Psychometric analysis of the eHealth Literacy Scale in Portuguese older adults (eHEALS-PT24)

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Abstract

Background: In this era of digitalization, eHealth interventions are used to engage patients in healthcare and help them manage their own health. Prior studies showed that this can be particularly interesting for chronic disease self-management and self-care in older adults. Despite of older adults becoming increasingly active on the Internet, they continue to struggle in seeking, finding, understanding, and evaluating health information from electronic sources, as well as applying the acquired knowledge to address or solve a health problem, due to lack or inadequate eHealth literacy. Thus, assessing and monitoring eHealth literacy is critical to support eHealth interventions and contribute to its effectiveness.

Objective: This study aimed to describe the process of translation, adaptation, and validation of eHealth Literacy Scale (eHEALS) in Portuguese older adults.

Methods: We adapted the eHEALS in Portuguese older adults and test its full psychometric properties by carrying out two studies: a) general psychometric analysis (n=80) (Study 1); b) confirmatory factor analysis (n=301) (Study 2). The cross-cultural adaption followed the steps of forward-(blind)backward translation, evaluation of the translations by a committee of judges, pilot testing, and full psychometric testing of the pre-final version of the scale.

Results: We tested stability, reliability, construct validity (exploratory and confirmatory factor analyses and hypothesis testing) and model fit. In Study 1, 58.8% of the respondents were male and 41.3% female, with ages between 65 and 88 years old. In Study 2, 56.5% were male and 43.5% female, with ages between 65 and 88 years old. Scale and items stability showed moderate and strong Pearson's correlations between all items (Study 1: 0.42?r?0.91; Study 2: 0.81?r?0.96), statistically significant (P<.001). Reliability was adequate for Study 1 (?=0.92) and Study 2 (?=0.98). The exploratory factor analysis yielded a single-factor structure, explaining 58,3% of the variance in Study 1 and 86,4% in Study 2. In confirmatory analysis (Study 2), the model fit was mixed: Chi-Square test was significant (?²=265, df=20, P<.001), CFI (0.94) and TLI (0.91) were acceptable, and RMSEA (0.20) indicated a poor fit. In such case, we compared one, two and three-factor structures, deciding for the unidimensional one. In Study 1, eHEALS-PT24 mean score was 27.25 (SD 5.61), with 43.8% of participants showing low levels of eHealth literacy and 11.3% high levels. In Study 2, eHEALS-PT24 mean score was 23.31 (SD 9.53), with 38.2% of participants showing low levels of eHealth literacy and 23.6% high levels. The analysis by subgroups showed statistically significant differences in demographic variables (age, residence area and education levels), with exception for gender.

Conclusions: The findings suggest eHEALS-PT24 as a reliable and valid instrument to assess eHealth literacy in Portuguese older adults. Therefore, this instrument can be integrated to support the implementation process of eHealth interventions.

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Abstract

Background: In this era of digitalization, eHealth interventions are used to engage patients in healthcare and help them manage their own health. Prior studies showed that this can be particularly interesting for chronic disease self-management and self-care in older adults. Despite of older adults becoming increasingly active on the Internet, they continue to struggle in seeking, finding, understanding, and evaluating health information from electronic sources, as well as applying the acquired knowledge to address or solve a health problem, due to lack or inadequate eHealth literacy. Thus, assessing and monitoring eHealth literacy is critical to support eHealth interventions and contribute to its effectiveness.
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Conclusions: The findings suggest eHEALS-PT24 as a reliable and valid instrument to assess eHealth literacy in Portuguese older adults. Therefore, this instrument can be integrated to support the implementation process of eHealth interventions.

Keywords: eHealth; health literacy; elderly; psychometric properties; public health

Introduction

The Internet is today the main source of health information. According to the survey Flash Eurobarometer 404 [1], 8 in 10 Europeans (80%) used the Internet for private matters, with the majority (59%) using it for health information searching purposes. The increasing number of Internet users has been influencing health systems globally, investing in the provision of eHealth services. In recent years, there have been great efforts to use eHealth interventions to engage patients in healthcare and help them manage their own health, particularly among older adults to chronic disease self-management and self-care [2-4]. However, despite the mass access to Internet and other electronic sources, there continues to be a lack of skills to access valid and reliable health information, as well as understand, evaluate, and apply it adequately for decision-making purposes [5-7]. Considering this condition, eHealth literacy has emerged as a new concept in healthcare and a challenge in public health [8].

According to Norman and Skinner [9], eHealth literacy is defined as ‘the ability to seek, find, understand, and evaluate information from electronic sources and apply to knowledge gained to address or solve a health problem. Based on this, individuals should be able to perform basic or advanced information retrieval, distinguish documents from reliable sources (e.g., authoritative ones or scientific evidence-based), and understand eHealth terminology. Furthermore, this set of skills requires the ability to use information and communication technologies (ICT), think critically about their nature and efficiently navigate in different electronic resources to obtain the information for health-related decision making.

Considering that eHealth literacy is not a static set of skills, changing over time, Norman and Skinner [9] consider the importance of assessing and monitoring eHealth literacy as critical to support eHealth interventions. In recent years, indeed, older adults have becoming increasingly active on the Internet and interested in digital health care services to manage their health, however, limited attention has been given to measure the eHealth literacy in this population. Therefore, we sought to address this gap by translating, cultural adapting and validating a scale for Portuguese older adults which measures eHealth literacy levels.

