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ORIGINAL ARTICLE

Psychometric properties and measurement equivalence of the English and Chinese versions of the Beck Anxiety Inventory in patients with breast cancer

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Abstract
Background There is a lack of psychometric data for both the English and Chinese versions of Beck Anxiety Inventory (BAI) to support its usage among breast cancer patients. This study examined the psychometric properties and measurement equivalence of the English and Chinese versions of BAI among breast cancer patients in Singapore.
Methods Patients were recruited from two major cancer centers in Singapore. The criterion and construct validity of BAI was assessed by its correlation strength with (1) the emotional functioning subdomain of EORTC QLQ-C30 and (2) constructs related to anxiety, namely fatigue, dyspnea, and quality of life. The known-group validity was assessed according to the patients' breast cancer stage, religious beliefs, and emotional functioning levels. The internal consistency of the BAI domains was evaluated using Cronbach's alpha coefficient. Regression analysis was performed to compare the BAI total and domain scores between the two language versions.
Results Data from 244 patients (144 English-speaking and 100 Chinese-speaking) were analyzed. For both language versions, the BAI total scores correlated moderately with the EORTC QLQ-C30 emotional functioning subdomain (r = −0.655 and −0.601). Correlations with fatigue, quality of life, and dyspnea were moderate ($|r|$ = 0.456–0.606). Patients with poorer emotional functioning reported higher anxiety levels, establishing known-group validity. All BAI domains demonstrated satisfactory internal consistencies (α = 0.74–0.87), except for the panic domain (α = 0.57–0.61). Possible measurement equivalence between the language versions was established.
Conclusion Both English and Chinese versions of BAI are valid, reliable, and possibly equivalent for future use.

Keywords Cancer · Oncology · Anxiety · Beck anxiety inventory · Measurement equivalence · Validation

Introduction

Anxiety refers to a general unpleasant state due to excessive worry or fear [1]. Among patients diagnosed with breast cancer, anxiety symptoms typically arise from the fear of deterioration in condition and the uncertainty in treatment outcomes [1]. Anxiety symptoms can be broadly classified into physical and emotional components. Physical symptoms include sweating, trembling, and numbness; whereas emotional symptoms include nervousness, irritability, and fear of the worst happening [1, 2]. Previous studies had also shown that approximately half of the newly diagnosed breast cancer patients were afflicted with varying degrees of anxiety symptoms, with greater prominence noted among patients receiving chemotherapy [3–5]. Anxiety symptoms are often associated with poorer quality of life and greater impairment in daily functioning [6–8]; hence, accentuating the need to alleviate this undesirable adverse effect. However, anxiety is often underdiagnosed and hence under-treated [2, 9]. Appropriate instruments that measure anxiety levels are then vital to aid in the study of anxiety among breast cancer patients.

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In the literature, numerous patient-reported outcome tools have been developed to measure the severity of anxiety. Among them, the State-Trait Anxiety Inventory (STAI) and the Hospital Anxiety and Depression Scale (HADS) are most commonly used [10]. While the former is limited by its ability to make a distinction between depression and anxiety symptoms [11], the latter is more suitable for assessing subjective anxiety symptoms [10]. On the contrary, the Beck Anxiety Inventory (BAI) is a tool dedicated to assess self-reported anxiety. Although some of the somatic symptoms in the BAI may overlap with the physical aspects of breast cancer, this inclusion in addition to the subjective aspects is valuable to comprehensively and holistically evaluate a patient's anxiety level.

The validity and psychometric properties of BAI have been well established in both healthy and diseased populations characterized by various psychiatric disorders [12–17]. Besides the English version of BAI, the psychometric properties of other language versions like the Spanish version were evaluated to confirm the instrument's cross-cultural validity [18]. In particular, the English and Chinese versions of BAI are available to the Singaporean community since these are the two major spoken and written languages. However, there is a lack of psychometric data at present for both the English and Chinese versions of BAI to support its usage among breast cancer patients in Singapore.

Hence, validation studies on the English and Chinese version of BAI are not only valuable to establish their clinical significance as reliable instruments, but also to address the frequently overlooked issue of equivalence of translated scales. By demonstrating that the two BAI language versions are equivalent, the scores from both versions can be subsequently combined with a satisfactory level of reliability to produce a more robust and representative dataset for future analysis. Measurement equivalence between different language versions of the same patient report tool can facilitate the pooling of data from multinational studies into a single analytical framework in clinical trials and/or observational research. Therefore, this study was designed (1) to evaluate the cross-cultural validity of the BAI instrument among the English-speaking and Chinese-speaking breast cancer patients in Singapore, and (2) to assess the measurement equivalence of the two BAI language versions.

Methods

Study setting and population

This was a prospective study conducted at the National Cancer Centre Singapore and KK Women's and Children's Hospital where approximately 70 % of all cancer patients are treated. This study was approved by the Singhealth Institutional Review Board.

All eligible patients must be (1) diagnosed with breast cancer by a medical oncologist, (2) above 21 years of age, (3) able to read and understand English or Chinese, (4) scheduled to receive chemotherapy, and (5) chemotherapy and/or radiotherapy naïve. Patients were excluded if they were documented with brain metastasis; had a history of brain injury, evidence of delirium, dementia, or aphasia; previously diagnosed psychiatric illness, alcohol or drug abuse, or central nervous system diseases; were physically or mentally incapable of giving written consent; or were symptomatically ill. Eligible patients were categorized into English-speaking and Chinese-speaking groups based on their indicated mother tongue or preferred language used in daily communications.

