

Original Article

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The Persian version of Herth Hope Index in Iranian patients with cancer: A psychometric study

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Abstract

Objectives. Hope is a contextual concept that has significant effects on human well-being. This study aimed to evaluate the psychometric properties of the Persian version of the Herth Hope Index (P-HHI) among Iranian patients with cancer.

Method. This cross-sectional study was conducted on 320 patients with cancer from September to December 2020. After translating the HHI into Persian, content, convergent and discriminant, construct validity (exploratory and confirmatory factor analysis), and reliability of the P-HHI were assessed.

Results. The results of exploratory factor analysis showed that the P-HHI was composed of two factors: Life Expectancy and Thinking Positive, which explained 55.20% of the total variance.

Significance of results. The research revealed that the P-HHI has acceptable validity and reliability, which can be used to measure the hope concept among Iranian patients with cancer.

Introduction

Cancer survivors, especially in developing countries like Iran, endure physical suffering and psychosocial challenges during their cure journey (Acquati et al., 2018; Smith et al., 2019). Fear of an uncertain future, experiencing social and internal stigma, and intensified needs can result in feeling loneliness, depression (Sharif Nia et al., 2017), and hopelessness in a life-threatening condition such as cancer (Ettema et al., 2010; Ullrich et al., 2020; Masror Roudsary et al., 2022). These negative emotions could induce destructive impacts on patients' quality of life and their families due to lack of coping and adherence to treatment and intra-familial issues (Park et al., 2020).

In these threatening conditions, a positive emotion as hope behaves like a crucial inner resource for strengthening patients to deal with challenges and impacts of cancer in every stage of the disease (Nierop-van Baalen et al., 2019; Park et al., 2020). Hope plays a crucial role in adapting to distressing situations and coping with loss and adversities, improving the patients' mental health and well-being in different regions and socioeconomic classes (Soundy and Condon, 2015; Park et al., 2020; Sharif Nia et al., 2021b).

According to scientific literature, hope is a multidimensional concept with a philosophical nature that causes happiness, success, compatibility, spiritual and social support by finding purpose, and meaning in life (Cotter et al., 2018; Al-Rawashdeh et al., 2020; Pahlevan Sharif et al., 2020; Sharif Nia et al., 2021a). Having a positive role in satisfaction and quality of life and being useful in all wellness levels to illness (Akhlaghi et al., 2020), researchers in different fields and cultures have designed measures to evaluate the hope concept better (Al-Rawashdeh et al., 2020).

The Herth Hope Index (HHI) was created in 1991 (an abbreviated version of the Herth Hope Scale, HHS), based on multidimensional hope theory concerning different views, including philosophical, religious, psychosocial, and nursing (Herth, 1991; Nayeri et al., 2020). Developing HHI intends to gain a deep understanding and expression of the multiple dimensions of hope in clinical populations, reducing the difficulty and number of the items (Ishimwe et al., 2020). The HHI assesses hope using three factors: not lasting or permanent, attachment or interconnection, and preparedness and optimism (Herth, 1992). Some of the items in the HHI might be inappropriate for use in different contexts and populations due to various cultures, which can decrease the validity of the tool and results (Chan et al., 2012; Redlich-Amirav et al., 2018).

Many researchers have adapted and validated the HHI to measure hope in different contexts and populations, including Iran (Redlich-Amirav et al., 2018; Nayeri et al., 2020). However, most of the researchers have not performed a confirmatory analysis to assess the factors explored. On the other hand, most of the studies have evaluated that psychometric characteristics for the HHI had fair scores in their quality assessment (Redlich-Amirav et al., 2018). Besides, they should evaluate convergent and divergent validity, as well as construct reliability of the tool.

