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Psychometric properties of the Chinese version of the chemotherapy-induced taste alteration scale

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ABSTRACT

Purpose: The chemotherapy-induced taste alteration scale (CiTAS) is a reliable and valid instrument to comprehensively assess patients' taste alterations in an easy way. We aimed to translate it and test its psychometric properties among Chinese cancer patients undergoing chemotherapy.

Method: A convenience sample of 227 cancer patients were recruited in a tertiary cancer hospital in Beijing. The Chinese version of the CiTAS (C-CiTAS) was developed via rigorous translation methods. An exploratory structural equation model (ESEM) was used to test its construct validity. Correlations between the C-CiTAS scores and the European Organization for Research and Treatment of Cancer (EORTC) QLQ-C30 scores were calculated for convergent validity. The overall taste alterations scale (OTAS) score was used to test its discriminant validity. Reliabilities were also examined.

Results: The majority of patients undergoing chemotherapy experienced minor to mild taste alterations. The current factor analysis results using the ESEM supported the original factor solution of the CiTAS, and no item of the CiTAS was dropped. The C-CiTAS demonstrated good construct validity, convergent validity and discriminant validity. The Cronbach's alphas of the C-CiTAS were 0.900 for the overall scale and from 0.570 to 0.857 for the four subscales. Its test-retest reliability was 0.815 ($p < 0.01$).

Conclusions: The Chinese version of the CiTAS is a reliable and valid instrument to evaluate cancer patients' Chemotherapy-induced taste alterations in China.

1. Introduction

Chemotherapy is a significant treatment for cancer patients. Along with its treatment effect, patients often experience side effect symptoms, notably as fatigue, peripheral numbness of limbs, hair loss, nausea, loss of appetite. Recently, one side effect induced by chemotherapy, taste alterations (TAs), has attracted greater attention. In two systematic reviews, the prevalence of chemotherapy-induced TAs ranges between 20% and 84% in cancer patients (Gamper et al., 2012; Spotten et al., 2017). In our previously survey of 197 patients who had completed at least two cycles of cancer chemotherapy in Beijing, China, approximately 74% experienced TAs (Qian et al., 2017). TAs are even ranked as one of the most troublesome problems by cancer patients undergoing chemotherapy treatment (Sasaki et al., 2017; Wagland et al., 2016; Williams et al., 2015). However, TAs are often overlooked or misunderstood by health care professionals. Zabernigg et al. (2010) revealed that the prevalence of TAs was very high, however, they were given less attention in daily oncological practice and research. Skolin et al. (2006) studied the eating problems in children with cancer after start of chemotherapy. They found that both children and parents thought the predominant cause was altered taste. In contrast, nurses perceived nausea as the most important cause.

Taste perceptions allow us to assess the nutritional contents of food, support food intake and prevent potential toxin ingestion (Epstein and Barasch, 2010). Taste perception includes five basic modalities, i.e., salty, sweet, sour, bitter and umami (the savouriness of protein-rich foods) (Chandrashekar et al., 2006). Changes in taste can present themselves as loss of taste functions of the tongue (ageusia), unpleasant

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taste that does not originate from food or beverage (cacogeusia), decreased ability to taste (hypogeusia), abnormal sense of taste (parageusia), and continuous abnormal taste in the mouth, usually bitter or metallic (phantogeusia) (Epstein and Barasch, 2010; Kano and Kanda, 2013). As TAs are symptoms that rely on patients' personal experiences, it is important to include patients' subjective report for its assessment. However, there is no valid subjective instrument widely used in China to evaluate TAs for clinical practice and research. Researchers developed subjective assessments containing different items and responses, making it challenging to compare results across studies.

Kano and Kanda (2013) developed a chemotherapy-induced taste alteration scale (CiTAS), which may comprehensively evaluate the chemotherapy-induced TAs and associated outcomes for cancer patients over the past week. The CiTAS has 18 items evaluated on a 5-point Likert-type response. It consists of four dimensions to measure decline in basic taste, discomfort, phantogeusia and parageusia, as well as general taste alterations. The CiTAS was demonstrated to have good validities and reliabilities in Japan. It also has been translated and validated in Turkey (Sozeri and Kutluturkan, 2015, 2018) and Italy (Campagna et al., 2016, 2018). The purpose of this study was to translate the CiTAS (Kano and Kanda, 2013) into Chinese, and validate its psychometric properties.