The eHEALS

The “eHEALS: The eHealth Literacy Scale” (eHEALS), developed by Norman and Skinner [10], was the most frequently used instrument to measure eHealth literacy worldwide, covering 18

languages, 26 countries, and diverse populations and contexts (i.e., adolescents, adults, elderly, patients, healthy people, caregivers, health school professionals, community, and clinical practice) [11]. Since its development the eHEALS has been widely translated, adapted and validated in several countries, such as Brazil [12], China [13-16], Ethiopia [17], Germany [18,19], Greece [20], Hungary [21], Indonesia [22], Iran [23,24], Italy [25,26], Netherlands [27]; Norway [28,29], Poland [30,31], Portugal [32], Serbia [33], South Corea [34-36], Spain [37], Sweden [38], and also in countries with English as mother language [39-47].

The scale's development study [10], assessed the eHealth literacy of Canadian adolescents (n=664) aged between 13 and 21 years old, from 14 secondary schools. Considering the psychometrics tests results, the instrument showed a good internal consistency (α=0.88), with moderate to strong correlations between items ($0.51 \leq r \leq 0.76$) and a test-retest with moderate reliability ($0.40 \leq r \leq 0.68$). Also, a unidimensional structure was found in exploratory and confirmatory factor analyses, explaining 56% of the total variance.

In Portugal, and similarly to the original study, the eHEALS was translated, adapted, and validated in 2014, in a sample of adolescents (n=1215) attending secondary education. The results showed a good internal consistency (α=0.84) and a two-factor structure in the exploratory factor analysis (extraction of two factors with α=0.81 and α=0.73), explaining 61% of the total variance. From a subgroup analysis, the authors found statistically significant differences regarding the level of education. Variables such as gender and age, no statistically significant differences were found. No further translation, adaptation, and validation studies of eHEALS considering other target populations or contexts in Portugal have been carried out since then [32].

Studies with samples including older adults [24,36,39,43,44,48] showed good internal consistencies, with Cronbach's alpha ranging between 0.87 and 0.99. Regarding factor analysis, three studies [24,36,39] obtained one-dimensional structures and two other studies three-dimensional ones [43,44].

The questionnaire itself consists of eight items assessing the person's perception in relation to knowledge, comfort, and ability to find, evaluate and apply health ICT. Each of the items is scored at five points on a *Likert* scale ranging between "1" (totally disagree) and "5" (totally agree), with a total score from 8 to 40 points. The higher the score, the higher the level of eHealth literacy. Items 1 and 2 are related to awareness, items 3 and 4 to demand, items 6 and 7 to the evaluation of health resources and items 5 and 8 to the use of health information. The instrument also contains two additional items, not counting to the final score, which assess the participant's perception of using the Internet to access health information and make health decisions in terms of its usefulness and importance. The theoretical basis of the eHEALS was the social cognitive theory of Albert Bandura, and the Lily Model, which explains multiple components of the constructs based on six components of literacies – traditional (literacy and numeracy skills), health, information, scientific, media, and computer [10].

This paper presents and discusses the results of full psychometric testing of the eHEALS-PT24, which aimed to:

- translate, cultural adapt and validate the eHEALS for assessing eHealth literacy in Portuguese older adults;
- test full psychometric characteristics of the eHEALS to be used in Portuguese older adults;
- explore associations between eHealth literacy and sociodemographic variables.

Methods

Design

We followed a methodology for translating, adapting and validating instruments proposed by Sousa and Rojjanasrirat [49] – a seven-step guideline based on the review of existing recommendations in the scientific literature on the process of translation, cultural adaptation, and validation of instruments for use in cross-cultural healthcare.

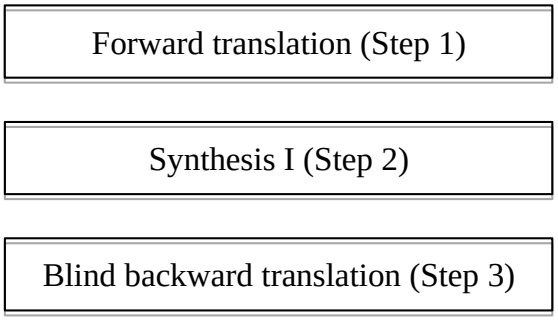
The original version of the questionnaire was independently translated to Portuguese by two translators with high proficiency in English: a translator with knowledge of the terminology used in healthcare; other, with knowledge of the cultural and linguistic characteristics of the population/target-language (forward translation) (Step 1). After this a third translator compared the two translated versions of the instrument and the original one to detect discrepancies. Also, a first meeting with a committee of experts with different backgrounds and expertise was held to evaluate discrepancies, composed by the two bilingual experts from the first step, the third bilingual translator, academia members and research team (Step 2). These two steps generated the preliminary translated version of the instrument for Portuguese language.

Independent blind backward translation to English was carried out by two translators whose mother language was English as spoken in United Kingdom: a translator with knowledge of the terminology used in healthcare; other, with knowledge of the cultural and linguistic characteristics of the population/target-language (Step 3). This step generated two retroverted versions of the original version of the instrument, which were then compared to the original one (in English) to detect discrepancies by the research team. Also, a second meeting with a committee of experts with different backgrounds and expertise was held to detect discrepancies, composed by all translators involved in the previous three steps, academia members and research team (Step 4). These two steps generated the pre-final version of the translated instrument, which was validated by the original authors.

The pre-final version of the instrument was then tested in a pilot study in the target language with a monolingual sample (n=15) to evaluate the instructions, items, and response format clarity (i.e., to establish whether the instrument could be satisfactorily understood and completed by people from the target population) (Step 5). As part of this step, a committee of experts was held to further examine the instrument for clarity of the instructions, items, and response format (content equivalence assessment). The fifth step generated some adjustments in the pre-final version of the instrument.