Furthermore, the HHI has better clinical relevance than Snyder's hope scale, previously validated and utilized in Iran. Thus, the HHI is more suitable for ill-health conditions due to a general conceptual basis. Multidimensional aspects of the HHI, such as having positive expectancy, a clear outlook on life approach, and giving and receiving love (to and from God and religious society), are more appropriate for Iranian patients. In other words, hope in Iran culture has a religious-spiritual base named religiosity (Sharif Nia et al., 2017, 2022). Perceived support from God and the religious community may be associated with more hopefulness or less fear of an unpredictable future of cancer and feeling lonely in hardiness and loss (Herth, 1991, 1992).

Most Iranians are Muslims surrounded by divinity favor and experiments and dependent on receiving his love, which is enormous power and unlimited resource (Pahlevan Sharif et al., 2018). Religious spirituality is an inspiration that helps patients improve their satisfaction and access better quality of life (psychological well-being) by finding meaning. Meaning in life leads to personal growth and acceptance of suffering and pain, which acts as a potent force (patient empowerment) or a successful coping strategy to adapt to adversities, life stressors, and threats (Corrigan et al., 2003; Maiko et al., 2019).

As hope is a contextual concept that has significant effects on well-being, this research addresses previous studies' shortcomings. Thus, the purpose of the present research is to evaluate the psychometric properties of the Persian version of the HHI (P-HHI) among Iranian patients with cancer.

Method

Design and participants

The cross-sectional design was used in this study to evaluate the psychometric properties of a Persian version of the P-HHI among Iranian patients who were suffering from cancer. The inclusion criteria in this study were being diagnosed as a patient with cancer, being at least 18 years old, willingness to participate at the study, and speaking Persian. The survey was conducted in Iran between September and December 2020, and convenience sampling was employed. The total sample of 320 participants was included in this study. The sample size was determined based on structural equation models, formulas that anticipated effect size = 0.18, desired statistical power level = 0.8, number of latent variables = 2, number of observed variables = 20, and probability level = 0.05. The characteristics profile of the participants is presented in Table 1.

Measures

There were two parts for the questionnaire: (1) patient's demographic information and (2) questions on the HHI. The HHI is a 12-item abbreviated instrument of the HHS that developed and validated by Herth (1991) with the aim to assess hope in

Table 1. Demographic profiles of the patients

Variable	n (%)	Variable	n (%)
Gender		Job status	
Male	154 (48.1)	Housekeeper	132 (41.3)
Female	166 (51.9)	Employed	24 (7.5)
Marital status		Freelance	
Single	40 (12.5)	Retired	64 (20.0)
Married	249 (77.8)	Others	23(7.2)
Divorced	12 (3.8)	Undergo cancer treatment	
Widow	19 (5.9)	Chemotherapy	202 (63.1)
Education level		Radiotherapy	
Illiterate	11 (3.4)	Surgery	6 (1.9)
Elementary	96 (30.0)	Chemotherapy and radiotherapy	35 (10.9)
Post elementary	50 (15.6)	Chemotherapy and surgery	45 (14.1)
High school	25 (7.8)	Surgery and radiotherapy	4 (1.3)
Diploma/Post diploma	95 (29.7)	All of the first three	14 (4.4)
Undergraduate	31 (9.7)	Refuse to answer	10 (3.1)
Postgraduate	12 (3.8)	Cancer stage	
Economic condition		Stage 1	30 (9.4)
Weak	107 (33.4)	Stage 2	43 (13.4)
Moderate	182 (56.9)	Stage 3	29 (9.1)
Good	26 (8.1)	Stage 4	34 (10.6)
Very good	5 (1.6)	Do not know	184 (57.5)
Staying area		Variable	Mean (SD)
Urban	272 (85.0)	Age	52.7 (21.9)
Rural	48 (15.0)	Diagnosed with cancer (months)	20.5 (27.2)

adults in clinical settings. Patients were asked to response to what extend they agree or disagree with each statement (e.g., "I have a positive outlook toward life") using a 4-point Likert scale ranging from 1 (Strongly Disagree) to 4 (Strongly Agree). In accord with the scoring procedure, two items were reversed scored (e.g., "I feel scared about my future").

