Developing a model of competence in the OR: Psychometric validation of the Perceived Perioperative Competence Scale-Revised

ABSTRACT

Title. Developing a model of competence in the OR: Psychometric validation of the Perceived Perioperative Competence Scale-Revised.

Aim: This paper describes the development and validation of the Revised Perioperative Competence Scale (PPCS-R).

Background. There is a lack of a psychometrically tested sound self-assessment tools to measure nurses' perceived competence in the Operating Room.

Methods. Content validity was established by a panel of international experts and the original 98-item scale was pilot tested with 345 nurses in Queensland, Australia. Following the removal of several items, a national sample that included all 3209 nurses who were members of the Australian College of Operating Room Nurses was surveyed using the 94-item version. Psychometric testing assessed content validity using exploratory factor analysis, internal consistency using Cronbach's alpha, and construct validity using the "known groups" technique. During item reduction, several preliminary factor analyses were performed on two random halves of the sample (n=550).

Results. Usable data for psychometric assessment were obtained from 1,122 nurses. The original 94-item scale was reduced to 40 items. The final factor analysis using the entire sample resulted in a 40 item six-factor solution. Cronbach's alpha for the 40-item scale was 0.96. Construct validation demonstrated significant differences (p <.0001) in

perceived competence scores relative to years of operating room experience and receipt of specialty education.

Conclusions. On the basis of these results, the psychometric properties of the PPCS-R were considered encouraging. Further testing of the tool in different samples of operating room nurses is necessary to enable cross-cultural comparisons.

Key Words

Perioperative; modified Delphi panel; validity; reliability; exploratory factor analysis; national survey; instrument.

What is already known about this topic:

- Specialty standards that define competent practice in perioperative environments have been developed based on expert opinion.
- In perioperative environments, competence involves both technical and non-technical skills and behaviours.
- Perceived competence has been measured across various nursing settings using generic measures.

What this paper adds:

- This study has identified underlying dimensions of perioperative competence which include: foundational skills and knowledge; leadership; collaboration; empathy; proficiency; and, professional development.
- The PCCS-R is the first perioperative-context specific tool to be rigorously developed and psychometrically validated.
- As a self-assessment tool, the PPCS-R may be used for reflection to assist OR nurses in identifying areas of strength and limitations.
- The PPCS-R may be used to augment perioperative nurses' annual performance review and to assist nurse managers and educators to strategize education initiatives to meet the needs of the staff profile.

INTRODUCTION

Throughout many countries, professional bodies regulate professional practice. In nursing, as with other professions, these professional bodies often rely on self-assessment of competence for ongoing registration. Beyond competency standards such as those that underpin curricula that lead to registration as a nurse (Australian Nursing & Midwifery Accreditation Council [ANMAC] formerly the Australian Nursing & Midwifery Council [ANMC], 2009) specialist competencies such as those developed by the Australian College of Operating Room Nurses (ACORN) provide some direction for self-assessment (ACORN, 2008; Association of periOperative Registered Nurses[AORN], 2008; Association for Perioperative Practice [APP], 2007). Nonetheless, specialty standards and competencies used to guide practice in the operating room (OR) are based on guiding principles that are open to interpretation and cannot be readily used empirically as a self-assessment instrument (Gillespie & Hamlin, 2009). Additionally, these standards are developed based on 'expert opinion' rather than on empirical evidence (Davies & Hamlin, 2003). To date, there have been limited theoretical and empirical models of perioperative competence. A valid and reliable instrument may advance nursing knowledge and contribute to theory development. While OR competence has previously been described (Gillespie, Chaboyer, Wallis *et al*., 2009b), identification, measurement and validation of its dimensions have to date, remained elusive. The overarching aim of this study was to psychometrically assess a scale that was developed to measure OR nurses' perceived competence.

LITERATURE REVIEW

Nursing competence is an eclectic concept, and incorporates more than just the ability to perform tasks; it is likely that the indicators used to imply competence should

reflect a broad range of normative items including cognitive, affective and psychomotor skills and abilities. These elements need to be integrated into the concept of competence if this term is to have any utility in assessing the degree to which nurses can be seen as safe practitioners with an adequate knowledge and skill base to practice. In the general sense, competence has been broadly conceptualized in relation to task performance; as a 'psychological construct' vis-à-vis the ability to effectively integrate cognitive, affective and psychomotor skills (Benner, 1984), and the functional adequacy and capacity to integrate knowledge and skills to attitudes and values in a specific contextual situation of practice (Girot, 1993; Paliadelis & Cruickshank, 2003). Yet, there are often contextual variations in the ways in which nursing competence is conceptualized in different clinical specialties.

In the OR context, competence has been conceived in relation technical and non-technicial skills (Gillespie & Hamlin, 2009). For example, technical skills have been described in relation to practical and situational knowledge (Gillespie *et al.,* 2009b; Prowse & Lyne, 2000), and knowledge of protocols and practice standards (Gillespie, Wallis, & Chaboyer, 2008; Riley & Peters, 2000). Whereas, non-technical skills have been explained in the context of providing holistc and empathic care (Bull & FitzGerald, 2006; Chard, 2000; Gillespie *et al.,* 2009b), coordination (Gillespie, Chaboyer, Wallis *et al.,* 2009a; Kondrat, 2001), and communication and teamwork (Lingard, Epsin, Whyte *et al.,* 2004; Nestral & Kidd, 2006). However, the majority of these studies were qualitative; and few nurse researchers have taken up the vexacious challenge of developing measures that conceptually and empirically capture the essence of nursing competence.

