed measures were deemed only partially realizable in everyday work ($M = 3.3$, $SD = 1.1$).

Implementation process

Stakeholder interviews revealed that provider surveys and work observation sessions addressed relevant aspects of the ED environment and that sufficient information was available prior to the intervention. Despite extensive staff information and communication efforts prior to study start, some ED providers felt not well informed about the project purpose and process; among interviewees, two out of nine respondents did not take full note of surveys and expressed limited time capacities to deal with available information.

Contextual factors and mental models

Nurses' intervention participation was deemed successful while there was concern about lack of physician involvement. Two interviewees explicitly mentioned the intervention's potential to improve ED work conditions. However, only two respondents expressed motivation to actively engage in improvement activities. Few expressed reservations that implementation of measures might be difficult due to organizational constraints (e.g., shortage of personnel resources). Main stakeholder expectations concerning the study were to raise awareness for ED workload in other wards and at hospital management level.

Intervention effects

When asked about changes in their work environment, three interviewees reported a deterioration of their work situation, while others reported no changes or slight improvements, especially relating to personal breaks. Three respondents reported a general increase in work stressors (i.e., increased patient numbers, insufficient staffing). Nonetheless, after study completion, the hospital's health promotion department decided to roll out the intervention to other hospital units. This was partly motivated by the overall positive feedback of ED providers concerning the participatory approach and involvement of representatives from the worker's council. Moreover, health circle meetings were considered a feasible opportunity for the evaluation of psychosocial risk factors at work.

Discussion

To the best of our knowledge, this study is the first to systematically investigate prospective effects of a multi-professional organizational-level intervention on ED work conditions, provider well-being, and quality of care. Patient perceptions of ED organization and waiting times, and survey respondents' self-reported job control and overtime hours improved while some indicators of provider well-being deteriorated. Given the lack of organizational-level intervention research in EDs [2], our results generate first valuable insights into the feasibility and effects of participatory interventions on ED provider and patient outcomes.

Theoretical assumptions of our study were based on the SEIPS model which links multiple factors of the work system with care processes and provider and patient outcomes [13, 14]. However, observed intervention effects in our study were inconsistent across different outcomes. Considering work factors, *job control* is a key resource for provider well-being and performance [1, 2]. Participatory interventions were shown to increase job autonomy partly due to their inclusive approach and employee-oriented focus [15, 20]. Our results confirm this assumption for the ED context since survey respondents reported significantly higher job control at follow-up. Furthermore, *workflow interruptions* are a major work stressor in EDs [29, 41]. In our study, inter-professional interruptions increased after the intervention, which suggests more face-to-face communication and information exchange across professions. Yet, we cannot infer about the underlying reasons and consequences of this increase, e.g., if additional interruptions were more helpful or necessary. Further, interruptions by relatives decreased which might indicate better information of patients and relatives about ED procedures resulting in less need to interrupt ED providers. Accordingly, a key finding of our study was that patients reported significant improvements in *ED organization and waiting times*. Generally, EDs are interrupt-driven

environments and excessive interruptions mitigate provider well-being and performance [6, 42, 43]. However, disruptions can also contribute to efficient and timely patient care [6, 44]. Our results hint to this double-edged sword: frequent interruptions among providers may promote patient-perceived ED organization and shorter waiting times but also contribute to inferior provider well-being.

Our results further corroborate that *burnout* is a chronic work-related hazard of the ED work environment that affects a significant proportion of ED physicians and nurses [2–4]. In our study, job satisfaction decreased while turnover intentions and depersonalization increased at follow-up. Available evidence on effects of organizational interventions on health-care provider mental well-being is inconsistent [18, 45]. Based on stakeholder interviews, we assume that observed deteriorations in well-being were related to provider's disappointment about shortcomings in the implementation of developed measures [46]. Furthermore, mental well-being might have affected ED providers' willingness to engage with intervention measures [18]. Low job satisfaction and low affective well-being were shown to predict intervention participation and evaluation of intervention effectiveness in elder care providers [47]. Moreover, since duration of personal breaks was unchanged over time, opportunities for respite or recovery from high work strain during ED shifts remained limited [30].

Finally, an unexpected study finding was that *social support* from colleagues decreased at follow-up. Designing sociotechnical work systems which promote effective teamwork is crucial for positive provider and patient outcomes [14]. However, in our study, ED providers reported concerns that initiated measures were not pursued due to resource limitations, institutional boundaries, and organizational constraints, i.e., financial cuts and a long-standing surge in patient load. Adverse contextual conditions as well as insufficient support by colleagues and managers in implementing measures might thus have led to disappointment and decreased trust within the ED team [17, 36, 48]. Moreover, those interventions with the highest progress of implementation at follow-up were related to improving communication and organization between ED providers, while solutions that involved more resources (i.e., personnel) were among those that were not (or not yet) implemented. Despite consistent participation and support of ED management throughout the study, providers may have developed a perception of limited support since effects did not exert on the ED organizational level as anticipated [17, 36].

Limitations

We established a mixed-methods ITS study design that allows robust inferences concerning prospective changes of outcomes between pre- and post-intervention assessments [21]. However, pragmatic improvement studies in dynamic clinical settings comprise multiple limitations.

First, although our study setting features a typical urban ED setting and relies on elaborated analyses, it lacks a control group. This limits inferences concerning causation as well as secular trends. We describe a realist approach that aimed to change ED work factors. This comprehensive approach targeting several task- and organizational-level aspects over one year does not allow for attribution of effects to single interventions or steps. Our participatory approach consists of several interventions of collective intertwined initiatives that occur in the course of a multitude of everyday concurrent events in patient care [17]. Therefore, we cannot attribute effects of specific measures to primary and secondary outcomes nor specify time lags of measures being effective. Second, our results strongly depend on local contextual factors and the process of intervention implementation [35]. In the study period, other process changes occurred, i.e., reorganization of the triage process and preparation of constructional expansion. ED providers thus might have perceived limited capacity to engage with intervention measures on top of high daily workloads. Nevertheless, our approach combined quantitative results with qualitative information from stakeholder interviews to shed light on these potentially relevant facilitators and barriers in intervention implementation [36, 46]. Third, we acknowledge the rather small longitudinal sample of provider surveys. Although high commitment in data collection and recruitment was undertaken, follow-up bias occurred. This might partially be due to high staff turnover rates which are generally characteristic of EDs [3]. To offset limitations of provider ratings which are prone to subjective bias, we further used objective and independent methods such as expert observation sessions, patient surveys, and register data to measure study outcomes. Yet, observations were confined to day-time shifts which limit inferences concerning provider workflow routines during evening or night shifts [49]. The patient survey tool has been previously applied in various populations including ED patients where it proved its reliability [6]. Specific investigations into the validity of the instrument for ED patient surveys are not yet reported. Fourth, our timing of follow-up assessment needs careful consideration [50]. For practical reasons, we used a one-year time lag. However, ongoing improvements might have failed to reach their full impact on work system factors and provider well-being at the time of our follow-up measurement [17, 51]. Finally, we acknowledge that ED work systems comprise multiple factors and that system interventions should comprehensively address various components to improve provider and patient outcomes [13, 17, 42, 52]. Yet, although preliminary evidence points to positive effects of comprehensive organizational-level interventions for provider outcomes [17], simultaneous effects for

patient care need to be elicited. In our study, solutions concerning other domains such as changes in technologies, tools, or environmental factors, were considered by ED providers in meetings but not prioritized for implementation. This refers particularly to resource constraints such as understaffing or structural provisions of the physical environment. Although we carefully introduced the intervention approach to providers and sought to manage stakeholder expectations in the beginning of the study, post-hoc, we cannot infer on specific anticipations or ‘implicit theories’ [36] of involved stakeholders, e.g., employee assumptions that hospital management would provide additional resources or prioritization of staff shortages.

Implications for practice and further research

Implementation of organizational-level interventions is time-consuming and evaluation of intervention effects is challenging [53]. We used a multi-disciplinary intervention that included both ED nurses and physicians in collaborative meetings and implementation of solutions. Yet, this partly resulted in perceptions of imbalanced involvement, efforts, and contributions of both professions. Future attempts should therefore seek opportunities to implement interventions that take account of the multi-disciplinary nature of ED work as well as consider unique expectations and needs of each profession in the course of participatory work design in clinical care [3]. Concerning methodological aspects, future studies should consider applying cluster-randomized and controlled designs across various ED settings as well as realist evaluation for intervention evaluation [46]. Varying follow-up measurement intervals should be considered to capture potentially time-delayed intervention effects [50]. With regard to intervention content, future studies should expand the scope of assessed work system factors as well as their differential effects on processes, provider and patient outcomes [14]. Furthermore, ED practitioners could expand or adapt existing tools and practices in performance management to include continuous improvement of work system factors [18]. Finally, although our intervention approach was well-accepted by ED providers, partial improvements in work conditions and patient evaluations of care were accompanied by deteriorations in provider mental well-being. Future studies of work system interventions should thus elucidate beneficial concomitants of provider well-being before and during intervention implementation in high stress care environments.

Conclusions

This study provides valuable first insights into the feasibility of organizational-level interventions in EDs to improve work conditions, provider well-being, and quality of care. Our findings indicate that interprofessional approaches targeting work system factors are well-accepted by ED physicians and

nurses. Improvement measures developed by ED providers largely focused on changes in organizational work factors. Improvements in job control, overtime hours, and patient perceptions of ED organization and waiting times were observed. However, provider well-being deteriorated over time. Future studies should further identify to what extent and under which circumstances work system interventions are beneficial for provider outcomes in high stress care environments.

Additional file

Additional file 1: Table S1. Dates of data collection. Dates of data collection at baseline and at follow-up. **Table S2** Panel attrition: Loss to follow-up analysis. Analysis of loss to follow-up in provider survey participants from baseline to follow-up. (PDF 36 kb)

Abbreviations

ARIMA: Autoregressive integrated moving average; ED: Emergency department; ESI: Emergency Severity Index; ITS: Interrupted time-series; SEIPS: Systems Engineering Initiative for Patient Safety

Acknowledgements

We would like to thank Joana Beck, Tobias Augenstein, Tobias Filmer, Jeannette Weber, Theresa Steeb, and Nikolaus Bürger for their support in data collection.

Funding

The study was supported by the Munich Centre of Health Sciences (MC-Health). The funding body did not have any role in the design of the study and collection, analysis, and interpretation of data and in writing the manuscript.

Availability of data and materials

Anonymized and de-identified data will be made available to other investigators upon request. Interested readers should contact the corresponding author.

Authors' contributions

All authors conceptualized and designed the study. AS and MWG were responsible for acquisition of data and intervention implementation. AS and MWG analyzed and interpreted the data regarding intervention effects. All authors drafted, read and approved the final manuscript.

Ethics approval and consent to participate

The Ethics Committee of the Medical Faculty, Munich University, approved the study (NR 327–15). Informed consent was obtained from participants in written (provider survey) and verbal form (participants in standardized work observations; participants in patient survey). Verbal consent was obtained because no personal data was collected from participants in work observations and from patients. The ethics committee approved this procedure.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Author details

¹Institute and Clinic for Occupational, Social, and Environmental Medicine, University Hospital, LMU Munich, Munich, Germany. ²Department of Emergency Medicine and Department of Medicine IV, Klinikum Augsburg, Augsburg, Germany.

Received: 15 August 2018 Accepted: 20 December 2018

Published online: 03 January 2019

References

- Johnston A, Abraham L, Greenslade J, Thom O, Carlstrom E, Wallis M, Crilly J. Review article: staff perception of the emergency department working environment: integrative review of the literature. *Emerg Med Australas*. 2016;28:7–26. <https://doi.org/10.1111/1742-6723.12522>.
- Basu S, Qayyum H, Mason S. Occupational stress in the ED: a systematic literature review. *Emerg Med J*. 2017;34:441–7. <https://doi.org/10.1136/ememed-2016-205827>.
- Adriaenssens J, de Gucht V, Maes S. Determinants and prevalence of burnout in emergency nurses: a systematic review of 25 years of research. *Int J Nurs Stud*. 2015;52:649–61. <https://doi.org/10.1016/j.ijnurstu.2014.11.004>.
- Bragard I, Dupuis G, Fleet R. Quality of work life, burnout, and stress in emergency department physicians: a qualitative review. *Eur J Emerg Med*. 2015;22:227–34. <https://doi.org/10.1097/MEJ.0000000000000194>.
- Nielsen KJ, Pedersen AH, Rasmussen K, Pape L, Mikkelsen KL. Work-related stressors and occurrence of adverse events in an ED. *Am J Emerg Med*. 2013;31:504–8. <https://doi.org/10.1016/j.ajem.2012.10.002>.
- Weigl M, Müller A, Holland S, Wedel S, Woloshynowych M. Work conditions, mental workload and patient care quality: a multisource study in the emergency department. *BMJ Qual Saf*. 2016;25:499–508. <https://doi.org/10.1136/bmjqs-2014-003744>.
- Jepson ZK, Darling CE, Kotkowski KA, Bird SB, Arce MW, Volturo GA, Reznick MA. Emergency department patient safety incident characterization: an observational analysis of the findings of a standardized peer review process. *BMC Emerg Med*. 2014;14:20. <https://doi.org/10.1186/1471-227X-14-20>.
- Schneider A, Weigl M. Associations between psychosocial work factors and provider mental well-being in emergency departments: a systematic review. *PLoS One*. 2018;13:e0197375. <https://doi.org/10.1371/journal.pone.0197375>.
- Büssing A, Ferrar K-M. Die Messung von Burnout. Untersuchung einer deutschen Fassung des Maslach Burnout Inventory (MBI-D) [Measuring burnout: a study of a German version of the Maslach Burnout Inventory (MBI-D)]. *Diagnostica*. 1992;38:328–53.
- Wei R, Ji H, Li J, Zhang L. Active intervention can decrease burnout in ED nurses. *J Emerg Nurs*. 2017;43:145–9. <https://doi.org/10.1016/j.jen.2016.07.011>.
- Ajeigbe DO, McNeese-Smith D, Leach LS, Phillips LR. Nurse-physician teamwork in the emergency department: impact on perceptions of job environment, autonomy, and control over practice. *J Nurs Adm*. 2013;43:142–8. <https://doi.org/10.1097/NNA.0b013e318283dc23>.
- Adriaenssens J, de Gucht V, Maes S. Causes and consequences of occupational stress in emergency nurses, a longitudinal study. *J Nurs Manag*. 2015;23:346–58. <https://doi.org/10.1111/jonm.12138>.
- Carayon P, Schoofs Hundt A, Karsh BT, Gurses AP, Alvarado CJ, Smith M, Flatley Brennan P. Work system design for patient safety: the SEIPS model. *Qual Saf Health Care*. 2006;15:i50–8. <https://doi.org/10.1136/qshc.2005.015842>.
- Carayon P, Wetterneck TB, Rivera-Rodriguez AJ, Hundt AS, Hoonakker P, Holden R, Gurses AP. Human factors systems approach to healthcare quality and patient safety. *Appl Ergon*. 2014;45:14–25. <https://doi.org/10.1016/j.apergo.2013.04.023>.
- Aust B, Ducki A. Comprehensive health promotion interventions at the workplace: experiences with health circles in Germany. *J Occup Health Psychol*. 2004;9:258–70. <https://doi.org/10.1037/1076-8998.9.3.258>.
- Leis JA, Shojania KG. A primer on PDSA: executing plan–do–study–act cycles in practice, not just in name. *BMJ Qual Saf*. 2017;26:572–7. <https://doi.org/10.1136/bmjqs-2016-006245>.
- Montano D, Hoven H, Siegrist J. Effects of organisational-level interventions at work on employees' health: a systematic review. *BMC Public Health*. 2014;14:135. <https://doi.org/10.1186/1471-2458-14-135>.
- von Thiele Schwarz U, Nielsen KM, Stenfors-Hayes T, Hasson H. Using kaizen to improve employee well-being: results from two organizational intervention studies. *Hum Relat*. 2017;70:966–93. <https://doi.org/10.1177/0018726716677071>.
- Stab N, Hacker W. Participatory redesign of work organisation in hospital nursing: a study of the implementation process. *J Nurs Manag*. 2018;26:382–92. <https://doi.org/10.1111/jonm.12545>.
- Nielsen K, Randall R, Holten A-L, González ER. Conducting organizational-level occupational health interventions: what works? *Work Stress*. 2010;24:234–59. <https://doi.org/10.1080/02678373.2010.515393>.
- Fretheim A, Tomic O. Statistical process control and interrupted time series: a golden opportunity for impact evaluation in quality improvement. *BMJ Qual Saf*. 2015;24:748–52. <https://doi.org/10.1136/bmjqs-2014-003756>.
- Fretheim A, Zhang F, Ross-Degnan D, Oxman AD, Cheyne H, Foy R, Goodacre S, Herrin J, Kerse N, McKinlay RJ, et al. A reanalysis of cluster randomized trials showed interrupted time-series studies were valuable in health system evaluation. *J Clin Epidemiol*. 2015;68:324–33. <https://doi.org/10.1016/j.jclinepi.2014.10.003>.
- Büssing A, Glaser J. Das Tätigkeits- und Arbeitsanalyseverfahren für das Krankenhaus - Selbstbeobachtungsversion (TAA-KH-S) [Work analysis instrument for hospitals - self report version (TAA-KH-S)]. Göttingen: Hogrefe; 2002.
- Weigl M, Schneider A. Associations of work characteristics, employee strain and self-perceived quality of care in emergency departments: a cross-sectional study. *Int Emerg Nurs*. 2017;30:20–4. <https://doi.org/10.1016/j.ienj.2016.07.002>.
- Kroenke K, Spitzer RL, Williams JBW. The patient health Questionnaire-2: validity of a two-item depression screener. *Med Care*. 2003;41:1284–92. <https://doi.org/10.1097/01.MLR.0000093487.78664.3C>.
- Kleijweg JHM, Verbraak MJPM, Van Dijk MK. The clinical utility of the Maslach burnout inventory in a clinical population. *Psychol Assess*. 2013;25:435–41. <https://doi.org/10.1037/a0031334>.
- Waterman AD, Garbutt J, Hazel E, Dunagan WC, Levinson W, Fraser VJ, Gallagher TH. The emotional impact of medical errors on practicing physicians in the United States and Canada. *Jt Comm J Qual Patient Saf*. 2007;33:467–76. [https://doi.org/10.1016/S1553-7250\(07\)33050-X](https://doi.org/10.1016/S1553-7250(07)33050-X).
- Pfeiffer Y, Manser T. Development of the German version of the hospital survey on patient safety culture: dimensionality and psychometric properties. *Saf Sci*. 2010;48:1452–62. <https://doi.org/10.1016/j.ssci.2010.07.002>.
- Weigl M, Müller A, Vincent C, Angerer P, Sevdalis N. The association of workflow interruptions and hospital doctors' workload: a prospective observational study. *BMJ Qual Saf*. 2012;21:399–407. <https://doi.org/10.1136/bmjqs-2011-000188>.
- Füchtbauer LM, Nørgaard B, Mogensen CB. Emergency department physicians spend only 25% of their working time on direct patient care. *Dan Med J*. 2013;60:A4558.
- Marteau TM, Bekker H. The development of a six-item short-form of the state scale of the Spielberger state-trait anxiety inventory (STAI). *Br J Clin Psychol*. 1992;31:301–6. <https://doi.org/10.1111/j.2044-8260.1992.tb00997.x>.
- Büssing A, Glaser J. Employee and client orientation in health care services. *Zeitschrift für Arbeits- und Organisationspsychologie*. 2003;47:222–8. <https://doi.org/10.1026/0932-4089.47.4.222>.
- Weigl M, Hoffmann F, Müller A, Barth N, Angerer P. Hospital paediatricians' workflow interruptions, performance, and care quality: a unit-based controlled intervention. *Eur J Pediatr*. 2014;173:637–45. <https://doi.org/10.1007/s00431-013-2232-z>.
- Weigl M, Hornung S, Angerer P, Siegrist J, Glaser J. The effects of improving hospital physicians working conditions on patient care: a prospective, controlled intervention study. *BMC Health Serv Res*. 2013;13:401. <https://doi.org/10.1186/1472-6963-13-401>.
- Nielsen K, Randall R. Opening the black box: presenting a model for evaluating organizational-level interventions. *Eur J Work Org Psych*. 2013;22:601–17. <https://doi.org/10.1080/1359432X.2012.690556>.
- Aust B, Rugulies R, Finken A, Jensen C. When workplace interventions lead to negative effects: learning from failures. *Scand J Public Health*. 2010;38:106–19. <https://doi.org/10.1177/1403494809354362>.
- Cohen J. *Statistical power analysis for the behavioral sciences*. Hillsdale: Erlbaum; 1988.
- Bernstein SL, Verghese V, Leung W, Lunney AT, Perez I. Development and validation of a new index to measure emergency department crowding. *Acad Emerg Med*. 2003;10:938–42. [https://doi.org/10.1197/S1069-6563\(03\)00311-7](https://doi.org/10.1197/S1069-6563(03)00311-7).
- Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. *J Clin Pharm Ther*. 2002;27:299–309. <https://doi.org/10.1046/j.1365-2710.2002.00430.x>.
- Miles MB, Huberman AM. *Qualitative data analysis: a sourcebook of new methods*. Beverly Hills: Sage Publications; 1984.
- Ramlakhan S, Qayyum H, Burke D, Brown R. The safety of emergency medicine. *Emerg Med J*. 2016;33:293–9. <https://doi.org/10.1136/ememed-2014-204564>.
- Werner NE, Holden RJ. Interruptions in the wild: development of a sociotechnical systems model of interruptions in the emergency department through a systematic review. *Appl Ergon*. 2015;51:244–54. <https://doi.org/10.1016/j.apergo.2015.05.010>.
- Jeanmonod R, Boyd M, Loewenthal M, Triner W. The nature of emergency department interruptions and their impact on patient satisfaction. *Emerg Med J*. 2010;27:376–9. <https://doi.org/10.1136/emj.2008.071134>.