Procedures

To conduct this study, we have contacted the developer of the HHI, Dr Kaye Herth, to get written permission for use of the HHI. We followed the forward-backward translation technique (Beaton et al., 2000) and two English-Persian translators were asked to independently translate the HHI from English to Persian. The two versions of translated P-HHI were then reviewed and evaluated by the experts (two faculty members who were fluent in English and Persian). Subsequently, the P-HHI was back-translated to English by a Persian-English translator and confirmed by the experts on the correctness of the translation.

Psychometric properties of the P-HHI

Content validity

The content validity of the P-HHI was evaluated in both qualitative and quantitative methods. In the stage of qualitative assessment, we provided the HHI questionnaire to 10 experts in the field of health and psychology to seek their feedback and comments on the appropriateness of the wording and usability of the items. To evaluate content validity quantitatively, the content validity ratio (CVR) and the modified kappa coefficient were used to ensure the instrument was fully represented the true meaning of the construct. To obtain the CVR, we requested the 10 experts to measure the essentiality of the items in the HHI construct based on the three options provided (1: Not essential; 2: Useful but not essential; and 3: Essential). Thereafter, the value of CVR was computed using the formula: $CVR = (NE - (N/2))/(N/2)$ (Cook and Beckman, 2006), where NE is the number of experts who measure the items as “Essential” and N is the total number of the experts. The cut-off value for the CVR in this study should be greater than 0.62 when the total number of experts was 10 (Lawshe, 1975). In items of modified kappa coefficient (K), the experts were asked to indicate the relevancy of each item (Relevant = 4, Irrelevant = 1), and the minimum value of modified kappa coefficient for each item should be 0.6 (Wynd et al., 2003).

Construct validity and reliability

Both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted to ensure the construct the validity and reliability of the P-HHI. The analysis was performed using SPSS version 26 and Amos version 26. Prior to data analysis, we randomly split the dataset into two, then we use the first half of the dataset for EFA ($n = 160$), the second half for CFA ($n = 160$). The maximum-likelihood EFA with Promax rotation was employed in this study; the Kaiser–Meyer–Olkin (KMO) and Bartlett’s test of sphericity were used to confirm the relevance and appropriateness of the data for performing the factor analysis. To extract the factor structure of the P-HHI, the following criteria were used: (a) eigenvalues >1 ; (b) communalities of each item >0.3 , and (c) scree plots (Cattell, 1966; Field, 2013; Rahmatpour et al., 2021). Subsequently, we conducted the maximum-likelihood CFA to confirm and validate the factor structure obtained from EFA. The recommended fit indices criteria were used to evaluate the model fit, such as Chi-square (χ^2) test, Chi-square (χ^2)/degree of freedom (df) ratio <3 , Goodness-of-Fit Index (GFI) >0.9 , Comparative Fit Index (CFI) >0.9 , Normed Fit Index (NFI) >0.9 , Incremental Fit Index (IFI) >0.9 , and Tucker–Lewis index (TLI) >0.9 , Standardized Root Mean Square Residual (SRMR) <0.09 , and Root Mean Square Error of Approximation (RMSEA) <0.08 (Hair et al., 2014; Pahlevan Sharif et al., 2019).

Next, the construct validity was assessed in both convergent and discriminant validity. To achieve convergent validity, each construct’s Composite Reliability (CR) should be greater than 0.7, and Average Variance Extracted (AVE) should be greater than 0.5 and less than its respective CR (Hair et al., 2014; She et al., 2021). For discriminant validity, the Fornell and Larcker and Heterotrait-monotrait ratio of correlation (HTMT) criteria were followed in this study. Specifically, the square root of each construct’s AVE should be greater than its correlation with other constructs (Fornell and Larcker, 1981), and all values of HTMT matrix should be less than 0.85 (Henseler et al., 2015).

Lastly, the reliability of the construct was assessed through its internal consistency, CR, and maximum reliability (MaxR).

To achieve good internal consistency, Cronbach’s alpha and McDonald’s omega should be greater than 0.7. Also, CR and MaxR greater than 0.7 indicate good construct reliability (Rahmatpour et al., 2020).

