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The development of a brief and practical work safety climate measure☆

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ABSTRACT

Background: Safety climate represents employees' shared perceptions of the value an organisation places on safety. Frequently safety climate measures are lengthy to comprehensively assess critical work safety factors, which makes their completion time consuming, particularly when used in conjunction with other work or performance measures. Consequently, organisations only employ such measures during safety crises, compromising their usefulness as a leading work safety indicator for identifying and remediating emerging safety issues before they become critical.

Objective: This study used statistical and practical methodological procedures to develop a brief safety climate measure for the regular monitoring and remediation of safety issues.

Method: An existing comprehensive and valid work safety climate measure (Nordic Occupational Safety Climate Questionnaire [NOSACQ-50]; Kines et al., 2011), was administered to disability support workers (N = 366) and hospitality employees (N = 111). Appropriate statistical procedures and practical usefulness measures including expert opinions of work health and safety researchers (N = 5) and practitioners (N = 14), correlations with physical and mental health measures, and item readability contributed to the selection of the most reliable and practically useful items for the brief measure.

Results: Utilising statistical and practical usefulness methods, a brief 24-item safety climate questionnaire was developed.

Conclusion: Study results support the usefulness of this brief 24-item work safety climate measure for both practice and research purposes. The study also demonstrated a procedurally sound and practically efficient item reduction method that considers both statistical findings and methods that enhance the practical usefulness of the measure in applied environments.

1. Introduction

Safety climate (Zohar, 1980) is understood as employees' shared perceptions of management and workgroup policies, practices, and procedures as they relate to workplace safety (Kines et al., 2011). Conceptually related but distinct from safety culture (Shea et al., 2021), a substantial body of research supports the relationship between a positive safety climate and favourable safety outcomes. These include safety commitment and compliance (Ajslev et al., 2017; Barbaranelli et al., 2015), safety participation (Beus et al., 2016; Griffin and Neal, 2000), safety motivation (Beus et al., 2016; Neal and Griffin, 2006), mindful safety practices (Dahl and Kongsvik, 2018), and self-reported safety behaviours (Pousette et al., 2008). Meta-analytic studies consistently demonstrate a direct, positive relationship between safety climate and safety-related behaviour and a negative association between safety climate and safety incidents at both the group and individual level (Beus et al., 2019; Christian et al., 2009). As a leading indicator, safety climate is useful as a predictor of safety outcomes when compared to traditional lagging indicators such as accident rates, lost time, and fatalities (Givehchi et al., 2017; Seo et al., 2004).

Although numerous safety climate measures have been developed, methodological issues such as unclear operationalisation of key terms such as 'safety climate' or 'injuries', content deficiency, and limited applicability affect their overall application and practicality (Beus et al., 2019). Similarly, despite the increasing use of big data for safety management decisions (see Wang and Wang, 2021 for a comprehensive review), the understanding of temporally specific perceptions of safety will remain important for many organisations, particularly those with fewer employees, and those without the technological capabilities for big data analysis, such as cloud computing and the development of

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machine learning algorithms. Regardless, a widely accepted, brief safety climate measure that can be implemented regularly for monitoring purposes could, if shared, further contribute to existing databases of safety big data (Ouyang et al., 2018).

A review by Vu and De Cieri (2015) found that of over 200 publicly available work safety climate measures, only 18 were considered satisfactory. Criteria used for identifying a satisfactory measure included item development methods, internal consistency ($\alpha > 0.7$), and construct validation. Of the measures reviewed by Vu and De Cieri, the Nordic Safety Climate Questionnaire (NOSACQ; Kines et al., 2011) was one of the most satisfactory. Unlike the majority of other satisfactory measures reviewed that were only management focussed, the NOSACQ is a 50-item scale that measures three management and four worker focussed safety climate dimensions. This management and worker level structure is consistent with Zohar's (1980) conceptualization of safety climate encompassing organisation-level safety climate arising from worker perceptions of managements' safety policies and procedures, and workgroup-level safety climate from perceptions of safety practices utilised to implement safety policies and procedures within workgroups.

The NOSACQ has demonstrated acceptable reliability and validity across numerous studies (The National Research Centre for Work Environment, 2020a,2020b), it has applicability across industry sectors, and has been translated into 35 languages, adding to its acceptance as an appropriate measure (Strauch, 2015). Guldenmund (2000) suggested that the variety of safety climate scales currently available makes benchmarking safety climate data difficult; however, NOSACQ has a large and regularly updated international benchmarking database for various organisational-types and industry sectors.

A practical problem with most work safety climate measures, including the 50-item NOSACQ, is that to be comprehensive they consist of a large number of items. Although useful for diagnosing a work safety crisis, completion time represents a response burden for participants (Nielsen et al., 2016). A meta-analysis by Rolstad et al. (2011) showed that greater response burden due to questionnaire length is negatively associated with response rates. Related to this, time taken to implement safety climate measures can be a deterrent for organisations, who therefore only implement the measures diagnostically rather than proactively to monitor safety conditions and identify emerging safety issues before they become critical (Flin, 1998). O'Connor et al. (2011) argue that using long questionnaires also increases the possibility of non-random measurement errors when collecting safety climate data; and it has been suggested that motivation to participate will be higher if questionnaires are quick and easy to complete (Krosnick and Presser, 2010). Accordingly, it would be useful for monitoring purposes if a brief safety climate measure could be created by selecting relatively few but critical items from an existing comprehensive measure as this would support its validity and allow the more comprehensive measure to be used for more detailed analysis of safety issues identified by the brief measure when required.

A brief work safety climate measure requiring reduced administration time would not only allow regular monitoring to identify emerging safety issues for remediation before they become critical, but it would also benefit research by allowing a work safety climate measure to be included in a battery of other measures without unduly increasing the response burden. However, to maintain the validity and reliability of the original measure from which a brief measure was derived, detailed methodological guidelines need to be followed. Goetz et al. (2013) propose six objectives when shortening composite measurement scales: 1) Document the original scale validity and the shortening objective; 2) Consider the conceptual model; 3) Preserve content validity; 4) Preserve psychometric properties; 5) Document the justification for item retention; and 6) Validate the short-form measure in an independent sample. The objectives outlined by Goetz et al. highlight one of the only attempts to structure and improve the methodology of developing brief versions of more comprehensive measurement scales.

