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ORIGINAL RESEARCH

Psychometric Testing of the Technological Competency as Caring in Nursing Instrument – Revised (English Version Including a Practice Dimension)

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Abstract

Background: The middle range theory Technological Competency as Caring in Nursing (TCCN) guides nursing practices. The TCCN Instrument (TCCNI) measures perception dimension of the theory and has been revised and translated into the Japanese language (TCCNI-R). Testing the translated version of the TCCNI-R to English language with the inclusion of a practice dimension is warranted.
Purpose: This study aims to determine the psychometric properties of the TCCNI-Revised English version with Practice dimension (TCCNI-RePract).
Methods: A web-based cross-sectional study was conducted with data from 202 valid questionnaire copies from professional nurses in selected hospitals and nurse educators in universities.
Results: The suitability for factor analysis was determined using Kaiser-Meyer-Olkin index (0.93), Bartlett's sphericity test of 3256.93, $p<0.001$, the anti-image correlations ranged between 0.87 and 0.96, and an average value of communalities of 0.66. In the four rotations conducted with the maximum likelihood method with a Harris-Kaiser Orthoblique rotation, four items were excluded with factor loadings less than 0.40. These results determined the final scale with 21 items and four subscales, namely: (1) Knowing the person (8 items); (2) Technological competency as Caring (6 items); (3) Technology and caring (4 items); and (4) Expression of nursing as Caring (3 items). Cronbach's alpha coefficient for the total scale was 0.94. With two dimensions of the TCCNI-RePract, the perception dimension had significantly higher scores than the practice dimension. When comparing mean factor point among the dimensions, the perception scores were significantly higher for Factor 1 and Factor 3.
Conclusion: The TCCNI-RePract is an acceptable tool that can reliably measure nurses' perception and practice of TCCN. It is affirmed that with this tool, measuring perception and practice status of TCCN theory is possible. It is considered that the evaluation results can be used to plan in-hospital education.

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1. Introduction

In the late 1960s, the nurses' greatest tools were pen and paper. Before the age of computing and the advent of computers, nurses relied on their senses to evaluate and monitor specific physiological changes in their patients (Pepito & Locsin, 2018). The nurses viewed the technology that appeared in the 1960s as useful and innovative to enhance the reliability and validity of nurses' traditional observations (Sandelowski, 1997a). However, there is a wide disparity between nurses who had a positive attitude towards the advent of technology and nurses who expressed critical arguments against technology who are focusing instead on the human relationship (Barnard, 1996). In the mid-1980s and late 1980s, nursing was broadly divided into functions, namely: (a) the performance of technically required medical functions and (b) supportive and

expressive practices (Fenton, 1987). The first function is focused on the technical and operational functions, while the latter centers on people, caring, and constitutes most independent functions.

With the rapid advancement of technology, nurses were enforced to discover how technology could influence nursing practices and explore its integration into the nursing profession (Sandelowski, 1997b). Neighbors and Eldred (1993) state that both technology and caring are essential to the attainment of quality in healthcare. Additionally, Barnard and Sandelowski (2001) critically considered the dichotomy between technology and human care in nursing by emphasizing the need to rethink the relationship between technology and nursing. Locsin (2005) developed a nursing theory among such a historical backdrop, namely, the Technological Competency as Caring in Nursing (TCCN). This TCCN theory is a middle-range theory that guides nursing practice and was developed based on Boykin's and Schoenhofer's (2001) grand theory. Based on TCCN, the technological competency of nurses promotes the understanding of persons as participants of care rather than as objects of care (Locsin, 2005).

Furthermore, Locsin (2005) argued that recipients (patient or family) of care are more likely to be treated as products in medical settings where technological needs are high. However, it is essential to regard the patient as an indispensable person in implementing patient-centered care (Locsin, 2005). Locsin (2017) also underlined the importance of theory-based nursing practice, arguing that understanding technology and recognizing care using technology as expressed in various nursing situations lead to harmonious nursing assistance through "Technology and Caring." Integrating nursing theory and practice improves the quality of nursing care and supports nurses in all settings (Ahtisham & Shannon, 2019; Neto et al., 2016), and ultimately provide better outcomes for patients and institutions (Dyess et al., 2010).

