

Teamwork and clinician burnout in Swiss intensive care: the predictive role of workload, and demographic and unit characteristics

Welp Annalena^a, Rothen Hans U.^b, Massarotto Paola^c, Manser Tanja^d

^a Work and Organisational Studies, University of Sydney Business School, Australia

^b Department of Intensive Care Medicine, Bern University Hospital, Inselspital, Bern, Switzerland

^c Institute of Intensive Medicine, University Hospital of Zurich, Switzerland

^d FHNW School of Applied Psychology, University of Applied Sciences and Arts Northwestern Switzerland, Olten, Switzerland

Summary

AIM: The levels of teamwork and clinician burnout in healthcare differ depending on demographic and unit characteristics. However, the impact of these characteristics varies between clinical settings. In addition, the impact of objectively measured workload in such settings is largely unknown. The aim of this study was to analyse the predictive role of demographic (e.g., professional experience) and unit (e.g., unit size) characteristics, and workload (e.g., nursing interventions) in explaining teamwork and clinician burnout in Swiss intensive care units (ICUs).

METHODS: This was a cross-sectional multi-source study. Participants were 1148 nurses and 243 physicians working in 55 ICUs. They provided demographic information and answered a questionnaire on teamwork and clinician burnout. In addition, unit characteristics and surrogate measures of workload were extracted from a central database that accumulates patient and unit data routinely collected by the ICUs. We conducted multilevel regression analyses to detect relationships between study variables.

RESULTS: Clinicians who worked predominantly dayshifts reported better teamwork and lower burnout. Physicians and clinicians in leadership positions also reported better teamwork. Clinicians in leadership positions furthermore reported higher personal accomplishment, whereas clinicians in training reported higher emotional exhaustion. Of the unit characteristics, workload was positively associated with self-reported burnout. Clinicians working in medical and surgical ICUs (compared with interdisciplinary and paediatric ICUs) reported higher emotional exhaustion. Clinicians working in university hospitals and in surgical/medical ICUs reported lower teamwork quality and higher burnout.

CONCLUSION: We identified several demographic and unit-based factors in Swiss ICUs that were associated with lower perceptions of the quality of teamwork and higher self-reported burnout. Discrepant experiences regarding the quality of teamwork based on professional role, pro-

fessional status and experience might affect team effectiveness. Furthermore, this study showed the importance of workload management, as objectively measured workload was associated with higher self-reported burnout. Results suggested that certain clinician groups (e.g., working predominantly night shifts) were at higher risk for burnout, thus highlighting the importance of providing additional support to these groups. Lastly, special attention should be paid to medical and surgical ICUs, which reported the highest level of burnout. Because this is a cross-sectional study, no conclusions can be drawn regarding causal relationships.

Keywords: health care team, teamwork, burnout, workload, intensive care, critical care, demographic characteristics, unit characteristics

Introduction

Intensive care units (ICUs) are challenging work environments, in which complex dependencies exist between teamwork and clinician burnout [1–3]. Perceived clinician burnout and teamwork quality can vary depending on demographic or unit characteristics, including workload. The purpose of this study was to identify risk factors in Swiss ICUs that explain clinician burnout and negative teamwork experiences.

Teamwork is central to healthcare delivery. However, working effectively as a team continues to constitute a challenge in critical care [4–6]. For instance, nurses have more negative attitudes towards teamwork than physicians [7]. These discrepant attitudes are attributed to hierarchical differences in which those with lower status may find it more difficult to speak up or feel that their input is not well received, which can adversely affect patient safety [8–10]. Furthermore, challenging working conditions in ICUs are associated with decreased wellbeing: for instance, extensive workload is associated with higher burnout [11, 12].

However, effects of demographic and unit characteristics seem to be specific to the setting, as they differ consider-

Correspondence:
Tanja Manser, PhD, FHNW School of Applied Psychology, University of Applied Sciences and Arts Northwestern Switzerland, Riggenbachstrasse 16, 4600 Olten, Switzerland, [tanja.manser\[at\]fhnw.ch](mailto:tanja.manser[at]fhnw.ch)

ably between studies. Healthcare delivery in ICUs varies across countries depending on factors such as available resources, cultural and best practice norms [13–17]. Thus, the findings of existing studies may not be transferable.

An international study investigating working conditions of nurses in low-acuity wards showed that Swiss nurses report lower burnout compared with nurses in other countries [18]. However, clinicians working in clinical areas with critically ill patients, such as ICUs, are generally at higher risk for burnout and its consequences – it is unlikely that Switzerland is an exception [11, 19].

Moreover, little is known about the impact of demographic characteristics on perceptions of teamwork and clinician burnout in Swiss ICUs. Lastly, objective workload and unit characteristics are rarely considered [20]. For instance, one study found that males (compared to females) and nurse assistants (compared to nurses and physicians) reported higher burnout; however, the role of unit characteristics was unclear [13].

The primary aim of this study was to explore the role of demographic characteristics related to the clinical context such as professional experience in explaining clinicians' experiences of teamwork and burnout. Based on previous studies investigating other work settings, we assume that clinicians in the early stages of their career (trainee status and low professional experience), and those working full time and predominantly nightshifts will experience higher burnout, as they are likely to perceive their work environment as more demanding [21–24]. Drawing from previous studies set in other healthcare contexts, we assume that clinicians in the later stages of their career (high professional experience and leadership positions), physicians and those that are part of the core team (i.e., working day shifts and full time) will report higher quality of teamwork [7, 25, 26].

The secondary aim of this study was to investigate the association of unit characteristics and workload with clinicians' perceptions of teamwork and clinician burnout. ICUs are based in different hospital types (e.g., university or regional), vary in size, and specialise in different sub-disciplines to address the needs of different patient populations. Due to these different patient populations, specific facets of workload, such as the amount of nursing interventions, are also likely to vary between ICUs [27, 28]. Based on the job demands-resources model, which states that physical, social and emotional workload can deplete employees' energy and results in decreased wellbeing, we propose that clinicians with higher workload will report lower quality of teamwork and higher burnout [21, 29]. We also explored the role of unit size, type of hospital and ICU specialisation. The results of this study help to identify potentially harmful ICU working conditions and occupational groups and that are at risk for experiencing low-quality teamwork and increased burnout, thus contributing to informed decisions on work design or preventative interventions.

Materials and methods

Sample and procedure

This cross-sectional study combined survey data from clinicians (including nurses and physicians) working in Swiss

ICUs with unit characteristics that were extracted from the MDSi database (“minimaler Datensatz der SGI-SSMI” [Schweizerische Gesellschaft für Intensivmedizin] – “minimal dataset of SGI-SSMI” [Swiss Society of Intensive Medicine]) which accumulates patient and unit data routinely collected by Swiss ICUs.

Consent to participate from clinicians and approval to use the MDSi data were acquired in three steps. First, we signed an agreement of collaboration with the steering committee of the SGI-SSMI in 2013. The SGI-SSMI initiated contact between the study team and the ICUs and provided us with the MDSi data of participating units for the duration of the study period. ICU nursing and medical leaders that chose to participate signed a consent form, thus agreeing to inclusion of the ICU's MDSi data. For confidentiality reasons, ICU leaders were responsible for forwarding an online questionnaire consisting of demographic questions and measures of teamwork and burnout to the staff in our name. Survey participants were assured complete anonymity and confidential handling of their data upon accessing the questionnaire and gave their consent to participate before they could proceed to the survey questions.

Unit characteristics and workload data were drawn from the MDSi database. To prevent identification of individual patients, after consultation with a medical consultant responsible for the MDSi database, unit means (nursing interventions) or sums (number of shifts with agitated patients/ventilation) were calculated from individual patient data by the company responsible for administration of MDSi data prior to data export.

Ethics approval was granted by the University of Fribourg (75, 2013-06-03) and, where required by cantonal legislation, cantonal ethics committees (Bern: Z044/13; Fribourg: 024/13-CER-FR; Zurich: 28/13). Data collection of the survey and from the MDSi database took place for one month on each unit in September and October 2013.

