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Carole Délétroz, Marina Allen, Achille Yameogo, Maxime Sasseville, Florian Naye, Alexandra Rouquette, Patrick Bodenmann & Marie-Pierre Gagnon

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Authors

Carole Délétroz, RN, PhD, HESAV School of Health Sciences - Vaud, HES-SO University of Applied Sciences and Arts Western Switzerland. carole.deletroz@hesav.ch.

Marina Canepa Allen, RN, MScPH, HESAV School of Health Sciences - Vaud, HES-SO University of Applied Sciences and Arts Western Switzerland. marina.canepaallen@hesav.ch

Achille R. Yameogo, MSc, Faculty of Nursing Sciences, Université Laval, 2325 Rue de l'Université, Québec, QC G1V 0A6, Canada. achille-roghemrazangba.yameogo.1@ulaval.ca

Maxime Sasseville, RN, PhD, Faculty of Nursing Sciences, Université Laval, 2325 Rue de l'Université, Québec, QC G1V 0A6, Canada. maxime.sasseville@fsi.ulaval.ca

Florian Naye, Doctoral Candidate, Université de Sherbrooke, Faculty of Medicine and Health Sciences, School of Rehabilitation, Research Centre of the CHUS, CIUSSS de l'Estrie-CHUS, 3001 12e Avenue N, Sherbrooke, QC, Canada. Florian.Naye2@USherbrooke.ca.

Alexandra Rouquette, MD, PhD, Paris-Saclay University, Inserm, UVSQ, CESP, DevPsy, Paris, France, Public Health and Epidemiology Department, AP-HP Paris-Sarclay, Bicêtre Hospital, Le Kremlin-Bicêtre, France. alexandra.rouquette@inserm.fr

Patrick Bodenmann, MD, MSc (LSHTM) Department of Vulnerabilities and Social Medicine, Unisanté, Lausanne & Faculty of Biology and Medicine, Vice-Dean Teaching and Diversity, University of Lausanne, Switzerland. Rue du Bugnon 44, 1011 Lausanne. patrick.bodenmann@unisante.ch

Marie-Pierre Gagnon, PhD, Faculty of Nursing Sciences, Université Laval, 2325 Rue de l'Université, Québec, QC G1V 0A6, Canada. marie-pierre.gagnon@fsi.ulaval.ca

Correspondence: Carole Délétroz, RN, MScN, PhD, HESAV School of Health Sciences - Vaud, HES-SO University of Applied Sciences and Arts Western Switzerland carole.deletroz@hesav.ch

Abstract

Background: This study aimed to systematically identify, synthesize, and evaluate measurement properties of patient-reported outcome measures (PROMs) of eHL in adult populations.

Method: A systematic review was conducted, considering studies reporting the development or validation of eHL instruments for adult populations. Four databases and grey literature were searched from January 2000 to 2024, with additional website searches up to 2022. Quality assessment, data analysis and synthesis followed the COSMIN methodology and findings were reported according to PRISMA 2020 guidelines. The GRADE framework was used to assess evidence quality.

Results: A total of 8558 citations were identified. Seven instruments, 89 articles and three reports were included in this review. The HL_{19}-DIGI, DHLI, TeHLI, eHLQ, eHLA and Lisane demonstrated sufficient ratings for aspects of content validity, albeit with varying levels of evidence, ranging from very low to high. Five instruments showed sufficient ratings for structural validity and internal consistency, but evidence on their reliability was insufficient. No information on responsiveness was mentioned in articles. The HL19-DIGI, DHLI, eHEALS and eHLQ were the most frequently investigated instruments.

Conclusion: This review identified 17 eHL instruments, of which seven demonstrated adequate content validity. However, insufficient evidence exists regarding psychometric properties for widespread implementation. It is strongly recommended that the content of these instruments be updated to reflect patients' evolving use of eHealth services, and that further psychometrics evaluations be conducted systematically.

Systematic review registration: PROSPERO CRD42021232765

Keywords: eHealth Literacy, Health Literacy, Psychometrics, Validation Studies, Systematic Review

Background

The increasing availability and use of personal digital devices (*e.g.* computers, tablets, and smartphones) and the Internet have shifted health information delivery from traditional face-to-face interactions to digital interventions (1, 2) and virtual care (3, 4). In this context, improving eHealth literacy (eHL) -a subset of health literacy- remains a global challenge (5,6). The European Health Literacy Survey (HLS_{19}) 2019-2021 revealed a high proportion of low or problematic eHL, with 75.8% of the population in Germany, 72% in Switzerland and 52.7% in Portugal affected (7). This widespread low eHL poses a barrier to effective health information delivery, potentially contributing to poorer health behaviors and outcomes. Studies measuring eHL in adults living with chronic disease reported positive effects of educational interventions on the improvements in self-reported eHL skills (8). It is therefore important to examine eHL in large longitudinal studies to improve the management of chronic health conditions (9) at the professional level, but also at the public level (10).

Norman and Skinner define eHL as "the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained for addressing or solving health problems" (5, p.3). eHL has a significant potential to improve health outcomes, bridge the digital divide, and reduce health inequalities (11). Kim and coll. found a positive correlation between eHL and health-related behaviors that indicate that eHL can be a mediator in the process by which health-related information leads to changes in health-related behaviors (12). Instruments to assess eHL inform Internet access to information and uses, but also patient-health providers communication intervention and can therefore facilitate a tailored information plan (13) or bring data for health policy decisions to strengthen eHL and health equity in many countries (14). Among available instruments, the e-Health Literacy

Scale (eHEALS) is the only instrument with available psychometric properties (8). However, the assessment of eHL is typically not considered by care providers and the issue of low digital health remains a current problem to address (15, 16). Patient-reported outcome measures (PROMs) are used to assess the patients' own views about their health, and existing PROMs are available to assess eHL in general (17). A recent descriptive review based on the nine measurement properties suggested by the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN), shows that the mostly reported measurement properties in studies, using PROMs (n=27) were structural validity and internal consistency, and none of the studies assessed measurement error and responsiveness (18). Current research on eHL highlights the need for specific measurements to assess whether eHealth initiatives are effectively enhancing patient care (19, 20).

The assessment of measurement properties of PROMs is essential to the quality evaluation and selection of instruments (21, 22). COSMIN conducted an international Delphi study with 57 experts to reach consensus on the terminology of measurement properties and suggested the following nine key properties for PROMs: content validity, structural validity, internal consistency, cross-cultural validity/measurement invariance, reliability, measurement error, criterion validity, hypotheses-testing construct validity, and responsiveness (21). However, strong evidence regarding the measurement properties of eHL instruments is lacking. To date, only a narrative review and a systematic review on eHL instruments have been published. The previous narrative review (23) summarized eHL instruments without conducting quality assessments or data synthesis. Similarly, a systematic review of the measurement proprieties of eHL instruments (24) synthesized and assessed the quality of data without considering grey literature reporting on instruments used in large-scale population surveys. Population surveys with representative samples of the adult population in each country using eHL instruments, they provide a solid database (25) to include in a systematic review. To the best of the

author's knowledge, no systematic review has comprehensively assessed the measurement properties of patient-reported outcome measure (PROMs) for eHL in adult populations, including grey literature reporting on population surveys. Therefore, the aim of this study was to systematically identify, synthesize, and evaluate measurement properties of patient-reported outcome measures (PROMs) of eHL in adult populations.

Method

Study design

This systematic review adhered to the Cochrane methods for conducting systematic reviews (26): developing a question and deciding the scope of the review, searching for studies, selecting studies and collecting data, assessing risk of bias in studies, analyzing data, interpretation and presenting results (27). It followed the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) guidelines (28). COSMIN methodological steps were conducted to assess the measurement properties of questionnaires: Methodological quality (COSMIN Risk of bias checklist), measurement proprieties (COSMIN updated criteria), Quality of evidence (Modified Grade), Overall recommendation (COSMIN) (29). Findings were reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 statement (30). The protocol for this systematic review was registered in PROSPERO (registration number CRD42021232765).

Review question

This systematic review addressed the following research question: Which instruments have been developed to assess eHealth literacy (eHL) in adult populations, and what are their psychometric properties?

Search strategy

Using an iterative process, the database search strategy was formulated and tested by an expert Health Sciences Librarian from Laval University (M-CL). Studies describing the

development and the validation of eHL PRO instruments from January 2000 until June 2024 were collected. A three-step search strategy was employed in this review (26). The first step involved an initial limited search of PubMed and CINAHL, where the titles and abstracts of relevant articles were screened for terms, keywords and index terms. This step informed the development of a tailored search for each information source. The second step involved a comprehensive search across four databases: CINAHL, PubMed, PsycINFO and Web of Science (see additional file 1). For the grey literature, ProQuest Dissertations and Thesis, OpenGrey, DART and BASE were consulted to locate relevant theses. In the third step, reference list of all identified reports and articles were screened for additional studies. A sample search strategy from PubMed, using a filter specifically created for the search of PROMs was utilized (31) and MeSh terms were updated by the same expert Health Sciences Librarian (see additional file 2). Furthermore, a specific search for each instrument identified during the initial search was performed, following COSMIN methodology. A search on Google© was conducted to locate unpublished reports through February 2022, and authors of original articles were contacted to request additional data. No date restrictions were applied. All searches were conducted in June 2022, with an update in June 2024.

