Title: Psychometric properties of the Safety Climate Survey (SCS) in Austrian acute care: factor structure, reliability and usability

Short running title: Psychometrics of the Safety Climate Survey

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1 Introduction

Every year, an unacceptable number of patients unnecessarily suffer injuries or die because of unsafe and poor quality care, since most of these injuries could be avoided.[1] A literature search carried out on behalf of the European Union came to the conclusion that adverse events occur in about 4-17 percent of patients, of which 44-50 percent are avoidable. This resulted in an excess direct costs of about 21 billion euros for the health care system in 2014.[2]

In 1999, the Institute of Medicine´s report ‘To Err is Human’ described the magnitude of the patient safety and has demonstrated the importance of safety culture in the health care environment.[3-5] The global need for quality of care and patient safety strategies was also recommended by the World Health Assembly.[6] Since 2004, the World Health Organization appeals to the member states to promote the concept as a Global Patient Safety Challenge.[7] Within the European Union, the ‘Luxembourg Declaration on Patient Safety’ marked the beginning of sustainable activities and measures in this area, particularly in Austria, Germany, and Switzerland. Hence in 2008, the Austrian government established ‘The Austrian Platform for Patient Safety’ with the goal of promoting patient and employee safety through research, coordination of projects, networking of experts, and information dissemination. In the context of the last health care reform, Austrian policy also decided to initiate a national strategy on patient safety.[8]

Internationally, patient safety has received much attention and safety culture has been identified as a key element in health organizations.[5,9] Safety culture can be considered an essential part of organizational and management factors and refers to shared beliefs, values, perceptions, attitudes, and competencies as well as behavioral patterns within an organization.[10,11] Study results point to a link between a culture of high patient safety and better patient outcomes.[12-15] Thus, it can safely be assumed that implementing a high organizational and safety culture increases quality of care.[4,9,16]

The safety climate in turn represents a subset of the safety culture and its measurable element.[4] Categorized as a psychological phenomenon, safety climate manifests itself as a well-established context variable in the analysis of work environment.[11,17] In the achievement of safety climate, health care organizations need to (1) create a safe workplace, (2) share perception of health care providers regarding the safety of their work environment, and (3) ensure effective dissemination of safety information.[16] In order to gain information and make an important contribution to the development of the safety culture, periodic surveys are recommended.[17,18] A wide range of instruments, measuring patient safety climate in health care organizations have been developed.[6] Those surveys obtain perceptions of hospital staff about the prevalence of safety-related attitudes and behaviors[19] and are useful for measuring organizational conditions that can lead to adverse events and patient harm in the healthcare organization.[3] For German-speaking countries, a review identified 11 instruments. Six of these are suitable measures that can be used to assess the safety climate in hospitals, such as the Safety Climate Survey (SCS).[18] The SCS was developed by the Center of Excellence for Patients, Safety Research and Practice at the University of Texas to measure the safety climate in acute care for all health professionals.[20] Internationally, this survey is widely used in different health care settings such as intensive care,[21,22] surgical units,[3,10] general medical wards,[17,23] or paramedical departments.[3] Compared to other safety climate measures, the SCS has fewer items and takes less time to complete, which makes it easier to administer, and hence, could increase the chance to obtain a high response rate.[10,17,24]

In order to measure patient safety climate in Austrian hospitals, the German version of the SCS was used.[24] Aim of this study is to explore the factor structure, reliability, and potential usefulness of the Safety Climate Survey in Austrian acute care.

2 Methods

Study setting and participants

This cross-sectional online-survey was part of a larger study to evaluate and optimize patient safety and safety culture in eight hospitals from one hospital operator in Austria. Health professionals in part- and full-time positions, who are involved in direct patient care, were invited to participate. Staff without direct patient care (e.g. administration) was excluded from the study. In total, 5,160 physicians (P), therapists (TH), nurses and midwives (NM) participated. One purpose of this survey was to reach sufficient numbers of respondents in order to carry out factor and reliability analyses. Under the expectation that response rates in acute care settings could be lower than 20% and aiming for 5-10 subjects for each item to be analysed as a necessary sample size for factor analyses[25], an exhaustive survey inviting all health care professionals with direct patient care was pursued.

