

Development and Validation of an Instrument to Assess Nursing Team Contexts and Competencies regarding Continuous Quality Improvement Culture

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Abstract

Background

Contextual factors and competencies profoundly influence the efficacy of quality improvement initiatives and the presence of an improvement culture, particularly at the team level. Quantitative research on the magnitude of influence and interplay between the most critical contextual factors and competencies remains scarce. This study aimed to develop and validate an instrument for assessing these factors and competencies influencing continuous quality improvement culture.

Methods

A multi-phase approach was used to develop and validate a psychometric instrument based on prior evidence. The validation process included an expert round, cognitive pretesting, and pilot testing in the target population. Psychometric analyses, performed on two consecutive samples, assessed item properties, reliability and exploratory and confirmatory factor analyses to examine and validate the alignment of latent variables with the theoretical framework.

Results

The process resulted in a 40-item instrument categorised in conceptual groupings under four constructs: 'motivation & trigger', 'continuous improvement at ward level', 'context at ward level', and 'context in organisation'. Items, groupings, and constructs demonstrated good to excellent reliability and validity. Latent factors from exploratory factor analyses aligned mainly with the theoretical framework and were cross-validated through confirmatory factor analyses, with three items excluded based on factor loadings, model fit, and theoretical rationale. The four constructs showed moderate inter-scale correlations, ideal internal consistency, and clear distinction, confirming the instrument's robustness and specificity.

Conclusion

This psychometrically validated instrument is a reliable and valid instrument for assessing the contextual factors and competencies influencing a continuous quality improvement culture in nursing teams, providing a solid foundation for future research.

1. Background

In response to global challenges, healthcare organisations increasingly employ quality improvement (QI) methodologies to innovate and improve care delivery (1, 2). Despite the widespread adoption of QI methods, the effectiveness varies greatly. Although some studies demonstrate improvements in (patient) outcomes, others report minimal or negligible effects (3, 4). These inconsistent results are likely caused by differences in the contextual influences around these QI initiatives (5, 6).

Contextual factors encompass all elements external to the QI initiative that can influence their execution or outcomes, such as organisational culture, resources, QI training, and competencies like leadership attitudes (6–8). While these factors exist across multiple levels within healthcare organisations, from the inner to the outer settings (9, 10), their

influence is particularly pronounced at the microsystem level (11). This underscores the critical role that factors at this team level may play in shaping QI outcomes.

Essential factors at the team level that can either facilitate or hinder QI include team culture, organisational support, team & peer leadership, team learning, psychological safety, and the competencies and capacity to work on QI (7, 8, 12). As the largest professional group in acute care, nurses are pivotal in QI efforts, particularly at the ward level (2, 6). Creating a work environment that supports nurses in QI initiatives can enhance the quality and efficiency of care and lead to better workforce outcomes (7).

Despite the significant impact of contextual factors and competencies on QI efforts, large-scale quantitative research aimed at quantifying their influence remains scarce (1, 7). An instrument to assess these variables' individual influence and interplay is essential to deepen our understanding of how context contributes to a continuous QI culture and influences the outcomes of QI initiatives in clinical microsystems. This study aimed to develop and psychometrically validate the Nursing team Context and Competencies regarding Continuous Quality Improvement (NCC-CQI), an instrument designed to assess contextual factors and competencies that can facilitate or hinder the presence of a continuous QI culture and the efficacy of QI initiatives in nursing teams.

2. Methods

2.1. Research design

A multi-phase development and validation process was followed to design a novel instrument, adhering to the framework proposed by Rattray and Jones (13). First, survey items were carefully selected based on existing literature and insights from previous qualitative research within this setting and domain. An expert panel evaluated the survey items. Both steps ensure content and construct validity. Second, face validity was tested on a small group using cognitive pretesting, and modifications were made. Finally, data were collected from two consecutive independent samples drawn from the target population. The first pilot sample was used to assess item properties and to conduct exploratory factor analyses (EFAs) to compare the factor structure with the underlying conceptual dimensions. The second sample was used to assess internal consistency and perform confirmatory factor analyses (CFAs) to test the model fit and assess construct validity. The data were analysed using IBM SPSS Statistics (Version 29.0) and RStudio (for CFA) (14, 15).

2.2. Development of the NCC-CQI

A comprehensive literature search was conducted to identify conceptual frameworks, models, and primary research related to facilitating and hindering contextual factors and competencies in QI within clinical microsystems or nursing teams. The Plan-Do-Study-Act (or PDSA) cycle is the most used QI methodology in healthcare teams (16) and is, therefore, used as a foundation. The researchers selected the relevant theoretical concepts and frameworks and translated these into survey questions. Clinical leadership attributes were identified as essential factors but were excluded from the survey development because Patrick et al. validated the Clinical Leadership Survey (17).

This literature review identified two conceptual frameworks that describe contextual factors and competencies influencing QI initiatives, focusing on the microsystem level. The revised Model for Understanding Success in Quality from Reed et al. (10) identifies contextual elements and competencies across different organisational levels, particularly those impacting QI teams and projects. Nelson et al. (18) created the Quality by Design model by investigating high-performing clinical microsystems, which offered a broader perspective on QI but essential insights on team level. Factors from these frameworks, informed by the PDSA method (16) and previous qualitative research (19), shaped the selection and formulation of 56 survey items, ensuring alignment with the theoretical underpinnings

of QI in nursing teams. Figure 1 shows the survey structure with four constructs and underlying conceptual groupings. The instrument was originally developed in Dutch, the native language of the target population. An English-language version is provided as Supplementary File 1 to support transparency.