According to the protocol followed, step 6 (preliminary psychometric testing of the pre-final version of the translated instrument with a bilingual sample) is rarely used, except when a bilingual population is accessible, which justified the option of not carry it out in this validation process.

Full psychometric testing (Step 7) involved reviewing and refining the items of the final version of the eHEALS for Portuguese, as well as establishing stability, internal consistency, validity, and model fit. This step encompassed two sub-studies: general psychometric characteristics of the instrument (n=80) (Study 1); confirmatory factor analysis (n=301) (Study 2).



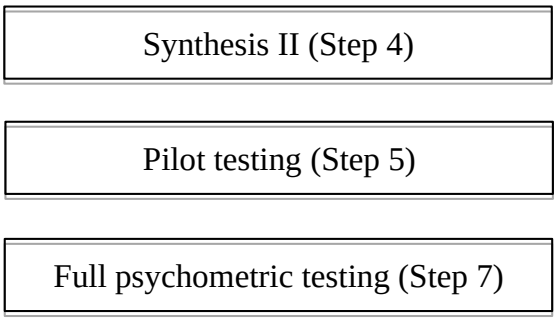


Figure 1. Steps of the protocol followed for translating, cultural adapting and validating the eHEALS.

Participants and recruitment

In Study 1, 80 older adults (aged 65 year or over) from general population were included. The sampling procedures were based on a convenience sample. Data collection was conducted by online questionnaire, between May and July 2022.
In Study 2, 301 older adults (aged 65 year or over) belonging of two Health Family Units (Primary Health Care) from Faro and Lisbon, namely: "*Ria Formosa* Health Family Unit" and "*CSI-Seixal* Health Family Unit" were included. The sampling procedures were based on a random sample. Data collection was conducted by online or in-person questionnaire, between May and July 2023.

Data analysis

The data analysis was conducted in several stages to ensure a comprehensive understanding of the psychometric properties of the eHEALS-PT24. The following steps outline our analytical approach:

Descriptive statistics
Initially, we performed descriptive statistical analyses to understand the basic features of the data. This included calculating means, standard deviations, frequencies, and percentages for all the variables, providing a snapshot of the sample characteristics.

Scale and items stability
To assess the scale and item stability, we calculated Pearson's correlations. We considered the following Pearson's correlation ranges: very weak (0.00-0.19), weak (0.20-0.39), moderate (0.40-0.59), strong (0.60 and 0.79), and very strong (0.80-0.99). Also, statistically significance when $P<.001$ [50].

Reliability analysis
To assess the internal consistency, we calculated Cronbach's alpha coefficients. A Cronbach's alpha value of 0.70 or higher was considered indicative of acceptable reliability [50].

Factor analysis
We conducted an Exploratory Factor Analysis (EFA) to explore the underlying factor structure of the scale. The Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity were used to assess the suitability of the data for factor analysis. Factors were extracted using principal component analysis and a Varimax rotation was applied to aid interpretability.

Following EFA, a Confirmatory Factor Analysis (CFA) was performed using structural equation modeling to verify the factor structure obtained from EFA. Model fit was evaluated using various indices including the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA) and Chi-square/df ratio.

Known-groups validity
To evaluate the known-groups validity, we compared eHEALS-PT24 scores across different sociodemographic groups (age, gender, residence area and education level) using independent t-Student tests, ANOVA or Kruskal-Wallis, as appropriate.

Statistical software
All analyses were performed using SPSS® and JAMOVI®.

By employing this multi-step analytical process, we aimed to rigorously evaluate the psychometric properties of the eHEALS-PT24, ensuring its reliability and validity in assessing eHealth literacy among Portuguese older adults.

Results

Pilot study

Prior to full psychometric testing, we carried out a pilot study, which we briefly summarize to support the results presented in this subchapter. The sampling procedure for piloting were based on a snowball sampling (n=15). Data collection was conducted by online questionnaire, between July and August 2020. The inter-rater agreement among the sample was above 80% for all items. As part of this step, a committee of experts was held to further examine the instrument for clarity of the instructions, items and response format; also, and to assess the content equivalence, content validity index at the item level (I-CVI=1) and at the scale level (S-CVI/Ave=1), as well as the (Fleiss) Kappa coefficient of agreement (K=0.24, P<.001) were calculated.

Participant's Characteristics

Study 1
The sample comprised 47 male (58.8%) and 33 female (41.3%) participants, with a mean age of 71 years old (SD 5.26), ranging from 65 and 88 years old. From the total sample (n=80), most of the participants were married/civil partner (n=63; 78.8%), living with their spouse (n=65; 81.3%) in urban area (n=70; 87.5%). Also, most of the respondents were retired (n=69, 86.3%). Regarding formal education, this was analysed according to the International Standard Classification of Education (ISCED), showing that the most general education level was upper secondary education – ISCED 3 (n=20; 25%), followed by primary education – ISCED 1 (n=17; 21.3%), and bachelor or equivalent degree – ISCED 6 (n=17; 21.3%). Concerning to the current health status, most participants reported a diagnosed chronic condition (n=58; 72.5%), mainly high blood pressure (n=29; 36.3%), diabetes (n=25; 31.2%) and dyslipidemia (n=8; 10%). Regarding prescribed medication, 85% of the sample (n=68) answered that they usually take medicines, with three being the average number of medicines per person and nine the maximum number. Sociodemographic data are presented in Table 1.