Study procedures

Using the consecutive sampling approach, all eligible patients were recruited at the outpatient clinics by a team of research assistants at the two study sites. Patients' demographic and clinical information such as age, education level, and cancer stage were collected from existing in-house electronic databases and patients' interviews. English and Chinese versions of the Beck Anxiety Inventory and the European Organization for Research and Treatment of Cancer Quality of Life Core 30 (EORTC QLQ-C30) questionnaires were completed during each 30-min interview. These questionnaires were administered to the English-speaking and Chinese-speaking patient groups respectively by trained bilingual interviewers to ensure administration coherency.

Tools

The BAI contains 21 items that assess the severity of clinical anxiety symptoms experienced by patients in the past month. It has four domains: autonomic, neurophysiological, panic, and subjective [11]. Patients will rate each symptom on a four-point Likert scale in increasing severity, from 0 (not at all) to 3 (severe). The global score is an arithmetic summation of the ratings across all 21 symptoms and ranges from 0 to 63. Higher global score indicates higher anxiety level. The Chinese version of BAI was adapted from a previous study conducted on patients with anxiety disorders in Singapore [19, 20].

The EORTC QLQ-C30 is designed specifically to assess cancer patients' health-related quality of life for the past week [21, 22]. The questionnaire consists of 30 items that are classified into the following: five functional scales (physical, role, emotional, cognitive, and social); three symptom scales (fatigue, nausea/vomiting, and pain); a global quality of life scale, and six single items (dyspnea, insomnia, appetite loss, constipation, diarrhea, and financial stability). Both the English and Chinese versions have been validated within the Singapore cancer population and have demonstrated satisfactory psychometric properties [23]. For this study, specific EORTC QLQ-C30 scales are utilized to

establish the validity of BAI and to provide determinants for known-group categorization.

Data analysis

The data collected were analyzed using the general principles of scale development according to the classical test theory. All statistical analyses were performed using the SPSS Statistics Version 23. Demographic and clinical characteristics of the sample were described by descriptive statistics, and a comparison of these characteristics was made between the English-speaking and Chinese-speaking groups. Chi-square test was used for categorical measures. Independent samples T test was used for continuous measures that can be approximated to be normally distributed; while a non-parametric test, Mann-Whitney *U* test, was used for continuous measures without normal distributions. All two-tailed significance tests were conducted at a significance level of 0.05.

Validity

To test the adequacy of BAI in measuring a patient's self-reported anxiety symptoms, the EORTC QLQ-C30 was used as a standard for validation because it has been previously validated in the Singapore cancer population [22–26]. Due to the non-normality nature of the data obtained, Spearman's correlation was performed for all correlation analyses [27]. A significant correlation is indicated by a *P* value less than 0.05. The magnitude of correlation values will denote the corresponding correlation strength: less than 0.4 being poor; 0.4 to 0.7 being moderate; and greater than 0.7 being strong.

Foremost, the criterion validity was assessed by the correlation between the BAI total score and the emotional functional scale of EORTC QLQ-C30 that measures the similar construct of anxiety. We then hypothesized that a higher BAI total score would correlate with patients exhibiting a lower state of emotional functioning. Next, convergent validity analysis of the BAI domains was performed to demonstrate that the BAI and its domains correlate appreciably with their known related constructs. Studies among breast cancer patients have suggested that anxiety is associated with a myriad of emotional factors including depression, fatigue, psychological disturbances and pain. These are collectively known as a symptom cluster [28]. Thus, we hypothesized that a higher BAI subjective domain score would also correlate with a lower state of emotional functioning. Additionally, fatigue is highly related to anxiety especially in breast cancer patients undergoing chemotherapy [9, 29–31]. Hence, by using the fatigue symptom scale of EORTC QLQ-C30, we hypothesized that higher BAI total and neurophysiological domain scores would correlate with a greater level of fatigue. Furthermore, anxiety and its associated symptoms would affect quality of life negatively [28, 32]. Consequently, we hypothesized that a higher BAI total score would correlate with a lower global quality of life score. The EORTC QLQ-C30 dyspnea item is a panic symptom characterized by breathlessness [33]. Therefore, we would expect a higher BAI panic domain score to correlate with a greater degree of the dyspnea symptom.

The discriminant validity of BAI was assessed on the basis that scales purported to measure different aspects of quality of life would be poorly correlated. Therefore, we hypothesized that the BAI total and domain scores would have poor correlations with the EORTC QLQ-C30 constipation and diarrhea items.