Measures

Predictors: demographic/unit characteristics and workload

Demographic characteristics

We collected data on professional role (nurse, physician), professional status (trainee/non-trainee and leadership/non-leadership role), level of employment (full-time/part-time), predominant shift (day/night), and professional experience and tenure in the ICU (all in years) via the online survey. Trainees were defined as nurses training to become an intensive care certified nurse and physicians training to become intensive care, anaesthesiology, surgery, emergency or internal medicine specialists. Leadership roles were defined as being the medical or nursing leader of the ICU.

Unit characteristics

We collected data on hospital type (university, cantonal/regional) and unit specialization (surgical/medical, paediatric, interdisciplinary) through the online survey.

Data on unit size (number of beds in use) were exported from the MDSi database.

Workload

We extracted three indicators from the MDSi that capture different aspects of workload: patient agitation, patient ventilation, and nursing interventions [30–32].

Patient agitation was assessed with the Sedation Agitation Scale (SAS) on a 7-point Likert scale (1 = unarousable, 7 = dangerous agitation) [33, 34]. Of note, the Richmond Agitation-Sedation Scale (RASS) is used in some units, with transformation to SAS during export in the central database [35]. In each shift, each patient is given a SAS score. We calculated the percentage of shifts with agitated patients by considering the total number of shifts across all patients in which a patient scored 4 (agitated) or higher on the SAS and divided it by the total number of shifts worked during the data collection period.

Patient ventilation. According to MDSi guidelines, patients are categorised as ventilated if they are mechanically ventilated at least 2 hours in a three-shift system or 3 hours in a two-shift system [36]. We calculated the percentage of shifts with ventilated patients by considering the total number of shifts across all patients in which a patient was categorised as ventilated, and divided it by the total number of shifts worked during the data collection period.

Nursing interventions were calculated based on the Nine Equivalents of Nursing Manpower Scale (NEMS) [31, 37, 38]. This instrument was designed to measure nursing workload in ICUs. A patient can be assigned a score between 0 and 56 on each shift based on nine different nursing care interventions (such as application of intravenous medication) that are weighted based on effort [31]. We considered the mean number of NEMS interventions per unit and multiplied it by the number of patients who had stayed in the unit during the data collection period to calculate the total workload. We then divided this figure by the number of full-time nursing equivalents (FTE; taken from the MDSi) of nurses with ICU specialization to adjust the total workload by the available nursing staff.

Outcomes: teamwork and burnout

All scales had previously been translated from English and validated in German, French, and Italian [39–47]. Besides theoretical considerations such as covering different aspects of teamwork and availability in three languages, the scales were chosen because they have been explicitly worded for or tested in the healthcare context, as not all aspects of teamwork (such as team innovation) are of significance in this context. We conducted a pilot study by asking 37 nurses and physicians in all three language regions to provide written feedback on questionnaire wording to ensure that the questionnaire had been correctly translated from English and German into French and Italian as spoken in Switzerland, that the correct terms for different professional roles etc. had been used in all languages, and that the questionnaire items were applicable to the healthcare context. The feedback showed that the items were applicable to the healthcare context and worded appropriately. Some slight alterations regarding correct vocabulary and technical terms (for professional roles) were made after consultation with native speakers of the respective languages and ICU experts. In addition, we improved our rationale for collecting demographic data. The individual scores for all teamwork and burnout scales were generated

by calculating the sum of all items and dividing it by the number of items.

Teamwork

We used three scales measuring cognitive, behavioural, and interpersonal aspects of teamwork. The nine-item *safety organising scale* assesses a teams' organising and coordination efforts, as well as underlying cognitions such as the extent to which team members share a cognitive representation on work processes [39, 40, 48]. A sample item is "We have a good map of each other's talents and skills". Responses were given on a 7-point Likert scale (1 = not at all, 7 = to a very great extent). The possible sum score on this scale ranges from 9 to 63.

The three-item *nurse-physician-relations scale* from the nursing work index revised (NWI-R) measures the quality of interprofessional teamwork (sample item: "Physicians and nurses have good working relationships") [41–43]. Responses were given on a 4-point Likert scale (1 = disagree, 4 = agree), which results in a sum score ranging from 3 to 12.

Finally, we measured *psychological safety*, which is defined as the shared belief that the team is safe for interpersonal risk-taking [49, 50]. A sample item of this seven-item scale is "Members of this team are able to bring up problems and tough issues". Responses were given on a 5-point Likert scale (1 = very inaccurate, 5 = very accurate). The sum score of this scale ranges between 5 and 35.

Clinician burnout

Burnout was assessed with the Maslach Burnout Inventory-Human Services (MBI-HSS), which is the standard instrument to assess burnout and has been validated in a variety of contexts and languages [44–47]. The MBI-HSS consists of the three dimensions *emotional exhaustion* – characterized by mental and physical fatigue (nine items, sample item "I feel mentally exhausted because of my work"), *depersonalisation*, which describes cognitive and emotional disengagement from one's job (five items, sample item "I doubt the significance of my work"), and *personal accomplishment* – the perception of achieving something worthwhile at one's job (seven items, reverse scored, sample item "I deal very effectively with the problems at my work"). Responses were given on a 7-point Likert scale (0 = never, 6 = always). The sum scores of this scale range from nine to 63 (emotional exhaustion), five to 35 (depersonalisation), and seven to 49 (personal accomplishment), respectively.

Open-ended questions

In addition to standardised measures, we invited participants to provide additional information they thought might be relevant in relation to teamwork and clinician burnout.

Analyses

We generated descriptive statistics of all measures, Pearson correlation coefficients between continuous variables and Cronbach's alpha reliability coefficients for the teamwork and burnout scales using SPSS version 24 (table S1 in appendix 1). Unit-level means of teamwork and burnout scales were calculated from individual scores and then correlated with unit-level variables to avoid over-inflation of

correlation coefficients by assigning the same value of a unit-level variables to all individuals of that unit (table S2). Participants were grouped into high, moderate or low categories of burnout on each of the three burnout dimensions based on the scoring scheme by Maslach et al. [46]

To investigate associations of teamwork and burnout with predictor variables, we conducted multilevel regression analyses using Mplus version 7 [51]. Dichotomous variables were dummy-coded. Categorical variables were dichotomised, dummy-coded and tested against a reference category according to standard guidelines (see table 2) [52].

Prior to the main analyses, we explored the data distribution of categorical data. Apart from the dichotomous and categorical variables, we found that personal accomplishment (skewness = -0.69, standard error [SE] = 0.06); kurtosis: 3.59, SE = 0.13) and nursing interventions (skewness = 1.89, SE = 0.30); kurtosis: 3.38, SE = .60) did not meet the criteria for normal univariate distribution (skew and kurtosis between -2 and +2) [53].

For this reason, we used the maximum likelihood parameter estimator (MLM) with standard errors that are robust to non-normality of data for estimating the model parameters. [51, 54].

Lastly, we thematically grouped participants' replies to the open-ended question by the two major topics teamwork and clinician burnout to illustrate the results of the statistical analyses.

Results

Out of 82 ICUs, 60 agreed to participate, which constitutes a participation rate of 73%. We excluded five ICUs from the analyses because of missing MDSi data or low response rate within the unit ($n < 3$) to allow for sufficient variety within teams following recommendations of previous studies, resulting in a final sample of 55 ICUs and 1496 nurses and physicians [55].

Descriptive statistics of the ICUs and clinicians are summarised in tables 1 and 2, respectively. Cronbach's alpha values for teamwork and burnout measures ranged from 0.60 to 0.91, indicating acceptable to excellent internal reliability (table S1 in appendix 1). Raw Pearson correlation

coefficients are reported in the online supplement (table S1 for individual level and table S2 for unit level variables). The results of the multilevel regression analyses are provided in table 2. Standardised regression coefficients are reported to account for the different scaling of predictor variables (see table 1). The coefficients indicate the change in the dependent variables that corresponds to the change of one standard deviation of the predictor variable [51].