Study 2

The sample comprised 170 male (56.5%) and 131 female (43.5%) participants, with a mean age of 72 years old (SD 5.15), ranging from 65 and 88 years old. From the total sample (n=301), most of the participants were married/civil partner (n=215; 71.4%), living with their spouse (n=267; 88.7%) in urban area (n=267; 88.7%). Also, most of the respondents were retired (n=271; 90%). Regarding formal education, this was analysed according to the ISCED, showing that the most general education level was primary education – ISCED 1 (n=116; 38.5%), followed by lower secondary education – ISCED 2 (n=51; 17%) and bachelor or equivalent degree – ISCED 6 (n=37; 12.3%).

Concerning to the current health status, most participants reported a diagnosed chronic condition (n=252; 83.7%), mainly diabetes (n=179; 59.5%), dyslipidemia (n=45; 15%), and high blood pressure (n=116; 38.5%). Regarding prescribed medication, 93% of the sample (n=279) answered that they usually take medicines, with three being the average number of medicines per person and ten the maximum number.

Sociodemographic data of both studies are presented in Table 1.

Table 1. Sociodemographic data

	Study 1		Study 2	
	n	**%**	***n***	**%**
Total	80	100	301	100
Average age: 71.20 years				
Gender				
Female	33	41.25	131	43.52
Male	47	58.75	170	56.48
Marital status				
Single	1	1.25	11	3.65
Married/Civil partner	63	78.75	215	71.43
Divorced	9	11.25	27	8.97
Separated	0	0.00	2	0.66
Widowed/Surviving civil partner	7	8.75	46	15.28
Household status				
Lives alone	9	11.25	52	17.28
Lives with spouse	65	81.25	203	67.44
Lives with spouse and other relatives	3	3.75	25	8.31
Lives with other relatives	3	3.75	21	6.98
Residence area				
Urban area	70	87.50	267	88.70
Rural area	10	12.50	34	11.30
Formal education				
ISCED 1 Primary education	17	21.25	116	38.54
ISCED 2 Lower secondary education	5	6.25	22	7.31
ISCED 3 Upper secondary education	20	25.00	51	16.94
ISCED 4 Post-secondary but not tertiary education	8	10.00	22	7.31
ISCED 5 Short-cycle tertiary education	8	10.00	27	8.97
ISCED 6 Bachelor or equivalent level	17	21.25	50	16.61
ISCED 7 Master or equivalent level	2	12.50	6	1.99

	Study 1		Study 2	
	n	**%**	***n***	**%**
ISCED 8 Doctoral or equivalent level	3	3.75	7	2.33
Employment status				
Employed	6	7.50	15	4.98
Self-employed	3	3.75	9	2.99
Retired	69	86.25	271	90.03
Unemployed	0	0.00	2	0.66
Fulfilling domestic tasks	1	1.25	3	1.00
Other	1	1.25	1	0.33
Diagnosis of chronic condition				
Yes	58	72.50	252	83.72
No	22	27.50	49	16.28
Chronic condition (top 3)				
Diabetes	25	31.25	179	59.47
Dyslipidemia	8	10.00	45	14.95
High blood pressure	29	36.25	116	38.54
Usual prescribed medication				
Yes	68	85.00	279	92.69
No	12	15.00	22	7.31
No. of medicines (mean):	3.10		3.10	

Stability

Study 1

From the stability's analysis (Pearson's correlation) of the eHEALS-PT24 we concluded correlations between all items of the scale, ranging between moderate and strong (with exception for one very strong correlation), statistically significant (*P*<.001), meaning questions related to the instrument with no redundancy. The lowest correlation value (r=0.42) was between items 1 and 8 (moderate correlation). In turn, the highest value (r=0.91) was a very strong correlation between items 2 and 3 (Table 2).

Study 2

From the stability's analysis (Pearson's correlation) of the eHEALS-PT24 we concluded correlations between all items of the scale, ranging between moderate and strong (with exception of one very strong value), statistically significant (*P*<.001), meaning questions related to the instrument with no redundancy. The lowest correlation value (r=0.81) was between items 1 and 8 (strong correlation). In turn, the highest value (r=0.96) was a very strong correlation between items 2 and 3 (Table 2).

Table 2. Lower triangle - Pearson's correlation (Study 1); Upper triangle - Pearson's correlation (Study 2)

		Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8
Item 1		1	0.91*	0.90*	0.87*	0.87*	0.83*	0.82*	0.81*
Item 2	*r*	0.66*	1	0,96*	0,90*	0,88*	0.86*	0.83*	0.83*
Item 3	*r*	0.59*	0.91*	1	0,90*	0,90*	0.86*	0.83*	0.83*
Item 4	*r*	0.60*	0.71*	0,63*	1	0,93*	0.87*	0.85*	0.83*
Item 5	*r*	0.59*	0.69*	0.65*	0.76*	1	0.87*	0.85*	0.85*
Item 6	*r*	0.44*	0.61*	0.54*	0.60*	0.55*	1	0.87*	0.83*
Item 7	*r*	0.51*	0.52*	0.45*	0.64*	0.55*	0.70*	1	0.85*
Item 8	*r*	0.42*	0.46*	0.47*	0.42*	0.45*	0.46*	0.47*	1

* *P*<.001

Reliability

Study 1

The analysis of the internal consistency of the eHEALS-PT24 showed an adequate Cronbach's alpha coefficient (α=0.92), meaning a well understood instrument by participants. Statistics after excluding one of the eight items did not indicate an increase in reliability: the value of the Cronbach's alpha ranged from 0.90 and 0.92 (Table 4). The mean total value in the eHealth literacy for the sample (n=80) was 27.25 (SD 5.61). The average score for each item was 3.0, ranging between 3.09 (item 8) and 3.55 (item 1) (Table 3).