Survey instrument

The questionnaire used in this study was the Swiss version of the Safety Climate Survey (SCS), which was translated from the original Safety Climate Survey[20,26] and adapted to the German-speaking population in Switzerland.[24] The SCS is considered to be a unidimensional instrument, which facilitates its transferability to other nations and cultures.[27] This is contrary to much of the literature describing safety climate as a complex multi-dimensional construct.[18] The instrument consists of 19 items, whereby one item is divided into three subitems.[27] Each item has to be rated on a 5-point Likert scale (*1= do not agree at all; 5= fully agree; 0= I cannot say*). Higher values in the participants' assessment correspond to a more positive safety climate. To evaluate safety climate, calculation of item mean values, total mean values or safety climate sum scores are recommended.[20] Psychometrics in terms of internal consistency in the Swiss version[24] correspond closely to those of the original SCS (α=0.86).[20] Although the SCS was designed to be used with all types of health care professions in hospitals, an explicit and empirically tested factor structure is missing.[18]

Data collection

Data collection was conducted online with the electronic tool Lime Survey from September to October 2019 over a period of six weeks and included two reminder e-mails every two weeks. The eligible population received information from their superiors as well as through the hospital organization's internal magazine, corporate communications and institutional website. To identify potential problems in practicability, comprehensibility, and technical possibilities of the online survey, a pretest in a sample of 34 health care professionals from the hospital's organization was performed and minor improvements in layout and survey interface features were adapted. Anonymous survey answers were archived and imported into IBM SPSS 27, wherein negatively poled items were recoded and data preparation, cleansing and analyses were performed.

Statistical analyses

We used common univariate statistics to describe the characteristics of the participants. In order to identify the factor structure of the German version of the instrument, an explorative factor analysis (EFA) was carried out applying principal components analysis (PCA). After examining the suitability of the correlation matrix for factor analysis in terms of means, kurtosis, and inter-item correlations[28], the Kaiser-Meyer-Olkin measure (KMO)[29] was used to examine the general fit and suitability of the items for EFA.

There are several methods for deciding number of factors to retain. We used the Kaiser Eigenvalue approach[30] in combination with theoretical considerations regarding the interpretability of the factors[28] as the predominant criterion to determine the adequate number of factors. Additionally, Parallel Analysis[31,] and Scree Plot[32,33] were consulted and critically compared to the results based on the Kaiser criterion.

Due to the fact that correlations of the underlying factors can theoretically be assumed, we performed an oblique rotation (promax method).[34] Following several recommendations for item assignment procedures,[35] items were assigned to factors according to the following strategy: a) items were assigned to certain factors based on the highest factor loadings, b) a cutoff of ≥0.40 was considered to be a relevant factor loading and items with loads less than 0.40 were eliminated, c) differences between factor loadings in case of cross-loading items had to be at least 0.20, and d) unambiguous theoretical considerations.

EFA was performed within the total sample as well as separately for the different health professional subgroups of physicians and nurses/midwives. Separate analysis for the sample of therapists was not feasible due to the rather small valid sample size in EFA. An optimal, both, physicians and nurses/midwives overarching factor structure was identified by aligning the respective factor structures. Ambiguous items or items loading on different factors in the two subsamples were excluded from further analyses. After reducing to an unambiguous factor structure valid and suitable for both professions, subscale mean indices using the original item values were computed. Following this instrument's final structure, internal consistency was assessed by calculating Cronbach's α as an indicator of the correlation between the individual elements and the factors.[36] Finally, we calculated possible differences in mean subscale scores between physicians and nurses/midwives using Student T-tests for independent samples. Statistical significance was set at $p<0.05$ (two-sided).

3 Results

Response rates and demographics

A total of 933 questionnaires (response rate 18.1%) were completed, including 713 nurses and midwives, 124 physicians, and 96 therapists. The average age of the participants ranges between 41 and 45 years in all professions and, with the exception of physicians, more women than men participated (78.4%). In all professions, the majority of participants worked in internal medicine wards (61.6%) and did not hold a managerial position (82.7%). Further details can be found in Table 1.

>>> Table 1 about here <<<

Exploratory Factor Analysis in total sample

To examine the underlying structure of SCS in Austrian acute care, a PCA with oblique rotation was performed. The correlation matrix was evaluated for substantial correlations. The KMO amounts to 0.889, which indicates that the sample is suitable for factor analysis.[37] Bartlett's test of sphericity also proved to be significant ($\chi^2(210)= 3{,}505.53$, $p<0.001$). Following Cattell`s guidelines for including the component at the point where the Scree Plot flattens out[38], this approach would suggest that two factors should be retained. A Parallel Analysis[31] also pointed towards a two-factor solution. Although reaching significance, only 38.2 % of the total variance could be explained in each respected PCA (Figure 1).

>>> Figure 1 about here <<<

The consideration of the Kaiser Eigenvalue criterion greater than one[30] identified six factors. This model explains 59.1 % of the total variance and was chosen based on additional theoretical considerations regarding the interpretability of the factors. Therefore, the SCS final solution includes six factors (α =0.859) with Eigenvalues ranging from 6.184 to 1.021. Two items (item 9, item 11) demonstrated loadings below 0.30. Six items loaded on the first factor (Eigenvalue=6.184), four items on factor two (Eigenvalue=1.559), three items on factor three (Eigenvalue=1.340), two items on factor four (Eigenvalue=1.202), three items on factor five (Eigenvalue=1.102), and one item on factor six (Eigenvalue=1.021). With the exception of two items with insufficient cross-loadings (item 9, item 11), a consistent factor structure could be identified (Table 2).