Responsiveness

To assess the responsiveness, the level of hope was assessed according to gender (by independent t -test) and marital status [by the one-way analysis of variance (ANOVA)].

Multivariate normality and outliers

This study evaluated both univariate and multivariate normality. The univariate distributions were tested for outliers, skewness, and kurtosis. The normality of the multivariate was assessed by Mardia’s coefficient of multivariate kurtosis, and the Mardia’s coefficient of more than 7.98 can be considered as indicative of departure from multivariate normality. Moreover, the outliers of the multivariate were identified using Mahalanobis distance ($p < 0.001$) (Kline, 2015).

Results

Demographic profiles of the patients

A convenience sampling method was used. In total, 320 cancer patients were participated in this study, which includes 154 males and 166 females with the mean age of 52.7 years ($SD = 21.9$). Most of the patients (63.1%) reported that they are undergoing chemotherapy treatment. 57.5% of the patients stated that they do not know their current cancer stage. Moreover, 56.9% of the patients reported having moderate economic condition and 33.4% reported that their economic condition was weak. The details of the demographic profiles of the patients are shown in Table 1.

Content validity

The CVR and modified kappa coefficient were computed to assess the content validity of the P-HHI. Based on the responses from 10 experts, the results showed that the CVR for the 12-item HHI was greater than 0.62 and the modified kappa coefficient for all items of the HHI was higher than 0.6. Hence, no item was removed in this stage.

Construct validity and reliability

The results of the maximum-likelihood EFA with Promax rotation on the P-HHI are reported in Table 2 ($n = 160$). The results indicated that the sampling was adequate and appropriate for the factor analysis where KMO was 0.820, and Bartlett’s Test of Sphericity was significant ($p < 0.001$, 404.552, $df = 36$). The analysis extracted two factors that consisted of nine items explaining for 55.20% of the total variance (five items for Factor 1 (Life Expectancy) and four items for Factor 2 (Thinking Positive)). Three items (4, 5, and 8) were excluded due to the lower communalities of less than 0.3.

Next, the factor structure obtained from the EFA was validated and confirmed through performing maximum-likelihood CFA ($n = 160$) using Amos version 26. Based on the modification indices, one pair of measurement error (between item 2 and item 6) was allowed to covary freely (Figure 1). The results showed that

Table 2. The result of EFA on the two factors Persian version of the HHI (N= 160)

Factors	Items	Factor loading	Communalities	Eigenvalues	Variance (%)
Life Expectancy	11. I believe that each day has potential	0.797	0.532	3.670	40.775
	10. I have a sense of direction	0.663	0.466		
	9. I am able to give and receive caring/love	0.611	0.406		
	7. I can recall happy/joyful times	0.603	0.405		
	12. I feel my life has value and worth	0.422	0.300		
Thinking Positive	1. I have a positive outlook toward life	0.772	0.553	1.298	14.426
	3. I feel all alone ^a .	0.712	0.475		
	2. I have short and/or long rang goals	0.551	0.425		
	6. I feel scared about my future ^a	0.542	0.319		

^aCoded reversely.