All identified citations were uploaded into EndNote X9 (32), and duplicates were manually removed. Additionally, four more duplicates were identified and removed using Covidence web tool (33) before screening.

Inclusion criteria

This review included studies focused on the development and/or validation (including psychometric quality) of PROMs of eHL in adults. Studies were required to meet the following inclusion criteria: related to human health, involving an adult population (≥18 years old), focused on the development and/or validation of eHL instruments, and published between 2000 and 2024 in English, French, Spanish, or Italian (languages read by the

researchers). Studies published from 2000 onwards were included, as the adoption of eHealth by health institutions began in the early 2000s, coinciding with the rapid emergence of digital technology (34).

The eHL of children and adolescents has been conceptualized in a contradictory manner, with the "digital generation" often seen as particularly competent and active users of the digital world (35). Therefore, studies assessing eHL among individuals under 18 years old were excluded. Additionally, studies that utilized an eHL instrument as an outcome measure without the primary goal of developing or validating the instrument were not included. Literature providing limited information, such as conference abstracts, review protocols, or notes were also excluded.

Study selection (selection process)

Four reviewers (CDE, FNA, MCA, MPG) independently screened the titles and abstracts of all identified citations against the inclusion criteria for the review. Following this, the same four reviewers assessed the full text of selected citations. Reasons for exclusion of full-text studies were documented and presented in the PRISMA 2020 flow diagram (Figure 1). Disagreements were resolved with another member of the research team (MSA).

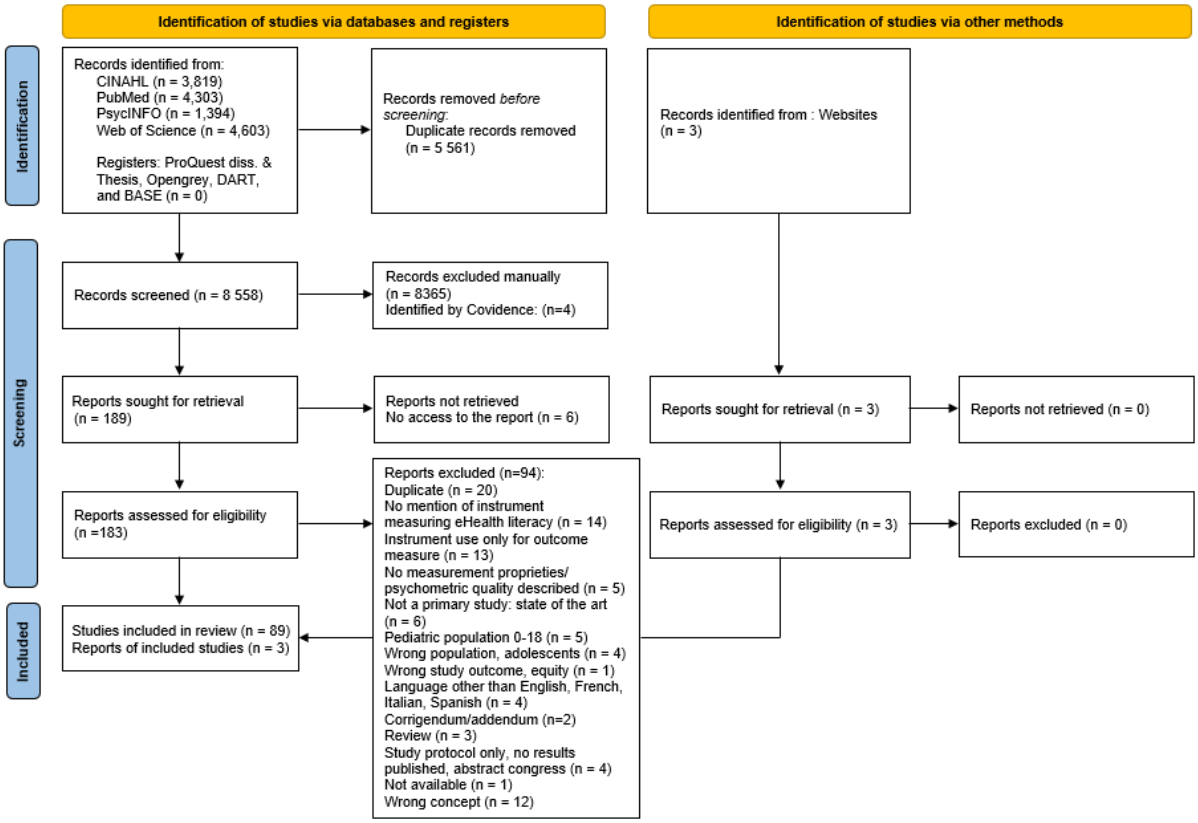

Figure 1 PRISMA flow diagram 2020 eHealth literacy (30)

Data extraction

Data extracted included general information about the characteristics of the instruments (i.e authors, title, DOI), specific details about the instrument (construct, number of items, population, response options, mode of administration, scoring system, language), and their measurment properties. Additionally, conceptual frameworks and specified definitions were presented in accordance with the COSMIN guidelines. Three researchers (CDE, FNA, MCA) independently extracted the qualitative data, while the quantitative data for all included studies were independently extracted by four researchers (CDE, AYA, FNA, MPG). Consensus was reached on the accuracy and completeness of the extracted data. Disagreements were resolved with another member of the research team (ARO).

Assessment of methodological quality of included studies and level of evidence

A three-steps method was employed to assess the methodological quality of the studies and the measurement proprieties of the instruments (29). Four researchers (CDE, AYA, FNA, MPG) independently conducted this assessment. A narrative synthesis of results was made (36).

Assessment of methodological quality

All studies that described the methods and results of PROM development, as well as additional studies assessing the content validity of specific PROMs, were considered. Each study was evaluated using the COSMIN Risk of Bias checklist (29, 37). Checklist items were rated as ‘‘very good’’, ‘‘adequate’’, ‘‘doubtful’’, ‘‘inadequate’’, or ‘‘not applicable’’.

Measurement proprieties assessment

Following the COSMIN taxonomy, the measurement properties assessed included validity (content validity, criterion validity, and construct validity, covering aspects such as structural validity, hypothesis testing, and cross-cultural validity), reliability (internal consistency, measurement error, and reliability), and responsiveness (38). Psychometrics validity was evaluated using Terwee et al.’s quality criteria (39). Each measurement property was classified as sufficient (+), insufficient (-), Inconsistent (+/-) or indeterminate (?) (29, 40). Content validity was rated based on the evidence provided by content validity studies included in this systematic review. For construct validity, the hypotheses formulated by the authors of each individual study were considered (29).

Quality of evidence assessment

The quality of the evidence was graded as “high”, “moderate”, “low,” or “very low” using a modified Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework by the first author (30). The criteria for downgrading the quality of evidence were based on: (1) risk of bias (i.e., the methodological quality of the studies), (2) inconsistency (i.e., unexplained variability in results across studies), (3) imprecision (i.e., total sample size

of the available studies), and (4) indirectness (i.e., evidence from populations different from population of interest in the review) (29, pp. 32-35). In line with COSMIN recommendations, the starting point for determining the quality of evidence for internal consistency was the quality of evidence for structural validity.

An overall recommendation for each instrument was formulated based solely on COSMIN guidelines (29) and the results of this review. According to COSMIN, PROMs are categorized as: (A) Suitable for use (PROMs with evidence of sufficient content validity AND at least low-quality evidence for sufficient internal consistency); (B) Potentially suitable for use (PROMs not classified in categories A or C); or (C) Not recommended (PROMs with high-quality evidence of an insufficient measurement property).

Given that content validity is the most critical measurement property of a PROM, as it ensures the instrument adequately reflects the construct being measured, and according to COSMIN, instruments with insufficient content validity were graded (C) (29). Seven instruments underwent a more in-depth assessment of their psychometric validity.

Results

Search and study selection

Electronic searches identified 14,119 records from PubMed, CINAHL, Web of Science, and PsycInfo. After removing duplicates, 8,558 records were screened. Additionally, three research reports were identified through manual searches on the M-POHL website (7). Thus, the total number of included sources was 89 and 3 reports. Figure 1 presents the PRISMA flow diagram (30). A list of excluded full-text articles is provided in Additional File 3.

No relevant records were found in grey literature databases, either through additional searching using the identified instrument names, or by applying the measurement-property filter in PubMed (31).

A total of 92 sources were associated with the following 17 instruments: HL_{19}-DIGI, TeHLI, eHealth Literacy Scale 2.0, eHLQ, eHLA, DHLI, eHEALS-E, e-HLS, HLSI, eHEALS, EDLQ, Lisane, DHLC, DHTL-AQ, eHLS-Web3.0, DHLA and GR-eHEALS. Theoretical and conceptual frameworks, definitions, and intended uses for these instruments are summarized in Additional File 4.

Characteristics of included PROMs

Seventeen different instruments assessing eHL were included in this review (see Additional File 5). Only four instruments were examined in multiple studies on large sample sizes: eHEALS, Digital Health Literacy (HL_{19}-DIGI), DHLI and the eHLQ. A total of 17 PROMs underwent assessment. Reliability was evaluated for 10 PROMs, validity for 16 PROMs, and internal consistency for 16 PROMs (see Additional File 6).