Known-group validity was performed to ascertain whether the BAI scores were able to distinguish groups with different known characteristics. Statistically significant difference in scores between the identified groups is denoted by a *P* value less than 0.05. First, we hypothesized that the patients diagnosed with an advanced stage of breast cancer (stage 0–2 vs. 3–4) and possessing a higher ECOG performance status (ECOG 0 vs. ECOG ≥ 1) would report higher BAI total and domain scores [6]. Second, religiosity has been proposed to be a moderator of anxiety levels in cancer patients [1]. Hence, we hypothesized that patients with religious beliefs would report lower BAI total and domain scores. Third, anxiety is associated with a cluster of emotional symptoms. Patients who scored higher in the EORTC QLQ-C30 items (item score 1–2 vs. 3–4) under the emotional functional scale were expected to report higher BAI total and domain scores. Finally, research has suggested that patients implicated with cognitive problems often experience anxiety [34, 35]. We then hypothesized that patients who encountered greater memory-related difficulties would have higher BAI total and domain scores. Mann-Whitney *U* test was used to compare the scores between the identified groups.

Reliability

Internal consistency of the BAI domains was evaluated using Cronbach's alpha coefficients (α). A Cronbach's alpha coefficient value of 0.7 and above will represent satisfactory consistency [36]. In order to identify inappropriately placed items of a particular domain, an item-to-domain correlation analysis was performed. For each item, the corrected item-to-domain correlation was tabulated after removing its contribution to its domain score.

Measurement equivalence

The clinical importance of the score differences observed between the English and Chinese versions of BAI was investigated using the method employed for establishing therapeutic equivalence in clinical trials [37, 38]. The degree of measurement equivalence between two language versions is the extent of similarity in their psychometric properties [39]. The differences in BAI scores might not be exclusively attributable to

Table 1 Baseline demographic and clinical information of patients

	Total (N = 244)		English-speaking patients (n = 144)		Chinese-speaking Patients (n = 100)		P value
	Frequency	%	Frequency	%	Frequency	%	
Demographic information							
Age (y), mean ± S.D.	50.83 ±9.15	–	48.85 ± 9.15	–	53.68 ±8.40	–	<0.001[#]
Education (y), mean ± S.D.	10.69 ± 3.90	–	12.33 ±3.00	–	8.33 ±3.84	–	<0.001[#]
Education (levels)							<0.001[#]
Low education	49	20.0	6	4.2	43	43.0	
None	5	2.0	0	0.0	5	5.0	
Primary	44	18.0	6	4.2	38	38.0	
High education	195	80.0	138	95.9	57	57.0	
Secondary	104	42.6	62	43.1	42	42.0	
Pre-university	46	18.9	37	25.7	9	9.0	
Graduate/postgraduate	45	18.4	39	27.1	6	6.0	
Race							<0.001[#]
Chinese	196	80.3	96	66.7	100	100	
Non-Chinese	48	19.7	48	33.3	0	0	
Malay	30	12.3	30	20.8	0	0	
Indian	8	3.3	8	5.6	0	0	
Others	10	4.1	10	6.9	0	0	
Marital status							0.80
Single	53	21.7	32	22.2	21	21.0	
Married	169	69.3	99	68.8	70	70.0	
Divorced	19	7.8	12	8.3	7	7.0	
Widowed	3	1.2	1	7.0	2	2.0	
Working status							<0.001[#]
Working	137	56.1	95	66.0	42	42.0	
Not working	107	43.9	49	34.0	58	58.0	
Residential type[a]							0.03[#]
Public	208	85.2	116	80.6	92	92.0	
Private	30	12.3	23	16.0	7	7.0	
Religion[b]							0.97
Religious	123	50.4	75	52.1	48	48.0	
No religious belief	33	13.5	20	13.9	13	13.0	
Clinical information							
Menopausal status							<0.001[#]
Pre-menopausal	117	48.0	84	58.3	33	33.0	
Post-menopausal	127	52.0	60	41.7	67	67.0	
Performance status (ECOG)							0.65
0	208	85.2	124	86.1	84	84.0	
≥1	36	14.8	20	13.9	16	16.0	
Breast cancer stage							0.70
0–2	162	66.4	97	67.4	65	65.0	
3–4	82	33.6	47	32.6	35	35.0	

ECOG Eastern Cooperative Oncology Group

[#] Denotes statistically significant difference ($P < 0.05$)

[a] Data were missing for six patients

[b] Data were missing for 88 patients

Table 2 Spearman's correlations between the BAI domains and EORTC QLQ-C30 subdomains for the English and Chinese versions of BAI

EORTC QLQ-C30	BAI domains									
	English version (n = 144)					Chinese version (n = 100)				
	Autonomic	Neurophysiological	Panic	Subjective	Total	Autonomic	Neurophysiological	Panic	Subjective	Total
Global QOL										
Global health status (GHS)	−0.305	−0.452	−0.258	−0.389	−0.475	−0.229[a]	−0.427	−0.366	−0.304	−0.456
Functional										
Emotional	−0.378	−0.540	−0.461	−0.648	−0.655	−0.216[a]	−0.385	−0.557	−0.645	−0.601
Symptom scales										
Fatigue	0.451	0.521	0.351	0.466	0.606	0.320	0.438	0.478	0.430	0.554
Single items										
Dyspnea	0.148[b]	0.266	0.572	0.277	0.350	0.244[a]	0.438	0.518	0.418	0.471
Constipation	0.274	0.037[b]	0.064[b]	−0.027[b]	0.105[b]	0.356	0.217[a]	0.208[a]	0.222[a]	0.300
Diarrhea	0.183[a]	0.067[b]	0.035[b]	0.140^	0.122[b]	0.121[b]	−0.012[b]	0.292	0.166[b]	0.160[b]