Study 2

The analysis of the internal consistency of the eHEALS-PT24 showed an adequate Cronbach's alpha coefficient (α=0.98), meaning a well understood instrument by participants. Statistics after excluding one of the eight items did not indicate an increase in reliability, with the Cronbach's alpha coefficient values remaining stable at 0.98 (Table 3). The mean total value in the eHealth literacy for the sample (n=301) was 23.31 (SD 9.53). The average score for each item was 3.0, ranging between 2.70 (item 8) and 2.99 (items 1 and 4) (Table 3).

Table 3. eHEALS-PT24 means, scale reliability after removing an item, and item-total correlation

	Items	Mean (SD[a])	Mean if item deleted	α if item deleted	Variance of the scale if item deleted	Item-to-total correlation
Study 1 (n=80)	Item 1	3.55 (0.80)	23.70	0.907	25.35	0.68
	Item 2	3.53 (0.87)	23.73	0.894	23.52	0.83
	Item 3	3.51 (0.87)	23.74	0.900	24.09	0.77
	Item 4	3.49 (0.94)	23.76	0.898	23.35	0.79
	Item 5	3.40 (0.88)	23.85	0.900	24.05	0.77
	Item 6	3.34 (0.94)	23.91	0.906	24.11	0.70
	Item 7	3.35 (0.89)	23.90	0.907	24.60	0.69
	Item 8	3.09 (0.87)	24.16	0.918	25.78	0.55
	Mean (SD) sum score	27.25 (5.61)				
Study 2 (n=301)	Item 1	2.99 (1.27)	20.33	0.978	69.58	0.91
	Item 2	2.95 (1.30)	20.37	0.977	68.89	0.94
	Item 3	2.97 (1.28)	20.34	0.977	69.08	0.94
	Item 4	2.99 (1.30)	20.32	0.977	68.99	0.93
	Item 5	2.96 (1.28)	20.35	0.977	69.31	0.94
	Item 6	2.88 (1.26)	20.43	0.978	70.10	0.91
	Item 7	2.87 (1.24)	20.44	0.979	70.74	0.89
	Item 8	2.70 (1.22)	20.61	0.980	71.27	0.88
	Mean (SD) sum score	23.31 (9.53)				

[a]SD: standard deviation. [b]All item-to-total correlations were significant as P<0,001.

(Construct) Validity - Exploratory factor analysis

Bartlett's Sphericity test corroborated the factorability of the correlation matrix for both studies (Study 1: X^2=446.87, P<.001; Study 2: X^2=3932.81, P<.001). Also, the Kaiser-Meyer-Olkin (KMO) test value demonstrated adequate sampling for both studies (Study 1: KMO=0.87; Study 2: KMO=0.94). Given the quality of Bartlett and KMO values, the criteria for factor analysis were gathered. By performing the exploratory factor analysis (EFA), we considered factors with eigenvalues above 1 for testing the structure of the instrument. In accordance with the original structure of the eHEALS [10], the Jamovi® extracted one factor for the structure of the eHEALS-PT24 for both studies (Study 1 and 2).

Study 1

In the EFA of Study 1 (n=80), a single factor showed moderate to strong loadings (0.57 to

0.89) (Table 4) but poor model fit indicators: Root Mean Square Error of Approximation (RMSEA) was high (0.20), Tucker-Lewis Index (TLI) below the threshold (0.79), and a significant Chi-square test (χ^2=83.7, df=20, *P*<.001). The factor explained 58.3% of the total variance.

Study 2

In the EFA of Study 2 (n=301), a single factor showed moderate to strong loadings (0.89 to 0.95) but poor model fit indicators: RMSEA was high (0.20), TLI below the threshold (0.91), and a significant Chi-square test (χ^2=271, df=20, *P*<.001). The factor explained 86.4% of the total variance.

Table 4. Factor loadings after Varimax rotation

	Study 1 (n=80)	Study 2 (n=301)
Items eHEALS-PT24	**Factor 1**	**Factor 1**
Item 1	0.72	0.92
Item 2	0.89	0.95
Item 3	0.82	0.95
Item 4	0.84	0.95
Item 5	0.81	0.95
Item 6	0.72	0.92
Item 7	0.70	0.90
Item 8	0.57	0.89

The single factor structure of eHEALS-PT24 for both studies (Study 1 and 2) was also empirically confirmed on screen plots (Figure 1).

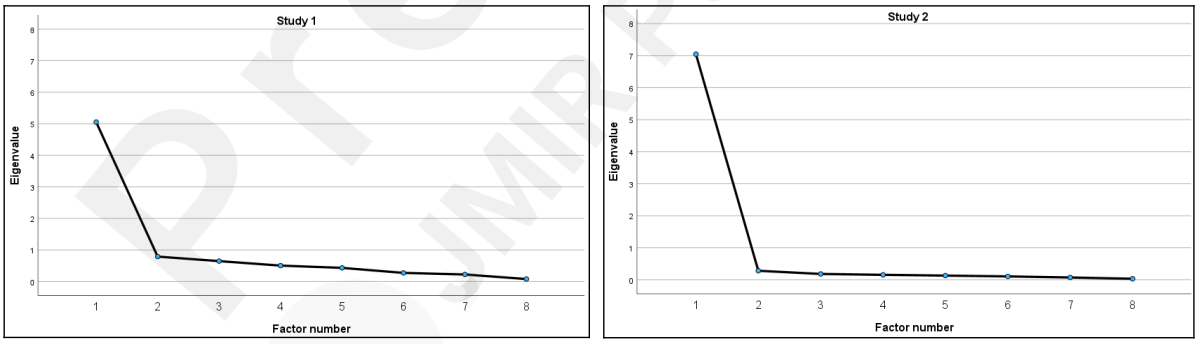


Figure 1. Screen plots for eHEALS-PT24 (Study 1 and 2)