Competence Measurement Tools

Some researchers have developed generic tools to measure percieved competence in nursing. Much of this work has quantified domains of generalist competence such as asessment, planning, evaluation, patient care, decision-making, cognitive ability, ego-strength, social participation, and research awarerness (Clinton, Murrells, & Robinson, 2005; Cowin, Hengstberger-Sims, Eager *et al*., 2008); work role, helping role, teaching-coaching, diagnostic functions, ensuring quality, and managing situations (Meretoja, Isoaho, & Leino-Kilpi, 2004); and, basic knowledge, management, professionalism, nursing process, problem-solving (Safadi, Jaradeh, Bandak *et al.,* 2010). It is worth noting that the subscale domains of some generic scales demonstrated internal consistencies of less than the recommended .70 (Clinton *et al*., 2005; Lofmark *et al*., 2006), suggesting that further development is required. Further, some of the scales used in these earlier studies were unable to detect group differences across the various comptetnece domains identified (Lofmark, Smide & Wikblad*,* 2006; Safadi *et al.,* 2010). Undoubtedly, a substantial limitation in using generic tools is their inability to capture the contextual nuances that characterize clinical practice in specialist areas (McGrath, Fox Young, Moxham *et al.,* 2006).

METHOD

Aim

The overall aim of this methodological study was to psychometrically evaluate the *Perceived Perioperative Competence Scale-Revised (PPCS-R)* in a national sample of OR nurses. Subsumed within this aim were two related objectives: 1) to identify the key underlying dimensions of perceived competence in OR nurses; and, 2) to select a parsimonious set of items that accurately and reliably represent those dimensions.

Instrument Development and Pilot Testing

Intial development of the PPCS-R was informed by the following: an integrated literature review; three earlier studies (Gillespie *et al.,* 2009b; Gillespie et al., 2007; Gillespie *et al*., 2008), a modified Delphi panel assessment; and a pilot survey (Gillespie, Chaboyer, Wallis *et al*., in press, 2011). From this earlier work, eight conceptual domains of competence (i.e., *technical and procedural knowledge; practical knowledge; aesthetic knowledge; communication; teamwork; coordination;* and, *clinical leadership*) were identifed *a priori* and definitions with respective scale items given to a modified Delphi panel to evaluate the relevancy and fit of items within each of these conceptual domains. The panel consisted of eight international perioperative nurse experts with postgraduate degrees and the PPCS-R was assessed in two rounds using the content validity index (CVI) to assess item relevancy (Polit, Beck, & Owen, 2007). The second round was conducted with a smaller panel of four experts drawn from the initial eight member pool. The panel experts assessed the content validity using the scale content validity index (S-CVI) and the scale items were reduced from 120 items to 98, and yielded a S-CVI of 0.97. During this assessment, redundant or ambiguous items were removed. There was no subsequent removal of items following the second review, and all 98 items were included in the next phase of development, the pilot survey.

The 98-item survey instrument was subsequently pilot tested in a sample of 345 OR nurses from two large metropolitan hospitals in Queensland, Australia (Gillespie *et al*., in press, 2011). Following this, it was decided that four scale items should be removed as nearly 20% of survey respondents indicated they had difficulty in answering those items. While the sample size for this previous study was insuffcient to support the use of an exploratory factor analysis (to enable item reduction), Cronbach's alpha for the total scale was .98 (n=134), and was consistently high, ranging from .89 to .95 for each of the eight *a priori* subscales (Gillespie *et al.,* in press, 2011).

In the current study, the 94-item PPCS-R uses a 5-point Likert response scale ranging from1 ('never') through to 5 ('always'). Demographic data in relation to gender, age, years of OR experience, level of education, perioperative role, and employment status were also collected as part of the survey.

Participants and Setting

The study reported here was a national survey of all 3,209 OR nurses who were members of the Australian College of Operating Room Nurses (ACORN) during the study period. Eligible participants included Registered Nurses (RN) who worked in clinical (i.e., circulating, instrument, anaesthetic and recovery room roles), education, management and/or combined perioperative roles across both public and private sectors. Enrolled Nurses (EN) were excluded due to the differences in their scope of practice.

Data Collection

Ethics approval to conduct the survey was given by the Human Research Ethics Committees of the universities. Permission was also sought from the ACORN Board to distribute the survey tool to the organisation's members. Permission was given but to protect members' privacy, ACORN undertook to distribute the survey tool itself, on behalf of the researchers. An information sheet explained the nature of the study and respondents were assured of anonymity, that participation was voluntary, and that they had the right to withdraw at any time. Consent was implied by the return of the completed survey form. Survey data were collected during 2010.

Data Analysis

Data were analysed using the statistical program *Predictive Analysis Software* (PASW Statistics® Version 18.0; Inc., Chicago, IL) for Windows, commonly referred to as SPSS. Both descriptive and inferential analyses were used in the psychometric evaluation of the PPCS-R. Specifically, psychometric testing involved assessment of content validity using exploratory factor analysis, internal consistency using Cronbach's alpha, and construct validity using the "known groups" technique.

The goals of the factor analysis were to test key underlying dimensions of perceived perioperative competence and to select a parsimonious set of items to reliably and accurately represent those dimensions (De Vellis, 2003). Given that the goal was to create an abbreviated scale that would be easy and efficient to administer, early analytic efforts focused on item elimination. As shown in the top three rows of Table 1, criteria were established for dropping items prior to factor analytic work for such reasons as a high rate of missingness, an extreme positive skew (i.e., ceiling effect),

low inter-item correlations, and high inter-item correlations to avoid issues of multicollinearity.

<Insert Table 1>

Factorability was assessed by means of the Kaiser-Meyer-Olkin (KMO) test, using a criterion of .80 (Polit, 2010). Measures of sampling adequacy (MSA) of individual items were inspected with the goal of dropping items whose MSA was .70 or lower.

Principal components analysis (PCA) was used to assess factorability and to further condense the item pool, using criteria outlined in Table 1. For these PCA analyses, the extraction criterion was set at an eigenvalue of 1.00 or greater, and varimax rotation was used. The criterion for assigning an item to a factor was a loading of .40 or higher. Inspection of the initial rotated factor matrix was used to further eliminate items that had low loadings (< .40) on all factors, or high loadings on multiple factors. Items with loadings of .35 or higher on multiple factors were dropped if the difference between two high loadings was less than .15 (e.g., an item with loadings of .53 and .41 on two factors would be dropped).