2. Methods

2.1. Participants

A convenience sample was recruited from the Department of Ambulatory Care as well as the Breast Cancer Prevention and Treatment Center of a tertiary cancer hospital in Beijing from March 1 to May 30, 2016. The inclusion criteria were as follows: (1) age 18 years or older; (2) a diagnosis of cancer by pathological evaluation; (3) completed at least two cycles of chemotherapy; (4) voluntarily agree to participate in the study. Patients were excluded if they: (1) were undergoing radiotherapy or biological target therapy; (2) were not able to eat by mouth; (3) had gastroesophageal reflux; (4) had serious oral infection; or (5) had cognition/language problems. In the instrument development study using factor analysis, a ratio of at least 10 participants per item should be planned (Dixon, 2005). In our study, two hundred fifty-six patients were invited, and 227 (88.7%) valid questionnaires were collected.

2.2. Translation of the CiTAS

Permission was obtained from Professor Kano (Kano and Kanda, 2013) for the translation of the CiTAS from English into Mandarin Chinese. The translation process was based on the guideline for instrument translation, adaptation and validation by Sousa and Rojjanasrirat (2011). It was conducted by experts knowledgeable about cancer nursing practice and research. Step 1 (forward translation), three bilingual oncology nurse experts translated the original CiTAS from English into Chinese independently. Step 2 (synthesis I), a fourth and fifth independent bilingual nurse experts compared between the three Chinese versions, and compared all the three Chinese versions with the original CiTAS in terms of the instructions, items, response formats regarding discrepancies and ambiguities of words, sentences and meanings. A committee approach was used with these five experts to resolve any discrepancies and ambiguities until consensus was achieved. A preliminary initial translated version of the CiTAS was derived. Step 3 (blind back-translation), the sixth and seventh bilingual nurse experts who did not have any knowledge about the original CiTAS translated the current version of the CiTAS back into English independently. Step 4 (synthesis II), the eighth bilingual methodologist was added into the previous seven-expert committee. A committee approach was used to compare between the two back-translations, and between both the two back-translations and the original English CiTAS to evaluate similarity of the instructions, items and response format regarding wording, sentence structure, meaning and relevance. Any ambiguities and discrepancies about cultural meaning and colloquialisms or idioms in words and sentences were discussed and resolved through consensus among the committee members. Then, a pre-final version of the CiTAS was derived, whose initial conceptual, semantic and content equivalence was established by the methodological approaches of this step.

Finally, the pre-final version of the CiTAS was distributed to five native Chinese-speaking cancer patients undergoing chemotherapy and two monolingual Chinese language experts to evaluate the clarity and cultural relevance of the translated scale. All of them unanimously agreed that it was understandable and cultural relevant, except the first six items. These items were "have difficulty tasting food/sweetness/saltiness/sourness/bitterness/umami", and their response options were "taste normally", "slightly/somewhat/quite difficult to taste", and "unable to taste at all". Two patients and both the Chinese linguists indicated that these double-negative descriptions made the items complex, and were not commonly used in Chinese language. After thorough discussion, patients, linguists and expert committee all agreed to remove "have difficulty" from the first six items, while their responses remained unchanged. A candidate Chinese version of CiTAS (C-CiTAS) was thus completed for the next stage of full psychometric testing.

2.3. Measurement and instruments

2.3.1. General information questionnaire

The general information questionnaire was developed by the researchers. Information collected included (1) demographic characteristics: age, gender, education, marital status, employment status, etc.; and (2) medical history: cancer diagnosis, time after cancer diagnosis, recurrence, pathological stage, surgery, chemotherapy, radiotherapy history, and oral mucositis.