During nursing's historical transitions, Locsin (1999) developed the Technological Caring Instrument (TCI) based on TCCN theory in 1999 to measure technical skills in critical care settings. Parcells and Locsin (2011) revised the TCI to develop the Technological Competency as Caring in Nursing Instrument (TCCNI). TCCNI has been translated and used in various countries (Biswas et al., 2016; Rincón-Álvarez & Chaparro-Díaz, 2017; Yuliati et al., 2019). Tanioka et al. translated and published TCCN theory in Japan in 2009 (Locsin, 2009). While going through that process, Tanioka (2018) realized that it would be effective if nurses' perception of TCCN theory and their actual practice situation following TCCN theory could be measured and expected to be used for in-service education and individual nurses' self-reflection. Therefore, Tanioka's research team has been developing an improved version of the TCCNI (Tanioka, 2018). For example, Kato et al. (2017), based on the TCCN theory, created the Perceived Inventory of Technological Competency as Caring in Nursing (PITCCN) and administered the survey among Japanese nurses' perceptions and practice situations of TCCN theory. According to Kato et al. (2017), the recognition of TCCN, that is, the perception of TCCN, is the intensive care unit nurses' agreement of Locsin's (2005) TCCN theory as measured by the PITCCN. Therefore, a higher score means higher recognition of TCCN. Alternatively, the practical situation of TCCN is their actual practice of TCCN based on his theory measured by evaluation of self-using PITCCN. Therefore, a higher score means a higher practice of TCCN. Their findings show that, although they were aware of the importance of TCCN theory, they cannot fully practice their profession based on this theory (Kato et al., 2017).

The PITCCN has been validated for criterion-related validity (Miyamoto et al., 2017, 2019). Moreover, the PITCCN was modeled by structural equation modeling, and its reliability and construct validity were verified using Cronbach's alpha (Ito et al., 2019). Tanioka (2018) also developed the Japanese version of the TCCNI from its original instrument. In addition, his team has developed the *Technological Competency as Caring in Nursing Instrument–Revised (TCCNI-R)* for use in both the Japanese and English languages.

Nakano et al. (2019, 2021) used the Japanese version of TCCNI-R to investigate the educational effects of TCCN theory on nursing administrators and found that teaching TCCN theory improved nursing administrators' understanding and perception of TCCN theory. Also, Yokotani et al. (2021) evaluated the Japanese version of the TCCNI-R by exploratory and confirmatory factor analysis by employing SEM to test for construct validity, and Cronbach's alpha confirmed its reliability. Based on the TCCNI–R, an English version focusing on the perception and practice dimension of the theory of TCCN was designed as the TCCNI-RePract.

The survey using TCCNI-R (Japanese language) was conducted with Japanese subjects. Findings of the study revealed that respondents were influenced by Japanese culture and social

background. Moreover, only few studies were available investigating differences between the perception and practice, which were pertinent (Kato et al., 2017). Also, no research has been conducted on the English version of TCCNI-R to clarify the perception dimension and practice dimension situation of TCCN theory. Consequently, investigating the differences between the perception and practice of TCCN theory and accumulating further knowledge, will be necessary to measure improved nursing practice, and caring expressions of both nurses and patients. Based on the TCCNI–R, an English version focusing on the perception and practice dimension of the theory of TCCN was designed and entitled the TCCNI-RePract (Revised for Practice).

This study aimed to determine the psychometric properties of the TCCNI-Revised English version with Practice dimension (TCCNI-RePract).

2. Methods

2.1 Research design

This study employed a web-based cross-sectional research design.

2.2 Setting and samples

This study was conducted using an international online survey platform (Survey Monkey©) from March to May 2021. This study used a convenience sampling method to recruit the subjects. The selection of subjects was based on the following inclusion criteria: working as nurses or nurse managers in the hospital, or nursing instructors supervising students for their clinical practice in the hospital. Exclusion criteria that made the subjects ineligible to participate in the survey included those who decided to quit and did not complete answering the questionnaire for any reason.

Statistical power analysis was conducted to estimate the sample size. In this study, the criterion set by Cohen (1988) was used, and the effect size was calculated using G*Power version 3.1.9.7. (Faul et al., 2007) with an effect size of $p = 0.3$, $\alpha = 0.05$, and power = 0.95, the predicted sample size using the formula for the paired t-test was 134. There were 202 subjects in this study who were nurses working in selected hospitals and academia. Therefore, it was considered that the sample size for this study is appropriate.