Unmarked correlations were all significant at the 0.01 level (two-tailed)

BAI Beck Anxiety Inventory, *EORTC QLQ-C30* European Organization for Research and Treatment of Cancer Quality of Life Core Questionnaire 30

[a] Correlation was significant at the 0.05 level (two-tailed)

[b] No significant correlation was observed at the 0.05 level (two-tailed)

the language variations, but instead, arise from the differences in other characteristics underlying the English-speaking and Chinese-speaking groups. Thus, it was important to adjust for the significant demographic, clinical, and EORTC QLQ-C30 scores differences. Univariate analysis was performed to identify these statistically significant variables that attained a P value of less than 0.05. These variables were included in the multiple regression analysis to tabulate the 95 % confidence intervals (95 % CI) of the adjusted mean difference. This 95 % CI had a 95 % probability of containing the real difference in mean scores that were solely attributable to the language's influence.

We adopted the equivalence margin construction from an equivalence study conducted by Cheung et al. [40]. Aligned with Cohen's proposition that an effect size of 0.2 to 0.5 S.D. (standard deviation) is small, we defined the equivalence margin to be ±0.25 S.D. [41]. Therefore, measurement equivalence would be established if 95 % CI of the adjusted mean difference fell within this equivalence margin. Else, the equivalence could still be possible if it did not exceed the ±0.5 S.D. range which represented the threshold for detecting a small difference [39, 41].

Results

Patient characteristics (Table 1)

A total of 244 breast cancer patients receiving chemotherapy were recruited. Among them, 144 (59.0 %) were English-speaking. Patients were predominantly Chinese (80.3 %) diagnosed with early breast cancer stages 1 or 2 (66.4 %). When compared to the English-speaking patients, the Chinese-speaking patients were found to be older (53.7 ± 8.4 vs. 48.9 ± 9.2 years, $P < 0.001$) and had fewer years of education (8.3 ± 3.8 vs. 12.3 ± 3.0 years, $P < 0.001$). Additionally, a higher proportion of Chinese-speaking patients were not working (58.0 vs. 34.0 %, $P < 0.001$) and majority of them stayed in public housing (92.0 vs. 80.6 %, $P = 0.03$). There were also more post-menopausal Chinese-speaking (67.0 vs. 41.7 %, $P < 0.001$) than English-speaking patients. No significant differences were observed for the other demographic and clinical characteristics.

Validity

In the assessment of criterion validity of both the English and Chinese versions of BAI, the EORTC QLQ-C30 emotional functional scale had a negative and moderate correlation with the BAI total score (r = −0.655 and −0.601, respectively) (Table 2). Regarding the correlations with related constructs, the EORTC QLQ-C30 emotional functional scale was similarly observed to be negatively and moderately correlated with the BAI subjective domain score (r = −0.648 and −0.645, respectively). Also, the EORTC QLQ-C30 fatigue symptom scale had a positive and moderate correlation with the BAI total (r = 0.606 and 0.554, respectively) and neurophysiological domain scores (r = 0.521 and 0.438, respectively). In terms of the impact of anxiety on patients' quality of life, the global quality of life scale demonstrated a negative and

Table 3 Comparison of the BAI total and domain scores between groups categorized by ECOG performance status, breast cancer stage, and EORTC QLQ-C30 items 21–25 for the English and Chinese versions of BAI