Because factor analysis can capitalize on spurious correlations, replication was considered an essential element of the analytic plan (Polit, 2010). All initial analyses were conducted on a randomly selected half sample, and then conclusions were validated by redoing the analyses with the second half-sample. If the basic factor structure was similar across the two sets of analyses, items that did not load on the same factor across analyses were eliminated because of their ambiguous dimensionality.

All items remaining after these initial analyses were factor analysed using PCA with the full sample. The results were used to form subscale and total scale scores whose internal consistency reliability was assessed using Cronbach's alpha. An alpha of .80 or higher was considered evidence of good reliability (De Vellis, 2003). To confirm the results, reliability estimates were computed for the full sample and for four random half samples. Alpha estimates in the half samples that differed by less than $\pm$ .02 from those in the full sample were considered as stable and acceptable.

To assess the construct validity of the scale, the "known groups" technique (Polit & Beck, 2008) was used to test the relationship between scale/subscale scores and two nurse characteristics: years of OR experience and receipt of specialized education. Specifically, it was hypothesized that perceived competency scores would be higher for more experienced nurses and for nurses who had received perioperative specialty education.

RESULTS

Sample Description

A total of 3209 surveys were distributed and 1205 returned. Of those returned, 16 were not completed and another 11 were "return to sender", leaving a response rate of 36.7%. Of the completed surveys, 40 of the respondents were ENs and, because of the differences in scope of practice, these survey responses were excluded from the analyses. This left 1138 questionnaires completed by RNs for a response rate of 35.5%.

As shown in Table 2, usable data for the psychometric assessment were obtained from 1,122 nurses. Consistent with the fact that the nurses were recruited through

professional organizations, the participants had considerable OR experience (mean = 19.9 years) and the majority had postgraduate education, including 71.1% who had received postgraduate perioperative specialty training. There was diversity in terms of current nursing classifications, with about one-third being RNs, another third being a clinical nurse (CN) or CN specialist, and the remaining third being a manager or educator. The majority of nurses (93.5%) were women, and about half (48.4%) were employed full-time when they completed the survey.

<Insert Table 2 here>

Preliminary Analyses

As shown in Table 1, 18 of the 94 original items were eliminated based on high rates of missingness (mostly items that were appropriate for managers only), extreme skew (items on which almost everyone claimed high levels of competence), or low inter-item correlations (mostly items that, upon reflection, were more about personality traits than about competence).

In the factorability assessment of the remaining 76 items, the KMO test was .97 for the first random half-sample and .96 for the second half-sample. Moreover, the MSAs for individual items ranged from .93 to .98 in the two half samples. Thus, initial analyses supported the decision to proceed with a factor analysis.

In the preliminary PCA with both half-samples, the initial solution resulted in 8 factors with eigenvalues greater than 1.0. Three items with high loadings on Factor 8 (whose eigenvalue of 1.04 just made the cut-off criterion of 1.0) suggested a factor that could be called “Feeling respected.” These items were: *I feel supported in my role by*

other members of the OR team (loading = .75)*, I feel as though my role in the OR team is respected by other team members* (loading = .80), and *My contribution to the OR team is appreciated by other team members* (loading = .77). Inasmuch as these items seemed to relate less to competence than to role gratification, and because only three items loaded on this 8th factor in the two independent analyses, the decision was made to drop these items. Six additional items were removed because they did not have high loadings on any factors in either subsample. Twenty items were removed because they had high loadings on multiple factors.

When another round of PCA was performed with the 47 remaining items, a factor solution of 6 factors emerged in both random half samples. Although the basic structure was similar across the two analyses in terms of eigenvalues, percentage of variance explained, and factor meaning, there were 7 items that did not load on the same factor in the two analyses. These 7 items were thus removed, leaving 40 items.

Final Principal Components Analysis

Table 3 presents the results from the final PCA of the 40 items, using data from the entire sample of nurses. Six factors with eigenvalues greater than 1.0 were extracted and rotated using varimax rotation. (The pattern matrix for obliquely rotated factors yielded similar results). Cumulatively, the 6 factors accounted for 58.6% of the total variance, with percentages ranging from 12.1% (Factor 1) to 8.4% (Factor 6).

<Insert Table 3 here>

The first factor, with a powerful eigenvalue of 15.34, had 9 items with loadings of .40 or higher, and was named Foundational Knowledge and Skills. The 9 items were

from 4 of the original domains, but 5 items were from the domain of Practical Knowledge. The item with the highest loading was *I know where to find equipment and supplies in the OR* (loading = .71).

The second factor, named Leadership, had 8 items with loadings greater than .40. These items mapped well onto the original domain of Leadership, with only one item drawn from another domain. The item with the highest loading (.66) was *I encourage team members to use innovative solutions to solve traditional problems.*

Factor 3, named Collaboration, had 6 items with high loadings, the highest of which (.70) was for the item *I treat team members as individuals who have different needs, abilities, and aspirations.* Items on this factor were drawn from comparable domains as originally conceptualized, including Communication, Teamwork, and Leadership.

Factor 4 had six items with high loadings and was named Proficiency. Three of the 6 items were from the original Professional Knowledge domain. The highest loading (.69) was for the item *Based on experience, I am able to identify actual or potential emergency situations and respond appropriately.*

All of the 5 items with high loadings on Factor 5, named Empathy were from the domain originally called Aesthetic Knowledge. The name Empathy was chosen because it was thought to have more universal communicative value. There was a strong marker variable on this factor, the item *I provide reassurance for patients using verbal and nonverbal strategies* (loading = .78).

The 6 highly-loaded items on Factor 6 involved nurses' efforts to keep up-to-date professionally, and was named Professional Development. Although this factor did not

have a powerful eigenvalue (1.22) and accounted for only 8.4% of explained variance, it was a highly stable and robust factor, emerging consistently in preliminary and final PCAs. Items on this factor were ones representing the Professional Knowledge domain primarily. The marker variable, with a loading of .78, was *I read current journals and literature that relate to clinical practice.*

The final scale, created on the basis of this factor analysis of 40 items, is named the Perceived Perioperative Competence Scale – Revised (PPCS-R) (Appendix).