>>> Table 2 about here <<<

Overarching factor structure for both physicians and nurses/midwives

Following the analysis of the overall data, the EFA was calculated separately for physicians and nurses/midwives. The therapists' data had to be excluded from further calculations due to the small final subsample size. Results demonstrate differences in the factor loadings of the individual items between the professions. In summary, four items (item 3, item 8, item 9, and item 11) demonstrate ambiguous factor loadings (cross-loadings) or different loadings in comparison between the samples of physicians and nurses/midwives. The final six-factor structure for SCS is presented in Table 3. The number of items per factor ranges from one to four items and factors were interpreted as representing the following underlying six themes: The first factor deals with accessing *communication culture and support* (four items), the second factor is about *organizational safety concerns* (four items), the third factor is about the access to *clinical leadership* (three items), the fourth factor has the aim to measure *briefings* (two items), the fifth factor deals with *patient safety promotion* (three items, and the sixth factor represents *adverse events* (one item).

>>> Table 3 about here <<<

Psychometric properties

Subscale means as well as internal consistency measures were calculated, both for the total sample and separately by professions (Table 4). Cronbach's alpha for the subscales in the total sample varies from α=0.752 to α=0.595, in the sample of physicians from α=0.794 to α=0.535, and in the sample of nurses/midwives from α=0.747 to α=0.593. Differences in item means between professions were calculated using Student t-tests. Nurses/midwives rated communication culture and support ($p<0.05$) as well as organisational safety concerns ($p<0.001$) significantly higher than physicians. In contrast, physicians considered clinical leadership to be more efficient than nurses/midwives ($p<0.05$) did. No differences were found relating to the subscales *briefings*, *patient safety promotion*, and *adverse events*. Detailed statistics are presented in Table 4.

>>> Table 4 about here <<<

4 Discussion

Due to a growing understanding of the importance and the relationship between safety culture, patient safety and the role of the safety climate as a key component, more health organizations should systematically conduct safety climate surveys on a regular basis.[12,39,40] International measures are available, but only few have been validated for acute care settings in the German-speaking countries. However, since surveys are often the basis for subsequent interventions, measures must be evaluated examining psychometric properties in the regarded specific context.[6] Therefore, the aim of this study was to explore the factor structure, reliability, and potential usefulness of the Safety Climate Survey in Austrian acute care.

Multi-dimensional factor structure and profession-specific deviations

The results in our Austrian sample clearly demonstrate that the SCS is not a unidimensional instrument as originally assumed.[20,24] The EFA for the total sample of physicians, nurses/midwives, and therapists illustrates a multi-dimensional instrument—irrelevant which factor extraction method was applied. Factor extraction using the Scree Test as well as the Parallel Analysis indicated a two-factor instrument explaining only about 38% of variance. The recognition of the Kaiser Eigenvalue criterion greater than one identified a solid six-factor solution explaining almost 60% of variance. Under the premise that more than 50% variance explanation should be reached, this six-factor solution seems to be appropriate. Also, explicit reference to multi-dimensionality is also consistent with comparable evidence from the literature: A comparison with other instruments makes it clear that different dimensions are used to assess the construct of safety climate. For example, the Hospital Survey on Patient Culture (HSOPSC) includes 12 dimensions of which seven relate to the work area and three dimensions to the hospital's safety culture. Two further dimensions are defined as outcome variables. Teamwork, communication and feedback culture, staffing, handoffs/transitions, support by management, patient safety concerns and overall perceptions of patient safety, organizational learning as well as dealing with errors are HSOPSC's main topics.[41] Other study results demonstrated that leadership factors like communication, commitment to safety and executive rounds, safeguarding mental and physical health, support of staff and empowerment, and organizational processes and individual factors are influencing safety climate.[42] Furthermore, the organizational culture, which is the starting point in the assessment of safety culture and subsequently safety climate, is generally considered to be a multidimensional construct.[18]

In the factor structure of SCS in the Austrian sample, aspects of communication culture and support, organizational safety concerns, clinical management, measures to promote patient safety and the handling of adverse events, and therefore, to some extent similar to the above mentioned themes were identified. Building upon the results of our explorative factor analyses, it becomes quite clear that future studies with SCS should refrain from interpreting safety climate as a unidimensional construct. Although there is a need for further replication of our study’s findings, the demonstrated six-factor structure must be considered and safety climate subscale mean scores rather than total safety climate sum scores should be calculated and used for description and interpretation.