Considering that large safety climate inventories pose issues related to time constraints in research and practical settings, this study aimed to use the guidelines provided by Goetz et al. (2013) as a basis for developing a brief work safety climate measure from an existing comprehensive instrument using both traditionally applied statistical approaches, and additional selection approaches to augment the practical usefulness of the measure. The NOSACQ-50 was selected for this purpose from other existing measures as it was identified as a satisfactory measure (Vu and De Cieri, 2015), it is not an industry specific measure, it has been widely translated into other languages, has a benchmarking database that allows organisations to compare their safety climate levels with others from similar industry types, and it has been used successfully in previous studies to identify and remediate work safety issues (Kirby et al., 2014).

The potential to shorten the NOSACQ has been recognised by others. Previous studies that have utilised brief versions of the NOSACQ-50 include Ajslev et al. (2017; 2018) who employed a five-item abridgement that they considered indicative of primary safety climate themes identified in the literature, namely, managerial and employee safety commitment, participation and engagement. However, the five items cover only four of the seven NOSACQ-50 dimensions. Similarly, Forsell et al. (2017) employed a validated 12-item NOSACQ version in their safety climate study involving the Swedish merchant fleet. Items selected represented the original seven-dimension NOSACQ-50 structure; however, five of the seven dimensions were only represented by one item and five items were drawn from the Management Safety Priority, Commitment and Competence dimension. While this brief NOSACQ version may be suitable in a battery of measures for research purposes, as was the case in the study undertaken by Forsell et al. (2017), a measure for regular monitoring may be more practically useful if it covers all seven of the existing NOSACQ-50 dimensions and retains more than one item of each of the dimensions. Thus, while this brief measure may be appropriate for research purposes in a larger survey, the goal of regular safety climate monitoring would arguably be best achieved by representing each of the seven original NOSACQ-50 dimensions equally, with at least several items so that the full scale versions of particular dimensions could be used to further investigate problems identified in the items used from one or more of those dimensions.

Traditionally, item reduction techniques for developing a brief measure would be psychometric, with reliance on statistical results for item selection (Rolstad et al., 2011). Although some studies have used safety climate researchers to provide a theoretical base for item selection (e.g., Beus et al., 2019; Kines et al., 2011) and to ensure that critical values and behaviours are assessed, rarely (if ever) are practitioners consulted. To ensure that the most practically and theoretically useful items are selected for safety climate evaluation, traditional item selection statistical methods (i.e., factor analyses, reliability analyses) need to be augmented by both work safety climate researcher and practitioner opinions (e.g., Work Health and Safety advisors or safety officers) from a range of different organisations. To further maintain the functionality, usefulness and content validity of the comprehensive version in a brief version, additional practical methods such as retaining levels of readability, and relationships to important dependent measures such as health and wellbeing also need to be considered.

Thus, this study aims to develop a brief, practical and general safety climate measure (i.e., non-industry-specific) using a combination of both statistical and practical analyses. A brief measure of this kind that is comprehensive enough to be used for monitoring and identifying specific emerging safety issues, and that allows for industry benchmarking may aid in facilitating a consensus for what could be considered best work safety practice (Pather, 2014).

2. Materials and methods

2.1. Participants

Three participants groups provided information for this research:

Safety researchers: Five safety researchers (three with PhDs and two with Honours degrees) from the University of Adelaide independently reviewed the NOSACQ items to identify items suitable for inclusion in a brief measure based on their work safety research experience.

Safety practitioners: Fourteen safety practitioners from different types of organisations within Australia were surveyed to identify the practically useful safety climate items for their particular organisation/industry for inclusion in a brief measure. The job roles of these participants included human resource managers/coordinators (n = 7), work health and safety representatives (n = 4), and work safety advisors (n = 3). Participants were recruited through advertisements placed on the National Safety Council of Australia online network and in the Australian Institute of Health and Safety eNewsletter. The survey was distributed to all practitioners who responded to the advertisement indicating their interest in participating.

Participants (10 male, 4 female) had a mean age of 47 years (SD = 8.95), averaged 19 years of work health and safety experience (SD = 8.95), and had educational backgrounds ranging from technical qualifications (e.g., Certificate IV in Work Health and Safety; n = 7) to tertiary qualifications (e.g., Graduate Diplomas, Masters Degrees, and PhDs; n = 7). Using the Australian Bureau of Statistics (ABS) classification of organisation size, participants represented small (n = 1), medium (n = 3), and large (n = 10) organisations. Of the 19 industry-types identified by the ABS (Trewin and Pink, 2006), 12 were represented: Agriculture, Forestry and Fishing; Mining; Manufacturing; Construction; Wholesale Trade; Retail Trade; Transport, Postal and Warehousing; Professional, Scientific and Technical Services; Public Administration and Safety; Education and Training; Health Care and Social Assistance; and Other Services (such as not-for-profits). Thus, a diverse range of work safety expertise contributed to development of the brief measure.

NOSACQ Respondents: Existing data from 477 participants (213 male, 260 female, 4 unspecified) with a mean age of 45.71 years (SD = 12.36) contributed to the statistical analysis portion of the project (366 Disability Support Workers [DSWs] and 111 Hospitality employees). Disability support work carries significant safety risks for employees, including repetitive strain injuries from heavy lifting, slips and falls due to hazards, muscle stress due to workload, as well as many psychosocial injury risks such as threats of violence from clients (SafeWork SA, 2021a). Hospitality work also carries safety risks such as muscular and musculoskeletal trauma, slipping hazards, fatigue, and cuts and burns, and also psychosocial risks such as violence, harassment and bullying (SafeWork SA, 2021b). Mean employment length was 9.09 years (SD = 8.95) for DSWs and 10.43 years (SD = 8.93) for hospitality employees. The DSW NOSACQ data were made available from a commissioned research study for SafeWork SA (Kirby et al., 2014) and the hospitality NOSACQ data came from a study by Heffernan et al. (2018).

