Original Paper

Structural Validation and Measurement Invariance Testing of the Chinese Version of the eHealth Literacy Scale Among Undergraduates: Cross-Sectional Study

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Abstract

Background: The eHealth Literacy Scale (eHEALS) was introduced in China in 2013 as one of the most important electronic health literacy measurement instruments. After a decade of development in China, it has received widespread attention, although its theoretical underpinnings have been challenged, thus demanding more robust research evidence of factorial validity and multigroup measurement properties.

Objective: This study aimed to evaluate the Chinese version of the eHEALS in terms of its measurement properties.

Methods: A cross-sectional survey was conducted in a university setting in China. Item statistics were checked for response distributions and floor and ceiling effects. Internal consistency reliability was confirmed with Cronbach α, split-half reliability, Cronbach α if an item was deleted, and item-total correlation. A total of 5 representative eHEALS factor structures were examined and contrasted using confirmatory factor analysis. The study used the item-level content validity index (I-CVI) and the average of the I-CVI scores of all items on the scale to assess the content validity of the dominance model. Furthermore, the validated dominance model was subsequently used to evaluate the relevance and representation of elements in the instrument and to assess measurement invariance across genders.

Results: A total of 972 respondents were identified, with a Cronbach α of .92, split-half reliability of 0.88, and item-total score correlation coefficients ranging from 0.715 to 0.781. Cronbach α if an item was deleted showed that all items should be retained. Acceptable content validity was supported by I-CVIs ≥0.80. The confirmatory factor analysis confirmed that the 3-factor model was acceptable. The measurement model met all relevant fit indices: average variance extracted from 0.663 to 0.680, composite reliability from 0.810 to 0.857, chi-square divided by the *df* of 4.768, root mean square error of approximation of 0.062, standardized root mean squared residual of 0.020, comparative fit index (CFI) of 0.987, and Tucker-Lewis index of 0.979. In addition, the scale demonstrated error variance invariance (Δnormed fit index=−0.016, Δincremental fit index=−0.012, ΔTucker-Lewis index=0.005, Δcomparative fit index=−0.012, Δrelative fit index=0.005, and Δroot mean square error of approximation=0.005).

Conclusions: A 3-factor model of the Chinese version of the eHEALS fits best, and our findings provide evidence for the strict measurement invariance of the instrument regarding gender.

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Introduction

Background

Health-related information is one of the most frequently searched topics on the internet [1,2]. Moreover, health literacy is emerging as a critical factor influencing health outcomes [3-9]. eHealth has emerged as a cost-effective approach that not only plays a key role in expanding the geographic accessibility of secondary prevention programs [10] but also represents a shift to a model of active patient engagement rather than passive acceptance [1].

China's recently announced 14th Five-Year Plan [11] and long-term goals to 2035 [12] aim to create a "Healthy China" by promoting "Internet+Precision Health Science." A health science data platform will address individuals' varying health needs throughout their lifetime. Providing electronic health information that meets the public's needs and eHealth literacy levels is crucial for informed decision-making [13]. Therefore, developing a tool that comprehensively assesses people's ability and literacy in comprehending and using web-based information and services is of utmost importance.

Norman and Skinner [14] developed the eHealth Literacy Scale (eHEALS) in 2006, the first assessment instrument to examine this concept. The eHealth literacy concept draws its theoretical foundation from the social cognitive theory and self-efficacy theory by Bandura [15]. These theories emphasize the significance of cognitive processes in learning and behavior changes. As articulated when their Lily model was developed, using social cognitive theory and self-efficacy theory as a conceptual foundation emphasizes that eHealth literacy places more emphasis on promoting competence and confidence than on directly measuring skills with a view to obtaining behavioral change and skill development [14]. Individuals learn and master new behaviors through observation, imitation, and reinforcement. They also develop self-efficacy beliefs about their ability to use these skills effectively, and this belief influences their motivation and ability to engage in certain behaviors. From the perspective of social cognitive theory, behavioral competence refers to the knowledge and skills needed to influence behaviors [16,17].

eHEALS has been translated and adapted for a total of 16 different languages [18] and has shown strong internal consistency and retest reliability across a wide range of age groups, from 12 to 91 years, in over 10 countries [19]. Research on the applicability of eHEALS in China began in 2013 [20]. Over the past decade, this measure has undergone extensive development and is no longer limited to high school students but has been successfully expanded to patients [21], older adults [22], and rural communities [23]. Furthermore, it has been validated as an ideal tool for assessing eHealth among diverse populations. The intracity traffic ban implemented in China during the COVID-19 pandemic posed a significant challenge to the health care system [24]. Consequently, the public has turned to alternative strategies, such as using social media platforms such as WeChat and Dou Yin (ie, TikTok) [25] as well as other digital health technologies [26], to obtain health care information and support and seek web-based medical assistance [27].

With the interest in this area, some specific research focuses have emerged on the psychometric properties of eHEALS. The first pertains to the factor structure of these instruments. For instance, an initial validation study of the eHEALS scale offered evidence that it measures a unidimensional construct [11], commonly referred to as the Lily model [28]. To the best of our knowledge, there are at least 11 factor structures of eHEALS to data [18,29-36]. However, evidence from published studies suggests that the single- and 2-factor structures of eHealth literacy instruments have controversial issues in confirmatory factor analysis (CFA), including poor fit indexes [33,34,37]. The adoption of a multifactorial structure has garnered considerable attention as an effective approach to comprehensively capture the multifaceted nature of eHealth literacy conceptualization. Two-factor structures tend to successfully capture dimensions that emphasize information search and communication skills and use of web-based health resources [29-31], which echoes the central types of literacies analytic and context-specific proposed by Norman and Skinner [28].

However, the two 3-factor structures of eHEALS, namely, awareness, skills, and evaluation, proposed by Sudbury-Riley et al [33], and information awareness, information seeking, and information engagement for eHealth information, developed by Paige et al [35], have received much attention in recent years because they are based on solid research evidence [18], and both the evaluate subdimension [33] and the information engagement subdimension [35] go beyond the individual's knowledge and perception of behavioral competence and are directly related to self-efficacy. Although some studies conducted in China have confirmed the unidimensionality of eHEALS using exploratory factor analysis [38,39], prior evidence suggests that more complex structural equation models should be used to construct the CFA of this critical measurement instrument, as has been done in other language versions of eHEALS [40-44].

