Health and Quality of Life Outcomes

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Psychometric properties and measurement invariance of the health behavior scale for cancer patients in Chinese cancer population

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Abstract

Background Health behavior plays a major role in the development, progression, and prognosis of cancer. The Health Behavior Scale for Cancer Patients (HBSCP) can be used to assess the level of health behavior in cancer patients. This study aimed to explore its psychometric properties and Measurement Invariance (MI) in the Chinese cancer population.

Methods A longitudinal study was conducted with 567 cancer patients across two hospitals, and 428 participants underwent a second assessment three months later. Analyses were performed to evaluate reliability (internal consistency), validity (structural validity, convergent validity, and criterion-related validity), and MI of the Chinese version of the HBSCP.

Results The two-factor structural model of the 9-item scale demonstrated an excellent fit in Confirmatory Factor Analysis (CFA). Psychometric analyses indicated strong internal consistency, with Cronbach's alpha coefficients ranging from 0.846 to 0.899 and McDonald's Omega values between 0.847 and 0.897. Convergent validity was supported by Composite Reliability (CR > 0.70) and Average Variance Extracted (AVE > 0.50). Criterion-related validity was established via significant correlations with the Health-Promoting Lifestyle Profile II (HPLP-II; $r = 0.653 \sim 0.760$). Multi-group CFA further confirmed MI across cancer types (ΔCFI&TLI < 0.01; ΔRMSEA < 0.015) and time groups (3-month interval).

Conclusions This study provides longitudinal evidence supporting the adequate psychometric properties and temporal stability of the Chinese version of the HBSCP, thus validating its utility for measuring health behavior in Chinese cancer populations. The Chinese HBSCP can serve as a tool for healthcare providers to assess the current status and changes in health behavior among cancer patients.

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Keywords Cancer, Healthy behavior, Longitudinal measurement invariance, Psychometric properties, Scale

Background

The International Agency for Research on Cancer (IARC) released a statistical report that projects 19.695 million new cases of cancer and 9.737 million deaths worldwide in 2022 [1]. By 2050, it is predicted that there will be a 77% increase in the number of cancer cases worldwide compared to 2022. However, 5-year survival rates are rising, and cancer mortality rates are down as a result of the use of effective early detection and improved cancer treatments [2]. With improvements in survival and the possibility that cancer may be viewed as a chronic disease, reducing health risk behavior such as sedentary behavior, smoking, and unhealthy diet, or conversely, developing and maintaining healthy behavior, becomes more prominent.

Health behaviors refer to conscious or unconscious actions undertaken by individuals or groups aimed at preventing disease, promoting health, or managing existing health problems [3]. According to Hagger et al. [4], health behaviors can be broadly categorized into health-promoting behaviors (e.g., balanced diet, proper nutrition, regular physical activity, and adherence to medical recommendations) and health-risk behaviors (e.g., tobacco use and excessive alcohol consumption) depending on their effects on individual health outcomes. There is a close and complex relationship between health behaviors and health outcomes [5], and research showed significant differences in health outcomes among different groups and types of health behaviors [6, 7]. Reducing illness incidence and death in the population by implementing a combination of health behaviors is an effective way to achieve overall health [8, 9]. Regarding the coverage of healthy behavior, researchers generally agree that it includes assessments of balanced nutrition, physical activity, adherence to medical care, avoidance of hazardous environmental risks, and stress management [10–12].

Numerous studies have demonstrated that health behavior is strongly related to the incidence and mortality of cancer, and are of great significance in cancer prevention, treatment, and rehabilitation [13–15]. Specifically, health promoting behaviors can effectively improve the treatment outcome of cancer patients, reduce the recurrence rate and mortality rate of cancer, and improve the quality of life of cancer survivors. While health risk behaviors can accelerate the development and progression of cancer. Cancer survivors are at a significantly higher risk than the general population for cancer recurrence, the development of secondary cancers, and various chronic diseases, including cardiovascular disease and type 2 diabetes [16, 17]. Therefore, they need to maintain a high level of healthcare and a healthy lifestyle even after completing cancer treatment [18–20]. In particular, cancer patients need to comply with medical care, maintain a balanced diet and healthy habits, and avoid risky behaviors such as smoking and lack of physical activity, which are also essential for the general population to prevent cancer and reduce their risk of other chronic diseases [21].