A panel of experts in quality management systems and QI within acute care hospitals reviewed the draft of the instrument. To be eligible, experts were required to hold a position as a quality coordinator or (middle) managers, with at least two years of practical experience with QI, particularly in coaching nursing teams. The expert panel was asked to review the multi-item, multi-dimensional survey for its intended purpose, rating the relevance of each item on a 4-point Likert scale. Based on their opinion, the content validity of individual items (I-CVI) and the averaging calculation method of scale-level content validity index (S-CVI/Ave) were determined. For the I-CVI, a cut-off of .78 and S-CVI/Ave .90 indicated acceptable content validity (20).

2.3. Testing the NCC-CQI

Cognitive pretesting, using the think-aloud technique, was conducted to ensure face validity, alignment with underlying constructs, and consistency in responses by examining comprehension, retrieval, judgment, and response mechanisms (21). In the first round, individual interviews with eligible respondents were conducted. The survey was revised based on their remarks and suggestions. Afterwards, middle managers validated the revised survey through a group interview.

Lastly, the multi-dimensional NCC-CQI survey was tested in two consecutive independent samples. In the first sample, data were collected to assess the item properties and to explore the factor structure in relation to the underlying theoretical framework. In the second sample, the instrument was administered to a larger group to evaluate construct validity through confirmatory procedures. Both samples were drawn from frontline caregivers in acute care hospitals (≥ 6 months of experience), excluding nurse managers.

Respondents rated the presence of contextual factors or competencies in their work environment using a 4-point Likert scale. As item completion was not mandatory, missing responses may indicate difficulty in evaluating specific aspects. Item analyses and EFAs were performed on the first dataset. Descriptive statistics, reliability analyses, CFAs were conducted on the second dataset to validate the underlying theoretical framework.

For item analysis, the three elements were investigated using data from the first sample, since survey responses were not mandatory. These included: first, heterogeneity of responses on one single response option and questions with a high proportion of non-responses. Next, internal consistency was tested by the corrected item-total and inter-item correlations with $< .30$ and $> .80$ as a cut-off for possible exclusions. Lastly, the Cronbach's alpha was calculated using data from the second sample. Given the substantial number of questions within each domain, particularly at the ward-level context, Cronbach's alpha was calculated for NCC-CQI and each construct (level 1) and conceptual groupings (level 2), except for *'motivation & trigger'* (only five survey questions), within the instrument.

Before the EFAs, various pre-analysis checks were conducted. First, the survey must have a stable population factor structure relative to the sample size. Ferguson & Cox (22) recommended a minimum of 100 participants and a minimal ratio of 2–10 participants for each variable, 2–6 variables for each factor and 2–6 participants for each factor. The normality of each variable is evaluated based on the skewness and kurtosis values using a threshold of ± 2.0 . The appropriateness of the correlation is assessed by using the Kaiser Meyer-Olkin (KMO) with a cut-off > 0.50 and Bartlett Test of Sphericity (BS) ($p < .05$) (22).

To determine the number of factors for the EFAs, the Kaiser criterion (eigenvalues > 1) was applied, supplemented by an inspection of the scree plot. If the scree plot's elbow suggested a different number of factors than indicated by the

Kaiser criterion, EFAs were conducted for both solutions. Additional checks, such as examining individual Measures of Sampling Adequacy (MSA) (cut-off .50), correlation matrix, correlation matrix determinant ($> .0001$) and communalities (cut-off .40), were also performed.

Given that the instrument comprises of four theoretically distinct but related constructs, four separate EFAs were conducted to ensure domain-specific factor structures were accurately identified. The main goal of this analysis was to identify all relevant factors, so iterative Principal Axis Factoring (PAF) was preferred (23). Considering the survey's design and the interrelations between factors, Direct Oblim with Kaiser normalisation was selected as the most appropriate rotation.

A score was calculated for each construct and conceptual grouping by taking the mean of the items comprising the (sub)scale. The extracted scales (construct) scores were summed to derive the final score for NCC-CQI. Inter-scale correlation coefficients and Cronbach's alpha for the NCC-CQI were calculated to demonstrate that the instrument's constructs were consistent and reliable.

To finalise the validation process, CFAs were conducted to cross-validate the findings of the EFAs, to test the factorial validity of the theoretical framework and assess model fit. Given the number of items per factor and total number of factors in the models, a sample size of 200 was deemed sufficient (24). Model parameters were estimated via maximum likelihood (ML). Model fit was evaluated using ratio of χ^2 to df , Comparative Fit Index (CFI), Incremental Fit Index (IFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA) and Standardised Root Mean Square Residual (SRMR) and compared against accepted criterion levels. Fit Ratio of ≤ 3 , CFI, IFI, and TLI of $> .95$ and RMSEA and SRMR $\leq .08$ are considered to indicate good model fit (25, 26).

Model modifications, including the addition of residual covariances, were considered based on statistically significant modification indices (MI > 3.84), standardised expected parameter change (SPEC $> .20$), and theoretical justification informed by prior evidence (27, 28). A threshold of $p < 0.05$ was used for all analyses (28). Model modifications based on MI and SPEC were evaluated using the Bayesian Information Criterion (BIC) and were discontinued when an increase in BIC indicated a decline in model fit relative to the prior solution (27).