The first instrument, the eHEALS, is a widely used 5-point Likert scale with eight items, originally developed in English (41) and translated into several languages, including: Dutch (42), Portuguese (43), German (44, 45), Swiss German (46), Korean (47,48,49), Spanish (50,51), Italian (52,53), Chinese (54,55, 56), Polish (57), Greek (58), Persian (59), Hungarian (60), Norwegian (61, 62), Ethiopian (63), Swedish (64), Sinhala (65), Arabic (66), Indonesian (67), Vietnamese (68), Brazilian (69, 70, 71) and French (72) . eHEALS has been used to assess diverse populations, including youths, adults, older adults, individuals with chronic conditions, caregivers, military personnel, and health professionals across school, community, and clinical settings. The second instrument, Digital Health Literacy (HL_{19}-DIGI), was developed to measure eHL in general adult populations. This 4-point Likert scale with eight items (73) has been employed in large samples across 13 countries participating in the HLS_{19} study, using various data collection methods. The third instrument, eHLQ, comprises 35 items scored on a 4-point Likert scale (74) and has been translated into Dutch (75), Swedish (76), and Serbian (77). The fourth instrument, DHLI includes 21 items scored on a 4-point Likert

scale. Initially developed for the general population, it was recently validated for use with teenagers (78) and older adults (79). DHLI has also been translated into Chinese (80), Korean (81), Brazilian Portuguese (82), and Turkish (83).

Furthermore, several instruments target specific technologies aspects, such as the use of online health communities (eHEALS-E, 84), online information searches (e-HLS,85; HLSI, 86) and online administrative tasks (TeHLI ,87). More recent instruments focus on assessing digital competences for older adults (EDLQ, 88) or citizens (DHLC, 89), the use of digital health technologies, services, and data (DHTL-AQ, 90), eHealth skills in Web 3.0 for self-health management and data usage (eHLS-Web3.0, 91), and the use of information by individuals with chronic diseases trough information and communication technologies (ICT) (Lisane, 92).

Assessment of the content validity: overall ratings and quality of evidence

The overall ratings and quality of evidence for content validity across the 17 instruments is presented in Table 1. eHEALS was rated as having sufficient, moderate-quality evidence for comprehensibility but displayed inconsistent low-quality evidence for relevance and insufficient, very low-quality evidence for comprehensiveness. Although e-HEALS designer chose a youth population for the initial development primarily because they have high levels of eHealth, the eHEALS as the most widely used research tool among adults, has been selected as an instrument and evaluated. Instruments such as HL_{19}-DIGI, DHLI, eHLQ and TeHLI received sufficient ratings for relevance, comprehensiveness, and comprehensibility albeit with low-to-moderate or very low-quality evidence. eHLA and Lisane received sufficient ratings with moderate to high-quality of evidence. Based on the content validity assessment, 11 instruments were rated as ‘‘C: Not recommended for use’’ (29). The

remaining seven instruments and their 17 associated PROMs underwent further psychometrics validity assessments.

Table 1 Overall rating and quality of evidence for the content validity of each instrument [a]

Instrument	Relevance		Comprehensiveness		Comprehensibility		
	Overall rating	Quality of evidence	Overall rating	Quality of evidence	Overall rating	Quality of evidence	recommendation
DHLI[b]	+	High	+	High	+	High	B
TeHLI[c]	+	Low	+	Very low	+	Low	B
HL19-DIGI[d]	+	Low	+	Very low	+	Low/Moderate	B
eHLQ[e]	+	High	+	High	+	High	B
eHLA[f]	+	Low	+	Low	+	Low	B
Lisane[g]	+	High	+	High	+	Moderate	B
eHEALS[h]	±	Low	−	Very low	+	Moderate	B
HSLI[i]	±	Low	+	Low	+	Low	C
eHLscale2.0[j]	−	Very low	−	Very low	−	Very low	C
e-HLS[k]	+	Low	±	Low	+	Low	C
eHEALS-E[l]	±	Moderate	±	Very low	±	Very low	C
EDHLQ[m]	±	Low	−	Low	−	Low/Moderate	C
DHLC[n]	−	Low	−	Low	−	Low	C
DHTL-AQ[o]	−	Low	−	Low	−	Low	C
DHLA[p]	−	Very low	−	Very low	−	Very low	C
eHLS-Web3.0[q]	±	Low	−	Very low	−	Very low	C C

a Sufficient (+), insufficient (−), and inconsistent (±).
Overall recommendation: (A) Suitable for use: PROMs with evidence of sufficient content validity AND at least low quality evidence for sufficient internal consistency; (B) Potentially suitable for use: PROMs not categorized in A or C; or (C) Not recommended: PROMs with high quality evidence of an insufficient measurement property.

b digital health literacy instrument.

c transactional eHealth literacy instrument.

d Digital Health Literacy.

e eHealth literacy questionnaire.

f eHealth literacy assessment toolkit.

g digital health literacy for people living with chronic conditions

h eHealth literacy scale.

i Health Literacy Skills Instrument.

j eHealth Literacy Scale 2.0.

k electronic health literacy scale.

l eHealth literacy scale-extended.

m Everyday Digital Literacy Questionnaire

n digital health literacy competencies for citizens

o digital health technology literacy assessment questionnaire

p digital health literacy assessment

q eHealth Skills in the Web 3.0

r revised German eHEALS was considered with eHEALS

Assessment of other measurement properties: Overall Ratings and Quality of Evidence

The results of the overall ratings and quality of evidence of measurement properties of seven instruments are presented in Tables 2 and 3. Structural validity, internal consistency, cross-cultural/measurement invariance, reliability, and hypotheses testing (convergent validity and discriminant/known-groups validity) are summarized in Additional File 6. No PROM presented sufficient evidence on reliability or measurement error.

Among the seven instruments, HL_{19}-DIGI (93), which follows a one-factor structure, exhibited the strongest level of evidence. It demonstrated sufficient high-quality evidence for structural validity (via Confirmatory Factor Analysis and Rasch analysis), internal consistency and hypotheses testing, including both convergent validity and discriminant/known- groups validity. There was also moderate high-quality evidence for cross-cultural measurement invariance, although some Differential Item Functioning (DIF) was observed across countries. No reliability data was available, as this was the first instance of the instrument being used.

Table 2 Measurement properties of structural validity, internal consistency, and cross-cultural/measurement invariance: Overall rating and quality of evidence[a]

Instrument	# of factors	Structural validity		Internal consistency		Cross-cultural/ measurement invariance	
		Overall rating	Quality of evidence	Overall rating	Quality of evidence	Overall rating	Quality of evidence
eHEALS[b]	1	-	Moderate	+	Moderate	+	High
eHEALS	2[c]	-	High	+	High	N/A[d]	N/A
eHEALS	2[e]	+	Low	+	Low	N/A	N/A
eHEALS	2[f]	-	High	+	High	N/A	N/A
eHEALS	3[g]	+	High	+	High	+	High
eHEALS	3[h]	+	Low	N/A	N/A	N/A	N/A
eHEALS	3[i]	+	High	+	High	+	High
eHEALS	Bifactor[j]	?	Low	N/A	N/A	N/A	N/A
HL19-DIGI[k]	1	+	High	+	High	±	High
DHLI[l]	7	+	Low	+	Low	N/A	N/A
DHLI	6[m]	+	High	+	High	N/A	N/A
DHLI	5[n]	+	Low	+	Low	N/A	N/A
DHLI	3[o]	+	High	+	High	N/A	N/A
eHLA[p]	7	?	Very low	-	Very low	N/A	N/A
eHLQ[q]	7	+	High	+	High	+	High
TeHLI[r]	4	+	High	+	High	N/A	N/A
Lisane[s]	N/A	-	N/A	+	Moderate	-	N/A

a Sufficient (+), insufficient (−), and inconsistent (±).

[b]The item numbers of the eHEALS are those assigned by Norman and Skinner (41).
eHealth literacy scale (41, 42, 47, 48, 49, 50, 52, 53, 54, 55, 56, 57, 59, 60, 64, 65, 66, 67, 68, 69, 70, 71, 94, 95, 96, 104, 105).

[c]Information seeking (items 1, 2, 3, 4, 5, 8), information appraisal (items 6, 7): Soellner et al. (44), Juvalta et al. (46), Diviani et al. (52), Wångdahl et al. (64), Foote et al (106).

[d]No information.

[e]Factor 1 (items 1, 2, 4), factor 2 (items 3, 5, 6, 7, 8): Neter et al. (97).

[f]Factor 1 (items 1, 2, 3, 4, 5), factor 2 (items 6, 7, 8): Efthymiou et al. (58), Dale et al. (61), Shiferaw (63), Chaniaud et al. (72)

[g]Awareness (items 3, 4), skills (items 1, 2, 5), evaluation (items 6, 7, 8): Sudbury-Riley et al. (98), al, Brørs (62), Long (107).

[h]Awareness (items 1, 2), skills (items 4, 5), evaluation (items 6, 7, 8): Hyde et al. (99), Gartrell et al (108).

[i]Information awareness (items 3, 4), information seeking (items 1, 5), information engagement (items 2, 6, 7, 8): Paige et al. (100).

[j]General factor (items 1, 2, 3, 4, 5, 6, 7, 8), subfactor 1 (items 1, 2, 3, 4, 5, 8), subfactor 2 (items 6, 7): Juvalta et al. (46).