Scale and Subscale Reliability of the PPCS-R

Based on the factor analysis, six subscale scores and a total PPC-R score were computed for study participants. Table 4 presents descriptive statistics for these 7 scores, including means, standard deviations, and score ranges. Comparison of actual score ranges with theoretically possible score ranges indicates that all scores were positively skewed—that is, respondents were more likely to perceive high rather than low levels of perioperative competence.

In terms of internal consistency, the values of Cronbach's alpha for the six subscales for the full sample ranged from .81 (Collaboration) to .89 (for both Foundational Knowledge/Skills and Leadership), which are all considered excellent. For the total PPCS-R scores, internal consistency reliability was a high .96. These strong reliabilities were extremely consistent, with only minor deviations across four randomly selected half samples. For example, alphas for the Professional Development subscale ranged from .85 in one subsample to .87 in another.

Table 5 displays the mean item scores and the distribution of item responses for each competence domain. Mean item scores ranged for each domain between 4.1 (± .66) and 4.5 (± .58). Out of a possible range of 1 to 5 (1=never-5=always), at least 70% of respondents scored 4 or above in relation to mean item scores in all of the PPCS-R subscales. In spite of the positive skew, there was still some variability across response options within each subscale.

<Insert Tables 4 & 5 here>

Construct Validation of the PPCS-R

If the PPCS-R was validly measuring nurses' perceptions of their competence, it would be predicted that nurses with more years of OR experience, and those with specialty education in perioperative nursing, would have higher scores than other nurses. Table 6 shows the results of tests of these hypotheses.

For the known-groups analysis involving years of OR experience, the sample was divided into three groups: those with fewer than 10 years of experience, those with 10 to 20 years of experience, and those with more than 20 years of experience. Across all six subscales and the total PPCS-R scores, group differences were statistically significant at $p < .001$, in the predicted direction. For example, the mean total PPCS-R scores for the three subgroups were 161.9, 174.8, and 180.1, respectively for groups with increasing OR experience. Pearson's r between the total PPCS-R scores and the continuous variable for years of OR experience was .36, $p < .001$.

In the second known-groups analysis, nurses who had received perioperative specialty education were compared to those who had not. As shown in Table 5, group

differences were statistically significant, and in the predicted direction, for the total PPCS-R scores and for all subscales except Empathy. On the basis of these analyses, the construct validity of the PPCS-R was deemed to be established.

<Insert Table 6 here>

DISCUSSION

The aim of the current study was to identify the dimensions of perioperative competence and to develop a parsimonious scale to assess OR nurses' perceived competence through item reduction. A comprehensive item pool and large sample of participants afforded the opportunity of eliminating redundant scale items. The PPCS-R has demonstrated a robust factor structure, excellent internal consistency overall, as well as for each of its six subscales. Additionally, the scale has the ability to discern group differences based on years of OR experience and education qualifications. To the best of our knowledge, this is the first study that has psychometrically tested a tool that measures the domains of perioperative competence.

In this study, item reduction was iterative and data-driven. In the preliminary factor analyses, we randomly divided the sample in half and performed a factor analysis on each subsample as a means of cross-validating the results, an approach that has been advocated elsewhere (Polit, 2010). In this respect, the results of this study were quite compelling – the two subsample analyses revealed similar factor structures. Clearly, the cross-validation process was made possible because of the very large number of participants; each subsample had in excess of 550 cases.

Technical and Non-Technical Domains of Perioperative Competence

The resulting six factor structure of the 40-item scale was robust and the domains of perioperative competence reflect aspects of *technical* and *non-technical skills* that have been identified elsewhere (Bull & FitzGerald, 2006; Gillespie & Hamlin, 2009; Lingard *et al.,* 2004). Subsumed in technical skills are competence domains of Foundational Knowledge and Skills, and Proficiency. Non-technical skills include the remaining four domains; Leadership, Collaboration, Empathy, and Professional Development. Figure 1 illustrates the empirical model based on the key underlying dimensions of perceived perioperative competence.

<Insert Figure 1 here>

In the realm of technical skills, the nine items included in the Foundational Knowledge and Skills domain are in fact, similar to the items in the original subscale, and reflect beginning technical skills, such as knowledge of instruments and procedures. It appears that all of the items typify some aspect of the 'bread-and-butter' skills and essential knowledge required for competent perioperative practice. For instance, familiarity with various surgical and/or anaesthetic equipment and instruments is part of being considered technically competent; a notion highlighted in previous work (Gillespie *et al,.* 2008; Riley & Peters, 2000; Sigurdsson, 2001). Interestingly the item, *I plan and coordinate the needs in the theatre I am allocated in* which was formerly incorporated in the Coordination subscale (Table 3, item 45) demonstrated the highest loading on this first factor (.64). This result suggests that room coordination is also a crucial aspect of developing fundamental skills around competent practice at the

operating room level. Notably, the coordinating role in the OR has been previously discussed exclusively in relation to the remit of the nurse manager, with little credence given to the importance of such skills as being fundamental to all levels of perioperative competence (Gillespie *et al.,* 2009a; Moss, Xiao, & Zubaidah, 2002).

The six items to emerge in the technical skills domain of Proficiency include items that were previously part of the Technical and Procedural subscale. Together, these items typify skills that are built on clinical exposure necessary to gain experience (Gillespie *et al*., in press, 2011). For instance, the marker item (i.e. factor loading of .69), *Based on experience, I am able to identify actual or potential emergency situations and respond appropriately* (Table 3, item 19) suggests that higher order skills (as opposed to a foundational/introductory level) are required to demonstrate advanced knowledge of the technical and procedural aspects of perioperative care. These empirical results suggest that technical skills development is based on a continuum of increasing complexity.