2.4. Ethical considerations

Ethical approval

was obtained from the UA/UZA Ethics Committee (Sample 1: Project ID 3061; Sample 2: Project ID 6852), and from internal ethics committees at participating hospitals when required by the respective institutions. The study was conducted in accordance with the Declaration of Helsinki, the International Council for Harmonisation Good Clinical Practice guidelines and all data were processed in compliance with the General Data Protection Regulation (GDPR). Participants were informed about the study at the beginning of the survey and provided informed consent through voluntary completion of the questionnaire.

2.5. Use of Artificial Intelligence Tools

During the preparation of this work, the author(s) used ChatGPT-4.0 to rephrase certain parts of the manuscript and to support the writing of the abstract. The tool was not used to generate text without textual input from the authors. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

3. Results

3.1. Development results

Seven experts, including quality coordinators, a COO, a middle manager, and a nursing administrative officer, assessed the 56 survey items. Twenty-two items had an I-CVI below 0.78. The research team reviewed items rated as "not relevant" by two experts (I-CVI = .71) and, based on prior research, retained seven items considered essential. As a result, the NCC-CQI was reduced to 41 items, with the average scale-level CVI of 0.91, indicating strong content validity.

3.2. Cognitive pretesting

Cognitive interviews were conducted with three nurses, two quality officers (one with a nursing background) and one nurse manager. The question-and-answer process revealed 16 items that presented difficulties with comprehending complex concepts, different interpretations, and problems in making a judgment. Additionally, the sequence of survey items was changed for a more logical structure. Guided by the interaction, the ambiguous items were refined through rewording and de-duplication. Three nurse middle managers validated this next version, consisting of 44 survey items.

3.3. Descriptive results

A total of 193 nurses participated in sample 1 and 252 in sample 2. The mean age was 39 years in sample 1 and 40 years in sample 2. Most participants were female (91% and 89%, respectively). On average, participants had 15.5 and 17.1 years of work experience, with 10.0 and 9.8 years at their current ward. In sample 1, the majority held a bachelor's degree (61%) or a postgraduate certificate (22%), while in sample 2, 46% held a bachelor's degree, 27% an associate degree, and 11% a postgraduate certificate (table 1).

Table 1: demographic characteristics of participants of sample 1 (N = 193) and sample 2 (N = 252)		
Characteristics	Sample 1	Sample 2
	Mean (SD) or n (%)	Mean (SD) or n (%)
Age	39,3 (12,7)	40,0 (11,5)
Gender		
Male	18 (9,3%)	28 (11,1%)
Female	175 (90,7%)	224 (88,9%)
Education		
Associate degree	15 (7,8%)	69 (27,4%)
Bachelor	118 (61,1%)	117 (46,4%)
Postgraduate Certificate	43 (22,3%)	27 (10,7%)
Master	10 (5,2%)	8 (3,2%)
Other	7 (3,6%)	31 (12,3%)
Years work experience	15,5 (12,6)	17,1 (11,5)
Years work experience in current ward	10,0 (9,4)	9,8 (8,7)

Table 2: Scale scores of NCC-CQI, constructs, conceptual grouping, internal consistency and reliability indices based on sample 2 (N = 252)

Construct and survey items	Mean (SD)	Construct			Conceptual grouping		
		Cronbach's alpha	Cronbach's alpha if item deleted	Corrected item-total correlation	Cronbach's alpha	Cronbach's alpha if item deleted	Corrected item-total correlation
Construct 1: Motivation & Trigger	2,97 (0,41)	0,77					
1. Pressures or other incentives from outside hospital motivate team to start QIP			0,74	0,48			
			0,68	0,67			
2. Evidence or best practices used to design QIP, tailored to ward context			0,73	0,52			
			0,74	0,48			
3. Relevant data create support for QIP			0,72	0,55			
4. Majority of team is highly motivated to improve care							
5. QIP are relevant to practice							
Construct 2: Continuous improvement at ward level	2,84 (0,44)	0,90					
Conceptual Grouping PDSA principles:	2,86 (0,46)				0,88		
			0,89	0,66		0,87	0,65
1. Evidence or best practices used to implement and evaluate QIP, tailored to ward context			0,88	0,70		0,86	0,74
			0,89	0,63		0,86	0,69
			0,88	0,71		0,86	0,74
2. QIP follow cyclical process until objective is achieved			0,89	0,70		0,86	0,73
3. QIP are first tested on limited scale			0,89	0,71		0,87	0,64
4. During QIP objective or expected outcome is set so that							

results can be evaluated 5. During QIP, results are frequently measured to understand impact of changes 6. Results QIP are communicated & discussed within team, and changes are made based on results					
Conceptual Grouping QI Focus & Skills:	2,82 (0,50)		0,77		
		0,89	0,59	0,75	0,52
8. Learning & improving is essential part of daily work team		0,88	0,73	0,69	0,64
		0,90	0,48	0,73	0,57
9. Team effectively use QI methods		0,89	0,59	0,71	0,60
10. Majority of team participated in QIP					
11. During QIP, members with knowledge of process or outcome of QIP are involved					
Construct 3: Context at ward level	3,08 (0,44)	0,94			
Conceptual Grouping Leadership nurse manager:	3,18 (0,50)		0,87		
Nurse manager:		0,94	0,53	0,86	0,66
		0,94	0,58	0,86	0,68
1. Thinks long-term and systemic		0,94	0,64	0,84	0,73
2. Aligns team objectives with organisational goals		0,94	0,62	0,84	0,75
		0,94	0,67	0,85	0,72
3. Fosters QI culture					
4. Is involved in QIP					
5. Allocates time for and support QIP					