[k]digital health literacy (73).

[l]digital health literacy instrument (101).

[m] digital health literacy instrument: 6 factors, Çetin et al. (83).

[n] digital health literacy instrument: 5 factors, Kim et al (49).

[o]digital health literacy instrument: 3 factors, Xie et al (79-80).

[p]eHealth literacy assessment toolkit (102).

[q]eHealth literacy questionnaire (74, 75, 76, 77).

[r]transactional eHealth literacy instrument (87).

[s]Lisane (103)

The second commonly used instrument, eHEALS, follows a single-factor structure but demonstrated insufficient moderate-quality evidence (see Tables 2 and 3). Internal consistency was supported by a qualitative summary of results, with Cronbach's alpha ranging from .84 to .93, omega of .99, person reliability of .80 to .87, person separation index of 2.36, item reliability index ranging from .61 to -.93 (negative values indicate poor item fit), and item separation index of 3.62, all rated as sufficient. However, reliability and hypothesis testing for convergent validity were found to have insufficient high-quality evidence. In addition to the single-factor structure, eHEALS has also been explored with a three-factors and two-factor structures, each with different subscale structures (see Table 2, 3).

Table 3 Measurement properties of reliability, convergent validity, and discriminant/known-groups validity: Overall rating and quality of evidence[a]

Instrument	# of factors	Reliability		Hypothesis testing: convergent validity		Hypothesis testing: discriminant/known-groups validity	
		Overall rating	Quality of evidence	Overall rating	Quality of evidence	Overall rating	Quality of evidence
eHEALS[b]	1	-	High	-	High	+	Moderate
eHEALS	2[c]	N/A[d]	N/A	±	Moderate	N/A	N/A
eHEALS	2[e]	N/A	N/A	+	Moderate	N/A	N/A
eHEALS	2[f]	+	Very low	+	Very low	N/A	N/A
eHEALS	3[g]	-	Low	-	High	+	High
eHEALS	3[h]	N/A	N/A	N/A	N/A	N/A	N/A
eHEALS	3[i]	N/A	N/A	N/A	N/A	+	High
eHEALS	Bifactor[j]	N/A	N/A	N/A	N/A	N/A	N/A
HL19-DIGI[k]	1	N/A	N/A	+	High	+	High
DHLI[l]	7	+	Low	–	High	N/A	N/A
DHLI	6[m]	+	Low	N/A	N/A	+	High
DHLI	5[n]	+	Low	+	Moderate	N/A	N/A
DHLI	3[o]	+	Low	+	Moderate	N/A	N/A
eHLA[p]	7	N/A	N/A	N/A	N/A	N/A	N/A
eHLQ[q]	7	±	Low	+	High	+	High
TeHLI[r]	4	N/A	N/A	±	Low	N/A	N/A
Lisane[s]	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[a] Sufficient (+), insufficient (−), and inconsistent (±).

[b] The item numbers of the eHEALS are those assigned by Norman and Skinner (41).
eHealth literacy scale (41, 42, 47, 48, 49, 50, 52, 53, 54, 55, 56, 57, 59, 60, 64, 65, 66, 67, 68, 69, 70, 71, 94, 95, 96, 104, 105).

[c] Information seeking (items 1, 2, 3, 4, 5, 8), information appraisal (items 6, 7): Soellner et al. (44), Juvalta et al. (46), Diviani et al. (52), Wångdahl et al. (64), Foote et al (106)

[d] No information.

[e] Factor 1 (items 1, 2, 4), factor 2 (items 3, 5, 6, 7, 8): Neter et al. (97).

[f]Factor 1 (items 1, 2, 3, 4, 5), factor 2 (items 6, 7, 8): Efthymiou et al. (58), Dale et al. (61), Shiferaw et al. (63), Chaniaud et al. (72)

[g]Awareness (items 3, 4), skills (items 1, 2, 5), evaluation (items 6, 7, 8): Sudbury-Riley et al. (98), Brørs et al. (62), Long et al. (107).

[h]Awareness (items 1, 2), skills (items 4, 5), evaluation (items 6, 7, 8): Hyde et al. (99), Gartrell et al (108).

[i]Information awareness (items 3, 4), information seeking (items 1, 5), information engagement (items 2, 6, 7, 8): Paige et al. (100).

[j]General factor (items 1, 2, 3, 4, 5, 6, 7, 8), subfactor 1 (items 1, 2, 3, 4, 5, 8), subfactor 2 (items 6, 7): Juvalta et al. (46).

[k]digital health literacy (73).

[l]digital health literacy instrument (101).

[m] digital health literacy instrument: 6 factors, Çetin et al. (83).

[n] digital health literacy instrument: 5 factors, Kim et al (49).

[o]digital health literacy instrument: 3 factors, Xie et al (79-80).

[p]eHealth literacy assessment toolkit (102).

[q]Health literacy questionnaire (74, 75, 76, 77).

[r]transactional eHealth literacy instrument (87).

[s]Lisane (103)

Regarding the DHLI (101), a seven-factor structure demonstrated sufficient low-quality evidence for structural validity. Although the instrument had high-quality evidence for internal consistency, this was downgraded to low-quality evidence due to the low-quality structural validity. Additionally, there was sufficient low-quality evidence for reliability and insufficient high-quality evidence for convergent validity. Variations of the DHLI with six-factor (83), five-factor (81) and three-factor structures (79-80) have also been explored (see Tables 2 and 3).

The eHLQ (74, 75, 76, 77) had sufficient high-quality evidence for structural validity, internal consistency, and measurement invariance. However, it had sufficient low-quality evidence for reliability and insufficient high-quality evidence for convergent validity. The eHLA (102) demonstrated indeterminate, very low-quality evidence for structural validity and insufficient very low-quality evidence for internal consistency. The TeHLI (100) showed sufficient high-quality evidence for both structural validity and internal consistency, but inconsistent low-

quality evidence for convergent validity. Finally, Lisane (103) had a moderate-quality of evidence for reliability.

Discussion

This systematic review identified 17 PROMs measuring eHealth Literacy (eHL). Seven instruments presented sufficient content validity. The HL19-DIGI emerged as the most psychometrically robust instrument, demonstrating sufficient high-quality evidence for structural validity, internal consistency, and both convergent and discriminant validity, though measurement error and responsiveness were not assessed. Based on the COSMIN criteria (39), seven instruments were classified "potentially suitable for use" (Grade B) for content validity. All PROMs included were assessed based on their results but need further investigation and reporting on measurement errors and responsiveness to complete data on measurement properties. Thus, none of the identified PROMs had adequate rating to recommend his use in research or clinical practice.

This review aimed to comprehensively assess the measurement properties of patient-reported outcome measure (PROMs) for eHL in adult populations, including grey literature reporting on population surveys. This review led us to extract measurement properties of 89 articles and three reports. Results showed that the development of PROMs has grown in the last three years with more than 10 new instruments compared to the results found by Lee et al. (24). Although the most widely used, the eHealth Literacy Scale (eHEALS), has limitations in scope and adaptability (110). The review also provides an overview of eHL PROMs validated to use for the population with chronic conditions, eHEALS (95, 54, 63) DHLI (101), eHLQ (109) and Lisane (103) and for caregivers of patients with Demetia (58). The point is that the focus of eHL should be on population health improvement, not just elevating eHL levels. Our results suggest that clinicians and researchers should know the limitations of these questionnaires and should use them with caution.

A critical finding is the limited content validity of most instruments. Only seven instruments were assessed with sufficient content validity (Relevance, Comprehensiveness and Comprehensibility) indicating that for most of them might not be relevant to measure chronic patients' eHL (111). Content validity refers to the degree to which the content of an instrument adequately reflects the construct to be measured (21). There is conceptual diversity across instruments, ranging from narrow operationalizations (e.g., digital information search and appraisal) to broader competencies (e.g., ability to engage with health services and technologies). Few instruments described their theoretical underpinnings, and many lacked a comprehensive framework aligned with current models of digital health engagement or digital determinants of health. The inconsistency in constructs also limits comparability across studies and may contribute to poor structural validity observed in several instruments. It is imperative to develop instruments that are easily understandable by patients in a comprehensive approach to eHL assessments addressing diversity and relevance to give response to patient needs (112).

The three factors eHeals structure reported in three studies (62, 98, 107) were found to be the best structures, with sufficient high-quality evidence for structural validity, internal consistency, hypotheses testing for convergent and divergent validity which is in line with the results of Lee et al (24). The three factors DHLI reported in two studies (79-80) and the six factors DHLI reported in Çetin et al. (83) were found to be new structures, with sufficient high-quality evidence for structural validity, internal consistency and moderate to high quality of evidence for hypotheses testing for convergent and divergent that need more investigation. Most evidence for measurement properties that were rated as low or very low quality is often due to small sample sizes, inadequate reporting, or non-replicated factor structures (113, 114). Measurement error and responsiveness, key properties for instruments intended for

monitoring change over time, were not evaluated in any included study, a significant gap for both researchers and practitioners aiming to assess digital health interventions (115). Finally, studies in the sample rarely involved assessments of longitudinal measurement aspects, namely the reliability and validity of change scores (responsiveness) that reflect the quality of outcome measurement instrument in clinical practice (116, 117).

