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Development and Validation of the Assessment of Health Literacy in Breast and Cervical Cancer Screening

Hae-Ra Han, PhD, RN, FAAN [Associate Professor],
The Johns Hopkins University School of Nursing, Baltimore, MD, USA

Boyun Huh, PhD, RN [Post-Doctoral Fellow],
The Johns Hopkins University School of Nursing, Baltimore, MD, USA

Miyong T. Kim, PhD, RN, FAAN [Professor],
University of Texas at Austin School of Nursing, Austin, TX, USA

Jiyun Kim, PhD, RN [Assistant Professor], and
Gachon University Department of Nursing, Seongnam-Si, Gyeonggi-Do, Korea

Tam Nguyen, PhD, MSN/MPH [Assistant Professor]
Boston College School of Nursing, Boston, MA, USA

Abstract

For many people limited health literacy is a major barrier to effective preventive health behavior such as cancer screening, yet a comprehensive health literacy measure that is specific to breast and cervical cancer screening is not readily available. The purpose of this paper is to describe the development and testing of a new instrument to measure health literacy in the context of breast and cervical cancer screening, the Assessment of Health Literacy in Cancer Screening (AHL-C). The AHL-C is based on Baker's conceptualization of health literacy and modeled from the two most popular health literacy tests, the Rapid Estimate of Adult Literacy in Medicine and the Test of Functional Health Literacy in Adults. The AHL-C consists of four subscales; print literacy, numeracy, comprehension, and familiarity. We used baseline data from 560 Korean American immigrant women who participated in a community-based randomized trial designed to test the effect of a health literacy-focused intervention to promote breast and cervical cancer screening. Rigorous psychometric testing supports that the AHL-C is reliable, valid, and significantly correlated with theoretically selected variables. Future research is needed to test the utility of the AHL-C in predicting cancer screening outcomes.

Keywords

health literacy; instrument; cancer; screening

Over the last decade, health literacy research has gained increasing attention because it is a significant determinant of health outcomes. Defined as "the degree to which individuals

Please address correspondence to: Hae-Ra Han, RN, PhD, FAAN, The Johns Hopkins University School of Nursing, 525 N. Wolfe St. Room 526, Baltimore, MD 21205, Phone: 410-614-2669, Fax: 410-203-2685, hhan3@jhu.edu.

have the capacity to obtain, process, and understand basic health information and services to make appropriate health decisions (U.S. Department of Health and Human Services, 2000),” health literacy has been associated with better compliance with healthcare provider recommendations, health appointments, and adoption of preventive care such as cancer screening (Bennett et al., 1998; Lindau, Tomori, McCarville, & Bennett, 2001; Weiss, Hart, McGee, & D'Estelle, 1992). Those with a lower level of education and income, non-English-speaking immigrants, and the elderly are disproportionately affected by low health literacy (Institute of Medicine, 2004). Low health literacy has been found to be a strong predictor of inadequate utilization of health care resources and poor health outcomes in vulnerable populations, especially among non-English-speaking immigrants (Institute of Medicine, 2004; Weinick, Zuvekas, & Cohen, 2000).

Several health literacy measures in current use have yielded valuable insights. In particular, the Rapid Estimate of Adult Literacy in Medicine (REALM) (Davis et al., 1993) and the Test of Functional Health Literacy in Adults (TOFHLA) (Parker, Baker, Williams, & Nurss, 1995) are the two most popular tests to assess health literacy in general populations. Nevertheless, they fail to address the particular health context in which health literacy needs to be screened. For example, REALM features general medical words and has limited utility in assessing health literacy in a specific context such as cancer or diabetes care. Likewise, the TOFHLA which measures the ability to apply information in the health care environment includes non-specific/general items and passages that are unique to the U.S. health care system (i.e., Medicaid application questions). As such, it cannot assess health literacy in a specific context. Moreover, some of the passages on the TOFHLA may cause difficulty for immigrants because the content is not relevant in countries outside the U.S. (Han, Kim, Kim, & Kim, 2011).

The characteristics of the health care settings in which individuals navigate and interact to obtain necessary information and care can vary depending on the conditions for which they seek care (e.g., cancer screening versus diabetes care). A context-specific health literacy assessment may be more useful when it is applied to individuals who are in need of obtaining further education and care for a certain condition (Institute of Medicine, 2004). The context-specific assessment can also function as an effective evaluation tool for targeted disease-specific interventions. Assessing health literacy within a specific context has been a growing trend. For example, the following context specific health literacy tools have been developed: the Literacy Assessment for Diabetes (Nath, Sylvester, Yasek, & Gunel, 2001), Diabetes Numeracy Test (Huizinga et al., 2008), Asthma Numeracy Questionnaire (Apter et al., 2006), Rapid Estimate of Adult Literacy in Genetics (REAL-G) (Erby, Roter, Larson, & Cho, 2008), High Blood Pressure-Focused Health Literacy Scale (Kim et al., 2012), and HIV-Related Health Literacy Scale (HIV-HL) (Ownby et al., 2013).