Conceptual Grouping Team Interdependence:	3,14 (0,51)		0,89		
Collaboration within team is characterised by:		0,94	0,74	0,85	0,78
		0,94	0,69	0,85	0,80
6. Trust		0,94	0,64	0,86	0,72
7. Teamwork		0,94	0,65	0,89	0,63
8. Willingness to help each other		0,94	0,70	0,87	0,71
9. Appreciation of complementary roles					
10. Recognition individual contributions to shared purpose					
Conceptual Grouping Relational Team Dynamics	2,96 (0,56)		0,88		
		0,94	0,69	0,88	0,63
13. Appreciate each other & use differences for benefit of team		0,94	0,75	0,80	0,83
		0,94	0,74	0,81	0,83
		0,94	0,67	0,87	0,67
14. Team listen to contribution of every member					
15. Contribution team members will be considered					
16. Different ideas are considered before decision					
Conceptual Grouping Decision Making & Accountability:	3,01 (0,54)		0,92		
		0,94	0,67	0,88	0,85
Working group or reference nurses:		0,94	0,66	0,92	0,76
17. Are given & take responsibility during QIP		0,94	0,69	0,89	0,83
		0,94	0,69	0,89	0,83
18. May decide on QIP					
19. Provide feedback and support to team during QIP					
20. Apply sufficient knowledge and					

skills to carry out QIP					
Construct 4: Context in the organisation	2,71 (0,52)	0,88			
Conceptual Grouping Organisational Leadership:	2,66 (0,59)	0,86			
Management and nurse middle managers:		0,87	0,68	0,83	0,69
1. Encourage team to execute QIP		0,86	0,75	0,80	0,77
2. Share information with team and between teams to execute QIP		0,86	0,72	0,83	0,71
3. Provide sufficient time and resources to team for QIP		0,86	0,71	0,84	0,68
4. Offer recognition & rewards to team for implementation of QIP					
Conceptual Grouping Organisational Support:	2,78 (0,52)	0,74			
5. Team members receive QI education and training		0,88	0,58	0,71	0,53
7. Data for QIP are available & accessible		0,88	0,60	0,64	0,59
8. Our Organisation provides support by deploying QI experts		0,87	0,67	0,63	0,59
TOTAL NCC-CQI score	11,61 (1,55)	Cronbach's alpha total score: 0,96			

QIP= Quality Improvement Projects

Table 2 presents the mean scores and distributions of the (sub)scales and the total score of the NCC-CQI based on sample 2. The results show that the use of PDSA principles and QI focus & skills, elements of continuous improvement, scored lower than motivation and triggers (Mean of respectively 2.86 and 2.82 versus 2.97). The ward-level context is the most present construct (Mean = 3.08, SD $\pm$ 0.44), which appeared to be positively influenced by the perception of microsystem leadership (Mean = 3.18, SD $\pm$ 0.50). In contrast, the perception of organisational

leadership (Mean = 2.66, SD $\pm$ 0.59) and support (Mean = 2.78, SD $\pm$ 0.52) emerged as the least present contextual factors.

3.4. Reliability

Data from sample 1 showed response heterogeneity and non-response rates were within acceptable limits (Table 3). Only one item scored more than 80% on the 'Agree' option, while another had a 6% non-response rate. Table 2 provides the Cronbach's alpha coefficients, Cronbach's alpha if item deleted and corrected item-total correlation for NCC-CQI and (sub)scales using data from sample 2. The four constructs and underlying conceptual groupings scored good to excellent for the reliability checks.

3.5. Exploratory factor analyses

The total sample size exceeds 100, and the number of cases per variable and factor was sufficient, indicating a stable population factor structure. Tests confirmed that each variable was approximately normally distributed. The suitability of the data for factor analysis was further assessed using the KMO and BS. For three PAFs, the KMO values ranged from 0.82 to 0.92, reflecting good to excellent sampling adequacy. The '*motivation & trigger*' construct yielded a KMO value of 0.54, indicating borderline suitability for factor analysis.

In addition, the individual MSA, correlation matrices, and communalities were also reviewed to ensure the appropriateness of the data for factor extraction. Most tests met the required criteria. However, two items within the construct, '*motivation & trigger*', slightly fell below the MSA cut-off (0.48 instead of the recommended 0.50), and in total, 4 items exhibited insufficient communality (see Supplementary file 2). Although the determinant of the correlation matrix for '*context at ward level*' did not meet the cut-off, the individual MSA values exceeded 0.50, and the data were considered acceptable for EFA.

Figure 2 shows the factors identified by the four separate PAFs and compares them with the theoretically driven factor structure (Factor loadings see Supplementary file 3). EFAs using PAF with Direct Oblim rotation resulted in a 2-factor model for '*motivation & trigger*', '*continuous improvement at ward level*' & '*context in organisation*' and a 4-factor model for '*context at ward level*'. The total variance explained by these models was 67%, 56%, 65%, and 69%, respectively.