All the measurements studies adhered to traditional concepts of psychometric assessment, which focus on reliability and validity. In this systematic review, we applied the COSMIN taxonomy consistently across included studies. Studies in the sample did not give results for all measurement proprieties in order to give a grade of recommendation. This systematic review highlights the need for further high-quality studies on responsiveness of PROMs aimed to assess eHL's knowledge and/or skill improvement in clinical practice.

Strengths and limitations

A systematic review of eHL instruments for adult populations was performed, including grey literature reporting on population surveys in English, French, Spanish, or Italian. We followed the COSMIN methodology for systematic review of PROM and the first author was trained to use it. A possible limitation of this study is that we didn't include the results from inadequate quality studies of weak content validity instruments (40), which may have resulted as meta-bias. To avoid inconsistency, the investigators met to discuss how to achieve consensus on subjective questions, and the reviewer trained to COSMIN methodology checked all ratings. Lisane instrument was developed by CDE, but assessment was made by FNA and AYA. Furthermore, the manuscript was revised according to an in-development reporting guidelines PRISMA-COSMIN for systematic reviews of outcomes measurement instruments (118).

Implications for Future Studies on eHealth Literacy Instruments

This review offers critical insight for future instrument development and selection in eHL. These findings reinforce recommendations in the measurement science community for greater

attention to instrument development protocols, particularly the use of qualitative methods (e.g., cognitive interviewing) and involvement of target populations in early stages of instrument design. Considering the dynamic nature of current digital health ecosystems (e.g., Web 3.0, wearables, AI-assisted tools), future instruments should aim to integrate competencies related to emerging digital health contexts, particularly those relevant to underserved populations and individuals managing chronic conditions. Current eHL instruments lack information mainly on measurement error and responsiveness. It is thus important to acknowledge these limitations when using these instruments in research.

Conclusion

This systematic review identified 17 eHealth Literacy (eHL) PROMs from 89 articles across four databases, as well as three reports from a website. A full evaluation of all measurement properties could not be completed due to insufficient information in the studies. Based on content validity assessments, ten PROMs are not recommended for use. Seven PROMs were identified as potentially suitable but require further high-quality research. Future psychometric studies on eHL instruments are strongly encouraged, particularly regarding their development and the assessment of the psychometric adequacy of change scores (responsiveness). It is essential that eHL instruments accurately reflect patients' ability to adapt to eHealth services.

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Contributors

Carole Délétroz: Conceptualization; Data curation; Formal analysis; Methodology; Validation; Roles/Writing - original draft; Writing - review & editing. **Marina Canepa Allen:** Data curation; Formal analysis; Methodology; Software; Writing - review & editing. **Achille Yameogo:** Data curation; Formal analysis; Methodology; Writing - review & editing. **Maxime Sasseville:** Conceptualization; Validation; Writing - review & editing. **Florian Naye:** Data curation; Formal analysis; Methodology; Writing - review & editing. **Alexandra Rouquette:** Methodology; Validation; Writing - review & editing. **Marie-Pierre Gagnon** and **Patrick Bodenmann:** Project administration; Conceptualization; Writing - review & editing.

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Competing Interest:

CDE is the author of the Lisane instrument.

Ethical approbation:

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Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Registration and protocol

PROSPERO CRD42021232765. This review was conducted according to the published protocol (119) in line with the COSMIN methodology.

Data availability statement

Data will be made available on request.

ORCID iDs

Carole Délétroz: https://orcid.org/0000-0003-4910-5439
Marina Canepa Allen: https://orcid.org/0000-0002-0858-8860

Achille R. Yameogo: https://orcid.org/0000-0002-8100-9044

Maxime Sasseville: https://orcid.org/0000-0003-1694-1414

Florian Naye: https://orcid.org/0000-0001-6545-7018

Alexandra Rouquette: https://orcid.org/0000-0002-2473-1719

Patrick Bodenmann: https://orcid.org/0000-0002-1058-1035

Marie-Pierre Gagnon: https://orcid.org/0000000207825457

References

1. World Health Organization. WHO guideline: recommendations on digital interventions for health system strengthening: web supplement 2: summary of findings and GRADE tables. World Health Organization; 2019. https://www.who.int/publications/i/item/WHO-RHR-19.8
2. World Health Organization. WHO guideline: Recommendations on digital interventions for health system strengthening. Research considerations. Geneva: World Health Organization; 2019. WHO/RHR/19.9) Licence: CC BY-NC-SA 3.0 IGO. In. https://www.who.int/publications/i/item/WHO-RHR-19.9
3. World Health Organisation. WHO Classification of digital interventions, services and applications in health: A shared language to describe the uses of digital technology for health, 2nd ed. World Health Organization; 2023. https://www.who.int/publications-detail-redirect/9789240081949
4. Heart and Stroke Foundation of Canada. CSBP-F20-Virtual Care Decision Framework. 2021. https://heartstrokeprod.azureedge.net/-/media/1-stroke-best-practices/csbp-f20-virtualcaredecisionframework-en.ashx
5. European Commission: Directorate-General for the Information Society and Media, European citizens' digital health literacy – Report, European Commission, 2014, https://data.europa.eu/doi/10.2759/86596
6. Novillo Ortiz D. Digital Health Literacy. First Meeting of the WHO GCM/NCD Working Group on Health Literacy for NCDs. Geneva, 2017. https://vdocuments.mx/digital-health-literacy-world-health-organization-first-meeting-of-the-who-gcmncd.html?page=1
7. M-POHL. Publications. s.d. https://m-pohl.net/HLS_Project_Publications_Presentations
8. Refahi H., Klein M., Feigerlova E. e-Health literacy skills in people with chronic diseases and what do the measurements tell us: a scoping review. Telemedicine and e-Health. 2023 Feb 29(2), 198-208. https://doi.org/10.1089/tmj.2022.0115
9. Marcolino MS, Oliveira JAQ, D'Agostino M, Ribeiro AL, Alkmim MBM, Novillo-Ortiz D. The Impact of mHealth Interventions: Systematic Review of Systematic Reviews. JMIR Mhealth Uhealth. 2018 Jan 17;6(1):e23. https://doi.org/10.2196/mhealth.8873
10. Van Kessel R, Wong BL, Clemens T, Brand H. Digital health literacy as a super determinant of health: more than simply the sum of its parts. Internet interventions. 2022 March 7;27:100500. https://doi.org/10.1016/j.invent.2022.100500
11. Yang K, Hu Y, Qi H. Digital Health Literacy: Bibliometric Analysis. J Med Internet Res 2022 July 24(7):e35816. URL: https://www.jmir.org/2022/7/e35816. DOI: 10.2196/35816
12. Kim, K., Shin, S., Kim, S., & Lee, E. The Relation Between eHealth Literacy and Health-Related Behaviors: Systematic Review and Meta-analysis. Journal of medical Internet research. 2023 Jan 30; 25:e40778. https://doi.org/10.2196/40778
13. Kaya B. Compétences en matière de santé. Relation patient-professionnel de santé et accès à l'information relative à la santé. 2018. Croix-Rouge suisse.
14. HLS-EU Consortium. Comparative report of health literacy in eight EU member states. The european health literacy survey HLS-EU. Maastricht: HLS-EU Consortium; 2012.
15. Délétroz, C., Del Grande, C., Amil, S., Bodenmann, P., Gagnon, MP., & Sasseville, M. Development of a patient-reported outcome measure of digital health literacy for chronic patients: results of a French international online Delphi study. BMC nursing. 2023 Dec 22(1), 476. https://doi.org/10.1186/s12912-023-01633-x
16. Yameogo AR, Délétroz C, Sasseville M, Amil S, Da SMAR, Plaisimond J, Bergeron F, Tadlaoui S, Bodenmann P, Gagnon MP. Effectiveness of interventions to improve digital health literacy in forced

migrant populations: A mixed methods systematic review. JMIR Preprints. 2024 Dec 69880. doi: 10.2196/preprints.69880.URL: https://preprints.jmir.org/preprint/69880