Grouping factors	Median ± S.D.					Median ± S.D.				
	BAI English version (N = 144)					BAI Chinese version (N = 100)				
	Autonomic	Neurophysiological	Panic	Subjective	BAI total score	Autonomic	Neurophysiological	Panic	Subjective	BAI total score
Performance status (ECOG)										
0 (n = 124[a],84[b])	2.00 ± 2.64	2.00 ± 3.15	1.00 ± 1.45	2.00 ± 2.64	8.00 ± 7.74	1.00 ± 1.84	2.00 ± 2.42	1.00 ± 1.53	1.00 ± 2.78	6.00 ± 6.50
≥1 (n = 20[a], 16[b])	2.50 ± 3.30	4.00 ± 3.96	1.00 ± 2.50	4.00 ± 4.44	11.50 ± 12.09	1.50 ± 2.46	2.50 ± 3.20	1.00 ± 1.54	3.00 ± 3.67	12.50 ± 7.77
P value	0.11	0.06	0.20	0.009*	0.02*	1.00	0.11	0.53	0.07	0.09
Breast cancer stage										
0–2 (n = 97[a], 65[b])	2.00 ± 2.82	2.00 ± 3.30	1.00 ± 1.67	2.00 ± 3.05	8.00 ± 8.88	1.00 ± 2.12	2.00 ± 2.64	1.00 ± 1.61	2.00 ± 3.06	7.00 ± 6.99
3–4 (n = 47[a], 35[b])	2.00 ± 2.692.69	2.00 ± 3.40	1.00 ± 1.64	2.00 ± 3.16	8.00 ± 8.49	1.00 ± 1.44	2.00 ± 2.50	1.00 ± 1.37	1.00 ± 2.86	6.00 ± 6.32
P value	0.91	0.99	0.64	0.93	0.91	0.15	0.37	0.65	0.36	0.18
Religion										
Religious (n = 75[a], 48[b])	2.00 ± 2.77	2.00 ± 3.53	0.00 ± 1.81	1.00 ± 3.24	7.00 ± 9.28	2.00 ± 1.91	2.00 ± 2.41	1.00 ± 1.32	1.00 ± 2.50	6.00 ± 6.00
No religion (n = 20[a], 13[b])	2.00 ± 2.21	4.00 ± 2.48	1.00 ± 1.64	2.00 ± 3.05	10.00 ± 7.40	1.00 ± 0.86	2.00 ± 2.93	1.00 ± 1.85	2.00 ± 2.99	11.00 ± 6.56
P value	0.78	0.09	0.45	0.15	0.18	0.18	0.26	0.69	0.44	0.60
EORTC item 21 (tense feeling)										
1–2 (n = 134[a], 95[b])	2.00 ± 2.54	2.00 ± 2.96	1.00 ± 1.43	2.00 ± 2.58	7.50 ± 7.31	1.00 ± 1.98	2.00 ± 2.60	1.00 ± 1.53	1.00 ± 2.92	6.00 ± 6.82
3–4 (n = 10[a], 5[b])	6.50 ± 3.70	7.50 ± 4.04	3.50 ± 2.80	8.50 ± 4.97	27.00 ± 12.24	1.00 ± 0.89	4.00 ± 2.28	3.00 ± 0.89	6.00 ± 2.61	13.00 ± 3.51
P value	0.002*	<0.001*	0.005*	0.001*	<0.001*	0.97	0.16	0.01*	0.008*	0.03*
EORTC item 22 (worry)										
1–2 (n = 127[a], 93[b])	2.00 ± 2.62	2.00 ± 2.95	1.00 ± 1.45	1.00 ± 2.21	7.00 ± 7.17	1.00 ± 1.88	2.00 ± 2.45	1.00 ± 1.30	1.00 ± 2.63	6.00 ± 5.97
3–4 (n = 17[a],7[b])	4.00 ± 3.20	6.00 ± 4.15	3.00 ± 2.15	6.00 ± 4.46	20.00 ± 11.00	3.00 ± 2.67	6.00 ± 3.19	3.00 ± 2.14	7.00 ± 3.58	19.00 ± 8.42
P value	0.006*	<0.001*	<0.001*	<0.001*	<0.001*	0.34	0.02*	<0.001*	0.001*	0.001*
EORTC item 23 (irritability)										
1–2 (n = 119[a], 96[b])	1.00 ± 2.38	2.00 ± 2.79	1.00 ± 1.41	1.00 ± 2.30	7.00 ± 6.92	1.00 ± 1.86	2.00 ± 2.57	1.00 ± 1.30	1.00 ± 2.82	6.00 ± 6.28
3–4 (n = 25[a], 4[b])	4.00 ± 3.55	5.00 ± 4.33	2.00 ± 2.26	4.00 ± 4.57	17.00 ± 11.32	1.00 ± 3.70	5.00 ± 2.65	4.00 ± 2.36	7.00 ± 3.65	15.00 ± 10.84
P value	<0.001*	<0.001*	0.002*	<0.001*	<0.001*	0.82	0.10	<0.001*	0.010*	0.02*
EORTC item 24 (depressed)										
1–2 (n = 134[a], 95[b])	2.00 ± 2.64	2.00 ± 2.89	1.00 ± 1.40	2.00 ± 2.35	7.50 ± 7.20	1.00 ± 1.86	2.00 ± 2.46	1.00 ± 1.26	1.00 ± 2.62	6.00 ± 5.87
3–4 (n = 10[a], 5[b])	4.00 ± 3.74	9.00 ± 4.28	4.00 ± 2.33	10.00 ± 4.69	28.00 ± 11.28	3.00 ± 3.11	6.00 ± 2.74	5.00 ± 2.30	10.00 ± 3.44	22.00 ± 8.41
P value	0.04*	<0.001*	<0.001*	<0.001*	<0.001*	0.36	0.005*	<0.001*	0.001*	0.001*
EORTC item 25 (difficulty in remembering things)										
1–2 (n = 130[a], 95[b])	2.00 ± 2.55	2.00 ± 2.97	1.00 ± 1.36	2.00 ± 2.47	7.00 ± 7.24	1.00 ± 1.83	2.00 ± 2.40	1.00 ± 1.33	1.00 ± 2.89	6.00 ± 6.10
3–4 (n = 14[a], 5[b])	4.50 ± 3.58	7.00 ± 4.45	4.00 ± 2.41	6.00 ± 4.76	23.00 ± 11.90	4.00 ± 1.92	7.00 ± 3.05	2.00 ± 3.27	3.00 ± 4.15	16.00 ± 9.97
P value	0.003*	0.002*	<0.001*	<0.001*	<0.001*	0.004*	0.003*	0.09	0.07	0.005*

BAI Beck Anxiety Inventory, *ECOG* Eastern Cooperative Oncology Group, *EORTC QLQ-C30* European Organization for Research and Treatment of Cancer Quality of Life Core Questionnaire 30

*Denotes statistically significant difference in scores between the identified groups ($P < 0.05$)