The second major research focus pertains to measurement invariance or equivalence, which is crucial for meaningful group comparisons. Specifically, it is important to establish measurement invariance, as measurement instruments designed for one culture or population may not necessarily measure the same constructs in another culture or population [45]. Examining the significance of measurement invariance when comparing eHEALS across cultures has been a long-standing concern that merits greater attention [32,46-48]. From previous research evidence, measurement invariance studies of eHEALS in other language settings have been particularly interested in participant antecedents, such as gender, age, and education level [42-44].

If the research basis for establishing measurement invariance is neglected, studies and comparisons of differences in access to and use of eHealth resources by different groups may produce ambiguous and erroneous results [33,35,42,45,49]. Although there have been reports of measurement invariance for eHEALS in recent years, to our knowledge, studies conducted in Chinese populations lack exploration of multifactor structures [20,23,39,50], particularly 3-factor structures [38]. Furthermore, there is a lack of evidence for invariance measurements, which are not helpful for the promotion and in-depth study of eHEALS in China.

Objectives

The purpose of this study was to examine the reliability of the version of the Chinese version of eHEALS (C-eHEALS) and its ability to differentiate extreme scale subjects. A comparison of the 5 models identified superior ones. Content validity and convergent validity were used to assess the appropriateness and relevance of the indicators, respectively. Cross-gender measurement invariance was examined for potential score differences because of structural factors or confounding variables.

Methods

Recruitment

A cross-sectional study was conducted at 2 universities in Guizhou Province, China. This study enrolled 1044 undergraduates. This study's data were collected during late September and early November 2021. The study used a hybrid sampling approach combining convenience and snowball sampling methods to overcome their limitations and create a more diverse participant cohort. After obtaining informed consent, participants were given the choice to complete the paper-and-pencil survey provided by their school counselor teacher or via Wen Juan Xing (a Chinese web questionnaire platform). Of the final 972 valid questionnaires (93.1% response rate), 98.3% (956/972) of participants chose the electronic survey, and 1.6% (16/972) completed the paper-and-pencil survey.

Ethics Approval

This study was approved by the Human Trials Ethics Committee of Guizhou Medical University (2021-LUNSHENDI-150).

Instruments

The following sociodemographic variables were measured across the sample: (1) gender (man or woman), (2) age (in years), (3) grade (freshman or sophomore and above), (4) body weight and height (to calculate the BMI), and (5) highest educational attainment of the mother (elementary school and below, junior high school, high school or secondary school, and junior college and above); (6) eHealth literacy was measured by the most widely recognized C-eHEALS [20]. The scale used in this study consists of 8 items, each of which is rated on a 5-point Likert-type scale that ranges from "strongly disagree" to "strongly agree." The C-eHEALS and sociodemographic question items are presented in Multimedia Appendix 1.

Statistical Analysis

Overview

CFA was performed with Amos (version 24.0; IBM Corp), the rest was performed with SPSS (version 24.0; IBM Corp). The data set is reported in Multimedia Appendix 2. Response distribution and floor and ceiling effects were used to describe the response pattern. Participant characteristics and comparisons of scores across groups were described as percentages and means (SD), respectively. The internal consistency reliability was estimated using Cronbach α and split-half reliability. Item-total correlations were also considered, as well as the α, if item deleted. Structural validity and convergent validity will be used to assess models with 5 different factor structures: the unidimensional structure of Norman and Skinner [28], 2-factor structure from Richtering et al [30] and Soellner et al [29], and the 3-factor structure by Sudbury-Riley et al [33] as well as Paige et al [35]. In addition, 3 analytic invariance tests were performed within the CFA framework to test whether the instrument functions similarly across genders.

Item Statistics and Internal Consistency Reliability

The response distribution for each item was analyzed for extreme item deficits at the end of the scale, which could limit the instrument's responsiveness. The criterion for floor and ceiling effects was that more than 15% of respondents achieved the lowest (strongly disagree) or highest scores (strongly agree), respectively [51].

Cronbach α >.70 is considered good, whereas a split-half reliability >0.70 is acceptable. Item-total correlations >0.70 are acceptable [52].

Construct Validity

CFA was used to test the structure of the C-eHEALS. Model fit was determined by the following indicators: chi-square/*df* (χ^2/*df*) ≤5 [53,54], root mean square error of approximation (RMSEA) ≤0.08 (this was considered fair), comparative fit index (CFI), Tucker-Lewis index (TLI) ≥0.95 (indicating a good model fit), and a standardized root mean squared residual (SRMR) ≤0.08 (considered as acceptable) [55].

Convergent Validity

Whether each item is closely related to its expected hypothesis structure (convergent validity) was tested by assessing factor loadings, average variance extracted (AVE), and composite reliability (CR). A total of 3 indicators of convergent validity—the standardized factor loadings of each latent variable—should be >0.50 in the first step, the AVE value should be >0.50 in the second step, and the CR should be >0.70 in the third step [56].

Content Validity

We used the item-level content validity index (I-CVI) to quantify the content validity of the target model. In addition, the average of the I-CVI scores of all items on the scale (S-CVI/Ave) was used to assess the adequacy of the item representation within the construct's content domain. The set criteria for I-CVI were ≥0.78 [57], and for S-CVI/Ave, it was ≥0.90 could be considered evidence of good content validity [57,58].

Measurement Invariance

The analysis follows the technique suggested by Byrne [59], with subsequent extensions. The first test was for configural invariance (configural model), in which no constraints were applied across the groups. The second test (measurement model) is used to test metric invariance and investigate whether the factor loadings are constrained to be equal across both groups. If they are equal, it can be assumed that the scale intervals are the same in both groups. The third test (structural model) found group equivalence with constrained factor loading parameters and equality constraints on the factor variances and covariances. Finally, the most restrictive test examined measurement error variance invariance, with additional equal error variances across observed variables, to test C-eHEALS's gender measurement invariance.

Model comparisons were performed using a chi-square test to test measurement invariance at each level and several model fit indices, such as normed fit index (NFI), incremental fit index (IFI), TLI, CFI, relative fit index (RFI), and RMSEA, to evaluate the fit of the final model. These increasingly restrictive models were tested in terms of the fit of the data to the model [60]. Invariance across subgroups is indicated by significant changes in model fit, and because the dependence of ΔCFI and ΔRMSEA on sample size is small, these 2 indices should not exceed 0.02 and 0.015 [61]. The null hypothesis of no difference in model comparisons was accepted if the increase in NFI, IFI, RFI, and TLI values was <0.05 [62].

Results

Participant Characteristics

The characteristics of the participants showed that the study had a larger participant base of women (590/972, 60.7%); most were freshmen (705/972, 72.5%) and had a BMI of ≤23.99 kg/m^2 (853/972, 87.8%). In addition, about half of the participants' mothers had an education level of elementary school or below (Table 1).

