ORIGINAL ARTICLE

Development and Validation of a Questionnaire on Safety Culture Elements Preference for Oil and Gas Industry

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ABSTRACT

Introduction: The oil and gas industry is characterized by its inherently high-risk environment, necessitating a robust safety culture to prevent accidents and protect employees. Given the sector's complexity and the critical nature of its operations, a systematic assessment of safety culture is essential for enhancing safety performance. However, there remains a notable absence of standardized tools specifically designed to measure safety culture within the oil and gas industry. This study aims to develop and validate a Safety Culture Questionnaire (SCQ) tailored for the oil and gas industry to systematically assess safety culture. **Materials and methods:** The SCQ was developed based on an extensive literature review and consultation with academician and industry experts. The questionnaire is structured based on four key constructs derived from safety culture frameworks: psychological (6 items), situational (15 items), behavioural (28 items), and element preference (3 items), totaling 52 questions. Content validity was assessed by a panel of seven experts, and reliability was evaluated using Cronbach's Alpha. **Results:** The Content Validity Index (CVI) ranged from 0.86 to 1.00, indicating strong validity. Cronbach's Alpha values demonstrated excellent reliability: 0.926 (psychological), 0.923 (situational), 0.982 (behavioural), and 0.912 (element preference). **Conclusion:** The validated SCQ is a reliable and valid tool for assessing safety culture in the oil and gas industry. It can be used to identify safety culture strengths and weaknesses, enabling organizations to target interventions more effectively and ultimately improve safety culture.
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INTRODUCTION

In the high-risk oil and gas industry, where accidents can lead to severe consequences, establishing a robust safety culture is crucial. Safety culture in this context refers to the way in which safety is managed in the workplace, encompassing attitudes, beliefs, perceptions and values shared by employees at all levels (1-2). Despite the critical importance of safety culture, measuring it accurately and effectively has remained a challenge, particularly due to the diverse operational contexts and geographic regions in which these industries operate (3). Historically, attempts to quantify safety culture have utilized various methodologies, but often without sufficient validation to ensure their effectiveness across different industries and operational settings (4). This has led to the development of tools that may not fully capture the nuances of safety culture in specific contexts, particularly in an industry as complex and varied as oil and gas. In response to this, there has been a growing emphasis on the need for a scientifically rigorous approach to developing these assessment tools (5,6).

A variety of tools have been developed to assess safety culture, including the Safety Attitudes Questionnaire (SAQ) and the IATA Aviation Safety Culture Survey (IASC), which have been used in sectors such as healthcare and aviation. (7, 8). The SAQ focuses on measuring attitudes and perceptions related to teamwork, safety climate, and job satisfaction, while the IASC surveys emphasize compliance and organizational

safety policies within aviation contexts. However, these tools are often insufficient for the oil and gas industry due to its unique operational complexities and high-risk nature (9). For example, the SAQ lacks situational specificity, making it challenging to address the diverse and hazardous working conditions found in oil and gas environments. Similarly, IASC safety surveys are tailored to International Civil Aviation Organization (ICAO) and does not account for the distinct safety management practices and cultural diversity inherent to oil and gas operations. Furthermore, many existing tools were designed in culturally homogeneous settings, limiting their adaptability to the workforce characteristic of the oil and gas sector. These limitations highlight the need for a tailored safety culture assessment tool that addresses the specific challenges and operational contexts of the oil and gas industry.

To address these challenges, the current study embarked on the development of a new questionnaire specifically designed for assessing safety culture within the oil and gas sector. This process began with a systematic literature review (SLR), which served to identify and prioritize the key elements of safety culture that are most relevant and critical to the industry. The SLR not only provided a foundational understanding of the existing knowledge base but also highlighted the gaps in current assessment practices, particularly in how they adapt to different cultural and operational environments (10,11). The outcome of this review was instrumental in constructing a questionnaire that is both comprehensive and sensitive to the industry's specific needs. The development process involved multiple stages, including item generation, expert reviews for content validity, and pilot testing to refine the instrument. A rigorous methodology is essential to assess the extent to which an instrument is influenced by measurement error (reliability) and accurately reflects the construct it is designed to measure (validity) (12).

This paper details the rigorous validity process undertaken before the questionnaire's broader distribution, ensuring that the final tool is robust, reliable, and capable of effectively measuring safety culture in diverse settings within the oil and gas industry. The primary objective of this research is not only to introduce a validated tool for safety culture assessment but also to contribute to the broader goal of enhancing safety management practices in the oil and gas industry. By providing a reliable measure of safety culture, the industry can better identify strengths and areas for improvement, leading to targeted interventions that enhance both safety outcomes and operational efficiency.