2.3 Instrument and data collection

In conducting this study, the research team contacted colleagues from various countries and regions, including the Philippines, United States of America, Saudi Arabia, and others, to distribute the questionnaire to their colleagues and nurse educators using the URL. In addition, nurse managers were also invited to participate online through the researchers networking activities. Similarly, the information regarding the study and URL was sent to them with the request to share the information about the research to their nursing staff and colleagues in the hospital settings. The questionnaire was also distributed through social media platforms (e.g., Facebook© and WhatsApp).

In this study, the researchers used TCCNI-RePract, an English version of TCCNI-R. In the TCCNI-R Japanese version, five questions were negatively stated (Yokotani et al., 2021). The formulation of the negatively stated question items usually effects a decrease in the bias of participant responses (Paulhus, 1991); however, a possible problem may arise when these items result in forming another factor or may influence the reliability of the instrument (Masuda et al., 2012). Therefore, in the TCCNI-RePract English version, the researchers did not formulate any negatively stated items, but rather, modified some items: From 25 items, 10 items were the same as the previous TCCNI-R, and 15 items were modified. Of 15 modified items, 5 reverse scoring questions (Q5, Q7, Q11, Q15, and Q24) were modified into normal score items, and 10 items (Q2, Q8, Q9, Q12, Q13, Q19, Q20, Q21, Q22, and Q25) were modified in terms of modifying, adding, or deleting the parts/contents of the sentence.

The first author and the second author of this study were the same persons who developed the TCCNI-R, therefore, permission in order to modify the tool was not required. Furthermore, the focus of the TCCNI-RePract included the practice dimensions of the theory, which was not included in the TCCNI-R Japanese version.

In this study, the TCCNI-RePract is an instrument that evaluates two dimensions of the TCCN theory, i.e., perception and practice. It comprises 25 items for each dimension, a total of 50 items. The perception dimension questionnaire items were developed with a 7-point Likert scale, with

values ranging from 1 as "Strongly Disagree" to 7 as "Strongly Agree." The practice dimension questionnaire items were developed with a 7-point Likert scale with values ranging from 1 as "Never" to 7 as "Always."

For establishing content validity, four experts in caring research were involved in administering the 50-item questionnaire of the TCCNI-RePract, and examined each item by considering the consistency of the constructs. A pilot study was administered to seven nurses who had 1 to 30 years of clinical nursing experience. Respondents were asked to write freely about the ease of answering the questionnaire, their response time, ease of understanding the questions, and indicate items for improvement. Based on the results, the questionnaire items were reviewed and revised.

2.4 Data analysis

In analyzing the data, the following steps were conducted. First, frequency (n) and percentage (%) were calculated to show the demographic characteristics of the study subjects. Subsequently, mean, standard deviation, and 95% confidence interval (CI) were calculated to assess the floor and ceiling effects. In order to verify whether or not the data fit prior to the exploratory factor analysis (EFA), Bartlett's sphericity tests were applied (p<0.0001), and the sampling adequacy was measured with the Kaiser-Meyer-Olkin (KMO) index. The anti-image correlations and communalities were determined for each item.

Next, construct validity of the scale was assessed with EFA. It was performed using the maximum likelihood method with a Harris-kaiser orthblique rotation. The Cronbach alpha was calculated to assess the reliability of the scale. The content validity index of the whole instrument was calculated. Afterward, paired t-test was used to compare the average total scores for the perception and practice dimension and the mean factor points (MFP) for each item. The practice dimension question items were used and matched with items of perception factors. Data analysis was performed using Microsoft Excel, SPSS statistical software version 27 (IBM Corp), R (version 4.0.4, R Foundation for Statistical Computing, Vienna, Austria) (R Core Team, 2018).

2.5 Ethical considerations

The ethical code for this international study was obtained from the Ethics Committee of Tokushima University Hospital (approval number 2914-3). Participation by the subjects was voluntary; no penalty was applied if they decided to quit the study at any time. Personal information was kept confidential by securing access using a password. All personal data were secured in the researcher's computer that was also accessible only through a password known only by the principal researcher.

3. Results

3.1 Characteristics of the respondents

Table 1 shows the demographic characteristics of the study subjects. A total of 202 respondents were included in this study. Most of them were female nurses (66.8%), aged 30 to less than 40 years (43.6%), and 83.6% of the subjects were nurses from the Philippines.