Several health literacy instruments are available in the context of cancer. Specifically, they include the Assessment of Colon Cancer Literacy (Pendlimari, Holubar, Hassinger, & Cima, 2012), the Cancer Literacy Score (Diviani & Schulz, 2012), and Cancer Literacy Assessment Tools (Williams, Reckase, & Rivera-Vasquez, 2008). The first two cancer specific instruments assess colon cancer-related health literacy (Pendlimari et al., 2012) and knowledge about general cancer risk, diagnosis, and treatment as well as coping with cancer

(Diviani & Schulz, 2012), respectively. The Cancer Literacy Assessment Tools (Williams et al., 2008) measure women's understanding of their personal and familial risk of breast and cervical cancers. The Cancer Literacy Assessment Tools were pilot-tested in 16 community health workers and their respective supervisors with a Cronbach's alpha of 0.91. The developers then revised the original version to develop the Breast Cancer Literacy Assessment Tool (B-CLAT) (Williams, Templin, & Hines, 2013) and the Cervical Cancer Literacy Assessment Tool (C-CLAT) (Williams & Templin, 2013). Even though the Cancer Literacy Assessment Tools and the revised tests (B-CLAT and C-CLAT) are breast and cervical cancer-specific, the items included in the measures primarily focus on knowledge (e.g., different types of exams available to detect breast cancer) and fail to assess the comprehensive range of skills needed for health literacy (Institute of Medicine, 2004). Consequently, a comprehensive health literacy measure that is specific to breast and cervical cancer screening is not readily available.

Therefore, we sought to develop a comprehensive cancer screening-specific health literacy measure that assesses individual's comprehension, familiarity, and recognition of words related to breast and cervical cancer screening. The development of this measure was firmly grounded in a theoretical framework, with the ultimate goal of creating a measure that is sensitive enough to capture the intervention effects of a health literacy-focused breast and cervical cancer control education and counseling program. This paper reports the development process and the psychometric properties of the breast and cervical cancer screening-specific health literacy instrument, the Assessment of Health Literacy in Cancer Screening (AHL-C), using a sample of first-generation Korean American women. In addition, preliminary evidence of its utility for evaluating cancer screening interventions as an outcome measure is presented.

Methods

We employed a two-phase instrumentation design process: instrument development and testing. The instrument development phase began with generating items for the AHL-C as described in the following section.

Development phase

Selection of items—We used multiple methods to create a comprehensive pool of test items for the AHL-C. First, we searched the literature for current practice guidelines on breast and cervical cancer screening (U.S. Preventive Services Taskforce, 2010). Relevant words were also collected from educational materials (e.g., pamphlets, brochures, websites) published by the Centers for Disease Prevention and Control, National Cancer Institute, and American Cancer Society. In addition, we used participant observation to explore common clinical encounters experienced by women when they go through breast and cervical cancer screening. In consultation with practicing clinicians, the study team selected nine settings where women seek care for breast and cervical cancer screening (e.g., primary care office, OB/GY clinic, breast center). A trained research assistant observed at least one encounter for each setting and completed field notes to inform the essential terminology needed to be understood by women when undergoing breast and cervical cancer screening. A panel of 10

people including Korean American women with previous breast and/or cervical cancer screening experiences, nurses, an OB/GYN, a nurse practitioner, and community health workers assessed the face validity and the appropriateness of the initial pool of items generated using the combined methods. Then, an expert panel (N=8) of clinicians and researchers with extensive experience in women's breast and cervical cancer screening rated each item for its relevance using a 4-point scale, with 1 being "not relevant" and 4 being "very relevant (Lynn, 1986)." A content validity index was calculated by the proportion of experts who gave an item a rating of 3 or 4. Items with at least 80% of endorsement rates were retained (Lynn, 1986), yielding 47 words specific to breast and cervical cancer. A pilot sample of 12 Korean American women was then asked to pronounce the 47 words. Twelve of the most frequently missed words with a 0.5 or greater item-total correlation (Erby et al., 2008) were retained on the final list to maximize discrimination.