MATERIALS AND METHODS

Study Population

The study engaged a specific cohort of 40 participants, comprising safety and health practitioners, policymakers, academicians, and industry employees in the Malaysian oil and gas sector. To ensure a robust content validation process, an expert panel was carefully selected from this cohort based on their roles, experience, and expertise in safety culture. The panel included senior safety and health officers with at least 5 years of experience in the oil and gas industry, policymakers involved in the formulation and implementation of safety regulations, academicians with research expertise in occupational safety and health, and experienced field-level employees with direct involvement in safety practices. This diverse composition ensured a comprehensive understanding of safety culture elements from strategic, academic, and practical perspectives. The sample size of 40 participants was chosen based on established guidelines for content validation studies, which recommend expert panels ranging from 5 to 40 participants to ensure sufficient reliability and diverse insights (13). Given the targeted nature of the study, focusing on domain experts rather than a general population, a sample size of 40 was deemed appropriate to balance expert diversity and feasibility while achieving meaningful validation results. This approach aligns with previous research in safety culture assessment, which emphasizes quality over quantity in expert-driven validation processes.

The selection of panel members was guided by their qualifications, such as professional certifications (e.g., NIOSH, DOSH), academic credentials (e.g., Ph.D. or Master's degrees in relevant fields) and their demonstrated contributions to safety culture through publications, policy development, or operational improvements. The inclusion of these experts was instrumental in validating the questionnaire's content, ensuring its relevance and applicability to the oil and gas sector. To facilitate broad and inclusive data collection, the questionnaire was distributed online and completed via self-administration. This approach ensured voluntary participation and adhered to ethical considerations, including informed consent. The online distribution method also overcame geographical limitations, enhancing the representativeness of the data across diverse operational and cultural contexts in the industry (14,15). Data collection was conducted in March 2024.

Questionnaire

To develop the questionnaire, an extensive literature review was conducted to identify relevant questionnaire items. Sources included major databases such as Web of Science, Scopus and SpringerLink (16-18). The questionnaire was structured according to Saaty's Analytic Hierarchy Process (AHP) methodology (19), ensuring alignment with established analytical standards. The questionnaire consisted of 52 questions, divided into four constructs: psychological, situational, behavioural and preference of element containing 6, 15, 28 and 3 questions respectively. In each section, participants were presented with pairs of variables representing different aspects of the three criteria and

were asked to indicate their preferences. Each variable was clearly defined to maintain clarity and consistency in the responses. Preferences were quantified using a Likert scale from 0 to 9, where 1 indicated equal importance, and 9 indicated absolute importance, with intermediate values reflecting varying degrees of preference. All questions were closed-ended to streamline the analysis process.

Face Validity

Face validity was conducted in a face-to-face format to enhance direct feedback and interaction. Each of the five respondents, who met the inclusion criteria for the target population of the formal study, was invited individually to review the questionnaire items and complete the face validity feedback form. This approach ensured that feedback was detailed and specific, allowing for immediate clarification and discussion of any ambiguities. This method emphasized measuring whether the items were expressed clearly and effectively, reducing confusion from excessive professionalism or ambiguity.

The selection of five respondents for face validity aligns with standard recommendations in psychometric research, where small expert panels (typically between 5 and 10 participants) are considered sufficient for qualitative evaluations of item clarity and relevance (20). Since face validity is a subjective assessment rather than a statistical validation, the primary objective was to gather focused, high-quality feedback from experienced professionals rather than achieving a large sample size (21, 22). The five respondents were selected based on their expertise in safety culture and occupational health, ensuring that their input was meaningful and representative of the target industry.

To assess the face validity of the questionnaire designed for prioritizing safety culture in the oil and gas industry, a panel of experts was assembled. This panel included academicians, industry practitioners, and policymakers, all with extensive knowledge of the psychological, situational, and behavioural aspects of safety culture. Each expert was provided with the questionnaire, and the Analytic Hierarchy Process (AHP) methodology employed in its design was explained to ensure they understood the rationale behind the scaling and pairing of variables. The experts were tasked with evaluating the relevance and clarity of each questionnaire item in relation to the defined constructs of psychological, situational, and behavioural criteria. They reviewed the definitions provided for each variable to determine their clarity and assessed whether the questionnaire items collectively captured the nuances of safety culture effectively. Special attention was given to the Likert scale, which ranged from 0 to 9, to evaluate whether it effectively captured the gradations in preference and importance as intended by the study's design.

Based on the feedback received from the five respondents, no modifications were deemed necessary, as all participants confirmed that the questionnaire items were clear, relevant, and comprehensible. The consistency in expert responses indicated that the questionnaire was well-structured and effectively captured the intended safety culture dimensions, supporting its readiness for further validation.

Content Validity Index

An expert panel comprising seven specialists was convened to establish the content validity of the research instrument intended for a pilot study. The panel included three safety and health practitioners from the oil and gas industry, one enforcement officer from the Department of Occupational Safety and Health, one officer from the National Institute of Occupational Safety and Health, and two academicians from Universiti Teknologi MARA and Universiti Putra Malaysia. These experts were selected based on their extensive knowledge and direct experience relevant to the research topic.