3.2 The score of perception and practice dimension

Table 2 shows the score of the perception and practice dimension. The item of perception dimension with the highest score was Q7 (M=6.53, SD=1.18, 95%CI=6.37-6.69) while the item with the lowest score was Q11 (M=4.66, SD=1.71, 95%CI=4.42-4.90). The item of practice dimension with the highest score was Q14 (M=6.58, SD=0.70, 95%CI=6.49-6.68) while the item with the lowest score was Q11 (M=4.44, SD=1.75, 95%CI=4.19-4.68).

3.3 The final exploratory factor analysis of the scale items

Table 3 shows the final exploratory factor analysis of the scale items, including the correlation among factors, and Cronbach's alpha for each factor, and overall scale.

A series of five exploratory factorial analyses were conducted to arrive at a best-fitting solution. As a result, there were four eigenvalues greater than 1.0; these four factors explained 50% of the total variance in the data; items were a factor loading of more than 0.40. EFA suggested four factors based on the scree-plot and the cumulative contribution rate, and these were seen to be conceptually appropriate from the meanings of the items assigned to each factor. Four items

with low factor loading were deleted (Q1, Q8, Q9, and Q11). For the final model derived from the exploratory factor analysis, an instrument with 21 items and a four-factor structure was created. Those four factors are: (1) Knowing the Person (8 items); (2) Technological Competency as Caring (6 items); (3) Technology and Caring (4 items); and (4) Expression of Nursing as Caring (3 items). Cronbach's alpha coefficient for the total scale was 0.94, and the respective coefficients for the four factors were 0.93, 0.87, 0.83, and 0.81, respectively. EFA suggested four factors based on the scree-plot and the cumulative contribution rate, and these were seen to be conceptually appropriate from the meanings of the items assigned to each factor.

Table 1. Participants' demographic characteristics (n=202)

Characteristics	f	%
Age (years)		
20-29	35	17.3
30-39	88	43.6
40-49	42	20.8
50 and above	37	18.3
Gender		
Female	135	66.8
Male	67	33.2
Education level		
Baccalaureate	51	25.3
Master	121	59.9
Doctorate	30	14.8
Working units or job description		
General ward	63	31.2
Special areas	59	29.2
Nursing educator	59	29.2
Nurse manager	21	10.4
Countries		
Philippines	169	83.6
United States of America	9	4.4
Saudi Arabia	5	2.5
Indonesia	5	2.5
Malaysia	4	2.0
United Arab Emirates	3	1.5
Qatar	2	1.0
New Zealand	1	0.5
Australia	1	0.5
Sweden	1	0.5
Nigeria	1	0.5
Singapore	1	0.5

KMO was 0.93, Bartlett test was 3256.93, $p<0.0001$, and the anti-image correlations ranged between 0.87 and 0.96. The communalities of the items were range from 0.361 to 0.859, and an average value of communalities was 0.66. In the four rotations done with the maximum likelihood method with a Harris-kaiser orthblique rotation, there were four eigenvalues greater than 1.0; 4 items were excluded because their factor loadings were less than 0.40.

3.4 The compared results of the average total scores for the perception and practice dimension and the MFP

Table 4 shows the compared results of the average total scores for the perception and practice dimension and the MFP for each. Factor 1 was the highest in the MFP for the perception dimension (M=6.37, SD=0.75). Factor 4 was the highest for MFP in the practice dimension (M=6.31, SD=0.71). As a result of comparing the Perception dimension total mean score with the Practice dimension total mean score by paired t-test, it was found that the Perception dimension had significantly higher scores than the practice dimension (t=3.87, $p<0.001$). Comparing each MFP of the perception and practice dimension, the scores of perception were significantly higher in Factor 1 (t=3.96, $p<0.001$) and Factor 3 (t=5.54; $p<0.001$).

Table 2. Participants' responses to the TCCNI-RePract: Perception and Practice dimension (n=202)