44. Sasangohar F, Donmez B, Trbovich P, Easty AC. Not all interruptions are created equal: positive interruptions in healthcare. *Proc Hum Factors Ergon Soc Annu Meet.* 2012;56:824–8. <https://doi.org/10.1177/1071181312561172>.
45. Ruotsalainen JH, Verbeek JH, Marine A, Serra C. Preventing occupational stress in healthcare workers. *Cochrane Database Syst Rev.* 2015;CD002892. <https://doi.org/10.1002/14651858.CD002892.pub3>.
46. Nielsen K, Miraglia M. What works for whom in which circumstances? On the need to move beyond the 'what works?' Question in organizational intervention research. *Hum Relat.* 2017;70:40–62. <https://doi.org/10.1177/0018726716670226>.
47. Nielsen K, Randall R. The importance of employee participation and perceptions of changes in procedures in a teamworking intervention. *Work Stress.* 2012;26:91–111. <https://doi.org/10.1080/02678373.2012.682721>.
48. Pannick S, Sevdalis N, Athanasiou T. Beyond clinical engagement: a pragmatic model for quality improvement interventions, aligning clinical and managerial priorities. *BMJ Qual Saf.* 2016;25:716–25. <https://doi.org/10.1136/bmjqs-2015-004453>.
49. Kirkegaard ML, Kines P, Nielsen HB, Garde AH. Occupational safety across jobs and shifts in emergency departments in Denmark. *Saf Sci.* 2018;103:70–5. <https://doi.org/10.1016/j.ssci.2017.11.014>.
50. Dormann C, Griffin MA. Optimal time lags in panel studies. *Psychol Methods.* 2015;20:489–505. <https://doi.org/10.1037/met0000041>.
51. Ford MT, Matthews RA, Wooldridge JD, Mishra V, Kakar UM, Strahan SR. How do occupational stressor-strain effects vary with time? A review and meta-analysis of the relevance of time lags in longitudinal studies. *Work Stress.* 2014;28:9–30. <https://doi.org/10.1080/02678373.2013.877096>.
52. Holden RJ, Carayon P, Gurses AP, Hoonakker P, Hundt AS, Ozok AA, Rivera-Rodriguez AJ. SEIPS 2.0: a human factors framework for studying and improving the work of healthcare professionals and patients. *Ergonomics.* 2013;56:1669–86. <https://doi.org/10.1080/00140139.2013.838643>.
53. Wears RL. Improvement and evaluation. *BMJ Qual Saf.* 2015;24:92–4. <https://doi.org/10.1136/bmjqs-2014-003889>.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions



4. Publication 3: Provider interruptions and quality of care in emergency departments

Schneider, A., Wehler, M., & Weigl, M. (2019). Provider interruptions and patient perceptions of care: an observational study in the emergency department. *BMJ Quality & Safety*, 28, 296-304.

Provider interruptions and patient perceptions of care: an observational study in the emergency department

Anna Schneider,¹ Markus Wehler,² Matthias Weigl¹

► Additional material is published online only. To view please visit the journal online (<http://dx.doi.org/10.1136/bmjqs-2018-007811>).

¹Institute and Outpatient Clinic for Occupational, Social and Environmental Medicine, University Hospital, LMU Munich, Munich

²Department of Emergency Medicine and Department of Medicine IV, Klinikum Augsburg, Augsburg, Germany

Correspondence to

Anna Schneider, Institute and Outpatient Clinic for Occupational, Social and Environmental Medicine, University Hospital, LMU Munich, Munich 80336, Germany; anna.schneider@med.lmu.de

Received 9 January 2018
Revised 15 August 2018
Accepted 7 September 2018



© Author(s) (or their employer(s)) 2018. No commercial re-use. See rights and permissions. Published by BMJ.

To cite: Schneider A, Wehler M, Weigl M. *BMJ Qual Saf* Epub ahead of print: [please include Day Month Year]. doi:10.1136/bmjqs-2018-007811

ABSTRACT

Background Interruptions are endemic in healthcare work environments. Yet, they can have positive effects in some instances and negative in others, with their net effect on quality of care still poorly understood. We aimed to distinguish beneficial and detrimental forms of interruptions of emergency department (ED) providers using patients' perceptions of ED care as a quality measure.

Methods An observational design was established. The study setting was an interdisciplinary ED of an academic tertiary referral hospital. Frequencies of interruption sources and contents were identified in systematic expert observations of ED physicians and nurses. Concurrently, patients rated overall quality of care, ED organisation, patient information and waiting times using a standardised survey. Associations were assessed with hierarchical linear models controlling for daily ED workload. Regression results were adjusted for multiple testing. Additionally, analyses were computed for ED physicians and nurses, separately.

Results On 40 days, 160 expert observation sessions were conducted. 1418 patients were surveyed. Frequent interruptions initiated by patients were associated with higher overall quality of care and ED organisation. Interruptions relating to coordination activities were associated with improved ratings of ED waiting times. However, interruptions containing information on previous cases were associated with inferior ratings of ED organisation. Specifically for nurses, overall interruptions were associated with superior patient reports of waiting time.

Conclusions Provider interruptions were differentially associated with patient perceptions of care. Whereas coordination-related and patient-initiated interruptions were beneficial to patient-perceived efficiency of ED operations, interruptions due to case-irrelevant communication were related to inferior patient ratings of ED organisation. The design of resilient healthcare systems requires a thorough consideration of beneficial and harmful effects of interruptions on providers' workflows and patient safety.

INTRODUCTION

Workflow interruptions are endemic in clinical environments.¹ Yet, 'interrupt-driven'² emergency departments

(EDs) are particularly affected settings to study the manifold effects of disrupted workflows on provider and care outcomes.^{3–7} EDs are complex socio-technical systems that are repeatedly identified as error-prone environments.⁵ Suboptimal ED patient care is attributed to adverse work system factors.^{8,9} Among these, provider interruptions receive broad attention due to their role in patient safety and quality of care.^{10–12} Emergency physicians and nurses attend to multiple patients in an uncertain and time-critical care setting with high coordination demands.⁴ Past studies identified interruption frequencies in ED providers ranging between 5.1 and 24.9 interruptions per hour.^{2,7,12–16}

Previous empirical evidence on effects of workflow interruptions is inconclusive and suggests ambivalent effects since interruptions are associated with both negative and positive outcomes.^{3,10,14} Adverse effects were postulated on the individual provider level, where experimental evidence showed negative associations with providers' task completion time and rates, decision-making processes, length of care interventions and errors.^{7,15,17} Nonetheless, interruptions may feature an intrinsic value and contribute to effective patient care and improved intra-team coordination.^{1,18,19} Potentially positive effects of interruptions such as time-sensitive communication of high-priority information were suggested.^{3,9,18} Workflow interruptions foster immediate provider responses, timely information exchange, and may preserve fast and safe delivery of care.^{9,14–16,19} In order to develop resilient care systems and to implement work redesign interventions that preserve patient care in dynamic and interruptive clinical environments, we

need to understand how interruptions are detrimental or beneficial to quality of care.³ We additionally need a thorough consideration of how contents of interruptive communication shape negative or positive effects for care.¹⁰

Real-time patient surveys offer valuable insights into the personal experience of patients and complement routine indicators of clinical, safety-related and disease-specific outcomes.^{20 21} The Institute of Medicine's influential report suggests that 'the best window on the safety and quality of care is through the eyes of the patient'.²² Patient-centredness is thus one of the six cornerstones of healthcare quality. Integrating patients' preferences, needs and values in care design and delivery is fundamental to preserve high quality. In order to achieve this aim, patient perspectives have to be systematically assessed.²² Patient ratings are a meaningful and feasible alternative to capture extracts of care quality.^{23 24}

Patient experiences are multidimensional and emerge from provider–patient communication, provider skills and interaction, as well as the physical environment.²¹ Provider interruptions could thus interfere with the patient experience on different levels during ED care and ultimately affect satisfaction, care experience and treatment adherence.^{21 23} Using patient experience as a proxy for ED care quality, we aimed to explore associations between provider interruptions, differentiated into sources and content, and patient-perceived care outcomes. We further sought to examine role-related differences in these associations for ED physicians and nurses, respectively.

METHODS

Study design and setting

An observational design was established applying day-level matched data of expert observation sessions of ED providers, patient evaluations of care and ED register data. The study setting is a 24-hour adult ED of an academic tertiary referral hospital with an annual volume of over 80 000 patients. The ED is organised into three sections according to patient's chief complaints: 10 bays for non-surgical patients, five bays for surgical patients, two resuscitation bays, and an observation and clinical decision unit with 24 beds. It is regularly staffed with physicians from internal medicine, trauma surgery and neurology, as well as further specialists on call. Data stem from a larger intervention project on ED work factors, provider well-being and quality of care.

Procedure and selection of ED providers and patients

Data collection was completed in February 2017. Before start, a stratified sampling procedure was established that ensured random and equal allocation of observation sessions across ED sections, professions and days of the week (including Saturdays and Sundays). On-site data collection by a three-member study team

took place from 10:00 to 17:00 to comprise the time of day with the highest patient arrival rates and thus highest workload for ED providers.²⁵ Patient:staff ratios in EDs differ between day, evening and night shifts. Research on the variance of interruption rates during different times of the day is scarce with preliminary findings pointing to non-significant differences across weekdays or time of the day.³ To control for the potential effect of varying patient:staff ratios across observations, an established ED workload measure was included in our analyses (see below).

Observation sessions of 90 min were randomly allocated per day across three ED sections, that is, non-surgical area, surgical area, and observation and clinical decision unit, and ED professions, that is, nurses and physicians. A higher number of nurses than physicians were sampled to reflect the distribution of the study ED's workforce. All senior and junior physicians and nurses working regularly in the ED were eligible. Consultants from other hospital units working occasionally in the ED were not included. On observation days, ED providers from the respective ED section and profession were approached, informed about the study and asked for verbal consent before start. No personal characteristics were obtained from observed ED providers.

For patient surveys, all registered patients undergoing treatment in the ED on days of on-site data collection were eligible. Inclusion criteria were not restricted to literacy, language, age or illness. However, patients with incapability to communicate due to illness severity or other physical and mental constraints were not surveyed. In these cases, accompanying relatives were asked to fill out the survey by proxy. Due to confidentiality constraints, no personal characteristics were obtained from patients.

Identification of workflow interruptions

On each observation day, four observation sessions with ED providers were conducted. Trained observers applied a standardised tool that reliably captures ED workflow interruptions.^{9 26} A workflow interruption was defined as an event that resulted in provider distraction from the task at hand thus causing discontinuation of the primary task, reallocation of attention, or task switching to the interrupting event or secondary task.^{9 26} Interruption sources were classified by observers according to predefined categories²⁷ into interruptions by (1) patients; (2) ED colleagues of the same profession, for example, nurse is interrupted by another nurse; (3) ED colleagues of another profession, for example, nurse is interrupted by a physician; (4) telephone/beeper; (5) patient's relatives; (6) technical malfunctions or missing supplies; and (7) information impediments or problems, for example, necessary information for task completion is missing such as unavailable patient charts. Concurrently, each interruption event was evaluated regarding its content,

that is, information referring to (1) current patient case at hand, (2) parallel case, (3) completed cases, (4) new and time-critical case, (5) coordination activities and (6) patient comfort. A detailed description of the observational tool with definitions and specific examples for each interruption category can be found elsewhere.²⁷ Each observed interruption was classified within one source and content category, respectively. Accordingly, multiple classifications of one specific interruption event within different categories of interruption sources and contents were not allowed. All observers had an educational background in health-care, experience in the clinical setting and familiarity with the ED context.

To establish inter-rater agreement, a stepwise procedure was applied.²⁸ First, observers underwent six non-systematic, pilot observation sessions on site to become familiar with the facility and observation tool and to discuss its application with a senior expert observer. Second, pairwise observations of ED providers were conducted to test for reliability in terms of interobserver agreement as well as to ensure calibration across all three observers. Overall, 20 pairwise observations were conducted (sum: 24 hours 41 min, 278 captured interruptions). The resulting kappa coefficient for sources of interruptions was 0.65 as well as 0.53 for interruption content. Both metrics indicate substantial inter-rater agreement and good reliability, given high-paced and complex ED workflows.²⁶

Patient perceptions of ED care

Patients were approached by study team members after their first consultation with an ED physician. After receiving study information and providing verbal consent, patients were asked to fill in the survey. On request, assistance was offered by study team members. A standardised survey instrument was applied, which reliably captures patient-perceived ED care (Munich Patient Inventory, see online appendix for survey items).⁹ Additional versions in English, Russian and Turkish language were available. Four major aspects of patient-perceived care were assessed: (1) *patient information* (two items, Cronbach's $\alpha=0.77$), (2) *ED organisation* (two items, $\alpha=0.49$) and (3) *waiting time* (three items, $\alpha=0.71$). Patients responded in a five-point format indicating better care with higher scores. Additionally, one question with a six-point response format asked patients for their (4) *general satisfaction with ED care* using school grades from 1=excellent to 6=unsatisfactory ("Overall, how do you evaluate care in this ED?").

Confirmatory factor analyses were conducted to scrutinise psychometric properties of the patient survey.²⁹ Fit indices were compared for two models to identify the factor structure best fitting the data, that is, χ^2 , root mean square error of approximation (RMSEA), comparative fit index (CFI) and Tucker-Lewis index (TLI). A one-factor model representing

one general patient satisfaction factor including all seven items ($\chi^2(df)=304.35(14)$, $p<0.001$, RMSEA=0.12, CFI=0.89, TLI=0.78) was tested against the assumed three-factor model including distinct scales for patient information, ED organisation and waiting time ($\chi^2(df)=107.58(11)$, $p<0.001$, RMSEA=0.08, CFI=0.96, TLI=0.91). Fit indices showed superior fit of the proposed three-factor structure ($\Delta\chi^2(df)=196.77(3)$, $p<0.001$). Hence, analyses confirmed factorial validity and psychometric feasibility of our patient survey tool.²⁹

Register data on daily ED workload

Crowding may confound patient evaluations of ED care.³⁰ To control for potential influences of providers' patient load, patients' acuity (Emergency Severity Index: ESI Score) and available staffing, relevant numbers were extracted from ED administrative records and staff rosters. Thereof, an adjusted measure of the Emergency Department Work Index was compiled to represent mean overall and profession-specific workload for each observation day.⁹

Data analyses

Hourly rates for overall and for all individual interruption sources and contents were calculated for each observation session and then averaged across four sessions to obtain mean rates for each of the 40 observation days. Differences in interruption rates between ED physicians and nurses were conducted as supplementary analyses. Unpaired t-tests were applied without prior hypotheses on direction or size of differences between professions and adjustment for multiple testing was performed (Holm-Bonferroni sequential correction procedure).³¹

The final multilevel dataset nested individual patient evaluations within the respective 40 observation days. Two-level mixed-effects linear regression models were used.³² Associations between observed interruption rates and patient-perceived care were modelled, accounting for clustering of patient evaluations within a day.³² First, associations between overall interruption rates and four care outcomes were analysed. Subsequently, associations between interruption rates from different sources and contents and care outcomes were calculated. Again, results were adjusted for multiple testing.³¹ Unadjusted (crude) and adjusted (for daily workload) regression estimates are reported with 95% CIs. Finally, the same procedure was repeated separately in physician and nurse samples. All statistical analyses were conducted with SPSS V.24.0 (IBM).

RESULTS

A total of 160 observation sessions were conducted: 99 with nurses (61.9%) and 61 with physicians (38.1%). All approached ED providers consented to be observed, except two nurses and one physician. Reasons for non-participation were not surveyed.

Table 1 Rates of emergency department (ED) providers' interruption sources and content

	Mean rate (SD)
Overall interruptions	8.70 (4.92)
Interruption sources (interruptions caused...)	
by patients	0.92 (1.19)
by ED colleagues of the same profession	2.55 (2.39)
by ED colleagues of another profession	2.47 (2.13)
by telephone/beeper	1.79 (1.52)
by patient's relatives	0.24 (0.49)
by technical malfunctions or missing supplies	0.42 (0.63)
by information impediments or problems	0.31 (0.60)
Interruption contents (interruption event related...)	
to current case	1.82 (2.08)
to parallel case	2.86 (2.79)
to completed cases	0.79 (1.01)
to new (time-critical) cases	0.16 (0.45)
to coordination activities	1.92 (1.98)
to patient comfort	0.27 (0.56)
Mean rate: interruptions per hour; n=160 observation sessions.	

Overall observation time was 240 hours and 42 min (mean duration of observation sessions: 1 hour 30 min 15 s). Fifty-five observations (34.4%) were conducted in the non-surgical section, 52 (32.5%) in the surgical section and 53 (33.1%) in the observation unit.

Interruption rates

Mean hourly interruption rates per day are presented in [table 1](#). ED providers were most frequently interrupted by colleagues from the same (mean, M=2.55 interruptions per hour; SD 2.39) or another profession (M=2.47; SD 2.13) or by telephone/beeper (M=1.79; SD 1.52). Contents of interruptions referred most frequently to information on parallel cases (M=2.86; SD 2.79), to coordination activities (M=1.92; SD 1.98) and to current cases (M=1.82; SD 2.08).

We additionally compared interruption rates between ED professions (cf., table E-1 in online supplementary material 1). After adjusting for multiple testing, only one difference remained significant: nurses were more often interrupted due to patient comfort issues than physicians.

Patient survey data and ED workload

Register data specified 4454 patients admitted to the ED during observation hours on days of on-site data collection. A total of 1602 patients (36.0%) were approached by the study team. Moreover, 184 patients denied study participation, resulting in a final sample of N=1418 (survey response rate: 88.5%) with a range of 16 to 51 surveyed patients per day. Reasons for non-participation were not surveyed. Mean daily workload, staffing levels and patient numbers in ESI categories are depicted in [table 2](#). Patients reported

Table 2 Daily emergency department (ED) workload data and patient perceptions of ED care

	Range	Mean (SD)
Control variables		
Overall patient no/day	89–171	120.23 (17.37)
ESI1 patients	0–4	0.90 (0.96)
ESI2 patients	2–36	15.95 (9.38)
ESI3 patients	37–100	66.27 (17.87)
ESI4 patients	2–43	17.87 (13.00)
ESI5 patients	0–14	3.70 (4.05)
Provider staffing levels/day	20.36–35.24	27.52 (3.20)
Daily ED workload*	8.09–15.41	11.21 (1.58)
Outcome: patients' perceptions of ED care		
Overall quality of care	1–6	4.69 (1.08)
ED organisation	1–5	3.36 (1.14)
Patient information	1–5	4.05 (1.06)
Waiting time	1–5	3.63 (1.13)
Scale range for overall quality of care (school grade, inversely coded): 1=very bad to 6=very good; scale range for other patient survey scales: 1=no, not at all to 5=yes, very much.		
*Adjusted Emergency Department Work Index.		
ESI, Emergency Severity Index.		

high overall satisfaction with ED care (M=4.69; SD 1.08). Patient evaluations of ED organisation (M=3.36; SD 1.14), patient information (M=4.05; SD 1.06) and waiting time (M=3.63; SD 1.13) were average. Percentage of missing data for care outcomes ranged between 0.56% for ED organisation and 6.49% for overall quality of ED care.

Associations between provider interruptions and patient ratings

Using hierarchical linear regression analyses, association estimates between ED provider interruptions and patient ratings were calculated (see [table 3](#)). The accumulated hourly rate of overall interruptions was positively associated with two patient outcomes: higher rates of workflow interruptions were related to superior patient perceptions of overall quality of ED care (adjusted estimate 0.03; 95% CI 0.01 to 0.06) and ED waiting time (0.04; 95% CI 0.01 to 0.07).

In the next step, we identified four statistically significant associations between individual interruption sources and contents with patient perceptions: patient interruptions were related to higher ratings of overall ED care (0.13; 0.05 to 0.22) and ED organisation (0.19; 0.07 to 0.30). Interruptions concerning information on completed cases were associated with inferior patient ratings of ED organisation (−0.28; −0.44 to −0.12). However, interruptions related to coordination activities were associated with more favourable patient evaluations of waiting time (0.10; 0.03 to 0.17).

Table 3 Fixed regression estimates of associations between emergency department (ED) workflow interruptions and patient perceptions of ED care

Predictors	Outcomes: patient perceptions of ED care							
	Overall quality of care		ED organisation		Patient information		Waiting time	
	Crude (95% CI)	Adjusted (95% CI)	Crude (95% CI)	Adjusted (95% CI)	Crude (95% CI)	Adjusted (95% CI)	Crude (95% CI)	Adjusted (95% CI)
Overall interruption rates	0.03* (0.01 to 0.06)	0.03* (0.003 to 0.05)	0.03* (0.0002 to 0.07)	0.03 (-0.001 to 0.07)	0.02 (-0.002 to 0.04)	0.02 (-0.004 to 0.04)	0.04** (0.01 to 0.07)	0.04** (0.01 to 0.07)
Interruption sources (interruptions caused...)								
By patients	0.14** (0.05 to 0.23)	0.13** (0.05 to 0.22)	0.19** (0.07 to 0.30)	0.19** (0.07 to 0.30)	0.08* (0.0001 to 0.17)	0.08 (-0.002 to 0.16)	0.15* (0.03 to 0.26)	0.14* (0.03 to 0.25)
By ED colleagues of same profession	0.04 (-0.01 to 0.10)	0.04 (-0.02 to 0.09)	0.06 (-0.01 to 0.12)	0.05 (-0.01 to 0.12)	0.03 (-0.01 to 0.08)	0.03 (-0.02 to 0.08)	0.08* (0.01 to 0.14)	0.07* (0.01 to 0.13)
By ED colleagues of another profession	0.03 (-0.04 to 0.10)	0.03 (-0.04 to 0.10)	0.08 (-0.01 to 0.17)	0.08 (-0.005 to 0.17)	0.06 (-0.005 to 0.12)	0.06 (-0.004 to 0.12)	0.08 (-0.001 to 0.17)	0.08* (0.002 to 0.16)
By telephone/beeper	0.07 (-0.02 to 0.16)	0.06 (-0.02 to 0.15)	0.04 (-0.07 to 0.15)	0.04 (-0.08 to 0.15)	0.05 (-0.03 to 0.12)	0.04 (-0.03 to 0.12)	0.09 (-0.02 to 0.19)	0.08 (-0.02 to 0.18)
By patient's relatives	-0.07 (-0.33 to 0.18)	-0.01 (-0.26 to 0.24)	-0.28 (-0.59 to 0.03)	-0.27 (-0.59 to 0.05)	-0.26* (-0.47 to -0.04)	-0.24* (-0.45 to -0.02)	-0.20 (-0.50 to 0.10)	-0.15 (-0.45 to 0.15)
By technical malfunctions or missing supplies	0.12 (-0.12 to 0.36)	0.09 (-0.14 to 0.32)	-0.07 (-0.38 to 0.23)	-0.09 (-0.39 to 0.21)	0.03 (-0.18 to 0.25)	0.02 (-0.19 to 0.23)	-0.05 (-0.34 to 0.24)	-0.08 (-0.36 to 0.20)
By information impediments or problems	-0.05 (-0.23 to 0.14)	-0.10 (-0.28 to 0.07)	-0.24* (-0.46 to -0.02)	-0.28* (-0.49 to -0.06)	-0.14 (-0.30 to 0.01)	-0.18* (-0.33 to -0.02)	-0.11 (-0.32 to 0.11)	-0.16 (-0.37 to 0.05)
Interruption contents (interruption event related...)								
To current case	0.05 (-0.01 to 0.10)	0.04 (-0.01 to 0.09)	0.08* (0.02 to 0.15)	0.08* (0.01 to 0.15)	0.04 (-0.01 to 0.09)	0.04 (-0.01 to 0.08)	0.06* (0.0004 to 0.13)	0.06 (-0.003 to 0.12)
To parallel case	0.05* (0.01 to 0.10)	0.04 (-0.003 to 0.09)	0.07* (0.01 to 0.13)	0.06* (0.004 to 0.12)	0.04 (0.002 to 0.08)	0.04 (-0.003 to 0.08)	0.08** (0.02 to 0.13)	0.07* (0.01 to 0.12)
To completed cases	-0.12 (-0.24 to 0.01)	-0.07 (-0.21 to 0.07)	-0.26** (-0.40 to -0.11)	-0.28** (-0.44 to -0.12)	-0.12* (-0.23 to -0.02)	-0.12 (-0.24 to 0.005)	-0.17* (-0.31 to -0.02)	-0.14 (-0.30 to 0.03)
To new (time-critical) cases	0.03 (-0.34 to 0.41)	0.10 (-0.26 to 0.45)	-0.17 (-0.63 to 0.30)	-0.14 (-0.61 to 0.32)	-0.16 (-0.48 to 0.15)	-0.13 (-0.45 to 0.18)	-0.07 (-0.51 to 0.38)	-0.02 (-0.45 to 0.41)
To coordination activities	0.07* (0.01 to 0.13)	0.06 (-0.002 to 0.10)	0.08* (0.001 to 0.16)	0.08 (-0.003 to 0.15)	0.06* (0.01 to 0.11)	0.06* (0.002 to 0.11)	0.11** (0.04 to 0.18)	0.10* (0.03 to 0.17)
To patient comfort	0.12 (-0.15 to 0.38)	0.12 (-0.13 to 0.37)	-0.01 (-0.34 to 0.33)	-0.01 (-0.34 to 0.33)	-0.07 (-0.30 to 0.16)	-0.07 (-0.30 to 0.15)	-0.05 (-0.37 to 0.27)	-0.05 (-0.35 to 0.25)

Estimates were adjusted for mean daily workload (mean staffing levels and patient acuity); * p<0.05, ** p<0.01; bold: statistically significant unadjusted and adjusted estimates of sources and contents (Holm-Bonferroni correction).

p, probability level.