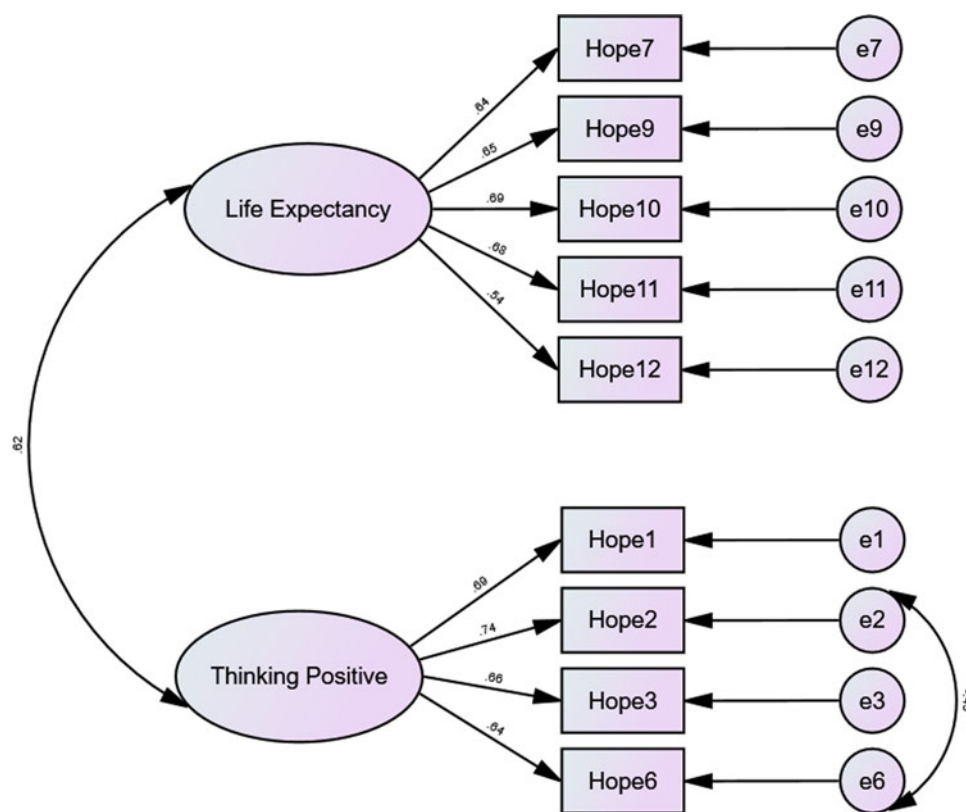


Fig. 1. Model of confirmatory factor analysis of the HHI in cancer patients (n = 160).

the two-factor measurement model fits the data well after reviewing modification indices ($\chi^2(25) = 36.250, p = 0.07, \chi^2/df = 1.450$, GFI = 0.953, CFI = 0.970, NFI = 0.913, IFI = 0.971, TLI = 0.957, SRMR = 0.050, RMSEA (90% CI) = 0.053 [0.001, 0.089]), and all factor loadings were greater than 0.5 and significant. According to Table 3, Cronbach’s alpha, McDonald’s omega, CR, and MaxR for both factors were greater than 0.7, indicating good internal consistency and construct reliability. Moreover, the AVE for both factors was slightly less than the required threshold of 0.5, and studies have argued that AVE is a strict measurement for convergent validity, and CR more than 0.7 can be used to evaluate convergent validity in psychological studies (Pahlevan Sharif et al., 2019, 2022). Therefore, this study achieved convergent

validity as CR for both factors were greater than 0.7 and higher than its respect AVE. For discriminant validity, as shown in Table 4, the results fulfilled the Fornell and Larcker criterion where the square root of AVE for each factor was higher than its correlation with other factor (Fornell and Larcker, 1981), also the value in the HTMT matrix was less than 0.85, indicating that this study established the good discriminant validity.

Responsiveness

Although men (36.22 ± 3.91) had more hope than women (35.67 ± 3.70), this difference was not statistically significant ($p = 0.20$). Also, the results showed that married people (38.08 ± 4.52) are

Table 3. Results of the construct reliability and convergent validity ($N = 160$)

Factors	Cronbach's alpha	McDonald's omega	CR	Max R	AVE
Life Expectancy	0.744	0.748	0.753	0.763	0.435
Thinking Positive	0.770	0.775	0.776	0.783	0.412

Table 4. Discriminant validity assessment using the Fornell and Larcker criterion and the HTMT matrix

	Factors	Life Expectancy	Thinking Positive
Fornell and Larcker criterion	Life Expectancy	0.659	
	Thinking Positive	0.614	0.641
Heterotrait-monotrait ratio of correlations (HTMT)	Life Expectancy		
	Thinking Positive	0.651	

more hopeful than single (36.05 ± 3.78), divorced (35.94 ± 3.65), and widowed (33.94 ± 5.13). This difference was statistically significant ($p = 0.03$).