The field of cancer-related health behavior has become particularly important in this context, and the accurate measurement of the health behavior of cancer patients is the basis for encouraging the advancement of research in this field. A more precise knowledge of the degree of health behavior among cancer survivors is required to deliver targeted interventions to cancer patients and consequently lower the risk of cancer progression. In 2021, Natalia Cecon et al. [22] developed the Health Behavior Scale for Cancer Patients (HBSCP) with the express purpose of gauging the health-related behaviors of cancer patients. The HBSCP has demonstrated strong reliability and high sensitivity in surveys involving sizable sample sizes. Given the importance of the health behavior of cancer patients and considering the current lack of specific assessment tools for health behavior of cancer patients in China, our research team followed the World Health Organization's recommended process of instrument translation and cross-cultural adaptation to complete the Chinese translation of the HBSCP, and conducted a small sample reliability and validity tests [23]. To further validate the reliability, validity, and generalizability of the Chinese version of the HBSCP across cancer types and time groups, a large sample empirical study was necessary.

In recent years, Measurement Invariance (MI) has become an important measure in tool stability testing. MI refers to the concept that the measurement instrument measures remain the same across situations, groups, or time, it emphasizes the consistency and stability of a measurement instrument across conditions [24]. The original version of the HBSCP was examined solely in breast cancer patients, with its reliability and validity established within this specific subgroup [22]. However, considering potential differences in health behavior across cancer types and the fact that cancer patients' health behavior may change over time due to factors such as disease progression, treatment advancement, shifts in personal health management perceptions, or the implementation of psychosocial interventions [25, 26], further validation of the HBSCP's structural stability is needed across different cancer types and longitudinal settings.

Therefore, this study aimed to evaluate the reliability (internal consistency), validity, and MI of the Chinese

version of the HBSCP in different cancer types and across time groups through longitudinal surveys, to provide a reliable tool for measuring health behavior in different cancer populations and longitudinal studies.

Methods

Introduction to the original version of the HBSCP

The original version of the HBSCP was developed by a multi-expert team of sociologists, psychologists, and health economics medicine through a multidimensional approach of literature research, dimension identification, and item wording [22]. The HBSCP consists of 9 items measuring two factors: "Healthcare Adherence" and "Personal Health Protective Behaviors." All items are scored on a 6-point Likert scale (from "1 = never" to "6 = always"). Total scores ranged from 6 to 54, with higher scores indicating higher levels of health behaviors among cancer patients. In the original study, the HBSCP had acceptable to good internal consistency (Cronbach's alpha of the original version of the HBSCP for the total scale and its two factors were 0.772, 0.663, and 0.793, respectively).

Participants and settings

According to the IARC report, the top 5 malignant tumors in the world in 2022 were lung cancer (12.4%), female breast cancer (11.5%), colorectal cancer (9.6%), prostate cancer (7.3%), and stomach cancer (4.9%). In China, the incidence rates of lung cancer, colorectal cancer, stomach cancer, and breast cancer have similarly been also long been ranked in the top 10 [27]. Based on such cancer incidence characteristics, this study intended to first explore the reliability, validity, and MI of the Chinese version of the HBSCP across cancer types through a cross-sectional survey; and then, evaluate the MI of the HBSCP again across time points by conducting a longitudinal follow-up survey of the participants 3 months later.

From February to October 2024, participants recruitment was completed among cancer patients attending two tertiary hospitals in Tianjin and Nanchang. The inclusion criteria for participants were as follows: (1) patients with pathologically confirmed lung cancer, gastrointestinal cancer (colorectal cancer or gastric cancer), or gynecological cancer (breast cancer or ovarian cancer); (2) aged above 18 years; (3) able to complete the questionnaire independently; and (4) voluntary participation. The exclusion criteria were patients with cognitive or psychiatric disorders and severe cardiac, hepatic, renal, and other serious complications.

The sample size was determined based on factor analysis requirements, that is, the sample size of 5 to 10 times the scale items and consideration of 20% invalid questionnaires [28]. A minimum of 108 patients were required for each of the three types of cancer.

Adaptation process

The Chinese version of the HBSCP was previously validated by our research team, with content validity assessed using the content validity index (CVI) at both the item level (I-CVI) and scale level (S-CVI). The I-CVI ranged from 0.93 to 1.00, and the S-CVI was 0.89, demonstrating strong content validity of the HBSCP [23]. Figure 1 illustrates the cross-cultural translation process of the HBSCP.

Procedures

A quantitative survey with a longitudinal design was used to ascertain the psychometric properties and Longitudinal Measurement Invariance (LMI) of HBSCP. This design required the distribution of questionnaires to patients at two time points within three months apart.

The research team was led by an associate professor, with two master's students and two registered nurses serving as research assistants, all of whom had received systematic training. Two data collectors were selected from each of the two hospitals and received uniform training to minimize survey and measurement bias. Patient recruitment was conducted by research members who approached the potential participants when they entered the hospitals. Research members presented the content and purpose of the research to potential participants, and assessed them to determine whether they met the inclusion and exclusion criteria. After obtaining written consent, the researchers distributed the questionnaires to the participants. Once the questionnaire was completed, the researchers immediately checked the questionnaire to ensure the integrity of the data. If there were missing values, the questionnaire would be returned to the participants to fill in. On average, the questionnaire was completed within 2 min, and the effective response rate was 100%.