17. Délétroz C., Canepa Allen M., Sasseville M., Rouquette A., Bodenmann, P., Gagnon, M.-P. Revue systématique des mesures de littératie en santé numérique pour les patients : résultats préliminaires. Science of Nursing and Health Practices. 2022 Oct 5(Supplément), 15. https://doi.org/10.7202/1093075ar
18. Lee EH, Kang EH, Kang HJ. Evaluation of studies on the measurement properties of self-reported instruments. Asian Nursing Research. 2020 Dec 1;14(5):267-76. https://doi.org/10.1016/j.anr.2020.11.004
19. Cheng C, Beauchamp A, Elsworth GR, Osborne RH. Applying the electronic health literacy lens: systematic review of electronic health interventions targeted at socially disadvantaged groups. Journal of medical Internet research. 2020 Aug 13;22(8):e18476.
20. Délétroz C, Bou-Malhab P, Bodenmann P, Gagnon, MP. Les spécificités de la littératie en santé numérique des patients à l'heure d'Internet et du numérique. In Bodenmann P, Vu F, Wolff H, Jackson Y (éds.), Vulnérabilités, diversités et équité en santé (75–84). Planète santé. 2022.
21. Mokkink LB., Terwee CB., Patrick DL., Alonso J., Stratford PW., Knol DL., Bouter LM., de Vet HC. The COSMIN study reached international consensus on taxonomy, terminology, and definitions of measurement properties for health-related patient-reported outcomes. Journal of clinical epidemiology. 2010 63(7), 737-745. https://doi.org/10.1016/j.jclinepi.2010.02.006
22. Fava GA, Tomba E, Sonino N. Clinimetrics: the science of clinical measurements. Int J Clin Pract 2012;66:11e5
23. Karnoe A, Kayser L. How is eHealth literacy measured and what do the measurements tell us? A systematic review. Knowlegde Management & E-Learning: An International Journal. 2015. 7(4):576-600. https://doi.org/10.34105/j.kmel.2015.07.038
24. Lee J, Lee EH, Chae D. eHealth Literacy Instruments: Systematic Review of Measurement Properties. J Med Internet Res. 2021 Nov 15;23(11):e30644. https://doi.org/10.2196/30644
25. Griebler R, Straßmayr C, Link T, Le C, Dietscher C, Levin-Zamir D. The M-POHL Health Literacy Population Survey 2024-2026 (HLS24). European Journal of Public Health. 2024 Nov;34(Supplement_3):ckae144-770.
26. Higgins JP, Green S. Cochrane handbook for systematic reviews of interventions (Vol. 4). Chichester (UK): John Wiley & Sons; 2011.
27. Higgins JPT, Lasserson T, Thomas J, Flemyng E, Churchill R. Methodological Expectations of Cochrane Intervention Reviews. Cochrane: London, Version August 2023
28. Prinsen, CAC, Mokkink, LB, Bouter, LM. et al. COSMIN guideline for systematic reviews of patient-reported outcome measures. Qual Life Res. 2018 Feb 27, 1147–1157. https://doi.org/10.1007/s11136-018-1798-3
29. Mokkink LB, Prinsen C, Patrick DL, Alonso J, Bouter LM, de Vet H, Terwee CB. COSMIN methodology for systematic reviews of patient-reported outcome measures (PROMs): User manual. Amsterdam Public Health research Institute; 2018. https://cosmin.nl/wp-content/uploads/COSMIN-syst-review-for-PROMs-manual_version-1_feb-2018.pdf
30. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuinness LA, Stewart LA, Thomas J, Tricco AC, Welch VA, Whiting P, Moher D. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021 Mar 29;372:n71. https://doi.org/10.1136/bmj.n71
31. Terwee CB, Jansma EP, Riphagen I, de Vet HC. Development of a methodological PubMed search filter for finding studies on measurement properties of measurement instruments. Qual Life Res. 2009 Oct;18(8):1115–23. https://doi.org/10.1007/s11136-009-9528-5
32. *EndNote*. Version 20.3, Build 16073. Clarivate Analytics; 2020.
33. *Covidence Systematic Review Software*. Veritas health innovation. Date unknown. Accessed June1, 2024. https://www.covidence.org/
34. Kim J, Jung H, Bates DW. History and Trends of "Personal Health Record" Research in PubMed. Healthc Inform Res. 2011 Mar;17(1):3-17. https://doi.org/10. 4258/hir.2011.17.1.3
35. Bittlingmayer UH, Dadaczynski K, Sahrai D, et al. Digitale Gesundheitskompetenz – Konzeptionelle Verortung, Erfassung und Förderung mit Fokus auf Kinder und Jugendliche. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz. 2020;63(2):176–184. https://doi.org/10.1007/s00103-019-03087-6
36. Rodgers M, Sowden A, Petticrew M, Arai L, Roberts H, Britten N, Popay J. Testing Methodological Guidance on the Conduct of Narrative Synthesis in Systematic Reviews: Effectiveness of Interventions

to Promote Smoke Alarm Ownership and Function. Evaluation. 2009;15(1):49–73. https://doi.org/10.1177/1356389008097871
37. Mokkink LB, de Vet HCW, Prinsen CAC, Patrick DL, Alonso J, Bouter LM, Terwee CB. COSMIN Risk of Bias checklist for systematic reviews of Patient-Reported Outcome Measures. Qual Life Res. 2018 May;27(5):1171–1179. https://doi.org/10.1007/s11136-017-1765-4
38. Mokkink LB, Terwee CB, Patrick DL, Alonso J, Stratford PW, Knol DL, Bouter LM, de Vet HC. The COSMIN study reached international consensus on taxonomy, terminology, and definitions of measurement properties for health-related patient-reported outcomes. Journal of clinical epidemiology. 2010 Jul 1;63(7):737-45.
39. Terwee CB, Bot SD, de Boer MR, van der Windt DA, Knol DL, Dekker J, Bouter LM, de Vet HC. Quality criteria were proposed for measurement properties of health status questionnaires. J Clin Epidemiol. 2007 Jan;60(1):34-42. https://doi.org/10.1016/j.jclinepi.2006.03.012
40. Terwee CB, Prinsen CAC, Chiarotto A, Westerman MJ, Patrick DL, Alonso J, Bouter LM, de Vet HCW, Mokkink LB. COSMIN methodology for evaluating the content validity of patient-reported outcome measures: a Delphi study. Qual Life Res. 2018 May;27(5):1159-1170. https://doi.org/10.1007/s11136-018-1829-0
41. Norman CD, Skinner HA. eHEALS: The eHealth Literacy Scale. J Med Internet Res. 2006 Nov 14;8(4):e27. https://doi.org/10.2196/jmir.8.4.e27
42. van der Vaart R, van Deursen AJ, Drossaert CH, Taal E, van Dijk JA, van de Laar MA. Does the eHealth Literacy Scale (eHEALS) measure what it intends to measure? Validation of a Dutch version of the eHEALS in two adult populations. J Med Internet Res. 2011 Nov 9;13(4):e86. https://doi.org/10.2196/jmir.1840
43. Tomás C, Queirós P, Ferreira T. Análise das propriedades psicométricas da versão portuguesa de um instrumento de avaliação de e-Literacia em Saúde. Revista de Enfermagem Referência. 2014;IV(2) :19–28. https://doi.org/10.12707/RIV14004
44. Soellner R, Huber S, Reder M. The concept of eHealth literacy and its measurement: German translation of the eHEALS. Journal of Media Psychology. 2014;26(1):29–38. https://doi.org/10.1027/1864-1105/a000104
45. Bäuerle A, Marsall M, Jahre LM, Rammos C, Mallien C, Skoda EM, Rassaf T, Lortz J, Teufel M. Psychometric properties of the German revised version of the eHealth literacy scale in individuals with cardiac diseases: Validation and test of measurement invariance. Digital Health. 2023 Aug;9:20552076231194915. doi: 10.1177/20552076231194915
46. 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. https://doi.org/10.2196/14492
47. Chung SY, Nahm ES. Testing reliability and validity of the eHealth Literacy Scale (eHEALS) for older adults recruited online. Comput Inform Nurs. 2015 Apr;33(4):150-156. https://doi.org/10.1097/CIN.0000000000000146
48. Chung S, Park BK, Nahm ES. The Korean eHealth Literacy Scale (K-eHEALS): Reliability and Validity Testing in Younger Adults Recruited Online. J Med Internet Res. 2018 Apr 20;20(4):e138. https://doi.org/10.2196/jmir.8759
49. Kim H, Yang E, Ryu H, Kim HJ, Jang SJ, Chang SJ. Psychometric comparisons of measures of eHealth literacy using a sample of Korean older adults. Int J Older People Nurs. 2021 May;16(3):e12369. https://doi.org/10.1111/opn.12369
50. Paramio Pérez G, Almagro BJ, Hernando Gómez Á, Aguaded Gómez JI. Validación de la escala eHealth Literacy (eHEALS) en población universitaria española [Validation of the eHealth Literacy Scale (eHEALS) in Spanish University Students]. Rev Esp Salud Publica. 2015 May-Jun;89(3):329-38. https://doi.org/10.4321/S1135-57272015000300010
51. Aponte J, Nokes KM. Validating an electronic health literacy scale in an older hispanic population. J Clin Nurs. 2017 Sep;26(17-18):2703-2711. https://doi.org/10.1111/jocn.13763
52. Diviani N, Dima AL, Schulz PJ. A Psychometric Analysis of the Italian Version of the eHealth Literacy Scale Using Item Response and Classical Test Theory Methods. J Med Internet Res. 2017 Apr 11;19(4):e114. https://doi.org/10.2196/jmir.6749
53. Del Giudice P, Bravo G, Poletto M, De Odorico A, Conte A, Brunelli L, Arnoldo L, Brusaferro S. Correlation Between eHealth Literacy and Health Literacy Using the eHealth Literacy Scale and Real-Life Experiences in the Health Sector as a Proxy Measure of Functional Health Literacy: Cross-Sectional Web-Based Survey. J Med Internet Res. 2018 Oct 31;20(10):e281. https://doi.org/10.2196/jmir.9401