2.3.2. Candidate Chinese version of the CiTAS

The C-CiTAS was translated from the CiTAS developed by Kano and Kanda (2013) to measure patients' self-report TAs over the recent week during their chemotherapy. It is comprised of 18 items evaluated on a 5-point Likert-type response. Item 1 to item 6 were graded as follows: 1 = taste normally, 2 = slightly difficulty to taste, 3 = somewhat difficult to taste, 4 = quite difficult to taste, and 5 = unable to taste at all. Item 7 to item 18 were graded as follows: 1 = no, 2 = slightly, 3 = somewhat, 4 = quite, and 5 = very. The four dimensions of the scale were decline in basic taste (items 2–6), discomfort (items 13–18), phantogeusia and parageusia (items 10–12), and general TAs (items 1, 7–9). The total score/subscale scores were obtained by adding up all scores in the scale/subscale, and then dividing it by the number of the items in this scale/subscale. The scores ranged from 1 to 5 points. A higher score indicates more severe TAs that patient experienced. The CiTAS had a Cronbach's alpha of 0.9, and a test-retest reliability of 0.94. It also demonstrated good validities (Kano and Kanda, 2013).

2.3.3. EORTC QLQ-C30

The European Organization for Research and Treatment of Cancer (EORTC) QLQ-C30 (Aaronson et al., 1993) is globally accepted and widely used as a valid instrument to measure quality of life (QoL). It includes a global QoL subscale, five functional subscales (i.e., physical, role, emotional, cognitive, and social functioning), three symptom subscales (i.e., fatigue, nausea/vomiting, and pain), and six single-symptom items (i.e., dyspnea, insomnia, appetite loss, constipation, diarrhea, and financial difficulties). The scoring procedure follows the scoring manual (Fayers, Aaronson et al., 1993). Scores range from 0 to 100. A higher score represents a better level of global QoL, a better level of functioning, and a worse level of symptom. The Chinese version of EORTC QLQ-C30 has been demonstrated to have good reliabilities and

validities (Wan et al., 2005).

Studies indicate that TAs are related to decreased quality of life, especially with physical function, role function, emotional function, social function, fatigue, nausea-vomiting and appetite loss (Campagna et al., 2018; de Vries et al., 2018; Kano and Kanda, 2013; Zabernigg et al., 2010). In order to test the convergent validity of the C-CiTAS, the correlations between the C-CiTAS scores and the scores of the EORTC QLQ-C30 were evaluated.

2.3.4. Overall taste alterations scale (OTAS)

We created a single-item 11-point scale to measure patients' overall taste alterations. In this scale, "0" meant "no change", and "10" was "totally changed". Patients were asked to rate their experiences within the past one week. In order to test discriminant validity, the relationship between the OTAS scores and the C-CiTAS scores was compared.

2.4. Data collection

By reviewing the hospital medical records of patients who were undergoing chemotherapy, we identified and invited eligible patients. All consenting participants completed the general information questionnaire. Medical histories were obtained from their medical records. If the participants returned to the hospital one week after chemotherapy, they completed the C-CiTAS, EORTC QLQ-C30 and OTAS questionnaire again. Otherwise, a hardcopy of the questionnaire was sent home with them, and the participant was interviewed by telephone one week later. For test-retest reliability testing, 17 participants completed the second survey of the C-CiTAS one week after their next consecutive cycle of chemotherapy.

2.5. Ethical consideration

Ethical approval was granted by the Research Ethical Review Committee of the university where the study was based (IRB00001052-16005). Information about the purpose of the study, survey content, voluntary participation, and confidentiality of personal information were provided to potential participants. The informed consent form was also attached to the questionnaire, and signed by consenting participant.

2.6. Data analysis

We factor analyzed the C-CiTAS items aiming to replicate the factor structure originally recommended by Kano and Kanda (2013). An exploratory structural equation model (ESEM) was applied to the 18 items of C-CiTAS. ESEM is a flexible, model-based factor analytic approach that allows specification of a predefined factor structure in an exploratory factor analysis context (Asparouhov and Muthén, 2009). A targeted rotation was applied to mimic the original factor solution (Browne, 2001). Specifically, in the ESEM, the items written to represent a domain factor (e.g., decline in basic taste) were estimated freely on the primary domain factor (e.g., decline in basic taste) but targeted at zero for all other non-primary domain factors (e.g., discomfort, phatogeusia and parageusia, and general taste alterations). Note that targeting estimates at a specific value did not fix the estimates at those values; rather estimates could vary about the targeted value.

