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Psychometric validation of the Perceived Perioperative Competence Scale-Revised Short Form

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Abstract

Aim: To develop a parsimonious, shortened version of the Perceived Perioperative Competence Scale-Revised for perioperative nurses to complete as part of their specialty training while retaining good psychometric properties.

Design: A longitudinal online survey was adopted.

Methods: A national sample of perioperative nurses from Australia completed an online survey at two different time points 6 months apart between February and October 2021. Confirmatory factor analysis was conducted for item reduction and construct validity, while criterion, convergent validity and internal consistency were examined.

Results: Usable data for psychometric assessment were obtained from 485 operating room nurses at time 1 and 164 nurses at time 2. The original 40-item revised scale was reduced to an 18-item measure, maintaining its six domains. Cronbach's alpha for the 18-item scale was .92 at time 1 and .90 at time 2. Scale validation demonstrated moderate to weak positive relationships in perceived competence scores relative to general self-efficacy, years of operating room experience, postgraduate education and recency of training.

Conclusions: Results suggest the 18-item Perceived Perioperative Competence Scale-Revised Short Form has initial robust psychometric properties and may be implemented in clinical settings as part of perioperative transition-to-practice, orientation programs and yearly professional development reviews.

Implications for the Profession: This short-form scale can help prepare perioperative nurses to demonstrate clinical competence in a climate of increasing professional demands using a valid measure of competence required in clinical practice.

Impact: Short and validated scales of perioperative competence are needed in clinical practice. Assessment of practising operating room nurses' perceived competence is essential in quality care provision, workforce planning and human resource management. This study provides an 18-item measure of the previously validated 40-item Perceived Perioperative Competence Scale-Revised. This scale can help provide an

option for future testing of perioperative nurses' competence in clinical or research settings.

Patient or Public Contribution: Perioperative nurses were involved in the design of the study, particularly in the assessment of validation of the tools used in the study.

KEYWORDS
clinical competence, competence scale, confirmatory factor analysis, nursing, operating room, professional development, reliability, validity

1 | INTRODUCTION

Providing competent nursing care for surgical patients is important to ensure they receive safe, patient-centred care in the operating room. Nursing competence involves cognitive, social and psychomotor skills nurses must have to safely perform their duties in their clinical area of practice (Jaensson et al., 2018). Perioperative competence includes skills and behaviours that require frequent assessment, up-to-date training and self-driven improvement by operating room (OR) nurses, also known as perioperative nurses. Professional bodies worldwide regulate the clinical practice, and these nursing bodies commonly rely on the self-assessment of competence for ongoing registration (Gillespie et al., 2012; Jeon et al., 2017).

2 | BACKGROUND

The Perceived Perioperative Competence Scale-Revised (PPCS-R) was developed to address a previous gap in the literature where standards for speciality competencies are used to guide practice in the OR. However, these standards lack a reliable and valid measurement of perioperative competence (Gillespie et al., 2012). The perioperative environment is a high-risk and complex clinical setting to be managed; therefore, it is imperative that patients receive evidence-based and high-quality care during surgery. Regardless of their country, perioperative nurses need to combine both technical and nontechnical skills (i.e. practical and situational knowledge, providing holistic and empathic care, coordination, communication and teamwork) (Gillespie et al., 2012) to minimize the risk of complications, adverse events and ensure safe practice.

Perioperative competence encompasses technical and nontechnical skills and has been conceptualized and empirically measured by six domains: foundational knowledge and skills, leadership, proficiency, empathy, professional development and collaboration (Gillespie et al., 2012). These six domains were operationalized in the PPCS-R by 40 items and are intended to be used in ongoing education programs overseen by nurse educators and managers to assess the perioperative nurses' levels of perceived competence and enable personal reflection on individual performance (Gillespie et al., 2012, 2018). The scale is used internationally and has been translated from English into Arabic, Chinese, Spanish, Swedish and Turkish. The measure can also be used informally to guide clinical practice and, ideally, lead to performance enhancement. Additionally, this scale can inform the development of education programs and interventions in perioperative nursing practice that aim to improve perioperative nurses' perceived competence (Gillespie et al., 2012). However, the number of items needed to complete the PPCS-R measure is a limitation. It is also unknown whether perioperative nursing competence changes over time and whether any engagement with mandatory or nonmandatory training influences it.

Scales that are shorter or more pragmatic versions of existing psychometrically valid scales are commonly used in assessing both clinical and nonclinical constructs such as performance, cognition (decision-making and or perception), personality, attitudes and physical or psychological functioning (DeVellis & Thorpe, 2021; Glasgow & Riley, 2013). The primary reason why short forms of existing measures are often developed is to reduce the time and cost associated with using the longer version of the measure. For example, studies could be conducted at a lower cost through short versions of scales, especially for expensive epidemiological surveys, while increasing the number of participants and avoiding participant fatigue, which might result in lower data quality (Kemper et al., 2018). Similar reductions in time and costs will apply to the clinical setting for management and evaluation of workplace competence. Additional reasons are evident in the initial psychometrics presented for scales, where opportunities may exist to improve a scale's measurement model (e.g. Cronbach's alpha improvement, reducing redundancy of similar items) and re-confirm the model fit in an updated sample (DeVellis & Thorpe, 2021).

3 | THE STUDY

3.1 | Aims

This study sought to establish the reliability and validity of the Perceived Perioperative Competence Scale-Revised Short Form (PPCS-R-SF). Therefore, the overarching aim of this study was to develop a parsimonious, shortened version of the PPCS-R while still maintaining good psychometric properties that will be less burdensome for participants to complete and more time-efficient for managers, educators and researchers. Subsumed within this aim are three related objectives:

1. From the existing 40-item PPCS-R measure, test that the items derived from the PPCS-R for the short-form version (18–24 items) remain an accurate and valid measure of perioperative competence in OR nurses.
2. To evaluate the relationship between perioperative nursing competence, self-efficacy, level of education, years of experience and training engagement, assessing both criterion and construct validity.
3. To examine whether perceived perioperative competence measured by the shortened version changes over time using a 6-month follow-up.

