Rasch Analysis of the Mobile Version of the eHealth Literacy Scale (m-eHEALS) in Cardiovascular Disease Patients

Yuhan Zhao, Yuan Luo, Yiqun Miao, Qiaoling Hou, NAMUNA DALLAKOTI, Ying Wu

Submitted to: Journal of Medical Internet Research
on: June 11, 2024

Table of Contents

Rasch Analysis of the Mobile Version of the eHealth Literacy Scale (m-eHEALS) in Cardiovascular Disease Patients

Yuhan Zhao[1]; Yuan Luo[1]; Yiqun Miao[1]; Qiaoling Hou[1]; NAMUNA DALLAKOTI[1]; Ying Wu[1]

[1]Capital Medical University Bei Jing CN

Corresponding Author:
Yuhan Zhao
Capital Medical University
??????????????10???????
Bei Jing
CN

Abstract

Background: Cardiovascular disease (CVD) is a leading global health issue with rising morbidity and mortality rates. Despite medical progress, effective self-management remains a challenge due to limited health knowledge among patients. The emergence of information technology offers new solutions for online self-management, but its success hinges on eHealth literacy. The m-eHEALS aim to assess this literacy, yet they have limitations, particularly in comprehensiveness and application to diverse populations.

Objective: To assess the m-eHEALS psychometric properties for CVD patients with Rasch analysis.

Methods: atients from neurology and cardiology departments in two Beijing hospitals were selected through continuous inclusion from February 20 to May 4, 2023. The study involved m-eHEALS and demographic information to examine CVD patients, focusing on unidimensionality, item fit, reliability, difficulty, item characteristic curve, and differential item functioning (DIF) using Rasch analysis.

Results: The scale divided into three dimensions showed items in the self-perception dimension aligning well, but items N4, N5, N6, N10, and N11 had poor fit. The person separation index was 4.02 (reliability = 0.94), and the item separation index was 8.96 (reliability = 0.99), with no ceiling or floor effect. DIF analysis revealed a 0.71 logit difference between genders for item N12.

Conclusions: The m-eHEALS has good psychometric properties in CVD patients, despite some items poorly matching subjects, suggesting future refinements and focus on subgroup characteristics to enhance scale accuracy and applicability.

(JMIR Preprints 11/06/2024:63128)
DOI: https://doi.org/10.2196/preprints.63128

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Rasch Analysis of the Mobile Version of the eHealth Literacy Scale (m-eHEALS) in Cardiovascular Disease Patients

Yuhan Zhao[1], Yuan Luo[1], Yiqun Miao[1], Qiaoling Hou[1], Namuna Dallakoti[1], Ying Wu[1],PhD, Prof Dr

Author Affiliations:

1. School of Nursing, Capital Medical University, Beijing, China

E-mail:

Yuhan Zhao: zyh3046432371@163.com.

Correspondence author:

Ying Wu, PhD, Prof Dr.

School of Nursing

Capital Medical University.

E-mail: helenywu@vip.163.com

Abstract

Background: Cardiovascular disease (CVD) is a leading global health issue with rising morbidity and mortality rates. Despite medical progress, effective self-management remains a challenge due to limited health knowledge among patients. The emergence of information technology offers new solutions for online self-management, but its success hinges on eHealth literacy. The m-eHEALS aim to assess this literacy, yet they have limitations, particularly in comprehensiveness and application to diverse populations. **Objective:** To assess the m-eHEALS psychometric properties for CVD patients with Rasch analysis. **Methods:** Patients from

neurology and cardiology departments in two Beijing hospitals were selected through continuous inclusion from February 20 to May 4, 2023. The study involved m-eHEALS and demographic information to examine CVD patients, focusing on unidimensionality, item fit, reliability, difficulty, item characteristic curve, and differential item functioning (DIF) using Rasch analysis. **Results:** The scale divided into three dimensions showed items in the self-perception dimension aligning well, but items N4, N5, N6, N10, and N11 had poor fit. The person separation index was 4.02 (reliability = 0.94), and the item separation index was 8.96 (reliability = 0.99), with no ceiling or floor effect. DIF analysis revealed a 0.71 logit difference between genders for item N12. **Conclusion:** The m-eHEALS has good psychometric properties in CVD patients, despite some items poorly matching subjects, suggesting future refinements and focus on subgroup characteristics to enhance scale accuracy and applicability.