The evaluation process was meticulously structured to ensure a comprehensive review and high relevance of the questionnaire items to the domain being measured. Each questionnaire item was subjected to rigorous scrutiny to assess its clarity, relevance, and unambiguous presentation. The structured approach used a four-point likert scale for the content assessment, as recommended by Polit and Beck (2006) (20) presented in Table I.

Table I: Four-points likert scale for content validity index (CVI)

Rating	Definition	Description
1	Not relevant	The item does not pertain to the domain being measured.
2	Somewhat relevant	The item shows some relevance but is inadequate in content.
3	Quite relevant.	The item is appropriate and offers significant relevance to the domain.
4	Highly relevant	The item is extremely pertinent and provides comprehensive coverage of the domain.

This four-point scale was chosen to prevent a neutral midpoint, thereby encouraging clear distinctions in the ratings provided by the experts. For the Content Validity Index (CVI) calculations, items rated as '3' or '4' were considered relevant, while items rated as '1' or '2' were deemed not relevant, indicating potential areas for revision or removal. The threshold for the Item-Level Content Validity Index (I-CVI) was set at ≥0.78, following the recommendations of Polit and Beck (2006). This threshold is widely recognized in the literature as an indicator of strong content validity and ensures that the instrument is sufficiently rigorous for further testing.

The ratings assigned by the panel were aggregated to calculate both the I-CVI for individual items and the

Scale-Level Content Validity Index (S-CVI) for the entire instrument. During the review process, experts were also encouraged to provide qualitative feedback on each item, suggesting possible modifications or expressing concerns regarding the wording and the item's alignment with the research objectives. This collaborative and iterative process was designed to enhance the precision and applicability of the research instrument, thereby ensuring its validity and effectiveness in capturing the necessary data for the study. During the content validation process, any items that scored below the threshold of ≥0.78 on the Item-Level Content Validity Index (I-CVI) were carefully reviewed and addressed based on feedback from the expert panel (22, 23). Low-scoring items were either revised for clarity, relevance, or alignment with the research objectives or in cases where the item was deemed irrelevant or redundant, removed entirely from the questionnaire (24, 25). This process ensured that the final set of items was highly relevant, clear, and representative of the safety culture dimensions being measured.

While the Content Validity Index (CVI) analysis primarily focused on the Item-Level Content Validity Index (I-CVI) to evaluate the relevance and clarity of individual items, the Scale-Level Content Validity Index (S-CVI) was not calculated in this study. The decision to omit S-CVI, including S-CVI/Average and S-CVI/Universal Agreement, was based on the relatively small size of the expert panel as the S-CVI/Universal Agreement method could lead to overly stringent thresholds that might underestimate the overall validity of the instrument (20, 26). Moreover, the primary aim of the validation process was to refine individual questionnaire items rather than assess the overall scale-level validity, which aligns with the specific research objectives. Future studies with larger expert panels may incorporate S-CVI measures to complement the I-CVI findings and provide additional insights into scale-level content validity.

Content Validation Ratio

This section outlines the use of the Content Validity Ratio (CVR), a measure originally proposed by Lawshe in 1975 (27), for assessing the essentiality of questionnaire items in the context of safety culture in the oil and gas industry. The CVR offers a quantitative assessment scale ranging from -1 to +1, reflecting a spectrum of expert opinions on the necessity of survey items. Expert Panel was formed based on selected group of subject matter experts is convened, bringing diverse insights from various facets of safety culture. Their expertise is critical in defining what constitutes 'essential' content within the survey. Each item of the questionnaire is rated by these experts using a four-point Likert scale, defined in Table II.

Table II: Four-points likert scale for content validity ratio (CVR)

Rating	Definition	Description
1	Not necessary	The item does not contribute essential information to the domain.
2	Useful but not essential	The item provides useful information but is not critical.
3	Essential	The item is fundamental and should be included in the survey.
4	Very essential	The item is crucial for comprehensive coverage of the survey domain.

The CVR for each item is calculated using the formula:

$$CVR = \frac{(n_e - N/2)}{N/2}$$

Here, n_e is the number of experts who rated the item as 'essential' or 'very essential' (ratings 3 and 4), and N is the total number of experts. Items receiving a CVR close to +1 are considered highly essential, indicating strong expert consensus. Conversely, items with a CVR near or below zero may be reconsidered or revised based on expert feedback.

Reliability Analysis

The application of Cronbach's alpha to evaluate the reliability of the newly developed Safety Culture Preference Survey was utilized. Cronbach's alpha provides a measure from 0 to 1, reflecting the degree of interrelatedness among the items on the survey. The calculation takes into account the number of items in the test, the average correlation among the items, and the dimensionality of the underlying construct. Commonly, alpha values between 0.70 and 0.90 are considered acceptable in psychometric testing, indicating sufficient internal consistency without excessive redundancy. Alpha values below 0.70 may suggest that the test items do not adequately capture the same construct or are poorly correlated. Alpha values exceeding 0.90 may indicate redundancy among items, suggesting that some items may be duplicative and could potentially be removed to streamline the survey. The alpha values for each dimension of the safety culture survey are critically analysed to ensure that each set of items consistently measures a single construct. Based on the alpha results, adjustments may be made to the survey to either refine or remove items to enhance the survey's overall reliability.