[a] Denotes the sample size of the defined group for English-speaking patients

[b] Denotes the sample size of the defined group for Chinese-speaking patients

Table 4 Internal consistency of the BAI domains and the corrected item-to-domain Spearman's correlations (by total and language versions of questionnaire)

Domain/scale	Item	Content (listed in English)	Combined BAI English and Chinese versions (N = 244)		BAI English version (n = 144)		BAI Chinese version (n = 100)	
			Corrected item-to-domain correlation[a]	Cronbach's α	Corrected item-to-domain correlation[a]	Cronbach's α	Corrected item-to-domain correlation[a]	Cronbach's α
Autonomic (4 items)	2	Feeling hot	0.651	0.77	0.718	0.81	0.511	0.62[c]
	18	Indigestion	0.408		0.445[b]		0.291[b]	
	20	Face flushed	0.581		0.648		0.370[b]	
	21	Hot/cold sweats	0.652		0.738		0.468	
Neurophysiological (7 items)	1	Numbness or tingling	0.414	0.79	0.383[b]	0.82	0.530	0.74
	3	Wobbliness in legs	0.551		0.572		0.490	
	6	Dizzy or lightheaded	0.594		0.605		0.572	
	8	Unsteady	0.629		0.647		0.572	
	12	Hands trembling	0.359[b]		0.423		0.240[b]	
	13	Shaky/unsteady	0.635		0.728		0.408	
	19	Faint/lightheaded	0.569		0.625		0.455	
Panic (4 items)	7	Heart pounding/racing	0.470	0.61[c]	0.503	0.64[c]	0.419	0.57[c]
	11	Feeling of choking	0.325[b]		0.343[b]		0.294[b]	
	15	Difficulty in breathing	0.573		0.632		0.491	
	16	Fear of dying	0.260[b]		0.264[b]		0.265[b]	
Subjective (6 items)	4	Unable to relax	0.560	0.86	0.585	0.85	0.550	0.87
	5	Fear of the worst happening	0.632		0.641		0.623	
	9	Terrified or afraid	0.664		0.630		0.734	
	10	Nervous	0.593		0.616		0.556	
	14	Fear of losing control	0.713		0.652		0.814	
	17	Scared	0.739		0.720		0.772	

All correlations were significant at the 0.01 level (two-tailed)

BAI Beck Anxiety Inventory

[a] The corrected item-to-domain correlation was calculated for each item by removing the contribution of the item's score to its corresponding domain score

[b] Denotes item with poor item-to-domain correlation (defined by a corrected $r < 0.400$)

[c] Denotes Cronbach's alpha coefficient that was less than the satisfactory level of 0.7

moderate correlation with the BAI total score ($r = -0.475$ and -0.456, respectively). Finally, the dyspnea scale showed a positive and moderate correlation with the BAI panic domain ($r = 0.572$ and 0.518, respectively). The EORTC QLQ-C30 constipation and diarrhea items measure constructs unrelated to anxiety. The correlations of these items with the BAI total and domain scores of both language versions were all either weak ($|r| = 0.183$–0.356) or insignificant at a significance level of 0.05 (two-tailed).

Known-group validity analysis revealed that both language versions of BAI were unable to discriminate between patients of different breast cancer stages and religious beliefs (Table 3). Nevertheless, it was observed that the English version was able to differentiate patients with different ECOG status by their BAI total scores (ECOG = 0, 8.00 ± 7.74 vs. ECOG ≥ 1, 11.50 ± 12.09, $P = 0.02$). Furthermore, the BAI total and individual domain scores of the English version demonstrated the ability to distinguish patients who were experiencing more tense feelings, worries, irritability, depression symptoms, and difficulties in recalling past events. On the other hand, the individual BAI domain scores of the Chinese version had a smaller range of discriminating ability. In particular, the autonomic domain score could only discern patients who were facing greater challenges in events recollection.

Table 5 Comparison of the EORTC QLQ-C30 subdomain scores between the English-speaking and Chinese-speaking patients using Mann-Whitney *U* Test

EORTC QLQ-C30	Median ± S.D.			*P*
	Total (N = 244)	English-speaking (n = 144)	Chinese-speaking (n = 100)	
Global QOL[a]				
Global health status	66.67 ± 19.33	66.67 ± 19.49	66.67 ± 19.15	0.36
Functional[a]				
Physical	86.67 ± 14.05	86.67 ± 15.39	86.67 ± 11.55	0.14
Role	100.00 ± 21.38	83.33 ± 23.68	100.00 ± 16.22	0.004*
Emotional	83.33 ± 19.32	83.33 ± 21.33	83.33 ± 15.89	0.53
Cognitive	83.33 ± 18.07	83.33 ± 18.63	100.00 ± 17.14	0.13
Social	83.33 ± 22.02	83.33 ± 24.06	83.33 ± 18.57	0.43
Symptom scales[b]				
Fatigue	33.33 ± 21.43	33.33 ± 23.12	22.22 ± 17.89	0.01*
Nausea and vomiting	0.00 ± 15.27	0.00 ± 16.83	0.00 ± 12.42	0.06
Pain	16.67 ± 21.13	16.67 ± 22.12	16.67 ± 19.72	0.79
Single items[b]				
Dyspnoea	0.00 ± 21.00	0.00 ± 21.57	0.00 ± 19.66	0.01*
Insomnia	33.33 ± 32.58	33.33 ± 35.14	33.33 ± 28.18	0.26
Appetite	0.00 ± 23.88	0.00 ± 26.44	0.00 ± 19.41	0.41
Constipation	0.00 ± 25.21	0.00 ± 26.44	0.00 ± 23.44	0.87
Diarrhea	0.00 ± 13.40	0.00 ± 13.80	0.00 ± 12.87	0.51
Financial	0.00 ± 32.57	0.00 ± 32.08	33.33 ± 33.06	0.10