Table 3: Response distributions for individual NCC-CQI survey items on sample 1 (N = 193)					
Construct and survey item	Missing * N (%)	Strongly disagree (%)	Disagree (%)	Agree (%)	Strongly agree (%)
Construct 1: Motivation & Trigger					
1. Pressures or other incentives from outside hospital motivate team to start QIP		3,6	32,1	59,1	5,2
2. Evidence or best practices used to design QIP, tailored to ward context	1 (0,5)	1,6	14,5	73,1	10,9
3. Relevant data create support for QIP		0,5	5,5	66,5	27,5
4. Majority of team is highly motivated to improve care	1 (0,5)	2,1	23,4	65,1	9,4
5. QIP are relevant to practice	11 (5,7)	0,5	3,1	59,9	36,5
Construct 2: Continuous improvement at ward level					
1. Evidence or best practices used to implement and evaluate QIP, tailored to ward context		0,0	11,9	81,3**	6,7
2. QIP follow cyclical process until objective is achieved	1 (0,5)	0,5	13,0	75,5	10,9
3. QIP are first tested on limited scale		0,5	21,2	67,9	10,4
4. During QIP objective or expected outcome is set so that results can be evaluated		0,5	13,5	75,1	10,9
5. During QIP results are frequently measured to understand impact of changes	2 (1,0)	0,5	23,0	70,2	6,3
6. Results QIP are communicated & discussed within team, and changes are made based on results		2,6	21,8	59,1	16,6
7. Relevant information is documented & communicated		1,0	25,9	62,2	10,9
8. Learning & improving is essential part of daily work team		0,5	9,3	56,0	34,2
9. Team effectively use QI methods	1 (0,5)	5,7	30,2	50,5	13,5
10. Majority of team participated in QIP	1 (0,5)	6,3	33,3	50,0	10,4
11. During QIP, members with knowledge of process or outcome of QIP is involved		2,1	16,1	67,4	14,5
Construct 3: context at ward level					
1. Manager thinks long-term and systemic	1 (0,5)	2,1	9,9	64,6	23,4
2. Manager aligns team objectives with organisational goals		2,1	13,5	64,2	20,2
3. Manager fosters QI culture	1 (0,5)	2,1	9,4	55,7	32,8

4. Manager is involved in QIP	1 (0,5)	2,6	5,7	53,6	38,0
5. Manager allocates time for and support QIP		3,1	16,1	48,7	32,1
6. Collaboration within team is characterised by trust		0,5	10,9	60,6	28,0
7. Collaboration within team is characterised by teamwork		1,0	11,4	58,0	29,5
8. Collaboration within team is characterised by willingness to help each other		1,0	10,9	60,1	28,0
9. Collaboration within team is characterised by appreciation of complementary roles		3,1	15,5	59,1	22,3
10. Collaboration within team is characterised by recognition individual contributions to shared purpose		1,0	11,9	66,3	20,7
11. Team members values communication & commitment for QIP		0,5	18,1	63,7	17,6
12. Team members are recognised for improving care		3,6	20,2	59,6	16,6
13. Appreciate each other & use differences for benefit of team		0,5	11,4	66,8	21,2
14. Team listen to contribution of every member		2,1	13,0	66,3	18,7
15. Contribution team member will be considered		2,6	20,2	61,1	16,1
16. Different ideas are considered before decision		1,6	17,6	66,3	14,5
17. Working group or reference nurses are given & take responsibility during QIP	1 (0,5)	1,0	13,0	69,3	16,7
18. Working group or reference nurses may make decision during QIP		1,0	17,1	67,9	14,0
19. Working group or reference nurses provide feedback and support to team during QIP	1 (0,5)	1,0	15,6	69,3	14,1
20. Working group or reference nurses apply sufficient knowledge and skills to carry out QIP		1,0	15,5	73,6	9,8
Construct 4: context in the organisation					
1. Management and nurse middle managers encourage team to execute QIP	2 (1,0)	3,1	19,4	60,2	17,3
2. Management and nurse middle managers share information with team and between teams to execute QIP	2 (1,0)	4,7	35,1	52,4	7,9
3. Management and nurse middle managers provide sufficient time and resources to	2 (1,0)	9,9	41,9	44,0	4,2

team for QIP					
4. Management and nurse middle managers offer recognition & rewards to team for implementation QIP	2 (1,0)	14,1	44,0	39,3	2,6
5. Team members receive QI education and training	1 (0,5)	4,7	25,1	62,3	7,9
6. Organisation have system for data collection & management	3 (1,6)	3,2	26,8	60,5	9,6
7. Data for QIP are available & accessible	4 (2,1)	3,2	29,1	60,8	6,9
8. Our organisation provides support by deploying QI experts	3 (1,6)	3,2	23,2	67,4	6,3

* = empty if no missing values, ** = exceeds the 80% cut-off in one response category

The variance explained by '*continuous improvement at ward level*' fell slightly below the 60% threshold, partly due to low communalities for some items (.36–.43), which weakened their contribution to the overall factor. A 3-factor solution based on the scree plot was tested, which resulted in 63% of total variance. However, it did not produce a clear factor structure and was discarded. For '*context in the organisation*', the initial factor model could not be obtained due to multicollinearity between two items. After removing one item, a distinct factor model emerged.

For the four EFAs, nine of the 43 items had a factor loading between 0.30 and 0.50. These items will be further tested by CFA. The remaining items had higher factor loadings, and only three showed cross-loadings, indicating good construct validity. The inter-scale correlation among the four constructs ranged from 0.40 to 0.60, with each construct demonstrating ideal internal consistency. These constructs were also sufficiently distinct to capture unique dimensions, confirming the instrument's robustness and specificity.

a. Confirmatory factor analyses

The factor structures, informed by the theoretical framework and explored through four EFAs, were cross-validated using CFA. Items with low factor loadings in the EFAs were critically reviewed in relation to their importance to the conceptual grouping. As a result of this review, one item from the conceptual grouping '*PDSA principles*' and two items from '*Relational Team Dynamics*' were excluded from the CFA models. Guided by the MI and SPEC values and with theoretical justification, nine residual covariances were added, distributed across the four models using BIC to provide the best fit relative to model complexity. After modification, the fit indices were all acceptable and demonstrated a good fit of the factor structure (see Table 4). Figure 3 shows the standardised factor loadings, residual variances, correlated residuals and latent variable correlations. The CFAs resulted in a final 40-item instrument (see Supplementary File 1 for English-language version).