While Exploratory Factor Analysis (EFA) or Confirmatory Factor Analysis (CFA) is typically expected for construct validation of newly developed questionnaires, these analyses were not performed in this study due to the primary focus on content validation and reliability assessment (28). Given the relatively small sample size and the study's objective to first establish an initial validation framework for the SCQ, conducting factor analysis would have been limited in its generalizability.

Future studies with larger and more diverse samples should employ EFA to explore the underlying factor structure of the SCQ and CFA to confirm its construct validity across different industry settings. These additional analyses will further strengthen the psychometric robustness of the SCQ, ensuring its applicability across broader populations (29).

Statistical analysis

The structured approach to the statistical analysis of the pilot study was conducted to verify the validity and reliability of the Safety Culture Questionnaire (SCQ). Data for the pilot study was collected via an online survey administered using Google Forms, ensuring efficient and broad accessibility. Responses were automatically recorded and stored securely online, facilitating a streamlined data collection process. The complete dataset was exported from Google Forms and directly imported into SPSS version 29.0 for comprehensive analysis. Prior to analysis, data was checked for completeness and consistency to ensure the accuracy of the results.

The analysis was strictly confined to content validity and reliability assessments, aligning with the research objectives to refine the survey's design based on empirical evidence. Statistical analysis methods to assess the extent to which the survey items are an adequate reflection of the construct to measure the domain of safety culture. Cronbach's alpha was calculated to evaluate the internal consistency of the survey, ensuring that the items reliably measure the same concept. Descriptive statistics were not performed as the primary focus was to validate the instrument's content and structure rather than to explore the data distribution or demographic characteristics of the sample.

Ethical Clearance

The study was approved by the Research Ethics Committee (REC) of UiTM under the reference number: REC/07/2023 (PG/MR/251) dated on 21st Jul 2023. The approval duration was July 2023 until September 2024.

RESULTS

Face Validity

Based on the feedback from the five respondents, the questionnaire content was clearly understood with no noted ambiguities. The time required to complete the questionnaire ranged from 15 to 20 minutes.

Content Validity Index

The Content Validity Index (CVI) analysis demonstrated acceptable levels of content validity across all constructs following a comprehensive evaluation (16). Dimension-specific insights revealed strong performance in the psychological, situational, and behavioural constructs, as well as the element preference category. Within the psychological construct, all six items achieved CVI scores ranging from 0.86 to 1.00. Items P1, P2, and P3 were collectively rated as highly relevant (CVI = 1.00), reflecting their clarity and alignment with the construct, while items P4, P5, and P6 scored slightly lower (CVI = 0.86). Similarly, the situational construct exhibited strong validity, with all 15 items achieving CVI scores of 0.86 or higher. Twelve items were consistently rated as highly relevant (CVI = 1.00), indicating a high level of agreement on their importance, whereas items S10, S13, and S14 (CVI = 0.86). The behavioural construct showed the variability, with CVI scores ranging from 0.86 to 1.00 across 28 items. While items such as B1, B2, and B3 achieved perfect scores (CVI = 1.00), others, including B5 and B8, scored slightly lower (CVI = 0.86), reflecting the inherent complexity of capturing nuanced safety behaviours. Finally, the element preference category demonstrated unanimous agreement across all items (CVI = 1.00), underscoring the clarity and importance of these elements in assessing safety culture priorities. These results highlight the overall robustness of the instrument, with most items exceeding the threshold for content validity. The findings are detailed in Table III.

Table III: Content validity index (CVI)