AHL-C structure—Building on the conceptual model of health literacy presented by the Institute of Medicine (2004), Baker (2006) suggests that there are two sub-domains of health literacy at the individual level. They include reading fluency and prior knowledge. Reading fluency refers to "the ability to mentally process written materials and form new knowledge (p. 898)" (Baker, 2006). Reading fluency includes a variety of skill sets such as the ability to read and understand written documents (print literacy) and to apply arithmetic operations and use numerical information in printed materials (numeracy). On the other hand, prior knowledge is defined as "an individual's knowledge at the time before he/she reads health-related materials or speaks to a health care professional (p. 879)," and includes vocabulary (comprehension—knowing which words mean what) and conceptual knowledge (familiarity—understanding aspects of the world) (Baker, 2006).

The structure of the AHL-C was developed based on the Baker's conceptualization and includes the following subscales: print literacy, numeracy, comprehension, and familiarity. The *print literacy subscale* was modeled on the two most popular global health literacy tests, the REALM and the TOFHLA (see Appendix A). First section of the print literacy subscale (Reading test) includes simple questions in a REALM-like instrument to test the individual's reading ability (12 items). The second section of the subscale requires examinees to complete 12 clause-type items (i.e. fill in the blank sentences) as in the case of the TOFHLA. The passages used for the second section of the print literacy subscale are based on the navigational trajectory required for cancer screening (e.g., check-in at OB/GYN clinic, communication between a woman and a doctor about breast self-examination and risk factors for breast and cervical cancers, appointment making for a mammogram test). The items on the print literacy subscale were scored as correct/incorrect, with total possible scores ranging from 0 to 24.

The *numeracy subscale* included four items. The scale was adapted from a popular numeracy assessment tool, the Newest Vital Sign (NVS) (Weiss et al., 2005). We modified the items on the NVS to make them more relevant to cancer prevention. For example, the original NVS asks questions about an ice cream nutrition label. In the AHL-C, we used a nutrition label for pizza since weight control and reduced calorie intake are important dietary behaviors for preventing cancer (see Appendix B). Total possible scores ranged from 0 to 4, with one point assigned for each correct response.

The *comprehension subscale* consisted of 12 items which require an individual to associate each term to a word or a picture of the meaning to demonstrate comprehension. As was the case for the print literacy and numeracy subscales, the items on the comprehension subscale were scored as correct/incorrect, with total possible scores ranging from 0 to 12.

Finally, the *familiarity subscale* asked participants their level of familiarity with the 12 items in the print literacy subscale on a 5-point Likert scale from 0 (not at all familiar—never heard of the word before) to 4 (very familiar—can use the word proficiently). For ease of understanding, scores on the familiarity subscale were recalibrated for each item on a 0–1 point scale so that total possible scores ranged from 0 to 12 (see Appendix C). The AHL-C was written at the 6th grade reading level.

Testing Phase

Sample and Design—Data were obtained from a sample of Korean American women who participated in a community-based intervention study—Better Breast and Cervical Cancer Control for Korean American Women—which was designed to promote breast and cervical cancer screening among non-adherent Korean women. The parent study is a cluster-randomized controlled trial in which trained lay health workers deliver health literacy-focused education and navigation assistance to Korean women in the study for 6 months. Eligibility was based on the following inclusion criteria: a) self-identified as a Korean American woman; b) aged 21–65 years; c) have no mammogram and/or Pap test within the last 24 months; d) able to read and write Korean or English; and e) willing to provide written informed consent to allow the researchers to audit medical records for mammography and/or Pap test use. Participants were recruited from ethnic churches located in the Baltimore-Washington Metropolitan Area. A total of 560 eligible Korean American women completed the study questionnaire at baseline. At 6 months follow-up, 527 women participated in the final data collection. We used the baseline data to test the psychometrics of the newly developed AHL-C measure and the 6-month follow-up data to evaluate the utility of the AHL-C as an intervention outcome assessment tool.

Procedures—After approval of the study protocol by the Institutional Review Board, potential participants were identified by trained lay health workers. Trained bilingual research staff approached these participants, briefly explained the study to them, verified eligibility, and asked those eligible to participate in the study. The research staff then obtained informed consent from each woman who agreed to participate, and administered study instruments. To assess the print literacy subscale, participants were given a laminated list of words and instructed to pronounce each word. Trained research staff scored answers, checking (+) for each item correctly pronounced and (−) for any word that was either not attempted or was mispronounced. If the participant took more than 5 seconds on a certain item, they were told to skip the item and proceed to the next word. The number of correctly pronounced words (+) was then counted to calculate a sum score. Similarly, to assess comprehension, participants were instructed to complete the clause test to apply their health literacy in the navigational trajectory required for cancer screening. To assess numeracy, research staff showed a laminated nutritional label to participants and recorded their responses to the four questions. Finally, participants selected their level of familiarity with

the 12 items in the print literacy subscale. It took about 10–15 min to complete the AHL-C. Participants received $20 for their participation.