(Construct) Validity – Confirmatory factor analysis

Regarding CFA for Study 2 (n=301), a single-factor model demonstrated high item loadings (standardized estimates 0.88 to 0.97) (Table 5). However, the model fit was mixed: Chi-Square test was significant (χ^2=265, df=20, *P*<.001), Comparative Fit Index (CFI) was acceptable (0.94), while TLI (0.91) was marginally acceptable, and RMSEA (0.20) indicated a poor fit. This suggesting the model may not fit the data well.

Given the RMSEA values obtained for one dimension, and due the variability of factor structures in the literature, we compared the indexes for one, two and three-factor structures for Study 2 (Table 6).

For two factors model we followed Tomas and Colleagues [32], dividing items 1-5 (factor 1) and items 6-8 (factor 2). High item loadings (standardized estimates 0.90 to 0.97) were obtained (Table 5). However, the model fit was mixed: CFI was acceptable (0.96), while TLI (0.94) was marginally acceptable, and RMSEA (0.17) indicated a poor fit. The Chi-Square test was significant (χ^2=188, df=19, *P*<.001), suggesting the model may not fit the data well.

For three factors model we followed Stellefson and Colleagues [43], dividing items 1-2 (factor 1), items 3-5 (factor 2), and items 6-8 (factor 3). High item loadings (standardized estimates 0.90 to 0.98) were obtained (Table 5). However, the model fit was mixed: CFI was acceptable (0.96), while TLI (0.93) was marginally acceptable, and RMSEA (0.18) indicated a poor fit. The Chi-Square test was significant (χ^2=179, df=17, *P*<.001), suggesting the model may not fit the data well.

Table 5. Factor loadings after Varimax rotation

	Study 2 (n=301)	Study 2 (n=301)		Study 2 (n=301)		
Items eHEALS-PT24	**Factor 1**	**Factor 1**	**Factor 2**	**Factor 1**	**Factor 2**	**Factor 3**
Item 1	0.93	0.93		0.94		
Item 2	0.96	0.97		0.98		
Item 3	0.97	0.97			0.97	
Item 4	0.94	0.94			0.94	
Item 5	0.94	0.94			0.94	
Item 6	0.91		0.93			0.93
Item 7	0.89		0.93			0.93
Item 8	0.88		0.90			0.90

Table 6. Global model fit indices

Indices	1 Factor	2 Factors	3 Factors
RMSEA (90% CI)	0.20	0.17	0.18
CFI	0.94	0.96	0.96
TLI	0.91	0.94	0.93
Chi-square test, *P* value	<.001	<.001	<.001

Interpretation of the eHEALS-PT24 scores

To determine high or low eHealth literacy levels, we based on the mean total and standard deviation values. Therefore, participants were divided into two groups for each study:

- Study 1: (1) low level of eHealth literacy (≤27 points); (2) high level of eHealth literacy (>32 points);
- Study 2: (1) low level of eHealth literacy (≤23 points); (2) high level of eHealth literacy (>31 points).

In Study 1, 35 participants (43.8%) had low levels of eHealth literacy and 9 (11.3%) high levels. In Study 2, 115 participants (38.2%) had low levels of eHealth literacy and 71 (23.6%) high levels.

(Construct) Validity – Hypothesis testing

We performed hypothesis testing for study 2, as presented in the following subchapters.

Association between eHealth literacy and age (Student's t-test and Pearson's correlation)
To analyze the association between eHealth literacy and age participants were distributed into two different groups: (1) 65-79 years old (elderly); (2) ≥80 years old (great elderly). The first group comprised a total of 269 participants (89.4%) and the second a total of 32 participants (10.6%). The analysis showed differences statistically significant between the level of eHealth literacy (total scale value) and age (t=3.94, *P*<.001). Elderly individuals had on average 7.0 points higher of eHEALS scores than great elderly. We also carried out a correlation analysis between both variables (Pearson's correlation), which showed that variables are inversely related, which means the greater one variable the smaller the other (r=-0.355, *P* <.001).

Association between eHealth literacy and gender (Student's t-test)
Female respondents showed an average of 23.68 points (SD 9.89) and males 23.03 points (SD 9.26), however, no statistically significant differences between eHealth literacy levels (total scale value) and gender were found (t=0.59; *P*=.309).

Association between eHealth literacy and residence area (Student's t-test)

Statistically significant differences between eHealth literacy levels (total scale value) and residence area were found (t=4.19, *P*<.001). Participants living in urban area showed an average of 24.11 points (SD 9,16) and those living in rural area 17.03 points (SD 10.15).

Association between eHealth literacy and education level (One-way ANOVA or Kruskal-Wallis)
Statistically significant differences between eHealth literacy levels (total scale value) and education level were found (F=10.24, *P*<.001), with the highest mean values corresponding to the education levels of Doctoral or equivalent level (ISCED 8) ($\bar{x}$=31.57, SD 4.20), Master or equivalent (ISCED 7) ($\bar{x}$=29.17, SD 5.60), and Post-secondary but not tertiary education (ISCED 4) ($\bar{x}$=27.68, SD 8.52). Since some of the education levels had non-representative samples (ISCED 2,4,5,7 and 8), we tested the association between eHealth literacy and education level using Kruskal-Wallis (H=58.56, *P*<.001). In this analysis, we found statistically significant differences between participants with primary education (ISCED 1) and all other education levels, with exception for lower secondary education (ISCED 2) and Master or equivalent (ISCED 7). No more statistically significant differences were found.