Robust weighted least squares (WLSMV) was used as the estimator for modeling the ordered categorical items of C-CiTAS. The WLSMV makes no distributional assumptions and fit the model to polychoric correlations of the data (Kline, 2016). Model goodness-of-fit followed the examination of exact statistics chi-squared value and approximate statistics including comparative fit index (CFI) and root mean square error of approximation (RMSEA). Cutoff values necessary for acceptable model fit was recommended with CFI > 0.95 and RMSEA < 0.06 (Kline, 2016). ESEM was conducted using Mplus 7.

Convergent validity was examined with Spearman correlation coefficients between participants' C-CiTAS scores and their EORTC QLQ-C30 scores. In order to examine discriminate validity, participants were divided into four approximately quartile groups according to their OTAS scores. C-CiTAS mean scores of these four groups were compared using nonparametric methods (Kruskal-Wallis Test). Cronbach's alphas were obtained as an index of internal consistency reliability. In terms of the test-retest reliability, Spearman correlation coefficients were calculated between the C-CiTAS scores at the first and second surveys.

3. Results

3.1. Participant demographics and clinical backgrounds

The mean age of the 227 participants was 50.2 ± 11.9 (median: 51.0; range: 18–79) years. The mean time since diagnosis was 8.4 ± 11.6 (median: 5.0; range: 2–84) months. One hundred and twenty-one (53.3%) participants had undergone surgery, and 10 (4.4%) had undergone radiotherapy before starting chemotherapy. The most frequent (47%) cancer diagnosis was breast cancer. Twenty-four (10.6%) participants had recurrence of cancer. No participant had oral mucositis. Other demographic and clinical characteristics of the participants are displayed in Table 1.

3.2. Description of C-CiTAS items

The mean and standard deviation of individual items and frequency of response in each category are listed in Table 2. The majority of participants experienced minor to mild taste alteration problems. Item 16 "(have difficulty) eating oily food" had the highest mean score, while item 5 "(have difficulty) tasting bitterness" yielded the lowest one.

Table 3 displays the polychoric correlations among all items. Polychoric correlation is the most general estimated Pearson correlation and used to describe covariance structure for observed categorical data. The correlation matrix was used in the factor analysis that tested the construct validity of C-CiTAS in section 3.3.1.

3.3. Validity

3.3.1. Construct validity

The ESEM model fit the data acceptably, χ^2 (87) = 144.8, $p < 0.001$. RMSEA = 0.054, CFI = 0.987, offering evidence to support a replication of original 4-factor structure with the Chinese version of CiTAS. Standardized loadings of each item on the four factors were reported in Table 4. To enable direct comparisons, we structured the results following the layout of the original factor solution (Table 2 in Kano and Kanda, 2013).

All items loaded significantly on their target factors. All loadings were of high effect sizes which were greater than 0.45 except item 11 'Have a bad taste in the mouth' (0.274). This was also the item that drove down the internal consistency Cronbach's alpha reported in the table. Without this item, the Cronbach's alpha of factor rose to 0.719.

There were some significant cross-loadings, but only a few were of sizable effect. Item 6 '(Have difficulty) tasting umami' of factor 1 (0.512) cross loaded on factor 4 (0.469), suggesting it functioned as both an indicator of decline in basic taste and general taste alterations. Similarly, item 1 '(Have difficulty) tasting food' of factor 4 (0.452) cross loaded on factor 1 (0.415). The four factors were moderately and positively correlated with each other. Factor 1 correlated with factor 2 at $r = 0.41$, factor 3 at $r = 0.24$, factor 4 at $r = 0.59$. Factor 2 correlated with factor 3 at $r = 0.38$, with factor 4 at $r = 0.58$. Factor 3 correlated with factor 4 at $r = 0.26$.

3.3.2. Convergent validity

The correlation coefficients between all the C-CiTAS scores and the EORTC QLQ-C30 QoL scores ranged from −0.202 to −0.476

Table 1
Participants' demographic and clinical characteristics (n = 227).