4 | METHODS

4.1 | Design

This study used a quantitative design of a longitudinal online survey approach with two time points.

4.2 | Measures

The initial online survey contained 63 items, including the 40-item PPCS-R, general self-efficacy scale (10 items) and demographics, taking approximately 15–20 min to complete. Demographic questions (n = 13) included age, gender, role, years of experience, professional qualifications, engagement in previous speciality training, engagement in generic hospital training, mandatory and nonmandatory (including personal/professional development) and matching code. The second survey of 41 items included the same general self-efficacy scale, demographic items, additional items on training engagement and the shortened PPC-R scale developed from the first data sample.

4.2.1 | Perceived nursing competence

Previously developed and validated in Australia, using a large sample of over 1000 perioperative nurses, perceived competence was measured using the PPCS-R (Gillespie et al., 2012). The revised version contains 40 items, has six subscales that distinct domains of perioperative competence: foundational knowledge and skills, leadership, collaboration, proficiency, empathy and professional development, and uses a five-point frequency scale from *never* (1) to *always* (5). Full details about the scale are available from Gillespie et al. (2012).

4.2.2 | General self-efficacy

General self-efficacy (GSE) was measured using Schwarzer and Jerusalem's GSE scale, a widely used instrument for measuring self-efficacy (Schwarzer & Jerusalem, 1995). The GSE has 10 items and uses a four-point response scale from *not at all true* (1) to *exactly true* (4). Total scores are summed, ranging from 10 to 40, with higher scores signifying greater self-efficacy. Previous studies have shown that the internal consistency for GSE measured using Cronbach's alphas ranges from .76 to .90 (Schwarzer & Jerusalem, 1995). GSE was measured at both time points for construct validity evaluation.

4.3 | Participants and setting

We employed a census survey of 5250 OR nurses who are members or associate members of the Australian College of Perioperative Nurses (ACORN). Registered Nurses (RNs) working in perioperative clinical roles (i.e. circulating, anaesthetic or postanaesthetic care unit), education and management were invited to participate.

4.4 | Recruitment and data collection

Participants were approached to participate via email distribution organized independently of the researchers via the professional body, the Australian College of Perioperative Nurses (ACORN) and snowballing through social media outlets (e.g. Facebook and Twitter). ACORN is Australia's peak body for perioperative nurses and has the largest membership base. Liaising with ACORN and the various state branches across the nation (e.g. New South Wales, Queensland and Victoria) were imperative to gain access to a representative sample of perioperative nurses across Australia. Participation involved completing two anonymous online surveys developed through Griffith University's research survey tool, set 6 months apart. Time point data were matched by having participants create unique codes using nonidentifiable information (favourite holiday destination and year). A reduced item survey was provided at the second time point, developed from the findings at time 1. For both time points, the online survey was available over 4 weeks. Data were collected between February–March and September–October 2021.

4.5 | Data analysis, validity and reliability

The sample, item, subscale and scale scores for the two time points were summarized using descriptive statistics. Several summary measures assessed item performance, including means and standard deviations (SDs), corrected item-total correlations and changes in Cronbach's alpha. Cronbach's alpha of the total scale and for the subscales was used to evaluate internal consistency. Evaluation cut-offs for suitable internal consistency were set to a Cronbach's alpha of >0.8, which is consistent with recognized suggestions by DeVellis and Thorpe (2021).

The primary analysis of the study was to conduct a Confirmatory Factor Analysis (CFA) on the existing 40-item PPCS-R to then test a reduced sub-set of items that continues to reliably and with

supporting validity, measure the six domains within the existing PPCS (foundational knowledge and skills, leadership, proficiency, collaboration, empathy and professional development), addressing study objective 1. Using the scale's established theory (Gillespie et al., 2012), it is assumed that the six factors are intercorrelated because they measure different but related aspects of one construct, perceived perioperative competence. Normality was examined using the skew and kurtosis estimates with their critical ratios. A widely accepted guide for sample size estimates 10 respondents per parameter for normal data, and if normality assumptions have not been met, this is increased to 15–20 respondents per parameter (Kline, 2011). Therefore, a sample size range of 400–800 was needed.

The models were fitted to a covariance-based structural equation model with a maximum likelihood robust estimator using the 'lavaan' package in R (lavaan version 0.6–13, R version 4.2.2 for Windows). As recommended by Byrne (2010), Confirmatory factor analysis model fit evaluation examined the Chi-square/degrees of freedom (χ^2/df (normed χ^2)), with a cut-off χ^2/df of <3. The standardized root-mean-square residual (SRMR) is <0.10, the comparative fit index (CFI) of >0.90, the Tucker-Lewis index (TLI) of >0.90 and the root-mean-square error of approximation (RMSEA) of <0.08 (Byrne, 2010). In reducing the number of items from the 40-item scale, we first examined potential item redundancy by removing items with high standardized residuals (values >2.58 are large) and low item-total correlations <.50 (DeVellis & Thorpe, 2021; Kemper et al., 2018). It was also important that each factor was retained and equally weighted. Items were removed one by one until there was no indication of item redundancy, and the abovementioned methods could not further improve model fit.

To address objective 2, additional supporting validity (construct and criterion validity) was tested, using correlations (Spearman's rho) to explore whether the revised scale for perioperative competence is related to self-efficacy, years of experience in the OR, postgraduate education and previous perioperative speciality training received. If group differences were identified, measurement invariance (configural and metric) would be assessed to determine whether responses on the revised scale depended on group membership (Byrne, 2008).