Associations with teamwork

Demographic characteristics

Physicians (compared with nurses), clinicians in leadership positions, and clinicians working predominantly day shifts reported higher quality of teamwork dimensions. Clinicians with longer ICU tenure reported better safety organising and trainees reported lower interprofessional teamwork (table 2).

Unit characteristics

Clinicians reported lower safety organising in ICUs with a higher proportion of shifts with mechanical ventilation and in university hospitals. Clinicians also reported higher psychological safety in larger ICUs.

Burnout categories

Of the 1496 study participants, 11.8% scored high on all burnout dimensions. Of these, 37.8% reported high emotional exhaustion, 35.8% high depersonalisation, and 6.8% reported low personal accomplishment. Compared with normative scores of the MBI, participants of the current study scored higher on emotional exhaustion and depersonalisation, and lower on personal accomplishment [46]. Details on participants' burnout scores are presented in table 3.

Associations with burnout

Demographic characteristics

Clinicians working predominantly night shifts reported higher burnout. Furthermore, trainees reported higher emo-

Table 1: Descriptive statistics of intensive care units (n = 55).

| | | Frequency | Per cent | | |
|---|---|-----------|--------------------|--------|--------------|
| Type of hospital | University | 7 | 12.7 | | |
| | Cantonal/Regional | 48 | 87.3 | | |
| Type of ICU | Medical/Surgical | 12 | 21.8 | | |
| | Paediatric | 2 | 3.6 | | |
| | Interdisciplinary | 41 | 74.5 | | |
| | | Mean | Standard deviation | Median | Range |
| Unit size (number of beds in use) | | 14.0 | 5.4 | 8.0 | 6.0–34.1 |
| Number of patients during survey period | | 81.7 | 50.1 | 73.0 | 20.0–309.0 |
| Number of nursing shifts during survey period | | 685.9 | 448.3 | 542.0 | 190.0–2324.0 |
| Full time equivalents [*] | | 26.4 | 24.4 | 18.4 | 3.3–144.4 |
| Workload | Nursing interventions [†] (number) | 727.9 | 357.3 | 620.1 | 219.1–1974.8 |
| | Patient agitation [‡] (%) | 10.5 | 10.5 | 7.3 | 0.0–55.0 |
| | Ventilation days [§] (%) | 30.6 | 18.7 | 31.4 | 0.0–78.0 |

Note: All data except type of hospital were taken from the MDSi. * Equivalent of nurses working full-time † Number of nursing interventions as recorded via the NEMS (nine equivalents of nursing manpower) scale × total number of shifts / FTE [31, 37, 38]. ‡ Percentage of shifts during survey period with patients scoring > 4 on the SAS (sedation agitation scale) [35, 36]. § Percentage of shifts during survey period with mechanical ventilation. Please refer to the methods section for a detailed description of the variables.

tional exhaustion, those with low professional experience reported higher depersonalisation, and clinicians in leadership positions reported higher personal accomplishment (see table 2).

Unit characteristics

Analyses of teamwork (safety organising, psychological safety, interprofessional teamwork,) and burnout (emotional exhaustion, depersonalisation, personal accomplishment) on demographic and unit characteristics are summarised in table 4. Clinicians working on ICUs with more mechanical ventilation or agitated patients reported higher emotional exhaustion. More nursing interventions predicted higher depersonalization and lower personal accomplishment scores. Perception of personal accomplishment was also significantly lower in university hospitals (compared to cantonal/regional hospitals). Clinicians working in paediatric ICUs (compared to interdisciplinary ICUs) reported lower emotional exhaustion and depersonalization; whereas clinicians working in surgical/medical ICUs (compared to interdisciplinary ICUs) reported higher emotional exhaustion.

Clinicians' views on teamwork and burnout

The selected quotes in table S3 (appendix 1) of the online supplement point out challenges regarding effective teamwork and communication across professional and hierarchical boundaries and levels of experience. They also highlight stressors besides quantitative workload, such as agitated and complex patients and competitive work cultures. Finally, the preventive effects of work environments characterized by good interprofessional collaboration and positive team climate became apparent.

Discussion

The present study shows that workload on ICUs is associated with clinician burnout, and, to a lesser extent, with reduced perceptions of safety organizing. One third of clinicians reported high levels of at least one burnout dimension. The study expands the knowledge of demographic characteristics in the Swiss intensive care context.

Differences in perceptions of teamwork and burnout

The consistent pattern of demographic characteristics associated with certain perceptions of teamwork is in line with previous studies on discrepant attitudes toward teamwork

Table 2: Descriptive statistics of survey participants (n = 1496).

| | | Frequency | Per cent | | |
|---------------------------------|--------------------------------|-----------|--------------------|--------|-----------|
| Language* | German | 1121 | 74.9 | | |
| | French | 247 | 16.5 | | |
| | Italian | 128 | 8.6 | | |
| Gender* | Male | 366 | 24.5 | | |
| | Female | 1041 | 69.6 | | |
| Professional role* | Nurse | 1148 | 76.7 | | |
| | Physician | 243 | 16.2 | | |
| | Head RNs | 123 | 5.2 | | |
| | Intensive care RNs | 793 | 52.9 | | |
| | RNs in intensive care training | 117 | 7.8 | | |
| | Head physicians | 83 | 4.7 | | |
| | Senior physicians | 85 | 5.7 | | |
| | Resident physicians | 77 | 5.1 | | |
| Level of employment* | Full time | 725 | 48.5 | | |
| | Part time | 695 | 46.5 | | |
| Predominant shift* | Day | 1013 | 67.7 | | |
| | Night | 407 | 27.2 | | |
| | | Mean | Standard deviation | Median | Range |
| Age (years) | | 39.6 | 9.4 | 39.0 | 19.0–63.0 |
| Professional experience (years) | | 12.6 | 8.9 | 11.0 | 0.0–43.0 |
| Tenure (years in ICU) | | 8.2 | 7.7 | 6.0 | 0.0–37.0 |
| Teamwork | Safety organising | 5.2 | 0.8 | 5.3 | 1.0–7.0 |
| | Psychological safety | 3.7 | 0.6 | 3.7 | 1.0–4.0 |
| | Interprofessional teamwork | 3.1 | 0.6 | 3.0 | 1.1–5.0 |
| Burnout | Emotional exhaustion | 2.7 | 0.8 | 2.7 | 1.0–5.6 |
| | Depersonalisation | 2.3 | 0.8 | 2.2 | 1.0–5.0 |
| | Personal accomplishment | 4.8 | 0.5 | 4.9 | 1.0–6.0 |

All variables were taken from the survey. RN = registered nurse. Safety organising, interprofessional collaboration and psychological safety are subdimensions of teamwork. Emotional exhaustion, depersonalisation, and personal accomplishment are subdimensions of burnout. Please refer to the methods section for a detailed description of the variables. * Missing from 100%: participants did not provide this information

Table 3: Number and percentage of participants reporting high, moderate, and low levels of the respective burnout dimensions (n = 1496).

| | High | | Moderate | | Low | |
|-------------------------|-----------|----------|-----------|----------|-----------|----------|
| | Frequency | Per cent | Frequency | Per cent | Frequency | Per cent |
| Emotional exhaustion | 567 | 37.8 | 722 | 48.1 | 212 | 9.3 |
| Depersonalisation | 537 | 35.8 | 825 | 55.0 | 139 | 9.3 |
| Personal accomplishment | 408 | 27.2 | 991 | 66.0 | 102 | 6.8 |

depending on professional role and seniority. They may stem from the different cultures in which nurses and physicians are educated. Moreover, clinicians in higher levels of the healthcare hierarchy might be less affected by difficulties to speak up or to resolve conflict [7].