Perception dimension		M	SD	95% CI
Q1	Nurses must emphasize thoughtfulness and consideration for patients.	5.22	2.56	4.86 - 5.57
Q2	Nurses are professionals who express caring utilizing competency with technology.	5.96	1.60	5.74 - 6.18
Q3	Nurses have to provide care for patients by using necessary technologies.	6.04	1.27	5.86 - 6.22
Q4	Nurses must provide nursing care through the harmonious relationship between technology and caring.	6.27	1.12	6.11 - 6.42
Q5	Nurses need to consider providing nursing care because each patient's wishes always change.	6.22	0.99	6.08 - 6.36
Q6	Nurses must make a plan of care together with the patient to ensure quality nursing.	6.30	1.32	6.12 - 6.49
Q7	Nurses need to know patient's health data in order to take care of the patient.	6.53	1.18	6.37 - 6.69
Q8	Nurses must share information with their patients in order to know them better.	5.72	1.26	5.55 - 5.90
Q9	Nurses must provide care with a thorough understanding of their own competency.	6.41	1.03	6.26 - 6.55
Q10	Nurses have to use technology in order to know patients as persons who are complete and to maintain honest relationships with them.	5.72	1.26	5.54 - 5.89
Q11	Nurses must finish nursing duties within a specific time even if they cannot completely know the patients, for example, their emotional needs or feelings.	4.66	1.71	4.42 - 4.90
Q12	Nurses must respect patients' beliefs and focus on their recovery while anticipating their hopes, needs, and desires.	6.35	1.07	6.20 - 6.50
Q13	Nurses need to maintain patients' lifestyles and allow them to regain their healthy lives.	6.05	1.17	5.89 - 6.22
Q14	Nurses must emphasize thoughtful consideration of patient's feelings, encouragement, and respect.	6.47	0.98	6.33 - 6.61
Q15	Nurses need to provide timely nursing care in accordance with patients' physical and emotional conditions.	6.46	0.94	6.33 - 6.59
Q16	Nurses must be devoted towards meeting the patient's needs, hopes, wishes, and dreams.	6.28	0.93	6.15 - 6.41
Q17	Nurses must act by carefully listening to the patients' voices and expressing compassion.	6.47	0.84	6.35 - 6.59
Q18	Nurses must consider patient's stress and anxiety level occurring within the nurse-patient relationship.	6.46	0.81	6.34 - 6.57
Q19	Nurses have to know the patients not only focusing on their physical aspects but also on accurately understanding "who they are as persons."	6.34	0.91	6.21 - 6.46
Q20	Nurses' competence includes the use of healthcare technologies from the perspective of caring in nursing.	6.36	0.80	6.25 - 6.47
Q21	Knowing the patient is understanding the whole person.	6.44	0.95	6.30 - 6.57
Q22	Nursing as caring is the involvement of nurses with patients and their families in ways that allow them to grow together in the shared nursing situation.	6.25	0.94	6.12 - 6.38
Q23	Nurses use technologies with competency in order to know patients and their families.	6.06	0.95	5.93 - 6.19
Q24	Technology is useful for understanding patients' health conditions.	6.24	0.90	6.11 - 6.36
Q25	Nurses use technology with competency as caring to facilitate patients' recovery with enhanced self-esteem.	6.09	1.01	5.95 - 6.23

Table 2. Continued

Practice dimension		M	SD	95% CI
Q1	I emphasize thoughtfulness and consideration of patients.	6.33	0.99	6.19 - 6.47
Q2	I express caring utilizing competency with technology.	5.84	1.13	5.68 - 6.00
Q3	I provide care for patients by using necessary technologies.	5.92	1.02	5.78 - 6.06
Q4	I am providing nursing care through the harmonious relationship between technology and caring.	6.06	0.98	5.93 - 6.20
Q5	I consider patients' wishes in providing nursing care because their wishes always change.	5.91	1.01	5.77 - 6.05
Q6	I am making care plans together with the patient to ensure quality care.	6.11	1.05	5.97 - 6.26
Q7	I am assessing patient's health data when taking care of patients.	6.58	0.72	6.48 - 6.68
Q8	I share information with patients to get to know them better.	5.36	1.45	5.16 - 5.56
Q9	I am providing nursing care with a thorough understanding of my own competency.	6.42	0.84	6.30 - 6.53
Q10	I use technology to know patients as complete and to maintain honest relationships with them.	5.54	1.28	5.37 - 5.72
Q11	I finish my work within the established work time even if I could not know the patient's emotional needs or feelings.	4.44	1.75	4.19 - 4.68
Q12	I respect patients' beliefs, focus on their recovery, and anticipate their hopes, needs, and desires.	6.36	0.82	6.25 - 6.47
Q13	I am caring for patients to maintain their lifestyles and allow them to regain their healthy lives.	6.02	1.07	5.88 - 6.17
Q14	I am considerate, supportive, and respectful of the patient.	6.58	0.70	6.49 - 6.68
Q15	I provide timely nursing care in accordance with patients' physical and emotional conditions.	6.31	0.81	6.19 - 6.42
Q16	I am caring for patients to fulfill their needs, hopes, and dreams.	5.96	0.98	5.82 - 6.09
Q17	I am listening to the patient's voices and showing my compassion.	6.26	0.84	6.14 - 6.37
Q18	I provide care and consider the stress and anxieties that the patient has during a nurse-patient relationship.	6.23	0.87	6.11 - 6.35
Q19	I am working to know patients by focusing on their physical aspects and by understanding who the patient is.	6.12	0.92	5.99 - 6.25
Q20	I use healthcare technologies as one of my nursing competencies from the perspective of caring in nursing.	6.06	0.97	5.93 - 6.20
Q21	I am working to know the patient by understanding the patient as a whole.	6.25	0.95	6.12 - 6.38
Q22	I am providing nursing care by involving patients and families and including me in their growth within the nursing situations.	6.14	0.98	6.01 - 6.28
Q23	I use technologies with competence as an expression of my caring in order to know patients and their families.	5.76	1.13	5.61 - 5.92
Q24	I use technology to understand patients' health conditions.	5.88	1.12	5.72 - 6.03
Q25	I am using technology and providing caring to facilitate patients' recovery with enhanced self-esteem.	5.88	1.09	5.72 - 6.03