To address objective 3, a paired-sample t-test was conducted to explore whether perceived perioperative competence changed over time using the revised measures of PPCS-R. Two time points are proposed, time 1 and time 2 (6 months later). If statistically significant predictors or group differences were found during initial sampling (e.g. years of experience and role), the model would change to control for these influences (e.g. using repeated-measures ANCOVA, sample size permitting).

Data were exported from the online survey centre and downloaded for cleaning and analysis via IBM SPSS Statistics for Windows, Version 27.0. (IBM Corp., Armonk, NY), R version 4.2.2 (R Core Team, 2022) and RStudio 2022, Version 12.0 Build 353 (Rstudio Team, 2020). A p-value of .05 was applied to examine statistical significance. However, confidence intervals were used instead to interpret the findings when possible.

4.6 | Ethical considerations

This study was granted ethics approval by the Griffith University Human Ethics Committee (Ref No: 2020/687). As an incentive, a prize draw to win 1 of 3 perioperative textbooks was offered to participants who completed the study at time 2. All participants provided informed consent, and none withdrew from the study.

5 | RESULTS

5.1 | Nurses' characteristics

At time 1, 677 responders engaged in the online survey. However, 52 (7.7%) responders did not provide consent, and 158 (23.3%) responders did not fully complete the survey. Of the 158 incomplete submissions, only 18 (11.4%) responses could be retained for data analysis after cleaning, resulting in a total sample size of 485 for this time point. Most of the sample were female, located in the Australian states of Victoria, New South Wales and Queensland, were members of the perioperative professional body of Australia (ACORN) and identified as registered nurses, with the primary role being a circulating/instrument nurse. The mean age was 48.6 years (SD = 10.8). Responders reported being highly educated, with 70.3% holding either a postgraduate certificate or diploma in the perioperative specialty. In comparison, 61.0% reported having postgraduate perioperative specialty education or training (e.g. transition-to-practice program). Collectively, the average years of experience in the OR was 19.6 (SD = 11.7), with 30.1% indicating they had received perioperative speciality training more than 3 years ago.

At the second time point, 6 months later, 292 participants responded to the online survey, where a total of 64 (21.9%) cases were removed due to having too much missing data (e.g. >20% missing). Of the remaining 228 retained surveys, 164 (71.9%) indicated they were new participants and 64 (28.1%) participants indicated they were returning from time 1 (n = 485) to complete the follow-up survey. Therefore, only 64 of the initial 485 (13.2%) participants returned for the follow-up survey. This second independent sample (N = 164), with returnees removed, was also primarily female, located from the Australian states of Victoria, Queensland and New South Wales, and identified as registered nurses, with their primary role being circulating/instrument nurse in the OR. The average age was 48.3 years (SD = 11.1), and the responders also reported being highly educated, with 70.7% indicating they held a postgraduate certificate or diploma in the perioperative specialty, while 62.2% indicated they had completed industry-run courses or training (e.g. from Stryker, Smith & Nephew). Collectively, the average years of experience in the OR was 20.3 (SD = 11.2), with 29.9% indicating they had received perioperative speciality training 1–3 years ago. All 164 survey responders indicated they had not previously completed the time 1 or a similar survey about perioperative competence. The characteristics of the samples at each time point are provided in Table 1.

TABLE 1 Sample demographics for time points 1 and 2.

Characteristics	Time 1 (*N* = 485)		Time 2 (*N* = 164)	
	n	%	*n*	%
Years of experience >10 years	352	72.6	122	79.7
Gender, female	428	88.2	140	85.4
ACORN membership	365	75.3	122	74.4
Stand-alone day surgery unit	48	9.9	17	10.4
Location				
Queensland	94	19.4	28	17.1
New South Wales	114	23.5	27	16.5
Western Australia	35	7.2	13	7.9
South Australia	42	8.7	18	11.0
Victoria	120	24.7	47	28.7
Australian Capital Territory	9	1.9	5	3.0
Tasmania	15	3.1	8	4.9
Northern Territory	10	2.1	1	0.6
New Zealand	3	0.6	2	1.2
Other (international)	43	8.9	0	0.0
Professional designation				
Enrolled/endorsement (or Division .2) nurse	15	3.0	5	3.0
Registered nurse	193	38.8	62	37.8
Clinical nurse/clinical nurse specialist	123	25.4	44	26.8
Clinical/nurse educator	63	13.0	21	12.8
Nurse manager	62	12.8	21	12.8
Primary role in the operating room				
Circulating/instrument nurse	288	59.4	103	62.8
PACU nurse	20	4.1	8	4.9
Anaesthetic nurse	62	12.8	15	9.1
Multiple roles	46	9.5	16	9.8
Management	29	6	9	5.5
Perioperative educator	12	2.5	0	0
Education				
Hospital certificate	140	28.9	50	30.5
Associate degree	11	2.3	4	2.4
Undergraduate degree	158	32.6	56	34.1
Postgraduate qualification (e.g. certificate, diploma)	341	70.3	116	70.7
Master's degree	80	16.5	21	12.8
Doctorate degree	11	2.3	0	0
Training				
Industry-run courses (e.g. from Stryker, Smith & Nephew, etc.)	4	0.8	102	62.2
Perioperative leadership/management courses (e.g. train the trainer)	16	3.3	73	44.5
High dependency unit/coronary care unit airway management, trauma training	5	1.0	43	26.2
Communication for safety (e.g. human factors and nontechnical skills) in the perioperative setting	40	8.2	62	37.8
Preceptorship training	5	1.0	81	49.4
Professional development for perioperative (e.g. ACORN conference)	210	43.3	93	56.7
Recency of training				
Less than a month	23	4.7	12	7.3
2–3 months	7	1.4	9	5.5
3–6 months	15	3.1	11	6.7
6–12 months	46	9.5	19	11.6
1–3 years	62	12.8	49	29.9
More than 3 years ago	146	30.1	38	23.2

Abbreviations: ACORN, Australian College of Perioperative Nurses; PACU, postanaesthetic care unit.