In the patient safety literature, leadership has previously been described in relation to non-technical skills (Flin, O'Connor & Crichton, 2008). In this study, the eight items that encompass the Leadership domain focus on mentoring staff, delegating tasks and conflict management. Unsurprisingly, the majority of these items formed part of the Clinical Leadership scale in the earlier version of the subscale. It seems that leadership is a significant attribute of perioperative competence (Coe & Gould, 2007). The item, *I delegate aspects of care according to role, functions, capabilities and learning needs of other team members* which had a loading of .65 on this second factor (Table 3, item 89) was previously conceptualized as being on the Coordination subscale. Delegation of care appears to fall within the remit of leadership rather than as a function of coordination in

the perioperative environment. This difference has been accentuated in recent qualitative research (Gillespie *et al.,* 2009a), and encouragingly, our quantitative results have contributed to lending some empirical support to these earlier findings.

The six items that comprise the non-technical skills domain of Collaboration characterize behaviours around seeking and rendering assistance, tailoring communications to the situation, and respect for other team members. Five of these six items were previously included in the Communication and Teamwork subscales. Item 76, *I treat members as individuals who have different needs, abilities and aspirations* (Table 3) was formerly included in the Clinical Leadership subscale. In the current study, this item demonstrated the highest factor loading on component three (.70). Collectively these empirical results suggest that collaborative behaviours also incorporate the notion of valuing the input of team members. While the importance of interpersonal relations has been qualitatively described in relation to the OR context (Gillespie, Chaboyer, Wallis *et al.,* 2009c; Gillespie *et al.,* 2008; Nestral & Kidd, 2006; Sigurdsson, 2001), it has also been acknowledged in work around generic competence development in other nursing contexts (Cowin *et al.,* 2008). In spite of the contextual variation, it seems clear that the complexity of competence development and the need to conceptualize and measure competence in a more holistic manner is increasingly being recognized (Cowin *et al*., 2008; Lofmark *et al*., 2006).

The five items within the non-technical domain of Empathy were originally included in the Aesthetic Knowledge subscale of the previous iteration of the PCCS-R. Behaviours that characterize this factor centre on providing reassurance to perioperative patients, actively listening, and establishing rapport. The relationship between the individual items and the factor was robust; individual item loadings ranged

from .66 to .78. These results are encouraging and imply that OR nurses believe that patient-centred caring behaviours are essential in perioperative competence. Holistic caring in the context of perioperative practice is increasingly being recognized as an essential attribute of competence (Bull & FitzGerald, 2006; Chard, 2000; Gillespie *et al*., 2009b; Sigurdsson, 2001); and these empirical results lend added support to this domain of perioperative competence.

Most of the six items included in the non-technical domain of Professional Development were originally in the Professional Knowledge subscale of the earlier version. In this study, items representing professional development behaviours describe using available resources and reading professional journals to keep up-to-date with the latest practices and technologies – all of which target some aspect of professional awareness. In spite of accounting for the lowest proportion of explained variance (after rotation), this factor was particularly robust. Notably, domains that relate to professional development have also been identified in the development and testing of some generic competence measures (Clinton *et al.,* 2005; Lofmark *et al*., 2006; Meretoja *et al*., 2004; Safadi et al., 2010). For instance, during psychometric evaluation of the 73-item Nurse Competence Scale (NCS), Meretoja *et al.* (2004) delineated six items that tapped into aspects of professional development around the planning and implementation of research findings, and named the domain 'Ensuring Quality'. Indeed the inclusion of professional development behaviours in nursing competence measures is encouraging as it acknowledges the contribution of such behaviours in enhancing nursing practice.

Scale Reliability and Construct Validity

The internal consistency of the PPCS-R was tested by item analyses to examine the extent to which all pertinent items measure the same construct. In this study, items that did not demonstrate high inter-item correlations were deleted. The PCA results were confirmed by computing reliability estimates for the six subscales in four randomly split subsamples, which added further credence to the robustness of the PCA results. Cronbach's alpha estimates for each subsample were highly acceptable and stable. Nevertheless, internal consistency alone does not provide a sufficiently sound basis upon which to evaluate reliability. It is also important to use test-retest methods to assess the stability of this newly developed scale.

In relation to construct validity, our results support the hypothesis that OR nurses with more clinical experience and those with perioperative qualifications had higher levels of perceived competence across most competence domains and the total scale. Notably however, there was one exception: there were no differences in relation to perioperative education in the Empathy subscale. This result is conceptually congruent as one would not expect that nurses with perioperative qualifications would be more empathic than nurses without such qualifications. That the PPCS-R was able to discern group differences on the basis of years of OR experience and perioperative specialty education is certainly encouraging.

Limitations and Recommendations

This methodological study has contributed to gaining an understanding of the underlying dimensions of perioperative nurse competence using a parsimonious scale

that is reliable and has demonstrated construct validity. However, this study has some limitations. First, the use of a professional association gives rise to selection bias and thus may not be representative of all perioperative nurses working across Australia. Previous research has demonstrated significant statistical differences in relation to age, experience, and speciality qualifications in nurses who belong to a professional association, and those who do not (Gillespie, Chaboyer, & Wallis, 2010). In spite of this, the large sample size allowed us to pragmatically focus our efforts on reducing the dataset to a more manageable size while retaining a comprehensive selection of universal items that capture a latent variable (De Vellis, 2003). Clearly future use of the shortened 40-item version of the PPCS-R will be less onerous for participants to complete than the original 96-item scale, thus increasing its acceptability in relation to its ease of use and the time taken to complete the survey (Waltz *et al*., 2007).

Second, the sample of OR nurses in this study was reasonably homogeneous. Yet, despite the fact that responses were positively skewed (towards being more competent), there was still variation in item responses (Table 5). As such, there is limited evidence to suggest a ceiling effect. We recommend future testing of the 40-item PPCS-R in samples where there is greater heterogeneity – for instance, in samples of OR nurses working in the public and private sectors and across countries, to enable comparisons. Further testing of the PPCS-R in evaluating the effect of perioperative educational interventions and programs is also recommended.