Variables	Frequency (%)
Gender	
Male	84 (37.0)
Female	143 (63.0)
Residence	
North China	212 (93.4)
South China	15 (6.6)
Education	
Primary school or lower	24 (10.6)
Junior high school	53 (23.3)
Senior high school or technical school	62 (27.3)
Associate degree or above	88 (38.8)
Marital status	
Have spouse	216 (95.2)
No spouse	11 (4.8)
Work	
Retired due to disease	116 (51.1)
Retired due to age	72 (31.7)
Part-time work	21 (9.3)
Full-time Work	18 (7.9)
Cancer site	
breast cancer	108 (47.6)
colorectal cancer	51 (22.5)
gastric cancer	20 (8.8)
lymphoma	16 (7.0)
lung cancer	13 (5.7)
esophageal cancer	10 (4.4)
pancreatic cancer	4 (1.8)
bladder cancer	1 (0.4)
cervical cancer	1 (0.4)
thymic carcinoma	1 (0.4)
hemangiosarcoma	1 (0.4)
carcinoma of ureter	1 (0.4)
Pathology stage	
1	15 (6.6)
2	79 (34.8)
3	56 (24.7)
4	55 (24.2)
Not clear	22 (9.7)
Chemotherapy Plan	
Neo-adjuvant chemotherapy	83 (36.6)
Adjuvant chemotherapy	89 (39.2)
Systemic chemotherapy	55 (24.2)
Chemotherapy regimen	
Oxaliplatin + capecitabine	50 (22.0)
Taxol/docetaxel	39 (17.2)
Taxol + cisplatin/carboplatin/nedaplatin	39 (17.2)
Cyclophosphamide + doxorubicin/pirarubicin/epirubicin	22 (9.7)
Doxorubicin/pirarubicin + bleomycin + vincristine + dacarbazine	15 (6.6)
Oxaliplatin + tegafur	12 (5.3)
Cyclophosphamide + pirarubicin/epirubicin + fluorouracil	12 (5.3)
Gemcitabine + cisplatin/carboplatin	7 (3.1)
Irinotecan + calcium folinate + fluorouracil	5 (2.2)
Capecitabine + taxol/docetaxel	5 (2.2)
Gemcitabine	3 (1.3)
Others	18 (7.9)
Chemotherapy cycles	
3	86 (37.9)
4	52 (22.9)
5	31 (13.7)
6	21 (9.3)
7	21 (9.3)
8	13 (5.7)
9	3 (1.3)

($p < 0.001$ or $p < 0.01$). All C-CiTAS scores were negatively correlated with the scores of physical functioning, role functioning and emotional functioning ($r = -0.156 \sim -0.494$, $p < 0.001$, $p < 0.01$ or $p < 0.05$). Some C-CiTAS scores had negative correlations with social functioning. Moreover, all C-CiTAS scores yielded positive correlation coefficients with the symptoms of fatigue, nausea/vomiting and appetite loss ($r = 0.158$–0.742, $p < 0.001$ or $p < 0.05$). The results are listed in Table 5.

3.3.3. Discriminant validity

The results in Table 6 show that the C-CiTAS total scores or subscale scores were significantly different between these four OTAS score groups (all $p < 0.001$).

3.4. Reliability

The internal consistency reliability of the total C-CiTAS achieved

Table 2
Descriptive statistics of individual items and frequency counts in each response category for C-CiTAS (n = 227).