5.2 | PPCS-R CFA with time 1 sample

First, the initial 40-item revised measure CFA was run as a starting point to establish model fit. For the first iteration of the model, the analysis indicated poor fit to data on the majority of the indices (robust statistics reported): CMIN 2254.08; CMIN/DF 3.11, $p < .001$; CFI = .89; TLI = .89; SRMR = 0.05, RMSEA = .06, 90%CI .06–.07. Individual item estimates for contribution to their factors are presented in Table 2. *R*-square is also reported for each factor in Table 2. The six factors predicted 62.3% of the variance in perceived perioperative competence. Based on the CFA, six subscale scores and a total PPCS-R score were computed for the participants with the scale descriptive statistics and the internal consistency in Table 3. All factors had a substantial positive skew, requiring the maximum likelihood estimation with robust standard errors. Overall, the total scale score indicated that responders were more likely to perceive themselves as having high levels of perioperative competence by reporting more frequent engagement in the behaviours outlined in the items.

5.3 | Item reduction and construct validity of the PPCS-R short form

Item reduction was undertaken by examining item redundancy of standardized residuals (high values >2.58) and standardized item-total correlations <.50. Using this process, for the time 1 sample responses (*N* = 485), a total of 22 items were systematically removed

TABLE 2 Parameter estimates for 40-item PPCS-R ($N = 485$).

		Loading	SE loading	*p*	*β*	Error variance
Foundational knowledge and skills: $R^2 = 63.6\%$						
1	I am familiar with most of the instrumentation in different specialties	1.000	–	–	.644	.585
2	I know where to find equipment and supplies in the OR	0.886	.067	<.001	.679	.538
3	My local knowledge of this department assists me to perform my OR role	0.940	.076	<.001	.714	.490
4	I understand and anticipate the surgical procedure	1.026	.059	<.001	.756	.428
5	I am familiar with the technological equipment used in the OR	0.980	.064	<.001	.723	.477
6	When I am allocated to an area of the OR that is unfamiliar, I draw on my skills and experience	0.975	.079	<.001	.667	.555
7	I plan and coordinate the needs in the theatre I am allocated	1.019	.078	<.001	.730	.467
8	I know instinctively when surgery is not going well and am able to respond appropriately	0.998	.078	<.001	.754	.431
9	Knowing the location of equipment in the OR assists me to perform my OR role	0.720	.090	<.001	.657	.568
Leadership: $R^2 = 72.2\%$						
10	I take a leadership role to ensure the smooth running of the theatre	1.000	–	–	.776	.398
11	I make difficult decisions when necessary	1.035	.041	<.001	.810	.344
12	I take an active role in preceptoring or mentoring lesser experienced nurses	0.946	.050	<.001	.760	.423
13	I manage clinical situations when there is conflict between staff	1.138	.063	<.001	.792	.372
14	I provide clinical guidance to other staff members	1.036	.052	<.001	.815	.335
15	I encourage team members to use innovative solutions to solve traditional problems	1.057	.055	<.001	.808	.346
16	I delegate aspects of care according to role, functions, capabilities and learning needs of other team members	1.105	.059	<.001	.816	.334
17	I encourage active involvement in clinical decision-making processes	0.969	.058	<.001	.777	.396
Proficiency: $R^2 = 53.2\%$						
18	I use appropriate methods of communication according to the needs of the situation	1.000	–	–	.756	.428
19	I feel comfortable in seeking assistance from my colleagues when I am unsure	0.782	.064	<.001	.573	.672
20	I tailor my communication based on the mix of personalities in the team	0.796	.056	<.001	.617	.620
21	I respect the level of expertise of other members of the team	0.598	.079	<.001	.543	.706
22	I treat members as individuals who have different needs, abilities and aspirations	0.720	.086	<.001	.639	.592
23	When communicating with other team members, I use language that is appropriate to the situation	0.798	.077	<.001	.705	.503
Collaboration: $R^2 = 85.9\%$						
24	I have mastered the terminology and vocabulary of OR nursing	1.000	–	–	.713	.491
25	I troubleshoot and take appropriate action in the event of machine/equipment failures	0.993	.067	<.001	.688	.527

(Continues)

TABLE 2 (Continued)

		Loading	SE loading	*p*	*β*	Error variance
26	Based on experience, I am able to identify actual or potential emergency situations and respond appropriately	1.133	.074	<.001	.828	.315
27	I apply specialist knowledge in providing care for OR patients	1.113	.074	<.001	.804	.353
28	I have the right amount of knowledge to practice in this specialty	1.097	.073	<.001	.751	.436
29	I am able to anticipate the needs of the situation	1.044	.076	<.001	.819	.330
Empathy: $R^2 = 29.4\%$						
30	I provide reassurance for patients using verbal and nonverbal strategies	1.000	—	—	.875	.234
31	I use strategies to make the patient feel more comfortable	1.051	.033	<.001	.885	.217
32	I provide appropriate reassurance and explanation for OR patients	1.162	.044	<.001	.928	.139
33	I actively listen to the patient and significant others to obtain necessary information	1.038	.058	<.001	.845	.287
34	I establish rapport with patients who enhance their ability to express feelings and concerns	1.142	.060	<.001	.824	.322
Professional development: $R^2 = 69.5\%$						
35	I maintain current knowledge of and incorporate relevant organizational policies into practice	1.000	—	—	.717	.486
36	I have detailed knowledge of anatomy and physiology	0.950	.076	<.001	.652	.575
37	I maintain knowledge of and incorporate relevant standards into my practice	1.020	.061	<.001	.790	.377
38	I read current journals and literature that relate to clinical practice	1.339	.099	<.001	.740	.452
39	I keep up with the technical changes in procedures and equipment	1.321	.086	<.001	.830	.312
40	I use available resources to maintain current OR practice	1.279	.092	<.001	.802	.356

Abbreviations: OR, operating room; PPCS-R, Perceived Perioperative Competence Scale-Revised; SE, standard error.