Table 1. Summary of participant characteristics (N=972).

	Total, n (%)	Item score, mean (SD)							
		Item 1[a]	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8
Gender									
Man	382 (39.3)	3.58 (0.76)	3.60 (0.79)	3.63 (0.80)	3.62 (0.83)	3.63 (0.82)	3.59 (0.79)	3.54 (0.83)	3.48 (0.79)
Woman	590 (60.7)	3.58 (0.79)	3.56 (0.81)	3.64 (0.80)	3.60 (0.79)	3.71 (0.74)	3.60 (0.76)	3.59 (0.77)	3.44 (0.79)
Age (y)									
≤19	544 (56)	3.66 (0.76)	3.66 (0.80)	3.72 (0.80)	3.68 (0.81)	3.78 (0.74)	3.68 (0.77)	3.70 (0.78)	3.54 (0.80)
20-21	310 (31.9)	3.51 (0.79)	3.48 (0.80)	3.55 (0.78)	3.55 (0.79)	3.59 (0.77)	3.51 (0.77)	3.45 (0.76)	3.38 (0.75)
≥22	118 (12.1)	3.40 (0.79)	3.42 (0.77)	3.45 (0.76)	3.42 (0.80)	3.45 (0.81)	3.41 (0.75)	3.28 (0.81)	3.27 (0.79)
Grade									
Freshman	705 (72.5)	3.66 (0.75)	3.64 (0.80)	3.70 (0.79)	3.66 (0.80)	3.74 (0.75)	3.66 (0.77)	3.64 (0.80)	3.51 (0.80)
Others[b]	267 (27.5)	3.38 (0.81)	3.40 (0.79)	3.45 (0.79)	3.47 (0.80)	3.50 (0.79)	3.42 (0.77)	3.40 (0.76)	3.30 (0.75)
BMI (kg/m²)									
≤23.99	853 (87.8)	3.56 (0.78)	3.56 (0.80)	3.63 (0.80)	3.61 (0.80)	3.68 (0.76)	3.58 (0.77)	3.55 (0.78)	3.45 (0.78)
≥24 to 27.99	119 (12.2)	3.70 (0.79)	3.65 (0.80)	3.67 (0.78)	3.63 (0.83)	3.67 (0.82)	3.67 (0.82)	3.69 (0.85)	3.53 (0.85)
Highest education attainment of mother[c]									
Level 1	508 (53.2)	3.56 (0.77)	3.56 (0.80)	3.63 (0.80)	3.62 (0.83)	3.67 (0.78)	3.57 (0.77)	3.54 (0.80)	3.43 (0.80)
Level 2	278 (29.1)	3.58 (0.80)	3.62 (0.77)	3.65 (0.80)	3.59 (0.79)	3.65 (0.76)	3.62 (0.79)	3.59 (0.79)	3.50 (0.80)
Level 3	93 (9.7)	3.66 (0.80)	3.56 (0.81)	3.65 (0.83)	3.65 (0.83)	3.71 (0.76)	3.65 (0.76)	3.62 (0.77)	3.53 (0.77)
Level 4	76 (8)	3.57 (0.74)	3.54 (0.84)	3.63 (0.78)	3.61 (0.75)	3.75 (0.75)	3.67 (0.76)	3.66 (0.78)	3.43 (0.75)

[a]Item 1 in Chinese eHealth Literacy Scale.

[b]Others: sophomores and above.

[c]Missing data=17 (17 reported that they did not know the highest educational attainment of their mothers). Level 1, elementary school and below; level 2, junior high school; level 3, high school or secondary school; and level 4, junior college and above.

Score Comparison Across Groups

All groups had mean scores of ≥3.0 or higher, with scores between genders being very close on most items, and men and women having the same mean score on item 1 (Table 1). Participants aged ≤19 years had the highest mean scores across all items (from 3.54 to 3.78), followed by participants aged 20

to 21 years (from 3.38 to 3.59) and then by participants aged ≥22 years (from 3.27 to 3.45). Similarly, freshmen scored higher than sophomores and above on all items. Participants with a BMI between 24 and 27.99 had higher mean scores for all items compared with those with a BMI ≤23.99 kg/m^2, and only slightly lower mean scores for item 5. The score differences were most pronounced for items 1 and 7, with the smallest differences for item 5. The highest mean scores for all items were found in the group in which the mother's highest level of education was high school or secondary school.

Response Distributions

In general, the responses to this tool were not evenly distributed across all levels. For all items, level 1 (strongly disagree) had the lowest percentage of responses, with item 4 and item 7 having the lowest percentage of responses at level 1, both at 0.6% (6/972). The proportion of responses at level 2 (disagree)

was the next lowest, ranging from 5.7% (55/972) for item 5 to 8.1% (79/972) for item 8. Some level 3 (undecided) and level 4 (agree) responses were close to each other compared with the distribution of the other levels. Level 4 had the highest percentage of responses and was the highest for item 5 (514/972, 52.9%). It is important to note that this pattern did not hold for item 8, as the proportion of responses at level 3 was higher than that at level 4 (414/972, 42.6%).

Internal Consistency Reliability and Item Statistics

Table 2 shows that the reliability of the scale was ideal, as the Cronbach α was 0.92 and the split-half reliability was 0.88. In addition, the results of the Cronbach α if item deleted analysis indicated that all items should be retained and that the item-total correlation coefficient was between 0.715 and 0.781. Item 8 was rated as the most difficult item (mean score of 3.46), whereas item 5 was rated as the easiest (mean score of 3.68). There was no floor or ceiling effect on any of the items.

Table 2. Internal consistency reliability and item statistics of the Chinese version of the eHealth Literacy Scale.

	Internal consistency reliability[a]		Item statistics		
	α if item deleted	Item-total correlation	Score, mean (SD)	Floor (n=972), n (%)	Ceiling (n=972), n (%)
Item 1[b]	.915	0.715	3.58 (0.78)	9 (0.9)	87 (9)
Item 2[c]	.912	0.750	3.57 (0.80)	8 (0.8)	94 (9.7)
Item 3[d]	.910	0.772	3.63 (0.79)	8 (0.8)	105 (10.8)
Item 4[e]	.914	0.725	3.61 (0.81)	6 (0.6)	106 (10.9)
Item 5[f]	.910	0.781	3.68 (0.77)	7 (0.7)	106 (10.9)
Item 6[g]	.914	0.725	3.59 (0.77)	7 (0.7)	92 (9.5)
Item 7[h]	.914	0.723	3.57 (0.79)	6 (0.6)	100 (10.3)
Item 8[i]	.914	0.727	3.46 (0.79)	10 (1)	73 (7.5)
Overall	N/A[j]	N/A	28.69 (5.08)[k]	4 (0.4)	42 (4.3)

[a]Cronbach α=.92; split-half reliability=0.88.