Scale	Items Code (Table 5)	Relevant	Not relevant	CVIs	Interpretation
Psychological	P1	7	0	1.00	Appropriate
	P2	7	0	1.00	Appropriate
	P3	7	0	1.00	Appropriate
	P4	6	1	0.86	Appropriate
	P5	6	1	0.86	Appropriate
	P6	6	1	0.86	Appropriate
Situational	S1	7	0	1.00	Appropriate
	S2	7	0	1.00	Appropriate
	S3	7	0	1.00	Appropriate
	S4	7	0	1.00	Appropriate
	S5	7	0	1.00	Appropriate
	S6	7	0	1.00	Appropriate
	S7	6	0	1.00	Appropriate
	S8	7	0	1.00	Appropriate
	S9	7	0	1.00	Appropriate
	S10	6	1	0.86	Appropriate
	S11	7	0	1.00	Appropriate
	S12	7	0	1.00	Appropriate
	S13	6	1	0.86	Appropriate
	S14	6	1	0.86	Appropriate
	S15	7	0	1.00	Appropriate
Behavioural	B1	7	0	1.00	Appropriate
	B2	7	0	1.00	Appropriate
	B3	7	0	1.00	Appropriate
	B4	7	0	1.00	Appropriate
	B5	6	1	0.86	Appropriate
	B6	7	0	1.00	Appropriate
	B7	7	0	1.00	Appropriate
	B8	6	1	0.86	Appropriate
	B9	6	1	0.86	Appropriate
	B10	7	0	1.00	Appropriate
	B11	6	1	0.86	Appropriate
	B12	6	1	0.86	Appropriate
	B13	6	1	0.86	Appropriate
	B14	6	1	0.86	Appropriate
	B15	6	1	0.86	Appropriate
	B16	6	1	0.86	Appropriate
	B17	6	1	0.86	Appropriate
	B18	6	1	0.86	Appropriate
	B19	6	1	0.86	Appropriate
	B20	6	1	0.86	Appropriate
	B21	7	0	1.00	Appropriate
	B22	7	0	1.00	Appropriate
	B23	6	1	0.86	Appropriate
	B24	6	1	0.86	Appropriate
	B25	6	1	0.86	Appropriate
	B26	6	1	0.86	
	B27	6	1	0.86	Appropriate
	B28	6	1	0.86	Appropriate
Significant Safety Culture Element	SE1	7	0	1.00	Appropriate
	SE2	7	0	1.00	Appropriate
	SE3	7	0	1.00	Appropriate

Content Validation Ratio

The Content Validity Ratio (CVR) analysis confirmed the content validity of the questionnaire, with all items meeting or exceeding the minimum acceptable CVR threshold of 0.50, as recommended for a panel of seven experts The psychological construct demonstrated strong content validity, with all six items achieving CVR scores between 0.86 and 1.00. Items P1, P2, and P3 achieved unanimous agreement (CVR = 1.00), indicating their high relevance, while items P4, P5, and P6 (CVR =

0.86). Similarly, the situational construct exhibited high validity, with 12 of the 15 items rated as essential by all experts (CVR = 1.00). However, items S3, S7, S13, and S14 scored slightly lower (CVR = 0.71). The behavioural construct displayed slightly greater variability, with CVR scores ranging from 0.71 to 1.00 across its 28 items. Several items, such as B1, B2, B3, B6, B7, B21, and B22, achieved perfect scores (CVR = 1.00), reflecting their strong alignment with the construct's objectives. Conversely, items including B11, B16, B20, B23, and B26 (CVR = 0.71). Lastly, the significant safety culture element construct exhibited unanimous agreement across all three items (SE1, SE2, and SE3), each achieving CVR = 1.00, underscoring their importance in assessing safety culture priorities.

Although some items received moderate expert agreement (CVR = 0.71), they were retained in the questionnaire due to their conceptual relevance and practical significance in capturing the dimensions of safety culture. Additionally, these items were not deemed problematic by the expert panel, and no recommendations were made for their removal or modification. To ensure clarity and contextual alignment, future studies may consider further refinement or rewording of these items based on larger-scale pilot testing and factor analysis. Overall, the CVR analysis validated the questionnaire's robustness in addressing key dimensions of safety culture while identifying specific items for further refinement to enhance clarity and contextual alignment. The CVR results are presented in Table IV.

Table IV: Content validity ratio (CVR)

Scale	Items Code (Table 5)	Essential SME	Not Essential SME	CVRs	Interpretation
Psychological	P1	7	0	1.00	Appropriate
	P2	7	0	1.00	Appropriate
	P3	7	0	1.00	Appropriate
	P4	6	1	0.86	Appropriate
	P5	6	1	0.86	Appropriate
	P6	6	1	0.86	Appropriate
Situational	S1	7	0	1.00	Appropriate
	S2	7	0	1.00	Appropriate
	S3	5	2	0.71	Appropriate
	S4	6	1	0.86	Appropriate
	S5	6	1	0.86	Appropriate
	S6	7	1	0.86	Appropriate
	S7	5	2	0.71	Appropriate
	S8	7	0	1.00	Appropriate
	S9	6	1	0.86	Appropriate
	S10	6	1	0.86	Appropriate
	S11	7	0	1.00	Appropriate
	S12	7	0	1.00	Appropriate
	S13	5	2	0.71	Appropriate
	S14	5	2	0.71	Appropriate
	S15	6	1	0.86	Appropriate
Behavioural	B1	7	0	1.00	Appropriate
	B2	7	0	1.00	Appropriate
	B3	7	0	1.00	Appropriate
	B4	6	1	0.86	Appropriate
	B5	6	1	0.86	Appropriate
	B6	7	0	1.00	Appropriate
	B7	7	0	1.00	Appropriate
	B8	6	1	0.86	Appropriate
	B9	6	1	0.86	Appropriate
	B10	6	1	0.86	Appropriate
	B11	5	2	0.71	Appropriate
	B12	6	1	0.86	Appropriate
	B13	6	1	0.86	Appropriate
	B14	6	1	0.86	Appropriate
	B15	6	1	0.86	Appropriate
	B16	5	2	0.71	Appropriate
	B17	6	1	0.86	Appropriate
	B18	6	1	0.86	Appropriate
	B19	6	1	0.86	Appropriate
	B20	5	2	0.71	Appropriate

CONTINUE

Table IV: Content validity ratio (CVR) (CONT.)