TABLE 3 Scale and subscale internal consistency of the PPCS-R and PPCS-R-SF time 1 and time 2.

	Time 1 (N = 485)								Time 2 (N = 164)			
	PPCS-R				PPCS-R-SF				PPCS-R-SF			
Subscale name	Items	Mean (SD)	Range	α	Items	Mean (SD)	Range	α	Items	Mean (SD)	Range	α
Foundational knowledge/and skills	9	37.50 (5.48)	14–45	0.90	3	11.56 (2.19)	4–15	0.80	3	11.46 (2.21)	5–15	0.82
Leadership	8	30.22 (7.28)	9–40	0.93	3	11.33 (2.84)	3–15	0.84	3	11.87 (2.47)	6–15	0.79
Collaboration	6	26.47 (3.14)	15–30	0.81	3	12.99 (1.91)	6–15	0.72	3	13.22 (1.62)	7–15	0.61
Proficiency	6	25.90 (3.75)	6–30	0.89	3	13.08 (2.00)	3–15	0.82	3	13.02 (1.78)	7–15	0.68
Empathy	5	21.71 (3.76)	8–25	0.94	3	13.11 (2.28)	5–15	0.91	3	13.56 (2.06)	6–15	0.90
Professional development	6	24.39 (4.04)	11–30	0.88	3	11.81 (2.45)	4–15	0.86	3	11.68 (2.41)	6–15	0.85
Total scale	40	166.80 (21.11)	97–200	0.96	18	73.88 (10.32)	33–90	0.92	18	74.82 (9.15)	48–90	0.90

Abbreviations: PPCS-R, Perceived Perioperative Competence Scale-Revised; PPCS-R-SF, Perceived Perioperative Competence Scale-Revised Short Form; SD, standard deviation.

from the scale, with the CFA model re-run until the final CFA model resulted in the following good model fit indicators (robust statistics are reported): CMIN 246.97; CMIN/DF 1.91, $p = <.001$; CFI = .98; TLI = 0.98; SRMR = 0.04, RMSEA = .04, 90%CI .03–.05. The parsimonious PPCS-R 18-items, now referred to as the PPC-R short form (SF), had 3 items remaining for each factor, where the individual item estimates for contribution to its factor are presented in Table 4. In the measurement models, all items statistically significantly loaded onto their respective factors, and no items found negative variances or negligible standardized loadings. The model predicted 52.2% of the variance in foundational knowledge and skills, 81.2% in leadership, 57.3% in proficiency, 83.7% in collaboration, 27.9% in empathy and 59.2% of the variance in professional development. Combined, the six factors predict 60.3% of the total variance in perceived perioperative competence in perioperative nurses. The scale descriptive statistics and the internal consistency are also displayed in Table 3. Reducing the item count from 40 to 18 significantly improved the model fit based on the standard (not robust) statistics, χ^2 diff = 1765.9, $p < .001$.

The reduced 18-item PPC-R- SF model was tested again in the second independent sample ($N = 164$) who completed the survey for the first time at the second time point and had acceptable model fit: CMIN 261.06; CMIN/DF 2.02, $p = <.001$; CFI = .92; TLI = .90; SRMR = 0.07, RMSEA = .08, 90%CI .07–.09. The fit statistics for this second smaller sample were poorer than the first sample, but it still met recommended cut-offs for assessing acceptable model fit. The individual item parameter estimates from the CFA for the short-form measure at both time points are presented in Table 4. Using this smaller independent sample at time 2, the model predicted 60.7% of the variance in foundational knowledge and skills, 90.1% in leadership, 41.8% in proficiency, 80.1% in collaboration, 15.8% in empathy and 54.3% of the variance in professional development. Combined, the six factors predict 57.1% of the total variance in perceived perioperative competence in perioperative nurses. The finalized 18-item PPCS-R-SF is presented in Appendix A, Table A1.

5.4 | Convergent and criterion validity

The correlation matrix between the scale, scale domains, self-efficacy, years of experience in the OR, having a postgraduate qualification and recency in perioperative training received is presented in Table 5 for Time 1 and Time 2. As expected, the between-factor correlations were positive and related, without any concerning overlap to indicate the factors were too similar (i.e. correlations over .70). Each factor also contributed to the overall scale for the PPCS-R and the PPCS-R-SF. The PPCS-R-SF scale and self-efficacy were positive and moderately related (Spearman's rho = .53 for time 1 and .58 for time 2) at both time points, indicating convergent validity. Those who had 10 or more years of experience in the OR, had a postgraduate qualification and received specialized perioperative training within the last 3 years also reported higher levels of perceived perioperative competence for the total 40 items and the short-form

TABLE 4 Parameter Estimates for the 18-item PPC-R-SF.