[b]I know what health resources are available on the internet.

[c]I know where to find helpful health resources on the internet.

[d]I know how to find helpful health resources on the internet.

[e]I know how to use the internet to answer my questions about health.

[f]I know how to use the health information I find on the internet to help me.

[g]I have the skills I need to evaluate the health resources I find on the internet.

[h]I can tell high-quality health resources from low-quality health resources on the internet.

[i]I feel confident using information from the internet to make health decisions.

[j]N/A: not applicable.

[k]The overall scores of the Chinese version of eHealth Literacy Scale range between 8 and 40.

Construct Validity and Convergent Validity

As presented in Tables 3 and 4, the results of the CFA showed that the 1-factor model had a poor fit, with high χ^2/df (16.325) and RMSEA (0.126). However, the standardized factor loadings for the 1-factor model were high, ranging from 0.751 to 0.811, indicating good item properties. The standard factor loadings ranged from 0.769 to 0.834 for the 2-factor-1 model and from 0.761 to 0.825 for the 2-factor-2 model. Similar to the 1-factor

model, both models suggested good fits based on the SRMR, CFI, and TLI, whereas RMSEA and χ^2/df showed poor fits. For 3-factor-1 model, the standard factor loadings ranged from 0.786 to 0.844, and among all 5 models, only this model had all the fit indicators that met the suggested cutoff values (χ^2/df=4.768, RMSEA=0.062, SRMR=0.020, CFI=0.987, TLI=0.979). Examination of the 3-factor-2 model revealed ideal SRMR, CFI, and TLI, but high χ^2/df and RMSEA values.

The results of the analysis of convergent validity are reported in Multimedia Appendix 3. C-eHEALS 1-dimensional factor structure models, two 2-factor models, and two 3-factor models all had standardized factor loadings of more than 0.50, AVE values >0.50, and CR values >0.70, indicating good convergent validity.

Table 3. Confirmatory factor analysis of 5 solutions for Chinese version of the eHealth Literacy Scale (part 1).

| 1-factor[a] | | 2-factor | | | | 3-factor | | | |
| Item | Estimate | 2-factor-1[b] | | 2-factor-2[c] | | 3-factor-1[d] | | 3-factor-2[e] | |
		Subdomain	Estimate	Subdomain	Estimate	Subdomain	Estimate	Subdomain	Estimate
1	0.753	Knowledge about resources	0.769	Information seeking	0.761	Awareness	0.805	Information awareness	0.807
2	0.787	Knowledge about resources	0.803	Information seeking	0.795	Awareness	0.844	Information awareness	0.841
3	0.811	Knowledge about resources	0.834	Information seeking	0.822	Skills	0.834	Information seeking	0.817
4	0.766	Knowledge about resources	0.777	Information seeking	0.773	Skills	0.786	Information seeking	0.814
5	0.819	Knowledge about resources	0.817	Information seeking	0.819	Skills	0.827	Information engagement	0.752
6	0.753	Evaluation of resources	0.814	Information seeking	0.742	Evaluate	0.814	Information engagement	0.787
7	0.751	Evaluation of resources	0.821	Information appraisal	0.825	Evaluate	0.821	Information engagement	0.790
8	0.754	Evaluation of resources	0.807	Information appraisal	0.822	Evaluate	0.807	Information engagement	0.789

[a]In accordance with the model proposed by Norman and Skinner [14].

[b]In accordance with the model proposed by Richtering et al [30]. Corresponding to the item number in the 1-factor model, items 1 to 5, 6 to 8 belong to the knowledge about resources and the evaluation of resources subdomain, respectively.

[c]In accordance with the model proposed by Soellner et al [29]. Corresponding to the item number in the 1-factor model, items 1 to 5 and 8, 6, and 7 belong to the information seeking and information appraisal subdomains, respectively.

[d]In accordance with the model proposed by Sudbury-Riley et al [33]. Corresponding to the item number in the 1-factor model, items 1 and 2, 3 to 5, and 6 to 8 belong to the awareness, the skills, and the evaluate subdomains, respectively.

[e]In accordance with the model proposed by Paige et al [35]. Corresponding to the item number in the 1-factor model, items 1 and 2, 3 and 5, 4 and 6 to 8 belong to the information awareness, the information seeking, and the information engagement subdomains, respectively.

Table 4. Confirmatory factor analysis of 5 solutions for Chinese version of the eHealth Literacy Scale (part 2).

	1-factor[a]	2-factor		3-factor	
		2-factor-1[b]	2-factor-2[c]	3-factor-1[d]	3-factor-2[e]
Chi-square (df)	326.499 (20)	119.551 (19)	241.950 (19)	81.051 (17)	210.129 (17)
Root mean square error of approximation	0.126	0.074	0.110	0.062	0.108
Standardized root mean squared residual	0.043	0.020	0.039	0.020	0.036
Comparative fit index	0.938	0.980	0.955	0.987	0.961
Tucker-Lewis index	0.913	0.970	0.934	0.979	0.936

[a]In accordance with the model proposed by Norman and Skinner [14].

[b]In accordance with the model proposed by Richtering et al [30]. Corresponding to the item number in the 1-factor model, items 1 to 5, 6 to 8 belong to the knowledge about resources and the evaluation of resources subdomain, respectively.

[c]In accordance with the model proposed by Soellner et al [29]. Corresponding to the item number in the 1-factor model, items 1 to 5 and 8, 6, and 7 belong to the information seeking and information appraisal subdomains, respectively.

[d]In accordance with the model proposed by Sudbury-Riley et al [33]. Corresponding to the item number in the 1-factor model, items 1 and 2, 3 to 5, and 6 to 8 belong to the awareness, the skills, and the evaluate subdomains, respectively.

[e]In accordance with the model proposed by Paige et al [35]. Corresponding to the item number in the 1-factor model, items 1 and 2, 3 and 5, 4 and 6 to 8 belong to the information awareness, the information seeking, and the information engagement subdomains, respectively.

Content Validity

A panel of experienced experts, including a professor, an associate professor, a graduate student, and 2 doctoral candidates with research expertise in health care, assessed the relevance of the 8 items in the scale. Items were rated on a 4-point Likert scale, where 1 indicated "not relevant," 2 indicated "marginally relevant," 3 indicated "quite relevant," and 4 indicated "strongly relevant." The I-CVI was calculated from the experts' relevance ratings for items 3 or 4, whereas the S-CVI/Ave was derived by averaging the proportional relevance judgments of all experts (Multimedia Appendix 4). Although S-CVI/Ave was slightly below 0.90, all 5 experts had I-CVIs equal to or above 0.80, indicating strong content validity for the 3-factor model [57].