Item number in CiTAS and item content	M(SD)	1	2	3	4	5
v1.(Have difficulty) tasting food	1.94 (1.30)	131	29	33	18	16
v2.(Have difficulty) tasting sweetness	1.37 (0.94)	189	13	14	2	9
v3.(Have difficulty) tasting saltiness	1.72 (1.16)	147	31	24	15	10
v4.(Have difficulty) tasting sourness	1.23 (0.77)	203	7	10	2	5
v5.(Have difficulty) tasting bitterness	1.16 (0.67)	213	2	6	2	4
v6.(Have difficulty) tasting umami (savoriness: it's like a brothy taste or the taste brought out by adding monosodium glutamate (MSG))	1.79 (1.28)	149	23	26	11	18
v7.Unable to perceive the smell or flavor of food	1.65 (1.19)	165	12	28	9	13
v8.Everything tastes bad	2.32 (1.30)	84	52	42	32	17
v9.Food doesn't taste as it should	1.93 (1.24)	127	33	35	20	12
v10.Have a bitter taste in the mouth	1.66 (0.84)	125	62	33	7	0
v11.Have a bad taste in the mouth	1.50 (0.85)	158	32	29	8	0
v12.Everything tastes bitter	1.31 (0.69)	183	22	18	4	0
v13.Feel nauseated or queasy	2.05 (1.07)	87	73	39	24	4
v14.Bothered by the smell of food	1.95 (1.18)	120	37	38	26	6
v15.Have difficulty eating hot food	1.24 (0.56)	185	30	11	1	0
v16.Have difficulty eating oily food	2.42 (1.44)	89	42	36	32	28
v17.Have difficulty eating meat	2.21 (1.38)	106	37	35	29	20
v18.Have a reduced appetite	2.11 (1.18)	94	60	34	32	7

0.900. The Cronbach's alphas of the subscales ranged from 0.570 to 0.857 (see Table 4). A total of 17 participants completed the questionnaire twice. The mean interval time between the two surveys was 16.18 ± 7.828 (range: 7–28) days. The test-retest reliability correlation coefficient of the total C-CiTAS was 0.815 ($p < 0.01$).

4. Discussion

Our study provided basic information about Chinese patients' TAs during their chemotherapy, and demonstrated that the C-CiTAS is a reliable and valid tool to assess chemotherapy-induced taste alterations in China.

The results in Table 2 showed that the majority of patients experienced minor to mild taste alteration problems. Some patients in our study even said they didn't recognize the more or less TAs until they read the C-CiTAS. This might be the reason why TAs are easy to be neglected, though the prevalence of TAs is high. Currently, there are few evidence-based strategies for preventing or managing TAs in adult oncology patients (Thorne et al., 2015). The evaluation of TAs with a standard scale would help health care professionals, patients themselves and researchers to better understand patients' taste problems related to chemotherapeutic treatments, and reduce the influences of these problems.

In this study, an exploratory structural equation model (ESEM) was used for factor analysis. The ESEM is indeed a combination of both exploratory factor analysis and confirmatory factor analysis. Our results largely supported the original factor structure proposed by Kano and Kanda (2013) despite one weak item of factor 2. Because of this issue being relatively minor and largely attributable to sampling errors, we leaned toward a 'replication' of the original results in the Chinese version, instead of a revision, such that the literature on this scale can be consistent and cumulative. Therefore, the results supported the original structure of the CiTAS, and suggested its good construct validity.

In the examination of convergent validity, we chose the EORTC QLQ-C30 to measure patients' quality of life instead of the Short Form-8 (SF-8) QOL measure by Kano and Kanda (2013). Our consideration was that the EORTC QLQ-C30 was developed specifically for cancer patients, and might be more appropriate in this study. Our results revealed that the C-CiTAS scores were negatively correlated with QoL score and functional scores, and were positively correlated with symptoms of fatigue, nausea/vomiting and appetite loss (see Table 5). The results are consistent with those of the CiTAS (Kano and Kanda, 2013) and other studies (Campagna et al., 2018; de Vries et al., 2018; Zabernigg et al., 2010). These results also support the importance of translating the CiTAS into Chinese. Using valid scale for TAs will help both physicians and patients to deal with the TAs, and thus improve their quality of life.