Third, we measured nurses' perceived competence rather than actual competence; that is, we did not perform structured observations of nurses' performance in the clinical milieu. While there has been some criticism levelled at using self-report measures of competence (Brazen, 2008; Watson, Stimpson, Topping *et al.,* 2002), self-

assessment may be used as a tool for reflective practice, and could ideally be seen as an adjunct to other methods of assessment. In future work, measuring the relationship between both perceived and actual competence would further strengthen the convergent validity of this newly developed instrument.

Lastly, our final model of perioperative perceived competence was data-driven: That is, we consciously made decisions about the elimination of scale items and factors based on statistical results. Yet, the factor structure was stable and replicable in two random subsamples of perioperative nurses, supporting the final allocation of items to subscales—and potentially offering new insights into how to conceptualize perioperative competence. Our aim was to create a parsimonious scale that would have increased acceptability for use in subsequent samples. The PPCS-R has the potential to be used as a tool for personal reflection, as well as a diagnostic measure for informing the ongoing development of education programs and interventions in perioperative nursing practice.

CONCLUSION

Our methodological study has contributed to advancing theory development and measurement of perioperative competence. Despite the associated challenges in conceptualizing and measuring the ecclectic concept of competence, the results of this study indicate that the PPCS-R captures the latent domains of perceived competence in the perioperative milieu. Saliently, useful self-assessment of performance depends upon the accurate measurement of underlying cognitive and affective qualities and skills. The PPCS-R is a cost-effective tool that may be used by nurses and nurse managers to assess

the level of perceived perioperative competence and offers nurses the opportunity to glean important insights into individual performance through reflection. Undoubtedly, perceived competence is dynamic and situationally-dependent, and thus its assessment is iterative and should extend across perioperative nurses' career.

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Figure 1: Empirical model derived through PCA of the domains of perioperative competence.

Table 1: Examples of Item Removals for Different Causes

Reason for Item Removal	Criterion	Example of a Removed Item	Number of items removed
High rate of missing values	> 5 % missing	*I take into account skill mix requirements when allocating nursing staff*	8
Extreme positive skew	25th percentile value was 5.0 ("always")	*I pass on relevant information about the patient to other team members as appropriate*	9[a]
Low inter-item correlations	Multiple inter-item correlations < .25	*If someone speaks abruptly to me, I do not take it personally*	7[a]
Low MSA (sampling adequacy)	.70 or lower	None	0
Low item communalities	Communality < .40	None	0
High loadings on multiple factors	Loadings of > .35 on 2+ scales, loading differences < .15	*I see the bigger picture when planning and/or coordinating care*	20
No high loadings on any factor	All loadings < .40	*I recognize a colleague's need for help and support*	6
Unstable loadings/ ambiguous dimensionality	Items loaded on different factors in the 2 random half samples	*When the patient is anaesthetised, I ensure that body exposure is kept to a minimum*	7

[a] Six items had both extreme skew and low inter-item correlations.

Table 2: Characteristics of Operating Room (OR) Nurses in the Sample (*N* = 1,122)

Characteristic	*n**	%	Mean (SD)
Age (years)			47.8 (9.7)
Years of OR experience			19.9 (10.5)
Gender, female	1042	93.5	
Highest education			
Certificate or Associate's degree	194	17.3	
Baccalaureate	132	11.8	
Graduate certificate	455	40.8	
Graduate diploma	228	20.4	
Masters or doctorate	107	9.6	
Obtained perioperative specialty education	790	71.1	
Primary role in OR			
Circulating/instrument	622	56.0	
Post-anaesthesia recovery unit/anaesthesia	133	11.9	
Combined/rotating roles	167	15.0	
Management/education/both	189	16.9	
Nursing classification			
RN	368	32.9	
CN or CN specialist	396	35.5	
Clinical nurse educator/nurse educator	105	9.4	
Nurse manager or other	248	22.2	
Employment status			
Full-time	541	48.4	
Part-time or casual	528	47.3	
Not currently employed	48	4.3	

*Missing values not replaced.

Table 3: Rotated Factor Matrix for Principal Component Analysis of 40-item PPCS-R (N=1122), and Original Subscale Classification

Item	Factor Loadings[a]						Original Subscale[b]
	1	2	3	4	5	6	
Q10. I am familiar with most of the instrumentation in different specialties	**.67**	.17	.00	.22	-.01	.21	Tech Know
Q11. I know where to find equipment and supplies in the OR	**.71**	.16	.13	.17	.08	.13	Prac Know
Q35. My local knowledge of this department assists me to perform my OR role	**.49**	.20	.31	.26	.18	.13	Prac Know
Q41. I understand and anticipate the surgical procedure	**.65**	.21	.16	.30	.11	.21	Prof Know
Q42. I am familiar with the technological equipment used in the OR	**.70**	.16	.17	.22	.05	.22	Tech Know
Q43. When I am allocated to an area of the OR that is unfamiliar, I draw on my skills and experience	**.46**	.23	.30	.13	.20	.18	Prac Know
Q45. I plan and coordinate the needs in the theatre I am allocated	**.64**	.39	.13	.13	.15	.04	Coordination
Q48. I know instinctively when surgery is not going well and am able to respond appropriately	**.56**	.30	.10	.27	.09	.26	Prac Know
Q63. Knowing the location of equipment in the OR assists me to perform my OR role	**.57**	.04	.39	.06	.20	.04	Prac Know
Q8. I take a leadership role to ensure the smooth running of the theatre	.36	**.65**	.00	.32	-.01	.04	Leadership
Q16. I make difficult decisions when necessary	.17	**.57**	.13	.36	.11	.25	Leadership
Q32. I take an active role in preceptoring or mentoring lesser experienced nurses	.24	**.56**	.12	.16	.28	.09	Leadership
Q40. I manage clinical situations when there is conflict between staff	.21	**.62**	.15	.15	.13	.28	Leadership
Q46. I provide clinical guidance to other staff members	.37	**.61**	.15	.23	.21	.18	Leadership
Q84. I encourage team members to use innovative solutions to solve traditional problems	.14	**.66**	.28	.07	.17	.26	Leadership
Q89. I delegate aspects of care according to role, functions, capabilities and learning needs of other team members	.21	**.65**	.26	.21	.13	.08	Coordination
Q90. I encourage active involvement in clinical decision-making processes	.09	**.63**	.33	.15	.20	.28	Leadership