Measurement Invariance

Table 5 describes the entire validation process of the cross-gender invariance measurement test based on the 3-factor model of Sudbury-Riley et al [33].

Table 5. Fit statistic summary for testing measurement invariance in the 3-factor solution of Sudbury-Riley et al [33].

Model	Chi-square (df)	Normed fit index	Incremental fit index	Tucker-Lewis index	Comparative fit index	Relative fit index	Root mean square error of approximation	Akaike information criterion	Model comparison, $\Delta\chi^2$ (Δdf)[a]
Model 1[a]	98.145 (34)	0.981	0.987	0.979	0.987	0.968	0.044	174.145	N/A[b]
Model 2[c]	101.124 (39)	0.980	0.988	0.982	0.988	0.971	0.041	167.124	2.979 (5)
Model 3[d]	113.937 (45)	0.978	0.986	0.983	0.986	0.972	0.040	167.937	15.792 (11)
Model 4[e]	176.239 (53)	0.965	0.975	0.974	0.975	0.963	0.049	214.239	78.094[f] (19)

[a]Model 1 is the configural model.

[b]N/A: not applicable.

[c]Model 2 is the measurement model.

[d]Model 3 is the structural model.

[e]Model 4 is the error variance invariance model.

[f]$P<.001$.

First, as stated in the Statistical Analysis section, the baseline model was successful in establishing configural invariance. Second, the measurement model was built on a configural model that constricted the equality of factor loadings between the 2 gender groups. The change in χ^2/df was not statistically significant, and the results (ΔNFI=−0.001, ΔIFI=0.001, ΔTLI=0.003, ΔCFI=0.001, ΔRFI=0.003, ΔRMSEA=−0.003) supported the factor loadings of each latent variable between

different groups being comparable, thus implying that the metric in variance (or weak invariance) was established. Furthermore, based on the measurement model, the structural model hypothesized that the factor variances and covariances are equal across genders. The results showed that the model did not deteriorate significantly (ΔNFI=−0.003, ΔIFI=−0.001, ΔTLI=0.004, ΔCFI=−0.001, ΔRFI=0.004, ΔRMSEA=−0.004), again the change in χ^2/df was not statistically significant, invariance was supported. Finally, we tested whether the error variance invariance had a cross-group equivalence. The change in chi-square (χ^2/df=4.110) was statistically significant at P<.001, implying that the error variance invariance was rejected. Moreover, the Akaike information criterion value for the measurement model (value=167.124) was lower than that of the models testing for configural (value=174.145) invariance, and the Δ values were well below the cutoff values (ΔNFI=−0.016, ΔIFI=−0.012, ΔTLI=0.005, ΔCFI=−0.012, ΔRFI=0.005, ΔRMSEA=0.005). Taken together, these results partially support strict invariance.

Discussion

Principal Findings

C-eHEALS is a valid and reliable instrument, unlike the previous validation of the Lily and 2-factor models that have been validated in the Chinese population [23,38,39,50]. We found that it is possible to have a multifaceted structure in the Chinese population, and after comparing the 5 representative models, the 3-factor model yielded the best results. This model responds to the following 3 factors: awareness, skills, and evaluate [33]. As eHEALS has received much attention, it has faced validity controversies [63-66], and because of this, research evidence of invariance measurement across countries is necessary when making cross-national comparisons [42-48]. To our knowledge, this is the first invariance measurement study conducted on C-eHEALS and contributes research evidence to support the measurement invariance of gender. These findings will help organizations revert to original social cognitive theory base of Norman and Skinner [14] in their strategy development to ensure that eHealth resources are developed and used as effectively as possible.

Comparison With Prior Work

In contrast to our undergraduate sample, the sample in a previous Chinese study was drawn from inpatients [38], chronic patients [50], general community residents [39], and rural populations [23]. In addition to the fact that our sample of undergraduates is different from the abovementioned studies, an important reason is that this sample is somewhat representative of the young adult population in China and has the characteristic of being active in web-based information searches.

In terms of study content, as we previously noted, the C-eHEALS multidimensional factor structure has not received much attention from Chinese researchers; therefore, we only found comparable results in the study by Xu et al [38]. First, the same situation appeared in both studies: in the fit analysis of the unidimensional structural model, χ^2/df and RMSEA were unsatisfactory, whereas the values of SRMR were acceptable

(whether the model was revised or not) [53-55]. Second, with the 2-factor solution of knowledge about resources versus evaluation of resources in eHEALS, the RMSEA of this study was acceptable but showed worse fit results in their initial 2-factor model [38]. Similar to the unidimensional model, χ^2/df was unsatisfactory in both studies, whereas the SRMR values were acceptable. The study by Xu et al [38] showed that the revised 2-factor model showed a better fit, and as this study did not involve model modification, we roughly compared the superior model of this study (3-factor-1) with it and found that the fit indices of the 2 models were relatively close.

This study provides preliminary evidence of invariance measures for the 3-factor structure of C-eHEALS. However, this cannot be compared with the results of other Chinese studies. Other studies on measurement invariance in languages other than the English language also considered invariance measures across gender, education level, and age groups [42-44].

In addition, this study follows the factor structure proposed by Sudbury-Riley et al [33], and it is important to note that the last nested invariance measurement model is different in the 2 studies; specifically, in their work, scalar invariance tests means factor loadings and intercepts are constrained, whereas the third model in our procedure is the error variance invariance model. As previous studies have pointed out, full invariance is difficult to obtain [49]. Although the error variances associated with each observed variable item are also part of the measurement model, testing their equality across groups is considered too stringent and is therefore rarely implemented [59]. Even so, although the change in χ^2 was significant in the last model tested in both studies, evidence for strict invariance is supported, considering that the changes in the other fit metrics were within the permissible range [61,62].

Limitations

Using undergraduates as a representative group of young adults loses the significance of the contrast from differences in educational attainment, as well as the contrast between urban and rural areas among young adults in China. Convenience and snowballing sampling methods may lack rigorous control of random sampling techniques, and the lack of control over participant selection may compromise the study's validity. The study's reliance on self-reported data may have introduced response biases, and in this study, social desirability bias was not negligible. As too few participants chose paper-and-pencil surveys in our mixed-mode surveys, we were not confident in conducting an invariance measurement test of paper-and-pencil versus electronic surveys. However, based on the popularity of electronic surveys, such tests are necessary. Furthermore, various invariance measurement test procedures will need to be carefully considered in future studies to make them more comparable with each other. More importantly, the translated version of the eHEALS as a measurement instrument may encounter language barriers that potentially affect respondents' comprehension and responses. Misinterpretations or misunderstandings because of linguistic differences may limit cross-cultural generalizability, thereby not fully capturing the cultural intricacies in the findings.