Table 4: Goodness-of-fit indices for the confirmatory models				
Index	Motivation & trigger	Continuous improvement at ward level	Context at ward level	Context in organisation
CFI	.994	.956	.965	.986
IFI	.994	.957	.965	.987
TLI	.984	.939	.956	.976
RMSEA	.048	.081	.061	.061
SRMR	.019	.044	.041	.024
Chi-square goodness-of-fit test	$\chi^2 = 6.330$; df = 4; p = .176	$\chi^2 = 84.988$; df = 32; p < .001	$\chi^2 = 239.774$; df = 124; p < .001	$\chi^2 = 23.311$; df = 12; p = .025
Fit ratio	$\chi^2 / df = 1.58$	$\chi^2 / df = 2.65$	$\chi^2 / df = 1.93$	$\chi^2 / df = 1.94$

4. Discussion

a. Statement of principal findings

This study developed and validated the 40-item NCC-CQI to assess contextual factors and competencies influencing a continuous QI culture and QI efficacy in nursing teams. The multi-phase process confirmed the instrument's reliability, with an overall Cronbach's alpha of .96. Validity was established across 10 conceptual groupings and four constructs, although the EFA for the '*continuous improvement at ward level*' construct explained slightly less than the recommended 60% of the total variance. EFAs supported the theoretically driven factor structure, with 82% of item loadings above .50 and only 3 items cross-loading. Inter-scale correlations confirmed distinct yet related constructs, supporting the use of oblique rotation and ensuring conceptual robustness. During CFAs, the instrument was slightly adjusted with the exclusion of three items, resulting in a well-fitting factor structure that aligned with EFA findings.

b. Interpretation within the context of the wider literature

Consistent with prior research, '*context at ward level*' emerged as the key factor for QI, with nurse manager leadership, team interdependence, and teamwork being critical components (7, 11, 12). The findings underscore the need for a supportive and relational leadership style to promote QI (1, 7, 29). Recent literature highlights the importance of team reflexivity in team learning and performance improvements (30). Teams that collaborate effectively through reflection and adaptation, mediated by shared mental models of tasks and roles, are more likely to achieve sustained success in QI (1, 12, 31). While organisational leadership and support were identified as less present factors in our study, their presence can significantly enhance QI efforts, whereas their absence may impede progress (7, 8, 12).

Frontline staff motivation is critical for QI success (5, 7, 10, 19). In our study, the presence of practically relevant projects was associated with higher motivation compared to team-wide motivation to improve care, while external pressure was the least present as a motivating factor. Despite nurses' belief in shared QI responsibility, some feel it lies outside their responsibility or lack accountability (32).

The variance explained by '*continuous improvement at ward level*' was slightly below the threshold. Items influencing this result, by low factor loadings and communalities, focus on using evidence in QI projects, the iterative aspect, and

documentation and communication about QI projects. While iterative cycles are fundamental to PDSA-based QI, they are often overlooked in practice (16), and documentation is seen as an administrative obstacle (19). Ongoing QI training and shared learning enhance nurse engagement (7, 12), suggesting that further research is needed to explore the impact of this construct.

c. Strengths and limitations

Our systematic approach, guided by Rattray and Jones' framework (13), ensures a robust, reliable, and valid instrument. Key strengths included the involvement of an expert panel and cognitive pretesting with eligible participants, which enhanced construct, content, and face validity. Additionally, rigorous psychometric analyses were applied to confirm the theoretical framework and minimise bias. Initial sample size limitations were addressed through broader data collection, resulting in a more randomised and representative sample.

Several limitations should be noted. Concurrent validity could not be assessed due to the absence of an appropriate instrument. The study's exclusive focus on Belgium may limit generalizability due to contextual, cultural, or regulatory factors influencing quality management practices. Finally, the NCC-CQI relies on self-reported data about the research domain, which may result in recall bias or inaccuracies due to knowledge gaps about QI.

d. Implications for policy and practice

As healthcare organisations and nursing teams strive to improve care delivery, creating optimal conditions for QI is essential to ensure QI efficacy. The developed constructs and NCC-CQI offer a method to assess these conditions at the level of the nursing team. By utilising this instrument at the team level, nurses and managers can gain valuable insights into the presence of these context factors and skills on their wards. Organisational or team strategies can address absent or low-scoring elements to enhance a QI-supportive work environment. The NCC-CQI can also serve as a (continuous) evaluation tool for implementing QI tools and programs. These approaches can facilitate more targeted and effective QI initiatives, promoting continuous improvement in nursing teams.

e. Recommendations for Further Research

Despite the recognised importance of contextual factors and competencies in shaping QI efficacy, large-scale quantitative research aimed at quantifying their influence remains scarce (1, 7). Utilising the developed NCC-CQI to evaluate the magnitude of influence and interplay between the most critical contextual factors and competencies offers a valuable opportunity. This helps bridge the gap in quantitative results and deepens our understanding of how context supports a continuous QI culture and influences the outcomes of QI initiatives.