Q6. I use appropriate methods of communication according to the needs of the situation	.17	.12	**.53**	.37	.20	.03	Communication
Q29. I feel comfortable in seeking assistance from my colleagues when I am unsure	.19	.08	**.51**	.12	.15	.10	Teamwork
Q38. I tailor my communication based on the mix of personalities in the team	.16	.30	**.53**	.11	.14	.19	Communication
Q73. I respect the level of expertise of other members of the team	.05	.15	**.66**	.11	.18	.10	Teamwork
Q76. I treat members as individuals who have different needs, abilities and aspirations	.10	.20	**.70**	.08	.15	.23	Leader
Q82. When communicating with other team members, I use language that is appropriate to the situation	.20	.14	**.67**	.19	.24	.13	Communication
Q1.I have mastered the terminology and vocabulary of OR nursing	.28	.09	.19	**.67**	.00	.10	Prof Know
Q2. I troubleshoot and take appropriate action in the event of machine / equipment failures	.17	.15	.21	**.59**	.18	.08	Tech Know
Q3. Based on experience, I am able to identify actual or potential emergency situations and respond appropriately	.14	.30	.16	**.69**	.15	.19	Prac Know
Q9. I apply specialist knowledge in providing care for OR patients	.29	.28	.14	**.57**	.19	.126	Prof Know
Q17. I have the right amount of knowledge to practice in this specialty	.24	.23	.07	**.65**	.06	.25	Prof Know
Q19. I am able to anticipate the needs of the situation	.37	.22	.17	**.49**	.37	.22	Prac Know
Q12. I provide reassurance for patients using verbal and non-verbal strategies	.07	.12	.10	.15	**.78**	.10	Aesth Know
Q.20 I use strategies to make the patient feel more comfortable	.12	.09	.20	.18	**.69**	.13	Aesth Know
Q.64 I provide appropriate reassurance and explanation for OR patients	.18	.19	.24	.10	**.73**	.19	Aesth Know
Q80. I actively listen to the patient and significant others to obtain necessary information	.15	.15	.34	.07	**.66**	.14	Aesth Know
Q86. I establish rapport with patients that enhances their ability to express feelings and concerns	.02	.21	.20	.01	**.73**	.24	Aesth Know
Q25. I maintain current knowledge of, and incorporate relevant organisational policies into practice	.23	.24	.16	.27	.21	**.60**	Prof Know
Q47. I have detailed knowledge of anatomy and physiology	.24	.23	.09	.32	.12	**.50**	Prof Know
Q54. I maintain knowledge of, and incorporate relevant standards into my practice	.25	.22	.17	.23	.22	**.58**	Prof Know

Q61. I read current journals and literature that relate to clinical practice	.09	.15	.16	.09	.19	**.78**	Prof Know
Q62. I keep up with the technical changes in procedures and equipment	.39	.18	.19	.11	.16	**.67**	Tech Know
Q69. I use available resources to maintain current OR practice	.18	.22	.37	.16	.26	**.52**	Prof Know
Eigenvalue	15.34	2.64	1.56	1.40	1.26	1.22	
Percentage of explained variance, after rotation (Total = 58.6%)	12.1%	11.1%	9.2%	9.0%	8.8%	8.4%	

Note. Factor extraction used the criterion of an eigenvalue $\geq$ 1.0. Varimax rotation was used for factor rotation. Loadings $\geq$ .40 are bolded.

[a]Factors were named as follows: 1 = Foundational Knowledge and Skills; 2 = Leadership; 3 = Collaboration; 4 = Proficiency; 5 = Empathy, 6 = Professional Development.

[b]Original subscales used for developing items were: Prof Know = Professional Knowledge; Tech Know = Technical/Procedural Knowledge; Prac Know = Practical Knowledge; Aesth Know = Aesthetic Knowledge; Teamwork = Teamwork; Comm = Communication; Coord = Coordination; Leader = Clinical Leadership.

Table 4: Means, Variability, and Reliability for Subscales of the Perceived Perioperative Competence Scale—Revised (PPCS-R)

Subscale Name (Number of items)	Mean (SD)	Actual range of scores	Possible range of scores	Cronbach's alpha, full sample	Alpha range, half samples[a]
Foundational Knowledge & Skills (9)	39.6 (4.7)	11 – 45	9 – 45	.89	.88 - .90
Leadership (8)	33.5 (5.3)	11 – 40	8 – 40	.89	.89 - .89
Collaboration (6)	27.1 (2.6)	13 – 30	6 – 30	.81	.80 - .81
Proficiency (6)	26.7 (3.0)	12 – 30	6 – 30	.84	.83 - .85
Empathy (5)	22.4 (2.8)	8 – 25	5 – 25	.86	.85 - .86
Professional Development (6)	25.4 (3.5)	13 – 30	6 – 30	.86	.85 - .87
Total Scale (40)	174.7 (18.0)	83 – 200	40 – 200	.96	.96 - .96

Note. The sample size for these analyses was 1,122.

[a]Cronbach's alpha was computed for four randomly selected half samples to test stability of reliability estimates. Subsample *N*s ranged from 555 to 567. The ranges shown are the lowest and highest alpha in the 4 half samples for the respective subscales.