Measurements—A study questionnaire was developed to collect basic socio-demographic information such as age, education, marital status, employment status, English proficiency, and years of residence in the United States. Cancer-specific health literacy was measured using the new tool, the AHL-C. We also administered the standard REALM (Davis et al., 1993) as an additional outcome measure of health literacy. The REALM is one of the most popular validated instruments and has been used to assess the individual's ability to pronounce 66 medically relevant English words (i.e., words recognition test). The REALM compares favorably with other health literacy assessments with correlation coefficients of 0.80–0.90 (Davis et al., 1993). The REALM was validated in Korean American women (Han, Kim, Kim, & Kim, 2011). The REALM yielded a reliability coefficient of 0.98 in the current sample of Korean women. Cancer knowledge was assessed using two validated tests: the Breast Cancer Knowledge (BCK) Test (McCance, Mooney, Smith, & Field, 1990) and the Cervical Cancer Knowledge (CCK) Test (Park, Chang, & Chung, 2005). The BCK Test consists of 18 true or false items (e.g., "Most breast cancer is associated with hereditary factors."). Similarly, the CCK Test consists of 10 true or false items (e.g., "Heavy smokers have an increased risk of cervical cancer)". The BCK and CCK tests have been validated in Korean women, with reliability coefficients of 0.80–0.89 (Park, Chang, & Chung, 2005). The BCK and CCK tests yielded respective internal consistency reliability coefficients of 0.81 and 0.74 in the study sample.

Analysis—Descriptive statistics were used to summarize participant's socio-demographic characteristics and health literacy scores. Coefficients for internal consistency reliability of the AHL-C were estimated by KR-20 for Yes/No responses and Cronbach's alpha for Likert-type responses. Internal consistency reliability coefficients of 0.70 or greater were considered acceptable (Nunnally, 1994). Item analysis was also performed. Item-total correlations greater than 0.15 were considered adequate (Nunnally, 1994). Pearson's correlation coefficients were used to calculate the correlations between the AHL-C subscales and known covariates such as age, educational level, English proficiency, and cancer knowledge to demonstrate evidence of construct validity (Institute of Medicine, 2004; Lindau et al., 2002; Scott, Gazmararian, Williams, & Baker, 2002). Analyses of covariance (ANCOVAs) were then performed to compare the magnitude of within-group changes in the level of health literacy after 6-month intervention with baseline controlled. Statistical significance was determined at the level of *p*-value less than 0.05.

Results

Participant characteristics

Socio-demographic characteristics of the participants are presented in Table 1. The majority of the sample were middle-aged (mean age=46.0±8.6 years), married or partnered (85.7%), and were well educated with nearly two thirds (64.8%) having completed some college or more. Three out of five (60%) were employed full- or part-time and all were born in Korea. The mean length of stay in the US was 16.5 (±9.7) years with about 70% of women having

been in the US for 10 years or more. While less than one-third of the participants felt “very comfortable” or “comfortable” about their household income level, only 37.9% of the sample reported having medical insurance and 34.5% reported having a primary care provider. As for English proficiency, most Korean American women in the study reported their English as being poor or fair, and less than one in four (23.4%) rated their English proficiency as fluent.

Descriptive psychometrics of the AHL-C

Table 2 shows the means, standard deviation, and reliability coefficients of the AHL-C scales. Internal consistency reliability coefficients ranged from 0.70 for the Numeracy scale to 0.96 for the familiarity scale with a reliability coefficient of 0.96 for the total scale, indicating excellent internal consistency reliability. The item-total correlations for all items on the AHL-C scale also met the a priori cut-off score, ranging from 0.18 to 0.86.

Validity testing

We tested the construct validity of the AHL-C by correlating its total scores with theoretically relevant variables including age, education, English proficiency, and breast and cervical cancer knowledge. Table 3 presents correlation coefficients between the theoretically relevant variables and AHL-C scales. The AHL-C scales showed statistically significant negative correlations with age and positive correlations with education and English proficiency ($p<0.05$ for all correlation coefficients). Health literacy as measured by the AHL-C was also significantly positively correlated with both breast ($r=0.11–0.26$, $p<0.05$) and cervical cancer knowledge ($r=0.11–0.24$, $p<0.05$). Finally, the reading fluency subscale was positively correlated with the prior knowledge subscale as well as the total AHL-C ($r=0.66$ and 0.93, respectively; $p<0.05$ for both), indicating convergent validity.