		Time 1 $N = 485$					Time 2 $N = 164$				
		Loading	SE loading	*p*	β	Error variance	Loading	SE loading	*p*	β	Error variance
Foundational knowledge and skills											
1	I am familiar with most of the instrumentation in different specialties	1.000	–	–	.695	.516	1.000	–	–	.730	.468
4	I understand and anticipate the surgical procedure	1.006	.068	<.001	.801	.358	0.861	.095	<.001	.809	.345
5	I am familiar with the technological equipment used in the OR	0.981	.072	<.001	.781	.390	0.978	.099	<.001	.819	.330
Leadership											
11	I make difficult decisions when necessary	1.000	–	–	.783	.388	1.000	–	–	.786	.382
14	I provide clinical guidance to other staff members	1.013	.050	<.001	.797	.364	0.920	.084	<.001	.772	.403
15	I encourage team members to use innovative solutions to solve traditional problems	1.052	.053	<.001	.805	.352	0.886	.100	<.001	.702	.507
Proficiency											
18	I use appropriate methods of communication according to the needs of the situation	1.000	–	–	.841	.292	1.000	–	–	.797	.365
19	I feel comfortable in seeking assistance from my colleagues when I am unsure	0.689	.062	<.001	.561	.685	0.569	.118	<.001	.484	.766
20	I tailor my communication based on the mix of personalities in the team	0.731	.068	<.001	.630	.603	0.625	.113	<.001	.507	.743
Collaboration											
25	I troubleshoot and take appropriate action in the event of machine/equipment failures	1.000	–	–	.703	.505	1.000	–	–	.479	.771
26	Based on experience, I am able to identify actual or potential emergency situations and respond appropriately	1.146	.075	<.001	.850	.277	1.542	.118	<.001	.743	.447
27	I apply specialist knowledge in providing care for OR patients	1.085	.084	<.001	.796	.366	1.556	.133	<.001	.765	.415
Empathy											
31	I use strategies to make the patient feel more comfortable	1.000	–	–	.850	.278	1.000	–	–	.829	.313
32	I provide appropriate reassurance and explanation for OR patients	1.190	.058	<.001	.959	.081	1.334	.118	<.001	.962	.074
33	I actively listen to the patient and significant others to obtain necessary information	1.015	.060	<.001	.833	.305	1.155	.124	<.001	.833	.306
Professional development											
38	I read current journals and literature that relate to clinical practice	1.000	–	–	.767	.411	1.000	–	–	.717	.485
39	I keep up with the technical changes in procedures and equipment	1.000	.050	<.001	.872	.239	1.040	.098	<.001	.848	.280
40	I use available resources to maintain current OR practice	0.949	.048	<.001	.827	.316	1.059	.116	<.001	.869	.245

Abbreviations: OR, operating room; SE, standard error.

TABLE 5 Correlation matrixes of the scales, factors and predictors.

Variable	PPC-R	F1	F2	F3	F4	F5	F6	GSE	>10 years in OR	Post grad	Recency training
Time 1 ($N=485$)											
Perceived Perioperative Competence Revised (40-item) total	–										
Foundational knowledge & skills (F1)	.79**	–									
Leadership (F2)	.87**	.60**	–								
Collaboration (F3)	.72**	.51**	.52**	–							
Proficiency (F4)	.83**	.66**	.67**	.55**	–						
Empathy (F5)	.60**	.33**	.41**	.49**	.48**	–					
Professional development (F6)	.82**	.59**	.64**	.56**	.69**	.47**	–				
Generalized self-efficacy (GSE)	.53**	.43**	.48**	.40**	.52**	.31**	.44**	–			
10 years or >experience in OR	.27**	.24**	.26**	.11*	.30**	.12**	.23**	.17**	–		
Postgraduate qualification	.14**	.08	.19**	.06	.10*	.03	.15**	.09	.08	–	
Recency of speciality training <3 years	.14*	.14*	.11	.02	.18**	.05	.12*	.05	.27**	.07	–
PPC-R-SF	.95**	.77**	.84**	.70**	.82**	.61**	.83**	.53**	.28**	.14**	.13*
Time 2 ($N=134$)											
Perceived Perioperative Competence Revised Short Form (18-item) total[a]	**PPC-R-SF**	**F1-SF**	**F2-SF**	**F3-SF**	**F4-SF**	**F5-SF**	**F6-SF**	**GSE**	**>10 years in OR**	**Post Grad**	**Recency training**
Foundational knowledge & skills (F1)	.73**	–									
Leadership (F2)	.86**	.60**	–								
Collaboration (F3)	.59**	.28**	.47**	–							
Proficiency (F4)	.79**	.51**	.62**	.42**	–						
Empathy (F5)	.59**	.24**	.37**	.38**	.46**	–					
Professional development (F6)	.75**	.46**	.56**	.37**	.51**	.33**	–				
Generalized self-efficacy (GSE)	.58**	.36**	.59**	.29**	.58**	.30**	.43**	–			
10 years or >experience in OR	.40**	.28**	.41**	.16*	.33**	.24**	.23**	.27**	–		
Postgraduate qualification	.31**	.23**	.29**	.18*	.28**	.09	.23**	.15	.32**	–	
Recency of speciality training	.09	.08	.05	−.10	.05	.08	.01	−.01	.40**	.17*	–

[a]PPC-R was not measured at time 2.

*$p<.05$.; **$p<.001$.

version of the scale, indicating further support for criterion validity (see Table 5).

As years of experience in the OR was identified to have a moderate relationship with PPC-R-SF, we performed a measurement invariance test at the configural and metric levels to ensure the scale responses were not subject to group membership (i.e. those with low levels of experience and those with high levels of experience). After specifying the groups (responders with <10 years and those with ≥10 years of experience in the OR), configural variance was found to be met with the following acceptable model fit statistics: CMIN 352.07; CMIN/DF 1.47, $p = <.001$; TLI = .90, CFI = .96; SRMR = 0.05, RMSEA = .03, 90%CI .03–.04. Using Rstudio laavan multigroup analysis function, metric invariance was examined by constraining factor loadings to be equal across the groups and comparing this constrained model with the unconstrained configural model using a chi-square difference test. Metric invariance was met: χ^2 diff (12) = 4.97, $p = .959$.