54. 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. https://doi.org/10.3390/ijerph15071553
55. 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. https://doi.org/10.2196/15720
56. 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. Journal of Medical Internet Research. 2020 Dec 7;22(12):e18613. http://www.jmir.org/2020/12/e18613/
57. Duplaga M, Sobecka K, Wójcik S. The Reliability and Validity of the Telephone-Based and Online Polish eHealth Literacy Scale Based on Two Nationally Representative Samples. Int J Environ Res Public Health. 2019 Sep 3;16(17):3216. https://doi.org/10.3390/ijerph16173216
58. Efthymiou A, Middleton N, Charalambous A, Papastavrou E. Adapting the eHealth Literacy Scale for Carers of People With Chronic Diseases (eHeals-Carer) in a Sample of Greek and Cypriot Carers of People With Dementia: Reliability and Validation Study. J Med Internet Res. 2019 Nov 28;21(11):e12504. https://doi.org/10.2196/12504
59. 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. https://doi.org/10.1177/0163278719827997
60. Zrubka Z, Hajdu O, Rencz F, Baji P, Gulácsi L, Péntek M. Psychometric properties of the Hungarian version of the eHealth Literacy Scale. Eur J Health Econ. 2019 Jun;20(Suppl 1):57–69. https://doi.org/10.1007/s10198-019-01062-1
61. Dale JG, Lüthi A, Fundingsland Skaraas B, Rundereim T, Dale B. Testing Measurement Properties of the Norwegian Version of Electronic Health Literacy Scale (eHEALS) in a Group of Day Surgery Patients. J Multidiscip Healthc. 2020 Mar 9;13:241–247. https://doi.org/10.2147/JMDH.S242985
62. Brørs G, Wentzel-Larsen T, Dalen H, Hansen TB, Norman CD, Wahl A, Norekvål TM, CONCARD Investigators. Psychometric properties of the Norwegian version of the electronic Health Literacy Scale (eHEALS) among patients after percutaneous coronary intervention: cross-sectional validation study. Journal of medical Internet research. 2020 Jul 28;22(7):e17312. https://www.jmir.org/2020/7/e17312
63. Shiferaw KB. Validation of the Ethiopian Version of eHealth Literacy Scale (ET-eHEALS) in a Population with Chronic Disease. Risk Manag Healthc Policy. 2020 May 21;13:465-471. https://doi.org/10.2147/RMHP.S240829
64. Wångdahl J, Jaensson M, Dahlberg K, Nilsson U. The Swedish Version of the Electronic Health Literacy Scale: Prospective Psychometric Evaluation Study Including Thresholds Levels. JMIR Mhealth Uhealth. 2020 Feb 24;8(2):e16316. https://doi.org/10.2196/16316
65. Rathnayake S, Liyanage IP. Cross-cultural adaptation and psychometric properties of the Sinhala version of electronic health literacy scale: A cross-sectional validation study. Plos one. 2022 Apr 8;17(4):e0266515. E | https://doi.org/10.1371/journal.pone.0266515
66. Wångdahl J, Dahlberg K, Jaensson M, Nilsson U. Arabic version of the electronic health literacy scale in Arabic-speaking individuals in Sweden: prospective psychometric evaluation study. Journal of Medical Internet Research. 2021 Mar 22;23(3):e24466. https://www.jmir.org/2021/3/e24466
67. Wijaya MC, Kloping YP. Validity and reliability testing of the Indonesian version of the eHealth Literacy Scale during the COVID-19 pandemic. Health informatics journal. 2021 Jan;27(1):1460458220975466. https://doi.org/10.1177/1460458220975466
68. Le LT, Tran LT, Dang CS, Nguyen PD, Tran NA, Pham TH, Phan HT, Le XH. Testing reliability and validity of the Vietnamese version of the eHealth literacy scale (eHEALS) among medical students in Vietnam. International Journal of Medical Informatics. 2023 Feb 1;170:104962.
69. Mialhe FL, Moraes KL, Sampaio HA, Brasil VV, Vila VD, Soares GH, Rebustini F. Evaluating the psychometric properties of the eHealth Literacy Scale in Brazilian adults. Revista Brasileira de Enfermagem. 2021 Sep 6;75(1):e20201320. https://doi.org/10.1590/0034-7167-2020-1320
70. 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. International journal of medical informatics. 2021 Sep 1;153:104532. https://doi.org/10.1016/j.ijmedinf.2021.104532
71. de Barros JK, de Oliveira LP, de Barros Souza RC. Cross-cultural adaptation and evidence of the validity of the eHealth Literacy Scale for use in Brazil. Revista de Enfermagem Referência. 2022 Feb 1(1). https://doi.org/10.12707/RV21066
72. Chaniaud N, Sagnier C, Loup-Escande E. Translation and Validation Study of the French Version of the eHealth Literacy Scale: Web-Based Survey on a Student Population. JMIR Formative Research. 2022 Aug 31;6(8):e36777. https://formative.jmir.org/2022/8/e36777

73. M-POHL. The HLS_{19}-DIGI Instrument to measure Digital Health Literacy. 2022. https://m-pohl.net/sites/m-pohl.net/files/inline-files/Factsheet%20HLS19-DIGI.pdf
74. Kayser L, Karnoe A, Furstrand D, Batterham R, Christensen KB, Elsworth G, Osborne RH. A Multidimensional Tool Based on the eHealth Literacy Framework: Development and Initial Validity Testing of the eHealth Literacy Questionnaire (eHLQ). J Med Internet Res. 2018 Feb 12;20(2):e36. https://doi.org/10.2196/jmir.8371
75. Poot CC, Meijer E, Fokkema M, Chavannes NH, Osborne RH, Kayser L. Translation, cultural adaptation and validity assessment of the Dutch version of the eHealth Literacy Questionnaire: a mixed-method approach. BMC Public Health. 2023 May 30;23(1):1006. https://doi.org/10.1186/s12889-023-15869-4
76. Sjöström AE, Hajdarevic S, Hörnsten Å, Kristjánsdóttir Ó, Castor C, Isaksson U. The Swedish version of the eHealth literacy questionnaire: translation, cultural adaptation, and validation study. Journal of Medical Internet Research. 2023 Apr 12;25(1):e43267. https://www.jmir.org/2023/1/e43267
77. Vujkovic B, Brkovic V, Pajičić A, Pavlovic V, Stanisavljevic D, Krajnović D, Jovic Vranes A. Serbian Version of the eHealth Literacy Questionnaire (eHLQ): Translation, Cultural Adaptation, and Validation Study Among Primary Health Care Users. Journal of Medical Internet Research. 2024 May 9;26:e57963. https://www.jmir.org/2024/1/e57963
78. Park E, Kwon M. Testing the Digital Health Literacy Instrument for Adolescents: Cognitive Interviews. J Med Internet Res. 2021 Mar 15;23(3):e17856. https://doi.org/10.2196/17856
79. Xie L, Mo PK. Comparison of eHealth Literacy Scale (eHEALS) and Digital Health Literacy Instrument (DHLI) in assessing electronic health literacy in Chinese older adults: a mixed-methods approach. International Journal of Environmental Research and Public Health. 2023 Feb 13;20(4):3293. https://doi.org/10.3390/ ijerph20043293
80. Xie L, Hu H, Lin J, Mo PK. Psychometric validation of the Chinese digital health literacy instrument among Chinese older adults who have internet use experience. International Journal of Older People Nursing. 2024 Jan;19(1):e12568. https://doi.org/10.1111/opn.12568
81. Kim H, Yang E, Ryu H, Kim HJ, Jang SJ, Chang SJ. Psychometric comparisons of measures of eHealth literacy using a sample of Korean older adults. International Journal of Older People Nursing. 2021 May;16(3):e12369. https://doi.org/10.1111/opn.12369
82. Aprile 2024 Aprile DC, Ferretti-Rebustini RE, Peixoto E, Yamaguchi MU, Lopes T. Digital Health Literacy Instrument: Brazilian Version-Cross-Cultural Adaptation and Content Validity for Individuals With Heart Failure. Journal of Nursing Measurement. 2024 Mar 27:JNM-2023. http://dx.doi.org/10.1891/JNM-2023-0061
83. Çetin M, Gümüş R. Research into the relationship between digital health literacy and healthy lifestyle behaviors: an intergenerational comparison. Frontiers in Public Health. 2023 Nov 20;11:1259412. doi: 10.3389/fpubh.2023.1259412
84. Petrič G, Atanasova S, Kamin T. Ill Literates or Illiterates? Investigating the eHealth Literacy of Users of Online Health Communities. J Med Internet Res. 2017 Oct 4;19(10):e331. https://doi.org/10.2196/jmir.7372
85. Seçkin G, Yeatts D, Hughes S, Hudson C, Bell V. Being an Informed Consumer of Health Information and Assessment of Electronic Health Literacy in a National Sample of Internet Users: Validity and Reliability of the e-HLS Instrument. J Med Internet Res. 2016 Jul 11;18(7):e161. https://doi.org/10.2196/jmir.5496
86. McCormack L, Bann C, Squiers L, Berkman ND, Squire C, Schillinger D, Ohene-Frempong J, Hibbard J. Measuring health literacy: a pilot study of a new skills-based instrument. J Health Commun. 2010;15 Suppl 2:51–71. https://doi.org/10.1080/10810730.2010.499987
87. Paige SR, Stellefson M, Krieger JL, Miller MD, Cheong J, Anderson-Lewis C. Transactional eHealth Literacy: Developing and Testing a Multi-Dimensional Instrument. J Health Commun. 2019;24(10):737–748. https://doi.org/10.1080/10810730.2019.1666940
88. Choi J, Choi S, Song K, Baek J, Kim H, Choi M, Kim Y, Chu SH, Shin J. Everyday digital literacy questionnaire for older adults: instrument development and validation study. Journal of medical Internet research. 2023 Dec 14;25:e51616. https://www.jmir.org/2023/1/e51616
89. Rachmani E, Haikal H, Rimawati E. Development and validation of digital health literacy competencies for citizens (DHLC), an instrument for measuring digital health literacy in the community. Computer Methods and Programs in Biomedicine Update. 2022 Jan 1;2:100082. https://doi.org/10.1016/j.cmpbup.2022.100082
90. Yoon J, Lee M, Ahn JS, Oh D, Shin SY, Chang YJ, Cho J. Development and validation of digital health technology literacy assessment questionnaire. Journal of medical systems. 2022 Feb;46(2):13. https://doi.org/10.1007/s10916-022-01800-8
91. Liu HX, Chow BC, Liang W, Hassel H, Huang YW. Measuring a broad spectrum of eHealth skills in the Web 3.0 context using an eHealth Literacy Scale: Development and validation study. Journal of medical Internet research. 2021 Sep 23;23(9):e31627. https://www.jmir.org/2021/9/e31627