Scale	Items Code (Table 5)	Essential SME	Not Essential SME	CVRs	Interpretation
Psychological	P1	7	0	1.00	Appropriate
	P2	7	0	1.00	Appropriate
	P3	7	0	1.00	Appropriate
	P4	6	1	0.86	Appropriate
	P5	6	1	0.86	Appropriate
	P6	6	1	0.86	Appropriate
Situational	S1	7	0	1.00	Appropriate
	S2	7	0	1.00	Appropriate
	S3	5	2	0.71	Appropriate
	S4	6	1	0.86	Appropriate
	S5	6	1	0.86	Appropriate
	S6	7	1	0.86	Appropriate
	S7	5	2	0.71	Appropriate
	S8	7	0	1.00	Appropriate
	S9	6	1	0.86	Appropriate
	S10	6	1	0.86	Appropriate
	S11	7	0	1.00	Appropriate
	S12	7	0	1.00	Appropriate
	S13	5	2	0.71	Appropriate
	S14	5	2	0.71	Appropriate
	S15	6	1	0.86	Appropriate
Behavioural	B21	7	0	1.00	Appropriate
	B22	7	0	1.00	Appropriate
	B23	5	2	0.71	Appropriate
	B24	6	1	0.86	Appropriate
	B25	6	1	0.86	Appropriate
	B26	5	2	0.71	Appropriate
	B27	6	1	0.86	Appropriate
	B28	6	1	0.86	Appropriate
Significant Safety Culture Element	SE1	7	0	1.00	Appropriate
	SE2	7	0	1.00	Appropriate
	SE3	7	0	1.00	Appropriate

Reliability of the Questionnaire

The questionnaire item based on items code are shown in Table V. The Cronbach's alpha values for the Safety Culture Questionnaire (SCQ), as shown in Table VI. The result indicates strong internal consistency across all dimensions. Each dimension's alpha value surpasses the 0.7 threshold, demonstrating the questionnaire's reliability. These results affirm that the SCQ is a reliable instrument for evaluating safety culture in diverse contexts within the oil and gas industry.

While high Cronbach's alpha values (>0.90) suggest strong internal consistency, they may also indicate potential redundancy in questionnaire items. The behavioural dimension, in particular, recorded an alpha value of 0.982, which is notably high. However, upon reviewing the item pool, no immediate redundancies were identified, as each item captured distinct yet related aspects of behavioural safety culture. Given the comprehensive nature of the behavioural construct, which encompasses various sub-elements, high inter-item correlations were expected. Although no items were removed in this study, future refinements could involve exploratory factor analysis (EFA) to assess whether specific items can be consolidated or revised to reduce redundancy while maintaining conceptual integrity. Additionally, item-total correlations could be further analyzed to determine if any items contribute minimally to construct variance. These refinements will help streamline the SCQ for more efficient application in future studies.