Another point of interest with regard to the use of instruments is the specific cultural characteristics of the study population of interest and the local health care system. These influence the participants' response behavior as well as the perception and understanding of the questions, which ultimately changes the factor structure and the interpretation of the results.[43] The SCS was originally developed in the US in Texas, but is also used in Europe. Due to the unidimensionality, a better comparability of the results between the countries is pointed out.[20,24,26] However, our results illustrate a multidimensional instrument, which may well indicate a differentiated perception of safety climate. It is possible that there is no transferability here due to the different health systems. In addition, no theoretical basis can be found for the SCS, which makes further development in Austrian acute care even more difficult.

Assuming that there are different perceptions of the safety climate among health professionals, the factor structure per profession was also considered. One further key finding of this study relates to the result that the factor structure and thereby the shared factor patterns of physicians and nurses/midwives differ to a relevant degree. These findings may suggest that different health care professionals do not quite share the same basic concepts of the safety climate, that they ultimately perceive or understand SCS issues in a different way, or that the safety climate itself is a predominantly profession-specific rather than hospital organization-specific construct. Results from other studies also point to different predictors of nurses and physicians in their perception of the safety climate.[44] A ‘one size fits all’-principle seems to be inappropriate when examining safety climate in all health care staff even in the same hospital organization. As a recommendation for future approaches applying the SCS, we identified a six-factor solution (*communication culture and support, organizational safety concerns, clinical leadership, briefings, safety promotion, adverse events*) which proved compatible with both professional groups of physicians' and nurses/midwives' factor structures—however, in favor of an overarching factor structure of the SCS, five items had to be excluded from the final factor solution.

Psychometric properties

Mean subscale scores and Cronbach's α were calculated for the adapted and reduced instrument with the final six-factor structure. Although good (α=0.794) to low (α=0.535) internal consistency were observed, both for the total sample and separately by professions, there is potential for optimizing the reliability of the instrument. The rather low measures of internal consistency are to be expected due to a small number of items per factor; hence, no reliability calculation is necessary. In total, our study revealed several potential future directions to improve the measurement of safety climate using the Safety Climate Survey. In addition to the satisfactory overall psychometric properties including the identified item-reduction as well as the shared overarching six-factor structure between the professions, a crucial and useful characteristic of the instrument is its shortness, practicability and consequently the short time required to complete it. This aspect is an essential advantage over other instruments, especially when interviewing health professionals in large-scale studies focusing on entire acute care institutions.

Limitations

This study has several limitations in terms of small response rate and study design. Although the email addresses of the health professionals were obtained in advance, there is some risk that not everyone read the invitation to the survey or had access to a computer or mobile device. Another reason may be the generally low willingness to participate in online surveys and concerns about the anonymity of participation. As a consequence, rather low numbers in subsample size may limit the results of explorative factor analysis. Recommendations for minimum number of participants in EFA vary. However, taking into account variables with limited commonalities and factors with a small number of variables, a sample of at least 300 participants is often recommended for the implementation of multivariate procedures.[45] Other scholars have cautiously stated that a sample size of at least 100 participants may be poor but sufficient[35]. While the total sample size and the subsample size regarding nurses and midwives proves sufficient, this was not the case for the subsamples of physicians and especially therapists. Thus, it was not possible to include data from therapists in the analysis due to the low response rate. Additional limitation relates to the data collection in one hospital organization at a single point in time, which is why no re-test reliabilities could be calculated. Statements on the safety climate represent a snapshot and should be assessed on a regular basis.

5 Conclusions

It can be stated that there is a lack of evidence to support the theoretical basis of the surveys and limited understanding of the concept and interventional measures for safety climate.[46] In particular, since the historical development of the safety climate is based on findings from manufacturing and heavy industry and is related to the concepts of organizational culture,[47] instruments in health care still need to be optimized. Different dimensions must be acknowledged in the assessment of safety climate, which should at least take into account communication and team culture, organizational safety concerns, leadership skills, promotion of patient safety measures, and dealing with adverse events. Referring to the Safety Climate Survey, future efforts should focus on testing the identified six-factor structure applying confirmatory factor analyses in a large-scale study involving different health care professions. Without a thorough psychometric analysis of translated surveys, interpretation of the results and comparisons between professions in the local context may be flawed.

Conflict of interest

The authors declare no conflict of interest.

Ethical approval

Study design does not require the approval of an ethics committee. Participation in the survey was voluntary and anonymous. It is not possible to trace data back to individual persons. Health care staff had to approve and sign the data privacy statement. Furthermore, the consent of the workers' council to the survey was obtained.

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