5.5 | Internal consistency and change over time

As indicated previously, Cronbach's alpha assessing internal consistency for the 40-item and 18-item measures (time 1 and time 2) is presented in Table 3. For the 40-item original scale, high alphas for each domain ranged between .81 for the collaboration domain and .94 for the empathy domain. The overall total scale alpha was .96, indicating that item reduction would be beneficial (DeVellis & Thorpe, 2021). For the PPCS-R-SF measure at time 1, Cronbach's alphas ranged between .72 for collaboration and .91 for empathy, with a total scale alpha of .92. At the second time point 6 months later, when the short form was retested in a new sample, alphas ranged from .61 for collaboration and .90 for empathy, with a total scale score alpha of .90. In this smaller sample, internal consistency has generally been maintained with the shortened version of the scale as all domains and total scores were above recommended cut-offs, except the collaboration domain at the second measurement time.

For the 64 responders who completed both time points ($N = 64$), their PPCS-R-SF total scores were compared. At time 1, the responders' total scale score was 74.79 (SD = 9.58); at time 2, their total scale score was 75.00 (SD = 9.22). On average, these responders' scores on the PPCS-R-SF were consistent across time points, with little difference (mean difference = −0.20, SE = 1.08, 95% CI of the difference = −2.36–1.95). A repeated-measures ANCOVA to control for the effect of OR experience was not conducted due to the small sample size, and no differences in time point means were found.

6 | DISCUSSION

The current study aimed to further revise the widely used PPCS-R to a shorter valid, and reliable measure appropriate for busy clinical settings that prefer a shorter scale to reduce respondent burden and maximize time efficiency. Further, we examined whether perioperative competence, as measured in this scale, changes over time and is affected by the level of experience or training. Some key psychometric implications are discussed.

First, while it is considered that a minimum of three indicators are needed for factor identification, four is often considered a 'safer' and more reliable configuration (DeVellis & Thorpe, 2021). Yet, more than four may result in a failure of unidimensionality (i.e. multiple dimensions may be captured) (Hair et al., 2010). Our scale met the recommended minimum of three items per domain, and four items per domain were considered. However, model fit and problematic items that shared covariances that were too high indicated that a three item per domain was more robust in our shortened scale and led to the best model fit for our sample data.

Second, we acknowledge the six factors do not perform at the same level as the 40-item scale compared with the 18-item scale. Therefore, we recommend that researchers wanting to examine the factors separately, the validated 40 items may be more appropriate. However, the 18-item measure has good initial validity and internal consistency as a parsimonious scale of perceived perioperative competence. Additionally, the evaluation of internal consistency is well established, as a scale is said to be more internally reliable if a Cronbach alpha coefficient is nearer to 1, preferably at or over 0.8 (DeVellis & Thorpe, 2021). The lowest acceptable reliability coefficient for a well-developed measurement instrument is 0.8, with a reliability of 0.7 acceptable for a newly developed measure. However, clinical measures require higher reliability (DeVellis & Thorpe, 2021). Except for collaboration, the remaining factors meet these reliability thresholds for a developed instrument for the short form when the larger sample size is considered. We suspect that the collaboration item performance may have been lower in our sample due to the timing of data collection aligning with the impacts of the COVID-19 pandemic. Specifically, the decision to postpone elective surgeries across surgical specialties, workplace policy and procedure changes in line with government regulations, surgical practice, and training (Soltany et al., 2020) were some of the influences considered.

Third, measurement invariance for configural (no constraints applied) and metric (factor loadings were constrained to be equal across groups) was met when we examined sample group membership relative to substantial experience in the OR (≥10 years), indicating groups are not different at the model level (Byrne, 2008). However, scalar and strict invariance (i.e. applying equality constraints on factor loadings, intercepts and residual variances across groups) was not assessed in our study due to sample size and because it may result in misspecification by over-constraining the model and may result in a misrepresentation of the data (Byrne, 2008; Marsh et al., 2018).

Finally, in addition to the fit statistics indicating acceptable fit above prespecified cut-offs supporting the construct validity of the scale, convergent and criterion validity was also met, where we found statistically significant associations for those with higher PPC-R-SF scores, also reported higher general self-efficacy, have more experience in the OR, hold a postgraduate level of education and

had received perioperative speciality training in the past 3 years. Similar findings of perceived competence have been reported in other research (Blomberg et al., 2019; Falk-Brynhildsen et al., 2019; Gillespie et al., 2018; Jaensson et al., 2018; Shin & Kim, 2021; Sönmez & Ayoğlu, 2019), which was why these were considered as criteria to examine.

6.1 | Implications for clinical nursing

To ensure that perioperative nurses are well-equipped to provide safe patient care, assessing the perioperative competence of practising operating room nurses is an important process to consider (Falk-Brynhildsen et al., 2019; Gillespie et al., 2012; Sönmez & Ayoğlu, 2019). The perioperative nurse is expected to demonstrate technical skills such as maintaining asepsis, handling instrumentation, infection control, preventing the risk of retained items and managing biological specimens, and nontechnical skills, including proficient communication skills (von Vogelsang et al., 2020). Notably, experienced nurses are essentially novices when they enter the perioperative environment. They must navigate the lengthy, steep learning curve of gaining the specialized training and skills needed to reach competence in this specialty (Gillespie & Pearson, 2013; Uçak & Cebeci, 2021). Thus competence assessment of practising nurses, regardless of their experience level, is vital to informing ongoing clinical education planning (Hamlin, 2012).

The development and use of the reduced PPCS-R-SF in clinical settings is a time-efficient scale to administer and a key criterion for pragmatic measures (Glasgow & Riley, 2013; Kemper et al., 2018). Additional criteria include that the scale is easy to score and interpret and should result in less missing data and lead to actionable development (Glasgow & Riley, 2013). For example, the PPCS-R-SF can initiate nurses' self-reflection on their strengths and limitations. Perioperative nurse educators and nurse managers can identify opportunities for further professional development and specialized training can occur, for example, implementing more industry-run sessions on perioperative technology (Smith & Palesy, 2018) or improving their nontechnical skills in communication (Skråmm et al., 2021). It has relevant clinical benefits, such as efficient competence assessment for new staff, which can be implemented in annual reviews and professional development (Bindon, 2017). Therefore, this scale can help identify leaders in their perioperative field and those who may benefit from further training and support.