Table V: Items code of questionnaire

Scale	Items Code	ITEMS
Psychological	P1	How much more important is 'Safety Attitude' than 'Safety Influence' in its effects on Psychological?
	P2	How much more important is 'Safety Attitude' than 'Safety Knowledge' in its effects on Psychological?
	P3	How much more important is 'Safety Attitude' than 'Perception of Risk' in its effects on Psychological?
	P4	How much more important is 'Safety Influence' than 'Safety Knowledge' in its effects on Psychological?
	P5	How much more important is 'Safety Influence' than 'Perception of Risk' in its effects on Psychological?
	P6	How much more important is 'Safety Knowledge' than 'Perception of Risk' in its effects on Psychological?
Situational	S1	How much more important is 'Safety Rule' than 'Safe Reporting' in its effects on Situational?
	S2	How much more important is 'Safety Rule' than 'Working Environment' in its effects on Situational?
	S3	How much more important is 'Safety Rule' than 'Job Satisfaction' in its effects on Situational?
	S4	How much more important is 'Safety Rule' than 'Technology Equipment' in its effects on Situational?
	S5	How much more important is 'Safety Rule' than 'Accident Incident' in its effects on Situational?
	S6	How much more important is 'Safety Reporting' than 'Working Environment' in its effects on Situational?
	S7	How much more important is 'Safety Reporting' than 'Job Satisfaction' in its effects on Situational?
	S8	How much more important is 'Safety Reporting' than 'Technology Equipment' in its effects on Situational?
	S9	How much more important is 'Safety Reporting' than 'Accident and Incident' in its effects on Situational?
	S10	How much more important is 'Working Environment' than 'Job Satisfaction' in its effects on Situational?
	S11	How much more important is 'Working Environment' than 'Technology Equipment' in its effects on Situational?
	S12	How much more important is 'Working Environment' than 'Accident Incident' in its effects on Situational?
	S13	How much more important is 'Job Satisfaction' than 'Technology Equipment' in its effects on Situational?
	S14	How much more important is 'Job Satisfaction' than 'Accident Incident' in its effects on Situational?
	S15	How much more important is 'Technology Equipment' than 'Accident Incident' in its effects on Situational?
Behavioral	B1	How much more important is 'Management Commitment' than 'Safety Ownership' in its effects on Behavioural?
	B2	How much more important is 'Management Commitment' than 'Safety Training' in its effects on Behavioural?
	B3	How much more important is 'Management Commitment' than 'Safety Communication' in its effects on Behavioural?
	B4	How much more important is 'Management Commitment' than 'Reward Recognition' in its effects on Behavioural?
	B5	How much more important is 'Management Commitment' than 'Safety Investment' in its effects on Behavioural?
	B6	How much more important is 'Management Commitment' than 'Safety Competency' in its effects on Behavioural?
	B7	How much more important is 'Management Commitment' than 'Safety Commitment' in its effects on Behavioural?
	B8	How much more important is 'Safety Ownership' than 'Safety Training' in its effects on Behavioural?
	B9	How much more important is 'Safety Ownership' than 'Safety Communication' in its effects on Behavioural?
	B10	How much more important is 'Safety Ownership' than 'Reward Recognition' in its effects on Behavioural?
	B11	How much more important is 'Safety Ownership' than 'Safety Investment' in its effects on Behavioural?
	B12	How much more important is 'Safety Ownership' than 'Safety Competency' in its effects on Behavioural?
	B13	How much more important is 'Safety Ownership' than 'Safety Commitment' in its effects on Behavioural?
	B14	How much more important is 'Safety Training' than 'Safety Communication' in its effects on Behavioural?
	B15	How much more important is 'Safety Training' than 'Reward Recognition' in its effects on Behavioural?
	B16	How much more important is 'Safety Training' than 'Safety Investment' in its effects on Behavioural?
	B17	How much more important is 'Safety Training' than 'Safety Competency' in its effects on Behavioural?
	B18	How much more important is 'Safety Training' than 'Safety Commitment' in its effects on Behavioural?
	B19	How much more important is 'Safety Communication' than 'Reward Recognition' in its effects on Behavioural?
	B20	How much more important is 'Safety Communication' than 'Safety Investment' in its effects on Behavioural?
	B21	How much more important is 'Safety Communication' than 'Safety Competency' in its effects on Behavioural?
	B22	How much more important is 'Safety Communication' than 'Safety Commitment' in its effects on Behavioural?
	B23	How much more important is 'Reward Recognition' than 'Safety Investment' in its effects on Behavioural?
	B24	How much more important is 'Reward Recognition' than 'Safety Competency' in its effects on Behavioural?
	B25	How much more important is 'Reward Recognition' than 'Safety Commitment' in its effects on Behavioural?
	B26	How much more important is 'Safety Investment' than 'Safety Competency' in its effects on Behavioural?
	B27	How much more important is 'Safety Investment' than 'Safety Commitment' in its effects on Behavioural?
	B28	How much more important is 'Safety Competency' than 'Safety Commitment' in its effects on Behavioural?
Significant Of Safety Culture Elements	SE1	How much more important is 'Psychological' than 'Situational' in its effects on Safety Culture?
	SE2	How much more important is 'Psychological' than 'Behavioural' in its effects on Safety Culture?
	SE3	How much more important is 'Behavioural' than 'Situational' in its effects on Safety Culture?

Table VI: Cronbach's alpha of the safety culture questionnaire (SCQ)

	Cronbach's alpha	Items
Psychological	0.926	6
Situational	0.923	15
Behavioural	0.982	28
Significant Element Safety Culture	0.912	3
Total items		**52**

DISCUSSION

The CVI results demonstrate that all 52 items of the Safety Culture Questionnaire (SCQ) exhibit high relevance and appropriateness, with CVI values ranging from 0.86 to 1.00 across the psychological, situational, behavioural, and preference safety culture elements dimensions. These findings indicate strong content validity, as each item was deemed appropriate by the expert panel. Notably, items within the psychological and situational categories showed consistent appropriateness, reflecting the robust design of the questionnaire. The particularly high CVI values in the behavioural category underscore the importance of behavioural factors in fostering a proactive safety culture, as they directly influence employee behaviours and attitudes towards safety (30-32). The comprehensive consideration of these factors in the SCQ reflects a thorough understanding of what constitutes a strong safety culture, especially in high-risk sectors like oil and gas.

The CVR results further validate the essentiality of the SCQ items, with CVR values consistently meeting or exceeding the minimum threshold of 0.71. This indicates a high level of agreement among the expert panel regarding the necessity of these items. The psychological dimension again shows strong support, with all items achieving a CVR of 1.00, reaffirming their critical role in assessing safety culture. Similarly, the situational and behavioural dimensions also performed well, underscoring the importance of these elements in capturing the multifaceted nature of safety culture (33-35). The consistency in high CVR values across dimensions suggests that the SCQ is well-grounded in both theoretical and practical aspects, making it a reliable tool for measuring safety culture in complex environments like the oil and gas sector.