Means, standard deviations and significance of eHEALS-PT24 by subgroups (age, gender, residence area and education level) calculated in Study 2 are presented in Table 6.

Table 6. Means, standard deviations and significance of eHEALS-PT24 by subgroups (Study 2)

Variable	Level	Frequency (n)	%	eHEALS-PT24 ($\bar{x}$)	eHEALS-PT24 *(SD)*	eHEALS-PT24 ***(P)***
Age	65-79 years old	269	89.37	24.04	9.23	<.001
	≥ 80 years old	32	10.63	17.19	9.99	
Gender	Female	131	43.52	23.68	9.89	0.558
	Male	170	56.48	23.03	9.26	
Residence area	Urban	267	88.70	24,11	9.16	<.001
	Rural	34	11.30	17,03	10.15	
Education level	ISCED 1 – Primary education	116	38.54	17.84	9.91	<.001*
	ISCED 2 – Lower secondary education	22	7.31	24.86	8.67	
	ISCED 3 – Upper secondary education	51	16.94	26.67	7.25	
	ISCED 4 – Post-secondary but not tertiary education	22	7.31	27.68	8.52	
	ISCED 5 – Short-cycle tertiary education	27	8.97	27.07	6.71	
	ISCED 6 – Bachelor or equivalent level	50	16.61	26.08	7.62	
	ISCED 7 – Master or equivalent level	6	1.99	29.17	5.60	
	ISCED 8 – Doctoral or equivalent level	7	2.33	31.57	4.20	

*ANOVA and Kruskal-Wallis

Discussion

Principal Results

In this paper we have presented the translation, cultural adaptation, and validation of the eHEALS for Portuguese older adults (eHEALS-PT24) by carrying out a general psychometric analysis with a sample of 80 participants (Study 1), and a confirmatory factor analysis with a sample of 301 participants (Study 2). For this discussion, we highlight the findings obtained in Study 2 since it represents the final stage of the validation of eHEALS-PT24, according to the followed protocol [49].

Based on scale and items stability and reliability analysis, we concluded that eHEALS-PT24 is a reliable and valid instrument for measuring eHealth literacy. Correlations between all items of the eHEALS-PT24, ranging between moderate and strong ones, with statistically significance, indicated questions related to the instrument with no redundancy. Also, the instrument showed a good internal consistency, meaning a well understood instrument by participants. All items were considered valid to assess eHealth literacy levels in older adults, with very strong correlations between each other. Compared to the original study [10], internal consistency was higher (α=0.98), which is comparable with previous studies in older adults [24,36,39,43-44,48]. The only study showing a higher Cronbach's alpha than ours was a validation in older Hispanics [48] (α=0.99), but the sample was small (n=20), which was pointed out as a limitation on the referred study.

The eHEALS was originally developed with a single-factor structure [10], and in our study the same structure was yielded in EFA. Regarding CFA, a single-factor model demonstrated high item loadings (standardized estimates 0.88 to 0.97), however, the model fit was mixed: Chi-Square test was significant (χ^2=265, df=20, *P*<.001), CFI (0.94) and TLI (0.91) were both acceptable, and RMSEA (0.20) indicated a poor fit. The finding of a unidimensional structure also aligns with other studies applied in older adults [24,36,39], however, it contradicts the results of the two other studies carried out in older adults which obtained three-dimensional structures [43,44]. This variability of factor structures, and the RMSEA value obtained, led us to compare the indexes (i.e., Chi-Square, CFI, TLI, and RMSEA) for one, two and three-factor structures. All indexes fitted well, but RMSEA remained poor (0.20 for one factor; 0.17 for two factors and 0.18 for three factors), suggesting that the model may not fit the data well, what also happened in a previous study [36]. At the end, we decided for one-factor structure.

The eHEALS-PT24 mean score was 23.31 (SD 9.53), with 38.2% of participants showing low levels of eHealth literacy and 23.6% high levels. The average score for each item was 3.0, ranging between 2.70 (item 8) and 2.99 (items 1 and 4). Compared to other validations for older adults, the mean score is higher than Spain ($\bar{x}$=22,35; SD 12.96) [48], but lower than in China ($\bar{x}$=30.94; SD 6.00) [39] and in United States ($\bar{x}$=29.05; SD 5.75) [43].

The analysis by subgroups showed statistically significant differences in demographic variables (age, residence area and education levels), with exception for gender. We concluded that the greater the age the smaller the eHealth literacy (*P*<.001). Elderly (65-79 years old) had on average 7.0 points higher of eHEALS scores than great elderly (≥80 years old). Female respondents had on average 0.65 points higher eHEALS scores than

males, however, no statistically significant differences between eHealth literacy levels (total scale value) and gender were found (P=.309). The association of eHEALS and the residence area was statistically significant (P<.001), with participants living in urban area having on average 7,08 points higher of eHEALS scores than those living in rural area. Regarding education levels, the highest mean values corresponded to Doctoral or equivalent level (ISCED 8) ($\bar{x}$=31.57, SD 4.20), Master or equivalent (ISCED 7) ($\bar{x}$=29.17, SD 5.60), and post-secondary but not tertiary education (ISCED 4) ($\bar{x}$=27.68, SD 8.52). Despite of this, this result should be read with cautions since some education levels cases had non-representative samples (n<30). Therefore, we can argument that participants primary education (ISCED 1) had significant differences with all other education levels, with exception for lower secondary education (ISCED 2) and Master or equivalent (ISCED 7).