Role-specific associations between provider interruptions and patient ratings

In the last step, the above described hierarchical linear regression analyses were repeated separately for ED physicians and nurses (see tables E-2 and E-3 in online supplementary material 1). For nurses, after adjusting for nurse-specific daily workload, out of three initially significant associations, only patients' evaluations of waiting times were significantly associated with overall interruptions (0.03; 0.003 to 0.05). Concerning source-specific and content-specific interruption rates and after controlling for multiple testing, interruptions dealing with information on current cases were related to inferior patient perceptions of ED organisation (0.13; 0.05 to 0.21) while frequent interruptions on parallel cases increased ratings of waiting time (0.07; 0.02 to 0.11). After adjusting for nurse-specific daily workload, only interruptions concerning coordination activities were observed being related to superior patient ratings of waiting time (0.07; 0.02 to 0.12). In physicians, neither overall interruption rates nor individual types of interruptions were significantly associated with any of the four patient-perceived care outcomes (online supplementary material 1).

DISCUSSION

This study offers a novel approach to distinguish negative and positive forms of provider interruptions by exploring their associations with patient perceptions of care. Positive associations between overall as well as source-specific and content-specific rates of ED provider interruptions and patient perceptions of overall quality of care, ED organisation and waiting times were identified. The following contributions deserve careful consideration:

Generally, previous research predominantly focused on adverse outcomes of interruptions such as provider distraction, disruption of memory processes, increased risks of unfinished tasks and lapses in patient care.^{1 3 10 33} Broad evidence shows that highly interruptive clinical work environments contribute to providers' mental workload, suboptimal clinical performance and mitigate safety practices in health-care delivery.^{1 15 34} Our findings further advocate the need for a nuanced understanding of potentially desirable as well as harmful effects of workflow interruptions in highly dynamic work and collaborative care systems, that is, by taking into account sources and content of interruptive events.^{3 10 35} Although previous research suggests that any interruption of ED physicians' bedside interactions curbs patient satisfaction,³⁶ our results suggest that effects depend on sources and content of disruptive communication.

Our findings suggest further exploration of role-related differences in provider interruptions of ED nurses and physicians. Across all forms of interruptions, we merely identified one difference: nurses were more often interrupted due to patient comfort issues

than physicians. Additional analyses showed that rates of coordination-related interruptions in nurses were substantially associated with patient perceptions of waiting times. These observations underscore the pivotal role of nurses in coordinating ED patient flow and intraprofessional and interprofessional collaboration in the ED.³⁷

Provider interruptions due to coordination were associated with improved patient ratings of ED waiting times. Frequent communication events are essential in maintaining ED coordination and patient flow considering inevitable intersections in ED care processes, for example, among professions and functional areas.¹⁸ Accordingly, the highest amount of observed interruptions originated from present ED personnel. Interruptions due to coordination activities mostly encompassed professional communication concerning teamwork (eg, allocation of patients), patient flow (eg, assignment of patients to bays or further treatment) or other forms of work organisation (eg, information on absence due to work-related activities outside the ED or personal breaks). Interruptions related to intraprofessional and interprofessional coordination may thus be considered as 'value-adding' interruptions,¹ and contribute to facilitating ED patient flow and shortening waiting times, for example, when ED providers immediately allocate patients to free bays or collectively assign responsibilities for arriving patients.^{5 38} Previous research suggested associations between time to first physician contact, general ED length of stay and increased patient satisfaction.²⁰ Although we do not advocate for increasing coordination-related interruptions, our finding points to the necessity of allowing these interactions in ED work since the resulting activities and mutual information exchange between providers might foster ED patient flow. Interventions addressing proactive forms of coordination activities within provider teams, for example, unit huddles³⁹ or white boards with patient status information,⁴⁰ should further examine whether these innovations lead to fewer coordination-related interruptions and if these approaches fit with ED unit culture, that is, if they are accepted and employed by ED providers.

Second, interruptions concerning information on previous cases were associated with inferior patient perceptions of ED organisation. Post hoc, one potential explanation is that frequent interruptions related to previous cases signify providers' difficulties in the management of multiple patients and effective distribution of case information. Another assumption is that ED provider's mental load is stretched by additional or irrelevant information on previous cases which eventually impairs professionals' cognitive capacity to deal effectively with organisation demands and to communicate and coordinate effectively.^{9 38} Finally, these irrelevant distractions may cause information overload and drag on the delivery of patient care through inefficient care practice.

Third, frequent interruptions by patients were positively associated with patient experience of overall care and ED organisation. Patient-initiated interruptions were largely neglected in interruptions research so far.⁴¹ Thus, it remains unclear whether patients interrupt proactively to share important information with healthcare providers, for example, concerning their medical history, or whether they interrupt as a reaction to insufficient information received, for example, concerning missing discharge information. In our study, patient-initiated interruptions mostly occurred during direct interactions with providers, for example, in treatment areas. Patient interruptions referred to questions concerning treatment (eg, administration of prescribed medication at home) or organisation of their stay (eg, waiting times until admission to inpatient unit). Patient-initiated interruptions may thus increase patients' knowledge about their treatment status and pathway through the ED. However, patient-initiated interruptions may equally contribute to adverse organisational and provider outcomes such as delays in care, medication errors and mitigated provider well-being as shown in previous studies.^{3 42} Thus, instead of exposing ED providers to more frequent patient interruptions, for example, by increasing visibility of providers through physical layout,⁴³ future research should investigate information systems that assure comprehensive and individual patient information with fewer needs to disrupt providers.

Study limitations

Beyond general limitations of observational studies, several unique limitations of this study have to be considered. First, our findings draw on one interdisciplinary ED in Germany which limits generalisability. Our observations need to be replicated within other national healthcare systems, taking into account different characteristics of prehospital and intrahospital emergency care. Limited sample sizes confine statistical power, thus, observed findings should be interpreted with caution with regard to profession-specific analyses as well as non-significant results. Second, patient perceptions are a central pillar of healthcare quality.^{21 23 24} Nonetheless, future studies concerning the role of interruptions should complement patient reports with clinical and safety outcomes of ED care.⁴⁴ One scale of our patient survey instrument showed medium reliability. Nonetheless, confirmatory factor analyses confirmed the proposed factor structure. Future studies in this field should apply tools that are psychometrically robust.⁴⁵ Further, real-time patient surveys in the ED may be biased because of patients' concerns about anonymity, potential consequences for subsequent care or current incapability to respond adequately.³⁰ Third, we matched interruption rates and patient survey results within observation days. Since our patient surveys were not registered with time stamps, an hourly assignment of patient surveys

to the respective observed provider was not applicable, that is, to identify associations between interruption frequency and patient evaluations during particular provider–patient interactions.³⁶ Fourth, although we controlled analyses for ED workload, we acknowledge that our daily approximation may not entirely reflect actual workload during all individual 90 min observation sessions. However, our approach to adjust for ED workload is novel within this literature.³⁰ Future studies should further elucidate the role of patient load or crowding as a potentially mediating or moderating factor in the relationship between provider interruptions and patient perceptions of ED care. Fifth, although research suggests that interruption rates do not differ between times of day or across weekdays per SE,³ our results encompass ED peak patient arrival times during the day, excluding conclusions about interruption effects on patient perceptions during night shifts. Sixth, another potential confounder might be provider characteristics, for example, perceived responsiveness to patient requests or provider well-being. However, interpersonal behaviours and clinicians' personality are of limited influence on patient perceptions of care,⁴⁶ whereas occupational well-being of healthcare providers has a more profound effect on patient satisfaction.⁴⁷

Lastly, consistent to similar approaches, we attributed interruptions to specific sources.^{10 35} However, we cannot exclude that some interruptions were mediated through ED personnel, for example, a patient interrupts a nurse for pain medication who subsequently interrupts the observed physician.¹⁶ Our approach to classify events solely into one category does not take full account of potential multiple meanings and inherent implications of interruptive communication, for example, a nurse alert concerning the arrival of a time-critical patient does often imply subsequent coordination demands.³ Our interruption measure did not account for the assessment of serial or nested interruptions,⁴⁸ task complexities, behavioural strategies to deal with disruptions⁶ or interruption priorities. Altogether, this limits causal inferences concerning potential harm of disruptive events during ED care.^{10 12 14}

Implications for future research and ED practice

Concerning implications for practice, our findings suggest that ED practitioners should carefully identify unnecessary and potentially harmful provider interruptions, and aim to scrutinise potentially interconnected factors of the work environment before introducing interventions to manage interruptions in the ED.³ Instead of avoiding interruptions universally, the resilience of work systems to adverse effects from interruptions should be strengthened by allowing purposeful interruptions that promote professional collaboration, patient satisfaction and safe care.^{10 35} Our findings advocate for further investigations on the profession-specific effects of interruptions, including

sources, contents and type of interrupted activity, with particular attention to role-related sequelae of provider functioning, patient safety, and efficiency of ED care.¹⁰ However, although positive effects of interruptions are postulated, research in this domain should be conducted in light of striving for well-balanced work and care systems that promote safe patient care and well-designed work environments for providers.

CONCLUSIONS

EDs are complex and high-paced care environments with significant demands for providers and patients. Our findings provide first empirical support for the assumption that coordination-related or patient-initiated interruptions may be associated with benefits for ED care from the patient's perspective. Notwithstanding, to maintain high levels of patient safety and provider well-being, the establishment of resilient and well-balanced ED work systems must be prioritised.

Funding This study was supported by the Munich Centre for Health Sciences(MC-Health).

Competing interests None declared.

Patient consent Not required.

Ethics approval Ethics Committee of the Medical Faculty, Munich University (NR 327-15).

Provenance and peer review Not commissioned; internally peer reviewed.

REFERENCES

- Rivera-Rodriguez AJ, Karsh BT. Interruptions and distractions in healthcare: review and reappraisal. *Qual Saf Health Care* 2010;19:304–12.
- Chisholm CD, Collison EK, Nelson DR, *et al.* Emergency department workplace interruptions: are emergency physicians "interrupt-driven" and "multitasking"? *Acad Emerg Med* 2000;7:1239–43.
- Werner NE, Holden RJ. Interruptions in the wild: development of a sociotechnical systems model of interruptions in the emergency department through a systematic review. *Appl Ergon* 2015;51:244–54.
- Wears RL, Perry SJ. Human factors and ergonomics in the emergency department. *Ann Emerg Med* 2002;40:206–12.
- 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.
- Ratwani RM, Fong A, Puthumana JS, *et al.* Emergency physician use of cognitive strategies to manage interruptions. *Ann Emerg Med* 2017;70:683–7.
- 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.
- Nielsen KJ, Pedersen AH, Rasmussen K, *et al.* Work-related stressors and occurrence of adverse events in an ED. *Am J Emerg Med* 2013;31:504–8.
- Weigl M, Müller A, Holland S, *et al.* Work conditions, mental workload and patient care quality: a multisource study in the emergency department. *BMJ Qual Saf* 2016;25:499–508.
- McCurdie T, Sanderson P, Aitken LM. Traditions of research into interruptions in healthcare: a conceptual review. *Int J Nurs Stud* 2017;66:23–36.
- Grundgeiger T, Sanderson P. Interruptions in healthcare: theoretical views. *Int J Med Inform* 2009;78:293–307.
- Blocker RC, Heaton HA, Forsyth KL, *et al.* Physician, interrupted: workflow interruptions and patient care in the emergency department. *J Emerg Med* 2017;53:798–804.
- 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.
- Berg LM, Källberg AS, Göransson KE, *et al.* Interruptions in emergency department work: an observational and interview study. *BMJ Qual Saf* 2013;22:656–63.
- Westbrook JI, Coiera E, Dunsmuir WT, *et al.* The impact of interruptions on clinical task completion. *Qual Saf Health Care* 2010;19:284–9.
- Myers RA, McCarthy MC, Whitlatch A, *et al.* Differentiating between detrimental and beneficial interruptions: a mixed-methods study. *BMJ Qual Saf* 2016;25:881–8.
- Cole G, Stefanus D, Gardner H, *et al.* The impact of interruptions on the duration of nursing interventions: a direct observation study in an academic emergency department. *BMJ Qual Saf* 2016;25:457–65.
- Nugus P, Holdgate A, Fry M, *et al.* Work pressure and patient flow management in the emergency department: findings from an ethnographic study. *Acad Emerg Med* 2011;18:1045–52.
- Grundgeiger T, Dekker S, Sanderson P, *et al.* Obstacles to research on the effects of interruptions in healthcare. *BMJ Qual Saf* 2016;25:392–5.
- Burgemeister S, Kutz A, Conca A, *et al.* Comparative quality measures of emergency care: an outcome cockpit proposal to survey clinical processes in real life. *Open Access Emerg Med* 2017;9:97–106.
- Mohammed K, Nolan MB, Rajjo T, *et al.* Creating a patient-centered health care delivery system: a systematic review of health care quality from the patient perspective. *Am J Med Qual* 2016;31:12–21.
- Institute of Medicine. *Committee on quality of health care in America. Crossing the quality chasm: a new health system for the 21st century.* Washington, DC: National Academies Press, 2001.
- Anhang Price R, Elliott MN, Zaslavsky AM, *et al.* Examining the role of patient experience surveys in measuring health care quality. *Med Care Res Rev* 2014;71:522–54.
- Doyle C, Lennox L, Bell D. A systematic review of evidence on the links between patient experience and clinical safety and effectiveness. *BMJ Open* 2013;3:e001570.
- Schmiedhofer M, Möckel M, Slagman A, *et al.* Patient motives behind low-acuity visits to the emergency department in Germany: a qualitative study comparing urban and rural sites. *BMJ Open* 2016;6:e013323.
- Weigl M, Müller A, Vincent C, *et al.* The association of workflow interruptions and hospital doctors' workload: a prospective observational study. *BMJ Qual Saf* 2012;21:399–407.
- Weigl M, Beck J, Wehler M, *et al.* Workflow interruptions and stress at work: a mixed-methods study among physicians and nurses of a multidisciplinary emergency department. *BMJ Open* 2017;7:e019074.
- Carthey J. The role of structured observational research in health care. *Quality and Safety in Health Care* 2003;12:13ii–16.
- Brown TA. *Confirmatory factor analysis for applied research.* New York: The Guilford Press, 2006.

- 30 Wang H, Kline JA, Jackson BE, *et al.* The role of patient perception of crowding in the determination of real-time patient satisfaction at emergency department. *Int J Qual Health Care* 2017;29:722–7.
- 31 Holm S. A simple sequentially rejective multiple test procedure. *Scand Stat Theory Appl* 1979;6:65–70.
- 32 Peugh JL, Enders CK. Using the SPSS mixed procedure to fit cross-sectional and longitudinal multilevel models. *Educ Psychol Meas* 2005;65:717–41.
- 33 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.
- 34 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.
- 35 Sasangohar F, Donmez B, Trbovich P, *et al.* Not all interruptions are created equal: positive interruptions in healthcare. *Proc Hum Factors Ergon Soc Annu Meet* 2012;56:824–8.
- 36 Jeanmonod R, Boyd M, Loewenthal M, *et al.* The nature of emergency department interruptions and their impact on patient satisfaction. *Emerg Med J* 2010;27:376–9.
- 37 Benda NC, Hettinger AZ, Bisantz AM, *et al.* Communication in the electronic age: an analysis of face-to-face physician–nurse communication in the emergency department. *J Healthc Inform Res* 2017;1:218–30.
- 38 Flowerdew L, Brown R, Russ S, *et al.* Teams under pressure in the emergency department: an interview study. *Emerg Med J* 2012;29:e2.
- 39 Provost SM, Lanham HJ, Leykum LK, *et al.* Health care huddles: managing complexity to achieve high reliability. *Health Care Manage Rev* 2015;40:2–12.
- 40 Shen Y, Lee LH. Improving the wait time to consultation at the emergency department. *BMJ Open Qual* 2018;7:e000131.
- 41 Hedberg B, Larsson US. Environmental elements affecting the decision-making process in nursing practice. *J Clin Nurs* 2004;13:316–24.
- 42 Walter SR, Raban MZ, Dunsmuir WTM, *et al.* Emergency doctors' strategies to manage competing workload demands in an interruptive environment: an observational workflow time study. *Appl Ergon* 2017;58:454–60.
- 43 Gharaveis A, Hamilton DK, Pati D, *et al.* The impact of visibility on teamwork, collaborative communication, and security in emergency departments: an exploratory study. *HERD* 2017;193758671773529.
- 44 Raban MZ, Walter SR, Douglas HE, *et al.* Measuring the relationship between interruptions, multitasking and prescribing errors in an emergency department: a study protocol. *BMJ Open* 2015;5:e009076.
- 45 Bos N, Sizmur S, Graham C, *et al.* The accident and emergency department questionnaire: a measure for patients' experiences in the accident and emergency department. *BMJ Qual Saf* 2013;22:139–46.
- 46 Boerebach BC, Scheepers RA, van der Leeuw RM, *et al.* The impact of clinicians' personality and their interpersonal behaviors on the quality of patient care: a systematic review. *Int J Qual Health Care* 2014;26:426–81.
- 47 Scheepers RA, Boerebach BC, Arah OA, *et al.* A systematic review of the impact of physicians' occupational well-being on the quality of patient care. *Int J Behav Med* 2015;22:683–98.
- 48 Sasangohar F, Donmez B, Easty AC, *et al.* Effects of nested interruptions on task resumption: a laboratory study with intensive care nurses. *Hum Factors* 2017;59:628–39.

5. Publication 4: Cross-national comparison of provider time allocation and workflow interruptions in emergency departments

Schneider, A., Williams, D., Kalynych, K., Wehler, M., & Weigl, M. (2020). Physicians' and nurses' work time allocation and workflow interruptions in emergency departments: A comparative time-motion study across two countries. *Emergency Medicine Journal*, Epub ahead of print: 5 August 2020.

Physicians' and nurses' work time allocation and workflow interruptions in emergency departments: a comparative time-motion study across two countries

Anna Schneider ^{1,2}, Deborah J Williams,³ Colleen Kalynych,³ Markus Wehler,⁴ Matthias Weigl ¹

Handling editor Simon Carley

► Additional material is published online only. To view please visit the journal online (<http://dx.doi.org/10.1136/emmermed-2019-208508>).

¹Institute and Clinic for Occupational, Social and Environmental Medicine, University Hospital, LMU Munich, Munich, Germany
²Institute of Medical Sociology and Rehabilitation Science, Charité – Universitätsmedizin Berlin, Berlin, Germany
³Department of Emergency Medicine, University of Florida, College of Medicine Jacksonville, Jacksonville, Florida, USA
⁴Department of Emergency Medicine and Department of Medicine IV, University Hospital Augsburg, Augsburg, Germany

Correspondence to

Anna Schneider, Institute and Clinic for Occupational, Social and Environmental Medicine, University Hospital, LMU Munich, Munich, Germany; anna.schneider@med.lmu.de

Received 8 February 2019
 Revised 22 November 2019
 Accepted 3 March 2020

ABSTRACT

Background Globally, emergency department (ED) work is fast-paced and subject to interruptions, placing high coordination and communication demands on staff. Our study aimed to compare ED staffs' work time allocation and interruption rates across professional roles and two national settings.

Methods We conducted a time-motion study with standardised expert observations of ED physicians and nurses in Germany and the USA. Observers coded ED staffs' activities and workflow interruptions. General and generalised linear models were used to examine differences in activities and interruption rates between countries and ED professions.

Results 28 observations were conducted in the USA and 30 in Germany. Overall, the largest portion of time spent by ED staff in both settings was in documentation (22.0%). Physicians spent more time in verbal interaction with patients (9.9% vs 5.2% in nurses; $p=0.006$), in documentation (29.4% vs 15.6%; $p<0.001$) and other professional activities (13.0% vs 4.8%; $p=0.002$). Nurses allocated significantly more time to therapeutic (22.3% vs 6.0% in physicians; $p<0.001$) and organisational activities (20.4% vs 9.5%; $p<0.001$). Overall mean interruption rate per hour was 10.16 (US ED: 8.15, German ED: 12.04; $p<0.001$). American physicians and German nurses were most often disrupted by colleagues of the same profession (country: $B=-.27$, $p=0.027$; profession: $B=0.35$, $p=0.006$). German ED staff were interrupted more often by patients ($B=-.78$, $p=0.001$) and other sources ($B=-.76$, $p<0.001$) than American ED staff.