EORTC QLQ-C30 European Organization for Research and Treatment of Cancer Quality of Life Core Questionnaire 30

*Denotes statistically significant difference ($P < 0.05$). Variables (specifically the role functional scale, fatigue symptom scale, and dyspnea item) shown to be statistically different between the two language groups were included in the regression model to evaluate the measurement equivalence of the English and Chinese versions of BAI (Table 6)

[a] A higher score is indicative of a better functioning/ health status. The theoretical range for the global and functional scales is 0 to 100

[b] A higher score is indicative of more symptoms/difficulties. The theoretical range for the symptom scales and single items is 0 to 100

Reliability assessment (Table 4)

In the reliability analysis, satisfactory Cronbach's alpha values of greater than 0.7 were obtained for all domains except for the panic domain ($\alpha = 0.61$). In both language versions, satisfactory Cronbach's alpha values were obtained for the subjective ($\alpha = 0.85$ and 0.87, respectively) and neurophysiological domain ($\alpha = 0.83$ and 0.74, respectively). However, for the autonomic domain, satisfactory Cronbach's alpha value was attained only in the English version ($\alpha = 0.81$) and not in the Chinese version ($\alpha = 0.62$). For the panic domain, unsatisfactory Cronbach's alpha values were obtained in both language versions. In general, the Cronbach's alpha values for all the domains in the Chinese version were lower than that in the English version, with the exception of the subjective domain. Furthermore, in the item-to-domain correlation analysis, it was observed that the items "indigestion," "feeling of choking," and "fear of dying" had poor correlations with the other items in their corresponding domains.

Measurement equivalence of the English and Chinese versions of BAI

Demographic variables that were shown to be statistically different between the two language versions were age, years of education, race, working status, and residential type; while the menopausal status was shown to be the significant clinical variable (Table 1). Also, significant differences in the EORTC QLQ-C30 subdomain scores between the two language groups were detected for the following: role functioning ($P = 0.004$), fatigue symptom ($P = 0.01$), and dyspnea item ($P = 0.001$) (Table 5). Hence, these variables were adjusted for in the multiple regression model. No significant differences were detected in the BAI total and domain scores between the two language versions (Table 6). All 95 % CIs of the adjusted mean difference fell within the ±0.5 S.D. margin, but did not completely lie within the ±0.25 S.D. equivalence margin. Hence, this suggests possible measurement equivalence between the English and Chinese versions of BAI.

Table 6 The BAI total and domain scores (by total and language versions of questionnaire) and measurement equivalence between the English and Chinese versions of BAI

(Theoretical score range)	Mean ± S.D.			English vs. Chinese				
	Total (N = 238)	English-speaking (n = 139)	Chinese-speaking (n = 99)	Equivalence margin (±0.25 S.D.)	Equivalence margin (±0.5 S.D.)	Adjusted difference[a]	95 % CI of adjusted difference[b]	Equivalence (±0.25 S.D.)[c]
BAI total score (0–63)	9.32 ± 8.10	10.12 ± 8.84	8.18 ± 6.82	± 1.94	± 3.88	0.66	−1.30 to 2.63	Possible
Domains								
Autonomic (0–12)	2.41 ± 2.50	2.71 ± 2.81	2.00 ± 1.94	± 0.59	± 1.18	−0.03	−0.75 to 0.69	Possible
Neurophysiological (0–21)	2.95 ± 3.07	3.23 ± 3.35	2.57 ± 2.60	± 0.74	± 1.48	0.19	−0.61 to 0.99	Possible
Panic (0–12)	1.28 ± 1.62	1.35 ± 1.68	1.18 ± 1.53	± 0.40	± 0.80	0.27	−0.14 to 0.69	Possible
Subjective (0–18)	2.63 ± 3.07	2.76 ± 3.12	2.43 ± 3.00	± 0.76	± 1.52	0.25	−0.60 to 1.10	Possible

BAI Beck Anxiety Inventory

[a] Mean difference between the English and Chinese scores was adjusted for the relevant variables that showed statistical differences between the English and Chinese-speaking groups (Tables 1 and 5): age, years of education, race (Chinese vs. non-Chinese), working status (working vs. not working), residential type (HDB vs. private), menopausal status (pre-menopausal vs. post-menopausal), role functioning, fatigue symptom and dyspnoea item

[b] All 95 % CI of the adjusted difference did not exceed the equivalence margin threshold (±0.5 S.D.)

[c] Equivalence was assessed by comparing 95 % CI of the adjusted difference to the equivalence margin (±0.25 S.D.)