2.2. Measures

Work Safety Researcher and Practitioner Questionnaire: Safety researchers and practitioners were provided with NOSACQ-50 items and asked to "… rank the [NOSACQ] questions within each dimension according to their importance for assessing work safety attitudes and behaviours". Practitioners had the words "… in your type of organisation" included. A ranking example was provided. Practitioners were additionally asked two open-ended questions: "Are there any comments you would like to make about your rankings of the above safety climate items?" and "Are there any areas of safety that are important for the industry sector that you work in that were not included in the above list of safety items?".

Nordic Occupational Safety Climate Questionnaire (NOSACQ-50): The DSWs and hospitality worker respondents each rated their workplace safety climate using the 50-item NOSACQ. The NOSACQ measures seven safety climate dimensions: 1) Management Safety Priority, Commitment and Competence; 2) Management Safety Empowerment; 3) Management Safety Justice; 4) Workers' Safety Commitment; 5) Workers' Safety Priority and Risk Non-Acceptance; 6) Safety Communication, Learning, and Trust in Co-Worker Safety Competence; and 7) Workers' Trust in the Efficacy of Safety Systems. The measure utilises a 4-point Likert response (Strongly Agree, Agree, Disagree, Strongly Disagree) and employs positively (n = 29) and negatively (n = 21) worded questions. The NOSACQ-50 has consistently shown reliable and valid results across the research literature, and has an international benchmarking database of 57,270 workers and 17,098 leaders. According to the NOSACQ official interpretation guide, an average overall score of more than 3.30 out of four indicates a good safety climate level allowing for maintaining and continuing developments. A score of 3.00–3.30 indicates a fairly good safety climate level with slight need of improvement. A score of 2.70–2.99 shows a fairly low safety climate level with need of improvement, and a score below 2.70 indicates a low safety climate level with great need of improvement. The Appendix shows the full scale NOSACQ-50.

Health and Wellbeing Outcome Measures: In addition to the NOSACQ respondent data available from the DSW study by Kirby et al. (2014) and the study of hospitability workers by Heffernan et al. (2018), data for two health and wellbeing self-report measures were also available to examine the validity of the brief version of the NOSACQ compared with the full version. These measures were the Copenhagen Burnout Inventory (CBI; Kristensen et al., 2005) and the SF-8 Health Survey (Ware et al., 2000).

The 19-item CBI contains three scales that measure personal, work-related, and client-related burnout. Higher scores on the CBI scales represent higher levels of reported burnout. All three scales have shown high internal reliability, have differentiated well between occupational settings, and have been shown to predict future job outcomes including job absence and intention to quit (Kristensen et al., 2005). CBI responses were available for the DSWs and hospitality workers.

The SF-8 contains eight physical and mental health items covering general health, physical functioning, role physical (extent that physical health impacts work), bodily pain, vitality, social functioning, mental health, and role emotional (extent that emotional/mental health impacts work). These measures produce a score of general physical health and general mental health, with higher scores representing better health. The measure has been shown to be effective in monitoring the health of large-scale populations in outcome studies (Yiengprugsawan et al., 2014). SF-8 responses were only available for the DSWs.

2.3. Data analysis

A priori power analysis was conducted using G*Power (3.1.9.7) to compute required sample sizes using a 0.80 power level and $\alpha = 0.05$ significance criterion to detect a medium effect size (d = 0.3), with results showing appropriate sample sizes for all planned analyses. Normality of measures was investigated visually and using z-score calculations of skewness and kurtosis. Due to skewed distribution (12 measures), bootstrapping (using the bias-corrected and accelerated method with 2000 iterations) was used to calculate confidence intervals for descriptive statistics and to confirm parametric findings.

With respect to sample size for Factor Analysis, the literature supports the current sample as adequate based on minimum sample size of N = 100–150 (Tabachnik and Fidell, 2001) or N = 200 (Kline, 2005), and numbers of observed variables using a ratio of five cases per variable when latent variables have multiple indicators (Bentler and Chou, 1987), which in this case is 5*50 = 250.

2.4. Ethics

Ethical approval for this research was obtained through the University of Adelaide: Human Research Ethics Subcommittee (Code number: 19/61).

2.5. Procedure

Two approaches were used to reduce the 50-item NOSACQ to a brief version and these involved traditional statistical item reduction procedures and additional practical item reduction approaches.

The statistical item reduction procedures and inclusion and/or exclusion criteria included:

1. Exploratory Factor Analysis (EFA) undertaken using principal components extraction employing an oblique rotation (as correlated factors were expected based on extant theory). Following the advice of Watkins (2018), the pattern coefficients were the first focus in the analysis. According to Bandalos and Gerstner (2016) the practical usefulness of pattern coefficients ranges from 0.30 to 0.40; as a result, coefficients with an absolute value below 0.35 were suppressed. Items that fell below the 0.35 cut-off, items that loaded across more than one factor, or items that did not show unipolar loadings were considered for removal. Structure coefficients were also reviewed to evaluate consistency. Following the advice of Norman and Streiner (2014) the communalities table was examined and items with values less than 0.50 were considered for removal. Items that failed to load on any factor or loaded outside of the expected pattern were investigated and considered for removal.
2. Reliability analysis (using Cronbach's Alpha) undertaken to determine how dimension reliability would change with the removal of individual items from the scale. The aim was to identify items whose removal resulted in higher dimension reliability; these items were considered for removal.