Professional development is formalized through the annual performance review meeting. The performance review discussion allows OR nurses to identify other areas of continuing professional development in education and training, particularly their growth and enhancement of skills across various specialties (Shin & Kim, 2021). The PPCS-R-SF could instigate discussion around perioperative-specific progression (Hamlin, 2012). We recommended using this scale as an adjunct to be completed by staff before attending their annual performance review meeting, providing the impetus for perioperative nurses to regularly reflect on their perceived competence.

6.2 | Strengths and limitations of the work

In this study, though we attempted a census approach for recruitment, we recognize a low response rate was obtained, so the final sample may or may not be representative of the population as a whole. As the survey was anonymous, follow-up could not be conducted with the nonresponders. As a result, perioperative nurses who did not participate may have a different perspective and experience of perceived perioperative competence from those who did. However, our results show similar findings when larger samples (Gillespie et al., 2012; Jaensson et al., 2018) and smaller samples are used (Blomberg et al., 2019; Shin & Kim, 2021; Sönmez & Ayoğlu, 2019).

Test–retest reliability was not conducted at this stage; as such only initial evidence of reliability via internal consistency is present. The sample of nurses who did return to complete the survey twice (at 6 months returning) was small (13.2%), and many identified as new responders the second time, resulting in a second independent sample instead. The low returnee response rate prevented further testing on how nurses' perioperative competence could change over time and if there were additional influencing factors (e.g. type and or frequency of training). Nevertheless, results have indicated the PPCS-R-SF construct, convergent, and criterion validity are sound.

6.3 | Recommendations for further research

We provide the following recommendations to address identified limitations and future suggestions for this scale. First, future research on this scale should examine the test retest reliability using the full 40-item or revised 18-item scale to test its temporal stability and confirm its reliability as a competence measure. Further, this work would help understand how often test users should use the measure on their target sample and or if differences in the measure exist after an intervention of training (e.g. do low scorers of perceived competence improve after training, do more experienced members stay the same or change over time). Second, the time of 6 months was too long and may have contributed to poor retention at the second time point. Therefore, measuring a shorter time frame of 2–4 weeks may help retain participants and allow for appropriate test–retest reliability to be conducted.

Additionally, we acknowledge that our sample included older, highly experienced, and well-educated perioperative nurses throughout Australia, New Zealand, and other places worldwide. This may be because we sampled an Australian professional body ACORN where members who completed this study may be more representative of this demographic than if we sampled directly from hospitals. Therefore, future research should include samples drawn from other sources, such as hospitals undertaking day surgery procedures and tertiary hospitals, to explore further the impact of age and operating room experience on perioperative competence. Finally, as we found a positive (albeit weak) association between the recency of perioperative speciality training and reported perceived competence. We expect this relationship would be stronger if the

training were received within the past 12 months rather than the last 3 years. Therefore, future research is also recommended to explore the impact of recency of training as an intervention to help improve perioperative nurses' perceived competence.

7 | CONCLUSIONS

Identifying professional and educational development needs for perioperative nurses can be achieved by assessing their perioperative competence. We recommend evaluating perioperative nurses for their competence to help achieve effective quality assurance, workforce planning, and human resource management, ultimately improving patient safety and care. The Perceived Perioperative Scale could be implemented in clinical settings as part of the management for perioperative transition-to-practice, orientation programs, training and yearly professional development reviews. Further work is needed to examine predictors of perioperative competence to help support any evaluation and training initiatives.

AUTHOR CONTRIBUTIONS

All authors have agreed on the final version and meet at least one of the following criteria (recommended by the ICMJE [http://www.icmje.org/recommendations/]): (1) substantial contributions to conception and design, acquisition of data or analysis and interpretation of data; (2) drafting the article or revising it critically for important intellectual content.

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No conflict of interest has been declared by the authors.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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APPENDIX A

TABLE A1 The Perceived Perioperative Competency Scale-Revised Short Form (PPCS-R-SF).

	Instructions: Reflecting on your clinical perioperative practice, please read each statement and indicate on the response scale of 1–5 which corresponds closest with yourself.	
	Items	**Factor**
1	I am familiar with most of the instrumentation in different specialties	1
2	I understand and anticipate the surgical procedure	1
3	I am familiar with the technological equipment used in the OR	1
4	I make difficult decisions when necessary	2
5	I provide clinical guidance to other staff members	2
6	I encourage team members to use innovative solutions to solve traditional problems	2
7	I use appropriate methods of communication according to the needs of the situation	3
8	I feel comfortable in seeking assistance from my colleagues when I am unsure	3
9	I tailor my communication based on the mix of personalities in the team	3
10	I troubleshoot and take appropriate action in the event of machine/equipment failures	4
11	Based on experience, I am able to identify actual or potential emergency situations and respond appropriately	4
12	I apply specialist knowledge in providing care for OR patients	4
13	I use strategies to make the patient feel more comfortable	5
14	I provide appropriate reassurance and explanation for OR patients	5
15	I actively listen to the patient and significant others to obtain necessary information	5
16	I read current journals and literature that relate to clinical practice	6
17	I keep up with the technical changes in procedures and equipment	6
18	I use available resources to maintain current OR practice	6

Note: The PPCS-R-SF is measured using a response scale of *1 = never, 2 = sometimes, 3 = often, 4 = Very often and 5 = Always*. The full 40-item PPCS-R is available from the following source: Gillespie, B.M., Polit, D.F., Hamlin, L., Chaboyer, W., 2012. Developing a model of competence in the operating theatre: Psychometric validation of the Perceived Perioperative Competence Scale-Revised. International Journal of Nursing Studies 49 (1), 90–101. https://doi.org/10.1016/j.ijnurstu.2011.08.001.