Measures

(1) Demographics and Clinical Information

This part of the questionnaire was self-designed and included demographic characteristics and clinical information such as age, gender, education level, diagnosis, cancer stage, and comorbidities.

(2) Chinese version of the HBSCP

The scale is a 9-item, 2-factor instrument to assess the levels of health behavior in cancer patients. The HBSCP are scored on a 6-point Likert scale (from "1 = never" to "6 = always") with higher scores indicating higher levels of health behavior among cancer patients. Two subscale scores can also be calculated to assess the levels related to adherence to medical health services and individual protective health behavior. The original version of the HBSCP and the Chinese HBSCP are shown in Table 1.

(3) Health-Promoting Lifestyle Profile II (HPLP-II)

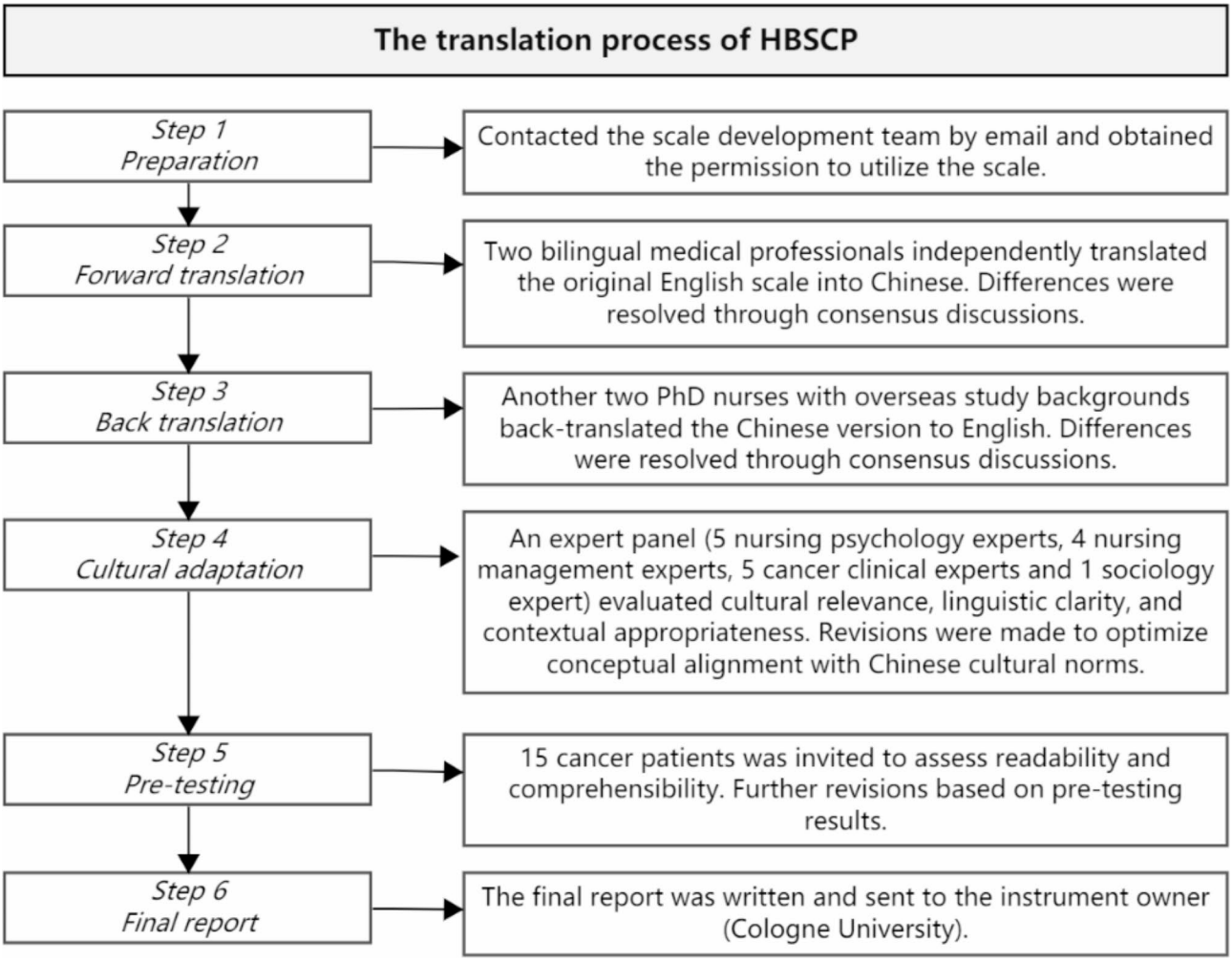

Fig. 1 Flowchart of HBSCP scale translation

The HPLP-II is a revision of the HPLP developed by Walker et al. [29], which is used to assess the current status of the health-promotion lifestyle of individuals and consists of 52 items in 6 factors: physical activity, health responsibility, stress management, nutrition, interpersonal relationships, and spiritual growth. All items are rated on a 4-point Likert scale (from "1 = not at all" to "4 = always"). The total score ranges from 52 to 208, with higher scores indicating better health promotion behaviors. The reliability and effectiveness of the HPLP-II has been validated in several regions [30–32]. The Chinese version of the HPLP-II also showed acceptable to good internal consistency (Cronbach's alpha ranged from 0.63 to 0.81 [33, 34]).

Statistical analyses

Statistical analyses were conducted with SPSS Statistics 27.0 and SPSS Amos 24.0, and a p-value < 0.05 was considered statistically significant. Descriptive statistics (frequency, percentages, means, and standard deviations) were used to describe the demographic characteristics of participants.

Item Analysis

An independent samples t-test was employed to separate the top 27% (high group) and the bottom 27% (low group) of the Chinese HBSCP total scores, which were arranged from low to high. Item with a t-value > 3 was retained. Cronbach's alpha was used to calculate the Corrected Item-Total Correlation (CITC), with a value of < 0.3 indicating a low correlation. If deleting an item increased the Cronbach's alpha, that item was removed [35].

Validity Analysis

(1) Structural validity: The factorial validity of the HBSCP at each time point was explored by estimating the proposed two-factor model. Observed items were used as indicators for the latent factor. Confirmatory Factor Analysis (CFA) was performed using AMOS. The maximum likelihood approach was used for estimation,

Table 1 The items in original HBSCP and its Chinese version

Item	Original English version	Target Chinese version
1	I keep up with my medical check-ups	我坚持进行体检
2	When there are acute health problems, I see a doctor quickly	出现严重健康问题时, 我会迅速就医
3	I follow treatments recommended by doctors	我遵循医生推荐的治疗方法