Practical item reduction procedures and inclusion and/or exclusion criteria included:

1. Determining NOSACQ-50 item readability utilising the Flesch-Kincaid Grade level, which was considered important for obtaining valid data in industries that have a higher risk of safety incidents (e.g., construction, manufacturing) with workers having lower educational requirements and/or who speak English as a second language. For reference, a Flesch-Kincaid Grade readability score of 10 requires the reader to have a Year 10 reading level to understand the text. A grade 8.0 reading level is recommended for most scales (Hall et al., 2010).
2. Safety climate researchers independently ranked the safety climate questions within each dimension from most to least important in terms of perceived usefulness for assessing work safety attitudes and behaviours. Items ranked in first, second, or third position were deemed most important; items that were not ranked most important by over 60% (a majority) of the researchers were considered for removal.
3. Work safety practitioners ranked the practical usefulness of items in each of the seven NOSACQ dimensions for assessing work safety in their particular organisation and industry, and also commented on the items and/or identified missing safety areas relevant for their industry. Items not ranked first, second, or third by over 50% of the practitioners were considered for removal. Qualitative responses from the participants were also analysed and utilised for determining item selection criteria.
4. Correlational analyses were conducted between the NOSACQ-50 items and five outcome variables from the CBI (Personal Stress, Work-Related Stress, Client-Related Stress) and the SF-8 Health Survey (Physical Health and Mental Health). The purpose of these correlations was to identify items that were associated with both physical and mental health and wellbeing to ensure the selected items were practically relevant and that the brief measure remained an effective leading indicator of work safety stress and health related outcomes. Items that did not correlate significantly with at least four of the five outcome variables were considered for removal.

3. Results

3.1. Statistical item reduction procedures

Table 1 provides the descriptive statistics for the DSW and hospitality worker well-being measures and for the NOSACQ-50 measure that was used for the statistical item reduction procedures. As can be seen there is a sufficient range of responses, without any floor or ceiling effects and thus the data is appropriate for item reduction methods.

3.1.1. Exploratory Factor Analysis (EFA)

Principal components analysis (N = 374) was employed on the 50-item NOSACQ. Bartlett's test of sphericity was significant (χ 2 (1225) = 11127.97, $p < .001$) indicating that the correlation matrix was not random and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.95, above the suggested 0.50 cut-off (Norman and Streiner, 2014). Thus the data were suitable for use. Initial extraction identified eight factors with eigenvalues greater than one, although visual scree plot examination suggested either a three-factor (accounting for 47.77% of variance) or five-factor solution (accounting for 54.12% of variance). In combination with parallel analysis it was determined that the three-factor solution best represented the data. The three factors (shown in Table 2) were categorised as representing 1) Management focussed safety climate; 2) Co-worker focussed safety climate; and 3) Worker Safety Priority and Risk Non-Acceptance. However, it is possible that extraction of this third factor was related to negative item wording with each of the items loading on this factor involving negative wording, although it is worth noting that not all negatively phrased NOSACQ items loaded accordingly. This possible explanation has some support in the research literature wherein various studies have examined the impact negatively worded questions can have on the dimensionality of survey measures (e.g., Chen and Jin, 2020; Molina et al., 2014; Suárez-Alvarez et al., 2018; Zhang et al., 2016). Despite not identifying the seven dimensions identified by Kines et al. (2011), criteria for retaining or removing items from the questionnaire were applied at the dimension level in order to maintain the conceptual structure underlying the original NOSACQ scale as recommended by Goetz et al. (2013), thereby allowing comparison between the original and shortened scale to determine the NOSACQ safety climate benchmarks.

In terms of criteria for retaining or removing items for a brief version,

Table 1
Descriptive statistics for the Copenhagen Burnout Inventory, SF-8 Health Survey, and NOSACQ-50 for the whole sample (N = 477).

Scales	Range	Mean (SD)
Copenhagen Burnout Inventory		
Personal burnout	0–100	42.30 (19.74)
Work-related burnout	0–100	36.62 (20.92)
Client-related burnout	0–95.83	23.51 (20.19)
SF-8 Health Survey		
Physical Health Component Score	19.17–63.72	49.68 (8.56)
Mental Health Component Score	11.35–62.91	48.03 (10.83)
NOSACQ-50		
Management Safety Priority, Commitment and Competence	1.00–4.00	3.00 (0.56)
Management Safety Empowerment	1.00–4.00	2.89 (0.57)
Management Safety Justice	1.00–4.00	2.96 (0.59)
Workers' Safety Commitment	1.83–4.00	3.18 (0.44)
Workers' Safety Priority & Risk Non-Acceptance	1.28–4.00	2.97 (0.49)
Safety Communication, Learning, and Trust in Co-Worker Safety Competence	1.25–4.00	3.15 (0.47)
Workers' Trust in the Efficacy of Safety Systems	1.00–4.00	3.20 (0.46)

Note: SF-8 Health Survey data was only available for DSWs.

Table 2
Pattern Matrix and Communalities for the three-factor solution from Principal Components Analysis with an Oblique Rotation for the NOSACQ-50.

NOSACQ Items		Factor 1 (Eigenvalue = 18.06)	Factor 2 (Eigenvalue = 3.57)	Factor 3 (Eigenvalue = 2.26)	Communalities
Management items	1	0.59			**.55**
	2	0.68			**.55**
	3r	0.35		0.36	.46
	4	0.58			.36
	5r	0.25		0.43	.37
	6	0.80			**.69**
	7	0.80			**.61**
	8r	0.77			**.63**
	9r	0.73			**.68**
	10	0.67			**.63**
	11	0.76			**.68**
	12	0.75			**.55**
	13r	0.58			**.55**
	14	0.74			**.64**
	15r	0.64			.46
	16	0.74			**.57**
	17	0.70			**.54**
	18r	0.57			**.54**
	19	0.70			**.65**
	20	0.76			**.62**
	21r	0.63			**.54**
	22	0.72			**.64**
Co-worker items	23		0.59		.48
	24		0.58		.45
	25r		0.39		**.52**
	26r				.49
	27		0.68		**.54**
	28r				.32
	29r			0.64	.42
	30r			0.68	.49
	31r			0.68	**.54**
	32r			0.60	**.62**
	33		0.36		.24
	34r			0.51	.29
	35r			0.75	**.61**
	36		0.70		**.59**
	37		0.75		**.64**
	38		0.74		**.70**
	39		0.77		**.67**
	40		0.78		**.71**
	41r				.23
	42		0.64		**.60**
	43		0.50		**.59**
	44				**.53**
	45r			0.40	**.52**
	46				**.58**
	47r				**.58**
	48		0.35		.49
	49r				**.55**
	50				**.55**

Note: Pattern coefficients <0.35 omitted; Communalities ≥0.50 in bold; r indicates negatively worded (reversed scored) items.