5. Conclusion

The NCC-CQI assessed the contextual factors and competencies influencing a continuous QI culture and QI efficacy in nursing teams. The multi-phase process confirmed the instrument's reliability and validity across 10 conceptual groupings and four constructs. This instrument can guide future research in evaluating key contextual factors and competencies to foster a continuous QI culture and improve QI efforts in nursing teams.

Abbreviations

BS	Bartlett Test of Sphericity
CFA	Confirmatory factor analysis

CFI	Comparative Fit Index
CVI	Content Validity Index
COO	Chief Operating Officer
Df	Degrees of freedom
EFA	Exploratory factor analysis
I-CVI	Content validity of individual items
IFI	Incremental Fit Index
KMO	Kaiser Meyer-Olkin
MI	Modification indices
ML	Maximum likelihood
MSA	Measures of Sampling Adequacy
NCC-CQI	Nursing team Context and Competencies regarding Continuous Quality Improvement
PAF	Principal Axis Factoring
PDSA	Plan-Do-Study-Act
QI	Quality improvement
QIP	Quality improvement project
RMSEA	Root Mean Square Error of Approximation
S-CVI/Ave	Scale-level content validity index
SD	Standard deviation
SRMR	Standardised Root Mean Square Residual
SPEC	Standardised expected parameter change
TLI	Tucker-Lewis Index
UA	Antwerp University
UZA	Antwerp University Hospital

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the UA/UZA Ethics Committee (Sample 1: Project ID 3061; Sample 2: Project ID 6852), and from internal ethics committees at participating hospitals when required by the respective institutions. The

study was conducted in accordance with the Declaration of Helsinki, the International Council for Harmonisation Good Clinical Practice guidelines and all data were processed in compliance with the General Data Protection Regulation (GDPR). Participants were informed about the study at the beginning of the survey and provided informed consent through voluntary completion of the questionnaire.

Consent for publication

Not applicable.

Availability of data and materials

Data is provided within the manuscript or supplementary information files. The datasets generated and analysed during the current study are not publicly available due to institutional privacy regulations but are available from the corresponding author (S.S.) on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

S.S. conceptualised the study, acquired funding, administered the project, and was responsible for data curation, investigation, and formal analysis. S.S. also drafted the original manuscript and led the writing, reviewing, and editing process.

P.V.B. and E.F. contributed to the conceptualisation, methodological design, supervision, and validation. Both critically reviewed and edited the manuscript.

S.V. contributed to data curation, methodology, and formal analysis, and reviewed and edited the manuscript.

All authors read and approved the final manuscript.