The reliability analysis, measured by Cronbach's Alpha, indicates excellent internal consistency for the SCQ across all dimensions. The psychological dimension achieved a Cronbach's Alpha of 0.926, the situational dimension 0.923, and the behavioural dimension 0.982, all of which exceed the widely accepted threshold of 0.7, demonstrating that the questionnaire items consistently measure the underlying constructs. The preference safety culture elements dimension also showed strong reliability with a Cronbach's Alpha of 0.912. These results not only validate the robustness of the SCQ but also emphasize its potential as a dependable instrument for ongoing safety culture assessments. These findings align with recent literature that underscores the importance of high internal consistency in safety culture assessments to ensure that interventions are based on reliable data (36-38).

When compared to existing safety culture assessment tools such as the Safety Attitudes Questionnaire (SAQ) and the Integrated Aviation Safety Culture (IASC) model, the SCQ differentiates itself by incorporating behavioural, situational, and psychological dimensions tailored specifically to the oil and gas industry. Unlike generic safety climate tools, the SCQ is structured to align with industry-specific risks, regulatory frameworks, and operational challenges, making it a more practical and targeted assessment tool for companies operating in high-risk environments. The SCQ also integrates the Analytic Hierarchy Process (AHP), allowing organizations to prioritize safety culture elements based on their specific operational needs. This feature enhances decision-making for targeted safety interventions, a capability not commonly found in traditional safety culture assessment instruments.

The SCQ's high reliability and content validity make it a valuable tool for organizations aiming to enhance safety performance in high-risk industries. To maximize its application, companies can implement the SCQ for safety audits, compliance assessments, and risk management. For safety audits, the SCQ can serve as an internal benchmarking tool to track safety culture performance across departments or sites. In compliance assessments, organizations can use the SCQ to evaluate adherence to industry standards and identify areas for regulatory improvement. Regarding risk management, the SCQ results can inform proactive safety interventions by identifying behavioural gaps that contribute to workplace hazards.

Recommendation

The validated Safety Culture Questionnaire (SCQ) offers significant potential for practical application in organizational settings, particularly in identifying safety culture gaps and guiding targeted interventions. Organizations can use the SCQ to assess psychological, situational, and behavioural dimensions of safety culture, enabling them to pinpoint strengths and weaknesses. By analyzing SCQ results, companies can develop data-driven interventions, such as leadership engagement programs, enhanced safety communication strategies, and targeted training initiatives to address identified deficiencies.

Future studies should focus on larger-scale validation across multiple oil and gas companies to confirm the SCQ's reliability and applicability in different operational environments. Additionally, cross-cultural validation in industries such as aviation, construction, and healthcare

could provide insights into the SCQ's adaptability across high-risk sectors. These extensions would strengthen the generalizability of the SCQ and enhance its potential as a standard safety culture assessment tool. Furthermore, longitudinal studies should be conducted to assess how SCQ scores evolve over time and whether interventions based on SCQ insights lead to measurable improvements in workplace safety. Establishing a benchmarking database using SCQ results across organizations would allow companies to compare safety culture performance against industry standards, fostering a culture of continuous improvement. For instance, organizations with high safety culture scores could serve as role models, sharing best practices with industry peers. Additionally, given the global nature of the oil and gas industry, future research should explore how organizational and cultural differences influence safety culture perceptions, ensuring that the SCQ remains relevant and adaptable for multinational organizations.

Strength and limitation

This study employed a rigorous validation process, incorporating Content Validity Index (CVI), Content Validity Ratio (CVR), and Cronbach's Alpha analysis, which ensured the questionnaire's robustness and reliability. The involvement of a diverse panel of experts from academia and the oil and gas industry contributed to the high content validity of the questionnaire, making it well-suited for practical application. The Cronbach's Alpha values across all domains indicate excellent internal consistency, reinforcing the questionnaire's reliability as a tool for assessing safety culture. The SCQ was specifically designed for the oil and gas industry, addressing the unique challenges and safety culture aspects relevant to this high-risk sector.

However, certain limitations should be acknowledged. While the study included a robust expert panel, the sample size may limit generalizability, necessitating larger-scale validation studies in diverse industry settings. The SCQ was designed and validated within the oil and gas sector, which may impact its applicability to other industries with different safety culture dynamics. Additionally, this study did not include a longitudinal assessment, which could provide insights into the SCQ's long-term reliability and effectiveness in tracking safety culture improvements over time. Future research should address these limitations by conducting multi-industry validations and longitudinal assessments.

CONCLUSION

The validated safety culture questionnaire represents a significant tool for future research, offering the potential to systematically identify and address critical elements of safety culture preferences. By facilitating targeted interventions, it stands to contribute meaningfully to the enhancement of occupational safety and health culture practices within organizations.

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