With regard to burnout, results indicate that the various occupational groups represented in this study may face different challenges: clinicians in training may be overwhelmed by the combination of the intensive care work environment and the demands of their training, and thus be at high risk for emotional exhaustion. Clinicians in leadership positions reported the highest levels of personal accomplishment, thus suggesting that as they progress through their careers they develop a sense of achievement – symptoms of burnout were not as prevalent [56].

Clinicians working predominantly night shifts stood out as a group in this study. During night shifts, fewer clinicians are available, thus increasing the responsibility and potentially workload of the demographic which might put them at risk for burnout and make effective teamwork – particularly communication with other members of the ward team – more difficult [57, 58]. According to previous studies, while working the night shift can but does not necessarily pose a health risk when well-managed, working over the regular shift length does [59–61].

The role of workload and occupational setting

In the present study, instead of subjective perceptions, we used workload surrogates extracted from the MDSi. Results indicated that both emotionally (e.g., caring for a

large proportion of agitated or ventilated patients) and quantitatively (e.g., more nursing interventions per FTE) demanding work environments carry a risk for increased burnout.

Finally, the occupational environment may play a role in shaping clinicians' perception of teamwork and burnout. University hospitals treat complex patients with higher mortality [62, 63]. This might explain why clinicians working in university hospitals reported lower safety organizing and personal accomplishment. Moreover, the balance of workload and resources associated with burnout may differ between ICU specialties [21].

Limitations

The cross-sectional analyses we conducted do not allow for assumptions concerning causal relationships. Not all ICUs in Switzerland participated in this study, hence, there may be a selection bias as some ICUs indicated during the recruitment phase that they felt unable to participate due to their high workload. If these ICUs had participated, associations between study variables might have been even more pronounced.

Previous studies yielded mixed results regarding the accuracy of organizational indicators such as NEMS or FTE's that were exported from the MDSi [38, 64, 65]. For instance, the ratio of registered nurses with ICU certification and registered nurses with no ICU certification may differ between units, resulting in a different skill mix and rendering some calculations using FTE's less reliable. For this reason, we chose to calculate the percentage of shifts with

Table 4: Results of multilevel regression analyses of teamwork (safety organising, psychological safety, interprofessional teamwork) and burnout (emotional exhaustion, depersonalisation, personal accomplishment) on demographic and unit characteristics.

| | Safety organising | Psychological safety | Interprofessional teamwork | Emotional exhaustion | Depersonalisation | Personal accomplishment |
|---|---------------------------|--------------------------|----------------------------|----------------------|--------------------------|--------------------------|
| | Estimate (SE) | Estimate (SE) | Estimate (SE) | Estimate (SE) | Estimate (SE) | Estimate (SE) |
| Individual level predictors | | | | | | |
| Professional role [†] | 0.17*** (0.04) | 0.18** (0.06) | 0.26*** (0.04) | 0.01 (0.04) | 0.04 (0.03) | 0.02 (0.04) |
| Professional experience (years) | -0.08 (0.06) | -0.01 (0.06) | -0.06 (0.05) | 0.08 (0.04) | -0.10** (0.04) | 0.01 (0.04) |
| Tenure (years in ICU) | 0.10 [†] (0.05) | 0.04 (0.04) | 0.05 (0.04) | -0.06 (0.04) | 0.01 (0.04) | 0.07 (0.04) |
| Trainee status [‡] | 0.02 (0.03) | -0.02 (0.03) | -0.06 [†] (0.03) | 0.10** (0.04) | 0.05 (0.04) | -0.03 (0.04) |
| Leadership role [§] | 0.07** (0.02) | 0.07** (0.03) | 0.12*** (0.03) | -0.03 (0.03) | -0.03 (0.02) | 0.07** (0.03) |
| Level of employment [¶] | 0.04 (0.03) | 0.01 (0.03) | 0.04 (0.03) | -0.02 (0.03) | 0.03 (0.03) | -0.04 (0.03) |
| Predominant shift | -0.10*** (0.03) | -0.09** (0.03) | -0.05 [†] (0.02) | 0.09** (0.03) | 0.09** (0.0) | -0.10** (0.03) |
| R ² | 0.06** (0.02) | 0.05 [†] (0.02) | 0.10*** (0.02) | 0.02** (0.01) | 0.03 [†] (0.01) | 0.03** (0.01) |
| Unit level predictors | | | | | | |
| Type of hospital ^{¶¶} : university | -0.54 [†] (0.25) | -0.21 (0.16) | -0.24 (0.21) | 0.21 (0.15) | 0.11 (0.13) | -0.48** (0.14) |
| Type of ICU : medical/surgical | 0.13 (0.20) | 0.07 (0.17) | 0.12 (0.15) | 0.43*** (0.10) | -0.09 (0.11) | -0.14 (0.14) |
| Type of ICU : paediatric | 0.00 (0.03) | -0.03 (0.03) | -0.03 (0.04) | -0.38*** (0.12) | -0.27*** (0.05) | 0.04 (0.05) |
| Unit size (number of beds in use) | 0.33 (0.03) | 0.31 [†] (0.16) | 0.12 (0.19) | -0.61** (0.20) | -0.07 (0.16) | 0.36 [†] (0.19) |
| Workload: | | | | | | |
| Nursing interventions ^{††} | -0.05 (0.05) | 0.10 (0.13) | -0.06 (0.14) | -0.18 (0.12) | 0.31 [†] (0.12) | -0.38** (0.14) |
| Patient agitation ^{‡‡} | -0.07 (0.07) | -0.19 (0.17) | 0.05 (0.12) | 0.58** (0.20) | -0.01 (0.13) | -0.08 (0.16) |
| Ventilation ^{§§} | -0.27 [†] (0.25) | -0.17 (0.14) | -0.04 (0.16) | 0.65*** (0.16) | 0.28 (0.18) | -0.41 (0.25) |
| R ² | 0.25** (0.13) | 0.15 [†] (0.05) | 0.06 (0.06) | 0.93*** (0.28) | 0.27* (0.14) | 0.54 [†] (0.26) |

n (individual level) = 1496; n (unit level) = 55. Standardised regression coefficients are reported. * p <0.05 (two-tailed test); ** p <0.01 (two-tailed test); *** p <0.001 (two-tailed test). SE = standard error. R² indicates the variance explained in each model. † Professional role: 0 = nurse, 1 = physician. ‡ Trainee status: 0 = not in training, 1 = in training. § Leadership role: 0 = no leadership role, 1 = leadership role. ¶ Level of employment: 0 = part-time, 1 = full-time. || Predominant shift: 0 = day, 1 = night. †† Nursing interventions as recorded via the NEMS (nine equivalents of nursing manpower) scale × total number of shifts / FTE (full-time equivalents) [31, 37, 38]. ††† Percentage of shifts during survey period with patients scoring >4 on the SAS (sedation agitation scale) [35, 36]. §§ Percentage of shifts during survey period with mechanical ventilation. ¶¶¶ Compared with regional and cantonal hospitals. |||| Compared with interdisciplinary ICUs. Please refer to the methods section for a detailed description of the variables.

ventilation and agitated patients as surrogates of workload instead of adjusting these figures using FTE's, as we consider the overall accuracy of NEMS scoring, documentation of mechanical ventilation and patients' agitation to be within clinically acceptable range [64]. Moreover, figures such as NEMS are also used by Swiss insurance companies for reimbursement, and this should guide the clinician to strive for valid documentation.

As teamwork and burnout are self-report measures, they represent individual's perceptions and could be biased by momentary emotional states etc. Abstract constructs cannot be measured with the same level of external accuracy as physical attributes. The advantage of self-report measures is to gain insight into otherwise non-observable states and attitudes. Ultimately, inner psychological states and cognitions are related to externally observable behaviours [66–68].

The magnitude of effect sizes shows that the predictors analyzed in this study are not the only variables in this context that are associated with perceptions of teamwork and burnout. This is to be expected, as other contextual variables have been extensively studied [69–71].