Limitations

There are some limitations in this study. Firstly, data was obtained both in online or in-person questionnaire. Secondly, the impossibility of generalizing the results to the elderly Portuguese population. Thirdly, eHEALS instrument measures a narrow scope of eHealth literacy may not fully capture the complex concept of the eHealth literacy at the moments since it was developed before social media era (Web 2.0). Nevertheless, the benefits of eHEALS (strong psychometric properties, brevity, and utility) outweigh its shortcoming, and the eHEALS arguably serves as a convenient instrument for health professionals.

Conclusions

In conclusion, the eHEALS-PT24 is a reliable and valid instrument to assess and monitor eHealth literacy of Portuguese older adults. This instrument will be useful in identifying older adults who may be able to use eHealth resources and participate in eHealth interventions aiming at engaging them in health care and helping them to manage their own health and, by extension, assess the effects of eHealth interventions. Further studies are needed employing the eHEALS-PT24 in a more representative sample of Portuguese older adults.

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Conflicts of Interest

None declared.

Abbreviations

CFI: Comparative fit index

EFA: Exploratory factor analysis

eHEALS: Health Literacy Scale

eHealth: Digital health

ICT: Information and communication technologies

ISCED: International Standard Classification of Education

KMO: Kaiser-Meyer-Olkin

RMSEA: Root mean square error of approximation

SPSS: Statistical Package for the Social Sciences®

TLI: Tucker-Lewis index

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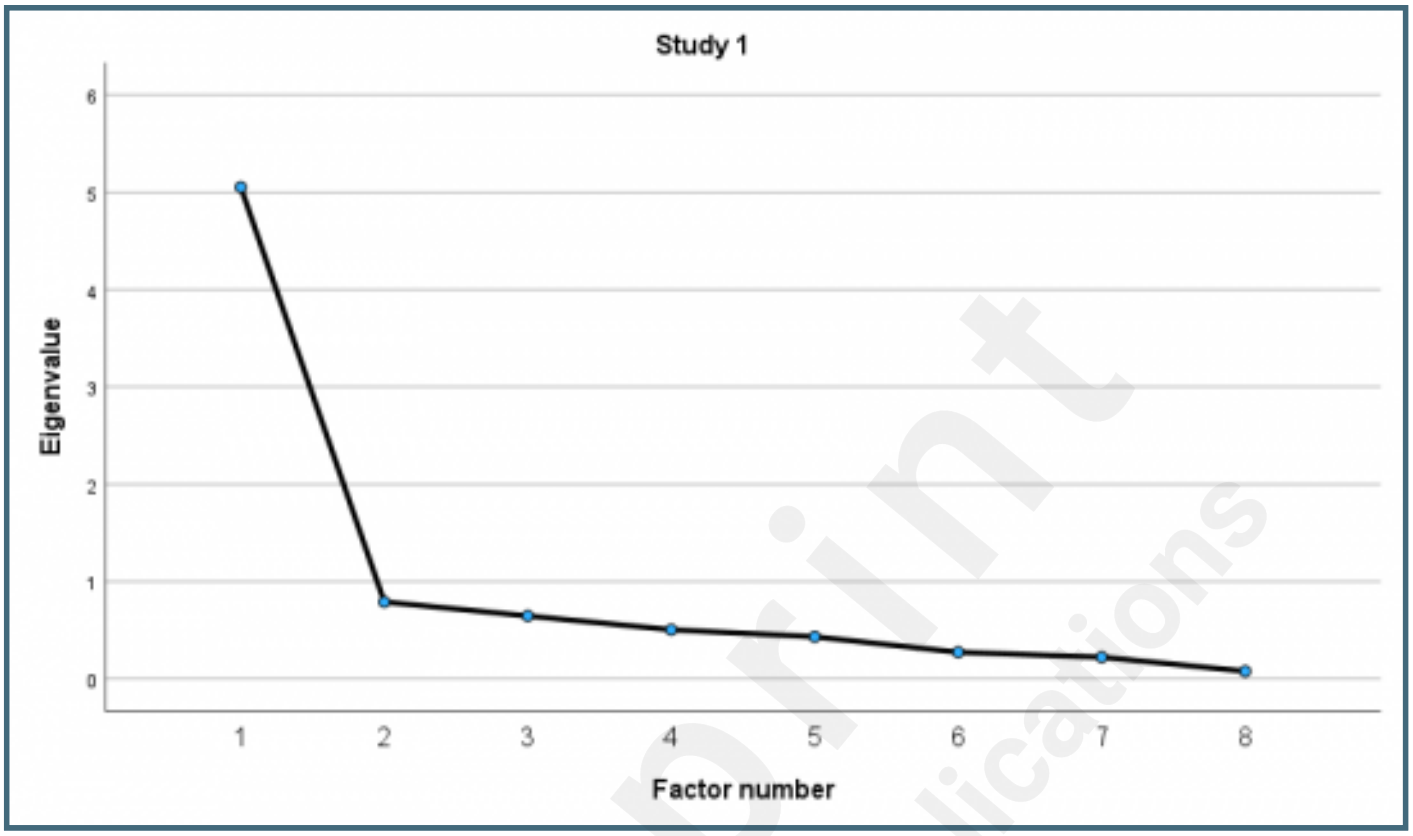
Supplementary Files

Figures

Screen plot for eHEALS-PT24 (Study 1).



Screen plot for eHEALS-PT24 (Study 2).