Discussion

This study aimed to examine the psychometric properties of the P-HHI among a sample of Iranian cancer patients. As a result, the final version of the P-HHI with two factors and nine items showed good internal consistency and construct validity and reliability.

The findings of the study supported the factorial validity of the two-factor model of the HHI that have conducted among different cultural and socio-demographic settings such as a sample of cognitively intact patients who live in Norwegian nursing home (Haugan et al., 2013), Dutch people with severe mental illness (Van Gestel-Timmermans et al., 2010), Spanish clinical population having carried out a suicide attempt (Sánchez-Teruel et al., 2021), Swedish palliative cancer patients (Benzein and Berg, 2003), US patients with cognitive impairment and their family caregivers (Hunsaker et al., 2016), and general Norwegian population (Wahl et al., 2004).

However, the findings of some studies indicated a one-factor solution best fit among adolescents and young adults with cancer (Phillips-Salimi et al., 2007) or three-factor solution among Chinese patients with heart failure (Chan et al., 2012) as it has been addressed by Herth's original work (Herth, 1991). The findings of a systematic review study that evaluate 13 HHI psychometric studies indicated that in 30% of the studies, the data could fit all three underlying factors introduced by Herth (1992), and 54% of studies confirmed a two-factor structure. Moreover, in 15% of selected studies, the validity and reliability test approved a one-factor structure (Nayeri et al., 2020). The varying factor structure of the HHI in different settings may result from methodological approaches as well as sample-dependent characteristic differences in studies (Rustøen et al., 2018).

The findings of the current study showed that the P-HHI consists of two factors in which factor one consists of five items

(items 7, 9, 10, 11, 12) and factor two consists of four items (1, 2, 3, 6). Similar to Wahl et al.'s (2004) study, both positively worded items (item 1: *I have a positive outlook toward life* and item 2: *I have short and/or long range goals*) and negatively worded items (item 3: *I feel all alone* and item 6: *I feel scared about my future*) loaded on second factor. While the bi-dimensional P-HHI model presented by the current study explaining for 55.20% of the total variance, the findings of Wahl et al.'s (2004) study indicated that the two-factor solution of the HHI represents 38% variance among the Norwegian sample. Whereas Benzein and Berg (2003) found a two-factor solution that explained 56% of the total variance, Van Gestel-Timmermans et al. (2010) also reported that the two-factor solution of the HHI explained 47% total variance.

The findings of the current study demonstrated that hope can stand for two factors including Life Expectancy and Thinking Positively in the Iranian patient with cancer. Life Expectancy refers to the average age of death in the population (Roser et al., 2013). The patient's age, comorbidity, cancer stage and type, as well as occurring disabilities affect on the Life Expectancy among patients (Repetto et al., 2001). Life Expectancy has been identified as the associated factor with hope in patients with cancer (Movahedi et al., 2015; Bovero et al., 2021).

Furthermore, positive thinking and optimism has a crucial effect on hope in patients with cancer, regardless their demographic characteristics (Nierop-van Baalen et al., 2020). Hope is a coping resource for patients who suffer from cancer and thinking positively can be considered as the hope-inspiring strategy. For Muslim patients, both Life Expectancy and positive thinking are rooted in the religious believes and are also correlated. Muslims believe that their lifespan is something that is ordained for them by God and if they die, they will continue their life in afterlife (Buturovic, 2016; Mehraby, 2020). The Muslims people may perceive death as a journey toward resurrection and communion with God (Bloomer and Al-Mutair, 2013). On the other hand, optimism is emphasized in Islam and people are advised to trust in God at all times, especially in times of hardship and suffering, and to be optimistic about what God ordains. The high correlation between Life Expectancy and Thinking Positively is demonstrated by the current study. Further studies are needed to test the revised P-HHI among the target population (patients with cancer).