Discussion Our findings corroborate that professional roles largely determine time allocation to specific activities. However, interruption rates indicate differences between countries, suggesting the need for context-specific solutions to work stressors.

INTRODUCTION

Globally, emergency departments (EDs) have seen a continuous rise in patient visits.¹ ED staff operate in fast-paced and complex clinical environments with persistent demands to coordinate and adapt work processes around the care of multiple patients.² Reconciling patient care activities with organisational and documentation duties is a key challenge for ED staff. Work factors such as crowding and staff communication patterns have been linked to patient satisfaction,³ medical errors⁴ and well-being of ED physicians and nurses.^{5,6} Workflow

Key messages

What is already known on this subject

- The previous decade witnessed increasing interest in work system factors in order to improve emergency department (ED) care practice and staffs' work life.
- Available investigations of ED staffs' work time allocation as well as workflow interruptions are limited to respective national settings without systematic comparisons across national healthcare systems.

What this study adds

- In this time motion study of an ED in the USA and one in Germany, we found similarities in the time physicians and nurses spend on various activities across countries. The interruption rate was higher in Germany versus the USA. The sources of interruptions differed, with physicians being more likely to be interrupted by colleagues in the USA, and ED staff by patients in Germany.
- Our results from two international settings corroborate that ED work stressors might be generic with prevailing profession-specific demands. However, interruption rates and their sources appear to differ across national settings suggesting that solutions to some of the stressors may differ depending on context.

interruptions have been identified as one of the most prevalent stressors in ED work.^{7–9} Multiple studies have described the distribution and prevalence of various ED work activities in specific national contexts, thus generating results with potentially limited external validity across national healthcare systems.^{10,11} Yet, systematic cross-national studies comparing ED work activities and work stressors are lacking. Furthermore, past research predominantly concentrated on ED physicians' work with insufficient reference to ED nurses. However, high-quality ED care relies on effective multidisciplinary teams.^{7,12}

There is an established tradition of empirical research into ED staff work activities in the USA,^{10,13} with an increasing interest in this topic in Europe in the past decade.^{11,14} Accordingly, studies suggest that ED staff in both German and American EDs allocate a large amount of working time to



© Author(s) (or their employer(s)) 2020. No commercial re-use. See rights and permissions. Published by BMJ.

To cite: Schneider A, Williams DJ, Kalynych C, et al. *Emerg Med J* Epub ahead of print: [please include Day Month Year]. doi:10.1136/emmermed-2019-208508

intradepartmental communication with other ED professionals besides direct patient care.^{10 11 14–17} As an integral characteristic of ED work, interruption rates for ED staff vary substantially across individual studies: between 5^{11 14 18} and nearly 8¹⁹ hourly interruptions in German EDs and between 0.5²⁰ and 12.5²¹ interruptions in American EDs.

This study aimed at quantifying the time allocation of ED staff to different activities and workflow interruptions in a European and an American setting. Assuming that ED work systems generally pursue identical aims, that is, evaluating and providing acute care to all persons in need,¹ we sought to focus our study on analyses of cross-national similarities and differences using a uniform measurement method. Comparative analyses act as guidelines for researchers and ED practitioners concerning the external validity of empirical results from different national settings. Furthermore, our research highlights generic demands of ED work and points to specific professional and higher-order work system challenges for ED staff. Identification of these factors informs respective measures to improve ED work practices and ED staff well-being.

METHODS

Patient and public involvement

No patient involved.

Design and settings

A time-motion study using standardised expert observations of ED staff was conducted between September 2016 and January 2017 in two EDs, one in the USA and one in Germany. This study was part of a larger research programme on ED work environments in Germany.²²

Both study EDs are affiliated with large, academic tertiary care centres situated in urban areas. The American setting is a 24-hour ED serving more than 90 000 adult and paediatric patients per year. Adults with medical, surgical or minor traumatic complaints are triaged to one of two sections according to the acuity of presentation. There are separate sections for major trauma (five bays), psychiatric emergencies (three beds), respiratory isolation (two beds), paediatrics (eight beds plus three resuscitation bays) and short-term observation (18 beds). The ED is staffed with board-certified emergency physicians, emergency medicine (EM) residents and (where appropriate) paediatric residents and paediatric EM fellows. Specialists are available on call, with the exception of the trauma surgery service that responds to all major traumas. ED nurses are specifically trained for the ED and rotate in all areas of the ED, except those in the designated paediatric ED and trauma centre. The German setting is a 24-hour interdisciplinary ED serving adult patients with mean yearly visits of over 85 000. It is organised in three sections according to patient's chief complaints: 10 separate bays for non-surgical patients, 5 separate bays for surgical patients, 2 resuscitation bays and an observation and clinical decision unit with 24 beds. The ED is regularly staffed with residents as well as senior physicians who have completed specialty training in internal medicine, neurology or trauma surgery. Further specialists are available on call. ED nurses regularly rotate through all three ED sections.

Data collection took place on 17 days in the American ED and on 20 days in the German ED. We conducted observations from Monday to Sunday during day and evening shifts. Participation was voluntary and consent was obtained prior to observation sessions.

Participants and procedure

In both settings, attending physicians, residents and registered nurses were eligible. Medical students, interns and ED technicians were excluded in both settings. In Germany, staff were observed in the non-surgical ED section while in the American ED, staff working in the resuscitation and high acuity sections were eligible.

Standardised observation sessions were conducted with an identical procedure and observational instrument in both settings.¹⁸ Expert observers with a professional background in healthcare and human factors shadowed ED staff members for 90 min sessions. Prior to start, observer training was completed onsite, consisting of pilot and pairwise observations as well as discussions concerning inconsistencies.

Prior to the first data collection period, we set out a stratified sampling procedure for the German ED that ensured random and equal allocation of observations to nurses and physicians, day of the week and time within the day. This observation plan ensured balanced representation of professions, days and daytime. Weekdays were oversampled in comparison to weekend days. The observation plan for the American ED replicated the allocation pattern of data collection in the German ED to obtain two comparable national samples. Prior to each observation, expert observers approached the first available and eligible ED staff member according to the observation plan and informed him or her about the study. After obtaining verbal consent, observers kept adequate distance and refrained from actively engaging with staff during observation. Observers carried a clipboard, documentation sheets, and a digital wristwatch to record work activities and work interruptions. No personal data were gathered from observed staff members.

Observation instrument

During observations, (A) activities of ED staff and (B) workflow interruptions were systematically captured with an established tool that has been applied in EDs as well as other clinical settings before.^{14 18} (A) Activities were coded in eight predefined categories (see online supplementary table A-1): (1) communication with patients and relatives, (2) diagnostic activities, (3) therapeutic or care activities, (4) documentation, (5) communication with ED colleagues, (6) communication with other persons and phone calls, (7) organisational activities and (8) other (professional) activities. During analysis, these categories were further grouped following Hollingsworth *et al*'s¹⁶ approach to distinguish between activities conducted directly on or with the patient (ie, direct patient care) and those conducted without direct reference or proximity to patients (ie, indirect patient care). (B) Workflow interruptions were defined as observable events that diverted a staff member's attention from the primary task and caused task-switching behaviours.¹⁵ We used an established taxonomy¹⁹ distinguishing five sources of interruptions, that is, who or what initiated the interruptive event: (1) patients, (2) colleagues of the same profession, (3) colleagues of another profession, (4) others, for example, phone, (5) technical or informational impediments, for example, technical malfunctions (eg, depleted battery in a blood glucose analyser) or missing test results.

Statistical analysis

No sample size calculations were performed prior to study start due to practical reasons that allowed only for a limited number of 90 min observations during preset, on-site observation days.

For statistical analysis, we first aggregated all observational data at the session level: proportions of time spent within each

Table 1 Description of samples from observation sessions

		Total sample (N=58)	USA (n=28)	Germany (n=30)
Observed professions	Nurses	31	13	18
	Physicians	27	15	12
Observation sessions	Mean duration (hh:mm:ss)	01:28:49	01:27:17	01:30:16
	Range (min; max, hh:mm:ss)	00:42:30; 01:50:06	00:42:30; 01:50:06	01:22:27; 01:35:56

activity in regard to total observation time as well as mean hourly interruption rates from different sources were calculated per session. Descriptive statistics for the overall sample as well as for national and professional subsamples were computed. To analyse comparability of national samples concerning the number of observed ED physicians and nurses and length of observation sessions, we ran univariate analyses of variance. To examine our main study objectives, we applied general linear models to analyse differences in activity patterns of ED staff between countries and professions. Since interruption events represent count data following a Poisson distribution, generalised linear models were performed to examine differences between countries and professions concerning time-adjusted incidences of observed interruptions. A significance level of $p \leq 0.05$ was applied. SPSS V.24.0 was used for all analyses (IBM).

RESULTS

Sample description

Overall, 58 observation sessions (total observation time: 85 hours 52 min 18 s) were conducted; 28 sessions in the USA (observation time: 40 hours 44 min 4 s) and 30 sessions in Germany (45 hours 8 min 14 s). **Table 1** depicts the allocation of sessions to countries and ED professions. We observed no significant differences between country samples concerning the number of observed ED nurses and physicians ($F=1.45$, $p=0.234$) and mean time per observation session ($F=0.16$, $p=0.688$).

ED staffs' time allocation to work activities

In both settings, the largest proportion of time was spent on indirect patient care, that is, documentation and charting activities (22.0% of total observation time), communication with ED colleagues (15.7%) and other professionals (5.8%) as well as organisational activities (15.3%). ED staff in both settings spent less time in direct patient care activities including communication with patients and relatives (7.4%), diagnostic (10.5%) and therapeutic activities (14.7%; **table 2**) than indirect patient care.

Significant differences in ED staff activities were observed for all activity categories (**table 2**). Multivariate analyses revealed the following role-related differences in observed activities: In both ED settings, nurses spent less time verbally interacting with patients and relatives compared with physicians (5.2% of nurses' vs 9.9% of physicians' total observation time; $p=0.006$). Similarly, nurses spent comparatively less time than physicians in documenting (15.6% vs 29.4%; $p<0.001$) and conducting other professional activities, for example, participating in meetings and teaching (4.8% vs 13.0%; $p=0.002$). However, nurses allocated significantly more time to therapeutic activities (22.3% vs 6.0%; $p<0.001$) and organisational activities (20.4% vs 9.5%; $p<0.001$) than physicians. Three significant differences between countries were identified: American staff spent less time with diagnostic activities than their German counterparts (6.3% vs 14.4%; $p=0.001$). Furthermore, American ED staff allocated

Table 2 ED staffs' proportional time allocation to work activities and differences between professions and countries

Activities	Overall M (95% CI)	Country*profession						Test for differences: GLM results	
		USA			Germany			Country B, p value	Profession B, p value
		USA M (95% CI)	Nurses M (95% CI)	Physicians M (95% CI)	Germany M (95% CI)	Nurses M (95% CI)	Physicians M (95% CI)		
Direct patient care activities	7.4 (5.5 to 9.2)	6.8 (3.8 to 9.7)	5.2 (3.1 to 7.2)	9.8 (5.1 to 14.5)	3.3 (0.5 to 6.1)	10.0 (5.8 to 14.2)	6.5 (3.6 to 9.5)	-1.83, 0.30	-4.95, 0.01
Communication with patients/relatives	10.5 (7.9 to 13.0)	6.3 (3.9 to 8.6)	11.0 (7.3 to 14.6)	7.1 (3.6 to 10.6)	5.3 (1.9 to 8.8)	13.4 (6.0 to 20.8)	15.0 (9.7 to 20.3)	-8.09, <0.01	-0.04, 0.99
Diagnostic activities	14.7 (10.7 to 18.7)	15.1 (9.5 to 20.8)	22.3 (17.4 to 27.1)	8.8 (0.0 to 17.6)	22.5 (17.2 to 27.8)	2.5 (-0.1 to 5.2)	22.1 (14.2 to 29.9)	3.16, 0.36	16.69, <0.01
Therapeutic activities	22.0 (19.0 to 25.1)	23.8 (19.8 to 27.9)	15.6 (13.1 to 18.1)	28.7 (22.5 to 35.0)	18.2 (14.7 to 21.7)	30.3 (22.5 to 38.0)	13.7 (10.2 to 17.1)	1.69, 0.50	-13.59, <0.01
Documentation	15.7 (13.4 to 18.1)	19.2 (15.6 to 22.8)	16.6 (12.9 to 20.3)	20.1 (15.6 to 24.6)	18.2 (11.8 to 24.6)	12.2 (6.5 to 18.0)	12.7 (9.2 to 16.1)	6.62, 0.01	-0.71, 0.75
Communication with ED colleagues	5.8 (4.7 to 6.9)	4.3 (2.9 to 5.8)	5.8 (4.4 to 7.2)	4.4 (2.0 to 6.8)	4.3 (2.5 to 6.1)	7.5 (4.7 to 10.2)	6.9 (4.9 to 8.9)	-2.82, 0.01	-0.35, 0.74
Communication with others/phone	15.3 (12.4 to 18.3)	16.9 (12.0 to 21.8)	13.8 (10.2 to 17.5)	9.9 (6.9 to 13.0)	25.0 (16.7 to 33.3)	8.9 (6.0 to 11.8)	17.2 (11.6 to 22.7)	4.65, 0.08	11.62, <0.01
Organisation	8.6 (5.7 to 11.5)	7.5 (3.7 to 11.3)	13.0 (7.6 to 18.4)	11.2 (5.0 to 17.4)	3.2 (0.0 to 6.4)	15.3 (4.8 to 25.8)	5.9 (3.0 to 8.8)	-3.37, 0.22	-8.66, <0.01
Other (professional) activities									

B: unstandardised regression coefficient; bold if $p<0.05$.

CI, confidence interval; ED, emergency department; GLM, general linear models; M, mean.

Table 3 Descriptive statistics for interruptions (mean interruption rates per hour) and GLM results

	Country		Profession		Country*profession				Test for differences: GLM results		
	Overall	USA	Germany	Nurses	Physicians	USA	Germany	Physicians	Nurses	Country	Profession
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	B, p value	B, p value
Overall interruptions	10.16 (6.30)	8.15 (4.85)	12.04 (6.97)	11.74 (7.28)	8.35 (4.41)	8.09 (4.59)	8.23 (5.32)	8.68 (4.37)	14.27 (7.57)	-0.34 , <0.01	0.27 , <0.01
Interruption sources											
Interruptions by patients	1.06 (1.22)	0.64 (0.87)	1.46 (1.38)	1.32 (1.41)	0.77 (0.91)	0.58 (0.84)	0.70 (0.94)	0.99 (0.97)	1.78 (1.54)	-0.78 , <0.01	0.41, 0.07
Interruptions by colleagues (same profession)	3.33 (3.00)	2.71 (2.04)	3.92 (3.61)	3.93 (3.68)	2.65 (1.77)	3.07 (1.57)	2.28 (2.48)	2.11 (1.93)	5.13 (3.99)	-0.27 , 0.03	0.35 , <0.01
Interruptions by colleagues (other profession)	3.15 (2.29)	2.73 (2.39)	3.53 (2.15)	3.59 (2.40)	2.64 (2.07)	2.16 (2.13)	3.39 (2.59)	3.23 (1.93)	3.73 (2.32)	-0.23, 0.08	0.23, 0.07
Other interruptions (phone, relatives, others)	1.77 (1.77)	1.07 (1.19)	2.43 (1.97)	2.08 (2.02)	1.42 (1.37)	1.15 (1.38)	0.97 (0.98)	1.76 (1.35)	2.88 (2.21)	-0.76 , <0.01	0.26, 0.13
Interruptions due to technical/information impediments	0.84 (0.91)	1.01 (0.96)	0.69 (0.85)	0.82 (0.89)	0.88 (0.96)	1.11 (0.73)	0.89 (1.19)	0.58 (1.15)	0.76 (0.62)	0.34, 0.17	-0.06, 0.80

B: unstandardised regression coefficient; bold if $p < 0.05$.
GLM, generalised linear models; M, mean; SD, standard deviation.

more time to communication with their ED colleagues (19.2% vs 12.5%; $p = 0.005$), while German ED staff spent more time with phone calls and communication with other professionals (7.1% vs 4.3% in American ED; $p = 0.009$).

ED staffs' workflow interruptions

Overall, mean hourly interruption rates of ED staff were 10.16 (SD: 6.30; see table 3). Mean hourly rate was 8.15 (SD: 4.85) in the American ED and 12.04 (SD: 6.97) in the German ED. ED staff in both countries were most often interrupted by ED colleagues of the same (3.33 interruptions per hour) or another profession (3.15 int/h). Fewest interruptions occurred due to missing information or technical malfunctions (0.84 int/hour).

Significant differences were observed by both country and professional role for the source of interruptions (table 3). Concerning country differences, ED staff in the USA were less often interrupted by patients than professionals in Germany (0.64 vs 1.46 int/hour; $p = 0.001$). Interruptions by colleagues of the same profession were significantly lower in the American ED compared with the German staff (2.71 vs 3.92; $p = 0.027$). In the German sample, nurses interrupted each other significantly more often than physicians (3.93 vs 2.65 in physicians; $p = 0.006$). In the USA, ED physicians interrupted each other more frequently as compared with nurses (2.28 vs 3.07 in physicians; see table 3). Furthermore, other interruptions, for example, by patients' relatives, were less often observed in the American than German ED (1.07 vs. 2.43; $p < 0.001$). Frequency of interruptions from colleagues of other professions and impediments did not differ between countries or professions.

DISCUSSION

Our cross-national study describes systematic comparisons of time allocation and workflow interruptions in two representative EDs, one in Germany and one in the USA. The following contributions can be drawn from our results:

First, our study supports previous findings, such that ED staff allocate most of their working time to indirect patient care activities, that is, documentation and charting activities, communication with colleagues and organisational activities.^{10 15 18 21} Amounts of time spent communicating and organising can be

attributed to high coordination demands in EDs that are inherent to emergency care and serve to uphold patient flow in this complex, uncertain and high-paced work environment.^{12 20} Yet, we identified national differences for direct communication activities with ED colleagues and phone calls: American ED staff communicated more frequently face to face with their colleagues while German ED staff dedicated more time to (intra-departmental) phone calls and other professional communication. Nonetheless, staff in both settings spent a substantial amount of time in professional communication.

Second, observed differences in activities mostly stemmed from professional roles indicating prevailing role-specific demands for ED physicians and ED nurses. In both national contexts, nurses were more often involved in organisational activities and direct patient care compared with physicians. ED physicians allocated more time to direct verbal communication with patients, documentation, and other professional activities, such as meetings and educating junior staff. European and American ED systems have different approaches for teaching and involving junior physicians undergoing specialty training. Further studies are thus warranted that apply more detailed assessments to scrutinise time allocation for teaching activities by ED staff. Likewise, our finding that ED physicians spent consistently more time in direct patient communication as well as documentation than nurses needs further consideration in order to identify other workplace factors influencing this role-related difference.

Third, German ED staff allocated more time to diagnostic activities than US staff, for example, for physical examinations, blood draws and ultrasound examinations. One explanation might be that ED physicians in particular pass through different training paths in sampled countries: While EM is a recognised specialty in the USA, physicians working in German EDs are predominantly trained internists, trauma surgeons or anaesthesiologists with an advanced certificate in EM. Thus, American ED physicians might rely less on comprehensive testing in the ED due to more technical knowledge and EM skills gained from their specialised residency. Alternatively, differences in country-specific professional roles might apply where physicians in American EDs delegate diagnostic tasks, for example, blood draws, to auxiliary ED staff. This explanation is supported by the

observation that American physicians spent 7.3% of their time in diagnostic activities compared with 15.1% by German physicians. Additionally, different organisational practices regarding required diagnostic tests for specific symptoms and the patient population might further account for observed differences.

Finally, the consistently high rate of workflow interruptions reflects high communication and organisation demands in both settings. Our findings reveal that intraprofessional interruptions were especially prevalent among American ED physicians as well as German ED nurses. We infer that these professional subgroups are central hubs of departmental organisation and information flow within respective EDs.^{9 20} They were also frequent recipients of interruptions by other sources, for example, by phone or patients' relatives. This may be due to their central role with regard to being in charge of care progress, transmitting information and dispatching care.^{4 9 23} Notwithstanding, further investigations are needed to elaborate these professional differences across national ED settings. We observed that German ED staff were more often interrupted by patients than their American counterparts. Post hoc, we assume that this can be attributed to two potentially underlying conditions: first, differences in patients' illness severity, such that patients in the observed American ED were in more severe and critical condition with less ability to interrupt; second, due to the physical layout of the German ED, patients and relatives in treatment areas were in proximate distance to ED staff.

Generally, inferences concerning the level of interruption rates across studies should take into account mesosystem and macrosystem factors in which particular ED settings are embedded.^{7 24} Furthermore, we did not study the effects of interruptions on process, staff and patient outcomes. Nor did we classify interruptions as appropriate, beneficial or detrimental to the above outcomes. Particularly in acute care, interruptions are necessary and inherent to clinical work, for example, by alerting a physician that a patient's condition is deteriorating.^{25 26}

Limitations

Our study is subject to potential limitations. First and foremost, conducting and evaluating cross-national research on work activities and interruptions is complex since work in each individual setting is shaped by components of the respective sociotechnical work system.^{7 27} Thus, this exploratory study did not include information on the acuity of ED patients, staff/patient ratios or professional tenure/hierarchical role of observed ED staff. Therefore, further investigation is needed into how these aspects may confound observations of role-related and country-related differences in EDs. However, our study provides a basis for future research incorporating larger and more diverse samples. Finally, observations of clinical practice are a valuable approach to study the complexity of healthcare work environments. However, ED staff often switch tasks or tend to multitask, which makes the identification of activities and interruptions by observations subject to bias.²⁸ Furthermore, observer presence may have influenced ED staffs' behaviour in the form of 'Hawthorne effect'. Nonetheless, we undertook several measures to minimise observer influence and to ensure reliability of our measures.

CONCLUSIONS

In this study comparing time allocation for work activities and interruption rates in EDs in two countries, we found that ED work systems pose common demands on nurses and physicians that outweigh unique national characteristics. Differences in interruption rates and sources suggest caution in applying

research results and general solutions to work stressors on this aspect of ED work beyond the specific context.