Table 5: Mean item scores for each of the six PPCS-R domains and frequencies for each response option

Subscale Name	Mean (SD) *n*= 1122	Never (1) *n* (%)	Sometimes (2) *n* (%)	Often (3) *n* (%)	Very Often (4) *n* (%)	Always (4) *n* (%)
Foundational Knowledge & Skills *n*=1124	4.3 (.37)	3(.3)	15 (1.3)	154 (13.7)	801 (71.3)	149 (13.3)
Leadership *n*=1129	4.1 (.66)	6 (.5)	57 (5.0)	280 (24.8)	655 (58.0)	131 (11.6)
Collaboration *n*=1130	4.5 (.49)	0 (0)	4 (3)	97 (8.5)	790 (69.9)	239 (21.2)
Proficiency *n*=1132	4.4 (.56)	0 (0)	11(.1)	139 (12.3)	752 (66.4)	229 (21.1)
Empathy *n*=1124	4.5 (.58)	1 (.1)	20 (1.8)	130 (11.5)	599 (53.1)	378 (33.5)
Professional Development *n*=1129	4.2 (.58)	0 (0)	25 (2.2)	271 (24.0)	690 (61.1)	142 (12.6)

Note. The sample size varies according to the categories of responses in each response option.

Table 6: Perceived Perioperative Competence-Revised (PPCS-R) Scale and Subscale Scores, by Years of Operating Room (OR) Experience and Receipt of Specialized Education

PPC-R Subscale	Years of OR Experience							Obtained Specialty Education[a]				
	< 10 years (*n* = 217)		10-20 years (*n* = 390)		> 20 years (*n* = 497)			No (*n* = 321)		Yes (*n* = 790)		
	Mean	SD	Mean	SD	Mean	SD	*F (p)*	Mean	SD	Mean	SD	*F (p)*
Foundational Knowledge & Skills	36.5	5.2	39.5	4.5	41.0	3.7	85.0 (<.001)	38.5	5.6	40.0	4.0	26.1 (< .001)
Leadership	29.5	6.1	33.7	5.0	35.0	4.3	91.9 (< .001)	32.3	6.1	34.0	4.9	25.2 (< .001)
Collaboration	26.1	3.1	27.1	2.6	27.5	2.4	22.1 (< .001)	26.7	3.0	27.2	2.5	6.4 (.01)
Proficiency	24.4	3.5	26.9	2.5	27.6	2.4	107.9 (<.001)	26.0	3.6	27.0	2.6	25.4 (< .001)
Empathy	21.8	3.1	22.4	3.0	22.7	2.5	7.9 (< .001)	22.2	3.0	22.5	2.7	3.2 (.07)
Professional Development	23.6	3.6	25.3	3.5	26.3	3.0	52.1 (< .001)	24.7	3.8	25.7	3.3	17.9 (< .001)
Total PPC-R Scale	161.9	19.4	174.8	17.0	180.1	15.1	90.3 (< .001)	170.4	21.1	176.4	16.2	26.0 (<.001)

[a]Obtained perioperative specialty education.

APPENDIX: Perceived Perioperative Competence Scale-Revised (PPCS-R)

#	***Circle the number which corresponds closest with yourself:***	**Never**	**Some-times**	**Often**	**Very Often**	**Always**
1	I am familiar with most of the instrumentation in different specialties	1	2	3	4	5
2	I know where to find equipment and supplies in the OR	1	2	3	4	5
3	My local knowledge of this department assists me to perform my OR role	1	2	3	4	5
4	I understand and anticipate the surgical procedure	1	2	3	4	5
5	I am familiar with the technological equipment used in the OR	1	2	3	4	5
6	When I am allocated to an area of the OR that is unfamiliar, I draw on my skills and experience	1	2	3	4	5
7	I plan and coordinate the needs in the theatre I am allocated	1	2	3	4	5
8	I know instinctively when surgery is not going well and am able to respond appropriately	1	2	3	4	5
9	Knowing the location of equipment in the OR assists me to perform my OR role	1	2	3	4	5
10	I take a leadership role to ensure the smooth running of the theatre	1	2	3	4	5
11	I make difficult decisions when necessary	1	2	3	4	5
12	I take an active role in preceptoring or mentoring lesser experienced nurses	1	2	3	4	5
13	I manage clinical situations when there is conflict between staff	1	2	3	4	5
14	I provide clinical guidance to other staff members	1	2	3	4	5
15	I encourage team members to use innovative solutions to solve	1	2	3	4	5

	traditional problems					
16	I delegate aspects of care according to role, functions, capabilities and learning needs of other team members	1	2	3	4	5
17	I encourage active involvement in clinical decision-making processes	1	2	3	4	5
18	I use appropriate methods of communication according to the needs of the situation	1	2	3	4	5
19	I feel comfortable in seeking assistance from my colleagues when I am unsure	1	2	3	4	5
20	I tailor my communication based on the mix of personalities in the team	1	2	3	4	5
21	I respect the level of expertise of other members of the team	1	2	3	4	5
22	I treat members as individuals who have different needs, abilities and aspirations	1	2	3	4	5
23	When communicating with other team members, I use language that is appropriate to the situation	1	2	3	4	5
24	I have mastered the terminology and vocabulary of OR nursing	1	2	3	4	5
25	I troubleshoot and take appropriate action in the event of machine / equipment failures	1	2	3	4	5
26	Based on experience, I am able to identify actual or potential emergency situations and respond appropriately	1	2	3	4	5
27	I apply specialist knowledge in providing care for OR patients	1	2	3	4	5
28	I have the right amount of knowledge to practice in this specialty	1	2	3	4	5
29	I am able to anticipate the needs of the situation	1	2	3	4	5
30	I provide reassurance for patients using verbal and non-verbal	1	2	3	4	5

	strategies					
31	I use strategies to make the patient feel more comfortable	1	2	3	4	5
32	I provide appropriate reassurance and explanation for OR patients	1	2	3	4	5
33	I actively listen to the patient and significant others to obtain necessary information	1	2	3	4	5
34	I establish rapport with patients that enhances their ability to express feelings and concerns	1	2	3	4	5
35	I maintain current knowledge of, and incorporate relevant organisational policies into practice	1	2	3	4	5
36	I have detailed knowledge of anatomy and physiology	1	2	3	4	5
37	I maintain knowledge of, and incorporate relevant standards into my practice	1	2	3	4	5
38	I read current journals and literature that relate to clinical practice	1	2	3	4	5
39	I keep up with the technical changes in procedures and equipment	1	2	3	4	5
40	I use available resources to maintain current OR practice	1	2	3	4	5