Practical implications

The results of the current study can inform practitioners that are aiming to improve teamwork and reduce burnout in ICUs of specific target areas. The differences between ICU and hospital type indicate that factors potentially affecting teamwork and burnout vary considerably depending on the work environment. Hence, there is no 'one size fits all' solution to improve teamwork and reduce burnout. Instead, some work environments may be particularly challenging and thus should be prioritized. In addition, the study identifies occupational groups potentially at risk for burnout.

Depending on differences in professional role or status or predominant shift, clinicians in this study did not experience teamwork in the same way, even though they are exposed to the same teamwork environment. Shared interactions and experiences between team members – may they be subtle and interpersonal or explicit and task-related – shape individual cognitions, emotions and motivation as well as team interpersonal and task-related behaviors. If certain groups of clinicians have the impression that their input is not valued or that different opinions exist on how to accomplish a certain task, it can impact team effectiveness and affect wellbeing [10, 72]. Thus, it is important for a team to include all members in interprofessional communication, and understand that besides medical skills and knowledge, team processes contribute significantly to performance.

We found that burnout levels in Swiss ICUs were much higher as compared to clinicians working in other medical specialties [18, 73]. Clinicians who are not a member of the core team may be particularly at risk for burnout. High workload may not just a subjectively perceived problem, but also an organizational concern and should be managed accordingly to avoid the negative consequences of burnout such as sick leave, reduced patient safety and associated financial costs [1, 74, 75].

Conclusion

This study contributes to explaining variance of teamwork and burnout in Swiss ICUs.

Based on levels of reported teamwork and burnout, university hospitals and surgical/medical ICUs may be particularly challenging work environments. Even though they are exposed to the same environment, members of different professional groups and statuses have different perceptions of teamwork quality, which may manifest in team behavior. Special attention should be paid to clinicians working night shifts. Fourth, high, objectively measured workload is associated with burnout and as such should be actively managed.

Acknowledgments

We would like to thank the Swiss Society for Intensive Care Medicine (SGI-SSMI), all study participants and the local study coordinators for their collaboration throughout this project. We would also like to thank Corinna Galliano and Mina Askovic for their help with translating participants' quotes into English.

Financial disclosure

This study was funded by the Swiss National Science Foundation (grant numbers PP00P1_128616 and P2FRP1_168482).

Potential competing interests

No potential conflicts of interest relevant to this article were reported.

References

- Welp A, Meier LL, Manser T. The interplay between teamwork, clinicians' emotional exhaustion, and clinician-rated patient safety: a longitudinal study. *Crit Care*. 2016;20(1):110. doi: <http://dx.doi.org/10.1186/s13054-016-1282-9>. PubMed.
- Spence Laschinger HK, Leiter MP. The impact of nursing work environments on patient safety outcomes: the mediating role of burnout/engagement. *J Nurs Adm*. 2006;36(5):259–67. doi: <http://dx.doi.org/10.1097/00005110-200605000-00019>. PubMed.
- Rathert C, Ishqaidif G, May DR. Improving work environments in health care: test of a theoretical framework. *Health Care Manage Rev*. 2009;34(4):334–43. doi: <http://dx.doi.org/10.1097/HMR.0b013e3181abce2b>. PubMed.
- Lingard L, Espin S, Evans C, Hawryluck L. The rules of the game: interprofessional collaboration on the intensive care unit team. *Crit Care*. 2004;8(6):R403–8. doi: <http://dx.doi.org/10.1186/cc2958>. PubMed.
- Vincent J-L, Creteur J. Paradigm shifts in critical care medicine: the progress we have made. *Crit Care*. 2015;19(Suppl 3):S10. PubMed.
- Manthous C, Nembhard IM, Hollingshead AB. Building effective critical care teams. *Crit Care*. 2011;15(4):307. doi: <http://dx.doi.org/10.1186/cc10255>. PubMed.
- Thomas EJ, Sexton JB, Helmreich RL. Discrepant attitudes about teamwork among critical care nurses and physicians. *Crit Care Med*. 2003;31(3):956–9. doi: <http://dx.doi.org/10.1097/01.CCM.0000056183.89175.76>. PubMed.
- Barzallo Salazar MJ, Minkoff H, Bayya J, Gillett B, Onoriode H, Weedon J, et al. Influence of surgeon behavior on trainee willingness to speak up: a randomized controlled trial. *J Am Coll Surg*. 2014;219(5):1001–7. doi: <http://dx.doi.org/10.1016/j.jamcollsurg.2014.07.933>. PubMed.
- Reid J, Bromiley M. Clinical human factors: the need to speak up to improve patient safety. *Nurs Stand*. 2012;26(35):35–40. doi: <http://dx.doi.org/10.7748/ns2012.05.26.35.35.c9084>. PubMed.
- Kolbe M, Burtcher MJ, Wacker J, Grande B, Nohynkova R, Manser T, et al. Speaking up is related to better team performance in simulated anesthesia inductions: an observational study. *Anesth Analg*. 2012;115(5):1099–108. doi: <http://dx.doi.org/10.1213/ANE.0b013e318269cd32>. PubMed.
- Estryn-Behar M, Doppia MA, Guetarni K, Fry C, Mached G, Pelloux P, et al. Emergency physicians accumulate more stress factors than other physicians—results from the French SESMAT study. *Emerg Med J*. 2011;28(5):397–410. doi: <http://dx.doi.org/10.1136/emj.2009.082594>. PubMed.
- Montgomery A, Spânu F, Băban A, Panagopoulou E. Job demands, burnout, and engagement among nurses: A multi-level analysis of OR-CAB data investigating the moderating effect of teamwork. *Burn Res*.