Discussion

To our knowledge, this is the first study to evaluate the validity, reliability and measurement equivalence of the English and Chinese versions of BAI among breast cancer patients in Singapore. Results revealed that both language versions are valid and reliable to a fairly satisfactory extent in assessing patients' perceived anxiety levels and are possibly equivalent.

As hypothesized, the validity analysis affirmed the adequacy of BAI in measuring patients' self-reported anxiety levels. The known-group validity analysis yielded results that deviated from our original hypotheses. Notably, the BAI total and domain scores were unable to distinguish patients with advanced breast cancer stage and poorer performance status. This could be attributed to the disproportionate sample size of each known group. Majority of the patients were diagnosed with breast cancer stage 2 and below (66.4 %) and possessed good performance status. Thus, the studied sample may not be fully representative of the entire spectrum of breast cancer patients in Singapore. Furthermore, the BAI total and domain scores were unable to discern patients based on their religious beliefs due to two reasons. Firstly, patients' religious beliefs do not indicate their engagement level in the religious activities. The mere presence of religious beliefs may not give an accurate reflection of its role in helping patients cope with their cancer states [42]. Secondly, some studies have demonstrated that anxiety levels did not correlate directly with the religious beliefs or activities, but with the interpretations of the meaning of life that were delivered through these beliefs [43, 44]. However, information on this spirituality facet could not be isolated from the sheer presence of religious beliefs. Hence, our data did not allow for a classification based on patients' perceptions of the meaning of life. Overall, the task to separate the patient pool into distinct groups by religious beliefs appears to be more complex than expected due to the underlying factor of spirituality [45]. Therefore, a more meaningful assessment will warrant the usage of additional tools like Spiritual Well-Being Scores to assist in the identification of known groups [44].

Satisfactory internal consistency was observed for all domains except for the panic domain. Furthermore, item-to-domain correlations indicated that majority of the items in the BAI were well related to the constructs of their corresponding domains. However, the items "feeling of choking" and "fear of dying" were highlighted to be problematic within the panic domain since they had poor correlation values of less than 0.40. The poor correlations are likely a consequence of problems in the original items rather than translation errors. For "feeling of choking," we postulate that patients may not fully understand the term "choking." For instance, patients may associate it to obstructions in the respiratory airways or gastrointestinal tract, instead of viewing it as a panic component. This case is further exemplified in patients with respiratory diseases, as they are more prone to identifying this familiar symptom as an implication of their illness and not relate it to a state of panic [46]. We have also identified "fear of dying" as a problematic item that deviated from its underlying construct of panic. We posit two reasons for this observation. Firstly, the understanding of "fear of dying" may be overlapped with "fear of worst happening" since death is essentially the worst outcome. Thus, the item could be more related to the subjective domain in measuring the emotional aspect

instead of the panic aspect as expected [47]. Moreover, the "fear of dying" among these early stage breast cancer patients may be milder and subtler since treatment options are readily available with optimistic success rates. Consequently, their ability to comprehend this fear as a panic symptom may be diminished.

We have also evaluated the measurement equivalence between the English and Chinese versions of BAI. This assessment is necessary before the data from the two language versions can be combined in a single analytical framework. After adjusting for the statistically significant demographic, clinical, and EORTC QLQ-C30 variables, the 95 % CIs derived from the multiple regression model reflected the contribution of language variation to the score differences. As all 95 % CIs partially overlapped with the pre-defined ±0.25 S.D. equivalence margin, measurement equivalence cannot be confirmed. Nonetheless, these results are encouraging evidence to support the equivalence of the English and Chinese versions of BAI among breast cancer patients in Singapore. An extensive study is required to verify the measurement equivalence definitively.

There are several limitations in this study. As this study was only conducted at one time point, only internal consistency was evaluated in the reliability assessment, and test-retest reliability could not be examined. In addition, while we acknowledge that the emotional functioning subscale of the EORTC QLQ-C30 is not conventionally accepted as a "gold standard" measure of anxiety, we have proceeded to validate the BAI tool using this subscale due to the nature of the study population concerned. The breast cancer population differs from the usual psychiatric and community samples, as the anxiety symptoms experienced by our target population manifest from the debilitating nature of cancer and chemotherapies that is not ascribable to psychiatric disorders. For example, patients could be plagued by anxiety from unknown treatment status as well as worrying about the recurrence of cancer [9]. Furthermore, as BAI encompasses somatic symptoms that are grounded in a particular disease state, we find the emotional functioning subscale of the EORTC QLQ-C30 to be the most appropriate in providing a context within cancer patients for a meaningful comparison. In other similar studies, EORTC QLQ-C30 has also been utilized as a reliable instrument for correlation analysis with other anxiety-assessing instruments [48, 49].

Conclusion

The BAI is a valid and reliable instrument for assessing the perceived anxiety levels among breast cancer patients in Singapore. Both language versions of the BAI have also demonstrated possible measurement equivalence. However, potentially problematic items may have compromised the internal consistency of the panic domain for both language versions. Thus, one should interpret the score of this panic domain with caution. Despite so, this study has provided some preliminary supportive evidence for the validity, reliability, and measurement equivalence of the two BAI language versions to establish their significance as clinical research tools in Singapore.

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Conflict of interest The authors declare that they have no competing interests.

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