4	I eat a balanced diet	我饮食均衡
5	I avoid sweets and sugary food	我避免吃甜食和含糖食物
6	I avoid high-fat food	我避免吃高油食物
7	I pay attention to my weight	我关注我的体重
8	I make sure I get regular exercise and physical activity	我确保我有规律的锻炼和体育活动
9	I make sure I get enough rest and relaxation	我确保自己得到足够的休息和放松

with the following fit indices applied to evaluate model adequacy: chi-square to degrees of freedom ratio ($^2/df$ < 3) [36], Comparative Fit Index (CFI > 0.95), Tucker-Lewis Index (TLI > 0.95), Standardized Root Mean Square Residual (SRMR < 0.08), and the Root Mean Square Error of Approximation (RMSEA < 0.06) [37].

(2) convergent validity: Convergent validity was assessed by examining the Average Variance Extracted (AVE > 0.50) and Composite Reliability (CR > 0.70), which were calculated using factor loadings and item uniqueness derived from the CFA results [38].

(3) Criterion-related validity: Criterion-related validity was measured by the Pearson correlation between HBSCP and HPLP-II, with a correlation coefficient (r) of 0.30 or higher considered acceptable (r = 0.30 and 0.50 represent moderate and large effects) [39, 40].

Internal Consistency Analysis

The Cronbach's alpha and McDonald's Omega of the total scale and each factor were calculated to assess the internal consistency of the HBSCP. When Cronbach's alpha ≥ 0.70 and McDonald's Omega ≥ 0.80, internal consistency is considered sufficient [41].

Measurement Invariance Test

Missing data were handled using multiple imputation, and the MI tests were conducted on the imputed datasets. LMI was used to ascertain the configural (similar factor structure), metric (similar factor loadings), and scalar invariance (similar intercepts) of the HBSCP across cancer types and time groups. Three nested models were constructed to test measurement invariance: (1) a configural invariance model specifying equivalent factor structures with freely estimated loadings and intercepts; (2) a metric invariance model successively imposing equality constraints on factor loadings; and (3) a scalar invariance model additionally constraining item intercept. Invariance was established by comparing these models based on the following criteria: changes in RMSEA (Δ value < 0.015), CFI (Δ value < 0.01), and TLI (Δ value < 0.01) [42].

Result

Sample Characteristics

The study proposed to recruit 200 participants for each of the three types of cancer, totaling 600 participants. However, in these potential participants, 33 eligible patients refused to participate for various reasons, resulting in a final baseline sample of 567 participants. After three months, when the researchers contacted the 567 participants again, 139 were lost to follow-up due to various reasons (refusal to participate, deterioration in health, or death), leaving a total of 428 participants in T2. The demographic and clinical characteristics, as well as scale scores of the T1 and T2 samples, were compared using chi-square tests for categorical variables and independent samples t-tests for continuous variables. Table 2 provides a full overview of the data.