4. Discussion

4.1 The demographic characteristics of the study subjects

This study was conducted in Japan. However, the TCCNI-RePract is in English, not in Japanese language. Respondents of this study were from other countries who speak and understand English. Therefore, Japan is not included in this section as there are no participants from Japan in the study.

Table 3. Exploratory factor analysis result of the TCCNI-RePract: Perception dimension

Total items Cronbach's alpha = 0.94		Factor loadings			
		F1	F2	F3	F4
Factor 1: Knowing the Person (Cronbach's alpha = 0.93)					
Q19	Nurses have to know the patients not only focusing on their physical aspects but also on accurately understanding.	0.94	0.00	-0.14	0.03
Q18	Nurses must consider patient's stress and anxiety level occurring within the nurse-patient relationship.	0.90	-0.05	-0.11	0.14
Q22	Nursing as caring is the involvement of nurses with patients and their families in ways that allow them to grow together in the shared nursing situation.	0.84	0.07	0.04	-0.06
Q17	Nurses must act by carefully listening to the patients' voices and expressing compassion.	0.82	-0.04	-0.01	0.17
Q21	Knowing the patient is understanding the whole person.	0.75	-0.04	0.02	0.02
Q16	Nurses must be devoted towards meeting the patient's needs, hopes, wishes, and dreams.	0.62	0.11	0.07	0.08
Q12	Nurses must respect patients' beliefs and focus on their recovery while anticipating their hopes, needs, and desires.	0.52	0.21	-0.11	0.16
Q20	Nurses' competence includes the use of healthcare technologies from the perspective of caring in nursing.	0.49	-0.02	0.34	0.06
Factor 2: Technological Competency as Caring (Cronbach's alpha = 0.87)					
Q4	Nurses must provide nursing care through the harmonious relationship between technology and caring.	0.09	0.89	0.05	-0.23
Q7	Nurses need to know patient's health data in order to take care of the patient.	-0.14	0.85	-0.09	0.30
Q3	Nurses have to provide care for patients by using necessary technologies.	-0.03	0.80	0.22	-0.23
Q6	Nurses must make a plan of care together with the patient to ensure quality nursing.	-0.10	0.79	-0.03	0.24
Q5	Nurses need to consider providing nursing care because each patient's wishes always change.	0.33	0.66	-0.05	-0.25
Q2	Nurses are professionals who express caring utilizing competency with technology.	0.11	0.57	-0.08	0.01
Factor 3: Technology and Caring (Cronbach's alpha = 0.83)					
Q23	Nurses use technologies with competency in order to know patients and their families.	0.00	-0.07	0.86	0.09
Q25	Nurses use technology with competency as caring to facilitate patients' recovery with enhanced self-esteem.	0.20	0.03	0.76	-0.19
Q24	Technology is useful for understanding patients' health conditions.	0.02	0.10	0.64	0.15
Q10	Nurses have to use technology in order to know patients as persons who are complete and to maintain honest relationships with them.	-0.15	-0.04	0.63	0.24
Factor 4: Expression of Nursing as Caring (Cronbach's alpha = 0.81)					
Q14	Nurses must emphasize thoughtful consideration of a patient's feelings, giving encouragement, and respect.	0.02	0.12	0.06	0.82
Q15	Nurses need to provide timely nursing care in accordance with patients' physical and emotional conditions.	0.29	-0.08	0.10	0.64
Q13	Nurses need to maintain patients' lifestyles and allow them to regain their healthy lives.	0.22	-0.17	0.10	0.51
Rotation sums of squared loading	Fixed value	5.35	3.72	2.52	2.20
The correlation factor between contents: significance probability (one-sided test) Pearson	Factor 1	1.00	0.59	0.67	0.64
	Factor 2	0.59	1.00	0.45	0.56
	Factor 3	0.67	0.45	1.00	0.40
	Factor 4	0.64	0.56	0.40	1.00