Keywords: cardiovascular disease, eHealth literacy, m-eHEALS, Rasch analysis

Background

Cardiovascular disease (CVD), encompassing a spectrum of heart and vascular conditions, is a leading cause of morbidity and mortality worldwide[1,2]. The global burden of CVD is significant, with prevalent cases increasing from 601 million in 2020 to 621 million in 2021, and deaths rising from 12.4 million in 1990 to 20.5 million in 2021[3]. This trend underscores the critical challenge CVD presents, not only in specific countries but across diverse global populations, overshadowing other diseases in terms of both morbidity and mortality rates[2]. Despite advances in medical technology, CVD mortality rates continue to climb, placing a profound impact on individuals, families, and societies at large. The World Health Organization (WHO) has noted that effective reduction in CVD mortality rates is possible through proper self-management behaviors, such as lifestyle modifications, regulated medication use, and proactive risk factor management. However, a common barrier to effective self-management is a widespread lack of

disease-related health knowledge among patients, impeding their ability to adopt essential self-management skills[4].

The rapid development of information technology, including the Internet, big data, and artificial intelligence, has dramatically transformed healthcare delivery, enabling the widespread dissemination of health information online [5]. Internet-based self-management has shown promise in managing disease symptoms, reducing healthcare costs, and enhancing quality of life [6,7]. However, the effectiveness of disease self-management via the Internet is ultimately limited by the concept of eHealth literacy, which is defined as the ability to seek, find, understand, appraise, and apply health information from electronic sources to deal with health-related problems[8]. It plays a significant role in patient empowerment and health management. Nurses, who are often at the forefront of patient care, play a crucial role in improving eHealth literacy. Their support is essential for enabling patients to make informed decisions and actively engage in their healthcare routines. Improving eHealth literacy in CVD patients is crucial for recognizing credible health information and making informed decisions. Studies have shown that enhancing eHealth literacy not only aids in self-management but also positively impacts treatment outcomes[9].

Some assessment tools have demonstrated effectiveness in assessing the eHealth literacy levels among diverse populations[10]. The eHealth Literacy Scale (eHEALS) is currently the most commonly used general assessment tool[11], with multiple language versions including Chinese[12], Korean[13], etc. However, the eHEALS has some limitations in its application, exhibiting variability in its structural dimensions, ranging from unidimensional to three-dimensional forms, in different studies[14]. Criticism has also emerged regarding its comprehensiveness, particularly in addressing the dynamic and social dimensions of eHealth[15], and its lack of attention to social media competencies[16]. To address these limitations, a mobile version of eHEALS (m-eHEALS) was developed, leveraging the ubiquity of mobile internet to assess eHealth literacy more

effectively [17]; [10]. While m-eHEALS has been primarily evaluated among younger demographics, its broader applicability, particularly among CVD patients, warrants further empirical research. The evaluation of scales is typically based on classic test theory (CTT) and item response theory (IRT). While CTT has been a traditional approach, it often assumes a linear relationship between variables and factors. However, this assumption is not always valid for every scale, including the m-eHEALS[18]. Moreover, the application of CTT to non-interval data, such as that derived from Likert scales, presents challenges without appropriate data transformation[19]. Therefore, there is a growing emphasis on employing more nuanced psychometric methods that transcend the limitations of CTT. This includes the implementation of Rasch analysis, a modern IRT approach known for enhancing the precision and effectiveness of scale evaluations[18-20]. Rasch analysis is particularly advantageous as it provides insights into the difficulty, discrimination, and overall fit of each item within the scale, thereby ensuring its relevance and applicability to specific populations[21].

Therefore, the study aims to validate the applicability of m-eHEALS among patients with CVD using Rasch analysis. We focus on a rigorous exploration of the scale's item fit, thereby enhancing our understanding of its effectiveness in assessing eHealth literacy among these patients.

Methods

Study Design and Participants

This study employed a consecutive inclusion approach to select patients from the neurology and cardiology departments of two general hospitals, from February 20 to May 4, 2023. Participants were diagnosed with at least one of the following diseases: ischemic heart disease (ICD-10 code: I 20-I 25), cerebrovascular disease (I 60-I 69), or hypertensive disease (I 10 -I 15). Diagnostic criteria were aligned with the latest clinical guidelines, including the ESC's recommendations for

stable coronary artery disease, the WHO's guidelines for cerebrovascular diseases, the ISH's hypertension management guidelines, and the AHA/ASA's stroke prevention and treatment guidelines, thus ensuring a standardized and evidence-based approach in our study. The inclusion criteria for the study were as follows: (1) patients possessing some level of comprehension, writing, or verbal ability; and (2) their informed consent and voluntary agreement to participate in the study. The exclusion criteria included: (1) individuals with mental illness, cognitive impairment, or intellectual disability confirmed by clinical records; (2) individuals in a coma or acute/critical illness stage indicated by clinical symptoms and vital signs; and (3) individuals with life-threatening diseases like cancer or severe organ failure documented in medical records. This research was approved by XXX university's Institutional Review Board (Approval No. 2015SY45).