Conclusions

The 3-factor structure of awareness, skills, and evaluate, based on a combination of social cognitive and self-efficacy theories, can inspire health care practitioners and researchers regarding the development of interventions for eHealth literacy. This study provides evidence of measurement invariance across genders under the factor structure described above, providing evidence that variation in scores are due to differences in the structure and not due to differences in other confounding variables.

Conflicts of Interest

None declared.

Multimedia Appendix 1

The Chinese version of the eHealth Literacy Scale and the sociodemographic question items.
[XLSX File (Microsoft Excel File), 10 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Data set.
[XLSX File (Microsoft Excel File), 83 KB-Multimedia Appendix 2]

Multimedia Appendix 3

Convergent validity analysis of 5 solutions for Chinese version of the eHealth Literacy Scale.
[XLSX File (Microsoft Excel File), 12 KB-Multimedia Appendix 3]

Multimedia Appendix 4

Content validation form.
[DOCX File , 40 KB-Multimedia Appendix 4]

References

1. McMullan M. Patients using the internet to obtain health information: how this affects the patient-health professional relationship. Patient Educ Couns. 2006 Oct;63(1-2):24-28 [doi: 10.1016/j.pec.2005.10.006] [Medline: 16406474]
2. Bidmon S, Terlutter R. Gender differences in searching for health information on the internet and the virtual patient-physician relationship in Germany: exploratory results on how men and women differ and why. J Med Internet Res. 2015 Jun 22;17(6):e156 [FREE Full text] [doi: 10.2196/jmir.4127] [Medline: 26099325]
3. Chari R, Warsh J, Ketterer T, Hossain J, Sharif I. Association between health literacy and child and adolescent obesity. Patient Educ Couns. 2014 Jan;94(1):61-66 [doi: 10.1016/j.pec.2013.09.006] [Medline: 24120396]
4. Nelson MC, Story M, Larson NI, Neumark-Sztainer D, Lytle LA. Emerging adulthood and college-aged youth: an overlooked age for weight-related behavior change. Obesity (Silver Spring). 2008 Oct;16(10):2205-2211 [FREE Full text] [doi: 10.1038/oby.2008.365] [Medline: 18719665]
5. Frisch AL, Camerini L, Diviani N, Schulz PJ. Defining and measuring health literacy: how can we profit from other literacy domains? Health Promot Int. 2012 Mar;27(1):117-126 [doi: 10.1093/heapro/dar043] [Medline: 21724626]
6. Ishikawa H, Takeuchi T, Yano E. Measuring functional, communicative, and critical health literacy among diabetic patients. Diabetes Care. 2008 May;31(5):874-879 [doi: 10.2337/dc07-1932] [Medline: 18299446]
7. Liu YB, Liu L, Li YF, Chen YL. Relationship between health literacy, health-related behaviors and health status: a survey of elderly Chinese. Int J Environ Res Public Health. 2015 Aug 18;12(8):9714-9725 [FREE Full text] [doi: 10.3390/ijerph120809714] [Medline: 26295246]
8. Berkman ND, Davis TC, McCormack L. Health literacy: what is it? J Health Commun. 2010;15 Suppl 2:9-19 [doi: 10.1080/10810730.2010.499985] [Medline: 20845189]
9. Howard DH, Gazmararian J, Parker RM. The impact of low health literacy on the medical costs of medicare managed care enrollees. Am J Med. 2005 Apr;118(4):371-377 [doi: 10.1016/j.amjmed.2005.01.010] [Medline: 15808134]
10. Brørs G, Pettersen TR, Hansen TB, Fridlund B, Hølvold LB, Lund H, et al. Modes of e-Health delivery in secondary prevention programmes for patients with coronary artery disease: a systematic review. BMC Health Serv Res. 2019 Jun 10;19(1):364 [FREE Full text] [doi: 10.1186/s12913-019-4106-1] [Medline: 31182100]
11. Notice on issuing the national health informatization plan for the "14th five-year plan". National Health Commission of the People's Republic of China. URL: http://www.nhc.gov.cn/cms-search/xxgk/getManuscriptXxgk.htm?id=49eb570ca79a42f688f9efac42e3c0f1 [accessed 2023-11-28]
12. Outline of the 14th five-year plan (2021-2025) for national economic and social development and vision 2035 of the people's Republic of China. The People's Government of Fujian Province. URL: https://www.fujian.gov.cn/english/news/202108/t20210809_5665713.htm [accessed 2023-11-12]

13. Opinions of the general office of the state council on promoting the development of "internet + medical health". Office of the State Council China Government. 2018 Apr 28. URL: http://www.gov.cn/zhengce/content/2018-04/28/content_5286645.htm [accessed 2023-11-12]

14. Norman CD, Skinner HA. eHEALS: the eHealth literacy scale. J Med Internet Res. 2006 Nov 14;8(4):e27 [FREE Full text] [doi: 10.2196/jmir.8.4.e27] [Medline: 17213046]

15. Bandura A, Freeman WH, Lightsey R. Self-Efficacy: The Exercise of Control. Cham, Switzerland. Springer; 1999.

16. Bandura A. Organisational applications of social cognitive theory. Aust J Manag. 1988 Dec;13(2):275-302 [doi: 10.1177/031289628801300210]

17. Bandura A. Health promotion by social cognitive means. Health Educ Behav. 2004 Apr;31(2):143-164 [doi: 10.1177/1090198104263660] [Medline: 15090118]

18. Lee J, Lee EH, Chae D. eHealth literacy instruments: systematic review of measurement properties. J Med Internet Res. 2021 Nov 15;23(11):e30644 [doi: 10.2196/30644] [Medline: 34779781]

19. Brown CA, Dickson R. Healthcare students' e-literacy skills. J Allied Health. 2010;39(3):179-184 [Medline: 21174023]

20. Guo SJ, Yu XM, Sun YY, Nie D, Li XM, Wang L. Adaptation and evaluation of Chinese version of eHEALS and its usage among senior high school students. Chin J Health Educ. 2013;2:106 [doi: 10.16168/j.cnki.issn.1002-9982.2013.02.019]