Acknowledgements This paper is dedicated to the memory of Robert Lewis Wears (Department of Emergency Medicine, UF Health, Jacksonville). RL Wears substantially enabled data collection in the American ED and contributed to design and preliminary interpretation of results. Most sadly, RL Wears passed away before the draft of this manuscript.

Contributors AS, MWeh and MWei conceptualised and designed the study. AS and MWei were responsible for acquisition of data. AS, DJW, CK and MWei analysed data. All authors interpreted the data regarding study hypotheses. All authors drafted, read and approved the final manuscript.

Funding The study was supported by the Munich Centre of Health Sciences (MC-Health).

Competing interests None declared.

Patient consent for publication Not required.

Ethics approval The Ethics Committee of the Medical Faculty, Munich University (NR 327–15) and the American ED's academic institutional review board approved the study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Anonymised and de-identified data will be made available to other investigators on reasonable request. Interested investigators should contact the corresponding author.

ORCID iDs

Anna Schneider <http://orcid.org/0000-0001-6287-6196>

Matthias Weigl <http://orcid.org/0000-0003-2408-1725>

REFERENCES

- Morganti KG, Bauhoff S, Blanchard JC, *et al.* *The evolving role of emergency departments in the United States*. Santa Monica, CA: RAND Corporation, 2013.
- Wears RL, Perry SJ. Human factors and ergonomics in the emergency department. *Ann Emerg Med* 2002;40:206–12.
- Welch SJ. Twenty years of patient satisfaction research applied to the emergency department: a qualitative review. *Am J Med Qual* 2010;25:64–72.
- 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.
- Basu S, Qayyum H, Mason S. Occupational stress in the ED: a systematic literature review. *Emerg Med J* 2017;34:441–7.
- Schneider A, Weigl M. Associations between psychosocial work factors and provider mental well-being in emergency departments: a systematic review. *PLoS One* 2018;13:e0197375.
- Werner NE, Holden RJ. Interruptions in the wild: development of a sociotechnical systems model of interruptions in the emergency department through a systematic review. *Appl Ergon* 2015;51:244–54.
- Allard J, Wyatt J, Bleakley A, *et al.* "Do you really need to ask me that now?": a self-audit of interruptions to the 'shop floor' practice of a UK consultant emergency physician. *Emerg Med J* 2012;29:872–6.
- Jeanmonod R, Boyd M, Loewenthal M, *et al.* The nature of emergency department interruptions and their impact on patient satisfaction. *Emerg Med J* 2010;27:376–9.
- 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.
- Mache S, Vitzthum K, Klapp BF, *et al.* Doctors' working conditions in emergency care units in Germany: a real-time assessment. *Emerg Med J* 2012;29:e1.
- Coiera E. Communication in emergency medical teams. In: Croskerry P, Cosby KS, eds. *Patient safety in emergency medicine*. Philadelphia, PA: Lippincott Williams & Wilkins, 2009: 187–91.
- Chisholm CD, Collison EK, Nelson DR, *et al.* Emergency department workplace interruptions: are emergency physicians "interrupt-driven" and "multitasking"? *Acad Emerg Med* 2000;7:1239–43.
- Weigl M, Müller A, Holland S, *et al.* Work conditions, mental workload and patient care quality: a multisource study in the emergency department. *BMJ Qual Saf* 2016;25:499–508.
- 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.
- Hollingsworth JC, Chisholm CD, Giles BK, *et al.* How do physicians and nurses spend their time in the emergency department? *Ann Emerg Med* 1998;31:87–91.
- 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.
- Weigl M, Müller A, Zupanc A, *et al.* Hospital doctors' workflow interruptions and activities: an observation study. *BMJ Qual Saf* 2011;20:491–7.

- 19 Weigl M, Beck J, Wehler M, *et al.* Workflow interruptions and stress atwork: a mixed-methods study among physicians and nurses of a multidisciplinary emergency department. *BMJ Open* 2017;7:e019074.
- 20 Fairbanks RJ, Bisantz AM, Sunm M. Emergency department communication links and patterns. *Ann Emerg Med* 2007;50:396–406.
- 21 Ratwani RM, Fong A, Puthumana JS, *et al.* Emergency physician use of cognitive strategies to manage interruptions. *Ann Emerg Med* 2017;70:683–7.
- 22 Schneider A, Wehler M, Weigl M. Effects of work conditions on provider mental well-being and quality of care: a mixed-methods intervention study in the emergency department. *BMC Emerg Med* 2019;19:1.
- 23 Berg LM, Källberg A-S, Göransson KE, *et al.* Interruptions in emergency department work: an observational and interview study. *BMJ Qual Saf* 2013;22:656–63.
- 24 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.
- 25 Walter SR. Interruptions in emergency medicine: things are not always what they seem. *Acad Emerg Med* 2018;25:1178–80.
- 26 Grundgeiger T, Dekker S, Sanderson P, *et al.* Obstacles to research on the effects of interruptions in healthcare. *BMJ Qual Saf* 2016;25:392–5.
- 27 Carayon P, Schoofs Hundt A, Karsh B-T, *et al.* Work system design for patient safety: the SEIPS model. *Qual Saf Health Care* 2006;15 Suppl 1:i50–8.
- 28 Walter SR, Raban MZ, Dunsmuir WTM, *et al.* Emergency doctors' strategies to manage competing workload demands in an interruptive environment: an observational workflow time study. *Appl Ergon* 2017;58:454–60.

6. Further manuscripts

6.1 Publication 5: Workflow interruptions and ED provider stress

Weigl, M., Beck, J., Wehler, M., & Schneider, A. (2017). Workflow interruptions and stress at work: A mixed-methods study among physicians and nurses of a multidisciplinary emergency department. *BMJ Open*, 7(12), e019074.

BMJ Open Workflow interruptions and stress atwork: a mixed-methods study among physicians and nurses of a multidisciplinary emergency department

Matthias Weigl,¹ Joana Beck,¹ Markus Wehler,² Anna Schneider¹

To cite: Weigl M, Beck J, Wehler M, *et al.* Workflow interruptions and stress atwork: a mixed-methods study among physicians and nurses of a multidisciplinary emergency department. *BMJ Open* 2017;7:e019074. doi:10.1136/bmjopen-2017-019074

► Prepublication history for this paper is available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2017-019074>).

MW and AS contributed equally.

Received 10 August 2017
Revised 14 November 2017
Accepted 15 November 2017



CrossMark

¹Institute and Outpatient Clinic for Occupational, Social and Environmental Medicine, Ludwig-Maximilians-University Munich, Munich, Germany

²Department of Emergency Medicine and Medicine IV, Klinikum Augsburg, Augsburg, Germany

Correspondence to

Dr Matthias Weigl;
matthias.weigl@med.lmu.de

ABSTRACT

Objectives Dealing with multiple workflow interruptions is a major challenge in emergency department (ED) work. This study aimed to establish a taxonomy of workflow interruptions that takes into account the content and purpose of interruptive communication. It further aimed to identify associations of workflow interruptions with ED professionals' work stress.

Design Combined data from expert observation sessions and concomitant self-evaluations of ED providers.

Setting ED of an academic community hospital in Germany.

Participants Multidisciplinary sample of ED physicians and nurses. 77 matched observation sessions of interruptions and self-evaluations of work stress were obtained on 20 randomly selected days.

Outcome measures ED professionals' stress evaluations were based on standardised measures. ED workload data on patient load, patient acuity and staffing were included as control variables in regression analyses.

Results Overall mean rate was 7.51 interruptions/hour. Interruptions were most frequently caused by ED colleagues of another profession (27.1%; mean interruptions/hour rate: 2.04), by ED colleagues of the same profession (24.1%; 1.81) and by telephone/beeper (21%; 1.57). Concerning the contents of interruption events, interruptions most frequently occurred referring to a parallel case under care (30.3%, 2.07), concerning the current case (19.1%; 1.28), or related to coordination activities (18.2%, 1.24). Regression analyses revealed that interruptive communication related to parallel cases significantly increased ED providers' stress levels ($\beta=0.24$, $P=0.03$). This association remained significant after controlling for ED workload.

Discussion Interruptions that refer to parallel cases under care were associated with increased stress among ED physicians and nurses. Our approach to distinguish between sources and contents of interruptions contributes to an improved understanding of potential benefits and risks of workflow interruptions in ED work environments. Despite some limitations, our findings add to future research on the implications of interruptions for effective and safe patient care and work in complex and dynamic care environments.

Strengths and limitations of this study

- Application of structured expert observation sessions ensures reliable identification of emergency department (ED) providers' workflow interruptions.
- Combination of observational data and provider ratings adds valuable information on ED staff experiences of interruptions.
- This study introduces an empirical quantification of interruption contents and interruptive communication in ED care settings.
- Study findings should be confirmed in multi-centre investigations.

INTRODUCTION

Emergency departments (EDs) are complex and challenging work environments with significant demands for care providers and inherent risks for quality of patient care.¹⁻³ Human factors and ergonomics contribute to the investigation and establishment of safe and efficient ED work.¹⁻⁴ Although EDs are 'interrupt driven' care environments,⁵⁻⁶ the nature and impact of interruptions on provider stress and ED care is yet not well understood.¹⁻²⁻⁴⁻⁷⁻⁸

We define workflow interruptions as an intrusion of an unexpected task or communication event, causing a discontinuation of the current task and an observable task switch behaviour.⁹ Thus, interruptions suspend clinician's attention from the focal task, requiring a shift of attention and task switching.²⁻⁹ ED physicians and nurses are frequently engaged in interruption-laden processes with 5.1 up to 15.5 interruptions/hour.²⁻⁵⁻¹⁰⁻¹⁴ In EDs, interruptions tend to occur more frequently than in other clinical settings.²⁻¹⁰ Moreover, in the course of dealing with interruptions, ED physicians fail to return to their initial task up to 20% of the time or they compensate through task short cuts.¹⁵

Likewise, interruptions affect length of interventions in the ED¹⁶ and are associated with lower patient satisfaction.¹⁷

Current research predominantly addresses potential negative influence of workflow interruptions.^{7 18 19} Workflow interruptions may mitigate clinicians' situational awareness and mental focus, increase fatigue, stress or frustration.²⁰ Highly interruptive work environments may contribute to failures, errors and quality losses.⁴ In contrast and concerning potential beneficial effects, in an attempt to accomplish fast and efficient patient care in the ED, interruptions might be inherent to complex ED work.^{3 4 6} Thus workflow interruptions are purposeful to ensure fast and safe delivery of care or to foster immediate communication, task completion and information transfer in the ED.^{6 12-14 19}

A previous review on interruptions in ED work called for further investigations that address proximal and distal outcomes of interruptions.⁷ Moreover, research is needed that elaborates potential adverse effects of interruptions as well as positive outcomes such that interruptions provide additional value to ED providers or organisational outcomes.^{7 14 21} Therefore approaches that comprehend the complexity of interruptions in ED work are needed.^{7 14} We therefore sought to expand previous research that mostly focused on the sources of interruptions by proposing a newly developed classification of interruptions in ED work that accounts for the sources and contents of interruption events.^{7 14} By drawing on a mixed-methods approach with ED professionals, our study aimed to:

1. identify interruption sources and contents of interruption events in ED work
2. determine associations between interruptions and ED professionals' work stress.

METHODS

Design and study setting

This mixed-methods study combined expert observation sessions on workflow interruptions and concomitant self-assessments by ED professionals concerning perceived disruptiveness and work stress. It was conducted in the ED of a major metropolitan academic medical centre with 84 000 yearly visits. In regard to size, patient census, work organisation, staffing and technological provisions, this interdisciplinary ED is one of the largest EDs in Germany. The study ED is staffed with physicians from trauma surgery, internal medicine and other specialties on 24hours duty. The ED consists of three treatment areas according to patient's chief complaints and condition: examination and treatment rooms for (1) internal as well as (2) patients with trauma and (3) one observation and clinical decision unit.

Staff received written and verbal information prior to data collection. Participation was voluntary and written consent was obtained. This study was part of a research programme on ED professionals' work conditions and care quality.

Sample and procedure

Trained observers shadowed ED professionals in 90 min sessions on 20 days. Eligible professionals were ED nurses and physicians undergoing specialty training or with completed specialty degree who worked in ED care on the respective 20 days of data collection. Overall, 80 observation sessions of ED professionals' workflow were scheduled. Observation sessions were randomly assigned to ED treatment areas and professions.

Observational and self-report measures

Observation sessions included sources and contents of workflow interruptions (see [table 1](#)). For identification of (1) sources, an established observation tool with eight different categories was used.^{6 22} For (2) contents, we developed a taxonomy that distinguishes between seven different content categories of interruptive communication (see [table 1](#)). The first four categories draw on previous attempts to differentiate between case-related and non-case-related interruption events.²³ Additionally, we included a category that accounts for interruptions that foster time and comfort aspects of patient care.¹⁴

ED professionals' self-reports on interruptions and work stress

Immediately after each observation session, the observed professional was asked to fill out a short self-assessment survey concerning the following outcomes:

Perceived interruptions

Three questions examined the perceived frequency, usefulness and disruptiveness of interruptions: (1) 'How often were you interrupted during your work?' (scale range from 0 'very few times' to 10 'very frequently'); (2) 'Were interruptions useful for your work (eg, to work more efficiently, to mitigate errors?)' (0 'not useful', 10 'very useful'); (3) 'Were interruptions disruptive for your work?' (0 'not disruptive', 10 'very disruptive').

Work stress

An established scale that quantifies the cognitive, emotional and physical aspects of work stress was used. STAI-6 scale has been frequently applied in healthcare professionals.²⁴ It consists of 6 statements with adjectives, for example, describing feeling calm (reversely coded), tense or upset. The answer scale ranges from 1 'no, not at all' to 4 'yes, completely'. The scale showed high reliability: Cronbach's alpha=0.82.

Additional information

Additional ED workload information was coded for each observation session: (1) treatment area, and (2) profession. Additionally, data was obtained on ED patient load (number of patients registered), ED staffing (number of physicians and nurses) and number of high acuity patients (share of patients with ESI levels 1 and 2).

Reliability testing

First, non-systematic observation sessions were carried out to test the applicability of the tool and to discuss

Table 1 Sources and contents of emergency department (ED) professionals' workflow interruptions (observation tool)

Category	Example
(1) Sources of interruptions (interruptions caused...)	
1 By patients	For example, patient asks charting nurse for expected waiting time
2 By ED colleagues of the same profession	For example, charting nurse is interrupted by another ED nurse who asks for missing chart
3 By ED colleagues of another profession	For example, charting nurse is interrupted by ED physician who informs her about the arrival of a new patient
4 By telephone/beeper	For example, ED physician receives a telephone call during patient examination
5 By patient's relatives	For example, woman asks charting nurse about her mother's diagnostic results
6 By any other person or professional not working in the ED	For example, police, ambulance personnel, or external service personnel
7 By technical malfunctions or missing supplies	For example, computer screen is frozen, ECG runs out of battery
8 By information impediments or problems	For example, necessary information for task completion is missing, patient chart is unavailable
(2) Contents of interruptions (interruption event...)	
1 Related to current case	Interruption provides information on current case of observed ED professional; for example, nurse informs physician about an external call from patient's husband.
2 Related to parallel case	Interruption provides information on another patient that is currently under treatment by observed ED professional but not in immediate care; for example, physician informs nurse that her patient in parallel room needs assistance with getting dressed, or nurse assistant informs nurse that her patient in the parallel room is going to be transferred to the operating room (OR).
3 Related to completed cases	Interruption provides information on a patient whose ED care has been completed or who is not under current care by observed ED professional; for example, nurse informs physicians about yesterday's referral of a trauma patient.
4 Related to a new case (time-critical)	Interruption provides information on a new critical patient who is not physically present in the ED yet; for example, beeper sets off with announcement of arrival of a new trauma patient.
5 Related to coordination activities	Interruption is not related to a specific patient but rather to the coordination of ED workflow or collaboration; that is, nurse informs physician about her absence for a break.
6 Related to patient comfort	Interruption refers to maintaining or improving patient experience and comfort in general; for example, relatives ask nurse where to find restrooms.
7 Others	Interruption events that cannot be classified.

inconsistencies. Afterwards, observation sessions with two trained observers were conducted on site to test tool's reliability. Finally, 14 pairwise observation sessions were carried out (sum: 15 hours, 23 min; range: 0:36–1:30). To avoid temporal misclassification, observational data was divided into 1 min phases. For each, both observer classification of interruption sources and contents were matched respectively. A total of 274 interruptions sources were coded with a resulting Kappa coefficient of 0.56. Concerning content of interruptions, a total of 269 scores were obtained (for five events, rates missed a classification). The resulting Kappa coefficient was 0.50. For both domains, inter-rater agreement was established.

Data analyses

Missing self-assessments of work stress were registered for three observation sessions, in two instances high patient

load prevented observed professionals to respond immediately afterwards. In three other observation sessions, observed ED professionals finished their shift prior to the planned session end (mainly due to shift changes) and other ED professionals followed within the same role. Here, self-evaluations of both observed ED professionals within the same observation session were aggregated for mean evaluation. Observational data and self-report data were matched for each of the observation sessions. Sum and mean values were computed. For each observation session, interruption rates were calculated respectively, that is, session's count of interruption events divided by its length. Analyses of variance were performed to explore group differences between professions and ED treatment areas. We then computed multivariate linear regression analyses between observed rates of interruptions and ED

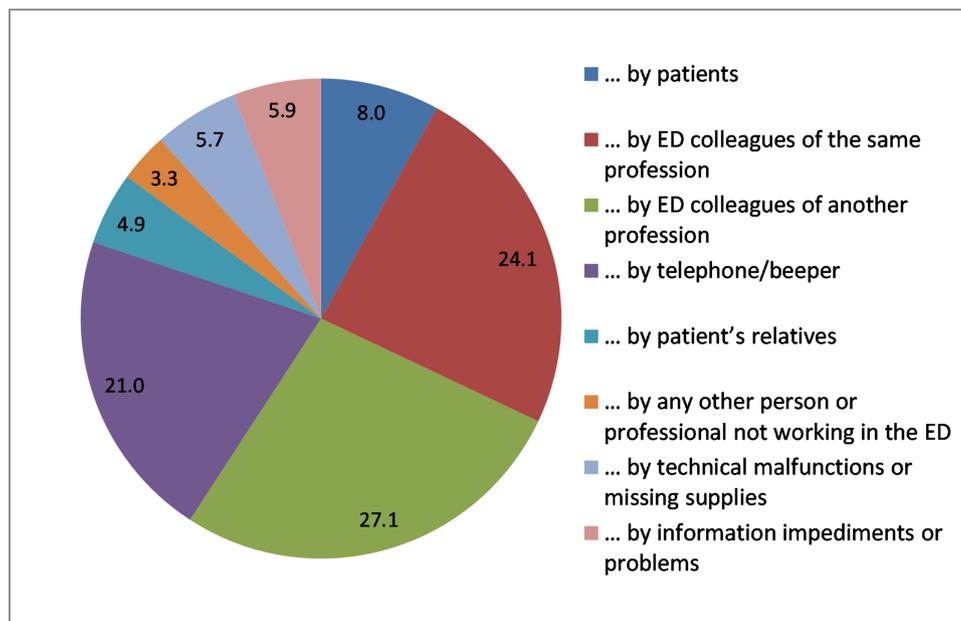


Figure 1 Sources of emergency department (ED) providers' workflow interruptions (n=877, in %).

providers' stress reports. Specifically, predictor variables were the interruption rates plus patient load and ED staffing to adjust the interruption estimates and outcome variable was work stress treated as continuous variable. Analyses were applied to data aggregated at session level. SPSS V.24.0 was used for statistical analyses (IBM).

RESULTS

Fifty (62.5%) observation sessions were conducted with ED nurses and 30 (37.5%) with ED physicians. Number and duration of observation sessions were comparable across ED treatment areas. For n=77 observation sessions, observational data and professionals' self-evaluations were matched. Average duration of observation sessions was 91.05 min (SD=4.44 min; range 77.4–106 min).

Sources and contents of observed workflow interruptions

Total observation time for the 77 sessions was 116 hours and 51 min. n=877 workflow interruptions were overall observed which resulted in an overall mean rate of 7.51 interruptions/hour. For the mean session level rates we obtained 7.53 interruptions/hour which varied across observation sessions (SD=3.9, range 0.67–19.3). **Figure 1** depicts the observed frequency of observed sources: interruptions by ED colleagues of other professions were most frequent (n=238, mean rate/hour \pm SD 2.04 \pm 1.84), followed by ED colleagues of the same profession (n=211, M=1.81 \pm 1.72), and telephone/beeper-related interruptions (n=184, M=1.58 \pm 1.3). All other interruption sources were recorded less frequently: interruptions by patients (n=70, M=0.6 \pm 0.86), interruptions due to information impediments or problems (n=52, M=0.45 \pm 0.72), interruptions due to equipment problems (n=50, M=0.43 \pm 0.62), interruptions by patient's relatives (n=43, M=0.37 \pm 0.59), and by any other person (n=29, M=0.25 \pm 0.56).

Figure 2 presents the distribution of n=791 observed contents of interruption events. Most frequently were interruptions related to parallel cases (n=240, M=2.07 \pm 1.84), followed by interruptions concerning the current case (n=151, M=1.28 \pm 1.26), and communication related to coordination activities (n=144, M=1.24 \pm 1.37). Others occurred less frequently: interruptions referring to completed cases (n=115, M=0.99 \pm 1.10), patient comfort-related interruptions (n=34, M=0.30 \pm 0.62), time-critical information concerning a new case (n=18, M=0.16 \pm 0.48), and other communication contents (n=89, M=0.76 \pm 0.81).

ED professionals' ratings of interruptions and work stress

Concomitant evaluations of observed ED professionals were obtained immediately after the observation session. Perceived interruption frequency was M=4.34 (SD=2.57). These ratings did not differ between nurses and physicians. Professionals working in the observation and clinical decision unit (M=5.31, SD=2.46) reported significantly more interruptions than ED professional working in the trauma section (M=3.17, SD=2.59; F(df=2)=5.08, P<0.01).

Perceived stress was M=10.8 (sum score, SD=2.91; scale range 6–24). ED professionals' work stress reports were normally distributed. There was no significant difference between professions. However, professionals in the trauma section reported lower stress levels (M=9.27, SD=3.24) than professionals in the internal medicine section (M=11.37, SD=2.69) and observation and clinical decision unit (M=11.77, SD=3.12; F(df=2)=6.28, P=0.03).