- 2015;2(2-3):71–9. doi: <http://dx.doi.org/10.1016/j.burn.2015.06.001>. PubMed.
- 13 Merlani P, Verdon M, Businger A, Domenighetti G, Pargger H, Ricou B; STRESI+ Group. Burnout in ICU caregivers: a multicenter study of factors associated to centers. *Am J Respir Crit Care Med*. 2011;184(10):1140–6. doi: <http://dx.doi.org/10.1164/rccm.201110-0068OC>. PubMed.
 - 14 Chen KY, Yang CM, Lien CH, Chiou HY, Lin MR, Chang HR, et al. Burnout, job satisfaction, and medical malpractice among physicians. *Int J Med Sci*. 2013;10(11):1471–8. doi: <http://dx.doi.org/10.7150/ijms.6743>. PubMed.
 - 15 Bratt MM, Broome M, Kelber S, Lostocco L. Influence of stress and nursing leadership on job satisfaction of pediatric intensive care unit nurses. *Am J Crit Care*. 2000;9(5):307–17. PubMed.
 - 16 Rafferty AM, Ball J, Aiken LH. Are teamwork and professional autonomy compatible, and do they result in improved hospital care? *Qual Health Care*. 2001;10(Suppl 2):ii32–7. PubMed.
 - 17 Azoulay E, Herridge M. Understanding ICU staff burnout: the show must go on. *Am J Respir Crit Care Med*. 2011;184(10):1099–100. doi: <http://dx.doi.org/10.1164/rccm.201109-1638ED>. PubMed.
 - 18 Aiken LH, Sermeus W, Van den Heede K, Sloane DM, Busse R, McKee M, et al. Patient safety, satisfaction, and quality of hospital care: cross sectional surveys of nurses and patients in 12 countries in Europe and the United States. *BMJ*. 2012;344(mar20 2):. doi: <http://dx.doi.org/10.1136/bmj.e1717>. PubMed.
 - 19 Garroutte-Orgeas M, Perrin M, Soufir L, Vesin A, Blot F, Maxime V, et al. The latroref study: medical errors are associated with symptoms of depression in ICU staff but not burnout or safety culture. *Intensive Care Med*. 2015;41(2):273–84. doi: <http://dx.doi.org/10.1007/s00134-014-3601-4>. PubMed.
 - 20 Murthy S, Wunsch H. Clinical review: International comparisons in critical care - lessons learned. *Crit Care*. 2012;16(2):218. doi: <http://dx.doi.org/10.1186/cc11140>. PubMed.
 - 21 Demerouti E, Bakker AB, Nachreiner F, Schaufeli WB. The job demands-resources model of burnout. *J Appl Psychol*. 2001;86(3):499–512. doi: <http://dx.doi.org/10.1037/0021-9010.86.3.499>. PubMed.
 - 22 Geurts S, Rutte C, Peeters M. Antecedents and consequences of work-home interference among medical residents. *Soc Sci Med*. 1999;48(9):1135–48. doi: [http://dx.doi.org/10.1016/S0277-9536\(98\)00425-0](http://dx.doi.org/10.1016/S0277-9536(98)00425-0). PubMed.
 - 23 Shanafelt TD, Bradley KA, Wipf JE, Back AL. Burnout and self-reported patient care in an internal medicine residency program. *Ann Intern Med*. 2002;136(5):358–67. doi: <http://dx.doi.org/10.7326/0003-4819-136-5-200203050-00008>. PubMed.
 - 24 Dyrbye LN, West CP, Satele D, Boone S, Tan L, Sloan J, et al. Burnout among U.S. medical students, residents, and early career physicians relative to the general U.S. population. *Acad Med*. 2014;89(3):443–51. doi: <http://dx.doi.org/10.1097/ACM.0000000000000134>. PubMed.
 - 25 Carney BT, West P, Neily J, Mills PD, Bagian JP. Differences in nurse and surgeon perceptions of teamwork: implications for use of a briefing checklist in the OR. *AORN J*. 2010;91(6):722–9. doi: <http://dx.doi.org/10.1016/j.aorn.2009.11.066>. PubMed.
 - 26 Kristensen S, Hammer A, Bartels P, Suñol R, Groene O, Thompson CA, et al. Quality management and perceptions of teamwork and safety climate in European hospitals. *Int J Qual Health Care*. 2015;27(6):499–506. doi: <http://dx.doi.org/10.1093/intqhc/mzv079>. PubMed.
 - 27 Pronovost PJ, Jenckes MW, Dorman T, Garrett E, Breslow MJ, Rosenfeld BA, et al. Organizational characteristics of intensive care units related to outcomes of abdominal aortic surgery. *JAMA*. 1999;281(14):1310–7. doi: <http://dx.doi.org/10.1001/jama.281.14.1310>. PubMed.
 - 28 Schmalenberg C, Kramer M. Types of intensive care units with the healthiest, most productive work environments. *Am J Crit Care*. 2007;16(5):458–68, quiz 469. PubMed.
 - 29 Shirom A, Nirel N, Vinokur AD. Work hours and caseload as predictors of physician burnout: The mediating effects by perceived workload and by autonomy. *Appl Psychol*. 2010;59(4):539–65.
 - 30 Guenther U, Koegl F, Theuerkauf N, Maylahn J, Andorfer U, Weykam J, et al. Pflegeaufwandsindizes TISS-10, TISS-28 and NEMS [Nursing workload indices TISS-10, TISS-28, and NEMS]. *Med Klin Intensivmed Notf Med*. 2016;111(1):57–64. doi: [German.]. <http://dx.doi.org/10.1007/s00063-015-0056-5>.
 - 31 Miranda DR, Moreno R, Iapichino G. Nine equivalents of nursing manpower use score (NEMS). *Intensive Care Med*. 1997;23(7):760–5. doi: <http://dx.doi.org/10.1007/s001340050406>. PubMed.
 - 32 Couchman BA, Wetzig SM, Coyer FM, Wheeler MK. Nursing care of the mechanically ventilated patient: what does the evidence say? *Part one. Intensive Crit Care Nurs*. 2007;23(1):4–14. doi: <http://dx.doi.org/10.1016/j.iccn.2006.08.005>. PubMed.
 - 33 Brandl KM, Langley KA, Riker RR, Dork LA, Quails CR, Levy H. Confirming the reliability of the sedation-agitation scale administered by ICU nurses without experience in its use. *Pharmacotherapy*. 2001;21(4):431–6. doi: <http://dx.doi.org/10.1592/phco.2001.21.5.431.34487>. PubMed.
 - 34 Riker RR, Picard JT, Fraser GL. Prospective evaluation of the Sedation-Agitation Scale for adult critically ill patients. *Crit Care Med*. 1999;27(7):1325–9. doi: <http://dx.doi.org/10.1097/00003246-199907000-00022>. PubMed.
 - 35 Sessler CN, Gosnell MS, Grap MJ, Brophy GM, O'Neal PV, Keane KA, et al. The Richmond Agitation-Sedation Scale: validity and reliability in adult intensive care unit patients. *Am J Respir Crit Care Med*. 2002;166(10):1338–44. doi: <http://dx.doi.org/10.1164/rccm.2107138>. PubMed.
 - 36 Schweizer Gesellschaft fuer Intensivmedizin (SGI) [Internet]. Minimaler Datensatz der SGI MDSi. Basel: SGI. 2013. German. Current version available from <https://www.sgi-ssmi.ch/de/datensatz.html?file=files/Dateiverwaltung/de/ressorts/quali/datsa/MDSiV27d.pdf>
 - 37 Carmona-Monge FJ, Rollán Rodríguez GM, Quirós Herranz C, García Gómez S, Marín-Morales D. Evaluation of the nursing workload through the Nine Equivalents for Nursing Manpower Use Scale and the Nursing Activities Score: a prospective correlation study. *Intensive Crit Care Nurs*. 2013;29(4):228–33. doi: <http://dx.doi.org/10.1016/j.iccn.2013.03.003>. PubMed.
 - 38 Rothen HU, Küng V, Ryser DH, Zürcher R, Regli B. Validation of “nine equivalents of nursing manpower use score” on an independent data sample. *Intensive Care Med*. 1999;25(6):606–11. doi: <http://dx.doi.org/10.1007/s001340050910>. PubMed.
 - 39 Ausserhofer D, Schubert M, Blegem M, De Geest S, Schwendimann R. Validity and reliability on three European language versions of the Safety Organizing Scale. *Int J Qual Health Care*. 2013;25(2):157–66. doi: <http://dx.doi.org/10.1093/intqhc/mzt001>. PubMed.
 - 40 Vogus TJ, Sutcliffe KM. The Safety Organizing Scale: development and validation of a behavioral measure of safety culture in hospital nursing units. *Med Care*. 2007;45(1):46–54. doi: <http://dx.doi.org/10.1097/01.mlr.0000244635.61178.7a>. PubMed.
 - 41 Ausserhofer D, Desmedt M, Schubert M, Schwendimann R, De Geest S. RN4Cast – Schweizer Ergebnisse der weltweit grössten Outcome-Studie in der Pflege. *Pflegenetz*. 2012;4-7. German.
 - 42 Lake ET. Development of the practice environment scale of the Nursing Work Index. *Res Nurs Health*. 2002;25(3):176–88. doi: <http://dx.doi.org/10.1002/nur.10032>. PubMed.
 - 43 Sermeus W, Aiken LH, Van den Heede K, Rafferty AM, Griffiths P, Moreno-Casbas MT, et al.; RN4CAST consortium. Nurse forecasting in Europe (RN4CAST): Rationale, design and methodology. *BMC Nurs*. 2011;10(1):6. doi: <http://dx.doi.org/10.1186/1472-6955-10-6>. PubMed.
 - 44 Büssing A, Glaser J. Managerial Stress und Burnout. A Collaborative International Study (CISMS). Die deutsche Untersuchung. München: Technische Universität, Lehrstuhl für Psychologie; 1998. German.
 - 45 Dion G, Tessier R. Validation de la traduction de l'Inventaire d'épuisement professionnel de Maslach et Jackson. *Can J Behav Sci*. 1994;26(2):210–27. doi: [French.]. <http://dx.doi.org/10.1037/0008-400X.26.2.210>.
 - 46 Maslach C, Jackson SE, Leiter MP. *Maslach Burnout Inventory Manual*. Palo Alto, CA: Consulting Psychologists Press; 1996.
 - 47 Pisanti R, Lombardo C, Lucidi F, Violani C, Lazzari D. Psychometric properties of the Maslach Burnout Inventory for Human Services among Italian nurses: a test of alternative models. *J Adv Nurs*. 2013;69(3):697–707. doi: <http://dx.doi.org/10.1111/j.1365-2648.2012.06114.x>. PubMed.
 - 48 Cannon-Bowers JA, Salas E, Converse S. Shared mental models in expert team decision making. In: Castellan NJ, editor. *Individual and group decision making*. Hillsdale, NJ: Lawrence Erlbaum Associates; 1993. p. 221–46.
 - 49 Edmondson A. Psychological safety and learning behavior in work teams. *Adm Sci Q*. 1999;44(2):350–83. doi: <http://dx.doi.org/10.2307/2666999>.
 - 50 Baer M, Frese M. Innovation is not enough: climates for initiative and psychological safety, process innovations, and firm performance. *J Organ Behav*. 2003;24(1):45–68. doi: <http://dx.doi.org/10.1002/job.179>.
 - 51 Muthén LK, Muthén BO. *Mplus User's Guide*. 6th ed. Los Angeles, CA: Muthén & Muthén; 2012.
 - 52 Hardy MA. *Regression with dummy variables*. Newbury Park, CA: Sage; 1993.
 - 53 George D, Mallery M. *SPSS for windows step by step: A simple guide and reference*, 17.0 update. 10th ed. Boston: Pearson; 2010.