Similar to the CiTAS (Kano and Kanda, 2013), participants in the

Table 3
Polychoric correlations among all the 18 ordinal variables used for factor analysis.

	v1	v2	v3	v4	v5	v6	v7	v8	v9	v10	v11	v12	v13	v14	v15	v16	v17	v18
v1	.																	
v2	0.645	.																
v3	0.682	0.680	.															
v4	0.691	0.805	0.651	.														
v5	0.526	0.809	0.635	0.929	.													
v6	0.734	0.711	0.621	0.796	0.741	.												
v7	0.614	0.394	0.472	0.598	0.525	0.638	.											
v8	0.671	0.532	0.442	0.683	0.470	0.730	0.674	.										
v9	0.745	0.604	0.567	0.687	0.561	0.760	0.747	0.814	.									
v10	0.305	0.176	0.141	0.338	0.245	0.223	0.241	0.383	0.358	.								
v11	0.221	0.183	0.076	0.276	0.133	0.117	0.216	0.335	0.343	0.274	.							
v12	0.363	0.350	0.309	0.252	0.222	0.282	0.196	0.369	0.370	0.745	0.245	.						
v13	0.308	0.155	0.131	0.371	0.357	0.223	0.324	0.479	0.379	0.439	0.429	0.438	.					
v14	0.494	0.443	0.436	0.557	0.367	0.417	0.307	0.608	0.452	0.309	0.275	0.412	0.568	.				
v15	0.256	0.301	0.304	0.170	0.049	0.263	0.235	0.369	0.210	0.128	−0.046	0.317	0.161	0.376	.			
v16	0.454	0.285	0.209	0.339	0.292	0.424	0.414	0.614	0.412	0.343	0.249	0.260	0.501	0.555	0.398	.		
v17	0.507	0.340	0.313	0.453	0.338	0.490	0.482	0.684	0.477	0.313	0.279	0.264	0.480	0.550	0.434	0.865	.	
v18	0.459	0.339	0.232	0.459	0.396	0.474	0.434	0.692	0.506	0.348	0.296	0.343	0.612	0.601	0.233	0.647	0.687	.

Table 4
Replication of original factor structure in C-CiTAS using targeted ESEM (n = 227). Statistically significant loadings were in bold terms.

Variable	α	Standardized Factor Loadings			
Item number and content in the original CiTAS		1	2	3	4
Factor 1: Decline in basic taste	.818				
v5.(Have difficulty) tasting bitterness		**0.999**	0.075	0.055	−0.148
v4.(Have difficulty) tasting sourness		**0.844**	0.109	0.082	0.068
v3.(Have difficulty) tasting saltiness		**0.678**	−0.075	−0.012	0.194
v2.(Have difficulty) tasting sweetness		**0.811**	−0.013	0.017	0.080
v6.(Have difficulty) tasting umami		**0.512**	0.067	−0.104	**0.469**
Factor 2: Discomfort	.833				
v17.Have difficulty eating meat		−0.001	**0.987**	**−0.201**	0.033
v16.Have difficulty eating oily food		−0.058	**0.989**	**−0.131**	−0.032
v18.Have a reduced appetite		−0.068	**0.638**	0.141	0.200
v15.Have difficulty eating hot food		0.229	**0.420**	−0.033	−0.146
v14.Bothered by the smell of food		**0.237**	**0.552**	**0.193**	−0.052
v13.Feel nauseated or queasy		−0.114	**0.521**	**0.396**	0.039
Factor 3: Phantogeusia and parageusia	.570				
v10.Have a bitter taste in the mouth		−0.031	0.086	**0.724**	0.081
v12.Everything tastes bitter		0.155	0.000	**0.874**	−0.037
v11.Have a bad taste in the mouth		−0.185	0.152	**0.274**	0.271
Factor 4: General taste alterations	.857				
v9.Food doesn't taste as it should		0.103	−0.103	**0.129**	**0.917**
v8.Everything tastes bad		0.054	**0.356**	0.067	**0.600**
v1.(Have difficulty) tasting food		**0.415**	0.085	0.024	**0.452**
v7.Unable to perceive the smell or flavor of food		0.092	0.053	−0.053	**0.707**

four approximately quartile OTAS score groups had different C-CiTAS mean scores (see Table 6). It implies that the C-CiTAS can differentiate patients with minor or major taste changes, and has good discriminate validity.

Except the subscale of phantogeusia and parageusia (0.570), the reliability coefficients of the total C-CiTAS and the other three subscales were all above 0.70, denoting good internal consistency reliability (Nunnally and Bernstein, 1994). These results are similar to those of the original scale (Kano and Kanda, 2013) and its Turkish version (Sozeri and Kutluturkan, 2018). The subscale of phantogeusia and parageusia consists of item 10, 11 and 12. In the examination of the construct validity, item 11 “have a bad taste in the mouth” was the only item with a factor loading less than 0.45 (0.274), and that the Cronbach's alpha of the factor would rise to 0.719 without it. Though we retained item 11 in this study, it needs to be further examined.