21. He Y, Guo L, Zauszniewski JA, Wei M, Zhang G, Lei X, et al. A reliability and validity study of the electronic health literacy scale among stroke patients in China. Top Stroke Rehabil. 2023 Apr;30(3):272-280 [doi: 10.1080/10749357.2021.2016100] [Medline: 34927574]

22. Li SJ, Yin YT, Cui GH, Xu HL. The associations among health-promoting lifestyle, eHealth literacy, and cognitive health in older Chinese adults: a cross-sectional study. Int J Environ Res Public Health. 2020 Mar 27;17(7):2263 [FREE Full text] [doi: 10.3390/ijerph17072263] [Medline: 32230935]

23. Ma Z, Wu M. The psychometric properties of the Chinese eHealth literacy scale (C-eHEALS) in a Chinese rural population: cross-sectional validation study. J Med Internet Res. 2019 Oct 22;21(10):e15720 [FREE Full text] [doi: 10.2196/15720] [Medline: 31642811]

24. Chen S, Zhang Z, Yang J, Wang J, Zhai X, Bärnighausen T, et al. Fangcang shelter hospitals: a novel concept for responding to public health emergencies. Lancet. 2020 Apr 18;395(10232):1305-1314 [FREE Full text] [doi: 10.1016/S0140-6736(20)30744-3] [Medline: 32247320]

25. Hua J, Shaw R. Corona virus (COVID-19) "Infodemic" and emerging issues through a data lens: the case of China. Int J Environ Res Public Health. 2020 Mar 30;17(7):2309 [FREE Full text] [doi: 10.3390/ijerph17072309] [Medline: 32235433]

26. Brørs G, Norman CD, Norekvål TM. Accelerated importance of eHealth literacy in the COVID-19 outbreak and beyond. Eur J Cardiovasc Nurs. 2020 Aug;19(6):458-461 [FREE Full text] [doi: 10.1177/1474515120941307] [Medline: 32667217]

27. Zhao X, Fan J, Basnyat I, Hu B. Online health information seeking using "#COVID-19 patient seeking help" on Weibo in Wuhan, China: descriptive study. J Med Internet Res. 2020 Oct 15;22(10):e22910 [FREE Full text] [doi: 10.2196/22910] [Medline: 33001838]

28. Norman CD, Skinner HA. eHealth literacy: essential skills for consumer health in a networked world. J Med Internet Res. 2006 Jun 16;8(2):e9 [FREE Full text] [doi: 10.2196/jmir.8.2.e9] [Medline: 16867972]

29. Soellner R, Huber S, Reder M. The concept of eHealth literacy and its measurement. J Media Psychol. 2014 Jan;26(1):29-38 [doi: 10.1027/1864-1105/a000104]

30. Richtering SS, Morris R, Soh SE, Barker A, Bampi F, Neubeck L, et al. Examination of an eHealth literacy scale and a health literacy scale in a population with moderate to high cardiovascular risk: Rasch analyses. PLoS One. 2017 Apr 27;12(4):e0175372 [FREE Full text] [doi: 10.1371/journal.pone.0175372] [Medline: 28448497]

31. Gazibara T, Cakic J, Cakic M, Pekmezovic T, Grgurevic A. eHealth and adolescents in Serbia: psychometric properties of eHeals questionnaire and contributing factors to better online health literacy. Health Promot Int. 2019 Aug 1;34(4):770-778 [doi: 10.1093/heapro/day028] [Medline: 29800141]

32. Holch P, Marwood JR. eHealth literacy in UK teenagers and young adults: exploration of predictors and factor structure of the eHealth literacy scale (eHEALS). JMIR Form Res. 2020 Sep 08;4(9):e14450 [FREE Full text] [doi: 10.2196/14450] [Medline: 32897230]

33. Sudbury-Riley L, FitzPatrick M, Schulz PJ. Exploring the measurement properties of the eHealth literacy scale (eHEALS) among baby boomers: a multinational test of measurement invariance. J Med Internet Res. 2017 Feb 27;19(2):e53 [FREE Full text] [doi: 10.2196/jmir.5998] [Medline: 28242590]

34. Hyde LL, Boyes AW, Evans TJ, Mackenzie LJ, Sanson-Fisher R. Three-factor structure of the eHealth literacy scale among magnetic resonance imaging and computed tomography outpatients: a confirmatory factor analysis. JMIR Hum Factors. 2018 Feb 19;5(1):e6 [FREE Full text] [doi: 10.2196/humanfactors.9039] [Medline: 29459356]

35. Paige SR, Miller MD, Krieger JL, Stellefson M, Cheong J. Electronic health literacy across the lifespan: measurement invariance study. J Med Internet Res. 2018 Jul 09;20(7):e10434 [FREE Full text] [doi: 10.2196/10434] [Medline: 29986848]

36. Juvalta S, Kerry MJ, Jaks R, Baumann I, Dratva J. Electronic health literacy in Swiss-German parents: cross-sectional study of eHealth literacy scale unidimensionality. J Med Internet Res. 2020 Mar 13;22(3):e14492 [FREE Full text] [doi: 10.2196/14492] [Medline: 32167476]

37.   Paige SR, Krieger JL, Stellefson M, Alber JM. eHealth literacy in chronic disease patients: an item response theory analysis of the eHealth literacy scale (eHEALS). Patient Educ Couns. 2017 Feb;100(2):320-326 [FREE Full text] [doi: 10.1016/j.pec.2016.09.008] [Medline: 27658660]

38.   Xu RH, Zhou L, Lu SY, Wong EL, Chang J, Wang D. Psychometric validation and cultural adaptation of the simplified Chinese eHealth literacy scale: cross-sectional study. J Med Internet Res. 2020 Dec 07;22(12):e18613 [FREE Full text] [doi: 10.2196/18613] [Medline: 33284123]

39.   Peng XQ, Chen Y, Zhang YC, Liu F, He HY, Luo T, et al. The status and influencing factors of cyberchondria during the COVID-19 epidemic. A cross-sectional study in Nanyang city of China. Front Psychol. 2021 Nov 11;12:712703 [FREE Full text] [doi: 10.3389/fpsyg.2021.712703] [Medline: 34858254]

40.   Mitsutake S, Shibata A, Ishii K, Okazaki K, Oka K. [Developing Japanese version of the eHealth literacy scale (eHEALS)]. Nihon Koshu Eisei Zasshi. 2011 May;58(5):361-371 [Medline: 21905612]

41.   Gartrell K, Han K, Trinkoff A, Cho H. Three-factor structure of the eHealth literacy scale and its relationship with nurses' health-promoting behaviours and performance quality. J Adv Nurs. 2020 Oct;76(10):2522-2530 [doi: 10.1111/jan.14490] [Medline: 33463741]