- 54 Hox JJ. Multilevel analysis. Techniques and applications. 2nd ed. New York: Routledge; 2010.
- 55 Van der Veg GS, Bunderson JS. Learning and performance in multidisciplinary teams: The importance of collective team identification. *Acad Manage J*. 2005;48(3):532–47.
- 56 Vargas C, Cañadas GA, Aguayo R, Fernández R, de la Fuente EI. Which occupational risk factors are associated with burnout in nursing? A meta-analytic study. *Int J Clin Health Psychol*. 2014;14(1):28–38. doi: [http://dx.doi.org/10.1016/S1697-2600\(14\)70034-1](http://dx.doi.org/10.1016/S1697-2600(14)70034-1).
- 57 Nilsson K, Campbell A-M, Andersson EP. Night nursing - staff's working experiences. *BMC Nurs*. 2008;7(1):13. doi: <http://dx.doi.org/10.1186/1472-6955-7-13>. PubMed.
- 58 Powell I. Can you see me? Experiences of nurses working night shift in Australian regional hospitals: a qualitative case study. *J Adv Nurs*. 2013;69(10):2172–84. doi: <http://dx.doi.org/10.1111/jan.12079>. PubMed.
- 59 Muecke S. Effects of rotating night shifts: literature review. *J Adv Nurs*. 2005;50(4):433–9. doi: <http://dx.doi.org/10.1111/j.1365-2648.2005.03409.x>. PubMed.
- 60 Admi H, Tzischinsky O, Epstein R, Herer P, Lavie P. Shift work in nursing: is it really a risk factor for nurses' health and patients' safety? *Nurs Econ*. 2008;26(4):250–7. PubMed.
- 61 Rogers AE, Hwang W-T, Scott LD, Aiken LH, Dinges DF. The working hours of hospital staff nurses and patient safety. *Health Aff (Millwood)*. 2004;23(4):202–12. doi: <http://dx.doi.org/10.1377/hlthaff.23.4.202>. PubMed.
- 62 Ayanian JZ, Weissman JS. Teaching hospitals and quality of care: a review of the literature. *Milbank Q*. 2002;80(3):569–93, v. doi: <http://dx.doi.org/10.1111/1468-0009.00023>. PubMed.
- 63 Martín-Lesende I, Recalde E, Viviane-Wunderling P, Pinar T, Borghesi F, Aguirre T, et al. Mortality in a cohort of complex patients with chronic illnesses and multimorbidity: a descriptive longitudinal study. *BMC Palliat Care*. 2016;15(1):42. doi: <http://dx.doi.org/10.1186/s12904-016-0111-x>. PubMed.
- 64 Perren A, Cerutti B, Merlani P, Perren I, Previsdomini M, Massarotto P, et al. SwissScoring—a nationwide survey of NEMS assessing practices and its accuracy. *Acta Anaesthesiol Scand*. 2014;58(4):478–86. doi: <http://dx.doi.org/10.1111/aas.12283>. PubMed.
- 65 Perren A, Previsdomini M, Perren I, Merlani P. High accuracy of the nine equivalents of nursing manpower use score assessed by critical care nurses. *Swiss Med Wkly*. 2012;142:. doi: <http://dx.doi.org/10.4414/sm.w.2012.13555>. PubMed.
- 66 Burtcher MJ, Kolbe M, Wacker J, Manser T. Interactions of team mental models and monitoring behaviors predict team performance in simulated anesthesia inductions. *J Exp Psychol Appl*. 2011;17(3):257–69. doi: <http://dx.doi.org/10.1037/a0025148>. PubMed.
- 67 Endacott R, Bogossian FE, Cooper SJ, Forbes H, Kain VJ, Young SC, et al.; First2Act Team. Leadership and teamwork in medical emergencies: performance of nursing students and registered nurses in simulated patient scenarios. *J Clin Nurs*. 2015;24(1-2):90–100. doi: <http://dx.doi.org/10.1111/jocn.12611>. PubMed.
- 68 Schraagen JM, Schouten T, Smit M, Haas F, van der Beek D, van de Ven J, et al. A prospective study of paediatric cardiac surgical microsystems: assessing the relationships between non-routine events, teamwork and patient outcomes. *BMJ Qual Saf*. 2011;20(7):599–603. doi: <http://dx.doi.org/10.1136/bmjqs.2010.048983>. PubMed.
- 69 Aronsson G, Theorell T, Grape T, Hammarström A, Hogstedt C, Marteinsdottir I, et al. A systematic review including meta-analysis of work environment and burnout symptoms. *BMC Public Health*. 2017;17(1):264. doi: <http://dx.doi.org/10.1186/s12889-017-4153-7>. PubMed.
- 70 DeChurch LA, Mesmer-Magnus JR. The cognitive underpinnings of effective teamwork: a meta-analysis. *J Appl Psychol*. 2010;95(1):32–53. doi: <http://dx.doi.org/10.1037/a0017328>. PubMed.
- 71 De Dreu CK, Weingart LR. Task versus relationship conflict, team performance, and team member satisfaction: a meta-analysis. *J Appl Psychol*. 2003;88(4):741–9. doi: <http://dx.doi.org/10.1037/0021-9010.88.4.741>. PubMed.
- 72 Bakker AB, Le Blanc PM, Schaufeli WB. Burnout contagion among intensive care nurses. *J Adv Nurs*. 2005;51(3):276–87. doi: <http://dx.doi.org/10.1111/j.1365-2648.2005.03494.x>. PubMed.
- 73 Arigoni F, Bovier PA, Sappino AP. Trend of burnout among Swiss doctors. *Swiss Med Wkly*. 2010;140:. PubMed.
- 74 Toppinen-Tanner S, Ojajarvi A, Väänänen A, Kalimo R, Jäppinen P. Burnout as a predictor of medically certified sick-leave absences and their diagnosed causes. *Behav Med*. 2005;31(1):18–27. doi: <http://dx.doi.org/10.3200/BMED.31.1.18-32>. PubMed.
- 75 Andel C, Davidow SL, Hollander M, Moreno DA. The economics of health care quality and medical errors. *J Health Care Finance*. 2012;39(1):39–50. PubMed.