92. Délétroz C, Del Grande C, Amil S, Bodenmann P, Gagnon MP, Sasseville M. Development of a patient-reported outcome measure of digital health literacy for chronic patients: results of a French international online Delphi study. BMC nursing. 2023 Dec 14;22(1):476. https://doi.org/10.1186/s12912-023-01633-x
93. M-POHL. International Report on the Methodology, Results, and Recommendations of the European Health Literacy Population Survey 2019-2021 (HLS_{19}) of M-POHL. Vienna: Austrian National Public Health Institute; 2021. https://m-pohl.net/sites/m-pohl.net/files/inline-files/HLS19%20International%20Report.pdf
94. Nguyen J, Moorhouse M, Curbow B, Christie J, Walsh-Childers K, Islam S. Construct Validity of the eHealth Literacy Scale (eHEALS) Among Two Adult Populations: A Rasch Analysis. JMIR Public Health Surveill. 2016 May 20;2(1):e24. https://doi.org/10.2196/publichealth.4967
95. 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. https://doi.org/10.1016/j.pec.2016.09.008
96. Stellefson M, Paige SR, Tennant B, Alber JM, Chaney BH, Chaney D, Grossman S. Reliability and Validity of the Telephone-Based eHealth Literacy Scale Among Older Adults: Cross-Sectional Survey. J Med Internet Res. 2017 Oct 26;19(10):e362. https://doi.org/10.2196/jmir.8481
97. Neter E, Brainin E, Baron-Epel O. The dimensionality of health literacy and eHealth literacy. The European Health Psychologist. 2015;17(6):275–280. https://www.ehps.net/ehp/index.php/contents/article/view/824/pdf_100
98. 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. https://doi.org/10.2196/jmir.5998
99. 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. https://doi.org/10.2196/humanfactors.9039
100. Paige SR, Stellefson M, Krieger JL, Anderson-Lewis C, Cheong J, Stopka C. Proposing a Transactional Model of eHealth Literacy: Concept Analysis. J Med Internet Res. 2018 Oct 2;20(10):e10175. https://doi.org/10.2196/10175
101. van der Vaart R, Drossaert C. Development of the Digital Health Literacy Instrument: Measuring a Broad Spectrum of Health 1.0 and Health 2.0 Skills. J Med Internet Res. 2017 Jan 24;19(1):e27. https://doi.org/10.2196/jmir.6709
102. Karnoe A, Furstrand D, Christensen KB, Norgaard O, Kayser L. Assessing Competencies Needed to Engage With Digital Health Services: Development of the eHealth Literacy Assessment Toolkit. J Med Internet Res. 2018 May 10;20(5):e178. https://doi.org/10.2196/jmir.8347
103. Délétroz C, Bienvenu C, Kaufmann, AL, Sasseville M, Amil S, Rouquette A, Bodenmann P, Gagnon, MP. Field Testing of the Preliminary Version of the Digital Health Literacy Instrument (Lisane) for Adults Living With a Chronic Disease. Science of Nursing and Health Practice. 2024 Sep 7:2. https://doi.org/10.62212/snahp-sips.100
104. Zhu Y, Wang X, You X, Zhao H, Guo Y, Cao W, Xin M, Li J. Cut-off value of the eHEALS score as a measure of eHealth skills among rural residents in Gansu, China. Digital Health. 2023 Oct;9:20552076231205269. doi: 10.1177/20552076231205269
105. Burzyńska J, Rękas M, Januszewicz P. Evaluating the psychometric properties of the eHealth literacy scale (eHEALS) among polish social Media users. International Journal of Environmental Research and Public Health. 2022 Mar 29;19(7):4067. https://doi.org/10.3390/ ijerph19074067
106. Foote D, Giger JT, Murray TD, Engelhardt E, Flaherty C. Validation of the eHEALTH literacy scale (Eheals) with military service members. Military Medicine. 2023 Nov 1;188(11-12):e3621-7. doi:https://doi.org/10.1093/milmed/usad315
107. Long C, Zheng L, Liu R, Duan Z. Structural Validation and Measurement Invariance Testing of the Chinese Version of the eHealth Literacy Scale Among Undergraduates: Cross-Sectional Study. Journal of Medical Internet Research. 2023 Dec 13;25:e48838. https://www.jmir.org/2023/1/e48838
108. 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. Journal of advanced nursing. 2020 Oct;76(10):2522-30. doi: 10.1111/jan.14490
109. Chen YC, Cheng C, Osborne RH, Kayser L, Liu CY, Chang LC. Validity testing and cultural adaptation of the eHealth Literacy Questionnaire (eHLQ) among people with chronic diseases in Taiwan: mixed methods study. Journal of Medical Internet Research. 2022 Jan 19;24(1):e32855. https://www.jmir.org/2022/1/e32855

110. Thorup CB, Uitto M, Butler-Henderson K, Wamala-Andersson S, Hoffrén-Mikkola M, Schack Thoft D, Korsbakke Emtekær Hæsum L, Irrazabal G, Pruneda González L, Valkama K. Choosing the Best Digital Health Literacy Measure for Research: Mixed Methods Study. Journal of Medical Internet Research. 2025 Apr 8;27:e59807
111. Wiegel J, Seppen B, van der Leeden, M, van der Esch, M, de Vries, R, & Bos, W. Adherence to Telemonitoring by Electronic Patient-Reported Outcome Measures in Patients with Chronic Diseases: A Systematic Review. International Journal of Environmental Research and Public Health. 2021. 18(19), 10161. https://doi.org/10.3390/ijerph181910161
112. Narra LR, Verdini N, Lapen K, Nipp R, Gillespie EF. Patient-reported outcomes in clinical trials: From an endpoint to an intervention in cancer care. InSeminars in Radiation Oncology 2023 Oct 1 (Vol. 33, No. 4, pp. 358-366). WB Saunders. https://doi.org/10.1016/j.semradonc.2023.07.002
113. Rouquette, A. et Falissard, B. (2011). Sample size requirements for the internal validation of psychiatric scales. *International journal of methods in psychiatric research*, *20*(4), 235–249. http://doi.org/10.1002/mpr.352
114. Prinsen CAC, Mokkink LB, Bouter LM, Alonso J, Patrick DL, de Vet HCW, Terwee CB. COSMIN guideline for systematic reviews of patient-reported outcome measures. Qual Life Res. 2018 May;27(5):1147-1157. https://doi.org/10.1007/s11136-018-1798-3
115. Bertucci F, AG LC, Monneur A, Fluzin S, Viens P, Maraninchi D, Goncalves A. E-health and" Cancer outside the hospital walls", Big Data and artificial intelligence. Bulletin du cancer. 2019 Sep 19;107(1):102-12. https://doi.org/10.1016/j.bulcan.2019.07.006
116. Polit DF. Assessing measurement in health: Beyond reliability and validity. Int J Nurs Stud. 2015 Nov;52(11):1746–1753. https://doi.org/10.1016/j.ijnurstu.2015.07.002
117. Mokkink L, Terwee C, de Vet H. Key concepts in clinical epidemiology: Responsiveness, the longitudinal aspect of validity. J Clin Epidemiol. 2021 Dec;140:159-162. https://doi.org/https://doi.org/10.1016/j.jclinepi.2021.06.002
118. Elsman EBM, Butcher NJ, Mokkink LB, Terwee CB, Tricco A, Gagnier JJ, Aiyegbusi OL, Barnett C, Smith M, Moher D, Offringa M. Study protocol for developing, piloting and disseminating the PRISMA-COSMIN guideline: a new reporting guideline for systematic reviews of outcome measurement instruments. Syst Rev. 2022 Jun 13;11(1):121. https://doi.org/10.1186/s13643-022-01994-5
119. Délétroz, C., Allen, M. C., Sasseville, M., Rouquette, A., Bodenmann, P., & Gagnon, M. P. (2022). eHealth literacy measurement tools: a systematic review protocol. Systematic reviews, 11(1), 1-9. https://doi.org/10.1186/s13643-022-02076-2

Additional files

Additional file 1. Database Searches

Additional file 2. Updated search filter no 1 for measurement properties/ PubMed (date 2021.02.01) (A01); Use of filter in other databases (A02)

Additional file 3. Excluded full texts and reasons for exclusion

Additional file 4. eHealth literacy instruments: framework, definition, and intended use

Additional file 5. Characteristics of instruments used to assess eHealth literacy

Additional file 6. Summary results for measurement properties