Concerning control variables, overall ED patient load was positively correlated with professionals' stress reports (r=0.31, P=0.01). We also identified an association between ED staffing and ED professionals' stress (r=0.26,

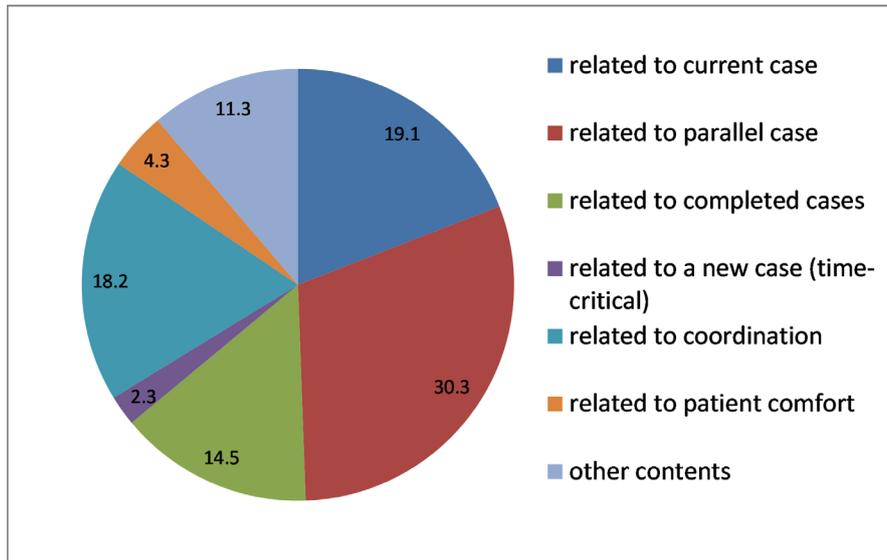


Figure 2 Contents of emergency department (ED) providers' workflow interruptions (n=791, in %).

P=0.02). Patient acuity was associated with patient load (r=0.48, P<0.01) but neither related to professionals' stress reports (r=0.13, P=0.26) nor to observed rates of interruption sources and contents.

Observed interruptions and ED professionals' work stress

After controlling for patient load and ED staffing, we found that higher rates of overall interruptions were related to increased reports of interruption frequency ($\beta=0.46$, P<0.01). This corroborates the validity of our approach such that interruption counts by observers were related to perceptions of observed ED professionals.

Table 2 reports associations between the three most frequent sources and contents of workflow interruptions

and ED professionals' work stress. The multivariate models satisfied the linear regression assumptions.

No associations between the three most frequent interruption sources and ED professionals' work stress were identified (cf, table 2). However frequent interruptions relating to parallel cases under care contributed significantly to increased work stress among ED professionals. This association remained robust after controlling for patient load and staffing.

DISCUSSION

This mixed-methods study identified sources and contents of workflow interruptions in a multidisciplinary ED. For the majority of observed interruption events and sources, no evidence for associations with provider stress at work was found. However, interruption events referring to parallel cases under care increased work stress among ED physicians and nurses. Our findings contribute to the knowledge base on ED workflow interruptions and work stress in several ways.

Our first aim was to apply a tool for expert observations with particular focus on sources and contents of interruptions. The vast majority of interruptions were caused by ED colleagues of the same and other ED professions as well as by telephone/beepers. These three sources accounted for almost 75% of all interruptions. This finding reflects the continuous need for intraprofessional and interprofessional communication within ED teams.³ Previous research in critical care settings showed that clinicians often assign high priority to interactions with colleagues.²

To the best of our knowledge, this is the first study that sought to quantify contents of interruptive communication events in ED workflows. We found that almost one-third of all interruptions were related to parallel cases under care. This indicates the substantial share of

Determinant	Outcome ED providers' work stress (β , P)
Source of workflow interruptions	
Overall (Sum score)	0.10, 0.34
... by colleagues of the same profession	0.08, 0.50
... by colleagues of another profession	0.05, 0.68
... by telephone/beeper	-0.01, 0.97
Content of workflow interruptions	
... related to current case under care	0.05, 0.63
... related to parallel case under care	0.22, 0.045
... related to coordination activities	-0.03, 0.76

n=77 observation sessions; β , regression coefficient; P, P value; adjusted for patient load (number of patients registered) and ED staffing (number of ED staff present).

ED communication that contains prompts for different patients receiving care.²⁵ Interruptions referring to the current case as well as to coordination activities were also prevalent.³ However, comfort-related interruptions that benefitted patients or their relatives were rare in comparison with interprofessional interruption contents.¹⁴ We also observed that interruptions containing urgent alerts occurred rarely.

Our second aim was to determine associations between workflow interruptions and ED professionals' work stress. Our approach provides a quantification of associations between interruptions and ED clinicians' stress experiences. The three most prevalent sources of workflow interruptions were not related to subsequent work stress reports after 90 min observation sessions. Two potential conclusions are drawn. (1) The mere count and frequency of interruptions from different sources do not contribute to ED professionals' work stress. (2) Referring to the magnitude of reported associations (in [table 2](#)), the effect of interruption rates on clinicians' stress was too small to detect within our study and its statistical power. Previous research of ED professionals showed that interruptions are perceived as disturbing or non-disturbing based on various factors of the interruption process such as content of the interruption, clinician's individual constitution and external factors.¹⁸

Nevertheless, taking into account the content of interruptions, we identified one significant association: increased interruption events on parallel cases under care were associated with increased self-reported work stress. This association was robust after controlling for patient load and ED staffing. Previous research found that interruptions were particularly detrimental during direct care activities by causing breaks in professionals' attention and patient treatment processes.¹⁴ Thus, interruption events containing information on parallel cases may divert the attentional focus of ED professionals from the current case under care, increase their work stress and eventually impair performance. Case-irrelevant information may evoke multitasking and task-switching behaviours and thus contribute to increased mental workload and work stress.² Moreover, ED professionals might compensate by working faster after interruptions which increases perceived stress.^{13 16} Our findings resonate well with cognitive load theory which proposes that interruption events that stretch cognitive resources, that is, provide additional information on another patient under care, are demanding. Frequent cognitive shifts and interruptions contribute to cumulated mental load, potentially mitigating ED professionals' attention and awareness.²⁶ Another potential underlying explanation for this finding might be that frequent information concerning parallel cases is indicative of high time pressure or insufficient case management among ED professionals. However, since we controlled for overall patient load and ED staffing, potential bias due to unmeasured workload is limited.

Furthermore, we found no evidence that interruptions related to the current case at hand were associated

with work stress. Disruptive information that refers to the current case might be perceived as beneficial interruptions that add value or inform subsequent treatment activities.^{7 21} Our findings are consistent with previous observations in operating room (OR) settings where case-relevant communication events contribute to smooth and effective team collaboration.²³

Limitations

Several limitations apply to our study. First, observational measures do not entirely convey complexities of the sociotechnical ED system as well as the interruption process.^{1 7 12} Our observation instrument does not distinguish between interruptive events that are clinically essential or appropriate and non-appropriate interruptions. This evaluation requires a strong clinical background of observers as well as careful consideration of the actual patient status which is almost unfeasible during on-site observations in highly dynamic ED care settings. Second, our observational tool underlies validity and reliability limitations that are inherent to observational research in dynamic ED environments. We acknowledge that inter-rater reliability was fair to good. Third, occasionally, exact assessment of communication contents was difficult, for example, particularly during rapid and short communication events concerning different cases. We also acknowledge that the content categories of our observational tool may bear overlap. Although stress among healthcare professionals contributes to adverse outcomes, we cannot infer about the potential impact of observed workflow interruptions on subsequent adverse patient outcomes, for example, medication administration errors.^{15 25 27} Within our main analyses, only one out of seven associations achieved significance. Since we applied no adjustment for multiple testing, we acknowledge that our discussion concerning significant associations should be considered carefully. Fourth, results should not be transferred to other ED environments without further consideration. Future investigations should draw on multi-centre trials that encompass varying complexities and dynamics of ED work settings. Observation sessions were carried out during day shifts only. Work practices during night shifts may differ. We did not randomly assign observations across time of day. Post hoc, we tested if study variables differed significantly between morning or afternoon observation sessions. Although we did not obtain significant differences for interruption rates and self-reports (results can be obtained from the corresponding author), our random selection procedure did not take account of variability within the day. Due to confidentiality restrictions we did not assess personal information of observed ED providers. We may have observed some providers multiple times, thus we suggest for future studies to acknowledge this potential bias, that is, clustering of individuals, and potentially nested data structures in analyses. Fifth, our correlational analyses limit inferences concerning causality. Previous reviews showed that evidence concerning causal links between

interruptions and errors is preliminary and deserves further studies with robust designs.^{21–27} We acknowledge that the distribution of our interruption events was skewed. Within our multivariate analyses we used linear regression that are considered robust if the predictor variable is distributed non-normally.²⁸ Given the borderline significance of our results, future studies should draw on well-powered samples and apply analyses that take account of Poisson-like distribution of interruption counts. Finally, several studies emphasise that the impact of interruptions also depends on task-related factors, for example, case complexity.^{27,18}

Implications

Findings of this mixed-methods study contribute to emerging literature concerning measures to understand interruptions and distractions in ED work systems.^{5,7,29} This study combined time-motion assessments and ED professionals' self-evaluations. Our findings advocate that the exclusive focus on interruption sources might limit inferences concerning the impact of interruptive communication on ED professionals' work stress. Taking into account the contents of interruption events may meaningfully expand the scope of previous research attempts that almost exclusively focused on sources of interruptions.⁷ Future research should also take account of social implications within the interruption process and investigate sequelae of disruptions beyond the individual level, for example, through social network analysis.³⁰ Potentially, adverse or beneficial effects of interruptions on the individual level, may be outweighed on the ED team level, for example, an individually disturbing interruption may assist team workflow or mitigate larger team-level stressors.^{7,30}

Concerning potential implications for ED practice, we found that interruptions including information on parallel cases are a frequent phenomenon and have an adverse effect on ED professionals' work stress. Yet, we assume that their strict prevention might implicate detrimental effects for efficiency and collaboration in ED workflows. Since interruptions in ED work unfold in a complex sociotechnical work and care environment,^{7,29} interventions to handle interruptions should consider this study's results in two ways. First, the mere count of interruption sources might be an ineffective approach to mitigate ED professionals' work stress. Future interventions in this field should focus on the contents of interruptions and actual purpose of interruptive communication. Moreover, interventions that target work stress in ED professionals should limit demands that concur with cognitive overload (ie, high working memory demands) or multitasking demands triggered through communication that does not relate to current cases.³¹ Work and process redesign approaches that seek to reduce disruptive communication in the ED, should consider interruption content and provider outcomes when mitigating workflow interruptions.²⁶ Finally, our study neglected further organisational, care and safety-related outcomes that should

be considered in future investigations, that is, workflow, collaboration and efficiency in care.

CONCLUSIONS

Our results highlight the importance of understanding interruptions and work stress within the ED environment. We found that the mere count of interruption sources was not associated with ED professionals' stress at work. Yet, interruptions containing information on parallel cases under care contributed to increased stress at work. Future investigations should further elucidate potential hazards and benefits of interruption events in ED work in the light of different safety and provider outcomes.

Acknowledgements We would like to thank Tobias Filmer, Jeannette Weber, Theresa Steeb and Nikolaus Bürger for their support in data collection. The results reported were part of the Doctoral Thesis requirements of Joana Beck (Ludwig-Maximilians-University Munich).

Contributors MWL and AS conceived the research idea. MWL, JB, MWR and AS contributed to the study design, collection and analysis of the data. MWL, JB, MWR and AS contributed to the drafts and revisions of the manuscript.

Funding This study was partly funded by the Munich Centre for Health Sciences (MC-Health).

Competing interests None declared.

Ethics approval The Ethics Committee of the Medical Faculty, Munich University, approved the study (NR 327–15).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement Anonymised and deidentified data will be made available to other investigators upon request. Interested readers should contact the corresponding author MWL (matthias.weigl@med.lmu.de) to obtain the data.

Open Access This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

© Article author(s) (or their employer(s) unless otherwise stated in the text of the article) 2017. All rights reserved. No commercial use is permitted unless otherwise expressly granted.

REFERENCES

1. Wears RL, Perry SJ. Human factors and ergonomics in the emergency department. *Ann Emerg Med* 2002;40:206–12.
2. 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.
3. Nugus P, Holdgate A, Fry M, et al. Work pressure and patient flow management in the emergency department: findings from an ethnographic study. *Acad Emerg Med* 2011;18:1045–52.
4. 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.
5. 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.
6. Weigl M, Müller A, Holland S, et al. Work conditions, mental workload and patient care quality: a multisource study in the emergency department. *BMJ Qual Saf* 2016;25:499–508.
7. Werner NE, Holden RJ. Interruptions in the wild: development of a sociotechnical systems model of interruptions in the emergency department through a systematic review. *Appl Ergon* 2015;51:244–54.
8. Ratwani RM, Fong A, Puthumana JS, et al. Emergency physician use of cognitive strategies to manage interruptions. *Ann Emerg Med* 2017;70:683–7.

9. Brixey JJ, Robinson DJ, Johnson CW, *et al.* A concept analysis of the phenomenon interruption. *ANS Adv Nurs Sci* 2007;30:E26–42.
10. Chisholm CD, Weaver CS, Whenmouth L, *et al.* A task analysis of emergency physician activities in academic and community settings. *Ann Emerg Med* 2011;58:117–22.
11. 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.
12. Berg LM, Källberg AS, Göransson KE, *et al.* Interruptions in emergency department work: an observational and interview study. *BMJ Qual Saf* 2013;22:656–63.
13. Westbrook JI, Coiera E, Dunsmuir WT, *et al.* The impact of interruptions on clinical task completion. *Qual Saf Health Care* 2010;19:284–9.
14. Myers RA, McCarthy MC, Whitlatch A, *et al.* Differentiating between detrimental and beneficial interruptions: a mixed-methods study. *BMJ Qual Saf* 2016;25:881–8.
15. 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.
16. Cole G, Stefanus D, Gardner H, *et al.* The impact of interruptions on the duration of nursing interventions: a direct observation study in an academic emergency department. *BMJ Qual Saf* 2016;25:457–65.
17. Jeanmonod R, Boyd M, Loewenthal M, *et al.* The nature of emergency department interruptions and their impact on patient satisfaction. *Emerg Med J* 2010;27:376–9.
18. Berg LM, Källberg AS, Ehrenberg A, *et al.* Factors influencing clinicians' perceptions of interruptions as disturbing or non-disturbing: a qualitative study. *Int Emerg Nurs* 2016;27:11–16.
19. Grundgeiger T, Dekker S, Sanderson P, *et al.* Obstacles to research on the effects of interruptions in healthcare. *BMJ Qual Saf* 2016;25:392–5.
20. Tucker AL, Spear SJ. Operational failures and interruptions in hospital nursing. *Health Serv Res* 2006;41:643–62.
21. Rivera-Rodriguez AJ, Karsh BT. Interruptions and distractions in healthcare: review and reappraisal. *Qual Saf Health Care* 2010;19:304–12.
22. Weigl M, Müller A, Vincent C, *et al.* The association of workflow interruptions and hospital doctors' workload: a prospective observational study. *BMJ Qual Saf* 2012;21:399–407.
23. Tschan F, Seelandt JC, Keller S, *et al.* Impact of case-relevant and case-irrelevant communication within the surgical team on surgical-site infection. *Br J Surg* 2015;102:1718–25.
24. Arora S, Hull L, Sevdalis N, *et al.* Factors compromising safety in surgery: stressful events in the operating room. *Am J Surg* 2010;199:60–5.
25. Walter SR, Raban MZ, Dunsmuir WTM, *et al.* Emergency doctors' strategies to manage competing workload demands in an interruptive environment: an observational workflow time study. *Appl Ergon* 2017;58:454–60.
26. Potter P, Wolf L, Boxerman S, *et al.* Understanding the cognitive work of nursing in the acute care environment. *J Nurs Adm* 2005;35:327–35.
27. Raban MZ, Walter SR, Douglas HE, *et al.* Measuring the relationship between interruptions, multitasking and prescribing errors in an emergency department: a study protocol. *BMJ Open* 2015;5:e009076.
28. Ernst AF, Albers CJ. Regression assumptions in clinical psychology research practice—a systematic review of common misconceptions. *PeerJ* 2017;5:e3323.
29. Morrison JB, Rudolph JW. Learning from accident and error: avoiding the hazards of workload, stress, and routine interruptions in the emergency department. *Acad Emerg Med* 2011;18:1246–54.
30. McCurdie T, Sanderson P, Aitken LM. Applying social network analysis to the examination of interruptions in healthcare. *Appl Ergon* 2018;67(Suppl C):50–60.
31. Douglas HE, Raban MZ, Walter SR, *et al.* Improving our understanding of multi-tasking in healthcare: drawing together the cognitive psychology and healthcare literature. *Appl Ergon* 2017;59:45–55.

6.2 Publication 6: ED psychosocial work characteristics, employee strain and quality of care

Weigl, M., & Schneider, A. (2017). Associations of work characteristics, employee strain and self-perceived quality of care in emergency departments: A cross-sectional study. *International Emergency Nursing*, 30, 20-24.



Contents lists available at ScienceDirect

International Emergency Nursing

journal homepage: www.elsevier.com/locate/aaen

Associations of work characteristics, employee strain and self-perceived quality of care in Emergency Departments: A cross-sectional study

Matthias Weigl* (Dr), Anna Schneider (MPH)

Institute and Outpatient Clinic for Occupational, Social, and Environmental Medicine, Medical Faculty, Ludwig-Maximilians-University, Munich, Germany

ARTICLE INFO

Article history:

Received 5 April 2016

Received in revised form 1 June 2016

Accepted 15 July 2016

Available online xxx

Keywords:

Emergency care

Work stress

Healthcare professionals

Quality

ABSTRACT

Background: The individual and shared effects of adverse work characteristics on patient care in Emergency Departments (ED) are yet not well understood. We investigated the associations of self-reported ED work characteristics, work-related strain, and perceived quality of care.

Methods: Questionnaire-based survey with standardized measures among N = 53 ED professionals (i.e., nurses, physicians, and administration staff). The study was conducted in the interdisciplinary ED of a German community hospital.

Results: A high prevalence of work-related strain was observed: 66.0% of ED professionals showed high levels of emotional exhaustion and 55.6% showed irritation scores above the cut-off value. ED staff reported high supervisor support and autonomy, paired with high time pressure and patient-related stressors. Multivariate analyses revealed that high time pressure and low supervisor support were associated with high work-related strain. Low staffing was related to inferior quality of ED care.

Conclusions: ED work systems involve high competing demands for ED professionals with substantial risks for work-related strain. Moreover, adverse ED work characteristics comprise risks for high quality patient care. Our results suggest that promoting work characteristics might foster ED staff functioning on the job as well as improve ED patient care.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

Patient safety and quality of care in emergency medicine are repeatedly in the center of scholarly attention [1]. Among the sources of diminished quality of care that have been recognized in Emergency Departments (ED), high demands and challenges of the work system are particularly relevant [2,3]. ED work is associated with a high potential for work-related stress which contributes to strain as well as diminished quality of care [4,5]. However, the role of these factors in augmenting or mitigating risks for patients is still not well understood [1].

EDs impose high demands on professionals, especially during periods of high pressure [6,7]. A plethora of work demands on various levels exist [3,7]. On the organizational level, demands encompass coordination and communication problems, lack of teamwork, disruptions/interruptions, and staff shortages [6,8]. On the social level, verbally and physically aggressive patients and their relatives have been mentioned [6,9]. On the task level, competing demands,

short timelines (i.e., targets for length of stay), communication overload and highly variable workloads were identified [6,10]. Leadership and supervisor support have been acknowledged as important resources in dealing with stressful workloads and client interactions [6]. Nevertheless, ED work can also be perceived as inspiring and challenging with regard to teamwork, communication and unique opportunities to obtain vital technical and non-technical skills [6].

To capture the complexity of ED work and its effects on employee and care outcomes, studies that capture contextual as well as employee factors are necessary [1,11]. Adverse work characteristics are hazards to ED professionals' functioning on the job as well as to quality of care [12,13]. Therefore individual and shared effects of ED work characteristics on employee strain and quality of care deserve consideration [14]. To the best of our knowledge, prior studies did not address yet the individual as well as the shared effects of contextual and employee factors for ED quality of care.

We set out to simultaneously investigate the associations between multiple contextual characteristics of ED work, employee well-being and quality of care [1,15]. Using a cross-sectional survey methodology, we attempted to answer the following questions: What are the associations between ED work characteristics

* Corresponding author at: Institute and Outpatient Clinic for Occupational, Social, and Environmental Medicine, Ludwig-Maximilians-University Munich, Ziemssenstrasse 1, 80336 Munich, Germany.

E-mail address: matthias.weigl@med.lmu.de (M. Weigl).

and ED professionals' strain and self-perceived quality of care? To what extent do work characteristics moderate the association of employee strain and quality of care in EDs?

2. Materials and methods

2.1. Design and setting

A cross-sectional survey was conducted in the ED of an urban hospital in Southern Germany, which operates 24 h and is staffed with surgical and internal medicine clinicians. It serves 16,600 patients per year. In regard to size, patient census, work organization, staffing levels, and technological provisions, this ED is comparable to the majority of EDs in Germany [16,17].

Hospital-based emergency medicine in Germany differs from the Anglo-American model in some respects. Increasingly, inter-professional, centralized EDs are implemented (like at our study site). There is no ED specialty certification for physicians in Germany, thus physicians often rotate temporarily from other hospital wards to the ED. Only a few physicians are permanently allocated to EDs. Due to the broad services of practice-based general practitioners (GPs) and specialists, patients are requested to firstly make use of GP consultations before entering ED care. However, utilisation of EDs has increased steadily. The vast majority of patients in Germany are enrolled in a statutory or private healthcare insurance. Both types of insurance cover urgent emergency care and hospital treatment.

In our study, we used a convenience sample. The reported survey was part of a project on ED staff well-being and quality improvement. The Ethics Committee of the Medical Faculty at the Ludwig-Maximilians-University Munich approved the study (NR 406-11).

2.2. Procedure and sample

All 86 staff members of the studied ED, i.e., physicians, nurses and administrative officers, were eligible for participation. Paper questionnaires with an enclosed information letter and consent form were distributed. Completed questionnaires were sent directly to the research team. Altogether, 86 questionnaires were distributed to 21 nurses, 51 physicians and 14 administrative officers working in the ED. Fifty three questionnaires were returned representing a response rate of 61.6%.