Table 2 shows that two items (items 3 and 5) loaded on more than one factor; both are management items addressing aspects of risk (e.g., item 5: *'Management accepts employees here taking risks when the work schedule is tight'*) and are negatively worded items. Fourteen items (4 management, 10 co-worker items) did not achieve the 0.50 communality criterion.

3.1.2. Reliability analysis

Cronbach's Alpha findings showed the internal consistency of the NOSACQ-50 dimensions was generally very good. As shown in Tables 3 and 4, there were only six items whose removal would result in higher dimension reliability, including two management items (items 5 and 18) and four co-worker items (items 26, 33, 34, and 41). These items were from five of the seven dimensions, with no items from the "Management safety empowerment" or the "Workers' trust in the efficacy of safety systems" dimensions. Of the six identified items, five were negatively worded (items 5, 18, 26, 34, 41) and one could be considered 'reverse oriented', meaning a negative particle has been added to the sentence, although the item is still scored as positive (item 33, *'We who work here never accept risk-taking even if the work schedule is tight'*). It has been demonstrated in previous research that both negative wording, and reverse oriented items increase participant difficulty and can lead to issues with interpretation and reliability (Swain et al., 2008; van Sonderen et al., 2013). This further supports the removal of these items.

3.2. Practical item reduction procedures

3.2.1. Flesch-Kincaid Grade reading levels

NOSACQ-50 reading levels ranged from 2.4 to 24.2 years (M = 10.52 years, SD = 4.99). The mean Flesch-Kincaid Grade of 10.52 exceeded the recommended grade 8 level so a further purpose of this analysis was to ensure the brief version reading level remained similar to the full NOSACQ. Higher reading grade levels were present for management items (M = 14.58 years, SD = 4.36) than co-worker items (M = 7.39 years, SD = 2.59). As shown in Tables 3 and 4, all but three co-worker items (items 40, 44, and 45) met the criterion of a reading grade of

Table 3
Summary of the statistical and practical item reduction procedures contributing to NOSACQ item retention.

NOSACQ Item Number	Statistical item reduction procedures			Practical item reduction procedures			
	EFA Coefficient (≥0.35)	Commun-alities (≥.50)	Removal Reduced Dimension Reliability	Readability (Flesch Kincaid Grade ≤10.5)	Researcher Selected (≥60%)	Practitioner Selected (≥50%)	Correlation with Outcome Variables (≥4/5)
Management items							
1	X	X	X		X	X	X
2	X	X	X				X
4	X		X			X	X
7	X	X	X		X		X
11	X	X	X			X	X
12	X	X	X			X	X
14	X	X	X		X		X
16	X	X	X		X	X	X
17	X	X	X		X	X	X
20	X	X	X	X	X	X	X
22	X	X	X			X	X
Co- worker items							
23	X		X	X	X	X	X
24	X		X	X		X	
27	X	X	X	X	X	X	X
30r			X	X	X	X	X
32r	X	X	X	X	X	X	X
35r		X	X	X	X		X
36	X	X	X	X	X	X	
39	X	X	X	X	X		
40	X	X	X				
43		X	X	X	X	X	X
46	X	X	X	X	X	X	X
48			X	X	X	X	
50	X	X	X	X		X	

Note: X indicates retention criterion met; r indicates negatively worded (reversed scored) items.

Table 4
Summary of the statistical and practical item reduction procedures contributing to NOSACQ item removal.

NOSACQ Item Number	Statistical item reduction procedures			Practical item reduction procedures			
	EFA Coefficient (<.35)	Communalities (<.50)	Removal Improved Dimension Reliability	Readability (Flesch Kincaid Grade >10.5)	Researcher Selected (<60%)	Practitioner Selected (<50%)	Correlation with Outcome Variables (<4/5)
Management items							
3r	X	X		X	X	X	
5r		X	X		X	X	
6				X	X	X	
8r					X	X	
9r				X	X	X	
10				X		X	
13r	X			X	X	X	
15r	X	X		X	X	X	
18r			X	X	X	X	
19				X	X		
21r				X	X	X	
Co- worker items							
25r	X				X	X	X
26r		X	X		X	X	X
28r	X	X			X	X	X
29r		X			X		
31r					X	X	
33		X	X		X		X
34r		X	X		X	X	X
37					X	X	
38					X	X	
41r		X	X		X	X	X
42	X				X	X	X
44				X	X	X	X
45r				X	X	X	X
47r					X	X	X
49r					X	X	X

Note: X indicates removal criterion met; r indicates negatively worded (reversed scored) items.

less than or equal to 10.5 years whereas all but three management items (items 5, 8, and 20) exceeded this criterion.

3.2.2. Safety climate researcher rankings

Researcher agreement on importance rankings ranged from 0 to 100% for the NOSACQ items. There were two items (items 1 and 20),

both management items, that were ranked as most important by all researchers. As indicated in Tables 3 and 4, seventeen of the 50 items were ranked by 60% of researchers as important (i.e., first, second or third) for assessing work safety attitudes and behaviours, including seven (32%) management items and 10 (36%) co-worker items.

3.2.3. Work safety practitioner rankings

Practitioner agreement on importance rankings ranged from 0 to 86%. There was no single item that all 14 safety practitioners ranked as being most important (i.e., ranked first, second, or third by the practitioners), with item 1 the highest-ranking item. Twenty-one items were ranked by 50% of the safety practitioners as important (i.e., first, second or third) for assessing work safety attitudes and behaviours, including nine (41%) management items and 12 (43%) co-worker items (see Tables 3 and 4).

In terms of safety practitioner responses to the open-ended questions "Are there any comments you would like to make about your rankings of the above safety climate questions?" 79% of practitioners (n = 11) provided a response. Responses were grouped into two themes: a preference for positively worded questions (n = 7), and problematic wording of questions (n = 5). Both of these qualitative themes supported decisions to remove negatively worded (e.g., item 5) and reverse oriented (e.g., item 33) items, and preferentially retain positively worded items when suitable alternatives were available. Sixty-four percent of practitioners provided a response to the question "Are there any areas of safety that are important for the industry sector that you work in that were not included in the above list of safety items?". The majority of responses (n = 5) did not highlight any specific safety areas missing, but similar comments were grouped into two themes: items to assist with the identification of mental health issues (n = 2), and desire for benchmarking (n = 2).