Item analysis

The results of the item analysis based on T1 data showed that the t value of the critical ratio of each item was 18.508 ~ 21.797 (P < 0.001), which indicated that the differentiation of each item was good. At T1, the CITC coefficients for each item ranged from 0.628 to 0.713, and all were above 0.4; The Cronbach's Alpha if Item Deleted (CAID) values were between 0.884 and 0.890, and all were below 0.900 (which is the overall Cronbach's Alpha of the scale). Due to these results, all items were retained.

Validity analysis

(1) Structural Validity

The CFA model with two latent subscales demonstrated an adequate fit across multiple fit indices. The following were the final fit statistics: T1 [($^2/df$ = 1.107, p < 0.001), TLI = 0.999, CFI = 0.999, RMSEA = 0.012], T2 [($^2/df$ = 1.108, p < 0.001), TLI = 0.998, CFI = 0.988, RMSEA = 0.016], respectively. Figure 2 shows the factor structure and model fit results of the HBSCP at T1 and T2.

(2) Convergent Validity

AVE and CR were used to test the convergent validity of the Chinese version of the HBSCP. The results showed that at T1 the AVE values of the two factors were 0.525

Table 2 Demographics, clinical characteristics and scale scores in T1 and T2 samples (TI, *N* = 567; T2, *N* = 428)

Variable	(M ± SD)/*N*(%)		t/ ^{2}	*P*
	T1(*N* = 567)	T2(*N* = 428)		
Demographic characteristics				
Age	53.58 ± 8.08	53.63 ± 8.18	-0.83	0.93
Gender			0.46	0.50
Male	143(25.22)	100(23.26)		
Female	424(74.77)	328(76.74)		
Education level			1.13	0.77
Primary school or less	146(25.75)	101(22.60)		
Junior high school	234(41.27)	174(40.65)		
Senior high school	106(18.69)	84(19.63)		
College and above	81(14.29)	69(16.12)		
Monthly income (yuan)			1.04	0.60
<3000	221(38.98)	158(36.92)		
3000 ~ 5000	232(40.92)	173(40.42)		
>5000	114(20.11)	97(22.66)		
Place of residence			0.74	0.39
City	336(59.26)	242(56.54)		
Rural	231(40.74)	186(43.46)		
Clinical Characteristics				
Cancer type			1.16	0.56
Lung cancer	185(32.63)	152(35.51)		
Digestive tract cancer	193(34.04)	134(31.31)		
Gynecological cancer	189(33.33)	142(33.18)		
Cancer staging			2.20	0.53
I	75(13.23)	53(12.38)		
II	224(39.51)	155(36.21)		
III	170(29.98)	136(31.78)		
IV	98(17.28)	84(19.63)		
Chemotherapy and radiation			1.69	0.64
Radiation	132(23.28)	87(20.33)		
Chemotherapy	201(35.45)	154(35.98)		
Chemotherapy and radiation	175(30.86)	135(31.54)		
Non-chemoradiotherapy	59(10.40)	52(12.15)		
Comorbidity			1.30	0.25
Yes	341(60.14)	242(56.54)		
No	226(39.86)	186(43.46)		
Medical insurance			1.04	0.31
Yes	465(82.01)	340(79.44)		
No	102(17.99)	88(20.56)		
Scale Scores				
Total Scale	29.94±5.60	33.14±4.60	-9.39	< 0.001
First factor	9.76±2.17	10.77±2.11	-7.24	< 0.001
Second factor	20.18±3.95	22.36±3.11	-9.20	< 0.001

Note. M: Mean, SD: Standard deviation, First factor: Adherence to medical health services, Second factor: Individual protective health behavior, The average exchange rate for 2024 was 1 USD = 7.1217 RMB (yuan)

and 0.656, and the CR values were 0.815 and 0.874. At T2, the AVE values of the two factors were 0.519 and 0.648, and the CR values were 0.847 and 0.866. All the characteristics at the two time points exhibited good acceptance, indicating that the convergent validity of the Chinese version of the HBSCP was satisfactory (Table 3).

(3) Criterion-related Validity

The criterion-related validity of the Chinese version of the HBSCP was evaluated using Pearson correlations with the HPLP-II. Findings indicated that the Chinese HBSCP possessed sufficient criterion-related validity. Specifically, at T1, the Chinese HBSCP showed a significant strong positive correlation with the HPLP-II (Total scale score: $r = 0.760$, First factor: $r = 0.653$, Second factor: $r = 0.728$, all $p < 0.001$). Similarly, at T2, the Chinese HBSCP also displayed a significant strong positive correlation with the HPLP-II (Total scale score: $r = 0.776$, First factor: $r = 0.663$, Second factor: $r = 0.732$, all $p < 0.001$).