Note. N= 202. The extraction method was the maximum likelihood method with a Harris-kaiser orthblique rotation. Factor loadings above 0.40 were shown in bold. F1= Factor 1, F2= Factor 2, F3= Factor 3, F4= Factor 4.

Table 4. The compared results of the perception and practice situation of the TCCNI-RePract average scores

Variable	Perception dimension		Practice dimension		*t* (201)	*p*
	MFP	*SD*	MFP	*SD*		
TCCNI-RePract average total score	6.25	0.72	6.09	0.65	3.87	< 0.001
F1 Knowing the Person	6.37	0.75	6.17	0.71	3.96	< 0.001
F2 Technological Competency as Caring	6.22	1.01	6.07	0.70	2.21	0.03
F3 Technology and Caring	6.03	0.85	5.76	0.97	5.54	< 0.001
F4 Nursing Expressions as Caring	6.33	0.88	6.31	0.71	0.41	0.68

Note. *N*= 202. Mean parameter values for each analysis are shown for perception and practice, as well as the results of a paired t-test comparing the parameter estimates between the two samples. Abbreviations: MFP = Mean factor points, *SD* = Standard Deviation, *p* = *p*-value, F1 = Factor 1, F2 = Factor 2, F3 = Factor 3, F4 = Factor 4.

4.2 The floor and ceiling effects

The ceiling effects of the items in the perception dimension were observed in all questions except Q8, Q10, Q11. No floor effect was observed in any items. Among the items of practice dimension, ceiling effects were observed in Q1, Q4, Q6, Q7, Q9, Q12-15, Q17-22, and Q24, while no floor effect was observed in any items.

Regarding the ceiling effect, it was thought that there are respondents scoring positively nearly "Strongly Agree" or "Always." However, items that the ceiling effect has not been confirmed, respondents have a different perception from the TCCN theory, or who have not practiced.

4.3 Exploratory factor analysis of perception dimension

An EFA of the perception dimension caused four items to be deleted, resulting in 21 items and four factors. As dimension reduction techniques seek to identify items with a shared variance, it has suggested removing any item with a communality score less than 0.2 (Child, 2006). According to this idea, our minimum value was 0.361; it was considered appropriate values. Moreover, an average value of communalities was 0.66, an average value between 0.5 and 0.6 is acceptable for sample sizes between 100 and 200 (MacCallum et al., 1999).

The difference in the English versions (other than language), between the TCCNI-R and the TCCNI-RePract is the added focus on the evaluation of practice situations. Perception dimension Factor 1: Knowing the Person is an essential concept in TCCN theory and knowing the person as an irreplaceable being who is constantly changing from moment to moment is the first process in the practice of nursing (Locsin, 2015). Factor 2: Technological Competency as Caring reflects the expression of caring as a technical competency of the nurse; Factor 3: Technology and Caring emphasize that technology and caring coexist in nursing (Locsin, 2017). Factor 4: Expression of Nursing as Caring reflects the emphasis on compassionate care while listening to the patient, meeting needs, and maintaining the patient's lifestyle.

Cronbach's alpha coefficient for the scale's internal consistency ranged from 0.81 to 0.93, and Cronbach's alpha coefficient was 0.94 overall, indicating that the reliability of the perception dimension was primarily achieved. However, a value was considered that there was an effect of the ceiling effect.

4.4 Differences between perception and practice dimension

In the process of comparing the average of the total score of perception and practice dimension and MFP, a significant difference was found between the average of the total score and the MFP of the first and third factors. Based on this result, in the mean scores of the total TCCNI-RePract scores, the mean scores of perceptions were higher than the mean scores of practice, which were similar to the results of the PITCCN study by Kato et al. (2017). Therefore, it was considered that while the usefulness and value of TCCN theory have been recognized, it may not have been put into practice or well-integrated into clinical settings.