Instrument

m-eHEALS was the primary instrument used in this study. This scale comprises three dimensions, including 12 items. Each item is scored on a 5-point Likert scale, ranging from "strongly disagree" (1 point) to "strongly agree" (5 points). The total score range is from 12 to 60 points, with higher scores indicating greater eHealth literacy. Specifically, the scale's dimensions are as follows: the self-perception dimension (items 1-3), the information access dimension (items 4-8), and the interaction judgement dimension (items 9-12). The overall Cronbach's alpha coefficient for the scale in our study was 0.91.

Participants, after providing informed consent, were requested to complete the m-eHEALS questionnaire. In addition to the scale, basic demographic information such as age, gender, educational background, individual monthly income, and course of CVD was also collected.

Statistical Analysis

Data entry, dataset management, and descriptive statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS Inc Chicago, Illinois, Version 26). Categorical

variables were described with frequency or percentage, while continuous variables were described with mean or median. To ensure accuracy, two authors(XXX and XX) independently aggregated and cross-checked the data.

Rasch analysis was conducted using Winsteps software (Version 3.72.3). The dimensionality was evaluated using Principal Component Analysis (PCA), which focuses on how well the observed variance matches the expected model variance. Analysing the first component's residual eigenvalue was part of this. The eigenvalue ranging from 1.40 to 2.10 is commonly seen as a sign of unidimensionality, implying that a single factor can provide sufficient explanation for the data. Infit and Outfit Mean Square (MNSQ) statistics were used to assess the item and individual's fit; acceptable limits for both were 0.5 to 1.5. Reliability was assessed through indices like the person separation index and person reliability, with acceptable levels set at 1.5 and 0.7, respectively. A person-item map was used to illustrate the hierarchy of item complexity and its alignment with individual abilities. Additionally, the Item Characteristic Curve (ICC) was utilized to analyze the relationship between item difficulty and subject ability. Differential Item Functioning (DIF) was investigated in gender-based subgroups, with significant DIF identified by a contrast exceeding 0.5 logits.

Results

Participants

The study included 302 CVD participants (Table 1). The average age of the participants was 59.3 years (SD = 11.4), with a predominance of male participants (65.9%) and a high proportion of married individuals (85.8%). A significant majority (66.9%) had attained senior high school education or less. Notably, 30.1% of the participants had been diagnosed with CVD for less than one year.

Table 1 Participants’socio-demographic characteristics (n = 302)

Category	Mean±SD / Percentage

Age (years)	59.3±11.4
Gender	
Male	65.9%
Female	34.1%
Marital status	
Single	2.0%
Married	85.8%
Divorced	2.3%
Widower	9.9%
Education background	
Primary school or below	15.2%
Junior high school	24.2%
Senior high school	27.5%
Junior college	15.6%
Bachelor's degree or above	17.5%
Individual monthly income (yuan)	
< 2000	20.9%
2000 - 4999	28.8%
5000 - 7999	23.8%
≥8000	26.5%
Course of CVD	
< 1 year	30.1%
1 - 5 years	21.9%
6 - 10 years	15.2%
11 - 20 years	18.9%
> 20 years	13.9%

Rasch analysis

Dimensionality

According to the results of PCA, the total explained variance of m-eHEALS is >50.0%, but the first component residual eigenvalue is >2.10, suggesting that the dimensions can be subdivided. In Table 2, each dimension was analyzed as a subscale and compared with the overall effect. It was found that the unidimensionality of each dimension was slightly better than the total scale. The eigenvalue of the Interactive judgment dimension was close to 2.10. It was within the acceptable range due to a certain degree of subjectivity in the dimensions.

Table 2 Unidimensionality test of the m-eHEALS scale

	model explained (%)	first contrast eigenvalues
Summary scale	70.5	3.1
Self-perception dimension	73.1	1.7
Information access dimension	71.8	1.9
Interactive judgment dimension	72.3	2.4

Item fit

Infit and Outfit MNSQ values suggested optimal model fit for all items in the self-perception dimension (Table 3).