2.3. Variables and measures

Sociodemographic measures included profession (nursing, physician, administration), job tenure (in years), and type of work contract (1 = full-time, 2 = part-time). Furthermore, average weekly overtime during the past month was inquired.

Ed work characteristics were measured with a validated self-report instrument for work analysis in hospitals [18]. It is a well-established instrument in Germany to evaluate health professionals work environment. Permission for use was granted by the authors. Five specific psychosocial work characteristics are investigated. The selection of measures was not based on a theoretical model. All scales ranged from 1 = no, not at all to 5 = yes, to a great extent. *Supervisor support* was measured with three items (e.g., "My direct supervisor provides clear feedback on my work performance"). *Staffing* was measured with one item ("Staffing in this ED is adequate"). *Time pressure* was measured with two items (e.g., "I often have too much work to do at once"). *Patient-related stressors* were measured with two items (e.g., "Care for multi-morbid patients is repeatedly burdening"). *Autonomy at work* was measured with a three-item scale drawn from the German version of

the Work-Design-Questionnaire [19]. An example item is "The job allows me to decide on the order in which things are done on the job".

ED professionals' work strain: The concept of irritation provides a useful measure of short-term changes in mental states related to work stress. It was measured with a six-item scale upon approval by the authors [20]. An example item is "Even at home I can't stop thinking about problems at work". Items were answered on a seven-point scale ranging from 1 = strongly disagree to 7 = strongly agree. ED professionals' emotional exhaustion was measured with a three-item scale from the German version of the Maslach Burnout Inventory [21]. An example item is "I feel burned out from my work". A frequency scale was applied from 1 = never to 6 = very often. Cut-offs to categorize ED professionals as having high or low work strain are based on normative classifications, where values above the scale means of irritation (M , $Mean > 3.10$) and emotional exhaustion ($M > 3.5$) are indicative of high work strain [22,23].

Quality of care: Before the start of the study, important quality of care indicators were identified in collaboration with the local department heads. Four major quality aspects were operationalized in the questionnaire (with the introductory question: "How do you rate the following aspects in this ED?"): (1) Internal patient transfer from the ED to hospital wards/ICU/ORs, (2) Quality of patient care in the ED?, (3) Length of stay in the ED?, (4) Quality of care in patients with extended lengths of stay? All four items were rated on a scale from 1 = very bad to 5 = very good.

2.4. Statistical methods

Descriptive analyses of study variables were computed for the overall group and for each ED profession separately. Mean differences were tested via analyses of variances. Subsequently, linear bivariate and multivariate regression analyses were conducted to determine individual and shared associations between ED work characteristics and work strain as well as self-perceived quality of care as outcome variables. All associations were controlled for type of work contract since exposure to work stressors is decreased in part-time work. Finally, moderation analyses were calculated. All possible combinations of different work characteristics and work-related strain were modelled to determine healthcare professionals' perceptions of quality of care as an outcome variable.

Prior to the main analyses we tested the psychometric reliabilities of our scales, which turned out to be satisfactory for supervisor support: $\alpha = 0.78$, time pressure: $\alpha = 0.82$, patient-related stressors: $\alpha = 0.77$, autonomy: $\alpha = 0.67$, irritation: $\alpha = 0.87$, exhaustion: $\alpha = 0.91$, and quality of care: $\alpha = 0.65$ [24]. Validity of our quality of care measure was established through an exploratory factor analysis (EFA, using orthogonal rotation, Varimax). Results suggested that all four quality of care items clustered into one single factor. All analyses were carried out with SPSS (23.0).

3. Results

Data were collected from 53 ED professionals: 29 physicians (54.7%), 13 nurses (24.5%), and 11 administration officers (20.8%). Forty one participants (77.4%) were working full-time while 11 worked part-time (20.8%; 1 missing value). Part-time employees were working $M = 19.9$ h per week ($SD = 12.2$). As Table 1 shows, nurses reported significantly higher job tenure than physicians and administration staff. Physicians reported significantly higher numbers of overwork hours compared to nurses and administration staff. For the overall group, we observed that two third of the participants reported emotional exhaustion above the cut-off value of $M > 3.5$ ($n = 35$, 66.0%); with the highest share in

Table 1
Characteristics of surveyed ED professionals.

		Overall group N = 53	ED Profession			Significance Test Chi ² /F, p
			Nurses N = 13 (24.5%)	Physicians N = 29 (54.7%)	Administration N = 11 (20.8%)	
Job tenure (years)	(M ± SD)	9.69 ± 8.57	15.46 ± 9.26	7.34 ± 7.05	9.05 ± 8.95	4.63; 0.01
Overtime per week (hours)	(M ± SD)	6.07 ± 5.37	2.49 ± 5.25	7.76 ± 4.92	2.67 ± 4.08	5.34; 0.01
Work contract	Full time	41 (77.4%)	8 (61.5%)	25 (89.3%)	8 (72.7%)	4.41; 0.11
	Part time	11 (20.8%)	5 (38.5%)	3 (10.7%)	3 (27.3%)	
Emotional exhaustion	Low (mean ≤ 3.5)	18 (34.0%)	6 (46.2%)	8 (27.6%)	4 (36.4%)	1.42; 0.49
	High (mean > 3.5)	35 (66.0%)	7 (53.8%)	21 (72.4%)	7 (63.6%)	
Irritation	Low (mean ≤ 3.1)	23 (43.4%)	4 (30.8%)	12 (48%)	7 (63.6%)	2.73; 0.26
	High (mean > 3.1)	30 (56.6%)	9 (69.2%)	17 (52%)	4 (36.4%)	

Note: M = Mean, SD = Standard deviation, p = significance level, bolded if $p < 0.05$. Frequency of missing values is not separately depicted; Scale Ranges: Emotional Exhaustion 1 = never to 6 = very often; Irritation 1 = strongly disagree to 7 = strongly agree.

physicians (72.4%). High irritation ($M > 3.10$) was reported by 56.6% of the ED staff ($n = 30$). No significant differences were observed between ED professions concerning work strain.

Table 2 reports the results of ED work characteristics and respective differences between ED professions. The overall group reported high autonomy and supervisor support whereas the rating of staffing levels was medium. Furthermore, high ratings of patient-related stressors and time pressure were observed. No statistically significant differences between the three ED professions were observed with regard to work characteristics. However, perceived quality of care was found to be lowest among administration and nursing staff compared to physicians, the only statistically significant finding in this section of results.

Regression analyses were calculated to determine bivariate (crude) and multivariate (adjusted) associations between work characteristics and employee strain and quality of care outcomes (Table 3). In bivariate associations, high autonomy at work and high supervisor support were associated with lower emotional exhaustion, whereas time pressure and patient-related stressors were associated with higher emotional exhaustion. In multivariate analyses, only time pressure was positively associated with ED professionals' emotional exhaustion. Supervisor support, time pressure, and patient-related stressors were associated with irritation in bivariate analyses. In the multivariate model, only supervisor support and time pressure remained significantly associated with irritation.

Higher ED staffing levels were found to be significantly associated with higher self-perceived quality of care in bivariate as well as multivariate analyses. In bivariate analyses, high time pressure was related to decreased evaluations of quality of care (Table 3).

ED professionals' emotional exhaustion and irritation were highly correlated with self-perceived quality of care: After adjusting for type of contract, increased exhaustion was correlated to lower ratings of perceived quality of care [$B = -0.30$ (95% CI $-0.57; -0.03$)]; while higher irritation related to decreased perceptions of quality of care [$B = -0.37$ (95% CI $-0.63; -0.11$)].

In the final step, potential moderation effects of work-related strain were tested between all five work characteristics and self-perceived quality of care. For emotional exhaustion, no significant moderation effects were found between work characteristics and quality of care. However, a significant moderation effect of irritation on the association of autonomy at work and quality of care [interaction term, $B = 0.30$; 95% CI: $0.02-0.57$] was observed. Thus, in ED staff with low autonomy, higher irritation was associated with lower reports of ED care quality.

4. Discussion

Previous research on ED work characteristics mostly included narrative descriptions of the ED work environment [3]. Associations between specific ED work characteristics and employees' work-related strain and quality of care outcomes were however rarely addressed. A key contribution of our study is the determination of associations between psychosocial work characteristics and employee strain as well as quality of care outcomes in a sample of different ED professionals, i.e., nurses, physicians, and ED administration staff.

Our results show that unfavorable ED work environments are associated with increased employee strain which is consistent to previous research on this topic [2,5]. Perceived time pressure con-

Table 2
ED work characteristics, employees' work-related strain, and self-perceived quality of care (overall and for each ED profession).

Variables	Overall Group N = 53 (M ± SD)	ED Profession			Significance (F; p)
		Nurses N = 13 (M ± SD)	Physicians N = 29 (M ± SD)	Administration N = 11 (M ± SD)	
<i>ED work characteristics</i>					
Autonomy	3.08 ± 0.76	2.79 ± 0.75	3.17 ± 0.65	3.15 ± 0.98	1.20; 0.31
Staffing	2.83 ± 1.07	2.54 ± 0.97	3.14 ± 0.95	2.36 ± 1.29	2.93; 0.06
Supervisor support	3.08 ± 0.90	3.10 ± 1.02	2.86 ± 0.80	3.61 ± 0.84	2.93; 0.06
Time pressure	3.17 ± 0.88	3.00 ± 0.87	3.34 ± 0.84	2.89 ± 0.98	1.40; 0.26
Patient-related stressors	3.63 ± 0.91 ^a	4.04 ± 0.80	3.59 ± 0.90	3.25 ± 0.95 ^a	2.34; 0.11
<i>Employee strain</i>					
Emotional exhaustion	3.98 ± 1.22	3.77 ± 1.42	4.29 ± 1.10	3.41 ± 1.08	2.46; 0.10
Irritation	3.33 ± 1.25	3.53 ± 1.38	3.48 ± 1.18	2.70 ± 1.16	1.84; 0.17
<i>Quality of care</i>					
Self-perceived quality of care	3.10 ± 0.58	2.92 ± 0.56	3.30 ± 0.56	2.77 ± 0.48	4.74; 0.01

Note: M = Mean, SD = Standard deviation, Significance testing: ANOVA, bolded if $p < 0.05$.

^a one missing value. Scale Ranges: Work characteristics 1 = no, not all to 5 = yes, to a very great extent; Emotional Exhaustion 1 = never to 6 = very often; Irritation 1 = strongly disagree to 7 = strongly agree; Quality of Care: 1 = very bad to 5 = very good.

Table 3
Associations between ED professionals' work characteristics, work-related strain and self-perceived quality of care (Linear regression analyses).

	ED professionals' strain and quality of care outcomes					
	Emotional exhaustion		Irritation		Self-perceived quality of care	
	Associations and significance testing		Associations and significance testing		Associations and significance testing	
	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted
Work characteristics	B [95% CI]	B [95% CI]	B [95% CI]	B [95% CI]	B [95% CI]	B [95% CI]
Autonomy	-0.36 [-0.66; -0.06]	-0.15 [-0.41; 0.10]	-0.21 [-0.52; 0.10]	0.05 [-0.19; 0.28]	0.18 [-0.13; 0.48]	0.05 [-0.24; 0.35]
Staffing	-0.07 [-0.37; 0.23]	-0.01 [-0.25; 0.22]	-0.19 [-0.49; 0.11]	-0.15 [-0.36; 0.07]	0.35 [0.08; 0.63]	0.35 [0.08; 0.62]
Supervisor support	-0.42 [-0.68; -0.15]	-0.23 [-0.48; 0.01]	-0.45 [-0.72; -0.19]	-0.24 [-0.47; -0.02]	0.16 [-0.12; 0.45]	0.07 [-0.22; 0.36]
Time pressure	0.63 [0.40; 0.86]	0.52 [0.26; 0.79]	0.68 [0.46; 0.90]	0.48 [0.24; 0.73]	-0.29 [-0.56; -0.02]	-0.09 [-0.40; 0.22]
Patient-related stressors	0.41 [0.14; 0.68]	0.01 [-0.27; 0.28]	0.57 [0.32; 0.82]	0.23 [-0.02; 0.49]	-0.31 [-0.59; -0.04]	-0.23 [-0.56; 0.09]

Note: M = Mean, SD = Standard deviation; B = non-standardized regression coefficient; 95% CI = Confidence interval; Tests for associations were computed with standardized variables; Crude (bivariate) and adjusted (multivariate) associations were controlled for type of contract (full-time/part-time); Participants with missing data were not excluded; bolded if $p < 0.05$.

tributed to increased emotional exhaustion (a core component of burnout) and irritation. Moreover, high supervisor support reduced the risk for irritation, suggesting that an employee-oriented leadership in EDs might serve as a valuable resource against ED professionals' strain [6]. Our findings corroborate that adverse ED work environments are likely to increase the risk of burnout and other critical mental health conditions [25].

Furthermore, our results showed that ED professionals' perceptions of adverse work conditions were associated with lower perceptions of quality of care. Particularly, insufficient perceptions of staffing levels were the most important determinant for inferior quality of care in the respective ED. Moreover, the association between ED professionals' work strain was buffered by high supervisor support indicating that resources in the work environment may contribute to less employee strain. Thus, well-designed ED work systems with an adequate number of healthcare professionals, contribute to employee functioning as well as to high-quality care practices [7,12].

Our investigation showed that ED staff reported high work stressors (i.e., time pressure and patient stressors) as well as high work resources, such as autonomy and supervisor support. This corroborates the prevailing view of EDs as both inspiring and potentially demoralizing working environments. In terms of Karasek's Demands-Control-Model, the surveyed ED professionals can be assigned to active jobs which are characterized by high degrees of job control paired with high job demands [26,27]. Notwithstanding, high work stressors need to be constantly evaluated and maintained at a feasible level [3].

Finally, our study contributes to existing literature on ED staffs' mental health [25]. A third of our surveyed ED professionals reported high emotional exhaustion scores with the highest prevalence among physicians. Thus ED professionals seem to be at a significant risk to experience adverse work stress.

We found that physicians reported significantly higher perceptions of quality of care than nurses and administration staff. This observation deserves further investigation in future studies. Post-hoc we assume that nurses and administrators are likely to be more directly confronted with the consequences of poor care practices since feedback from patients and relatives may first be directed to those ED professions. Another explanation for our specific sample of German physicians might be that they often rotate temporarily to EDs and thus are not fully aware of the spectrum of potential safety and care threats in this clinical environment.

4.1. Implications

Enhancing ED practices through the creation of efficient and reliable work systems is a major challenge. Our results corroborate that the improvement of ED work environments may concurrently

foster individual well-being of ED professionals as well as foster the quality of ED patient care. Future efforts and interventions should investigate the ability of redesign and improvement measures in ED work systems to improve employee as well as quality of care outcomes [3]. Longitudinal comprehensive investigations that account for the complexity and dynamics of ED work are suggested. Our results further support the continuous and comprehensive assessment of ED staff perceptions of the work environment [3]. Regular assessments of staff perceptions of the work environment (e.g., by means of psychosocial risk evaluations) may reduce the risk of work-related strain and burnout by identifying and preventing stressful work conditions [25]. Our findings may contribute to intervention studies that promote sound work environments in the ED as well as ED staff morale [3]. Interventions may include re-design activities of the ED work organization and other aspects of the work environment with an explicit involvement of concerned ED employees as well as measures to strengthen resilient strategies of ED staff in order to accomplish efficient and reliable ED care [28].

4.2. Limitations

This study has a number of limitations. First, the study design allows no causal inferences. It cannot be excluded that the direction of associations might be in the reverse direction, i.e., that highly-strained ED professionals evaluate the study outcomes worse than their less strained colleagues. Second, all outcomes draw on self-reports which creates the risk of common methods bias [29]. Previous studies used a wide range of different assessment tools for staff perceptions of the ED working environment. This methodical variance limits the comparability of findings across studies [3]. Although our tool to measure work characteristics is well-established for assessments in German hospitals, it is not widely used outside of German-speaking countries which limits the comparability of our results to similar assessments. Third, although the study ED is representative for the majority of EDs in Germany, our findings may not be generalizable to other (international) settings and health care institutions that may be subject to different public health services systems and work-related stressors and resources. Fourth, our investigation draws on a limited sample size. Although many studies in single ED facilities include comparatively small samples, the robustness of multivariate findings may be confined. Fifth, potential selection bias cannot be excluded. Sixth, although the outcome variable 'quality of care' used in this study showed satisfactory psychometric properties, further studies into the external validity of this measure are warranted. Seventh, due to the exploratory nature of our study we did not apply adjustments for multiple testing or checks for multi-collinearity among predictors. Eighth, due to confidentiality agreements, potentially

relevant demographic information was not collected, e.g., gender. Finally, we acknowledge that our selection of the set of studied ED work characteristics was mainly arbitrary. Therefore other potentially important ED work characteristics may have been missed. ED care systems are complex sociotechnical systems with a large spectrum of contextual and process factors that need to be considered in future studies [8,14].

5. Conclusions

Our results indicate that accomplishing reliable care in EDs depends on staff perceptions of the work environment as well as staff mental well-being. The design of beneficial ED work environments is a promising approach to ensure high-quality care practices. Our results suggest that staff perceptions of supervisor support and adequate staffing levels, as well as the reduction of ED professionals' work strain are important starting points for improvement efforts. This study contributes further to an increased understanding of the interplay of work characteristics, employee well-being and quality of care in EDs.

Acknowledgements

This work was supported by the Munich Centre of Health Sciences (MC-Health). We thank Dr. Susanne Wedel for her support.

References

- [1] Wears RL, Woloshynowych M, Brown R, Vincent CA. Reflective analysis of safety research in the hospital accident & emergency departments. *Appl. Ergon.* 2010;41:695–700.
- [2] Adriaenssens J, De Gucht V, Van Der Doef M, Maes S. Exploring the burden of emergency care: predictors of stress-health outcomes in emergency nurses. *J. Adv. Nurs.* 2011;67:1317–28.
- [3] Johnston A, Abraham L, Greenslade J, Thom O, Carlstrom E, Wallis M, Crilly J. Review article: staff perception of the emergency department working environment: integrative review of the literature. *Emerg. Med. Aust.* 2016.
- [4] Adriaenssens J, De Gucht V, Maes S. Determinants and prevalence of burnout in emergency nurses: a systematic review of 25 years of research. *Int. J. Nurs. Stud.* 2015;52:649–61.
- [5] Hunsaker S, Chen HC, Maughan D, Heaston S. Factors that influence the development of compassion fatigue, burnout, and compassion satisfaction in emergency department nurses. *J. Nurs. Scholarsh.* 2015;47:186–94.
- [6] Flowerdew L, Brown R, Russ S, Vincent C, Woloshynowych M. Teams under pressure in the emergency department: an interview study. *Emerg. Med. J.* 2012;29:e2.
- [7] Nielsen KJ, Pedersen AH, Rasmussen K, Pape L, Mikkelsen KL. Work-related stressors and occurrence of adverse events in an ED. *Am. J. Emerg. Med.* 2013;31:504–8.
- [8] Werner NE, Holden RJ. Interruptions in the wild: development of a sociotechnical systems model of interruptions in the emergency department through a systematic review. *Appl. Ergon.* 2015;51:244–54.
- [9] Adriaenssens J, de Gucht V, Maes S. The impact of traumatic events on emergency room nurses: findings from a questionnaire survey. *Int. J. Nurs. Stud.* 2012;49:1411–22.
- [10] Levin S, France DJ, Hemphill R, Jones I, Chen KY, Rickard D, Makowski R, Aronsky D. Tracking workload in the emergency department. *Hum. Factors* 2006;48:526–39.
- [11] Wears RL, Perry SJ. Human factors and ergonomics in the emergency department. *Ann. Emerg. Med.* 2002;40:206–12.
- [12] Rasmussen K, Pedersen AH, Pape L, Mikkelsen KL, Madsen MD, Nielsen KJ. Work environment influences adverse events in an emergency department. *Dan. Med. J.* 2014;61:A4812.
- [13] Spencer R, Coiera E, Logan P. Variation in communication loads on clinical staff in the emergency department. *Ann. Emerg. Med.* 2004;44:268–73.
- [14] Carayon P, Wetterneck TB, Rivera-Rodriguez AJ, Hundt AS, Hoonakker P, Holden R, Gurses AP. Human factors systems approach to healthcare quality and patient safety. *Appl. Ergon.* 2014;45:14–25.
- [15] Weigl M, Müller A, Holland S, Wedel S, Woloshynowych M. Work conditions, mental workload and patient care quality: a multisource study in the emergency department. *BMJ Qual. Saf.* 2016.
- [16] Brachmann M. Notaufnahmen in Deutschland [emergency units in Germany]. In: Eiff W, von Dodt C, Brachmann M, editors. *Management Der Notaufnahme [Management of the Emergency Unit]*. Stuttgart: Kohlhammer; 2011. p. 42–52.
- [17] Fleischmann T, Walter B. Interdisziplinäre Notaufnahmen in Deutschland: Eine Anlaufstelle für alle Notfälle. *Dtsch Arztebl* 2007;104:3164–6.
- [18] Büsing A, Glaser J. Work analysis instrument for hospitals (TAA-KH). A method for the psychological assessment of occupational health in hospitals. *Work Stress* 2000;14:190.
- [19] Stegmann S, van Dick R, Ullrich J, Charalambous J, Menzel B, Egold N, Wu TTC. The work design questionnaire – introduction and validation of a German version. *Zeitschrift für Arbeits- und Organisationspsychologie* 2010;54:1–28.
- [20] Mohr G, Müller A, Rigotti T, Aycan Z, Tschan F. The assessment of psychological strain in work contexts: concerning the structural equivalency of nine language adaptations of the irritation scale. *Eur. J. Psychol. Assess.* 2006;22:198–206.
- [21] Büsing A, Perrar KM. Measurement of Burnout. The German Version of the Maslach Burnout Inventory (MBI-D). *Diagnostica* 1992;38:328–53.
- [22] Kleijweg JH, Verbraak MJ, Van Dijk MK. The clinical utility of the Maslach Burnout inventory in a clinical population. *Psychol. Assess.* 2013;25:435–41.
- [23] Mohr G, Rigotti T. Irritation (Gereiztheit). In: Danner D, Glöckner-Rist A, editors. *Zusammenstellung Sozialwissenschaftlicher Items Und Skalen. ZIS-GEISIS*; 2014.
- [24] Bland JM, Altman DG. Cronbach's alpha. *BMJ* 1997;314:572.
- [25] Arora M, Asha S, Chinnappa J, Diwan AD. Review article: burnout in emergency medicine physicians. *Emerg. Med. Aust.* 2013;25:491–5.
- [26] Karasek RA. Job demands, job decision latitude and mental strain: implications for job redesign. *Adm. Sci. Q.* 1979;24:285–306.
- [27] Trousselard M, Dutheil F, Naughton G, Cosserant S, Amadon S, Duale C, Schoeffler P. Stress among nurses working in emergency, anaesthesiology and intensive care units depends on qualification: a job demand-control survey. *Int. Arch. Occup. Environ. Health* 2016;89:221–9.
- [28] Fairbanks RJ, Wears RL, Woods DD, Hollnagel E, Plsek P, Cook RI. Resilience and resilience engineering in health care. *Jt. Comm. J. Qual. Patient Saf.* 2014;40:376–83.
- [29] Podsakoff PM, MacKenzie SB, Lee JY, Podsakoff NP. Common method biases in behavioral research: a critical review of the literature and recommended remedies. *J. Appl. Psychol.* 2003;88:879–903.