Regarding the first factor, one must consider that nurses' caring behavior is influenced by several factors, including working conditions, workload, management support, and concern about patients' health conditions (Akansel et al., 2020). Also, Stavropoulou et al. (2020) suggested that organizational and functional issues, understaffing, increased workload, compassion fatigue, and professional burnout as factors complicating empathic care in practicing caring. In such circumstances, organizational support is becoming essential.

Regarding the third factor, as it was reported in previous studies of the practical status of TCCN theory, nurses who had received caring education were significantly more aware of TCCN theory than nurses who had not received caring education. However, no significant difference was found in the TCCN practice status. Nurses with long experience practiced TCCN theory significantly more than nurses with much less experience (Kato et al., 2017). In this study, the researchers did not compare the exact years of nurses' experience. Still, as it was reported, young and inexperienced nurses tended to show opposing views on the impact of technology on care (Bagherian et al., 2017). Also, a survey of midwives shows that survey participants put confidence in technology for its use, but at the same time are concerned about safety issues due to potential disabilities and lack of training when using it (Sinclair & Gardner, 2001).

Previous studies have shown that education in TCCN theory improves awareness and understanding of TCCN theory (Nakano et al., 2019, 2021). It cannot be denied that the experience of being educated in TCCN theory may affect the results of the survey. Also, providing continuous education and training is recognized as indispensable to improving nurses' caring practices (Sawatzky et al., 2009; Hsu et al., 2015). Knowledge and skills are essential for nurses in building relationships between nurses and patients, and building relationships depends on confidence in the technical abilities of individual nurses (Wiechula et al., 2016). As nurses become proficient in technology, they demonstrate a significant increase in efficiency in using technology to instantly and holistically comprehend people and find improvements to build strong patient connections in nursing practice (Locsin, 2005). When nurses say they know about a patient, the technology they use helps them understand the extent to which they understand the patient. Knowing the patient is an essential element of caring; all nurses should have the ability to obtain the clinical and personal information needed to know the patient (Kelley et al., 2013).

5. Implications and limitations

The implication of this study shows that it can compare perception and practice situation as attributes of the theory, and that this result can be used for evaluating on-the-job training (OJT) activities. The findings show that nurses were aware of the technology use in their care but might not have an optimum way to use those technologies in their practice. Therefore, managers and decision-makers in the hospital are suggested to support nursing staff to apply optimal use of technologies in nursing care through providing the supporting technologies, providing opportunities for nurses to use technologies in nursing care, and providing training or courses regarding the specific technology used in their unit. If the cause is the lack of self-confidence in nursing practice, we believe that in-service education is necessary to boost confidence.

A limitation of this study is that it involved nurses from various countries. However, the number of participants is not equal. As an international study, conducting similar study with a larger and more diverse sample size is necessary.

6. Conclusion

The TCCNI-RePract is an acceptable tool that can reliably measure nurses' perception and practice of TCCN. This scale can accurately and consistently measure nurses' perception and practice dimensions within four factors: 1) Knowing the Persons, 2) Technological Competency as Caring, 3) Technology and Caring, and 4) Expression of Nursing as Caring. Therefore, it is considered that the evaluation results can be used to plan in-hospital education.

Findings showed that nurses recognized the utility and value of TCCN theory in their practice. They were aware of the importance of technology use in understanding patients' needs, enhancing their self-esteem, promoting better health, and building better relationships with others. Hospitals and organizations promoting an environment of human caring must support nurses' continuing professional development, including the acquisition of new skills grounded on the latest evidence supporting nursing care practice for better health outcomes and optimum client satisfaction. Although nurses know the importance of using technology to deeply understand

patients, enhance their self-esteem, promote recovery, and build better relationships with patients, they cannot do so for various reasons. Therefore, there is a need for further studies to investigate the barriers and challenges that prevent nurses from providing nursing care with technology.

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Author's contribution

TY: Conceptualization, data collection, analysis, writing and revising the manuscript. TT: Conceptualization, data collection, analysis, writing and revising the manuscript. FB: Data collection, analysis, reviewing and revising the manuscript. YY: Conceptualization, reviewing and revising the manuscript. HI: Data analysis, reviewing and revising the manuscript. GP: Data collection, analysis, reviewing and revising the manuscript. MD: Data collection, analysis, writing, reviewing and revising the manuscript. RL: Conceptualization, analysis, writing and revising the manuscript. All authors agreed and approved the manuscript for publication.

Conflict of interest

None declared.

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