Table 3 Item fit statistics for the Self-perception dimension from the Rasch Analysis (n=302)

Self-perception dimension		Infit Statistics		Outfit Statistics	
		MNSQ	ZSTD	MNSQ	ZSTD
N1	The Internet has been beneficial for me in accessing health resources	1.18	1.9	1.15	1.3
N2	I know how to use the internet to answer my health questions	0.87	-1.3	0.90	-0.9
N3	I am confident in applying Internet information to make relevant decisions	0.77	-2.8	0.79	-2.2
	Mean	0.94	-0.7	0.95	-0.6
	SD	0.17	2.0	0.15	1.4

In the Information Access dimension, N4 exhibited an Infit MNSQ above 1.5, indicating a misfit to the model. N5 showed an outfit MNSQ below 0.5 but an acceptable infit MNSQ. The infit and outfit MNSQ values of item N6 were below 0.5, indicating a narrow response range (Table 4).

Table 4 Item fit statistics for the Information access dimension from the Rasch Analysis (n=302)

Information access dimension		Infit Statistics		Outfit Statistics	
		MNSQ	ZSTD	MNSQ	ZSTD
N4	I know how to go online to find useful information about health resources	1.52	4.8	1.19	1.1
N5	I know where to get useful health resource information from the internet	0.58	-4.5	0.44	-4.0
N6	In addition to computers, I am skilled at using web-enabled mobile devices (e.g., cell phones) to access health information	0.49	-6.2	0.40	-4.2
N7	I can use the internet to learn about health-related issues actively	1.40	4.0	1.27	1.8
N8	I will carefully consider whether even credible, high-quality health information applies to my particular situation	0.87	-1.2	0.73	-1.6
	Mean	0.97	-0.6	0.81	-1.4
	SD	0.42	4.4	0.36	2.5

In the interactive judging dimension, both item N10, with an infit MNSQ exceeding 1.5, and item N11, with an outfit MNSQ below 0.5, deviated from model expectations (Table 5). Overall, the mean Infit and Outfit MNSQ values (0.98 and 0.97, respectively) suggested a generally well-fitting scale.

Table 5 Item fit statistics for the Interactive judgment dimension from the Rasch Analysis (n=302)

	Interactive judgment dimension	Infit Statistics		Outfit Statistics	
		MNSQ	ZSTD	MNSQ	ZSTD
N9	I will provide my doctor with the information needed for diagnosis (e.g., description of my condition, past medical history, physiologic data, etc.) clearly and completely on the Internet	1.25	2.5	1.10	0.8
N10	I will follow or participate in a health-related forum, QQ group, or WeChat group	1.55	5.3	1.35	2.8
N11	I can distinguish between high-quality and low-quality health resource information on the internet	0.50	-6.7	0.45	-5.4
N12	I have the skills to evaluate good and bad information on health resources on the internet	0.57	-5.5	0.54	-4.4
	Mean	0.97	-1.1	0.86	-1.5
	SD	0.45	5.1	0.38	3.4

Reliability

The scale demonstrated excellent reliability, with a person separation index of 4.02 and a person reliability of 0.94, indicating effective differentiation between individuals' eHealth literacy levels. The item reliability index was high at 8.96 with a reliability of 0.99, suggesting consistent item difficulty across the scale. Dimension-specific analyses further supported the scale's construct validity by demonstrating good reliability across all dimensions. Specifically, the self-perception dimension showed a person separation index of 2.18 and a reliability of 0.83, while the information access dimension scored 2.56 and 0.88, respectively. Similarly, the interaction judgement dimension achieved a person separation index of 2.66 and a reliability of 0.88.

Item difficulty (hierarchy)

The person-item map (Fig. 1) illustrates the alignment between person ability and item difficulty. Easier items, such as N5 and N8, corresponded to lower ability levels, whereas more challenging items, like item 10, aligned with higher abilities. The items are spread across the continuum, despite some gaps in the scale, as seen in the person-item map. However, the distribution span of subjects was larger than that of the items, with the latter clustering mostly in the middle, leaving neither high- nor low-ability individuals with matching items.