The test-retest reliability of the total C-CiTAS yielded 0.815, demonstrating good stability of this scale. It is noteworthy that in Kano and Kanda (2013) study, they only selected participants who underwent treatment at one or two-week intervals. In the Turkish study (Sozeri and Kutluturkan, 2018), participants repeated the test two weeks after the first survey, though they received chemotherapy every three weeks. In our study, considering the variety of patient conditions, the interval time between two cycles of chemotherapy ranged from 7 to

Table 6
Comparison of the C-CiTAS scores between OTAS score groups (n = 227).

Total C-CiTAS or subscales	OTAS score groups (point)	n	Mean Rank	χ^2
Total C-CiTAS	0	60	52.27	110.559***
	1–2	49	97.40	
	3–5	64	131.41	
	6–10	54	177.02	
Decline in basic taste	0	60	79.36	56.163***
	1–2	49	94.22	
	3–5	64	123.04	
	6–10	54	159.72	
Discomfort	0	60	63.58	72.049***
	1–2	49	103.41	
	3–5	64	126.27	
	6–10	54	165.10	
Phantogeusia and parageusia	0	60	77.72	32.769***
	1–2	49	115.72	
	3–5	64	121.95	
	6–10	54	143.33	
General taste alterations	0	60	55.91	103.268***
	1–2	49	96.06	
	3–5	64	131.24	
	6–10	54	174.39	

***$p < 0.001$.

Table 5
Correlation coefficients between the C-CiTAS scores and the EORTC QLQ-C30 scores (n = 227).

Total C-CiTAS or subscales	Global health status	Functional scales				Symptoms		
	Quality of life	Physical functioning	Role functioning	Emotional functioning	Social functioning	Fatigue	Nausea/ vomiting	Appetite loss
Total C-CiTAS	−0.464***	−0.494***	−0.428***	−0.341***	−0.188**	0.487***	0.514***	0.687***
Decline in basic taste	−0.202**	−0.248***	−0.244***	−0.156*	–	0.256***	0.158*	0.332***
Discomfort	−0.476***	−0.494***	−0.432***	−0.330***	−0.174**	0.473***	0.620***	0.742***
Phantogeusia and parageusia	−0.278***	−0.324***	−0.250***	−0.187**	–	0.361***	0.472***	0.373***
General taste alterations	−0.417***	−0.397***	−0.329***	−0.310***	−0.162*	0.388***	0.352***	0.545***

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

28 days. The average lifespan of a taste receptor is 10 days. This rapid proliferation can be inhibited by chemotherapeutic drugs (Ravasco, 2005). Campagna et al. (2018) compared to every seven days, patients receiving chemotherapy every 21 days would experience a fluctuating pattern of taste perception, and were more likely to report a higher severity of TAs. Therefore, patients in similar test intervals are expected in future study of test-retest reliability.

There are some limitations in this study. First, data were collected only in one hospital in Beijing, and the majority of patients were from north China, which has different food habits from those in South China. Therefore, larger sample size in more areas in China is suggested in future studies. Second, as the majority of patients were from other places outside of Beijing, only 17 participants completed the questionnaire twice successfully, which would effect on the result on the stability of the scale.

5. Conclusion

Chemotherapy-induced TAs are common and distressing symptoms for cancer patients. Accurate evaluation of TAs may facilitate health care professionals and patients to screen the symptoms and explore self-management strategies. Our study demonstrated the C-CiTAS is a reliable and valid instrument, which can comprehensively assess Chinese patients' TAs induced by chemotherapy in an easy way. With the help of this scale, cancer patients' taste alteration symptoms can be recognized timely, and effective interventions are expected to be identified and applied for cancer patients in China.

Conflicts of interest statement

There is no undisclosed relationship and undisclosed funding source that may pose a competing interest on this manuscript.

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