3.2.4. Correlational analyses

An examination of the correlations between the individual NOSACQ items and the health and wellbeing measures found the number of significant correlations ranged from 0 to 5 (M = 3.96). All management items correlated significantly with the five health and wellbeing measures except item 13, which did not correlate with the physical health measure. There were three co-worker items that did not correlate significantly with any of the health and wellbeing measures (items 41, 44, and 47) and 16 (57%) co-worker items that did not meet the criterion of correlating significantly with four of the five health and wellbeing measures (see Tables 3 and 4).

3.3. Combining item reduction procedures

Items that met a number of selection criteria (e.g., appropriate and unipolar factor loading, positive impact on dimension reliability, significant correlation with dependent outcome variables, selected as highly important by both researchers and practitioners, and appropriate readability) were considered for retention and are shown in Table 3. Given the study aim of developing a practical measure of work safety climate for monitoring purposes, significant attention was paid to the items deemed most important by safety practitioners as these were seen as the strongest indicators of practical content validity. There was also a specific focus on any items commented on by safety practitioners as problematic in their wording. This criterion was also employed when deciding on which items should be removed (see Table 4). An example of problematic wording identified by the safety practitioners was item 34 "We who work here consider that our work is unsuitable for cowards". One safety practitioner commented: "*I have worked for over a decade in heavy construction in Australia … I've honestly never heard anything phrased in terms of 'cowardice' … it's a truly odd phrasing/question*". Comments from safety practitioners also highlighted a preference for positively compared to negatively worded questions. Examples include: "*Some statements may be better if put in the positive context …*" and "*… the fact that several of the sections had a group of "positive" and "negative" responses in the same section directed people (me) to naturally put the positive safety comments as a higher ranking than the negative ones*". This resulted in negatively worded questions that were the inverse of positively worded questions being considered for removal; for example, item 45 "We who work here consider that safety rounds/evaluations have no effect on safety" was removed in favour of item 48 "We who work here consider that safety rounds/evaluations help find serious hazards", given that they were ranked similarly based on statistical and practical criteria, the only discernible difference being the wording.

However, some negatively worded questions were still included in the 24-item measure if they displayed appropriate statistical strength, reliability, readability, and were ranked highly by both researchers and practitioners. An example of this is item 32, "We who work here break safety rules in order to complete work on time", which although negatively worded, remains statistically acceptable and was ranked highly by 80% of researchers and 50% of practitioners. In these situations, the negatively worded questions were retained rather than attempting to reword them positively.

The difference between this study and others that have attempted to produce shortened composite measures is that once an item was deemed statistically appropriate based on the predetermined cut-offs, more practical item selection techniques were employed. The goal was not to select the most statistically relevant items, it was instead to select the most practically relevant items that were simultaneously statistically appropriate. This process led to seven items, six of which were co-worker items, being selected for the final version of the brief measure that did not fulfil all of the statistical criteria. For example, item 4 ("Management places safety before production") had one of the lower pattern matrix coefficients (although still statistically acceptable) when compared to other items within the same dimension. However, the item was deemed highly practically significant by nine of fourteen safety practitioners.

3.4. Comparison of original and brief version

Following the application of the above criteria, a brief 24-item version was compiled and is shown in the Appendix. This process resulted in the original seven factors being represented with between three and four items compared to the six to nine items in the full NOSACQ-50. In addition to maintaining the dimension structure, the mean readability (Flesch-Kincaid Grade) requirements of the brief measure (~11 years) remained similar to the full NOSACQ (~10.5 years).

Table 5 shows the descriptive statistics for the seven dimensions of the 50 and 24-item NOSACQ versions. With regard to the reliability analysis of the brief version, six of the seven dimensions demonstrate acceptable reliability (>0.70), with the seventh-dimension approaching acceptability at .69. Although the brief version showed decreases in almost all of the seven dimensions (excluding Workers' Safety Commitment) this was not unexpected. Under classical testing theory scale reliability is dependent on the number of items, thus, reducing the number of items in a dimension would reduce reliability (Norman and Streiner, 2014).

To assess whether the NOSACQ international benchmarking database could be utilised when employing the shortened 24-item NOSACQ, the mean scores of the seven original dimensions and the 24-item versions were compared using a paired samples t-tests. Results are shown in Table 5. Although two significant differences were found between the dimension means, there was not a difference in mean score above 0.07 (using 95% confidence intervals), and all seven dimensions would still be classified in the same NOSACQ safety climate interpretation ranges outlined in the method, supporting the use of existing benchmarking data with the brief 24-item NOSACQ version.

Finally, the factor structure of the 24-item version was compared to the 50-item NOSACQ using principal components analysis with an

Table 5
Descriptive statistics, Cronbach's alpha values for the seven dimensions of the 50 and 24-item NOSACQ versions and mean comparisons using paired samples t-tests.

NOSACQ Dimensions	50-item NOSACQ			24-item NOSACQ			Paired *t*-test
	Number of items	Mean (SD)	Cronbach's α	Number of items	Mean (SD)	Cronbach's α	p-value (two-tailed)
Management Safety Priority, Commitment, and Competence	9	3.00 (0.56)	.88	4	3.00 (0.62)	.80	.589
Management Safety Empowerment	7	2.89 (0.57)	.89	4	2.89 (0.60)	.85	.185
Management Safety Justice	6	2.96 (0.59)	.88	3	2.96 (0.61)	.82	.504
Workers' Safety Commitment	6	3.18 (0.44)	.73	3	3.20 (0.50)	.75	.111
Workers' Safety Priority and Risk Non-Acceptance	7	2.97 (0.49)	.75	3	2.99 (0.60)	.69	.095
Safety Communication, Learning, and Trust in Co-Worker Safety Competence	8	3.15 (0.47)	.89	4	3.22 (0.49)	.85	<.001
Workers' Trust in the Efficacy of Safety Systems	7	3.20 (0.46)	.84	3	3.23 (0.48)	.73	.002