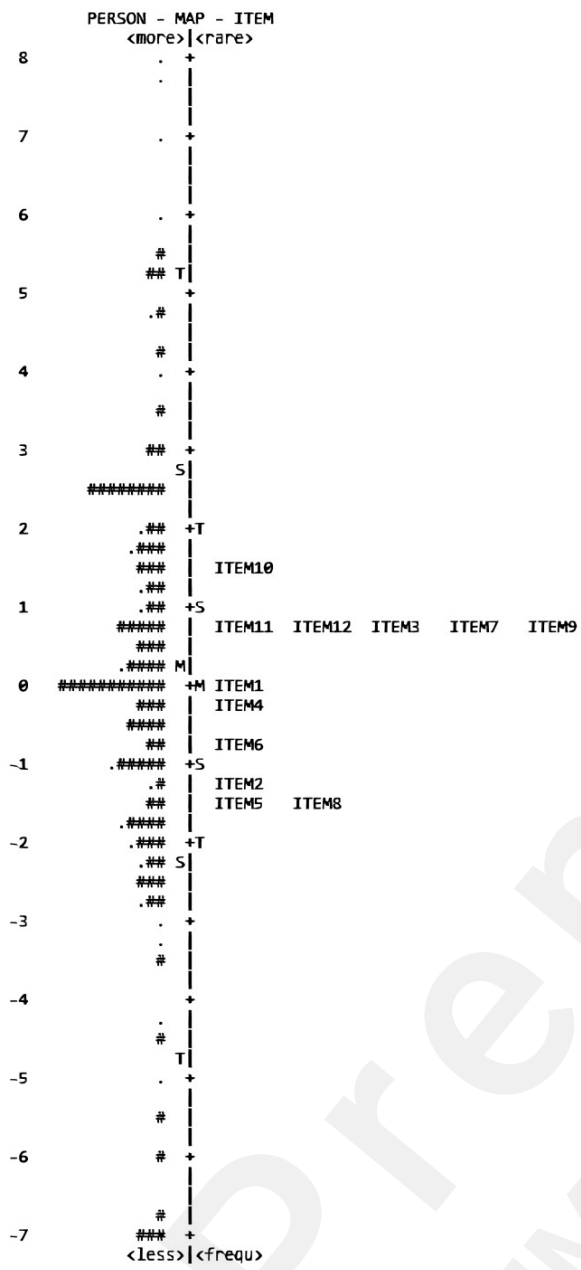

Fig. 1 Person-Item Map of the 12 m-eHEALS scale items in the Rasch Analysis (n = 302). Note: Each "#" =3 persons and each "." =1 to 2 persons; M = Mean persons' ability or mean items' difficulty; S = one standard deviation; T = two standard deviations. The vertical line is a continuum representing the measures of persons' ability (left side) and items' difficulty (right side), plotted in logit units. The person's ability and items' difficulty increase from the bottom to the top.

Item characteristic curve (ICC)

The ICCs (Fig. 2) showed that N2, N3, N6, N7, and N9 closely aligned with expected curves,

indicating well-calibrated difficulty and discrimination. While some items deviated from their expected ICCs, these variations were within acceptable limits, affirming the scale's overall adequate performance in measuring a range of eHealth literacy abilities.