Internal Consistency Analysis

At T1, the Cronbach's alpha coefficients for the two subscales were 0.849 and 0.873, respectively, and 0.900 for the total scale; the McDonald's Omega values were 0.851, 0.874, and 0.897 for the subscales and total scale, respectively. At T2, Cronbach's alpha coefficients were 0.846, 0.865, and 0.893, and McDonald's Omega values were 0.847, 0.866, and 0.891. These results demonstrate the satisfactory internal consistency of the HBSCP.

Measurement Invariance

To ensure the stability of the Chinese version of the HBSCP, we assessed the equivalence of the scale across cancer types and time groups. As shown in Table 4, the tests of invariance of HBSCP scores among different cancer types passed the construct, metric, and scalar model tests, and the tests of invariance among different time groups passed the construct and metric model tests.

Discussion

The impact of health behaviors on cancer prevention, development, and prognosis is well known [43]. Comprehensive, reliable, and valid assessment tools play a vital role in supporting diagnosis, planning treatment, and monitoring the progress of patient health behaviors. This study aims to determine the psychometric properties of the Chinese version of the HBSCP and its MI across cancer types and time groups in the Chinese cancer population. Overall, our findings showed that the Chinese version of the HBSCP has good internal consistency, validity, and measurement invariance.

Specifically, satisfactory internal consistency was identified, with both Cronbach's alpha and McDonald's Omega remaining above 0.80. The CFA showed that the Chinese version of the HBSCP contained two factors (adherence to medical health services and individual protective health behavior), which was consistent with the original version of the HBSCP [22]. On the factorial level, the results showed that all items loaded significantly and sufficiently on their respective factor at two time points. All standardized factor loadings loaded significantly on

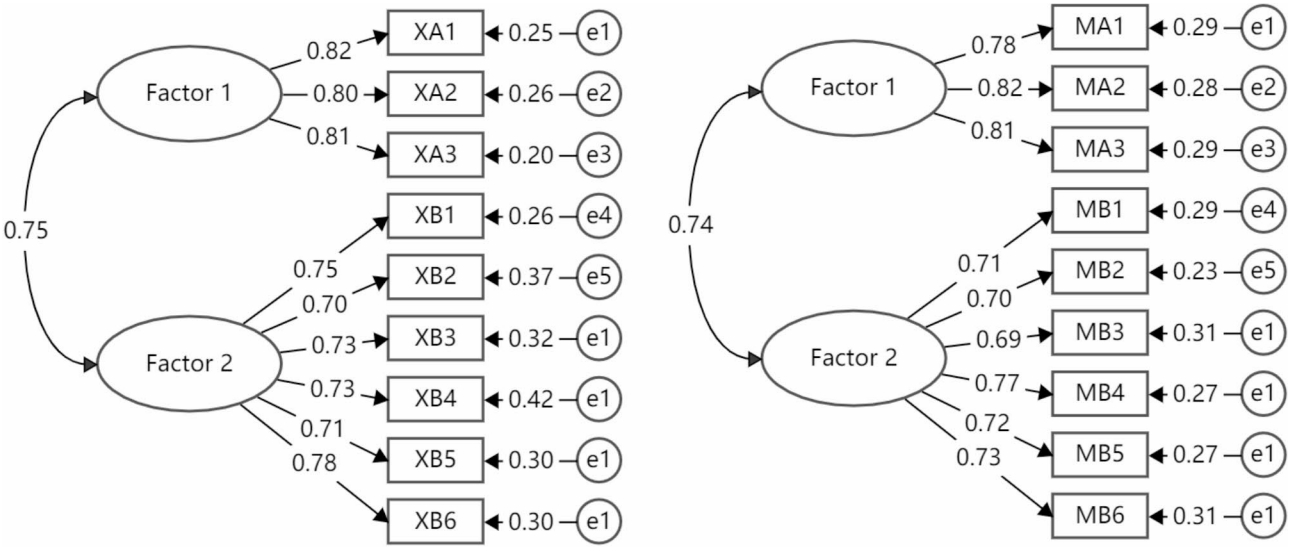

Fig. 2 Chinese version of the HBSCP confirmatory factor analysis structure diagram (T1 on the left and T2 on the right)
Note: XA1-XA3 and MA1-MA3 belong to the three items under the factor of adherence to medical health services; XB1-XB6 and MB1-MB6 belong to the six items under the factor of individual protective health behavior