Evaluation of the AHL-C as an outcome measure

Despite randomization, differences existed in the following health literacy subscale scores at baseline, all favoring the control group except for Numeracy: Clause Test, Numeracy, and Familiarity. Table 4 compares adjusted health literacy change scores between the intervention and control groups. As shown in Table 4, after controlling for baseline values of the health literacy outcome, the intervention group had significantly improved health literacy scores across all AHL-C subscales and the total scale as compared to the control group. However, no group difference emerged at 6 months when health literacy was measured by the REALM ($p=0.179$).

Discussion

Data from this developmental study suggests that AHL-C tool is a reliable and valid measure of health literacy in the context of breast and cervical cancer screening. Results show that the AHL-C was significantly correlated with both breast and cervical cancer knowledge and known covariates of health literacy such as age, education, and English proficiency. All the item-total correlations as well as internal consistency reliability coefficients were also above the acceptable range (Nunnally, 1994). Finding ideal ways of measuring health literacy is critical to address health disparity gaps observed in racial/ethnic

minorities, particularly those with limited health literacy (Innos & Horn-Ross, 2003; Institute of Medicine, 2004; Liu, Zhang, Deapen, Bernstein, & Ross, 2003; Liu, Zhang, Wu, Pike, & Deapen, 2012). This is particularly important given the wide range of adverse health outcomes resulting from limited health literacy (Bennett et al., 1998; Institute of Medicine, 2004; Lindau et al., 2001; Weiss et al., 1992). Our findings suggest the AHL-C has sound psychometric properties and is a comprehensive measure of health literacy in breast and cervical cancer screening.

Health literacy encompasses multifaceted skill sets such as print literacy, numeracy, comprehension, and conceptual knowledge (or familiarity) (Baker, 2006). Yet, a recent systematic review of ten studies which examined health literacy and cancer screening (Oldach & Katz, 2014) revealed that while the health literacy instruments used in the study were valid, they only addressed a subsample of the health literacy skill set. Indeed, most existing health literacy measures focus on reading fluency (Oldach & Katz, 2014), whereas the AHL-C includes an additional domain of health literacy, prior knowledge (i.e., comprehension and familiarity subscales) (Baker, 2006). Prior knowledge is of particular relevance to those who are naïve to the US healthcare system (e.g., recent immigrants) as their lack of prior knowledge can create cognitive as well as emotional barriers to understanding health information and navigating the healthcare system (Poureslami, Rootman, Doyle-Waters, Nimmon, & Fitzgerald, 2011). In fact, prior knowledge yielded slightly stronger correlations with both breast ($r=0.26$ vs. 0.19) and cervical cancer knowledge ($r=0.24$ vs. 0.20) than reading fluency in the study sample. Future research needs to address if prior knowledge leads to better health behavior and outcomes.

Results from this study suggest that the AHL-C may be an effective evaluation tool for assessing interventions designed to improve health literacy in the context of breast and cervical cancer screening. However, we were only able to look at short-term effects over a six-month period. Traditional health education programs involving individuals with low health literacy have primarily focused on adjusting the reading levels, using interpreters, or incorporating the use of video, audiotapes, or web-based decision aids (McCray, 2005; Bischoff, Perneger, Bovier, Loutan, & Stalder; 2003; Santo, Laizner, & Shohet, 2005; Miller et al., 2011). Few have included topic contents or activities that are directly focused on improving health literacy due, in part, to the lack of a sensitive instrument to measure health literacy (Kim et al., 2012). The AHL-C may be a useful evaluation tool for clinicians and researchers who work with populations in need of improving cancer screening health literacy.

While all the test instructions were given in Korean, the actual test items on the AHL-C were written in English. This may have caused some readers to question whether using test items in English is a valid approach because the traditional approach has been that an English instrument is typically translated into the language of a target population (such as Korean). Our decision was based on prior investigations in which the translation of the REALM and S-TOFHLA into Korean did not lead to a valid assessment of health literacy (Han et al., 2011)—with results suggesting marginal reliability and questionable validity, and a highly skewed distribution of health literacy scores due, in large part, to the fact that Korean is a phonetic language. The feature of a phonetic language (i.e., one can pronounce

words in the language so long as one can recognize its letters or alphabets) violates the design basis of popular health literacy tests based on reading fluency such as the REALM, which assumes a high correspondence between reading ability and comprehension (Han et al., 2011). An effort to translate the REALM into another phonetic language, Spanish, revealed similar problems (Nurss, Baker, Davis, Parker, & Williams, 1995). In addition, in the context of cancer screening, an individual navigates a health system in English at least partially, if not all, to obtain a screening test. Bilingual health personnel are difficult to identify in a minority community, let alone cancer screening facilities (e.g., mammogram facility). The sound evidence of reliability and validity of the AHL-C demonstrated in this study supports the approach taken in designing this measure.