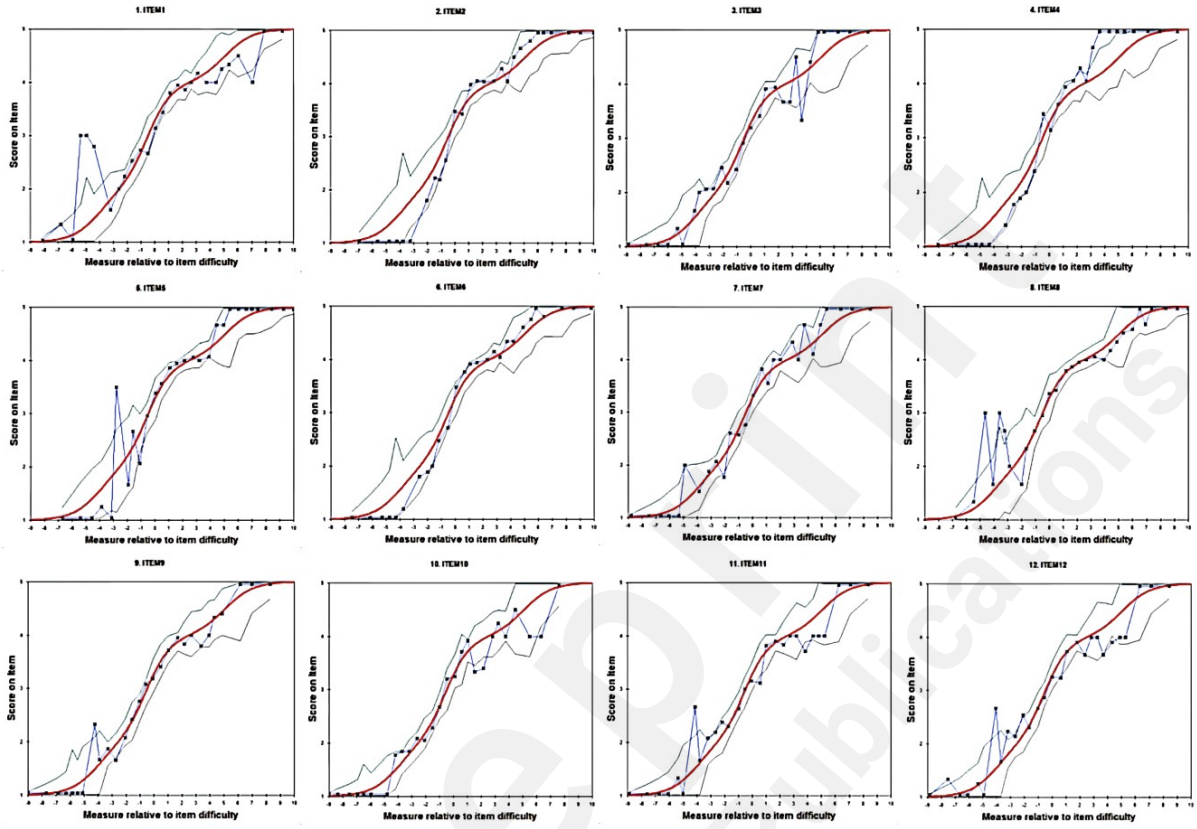

Fig. 2 Item characteristic curve of the 12 m-eHEALS scale items in the Rasch Analysis (n = 302). The red curve (Fig. 2) is the ICC expected by Rasch's model, the blue line is the ICC of the actual measurement, and "X" is the average of the measurements and scores of the observations in the interval; when the "X" on the blue line is at or very close to the red line, it indicates a good fit between the measurement and the model. The green and gray lines are two-sided 95% confidence intervals with a standard deviation of 1.96 from the red line in the vertical direction.

Differential item functioning (DIF)

DIF analysis revealed a significant gender-related discrepancy for N12, showing a difference of -0.71 logits, which suggests that women found this item more challenging than men.

Discussion

This study represents a novel application of Rasch analysis in assessing the m-eHEALS among patients with CVD. Through our rigorous evaluation of the scale, we have not only verified its overall efficacy in measuring the subtle differences in eHealth literacy but also identified key areas requiring refinement. Particularly notable is the identification of distinct dimensions within the scale that better align with the unique informational and digital interaction needs of the patient group. Our findings also reveal specific items that may require adjustment to enhance the scale's precision and relevance, thereby advancing the utility of m-eHEALS in clinical settings. This comprehensive evaluation significantly contributes to the evolving landscape of eHealth literacy assessment, emphasising the need for targeted and reliable tools for managing CVD in the digital era.

The dimensionality analysis revealed potential multidimensionality in the m-eHEALS, particularly highlighted by the first component's residual eigenvalue exceeding 2.10. This finding suggests that m-eHEALS may be measuring multiple aspects of eHealth literacy, consistent with previous studies highlighting its multidimensionality[17].

Most items showed a good fit to the Rasch model in the item fit analysis. This indicates that m-eHEALS items are generally appropriate for measuring eHealth literacy in the CVD population. All items of the self-perception dimension fit well with the model expectations, indicating that most CVD patients found the Internet to be very helpful in accessing health resources (N1). That may be attributed to the convenience and abundance of the Internet, which facilitates access to health information and the shaping of health behaviours[22,23]. Additionally, N2 and N3 further support the subjects' confidence and ability to use the Internet to inquire about health questions and search for online information. However, in information access, the Infit MNSQ value of N4 was greater than 1.5, indicating a possible mismatch between individuals' actual ability to retrieve online resources and their own perception of this ability. Additionally, the Outfit MNSQ

value for N5 was less than 0.5, suggesting the existence of a distinct subgroup among CVD patients who perceive or behave uniquely towards online health resources. For N6, both the Infit and Outfit MNSQ values were less than 0.5. This could be attributed to the widespread popularity of smartphones[24], which may result in the item not effectively distinguishing between subjects with different levels of proficiency.

In the dimension of interaction judgement, the Infit MNSQ value of N10 is greater than 1.5. Although individuals may believe they would become engaged in a health-related online community, their actual behaviour may differ. This difference could be influenced by several factors, such as the level of participation in the online community, the level of interactivity, and the barriers to participation that individuals face. The Outfit MNSQ value of N11 is less than 0.5. This could be because some individuals struggle to evaluate the quality of online information or because their actual behaviour does not align with their self-assessment. Due to the limited number of items included in each dimension, the statistical results could be more unpredictable, leading to notable variations in MNSQ values for some items. However, when all the items were analysed collectively, the stability of the statistical results improved significantly due to the expanded data. As a result, only some items that deviated significantly from the model expectations (specifically, N1 and N4) showed distinct variations in their MNSQ values. N1 and N4 are used to evaluate patients' capacity to collect and utilise online health resources effectively. Any observed bias may be closely linked to several factors, such as patients' current health status, proficiency in using the Internet, and information filtering ability[23]. This finding emphasises the complexity of applying scales and highlights the need for a deeper understanding of these fitting issues.