Table 3 Confirmatory factor analysis results (TI, *N* = 567; T2, *N* = 428)

Item	Factor	T1				T2			
		Factor loading	SE	CR	AVE	Factor loading	SE	CR	AVE
1	Adherence to medical health services	0.815		0.851	0.656	0.781		0.847	0.648
2		0.804	0.050			0.824	0.069		
3		0.810	0.044			0.809	0.066		
4	Individual protective health behavior	0.750		0.874	0.536	0.712		0.866	0.519
5		0.697	0.063			0.701	0.064		
6		0.728	0.061			0.691	0.073		
7		0.726	0.071			0.765	0.077		
8		0.712	0.058			0.722	0.072		
9		0.778	0.065			0.727	0.078		

Note. SE: standardized estimation, CR: composite reliability, AVE: average variance extracted

Table 4 Model fitting indicators for each equivalent model (TI, *N* = 567; T2, *N* = 428)

Model	^{2}	df	CFI	TLI	SRMR	RMSEA	ΔCFI	ΔTLI	ΔRMSEA
Cancer type									
Configural	85.987	78	0.997	0.996	0.027	0.023			
Metric	94.697	92	0.999	0.999	0.045	0.012	0.002	0.003	0.011
Scalar	113.867	106	0.997	0.997	0.046	0.020	0.002	0.002	0.008
Time									
Configural	64.772	52	0.996	0.995	0.020	0.024			
Metric	76.212	59	0.995	0.994	0.039	0.026	0.001	0.001	0.002
Scalar	603.937	66	0.842	0.828	0.125	0.138	0.153	0.166	0.112

Note: ^{2}: Chi-square; df: Degrees of freedom; CFI: Comparative fit index; TLI: Tucker-Lewis Index; SRMR: Standardized root mean square residual; RMSEA: Root mean square error of approximation; **Δ**CFI: change in comparative fit index relative to the preceding model; **Δ**RMSEA: change in root mean square error of approximation relative to the preceding model; **Δ**CFI < 0.01 and **Δ**RMSEA < 0.015 indicate a good model fit. The model was compared with the previous model with one less level of constraints

their respective factor and the factor loading of each item was above 0.50. Further, the AVE of the two factors was above 0.50, and the CR of the two factors was above 0.70, indicating that all items belong to their respective factors and the Chinese version of the HBSCP had a good convergent validity.

The HPLP-II primarily measures an individual's health-promoting lifestyle, while the HBSCP focuses more on post-cancer medical health service compliance and

personal protective health behaviors. The strong correlation between the HBSCP and the HPLP-II meet Cohen's criteria for large effect sizes [40], confirming the criterion validity of the HBSCP. The simplicity of the HBSCP (9 items compared to 52 items for the HPLP-II) and its ability to capture key dimensions of health behavior in cancer patients simultaneously make it well-suited for clinical settings.

There were no statistically significant differences in the demographic and clinical characteristics between the two samples at the T1 and T2 time points. Notably, cancer patients had higher HBSCP scores at T2 (three months after treatment) compared to T1 (immediately after treatment). We hypothesize that this increase may be due to patients adapting to their cancer diagnosis and treatment procedures, gradually adopting positive coping strategies, such as dietary modifications, increased physical activity, and enhanced communication with healthcare providers, among other measures aimed at slowing cancer progression and promoting physical health [44]. This suggests that cancer patient's health behaviors may change over time. Therefore, longitudinal invariance testing of measurement instruments is necessary.

Previous quantitative research on cancer-related health behavior has identified two key aspects of healthcare behaviors and individual health protection behaviors after a cancer diagnosis [14]. Firstly, better adherence to medical health services correlates with lower cancer recurrence and increased survival rates. The first subscale includes three items: regular medical check-ups, prompt medical intervention, and adherence treatments recommended. It is widely recognized that individuals who neglect health screenings face a higher risk of developing cancer [45]. Patients who engage in consistent health check-ups post-cancer diagnosis are more likely to identify health issues early, enabling timely treatment and minimizing adverse health consequences. Healthcare-seeking in response to acute issues is crucial for early cancer detection, thereby effectively lowering the risk of severe complications and high medical expenses [46, 47]. Adhering to specific medical guidelines can decrease recurrence and mortality rates among cancer survivors [48]. Secondly, lifestyles are well-established risk determinants for cancer, playing a pivotal role in treatment and management strategies [49]. The second subscale includes six items that consistent with findings by other researchers, for example, Ubago-Guisado et al. [50] and Monllor-Tormos et al. [51] found that the Mediterranean diet effectively prevents cancer and reduces recurrence. Diet and nutrition are critical in managing multimodal cancers, with evidence indicating that dietary factors should be integrated with antineoplastic therapies from diagnosis onward, as part of a diagnostic and therapeutic approach. Increasing research shows that physical activity not only alleviates the side effects of cancer treatment but also enhances treatment efficacy [49, 52, 53]. Additional studies have explored how relaxation techniques may slow cancer progression by alleviating pain and reducing anxiety, depression, and fears of recurrence during treatment [54–56]. Therefore, the HBSCP can provide comprehensive coverage of health behaviors related to cancer patients.