42.   Marsall M, Engelmann G, Skoda EM, Teufel M, Bäuerle A. Measuring electronic health literacy: development, validation, and test of measurement invariance of a revised German version of the eHealth literacy scale. J Med Internet Res. 2022 Feb 02;24(2):e28252 [FREE Full text] [doi: 10.2196/28252] [Medline: 35107437]

43.   Baek JJ, Soares GH, da Rosa GC, Mialhe FL, Biazevic MG, Michel-Crosato E. Network analysis and psychometric properties of the Brazilian version of the eHealth literacy scale in a dental clinic setting. Int J Med Inform. 2021 Sep;153:104532 [doi: 10.1016/j.ijmedinf.2021.104532] [Medline: 34298425]

44.   Lin CY, Broström A, Griffiths MD, Pakpour AH. Psychometric evaluation of the Persian eHealth literacy scale (eHEALS) among elder Iranians with heart failure. Eval Health Prof. 2020 Dec;43(4):222-229 [doi: 10.1177/0163278719827997] [Medline: 30744419]

45.   Milfont TL, Fischer R. Testing measurement invariance across groups: applications in cross-cultural research. Int J Psychol Res. 2010 Jun 30;3(1):111-130 [doi: 10.21500/20112084.857]

46.   Diviani N, van den Putte B, Meppelink CS, van Weert JC. Exploring the role of health literacy in the evaluation of online health information: insights from a mixed-methods study. Patient Educ Couns. 2016 Jun;99(6):1017-1025 [doi: 10.1016/j.pec.2016.01.007] [Medline: 26817407]

47.   Suri VR, Majid S, Chang YK, Foo S. Assessing the influence of health literacy on health information behaviors: a multi-domain skills-based approach. Patient Educ Couns. 2016 Jun;99(6):1038-1045 [doi: 10.1016/j.pec.2015.12.017] [Medline: 26794667]

48.   Reder M, Soellner R. Factor structure of the eHEALS. Diagnostica. 2022 Oct;68(4):209-218 [FREE Full text] [doi: 10.1026/0012-1924/a000294]

49.   Chen YJ, Tang TL. Attitude toward and propensity to engage in unethical behavior: measurement invariance across major among university students. J Bus Ethics. 2006 Jul 5;69:77-93 [doi: 10.1007/s10551-006-9069-6]

50.   Chang A, Schulz PJ. The measurements and an elaborated understanding of Chinese eHealth literacy (C-eHEALS) in chronic patients in China. Int J Environ Res Public Health. 2018 Jul 23;15(7):1553 [FREE Full text] [doi: 10.3390/ijerph15071553] [Medline: 30041420]

51.   McHorney CA, Tarlov AR. Individual-patient monitoring in clinical practice: are available health status surveys adequate? Qual Life Res. 1995 Aug;4(4):293-307 [doi: 10.1007/BF01593882] [Medline: 7550178]

52.   DeVellis RF. Scale Development: Theory and Applications, 2nd Edition. Thousand Oaks, CA. SAGE Publications; 2003.

53.   Schumacker RE, Lomax RG. A Beginner's Guide to Structural Equation Modeling, Fourth Edition. New York, NY. Psychology Press; 2004.

54.   Tabachnick BG, Fidell LS. Using Multivariate Statistics, 7th Edition. London, UK. Pearson Education; Jul 14, 2021.

55.   Hu LT, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Modeling Multidiscip J. 1999;6(1):1-55 [doi: 10.1080/10705519909540118]

56.   Hair JF, Babin BJ, Anderson RE. Multivariate Data Analysis, 8th Edition. Boston, MA. Cengage; 2019.

57.   Polit DF, Beck CT, Owen SV. Is the CVI an acceptable indicator of content validity? Appraisal and recommendations. Res Nurs Health. 2007 Aug;30(4):459-467 [doi: 10.1002/nur.20199] [Medline: 17654487]

58.   Lenz ER, Strickland O, Waltz CF. Measurement in Nursing and Health Research. Cham, Switzerland. Springer; Apr 17, 2010.

59.   Byrne BM. Structural Equation Modeling With AMOS: Basic Concepts, Applications, and Programming. Milton Park, UK. Taylor & Francis; Apr 2001.

60.   Bollen KA, Long JS. Testing Structural Equation Models. Thousand Oaks, CA. SAGE Publications; Feb 1993.

61.   Denovan A, Dagnall N, Dhingra K, Grogan S. Evaluating the perceived stress scale among UK university students: implications for stress measurement and management. Stud High Educ. 2017 Jun 22;44(1):120-133 [doi: 10.1080/03075079.2017.1340445]

62.   Little TD. Mean and covariance structures (MACS) analyses of cross-cultural data: practical and theoretical issues. Multivariate Behav Res. 1997 Jan 01;32(1):53-76 [doi: 10.1207/s15327906mbr3201_3] [Medline: 26751106]

63. Collins SA, Currie LM, Bakken S, Vawdrey DK, Stone PW. Health literacy screening instruments for eHealth applications: a systematic review. J Biomed Inform. 2012 Jun;45(3):598-607 [FREE Full text] [doi: 10.1016/j.jbi.2012.04.001] [Medline: 22521719]

64. Hu X, Bell RA, Kravitz RL, Orrange S. The prepared patient: information seeking of online support group members before their medical appointments. J Health Commun. 2012;17(8):960-978 [doi: 10.1080/10810730.2011.650828] [Medline: 22574697]

65. van Deursen AJ, van Dijk JA. Internet skills performance tests: are people ready for eHealth? J Med Internet Res. 2011 Apr 29;13(2):e35 [FREE Full text] [doi: 10.2196/jmir.1581] [Medline: 21531690]

66. Jordan JE, Osborne RH, Buchbinder R. Critical appraisal of health literacy indices revealed variable underlying constructs, narrow content and psychometric weaknesses. J Clin Epidemiol. 2011 Apr;64(4):366-379 [doi: 10.1016/j.jclinepi.2010.04.005] [Medline: 20638235]

Abbreviations

AVE: average variance extracted
C-eHEALS: Chinese version of eHealth Literacy Scale
CFA: confirmatory factor analysis
CFI: comparative fit index
CR: composite reliability
eHEALS: eHealth literacy scale
I-CVI: item-level content validity index
IFI: incremental fit index
NFI: normed fit index
RFI: relative fit index
RMSEA: root mean square error of approximation
S-CVI/Ave: average of the item-level content validity index scores of all items on the scale
SRMR: standardized root mean squared residual
TLI: Tucker-Lewis index