Limitations of the study should be acknowledged. First, we included only one ethnic group whose educational level was somewhat higher than that of general U.S. women aged 25 years or older (about 65% having completed some college or more in our sample vs. 59% in the general population) (U.S. Census Bureau, 2013). In addition, the majority of our sample (about 77%) reported limited English proficiency in comparison to 42% of the general U.S. population and 56% of general Korean Americans who spoke a non-English language at home (Ryan, 2013). Hence, we are not able to assess the extent to which our findings are generalizable to other ethnic groups or to those without English difficulty. Nevertheless, the educational level reported in our study sample is comparable to 68% of Asian women (25+ years) who reported having completed some college or more (U.S. Census Bureau, 2013). We deliberately chose our sample based on cancer disparities experienced by Korean American women. Further research is warranted to validate the AHL-C in a wider range of ethnic samples with varying levels of educational attainment and English proficiency.

Second, the study sample was mainly drawn from ethnic churches. We decided that churches would be ideal recruitment and intervention sites for the study population since the majority of Korean Americans (80%) regularly attend an ethnic church (Han, Kang, Kim, Ryu, & Kim, 2007; Kim, Kim, Juon, & Hill, 2000). The church is a central feature of life for a number of minority and recent immigrant groups, functioning as a main source of social support and information sharing (Jo, Maxwell, Yang, & Bastani, 2010; Lee, Hanner, Cho, Han, & Kim, 2008). It is possible that church goers might have unique experiences that differentiate them from non-church goers such as increased opportunities to learn about health information and exposure to medical terminologies or procedures which might affect their health literacy.

Third, in its current form, the AHL-C may be too long to use in a busy clinical setting, hence further efforts need to be made to shorten the scale as appropriate. Finally, we acknowledge that there are competing definitions of health literacy such as the definition by Williams (2008) that focuses on knowledge of personal and familial risk of cancer and knowledge about cancer screening test. We developed the AHL-C based on Baker's (2006) conceptualization of health literacy with print literacy, numeracy, comprehension, and familiarity domains.

As the field is moving forward with more sophisticated conceptualization of health literacy (von Wagner, Steptoe, Wolf & Wardle, 2009), it will be important to continue investigating

particular conceptualization and domains of health literacy that are most salient to cancer screening behavior and refine the concept definition accordingly.

Further development of the AHL-C will focus on improving the measure's feasibility by refining it based on item response theory. In the next phase, it would be important to test the sensitivity of the new instrument as an outcome measure in diverse populations. Additionally, while existing health literacy instruments are often time-consuming and costly to use in clinical practice (Johnson & Weiss, 2008), systematic investigation of the AHL-C using different test administration approaches (e.g., paper-pencil vs. computer-based) is warranted to enhance efficiency of the tool for use in multiple healthcare settings.

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Appendix A

Proportion of correct response on the Reading fluency subscale

Classification	Items	Response type	Correct (%)
Direction: 아래 단어들을 발음해 주십시오 (Please read out loud the listed words below).			
Reading test	1. Benign	correct/incorrect	24.4
	2. Biopsy	correct/incorrect	53.0
	3. Cervix	correct/incorrect	66.9
	4. Gynecology	correct/incorrect	34.7
	5. Human Papillomavirus	correct/incorrect	29.0
	6. Hysterectomy	correct/incorrect	33.5

Classification	Items	Response type	Correct (%)
	7. Malignant	correct/incorrect	40.4
	8. Mastectomy	correct/incorrect	56.0
	9. Metastasis	correct/incorrect	40.8
	10. Pelvic	correct/incorrect	69.2
	11. Uterus	correct/incorrect	51.7
	12. Vagina	correct/incorrect	37.6
	Average correct response for Reading test (%)		44.8
Direction: 다음 문장을 읽고 빈칸에 알맞은 단어를 골라 보십시오 (Please read the following and select the right response).			
Clause test	13. Please sit down and roll up your sleeve. I will measure your _____.	correct/incorrect	68.8
	14. Please have a seat. While you are waiting, please fill out this _____.	correct/incorrect	65.7
	15. Do you have your _____ card with you?	correct/incorrect	77.3
	16. Doctor: Please tell me whether you have abnormal symptoms such as _____ in your breast or	correct/incorrect	56.6
	17. _____from your nipple.	correct/incorrect	28.4
	18. If you feel any changes in your breasts during self-examination, call us to make an appointment for _____.	correct/incorrect	65.5
	19. For what test appointment does Mrs. Kim make a call?	correct/incorrect	78.2
	20. Where does Mrs. Kim call for this test?	correct/incorrect	77.7
	21. Does anybody in your family have cervical, ovarian or breast cancer? Mrs. Kim: Yes. My sister had a _____ because she had a 22._____in the uterus. I heard about the virus that causes cervical cancer. What is it?	correct/incorrect correct/incorrect	44.8 47.9
	23. What is the answer that the doctor gave to Mrs. Kim?	correct/incorrect	50.4
	24. What is the right test for the explanation?	correct/incorrect	44.8
	Average correct response for Clause test (%)		58.8
Direction: 아래의 정보는 피자의 영양라벨입니다. 잘 읽고 대답해 주십시오 (Below is the food label of pizza (Appendix B). Please read and answer the questions).			
Numeracy test	25. If you eat a piece of pizza, how many calories will you take?	correct/incorrect	65.2
	26. If you eat a piece of pizza for lunch, how many calories from saturated fat will you take?	correct/incorrect	26.8
	27. The doctor advises you to reduce cholesterol. If you do not eat a slice of pizza following that advice, how many calories would you reduce?	correct/incorrect	69.8
	28. If you eat a whole box of pizza, how many calories would you take?	correct/incorrect	52.5
	Average correct response for Numeracy test (%)		53.6