oblique rotation. Bartlett's test of sphericity was significant (χ 2 (276) = 4981.38, $p < .001$) indicating that the correlation matrix was not random, and the KMO statistic (0.95) was above the suggested 0.50 cut-off (Norman and Streiner, 2014). The analysis extracted three factors from the 24-item NOSACQ (accounting for 56% of variance), and these matched the factor structure of the three extracted from the 50-item NOSACQ. Thus, the item reduction had not altered the factor structure of the data which demonstrates the reduced version is measuring the same construct (safety climate) as the full measure. Similar to the factor structure of the full scale, all items within the third factor were negatively worded. This outcome is consistent with Roszkowski and Soven (2010) who reported that as few as two negatively worded questions can be defined as a separate factor, as well as the previously cited research that outlined the detrimental impact negatively worded questions can have on survey measures. Table 6 shows the pattern matrix for the reduced measure.

4. Discussion

Following the methodological guidelines of Goetz et al. (2013), results from this study support the 24-item NOSACQ as a brief, practical measurement scale for work safety climate. Practitioner opinions suggest that the selected items will be relevant for a wide range of organisations, and their comments did not indicate any critical missing items for specific types of organisations. Further application in a wider range of organisations and with other relevant outcome variables is necessary to determine the extent to which this brief measure could be generalised.

Assuming that each question takes approximately the same time to answer, this brief version would reduce survey completion time by half. Estimated completion time for the full scale is 20 min, meaning the brief survey could be completed in 10 min. This short completion time should encourage regular usage for the purpose of monitoring safety climate, rather than simply responding to safety concerns as they become critical. Acknowledgement of emerging problem areas with regard to safety can lead to remedial action that prevents costly incidents and/or accidents. Interventions may relate to management, co-worker, or risk areas as per the dimension structure of the measure. While Pronovost and Sexton (2005) recommend annual safety climate surveys, a shorter time investment involved with the brief version could see bi-annual or even quarterly reviews of safety climate. This would allow assessments of safety climate trends across business periods, and also for the evaluation of remedial safety-specific interventions, serving as a 'pulse' for

Table 6
Pattern matrix component structure for 24-item NOSACQ.

NOSACQ Items		Factor 1 (Eigenvalue = 9.88)	Factor 2 (Eigenvalue = 2.32)	Factor 3 (Eigenvalue = 1.24)	Communalities
Management items	1	0.66			**.57**
	2	0.77			**.62**
	4	0.66			.39
	7	0.80			**.58**
	11	0.75			**.62**
	12	0.75			**.57**
	14	0.77			**.66**
	16	0.75			**.56**
	17	0.73			**.56**
	20	0.76			**.62**
	22	0.70			**.63**
Co-worker items	23		0.70		**.54**
	24		0.59		.42
	27		0.68		**.53**
	30r			0.74	**.56**
	32r			0.73	**.66**
	35r			0.76	**.64**
	36		0.81		**.59**
	39		0.82		**.63**
	40		0.71		**.64**
	43		0.54		**.56**
	46		0.53		.39
	48		0.61		**.50**
	50		0.69		.40

Note: Pattern coefficients <0.35 omitted; Communalities ≥0.50 in bold; r indicates negatively worded (reversed scored) items.

employee safety climate. Comparatively, the full scale measure could be employed annually as part of a larger, comprehensive safety assessment. In this sense the brief survey could provide an indication of employee engagement with, and perception of, safety policies and procedures through the business year, whereas the full survey may assess annual safety targets and provide input to broader safety management goals. The alignment of the brief measure with the more comprehensive 50-item measure further suggests that parts of the latter could also be utilised to provide more detailed information when targeting specific areas with safety interventions. Results further demonstrated the same benchmarked scores for both measures, suggesting that the NOSACQ international benchmarks could be applied to either version. In research settings workplace safety climate is often measured as part of a larger assessment, thus the reduced measure supported in this study may benefit safety researchers by allowing for supplementary co-variate measures without the additional response burden cost.

This study highlights several advantages of combining both statistical and practical methods when it comes to measurement development and item reduction. For more general constructs such as work safety climate there are likely to be unique and context-specific facets relevant to different organisations. As a result, asking safety practitioners whether anything was missing from the measure was an important consideration to ensure the measure would remain widely applicable. This process also helped to highlight practical issues with the current measure in terms of item wording that was considered confusing or unsuitable for the target population. A further advantage of consulting with domain-specific practitioners for item reduction is that it can facilitate buy-in for the measure which may promote future use. Similarly, engaging practitioners in the survey design process may have the added benefit of shifting organisational focus upstream from retroactive outcomes to preventative, proactive measures (Davis et al., 2020). It has previously been mentioned that several measures of work safety climate exist, some with questionable validity or reliability, thus, collaborating with practitioners is an important step to bridging the gap between research and practice (Baker et al., 2015; Chang et al., 2015).

Utilising this new method for item reduction that extends beyond purely statistical methods did identify some potential issues. Readability was selected as a key practical component of the survey's usability and was intended to distinguish between items that performed similarly from a statistical perspective. According to Hall et al. (2010) items should have a mean readability score (measured by Flesch-Kincaid grade) of 8. However, in the case of the NOSACQ, all management level and several co-worker level items exceeded this threshold to begin with. Thus, readability measures were not useful in reducing the survey dimensions – particularly the management dimensions. As a result, readability scores were used to ensure that the reduced measure remained similar to the full version in terms of required reading ability and therefore usability.

Ultimately this study demonstrates the importance of determining the purpose of a measure before attempting item reduction. In this study one aim of the research team was to ensure that the shortened NOSACQ would continue to serve as a leading indicator for work safety outcomes. Hence, it was important for selected items to correlate with health and wellbeing measures and thus a high criterion of correlating with 4 of the 5 measures was set. The cut-off criteria for the other methods (e.g., researcher and practitioner ratings of >60% and >50% respectively) were similarly arbitrary but were set to represent a majority consensus. Researchers who wish to replicate this item reduction approach should consider selection criteria based on the purpose a shortened measure will serve. Proposing definitive rules or recommendations for the selection of items that will constitute a brief version of an existing measure would be unwise, as the optimal criteria is likely to vary according to construct, target population, and measurement purpose.