7 Conclusions and outlook

No panacea is currently available to improve psychosocial ED work factors while at the same time positively affecting ED employees' mental well-being and quality of patient care. Reasons stem from the complexity of the ED work system including profession- and institution-specific challenges and individual stress experiences of healthcare employees. However, a combination of multiple intertwined intervention measures targeting different aspects of the work environment might be promising in improving aspects of employee well-being and patient satisfaction.

Regarding organizational-level interventions, a strong focus on employee participation and employee activation in the preparation, implementation and evaluation of improvement measures is key to the success of participative approaches in work reorganization. However, appropriate actions to motivate and incorporate employees into work system improvement in the long-term require the adoption of practical framework conditions and supervisor and team support (Nielsen et al., 2010). The inclusion of external consultants or facilitators is seen as ambiguous with regard to long-term effects of organizational-level health interventions. Ideally, employees build an ownership which involves responsibility for project failures and successes including decision authority about planning and monitoring of the overall process and intervention (Nielsen et al., 2010). Studies found that if not all employees are given the opportunity to actively participate in the intervention, allegedly excluded employees might develop a cynical view of the intervention and subsequently report worse ratings of the work environment (Nielsen et al., 2010). However, due to multiple interests, shared norms and beliefs in different professional as well as organizational groups, it is difficult to develop measures and interventions which are to the advantage of all system participants and which are able to improve working conditions for all involved parties.

Systemic approaches to healthcare improvement incorporate the view that all changes to the work system can positively or negatively affect work factors, employee well-being and patient outcomes (Carayon, 2009). Thus, system modifications induced by interventions cannot be considered in isolation. So-called omnibus and discrete factors may be identified in the context of the intervention suggesting that specific events or prevailing characteristics of the work environment and employees, respectively, can affect intervention outcomes (Nielsen et al., 2010). EDs are embedded in the larger

system of a hospital and national healthcare system. This entails specific inherent limitations and barriers to intervention measures developed by employees. Some aspects can only be changed at a higher system level, e.g., hospital management or through legislation. It is also questionable if ED-inherent work conditions, e.g., time pressure or unpredictable patient load, are subject to change by employees since these conditions are dependent on external factors and are not in employees' direct realm. ED systems are adaptive and resilient to factors such as critical working conditions and the mental ill health of individual employees most of the time. Systems are thus dynamic and at times unpredictable since they self-organize and constantly adapt to new circumstances (Braithwaite et al., 2015). Ensuring staff autonomy is an important prerequisite for resilient systems since performance variability and the system's and person's ability to adjust to unforeseen circumstances is essential for high-quality outcomes.

Bearing in mind the concept of resilient healthcare, future studies on this topic should first take an observational approach by analyzing how EDs handle comprehensive organizational changes, i.e., by identifying system's resilience strategies to adjust ED performance to varying circumstances while maintaining high levels of care quality. Individual and collective strategies by employees to resist adverse psychosocial work factors have to be described, e.g., by observing processes and communication patterns over a longer period of time. So far, the focus of resilience engineering lay on system component's associations with patient safety and associated system failures (Hollnagel, Wears, et al., 2015). However, future studies should consider how system resilience comes at the cost or advantage of employee well-being. Thus, it is possible that the current adaptation process to system disturbances places extensive stress on employee's mental resources and capacities which might lead to mental ill health in the long term. Studies on how employee health and well-being can be explicitly integrated into the concept of complex adaptive systems and resilient health care as concurrent system determinants and outcomes, have to be conducted. Finally, every intervention design in EDs or other clinical environments should consider that "when dealing with a complex adaptive system, the way forward should be evolution, not revolution" (Clay-Williams, 2015, p. 133).

8 References

- Adriaenssens, J., de Gucht, V., & Maes, S. (2015). Determinants and prevalence of burnout in emergency nurses: A systematic review of 25 years of research. *International Journal of Nursing Studies*, *52*(2), 649-661.
- Alarcon, G. M., Eschleman, K. J., & Bowling, N. A. (2009). Relationships between personality variables and burnout: A meta-analysis. *Work & Stress*, *23*(3), 244-263.
- Aust, B., & Ducki, A. (2004). Comprehensive health promotion interventions at the workplace: Experiences with health circles in Germany. *Journal of Occupational Health Psychology*, *9*(3), 258-270.
- Bamberger, G. G. (2015). Von den Anfängen der systemischen Therapie. In *Lösungsorientierte Beratung* (5 ed., pp. 27-57). Weinheim: Beltz Verlagsgruppe.
- Basu, S., Qayyum, H., & Mason, S. (2017). Occupational stress in the ED: A systematic literature review. *Emergency Medicine Journal*, *34*, 441-447.
- Bragard, I., Dupuis, G., & Fleet, R. (2015). Quality of work life, burnout, and stress in emergency department physicians: A qualitative review. *European Journal of Emergency Medicine*, *22*(4), 227-234.
- Braithwaite, J., Clay-Williams, R., Nugus, P., & Plumb, J. (2015). Health care as a complex adaptive system. In E. Hollnagel, J. Braithwaite, & R. Wears (Eds.), *Resilient health care* (pp. 57-73). Surrey: Ashgate Publishing Limited.
- Brokmann, J. C., Pin, M., Bernhard, M., Walcher, F., & Gries, A. (2019). Neustrukturierung der stationären Notfallversorgung. [Restructuring of inpatient emergency treatment]. *Der Anaesthetist*, *68*(5), 261-269.
- Büssing, A., & Glaser, J. (2002). *Das Tätigkeits- und Arbeitsanalyseverfahren für das Krankenhaus – Selbstbeobachtungsversion (TAA-KH-S)*. [Work Analysis Instrument for Hospitals – Self Report Version (TAA-KH-S)]. Göttingen: Hogrefe.
- Büssing, A., & Glaser, J. (2003). Mitarbeiter- und Klientenorientierung im Gesundheitswesen. [Employee and client orientation in health care services]. *Zeitschrift für Arbeits- und Organisationspsychologie A&O*, *47*(4), 222-228.

- Büssing, A., & Perrar, K.-M. (1992). Die Messung von Burnout. Untersuchung einer deutschen Fassung des Maslach Burnout Inventory (MBI-D). [Measurement of burnout. Investigation of a German version of the Maslach Burnout Inventory (MBI-D)]. *Diagnostica*, 38, 328-353.
- Carayon, P. (2009). The balance theory and the work system model ... Twenty years later. *International Journal of Human-Computer Interaction*, 25(5), 313-327.
- Carayon, P., & Smith, M. J. (2000). Work organization and ergonomics. *Applied Ergonomics*, 31(6), 649-662.
- Clay-Williams, R. (2015). Re-structuring and the resilient organisation: Implications for health care. In E. Hollnagel, J. Braithwaite, & R. L. Wears (Eds.), *Resilient health care* (pp. 123-134). Surrey: Ashgate Publishing Limited.
- de Lange, A. H., Taris, T. W., Kompier, M. A. J., Houtman, I. L. D., & Bongers, P. M. (2003). "The very best of the millennium": Longitudinal research and the demand-control-(support) model. *Journal of Occupational Health Psychology*, 8(4), 282-305.
- de Shazer, S. (2004). Der Begriff „System“. In *Das Spiel mit Unterschieden: Wie therapeutische Lösungen lösen* (4 ed., pp. 36-48). Heidelberg: Carl-Auer-Systeme Verlag.
- Fuchs, C., Çelik, B., Brouns, S. H. A., Kaymak, U., & Haak, H. R. (2019). No age thresholds in the emergency department: A retrospective cohort study on age differences. *PLoS One*, 14(1), e0210743.
- Ganster, D. C., & Rosen, C. C. (2013). Work stress and employee health: A multidisciplinary review. *Journal of Management*, 39(5), 1085-1122.
- Greenwood-Ericksen, M. B., & Kocher, K. (2019). Trends in emergency department use by rural and urban populations in the United States. *JAMA Network Open*, 2(4), e191919.
- Hacker, W. (2003). Action regulation theory: A practical tool for the design of modern work processes? *European Journal of Work and Organizational Psychology*, 12(2), 105-130.
- Hall, L. H., Johnson, J., Watt, I., Tsipa, A., & O'Connor, D. B. (2016). Healthcare staff wellbeing, burnout, and patient safety: A systematic review. *PLoS One*, 11(7), e0159015.

-
- Handel, D. A., French, L. K., Nichol, J., Momberger, J., & Fu, R. (2014). Associations between patient and emergency department operational characteristics and patient satisfaction scores in an adult population. *Annals of Emergency Medicine, 64*(6), 604-608.
- Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In P. A. Hancock & N. Meshkati (Eds.), *Advances in Psychology* (Vol. 52, pp. 139-183). Amsterdam: Elsevier Science Publishers B.V.
- Hollnagel, E., Braithwaite, J., & Wears, R. (2015). Preface: On the need for resilience in health care. In E. Hollnagel, J. Braithwaite, & R. Wears (Eds.), *Resilient health care* (pp. xviii-xxvi). Surrey: Ashgate Publishing Limited.
- Hollnagel, E., Wears, R. L., & Braithwaite, J. (2015). From Safety-I to Safety-II: A white paper. The Resilient Health Care Net: Published simultaneously by the University of Southern Denmark, University of Florida, USA, and Macquarie University, Australia.
- Humphrey, S. E., Nahrgang, J. D., & Morgeson, F. P. (2007). Integrating motivational, social, and contextual work design features: A meta-analytic summary and theoretical extension of the work design literature. *Journal of Applied Psychology, 92*(5), 1332-1356.
- Kleijweg, J. H. M., Verbraak, M. J. P. M., & Van Dijk, M. K. (2013). The clinical utility of the Maslach Burnout Inventory in a clinical population. *Psychological Assessment, 25*(2), 435-441.
- Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2003). The Patient Health Questionnaire-2: Validity of a two-item depression screener. *Medical Care, 41*(11), 1284-1292.
- Leis, J. A., & Shojania, K. G. (2017). A primer on PDSA: Executing plan-do-study-act cycles in practice, not just in name. *BMJ Quality & Safety, 26*, 572-577.
- Magrabi, F., Li, S. Y. W., Dunn, A. G., & Coeira, E. (2011). Challenges in measuring the impact of interruption on patient safety and workflow outcomes. *Methods of Information in Medicine, 50*(5), 447-453.
- Marteau, T. M., & Bekker, H. (1992). The development of a six-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory (STAI). *British Journal of Clinical Psychology, 31*(3), 301-306.

- Mohr, G., Müller, A., Rigotti, T., Aycan, Z., & Tschan, F. (2006). The assessment of psychological strain in work contexts. *European Journal of Psychological Assessment*, 22(3), 198-206.
- Montano, D., Hoven, H., & Siegrist, J. (2014). Effects of organisational-level interventions at work on employees' health: A systematic review. *BMC Public Health*, 14, 135.
- Morganti, K. G., Bauhoff, S., Blanchard, J. C., Abir, M., Iyer, N., Smith, A., . . . Kellermann, A. L. (2013). The evolving role of emergency departments in the United States. Santa Monica: RAND Corporation.
- Morley, C., Unwin, M., Peterson, G. M., Stankovich, J., & Kinsman, L. (2018). Emergency department crowding: A systematic review of causes, consequences and solutions. *PLoS One*, 13(8), e0203316.
- National Academies of Sciences, Engineering, and Medicine (2019). Taking action against clinician burnout: A systems approach to professional well-being. Washington, DC: The National Academies Press.
- Nielsen, K., & Randall, R. (2013). Opening the black box: Presenting a model for evaluating organizational-level interventions. *European Journal of Work and Organizational Psychology*, 22(5), 601-617.
- Nielsen, K., Randall, R., Holten, A.-L., & González, E. R. (2010). Conducting organizational-level occupational health interventions: What works? *Work & Stress*, 24(3), 234-259.
- Nielsen, K. J., Pedersen, A. H., Rasmussen, K., Pape, L., & Mikkelsen, K. L. (2013). Work-related stressors and occurrence of adverse events in an ED. *American Journal of Emergency Medicine*, 31(3), 504-508.
- Ogilvie, D., Fayter, D., Petticrew, M., Sowden, A., Thomas, S., Whitehead, M., & Worthy, G. (2008). The harvest plot: A method for synthesising evidence about the differential effects of interventions. *BMC Medical Research Methodology*, 8, 8.
- Pfeiffer, Y., & Manser, T. (2010). Development of the German version of the Hospital Survey on Patient Safety Culture: Dimensionality and psychometric properties. *Safety Science*, 48(10), 1452-1462.

- Powell, M. P., Yu, X., Isehunwa, O., & Chang, C. F. (2018). National trends in hospital emergency department visits among those with and without multiple chronic conditions, 2007–2012. *Hospital Topics, 96*(1), 1-8.
- Pronovost, P. J., Cleeman, J. I., Wright, D., & Srinivasan, A. (2016). Fifteen years after "To Err is Human": A success story to learn from. *BMJ Quality & Safety, 25*, 396-399.
- Rasmussen, J., & Lind, M. (1981). Coping with complexity. Roskilde: Risø National Laboratory. Risø-M, No. 2293.
- Rödel, A., Siegrist, J., Hessel, A., & Brähler, E. (2004). Fragebogen zur Messung beruflicher Gratifikationskrisen. [Psychometric test of the questionnaire measuring effort-reward imbalance at work in a representative German sample]. *Zeitschrift für Differentielle und Diagnostische Psychologie, 25*(4), 227-238.
- Ruotsalainen, J., Serra, C., Marine, A., & Verbeek, J. (2008). Systematic review of interventions for reducing occupational stress in health care workers. *Scandinavian Journal of Work, Environment & Health, 34*(3), 169-178.
- Sasangohar, F., Donmez, B., Trbovich, P., & Easty, A. C. (2012). Not all interruptions are created equal: Positive interruptions in healthcare. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 56*(1), 824-828.
- Scherer, M., Lühmann, D., Kazek, A., Hansen, H., & Schäfer, I. (2017). Patienten in Notfallambulanzen - Querschnittstudie zur subjektiv empfundenen Behandlungsdringlichkeit und zu den Motiven, die Notfallambulanzen von Krankenhäusern aufzusuchen. [Patients attending emergency departments - a cross-sectional study of subjectively perceived treatment urgency and motivation for attending]. *Deutsches Ärzteblatt International, 114*, 645-652.
- Schneider, A., Wehler, M., & Weigl, M. (2019a). Effects of work conditions on provider mental well-being and quality of care: A mixed-methods intervention study in the emergency department. *BMC Emergency Medicine, 19*, 1.
- Schneider, A., Wehler, M., & Weigl, M. (2019b). Provider interruptions and patient perceptions of care: An observational study in the emergency department. *BMJ Quality & Safety, 28*, 296-304.

- Schneider, A., & Weigl, M. (2018). Associations between psychosocial work factors and provider mental well-being in emergency departments: A systematic review. *PLoS One*, *13*(6), e0197375.
- Schneider, A., Williams, D., Kalynych, K., Wehler, M., & Weigl, M. (in press). Physicians' and nurses' work time allocation and workflow interruptions in emergency departments: A comparative time-motion study across two countries. *Emergency Medicine Journal*.
- Schuettig, W., & Sundmacher, L. (2019). Ambulatory care-sensitive emergency department cases: A mixed methods approach to systemize and analyze cases in Germany. *European Journal of Public Health*, *29*(6), 1024-1030.
- Siegrist, J., Wege, N., Pühlhofer, F., & Wahrendorf, M. (2008). A short generic measure of work stress in the era of globalization: Effort–reward imbalance. *International Archives of Occupational and Environmental Health*, *82*, 1005 (2008).
- Son, C., Sasangohar, F., Rao, A. H., Larsen, E. P., & Neville, T. (2019). Resilient performance of emergency department: Patterns, models and strategies. *Safety Science*, *120*, 362-373.
- Sutcliffe, K. M., & Weick, K. E. (2015). Mindful organising and resilient health care. In E. Hollnagel, J. Braithwaite, & R. L. Wears (Eds.), *Resilient health care* (pp. 145-158). Surrey: Ashgate Publishing Limited.
- Thomas, N. K. (2004). Resident burnout. *JAMA*, *292*(23), 2880-2889.
- Tille, F., Röttger, J., Gibis, B., Busse, R., Kuhlmeier, A., & Schnitzer, S. (2019). Patients' perceptions of health system responsiveness in ambulatory care in Germany. *Patient Education and Counseling*, *102*(1), 162-171.
- Trentzsch, H., Dodt, C., Gehring, C., Veser, A., Jauch, K.-W., Prückner, S., & Studiengruppe „Runder Tisch Notfallversorgung Landeshauptstadt München“ (2019). Analyse der Behandlungszahlen in den Münchener Notaufnahmen des Jahres 2013/2014. [Analysis of treatment figures in the Munich emergency rooms 2013–2014]. *Gesundheitswesen*.
- Vogel, J. A., Rising, K. L., Jones, J., Bowden, M. L., Ginde, A. A., & Havranek, E. P. (2019). Reasons patients choose the emergency department over primary care: A qualitative metasynthesis. *Journal of General Internal Medicine*, *34*(11), 2610-2619.

- Wahlster, P., Czihal, T., Gibis, B., & Henschke, C. (2019). Sektorenübergreifende Entwicklungen in der Notfallversorgung – Eine umfassende Analyse ambulanter und stationärer Notfälle von 2009 bis 2015. [Developments in emergency care – analysis of emergency cases in in- and outpatient care from 2009 to 2015 in Germany]. *Gesundheitswesen*.
- Wallace, J. E., Lemaire, J. B., & Ghali, W. A. (2009). Physician wellness: A missing quality indicator. *Lancet*, 374(9702), 1714-1721.
- Waterman, A. D., Garbutt, J., Hazel, E., Dunagan, W. C., Levinson, W., Fraser, V. J., & Gallagher, T. H. (2007). The emotional impact of medical errors on practicing physicians in the United States and Canada. *Joint Commission Journal on Quality and Patient Safety*, 33(8), 467-476.
- Wears, R. L., & Perry, S. J. (2002). Human factors and ergonomics in the emergency department. *Annals of Emergency Medicine*, 40(2), 206-212.
- Wears, R. L., & Vincent, C. (2015). Relying on resilience: Too much of a good thing? In E. Hollnagel, J. Braithwaite, & R. Wears (Eds.), *Resilient health care* (pp. 135-144). Surrey: Ashgate Publishing Limited.
- Wears, R. L., Woloshynowych, M., Brown, R., & Vincent, C. A. (2010). Reflective analysis of safety research in the hospital accident & emergency departments. *Applied Ergonomics*, 41(5), 695-700.
- Weigl, M., Beck, J., Wehler, M., & Schneider, A. (2017). Workflow interruptions and stress at work: A mixed-methods study among physicians and nurses of a multidisciplinary emergency department. *BMJ Open*, 7(12), e019074.
- Weigl, M., Hoffmann, F., Müller, A., Barth, N., & Angerer, P. (2014). Hospital paediatricians' workflow interruptions, performance, and care quality: A unit-based controlled intervention. *European Journal of Pediatrics*, 173(5), 637-645.
- Weigl, M., Hornung, S., Angerer, P., Siegrist, J., & Glaser, J. (2013). The effects of improving hospital physicians working conditions on patient care: A prospective, controlled intervention study. *BMC Health Services Research*, 13, 401 (2013).

-
- Weigl, M., Müller, A., Holland, S., Wedel, S., & Woloshynowych, M. (2016). Work conditions, mental workload and patient care quality: A multisource study in the emergency department. *BMJ Quality & Safety, 25*, 499-508.
- Weigl, M., Müller, A., Vincent, C., Angerer, P., & Sevdalis, N. (2012). The association of workflow interruptions and hospital doctors' workload: A prospective observational study. *BMJ Quality & Safety, 21*, 399-407.
- Weigl, M., & Schneider, A. (2017). Associations of work characteristics, employee strain and self-perceived quality of care in emergency departments: A cross-sectional study. *International Emergency Nursing, 30*, 20-24.
- Werner, N. E., & Holden, R. J. (2015). Interruptions in the wild: Development of a sociotechnical systems model of interruptions in the emergency department through a systematic review. *Applied Ergonomics, 51*, 244-254.
- Westbrook, J. I., Raban, M. Z., & Walter, S. R. (2019). Interruptions and multitasking in clinical work: A summary of the evidence. In K. Zheng, J. Westbrook, T. G. Kannampallil, & V. L. Patel (Eds.), *Cognitive informatics: Reengineering clinical workflow for safer and more efficient care* (pp. 103-114). Cham: Springer International Publishing.
- Widmer, M. A., Swanson, R. C., Zink, B. J., & Pines, J. M. (2018). Complex systems thinking in emergency medicine: A novel paradigm for a rapidly changing and interconnected health care landscape. *Journal of Evaluation in Clinical Practice, 24*(3), 629-634.
- Williams, D. J. (2018). Brief history of the specialty of emergency medicine. *Emergency Medicine Journal, 35*, 139-141.

9 Addendum zur Dissertation

“Emergency departments as complex adaptive systems: Interrelationships between work system factors, employee well-being and quality of patient care”

The thesis author was primarily involved in the design of the overall intervention study used for Publications 2 to 5. This included the selection of the study design, study methods and recruitment and ongoing support of participating study sites. For Publications 1 to 4, the thesis author had primary responsibility for the conceptualization of the research question, data collection, data management and quality control, data analysis and interpretation as well as drafting and revision of manuscripts. Concerning additional Publication 5, the thesis author substantially contributed to data collection, data management and quality control as well as drafting of the manuscript. The thesis author was further involved in data interpretation and revision of this manuscript. With regard to Publication 6, the thesis author substantially contributed to data analysis and interpretation, drafting and revision of the manuscript.