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Figures



Figure 1

survey structure with four constructs and underlying conceptual groupings

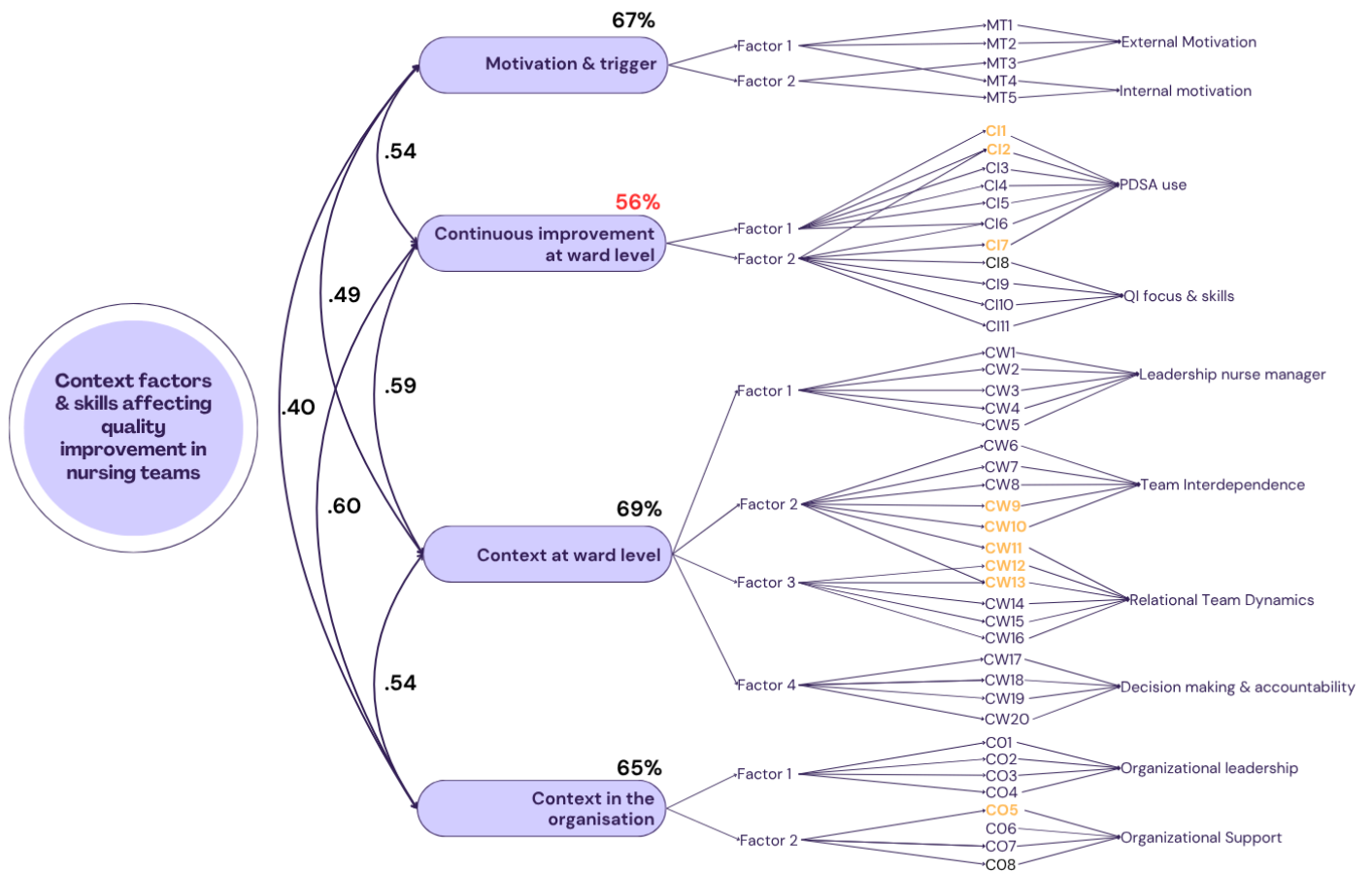


Figure 2

factor structure of four PAFs and comparison with theoretically driven factor structure and Inter-scale correlation coefficients between the four constructs

Continuous improvement at ward level does not achieve the threshold of 60% of total variance explained.

Factor loadings between .30 & .50 = **orange**

Factor loadings <.30 were suppressed

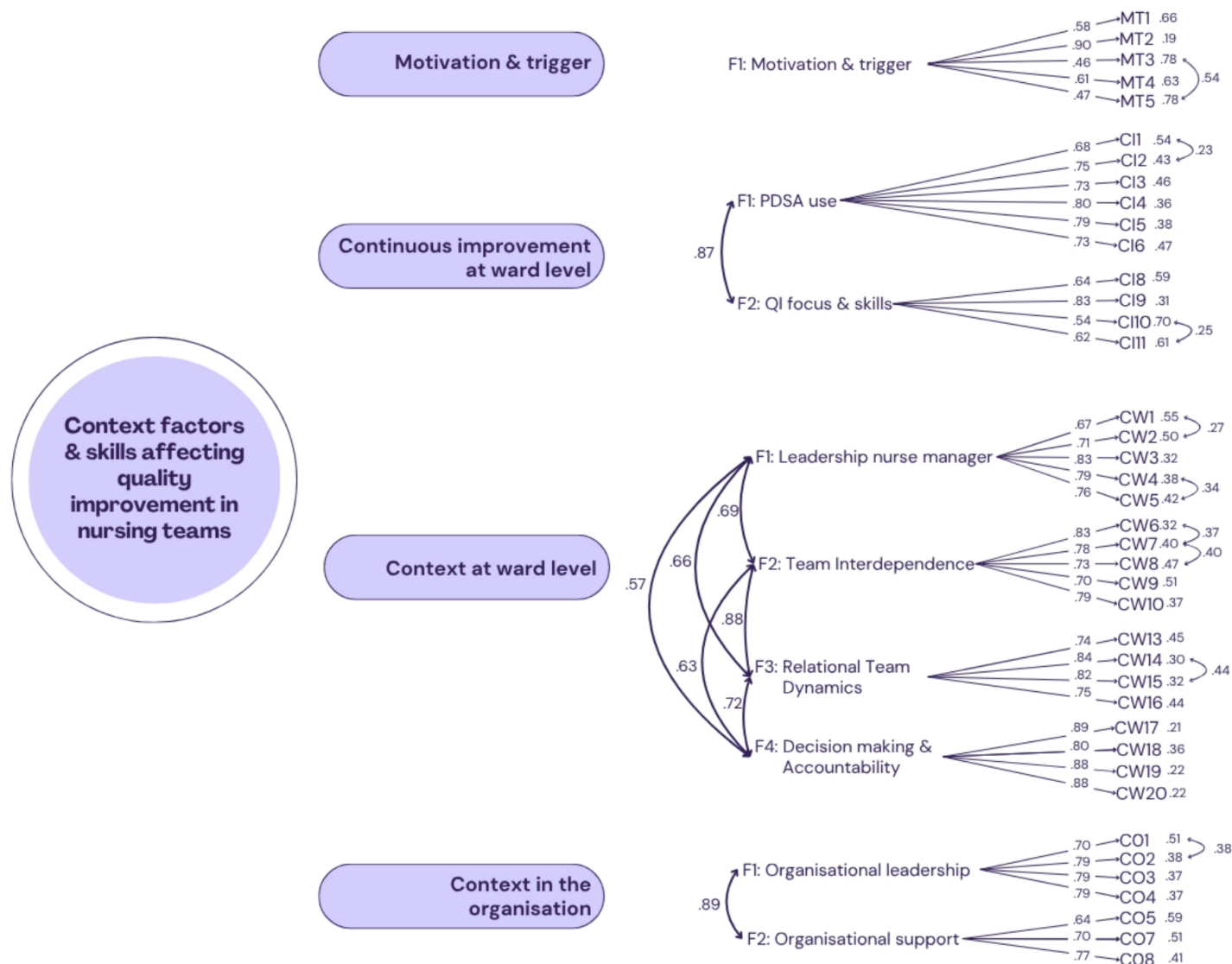


Figure 3

standardised factor loadings, residual variances, correlated errors introduced in the modification and latent variable correlations of the four CFAs

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