Appendix B

Nutrition label

Nutrition Facts

Serving Size ⅓ pizza (116g)

Serving Per Container 3

Amount Per Serving	
Calories 330	Calories from Fat 150
	% Daily Value*
Total Fat 17g	18%
Saturated Fat 7g	30%
Trans Fat 0g	
Cholesterol 35mg	3%
Sodium 690mg	50%
Total Carbohydrate 30g	13%
Dietary Fiber 2g	8%
Sugar 6g	
Protein 14g	

Vitamin A 8% ● Vitamin C 2%

Calcium 25% ● Iron 6%

***Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:**

	Calories	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300g	300g
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:

Fat 9 ● Carbohydrate 4 ● Protein 4

INGREDIENTS

CRUST: Enriched wheat flour (malted barley flour, niacin, ferrous sulfate, thiamin mononitrate, riboflavin, folic acid), water, soybean oil, contains less than 2% sugar, yeast, salt, baking powder (corn starch, sodium bicarbonate, sodium aluminum sulfate, monocalcium phosphate), soy flour, cornmeal.

SAUCE: Water, tomato paste, contains less than 2% sugar, salt, spices, dehydrated garlic and onion, soybean oil, modified corn starch, guar gum, parmesan cheese (cultured milk, salt, enzymes), xanthan gum, paprika, citric acid, soy flour.

PIZZA TOPPING: Italian Sausage: Pork, seasonings (spices, corn syrup solids, salt, garlic powder, chili pepper, caramel color), water, textured vegetable protein (soy protein concentrate, caramel color). Mozzarella Cheese Substitute: Water, partially hydrogenated soybean oil, rennet casein, sodium aluminum phosphate, corn starch, lactic acid, natural flavor, sodium citrate, sorbic acid (preservative), artificial color, enrichment blend (magnesium oxide)

Appendix C

Proportion of response on the Prior knowledge subscale

Classification	Items	Response type	Correct (%)
Direction: 단어와 단어의 정확한 뜻을 연결하세요 (Please find the correct meaning of each word listed below).			
Comprehension	1. Benign	correct/incorrect	17.9
	2. Biopsy	correct/incorrect	17.1
	3. Cervix	correct/incorrect	29.1
	4. Gynecology	correct/incorrect	38.8
	5. Human Papillomavirus	correct/incorrect	37.1
	6. Hysterectomy	correct/incorrect	22.7
	7. Malignant	correct/incorrect	22.5

Classification	Items	Response type	Correct (%)
	8. Mastectomy	correct/incorrect	23.8
	9. Metastasis	correct/incorrect	21.3
	10. Pelvic	correct/incorrect	22.9
	11. Uterus	correct/incorrect	30.5
	12. Vagina	correct/incorrect	40.9
	Average correct response for Comprehension (%)		27.1

Direction: 다음 단어들이 얼마나 익숙한지 한 가지만 골라 응답해 주세요 (The following questions are asking about how familiar you are with the words below. Please check the answer that is most appropriate).

		Not at all familiar (%)	Item mean (range=0–1)*
Familiarity	13. Benign	73.0	0.14
	14. Biopsy	55.4	0.24
	15. Cervix	66.8	0.18
	16. Gynecology	62.1	0.21
	17. Human Papillomavirus	70.0	0.15
	18. Hysterectomy	72.7	0.14
	19. Malignant	75.7	0.13
	20. Mastectomy	79.1	0.11
	21. Metastasis	80.1	0.10
	22. Pelvic	70.1	0.17
	23. Uterus	64.8	0.20
	24. Vagina	52.8	0.28
	Average item mean for Familiarity		0.17

* Recalibrated from 0–4 points to 0–1 point for ease of understanding.