Appendix 1

Supplementary data

Table S1: Individual-level Pearson correlations between demographic characteristics, and teamwork (safety organising, psychological safety, interprofessional teamwork) and burnout (emotional exhaustion, depersonalisation, personal accomplishment).

| | Cronbach's alpha | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|------------------------------------|------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 1 Professional role ^a | | | | | | | | | | | | | |
| 2 Trainee status ^b | | 0.32** | | | | | | | | | | | |
| 3 Leadership role ^c | | 0.21** | -0.06* | | | | | | | | | | |
| 4 Level of employment ^d | | 0.10** | 0.22** | -0.01 | | | | | | | | | |
| 5 Predominant shift ^e | | -0.11** | -0.05 | -0.20** | -0.09** | | | | | | | | |
| 6 Professional experience (years) | | -0.23** | -0.28** | 0.09** | -0.29** | 0.07* | | | | | | | |
| 7 Tenure (years in ICU) | | -0.16** | -0.31** | 0.16** | -0.23** | 0.06* | 0.75** | | | | | | |
| 8 Safety organising | 0.91 | 0.18** | 0.06* | 0.11** | 0.04 | -0.13** | 0.00 | -0.03 | | | | | |
| 9 Psychological safety | 0.86 | 0.19** | 0.01 | 0.10** | -0.03 | -0.09** | -0.02 | -0.03 | 0.60** | | | | |
| 10 Interprofessional teamwork | 0.83 | 0.24** | 0.03 | 0.16** | 0.04 | -0.11** | -0.02 | -0.04 | 0.48** | 0.47** | | | |
| 11 Emotional exhaustion | 0.87 | 0.00 | 0.10** | -0.05 | 0.01 | 0.08** | -0.01 | 0.01 | -0.26** | -0.30** | -0.23** | | |
| 12 Depersonalisation | 0.63 | 0.03 | 0.08** | -0.08** | 0.06* | 0.04 | -0.10** | -0.13** | -0.22** | -0.18** | -0.18** | 0.50** | |
| 13 Personal accomplishment | 0.60 | 0.02 | -0.04 | 0.11** | -0.04 | -0.08** | 0.10** | 0.10** | 0.30** | 0.25** | 0.24** | -0.35** | -0.43** |

n = 1496. * p < 0.05 (two-tailed test); ** p < 0.01 (two-tailed test); *** p < 0.001 (two-tailed test) ^a Professional role: 0 = nurse, 1 = physician. ^b Trainee status: 0 = not in training, 1 = in training (includes nurses and physicians in training). ^c Leadership role: 0 = no leadership role, 1 = leadership role (includes nurses and physicians in leadership roles). ^d Level of employment: 0 = part-time, 1 = full-time. ^e Predominant shift: 0 = day, 1 = night. All variables were taken from the survey. Please refer to the methods section for a detailed description of the variables.

Table S2: Unit-level Pearson correlations between unit characteristics, and teamwork (safety organising, psychological safety, interprofessional teamwork) and burnout (emotional exhaustion, depersonalisation, personal accomplishment).

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|--------------------------------------|--------|--------|--------|--------|---------|---------|--------|--------|---------|
| 1 Unit size (number of beds) | | | | | | | | | |
| 2 Nursing interventions ^a | -0.27* | | | | | | | | |
| 3 Patient agitation ^b | 0.72** | -0.23* | | | | | | | |
| 4 Ventilation ^c | 0.62** | -0.14 | 0.47** | | | | | | |
| 5 Safety organising | -0.26* | 0.00 | -0.27* | -0.27* | | | | | |
| 6 Psychological safety | 0.06 | 0.09 | -0.08 | -0.10 | 0.69** | | | | |
| 7 Interprofessional teamwork | -0.21 | 0.00 | -0.15 | -0.14 | 0.56** | 0.41** | | | |
| 8 Emotional exhaustion | 0.18 | -0.16 | 0.32** | 0.32** | -0.49** | -0.47** | -0.30* | | |
| 9 Depersonalisation | 0.06 | 0.27* | 0.03 | 0.17 | -0.44** | -0.24* | -0.27* | 0.47** | |
| 10 Personal accomplishment | -0.17 | -0.07 | -0.12 | -0.20 | 0.23* | 0.05 | 0.04 | -0.19 | -0.52** |

n = 55. * p < 0.05 (one-tailed test); ** p < 0.01 (one-tailed test); *** p < 0.001 (one-tailed test) ^a Nursing interventions as recorded via the NEMS scale * total number of shifts / FTE [31, 37, 38]. ^b Percentage of shifts during survey period with patients scoring >4 on the SAS scale [35, 36]. ^c Percentage of shifts during survey period with mechanical ventilation. Variables unit size, nursing interventions, patient agitation and ventilation were extracted from the MDSi. All other variables were taken from the survey. Please refer to the methods section for a detailed description of the variables.

Table S3: Selection of participants' responses to open-ended questions, grouped by topic.

| Teamwork | | Challenges to interprofessional collaboration / hierarchy | | Positive aspects and improvements | | |
|------------------|--|--|---|---|---|---|
| | | The residents...have ... inconsistent skills, but more discretion and sometimes less clinical insight [than nurses]- which makes it more difficult for me, when a resident exceeds his / her competence without consulting me. (<i>Anaesthetist, 46</i>) | | I have the chance to work in an intensive care unit in which the working atmosphere is excellent both in the collaboration between caregivers and between doctors of all levels and caregivers. I think that this atmosphere brings a lot to the quality of our work when it comes to the care of patients. (<i>Registered ICU nurse, 36</i>) | | |
| | | There is a gap in the relations between the top and the bottom, which has consequences on the interprofessional relations (doctors-nurses) but also on the hierarchical level (leadership position or not). (<i>Resident physician, 35</i>) | | Since [date], we have two doctors with Intensive Care training. One feels that the doctors take on responsibility for the patients as for us, we have clearer conversations. Cooperation is increasing. (<i>ICU head nurse, 41</i>) | | |
| | | Residents who ... are beginners sometimes complicate our collaboration. (<i>Registered ICU nurse, 43</i>) | | Because of the team climate it is still possible for me to work in this great profession after nine years. (<i>Registered ICU nurse, 49</i>) | | |
| | | | | Daily contact with the [nursing] management, the offices are side by side, thus short distances. (<i>Lead anaesthetist, 50</i>) | | |
| Strain / burnout | General comments | Personnel availability | Work environment | Teamwork | Shift work | Positive aspects / improvement |
| | I have been working 100% in my profession for 26 years and at the moment I feel exhausted after only a few days after my vacation...it worries me. (<i>Registered ICU nurse, 44</i>) | Personnel availability is the key to ... avoid overburdening employees. (<i>ICU trainee nurse, 29</i>) | In the last few years, things have changed. The patients are multimorbid, older, more confused, ... the noise level (alarms) is much higher. It is not possible to finish a task, and this promotes stress and dissatisfaction but also irritability. (<i>Registered ICU nurse, 43</i>) | I feel that within the intensive care teams ... there is always a kind of competition, a need to mark the territory, to acquire the trust of others and to prove oneself. This environment stresses me. (<i>Registered nurse, 26</i>) | I think night work is considerably more tiring than the other shifts. (<i>Registered ICU nurse, 46</i>) | It would be helpful to have someone in charge of supporting the staff psychologically, who can act promptly, and set up training that provides the possibility to use tools / strategies to improve team work and safety. I would set up group meetings on a monthly basis to get a sense of the motivation, the team climate and discuss any problematic situations. (<i>Registered nurse, 36</i>) |
| | I have the impression that I will not reach pension age alive, sane & calm if I keep working like this. (<i>Resident, 35</i>) | | At the safety level, I think the patients are safe but not the staff. We are often confronted with verbal and physical violence. (<i>Registered ICU nurse, 44</i>) | | One of the most severe burdens in our profession is the night shift. (<i>Paediatrician, 50</i>) | With the help of private supervision, I have been able to grow through the processing of many unpleasant experiences, to gain new strength and confidence. (<i>Registered ICU nurse, 36</i>) |
| | | | Delirious / confused patients are more stressful, and their number is increasing. (<i>Registered ICU nurse, 30</i>) | | | |

This table is intended for illustrative purposes. We did not formally analyse the responses to open-ended questions. Quotes were translated to English from French, German and Italian.