Given that health behaviors may vary by cancer type [15], we assessed the MI of the HBSCP across cancer types at T1. The results support structural, metric, and scale invariance, confirming the stability and equivalence of the HBSCP framework across cancer types. This finding facilitates cross-sectional group comparisons of HBSCP. Additionally, we evaluated the longitudinal invariance of the HBSCP at two-time points. While configural and metric invariance were confirmed, scalar invariance was not fully supported, potentially due to temporal fluctuations in sample means or evolving health behavior dynamics post-diagnosis. As previously mentioned, cancer patients may be motivated to improve their health management (e.g., adopting a balanced diet, increasing physical activity, and adhering to treatment) following a cancer diagnosis. Nonetheless, the overall structural and metric consistency suggests that the HBSCP is stable over time, allowing for longitudinal follow-up comparisons.

In summary, our results support the conclusion that the Chinese version of the HBSCP is stable across cancer types and time groups, providing a strong foundation for both cross-population and longitudinal comparisons. This stability is especially valuable for tracking behavioral changes in cancer patients during dynamic treatment phases (e.g., chemotherapy or survivorship care), as it ensures that observed differences reflect true behavioral shifts rather than measurement bias [24, 42].

Limitations

Finally, some limitations should be noted. First, participant recruitment was conducted solely in hospital settings; due to time and resource constraints, community-based cancer patients were not included. Second, the sample was limited to two provincial hospitals in Tianjin and Nanchang, China, leading to an overrepresentation of urban residents (approximately 60%). This may limit the generalizability of the findings, as most participants were treated locally rather than representing broader geographic populations. Third, measurement invariance needs to be tested across genders, with a higher proportion of women in this study (approximately 75%). Additionally, the reliability of the scale was evaluated solely through internal consistency measures (Cronbach's alpha and McDonald's Omega), while test-retest reliability was not assessed. Although longitudinal measurement

invariance analyses confirmed the structural equivalence of the scale across time points, the absence of individual-level score consistency evaluations limits the interpretation of its temporal stability in practical contexts. Future research should consider employing a multidimensional approach to comprehensively assess the reliability of the HBSCP scale. Finally, although longitudinal invariance was examined at three-month intervals, a longer follow-up period would be necessary to assess scale stability across critical survivorship phases (e.g., post-treatment transition, and long-term remission). To validate the scale in a broader and more representative sample, more comprehensive and diverse surveys are recommended for the future.

Conclusion

The findings of this study demonstrate that the Chinese version of the HBSCP is a psychometrically robust tool, exhibiting strong validity and invariance in assessing health behavior across cancer types and time points. Its ease of implementation and brevity make it a practical instrument for clinical use, enabling healthcare providers to efficiently evaluate and monitor health behavior. Importantly, the HBSCP provides a foundation for developing tailored interventions to address the unique needs of cancer patients, ultimately improving health outcomes and quality of life. By facilitating more precise and personalized care, the HBSCP has the potential to advance cancer management and enhance patient-centered care practices.

Abbreviations

AVE	Average Variance Extracted
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CITC	Corrected Item-Total Correlation
CR	Composite Reliability
HBSCP	Health Behavior Scale for Cancer Patients
HPLP-II	Health-Promoting Lifestyle Profile II
LMI	Longitudinal Measurement Invariance
MI	Measurement Invariance
RMSEA	Root Mean Square Error of Approximation
SRMR	Standardized Root Mean Square Residual
TLI	Tucker-Lewis Index

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Author contributions

Conceptualization, X.H. and Y.J.; methodology, Y.J. and Y.L.; software, X.H.; validation, X.H., Y.J., Y.L., and L.X.; formal analysis, Y.J., Y.L. and H.M.; investigation, Y.L. and L.X.; resources, H.M. and J.T.; data curation, Y.L. and L.X.; writing—original draft preparation, X.H.; writing—review and editing, X.H., Y.J. and J.T.; visualization, X.H.; supervision, Y.J. and J.T.; project administration, Y.J., Y.L., and L.X.

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Data availability

The data that support the findings of this study are available from correspondence author upon reasonable reasons due to the preservation of anonymity of the participants.

Declarations

Ethical approval and consent to participate

The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of Nanjing Medical University (Ethics No. 2024 – 398; Approved Date: March 8, 2024). All subjects participating in the study gave informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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