Table 1

Sample characteristics (N=560)

Variables	n (%)	Mean ± SD
Age, years (range=21–65)		46.0 ± 8.6
20–30s	145 (25.9)	
40s	199 (35.5)	
50–60s	216 (38.6)	
Marital status		
Married/Partnered	480 (85.7)	
Separated/Widowed/Divorced	61 (10.9)	
Never married	19 (3.4)	
Years of education (range=4–24)		14.6 ± 2.7
≤High school graduate	197 (35.2)	
Some college+	363 (64.8)	
Employment		
Working full- or part-time	336 (60.0)	
Unemployed or retired	224 (40.0)	
Length of stay in the US, years (range=0.1–62.3)		16.5 ± 9.7
<10 yrs	166 (29.6)	
10–19 yrs	193 (34.5)	
20–29 yrs	140 (25.0)	
30+ yrs	61 (10.9)	
Income level		
Very comfortable/Comfortable	150 (26.8)	
Just OK	193 (34.5)	
Uncomfortable/Very uncomfortable	217 (38.7)	
Have health insurance	212 (37.9)	
Have primary care physician	193 (34.5)	
English proficiency (range=1–4)		2.7 ± 0.9
Not at all/Poor	227 (40.5)	
Fair	202 (36.1)	
Fluent	131 (23.4)	

Table 2

Reliability testing of the AHL-C (N=560)

	Mean ± SD	Range	Reliability coefficient	Item-total correlation
Reading fluency[1]	14.59 ± 7.78	0–28	0.93	0.25–0.69
Reading test	5.38 ± 3.83	0–12	0.89	0.50–0.68
Clause test	7.06 ± 4.06	0–12	0.92	0.47–0.76
Numeracy	2.14 ± 1.36	0–4	0.70	0.49–0.55
Prior knowledge[2]	5.27 ± 5.92	0–24	0.95	0.41–0.77
Comprehension	3.24 ± 3.68	0–12	0.91	0.48–0.70
Familiarity	2.04 ± 2.86	0–12	0.96	0.63–0.86
AHL-C total[3]	19.87 ± 12.52	0–52	0.96	0.18–0.69

[1] Sum of Reading test, Clause test, and Numeracy.

[2] Sum of Comprehension and Familiarity.

[3] Sum of Reading fluency and Prior knowledge.

Table 3

Correlation coefficients for selected variables and AHL-C subscales (N=560)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age	--												
2. Education	−.31**	--											
3. English proficiency	−.19**	.33**	--										
4. Breast cancer knowledge	−.04	.20**	.08	--									
5. Cervical cancer knowledge	−.09*	.25**	.09*	.62**	--								
6. Reading fluency	−.34**	.49**	.62**	.19**	.20**	--							
7. Reading test	−.27**	.45**	.55**	.14**	.17**	.88**	--						
8. Clause test	−.31**	.43**	.59**	.20**	.19**	.90**	.64**	--					
9. Numeracy	−.22**	.25**	.27**	.11*	.11*	.54**	.33**	.39**	--				
10. Prior knowledge	−.23**	.35**	.49**	.26**	.24**	.66**	.58**	.63**	.26**	--			
11. Comprehension	−.26**	.34**	.44**	.26**	.22**	.66**	.57**	.65**	.26**	.93**	--		
12. Familiarity	−.14**	.27**	.44**	.21**	.22**	.52**	.47**	.47**	.21**	.88**	.64**	--	
13. AHL-C total	−.32**	.47*	.62**	.24**	.24**	.93**	.82**	.86**	.46**	.88**	.85**	.74**	--

* p<0.05;

** p<0.01

Table 4

Adjusted health literacy change scores at 6 months (N=527)

Health literacy	Intervention (n=261) mean (SD)	Control (n=266) mean (SD)	*p*[b]
Reading fluency	5.39 (7.21)	2.11 (4.65)	<.001
Reading test	2.69 (3.97)	1.59 (2.93)	<.001
Clause test[a]	2.59 (4.01)	0.52 (2.47)	<.001
Numeracy[a]	0.11 (1.66)	0.00 (1.53)	.026
Prior knowledge	5.55 (4.49)	2.14 (3.04)	<.001
Comprehension	0.96 (0.87)	0.63 (0.86)	<.001
Familiarity[a]	4.58 (4.22)	1.51 (2.78)	<.001
AHL-C total	10.97 (10.44)	4.25 (6.27)	<.001
REALM total	3.21 (16.77)	4.77 (11.18)	.295

[a] Indicates subscales for which there were baseline differences

[b] Between-group difference in change scores (calculated by scores at 6 months minus scores at baseline) after controlling for baseline values