The scale's high-reliability indicators are commendable at both the person and item levels. Consequently, eHEALS can effectively differentiate between individuals with varying levels of eHealth literacy, and the difficulty levels remain consistent across all items. Reliability analysis

confirmed that the scale showed good overall stability and internal consistency. Item analysis further indicated that the scale had a moderately difficult distribution. However, the range of abilities among subjects is wider than the range of item difficulties, indicating a shortage of items designed for both over- and under-rationalizers.

The ICC curves revealed that only the actual ICC curves of a few items aligned with the expected patterns. For individuals with different ability levels, certain items may require adjustments or refinements to better align with the expectation. The DIF analyses revealed a significant gender disparity. Specifically, there was a notable difficulty gap between men and women for N12, with female subjects experiencing a higher difficulty level than males by 0.71 logit units. According to previous studies, gender was not an influential factor in eHealth literacy[25,26]. This discrepancy may stem from various factors such as sample characteristics, differences in the measurement tool, cultural influences, and methodological variations. However, this observed gender difference highlights the importance of considering gender in such assessments and should be taken into account in their future applications.

There are limitations to this study. The limited generalizability of the findings to other populations may be attributed to the unique demographic and clinical characteristics of our sample. Furthermore, the existence of multidimensionality and item misfits indicates that the m-eHEALS has to be further refined. Expanding the scale to properly capture the entire range of eHealth literacy skills should be the main focus of future studies, especially for patients at the extremes of the health literacy continuum. To improve the scale's inclusion and equity, it is also crucial to look into the causes of the gender-related DIF in N12.

Conclusion

In conclusion, this study highlights areas for improvement while offering important evidence in favour of the validity and reliability of the m-eHEALS among people with CVD. By refining m-

eHEALS to better meet the eHealth literacy needs of CVD patients, healthcare providers can enhance their assessment and delivery of patient-centred care in the digital age. These initiatives will eventually result in focused and more effective healthcare services for this significant population.

Statement of conflict of interest

The authors have no conflict of interest

Reference

1. Roth GA, Mensah GA, Johnson CO, et al. Global Burden of Cardiovascular Diseases and Risk Factors, 1990-2019: Update From the GBD 2019 Study. *Journal of the American College of Cardiology*. Dec 22 2020;76(25):2982-3021. doi:10.1016/j.jacc.2020.11.010
2. Wang Z, Ma L, Liu M, Fan J, Hu S. Summary of the 2022 Report on Cardiovascular Health and Diseases in China. *Chinese medical journal*. Dec 20 2023;136(24):2899-2908. doi:10.1097/cm9.0000000000002927
3. Lindstrom M, DeCleene N, Dorsey H, et al. Global Burden of Cardiovascular Diseases and Risks Collaboration, 1990-2021. 2022;80(25):2372-2425. doi:doi:10.1016/j.jacc.2022.11.001
4. Puijk-Hekman S, van Gaal BG, Bredie SJ, Nijhuis-van der Sanden MW, van Dulmen S. Self-Management Support Program for Patients With Cardiovascular Diseases: User-Centered Development of the Tailored, Web-Based Program Vascular View. *JMIR research protocols*. Feb 8 2017;6(2):e18. doi:10.2196/resprot.6352
5. Awrahman BJ, Aziz Fatah C, Hamaamin MY. A Review of the Role and Challenges of Big Data in Healthcare Informatics and Analytics. *Computational intelligence and neuroscience*. 2022;2022:5317760. doi:10.1155/2022/5317760
6. Lear SA, Norena M, Banner D, et al. Assessment of an Interactive Digital Health–Based Self-management Program to Reduce Hospitalizations Among Patients With Multiple Chronic Diseases: A Randomized Clinical Trial. *JAMA Network Open*. 2021;4(12):e2140591-e2140591. doi:10.1001/jamanetworkopen.2021.40591 %J JAMA Network Open
7. Liu YY, Li YJ, Lu HB, Song CY, Yang TT, Xie J. Effectiveness of internet-based self-management interventions on pulmonary function in patients with chronic obstructive pulmonary disease: A systematic review and meta-analysis. *Journal of advanced nursing*. Aug 2023;79(8):2802-2814. doi:10.1111/jan.15693
8. Norman CD, Skinner HA. eHealth Literacy: Essential Skills for Consumer Health in a Networked World. *Journal of medical Internet research*. Jun 16 2006;8(2):e9. doi:10.2196/jmir.8.2.e9
9. Mihan A, Van Spall HGC. Interventions to enhance digital health equity in cardiovascular care. *Nature medicine*. Feb 14 2024;doi:10.1038/s41591-024-02815-z
10. Gao Y, Zhao JF, Xu LL, et al. Evaluation of the Chinese version of the electronic health literacy scale by the COSMIN operational guidelines. . *Chinese Journal of Gerontology(09)*. 2020;40(09):1968-1973. doi:DOI:10.3969/j.issn.1005-9202.2020.09.054.
11. Norman CD, Skinner HA. eHEALS: The eHealth Literacy Scale. *Journal of medical Internet research*. Nov 14 2006;8(4):e27. doi:10.2196/jmir.8.4.e27
12. Guo SJ, Yu XM, Sun YY, Nie D, Li XM, Wang L. eHEALS Health Literacy Scale Chineseization and Applicability Exploration. . *China Health Education(02)*. 2013;29(02):106-108+123.