This study included data from two types of organisations (both human service), and the use of two dependent outcome variables. Both the CBI and SF-8 were selected due to their established validity and practical relevance in research on using a work safety climate measure to remediate work safety issues (Kirby et al., 2014). However, a greater range of types of organisations and more dependent measures related to work safety are needed to better assess the usefulness of the 24-item NOSACQ when compared to the original measure. Additionally, in EFA there is always a component of subjectivity regarding scree plot analysis and factor structuring (Watkins, 2018), ultimately the factors are hypothetical constructs that cannot be measured directly and are instead inferred.

Future research is needed to investigate the practical relevance of item reduction methods used in this study. The value of the brief measure for monitoring and remedial purposes needs to be demonstrated in terms of its capacity to identify emerging safety issues in different types of organisations and to assess outcomes of implemented remedial strategies to deal with those issues. Following the guidelines described by Goetz et al. (2013) future research should aim to validate the shortened measure within an independent sample. Additionally, while this study followed a more comprehensive methodological process than usual for item reduction, the resulting 24-item measure should undergo further validation, potentially in the form of a Confirmatory Factor Analysis to assess the dimension structure. This may be particularly relevant given the potentially problematic impact of negatively worded questions in the survey.

5. Conclusion

This study aimed to develop a brief work safety monitoring measure to identify emerging safety issues before they become critical. The methods used enabled the development of a brief measure that retained key items in each factor of the comprehensive work safety measure on which it was based. Therefore, an identified issue might be further investigated using a relevant part of the comprehensive measure if required. Safety research will also benefit from this brief measure, particularly when multiple assessment measures are employed as part of a larger test battery.

The widespread monitoring use of a validated, brief measure for work safety climate may help to identify emerging work safety issues before they become critical, allowing the implementation of remedial strategies to prevent safety accidents and incidents that are costly to both individual workers and organisations. It may also help to develop a consensus concerning key practical issues in the development and maintenance of workplace safety. Its application as a monitoring tool could also assist in the benchmarking of safety climate standards and thereby contribute to a shared understanding of best work safety practice.

Author statement

Denvar Summers: Methodology, Formal Analysis, Writing – Original Draft, Visualization. **Aspa Sarris**: Conceptualization, Methodology, Writing – Review & Editing, Supervision. **Julia Harrie**s: Investigation, Writing – Review & Editing, Visualization, Supervision. **Neil Kirby**: Conceptualization, Investigation, Writing – Review & Editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix. Nordic Occupational Safety Climate Questionnaire (NOSCAQ-50). Note: ** = Item is used in the 24-item version and r indicates negatively worded (reversed scored) items

Dimension 1: Management safety priority, commitment and competence

1. Management encourages employees here to work in accordance with safety rules - even when the work schedule is tight. **
2. Management ensures that everyone receives the necessary information on safety. **
3r Management looks the other way when someone is careless with safety.
4. Management places safety before production. **
5r Management accepts employees here taking risks when the work schedule is tight.
6. We who work here have confidence in the management's ability to deal with safety.
7. Management ensures that safety problems discovered during safety rounds/evaluations are corrected immediately. **
8r When a risk is detected, management ignores it without action.
9r Management lacks the ability to deal with safety properly.

Dimension 2: Management safety empowerment

10. Management strives to design safety routines that are meaningful and actually work.
11. Management makes sure that everyone can influence safety in their work environment. **
12. Management encourages employees here to participate in decisions which affect their safety. **
13r Management never considers employees' suggestions regarding safety.
14. Management strives for everybody at the worksite to have high competence concerning safety and risks. **
15r Management never asks employees for their opinions before making decisions regarding safety.
16. Management involves employees in decisions regarding safety. **

Dimension 3: Management safety justice

17. Management collects accurate information in accident investigations. **
18r Fear of sanctions (negative consequences) from management discourages employees here from reporting near-miss accidents.
19. Management listens carefully to all who have been involved in an accident.
20. Management looks for causes, not guilty persons, when an accident occurs. **
21r Management always blames employees for accidents.
22. Management treats employees involved in an accident fairly. **

Dimension 4: Workers' safety commitment

23. We who work here try hard together to achieve a high level of safety. **
24. We who work here take joint responsibility to ensure that the workplace is always kept tidy. **
25r We who work here do not care about each others' safety.
26r We who work here avoid tackling risks that are discovered.
27. We who work here help each other to work safely. **
28r We who work here take no responsibility for each others' safety.

Dimension 5: Workers' safety priority and risk non-acceptance

29r We who work here regard risks as unavoidable.
30r We who work here consider minor accidents to be a normal part of our daily work. **
31r We who work here accept dangerous behaviour as long as there are no accidents.
32r We who work here break safety rules in order to complete work on time. **
33. We who work here never accept risk-taking even if the work schedule is tight.
34r We who work here consider that our work is unsuitable for cowards.
35r We who work here accept risk-taking at work. **

Dimension 6: Safety communication, learning, and trust in co-worker safety competence

36. We who work here try to find a solution if someone points out a safety problem. **
37. We who work here feel safe when working together.
38. We who work here have great trust in each others' ability to ensure safety.
39. We who work here learn from our experiences to prevent accidents. **
40. We who work here take each others' opinions and suggestions concerning safety seriously. **
41r We who work here seldom talk about safety.
42. We who work here always discuss safety issues when such issues come up.
43. We who work here can talk freely and openly about safety. **

Dimension 7: Workers' trust in the efficacy of safety systems

44. We who work here consider that a good safety representative plays an important role in preventing accidents.
45r We who work here consider that safety rounds/evaluations have no effect on safety.
46. We who work here consider that safety training is good for preventing accidents. **
47r We who work here consider early planning for safety as meaningless.
48. We who work here consider that safety rounds/evaluations help find serious hazards. **
49r We who work here consider safety training to be meaningless.
50. We who work here consider it important to have clear-cut goals for safety. **

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