The results of the study revealed that the P-HHI consists of nine items compared to the 12-item structure of the original HHI. Items 4, 5, and 8 were removed due to weak loadings of less than 0.3 and lower communalities of less than 0.2. These findings are in line with Phillips-Salimi et al.'s (2007) study on adolescents with cancer that indicated the item number 4 (*I can see a light and the end of the tunnel*) loaded less than 0.4 on HHI factors. Similarly, Rustøen et al. (2018) in their study reported that the item number 5 (*Faith that comforts*) failed to demonstrate acceptable fit with the hope construct, indicating more variations in scores on this item than expected in the Rasch model that was used to examine aspects of the HHI's validity. Although faith has

been identified as a component of hope (Dufault and Martocchio, 1985; Herth, 1992), the findings of different studies have suggested that there is a large variation in different cultural and religious settings. For example, Rustøen *et al.*'s (2018) study indicated that the Adult oncology outpatients may not experience faith but can still have hope. However, the studies that have been conducted among Muslim population demonstrated the positive correlation between hope and faith (Yaghoobzadeh *et al.*, 2019). Dismissing item number 8 (*Deep inner strength*) due to weak factor loading is not presented in the existing literature. Further studies are needed to investigate the underlying factors that determine hope among Iranian patients with cancer. It has been acknowledged that the factor structure of the HHI varies considerably across empirical studies, in terms of both the number of factors and the items comprising the different factors (Rustøen *et al.*, 2018).

The high level of CR, Cronbach's alpha, McDonald's omega, and the correlation between the items demonstrated that the revised two-factor structural of the P-HHI had good internal consistency and reliability. The current findings were in accordance with the previous studies that indicated the same results across different contexts (Van Gestel-Timmermans *et al.*, 2010; Haugan *et al.*, 2013; Sánchez-Teruel *et al.*, 2021).

The current study indicated that the two-factors P-HHI has adequate convergent validity as supported by the higher level of AVE and CR. Although the most previous studies have tested the HHI's convergent validity by providing empirical shreds of evidence for the relationship between the HHI and some other measures such as "McCorkle Symptom Distress Scale" or "Mishel Uncertainty in Illness Scale-Revised" (Phillips-Salimi *et al.*, 2007), AVE and CR were applied to examine the P-HHI convergent validity. The current study findings support by the previous studies regarding the adequate convergent validity of the HHI (Wahl *et al.*, 2004; Phillips-Salimi *et al.*, 2007; Sánchez-Teruel *et al.*, 2021).

Limitation

The current study has several limitations that need to be considered in time of generalizing the findings. The study applied a purposive sampling method from the selected geographical urban region in Iran. Non-probabilistic samples were enrolled in the current study that restricts the generalizability of the findings. Considering that the hope is culturally sensitive and the individual characteristics affect it (Herth, 1992; Rustøen *et al.*, 2018), further studies are needed to examine the P-HHI among patients with cancer.

Conclusion

The present study provides the first validation of the P-HHI among a sample of Iranian cancer patients. We found acceptable psychometric evidence for the 9-items two-factors P-HHI use in context of cancer patients in Iran. Therefore, the validated instrument can be used in future studies to access hope among patients with cancer in Iran. Also, further studies are needed to test the scale validity and reliability across the various cultural contexts.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Authors' contribution. The authors confirm contribution to the paper as follows: H.S.N. and D.K. performed study conception and design. D.K. carried out data collection. L.S. and H.S.N. involved in the analysis and interpretation of results. F.K.F., L.S., M.M., and P.R. prepared and drafted the manuscript. All authors reviewed the results and approved the final version of the manuscript.

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Conflicts of interest. There are no conflicts of interest by any of the authors of this study. All authors have participated in (a) conception and design, or analysis and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final version. This manuscript has not been submitted to, nor is under review at, another journal or other publishing venue. The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript.

Ethics approval. The ethical committee of the Mazandaran University of Medical Sciences approved the study (approval no: IR.MAZUMS.REC.1400.13738). All the participants signed the written consent forms. All the participants were assured regarding their privacy in this study and informed about volunteer entering the study and willingness to exclude from the study at any time.

Consent to participate. Informed consent was obtained from all individual participants included in the study.

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