doi:10.16168/j.cnki.issn.1002-9982.2013.02.019
13. Chung S, Park BK, Nahm ES. The Korean eHealth Literacy Scale (K-eHEALS): Reliability and Validity Testing in Younger Adults Recruited Online. *Journal of medical Internet research*. Apr 20 2018;20(4):e138. doi:10.2196/jmir.8759
14. Lee J, Lee EH, Chae D. eHealth Literacy Instruments: Systematic Review of Measurement Properties. *Journal of medical Internet research*. Nov 15 2021;23(11):e30644. doi:10.2196/30644
15. van der Vaart R, Drossaert CH, de Heus M, Taal E, van de Laar MA. Measuring actual eHealth literacy among patients with rheumatic diseases: a qualitative analysis of problems encountered using Health 1.0 and Health 2.0 applications. *Journal of medical Internet research*. Feb 11 2013;15(2):e27. doi:10.2196/jmir.2428
16. Norman C. eHealth literacy 2.0: problems and opportunities with an evolving concept. *Journal of medical Internet research*. Dec 23 2011;13(4):e125. doi:10.2196/jmir.2035
17. Wu YM, Zhang ME, Zhu LY. Consumer e-health literacy assessment and its application in mHealth. . *Consumer Economics (01)*. 2017;33(01):90-96+55.
18. Hambleton RK, Robin F, Xing D. Item response models for the analysis of educational and psychological test data. *Handbook of applied multivariate statistics and mathematical modeling*. 2000:553-581. doi:10.1016/b978-012691360-6/50020-3
19. Embretson SE, Reise SP. *Item response theory*. Psychology Press; 2013.
20. Wright BD, Masters GN. *Rating scale analysis*. MESA press; 1982.
21. Tesio L. Measuring behaviours and perceptions: Rasch analysis as a tool for rehabilitation research. *Journal of rehabilitation medicine*. May 2003;35(3):105-15. doi:10.1080/16501970310010448
22. Hansen AH, Bradway M, Broz J, et al. Inequalities in the Use of eHealth Between Socioeconomic Groups Among Patients With Type 1 and Type 2 Diabetes: Cross-Sectional Study. *Journal of medical Internet research*. May 29 2019;21(5):e13615. doi:10.2196/13615
23. Ramadas A, Chan CKY, Oldenburg B, Hussein Z, Quek KF. Randomised-controlled trial of a web-based dietary intervention for patients with type 2 diabetes: changes in health cognitions and glycemic control. *BMC public health*. Jun 8 2018;18(1):716. doi:10.1186/s12889-018-5640-1
24. Montag C, Lachmann B, Herrlich M, Zweig K. Addictive Features of Social Media/Messenger Platforms and Freemium Games against the Background of Psychological and Economic Theories. *International journal of environmental research and public health*. Jul 23 2019;16(14)doi:10.3390/ijerph16142612
25. Duan YW, Chen MY, Lu MM. Study on e-health literacy and influencing factors of elderly patients with coronary heart disease. . *Shanghai Nursing(11)*. 2022;22(11):37-40.
26. Ma J, Mai LX, Huang Q, Wen H, Zeng ZY. A study on the current status of e-health literacy and its influencing factors among people at high risk of cardiovascular diseases in Qingxiu District, Nanning City. . *Journal of Guangxi Medical University (02)*. 2023;40(02):321-326. doi:10.16190/j.cnki.45-1211/r.2023.02.022

Figure legends:

Figure 1. Person-Item Map of the 12 m-eHEALS scale items in the Rasch Analysis

Figure 2. Item characteristic curve of the 12 m-eHEALS scale items in the Rasch Analysis