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Reconceptualizing Health Literacy and the eHealth Literacy Scale (eHEALS): Evaluation of Psychometric Properties, Subdimensions, and Health-Related Internet Searching Behavior in Adult Outpatients Visiting a Tertiary Care Clinic

THESIS

Submitted in partial satisfaction of the requirements
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MASTER OF SCIENCE

in Biomedical and Translational Science

By

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DEDICATION

To

my wonderful wife, fantastic family,
thoughtful teachers, and compassionate colleagues

in recognition of their support.

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ABSTRACT OF THE THESIS

Reconceptualizing health literacy and the eHealth Literacy Scale (eHEALS): Evaluation of psychometric properties, subdimensions, and health-related internet searching behavior in adult outpatients visiting a tertiary care clinic

By

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Master of Science in Biomedical and Translational Science

University of California, Irvine, 2015

Professor Sherrie Kaplan, Chair

Recent reconceptualizations of health literacy have expanded beyond traditional literacy and numeracy skills to look more broadly at how patients interact within the healthcare environment. With the widespread use of the internet for health information, health literacy needs to be reframed to include eHealth literacy skills required to find, evaluate, and apply electronic health information to solve health problems. There is only one instrument to measure eHealth literacy, the eHealth Literacy Scale (eHEALS), and this instrument was originally validated in a group of high school students without disease. This study reevaluated the reliability and validity of the 8-item eHEALS in an adult outpatient population. Attention was paid to determine whether subdimensions existed within eHEALS that could be used to develop subscales to better categorize eHealth literacy deficiencies, and to further understand associations between low eHealth literacy, patient characteristics, and health-related internet use. Varimax rotated factor analysis provided preliminary evidence to support two eHealth Literacy subscales: Utilizing info & Evaluating info.

A multivariate linear regression model revealed statistically significant associations between low eHealth Literacy and patient characteristics including age, education, and access to smart phones. Furthermore, eHEALS demonstrated convergent validity in relation to the use of high quality websites. The likelihood of using high quality websites was significantly lower (OR = 0.26; 95% CI, 0.08 - 0.83; P = .02) for patients with low eHealth Literacy. Further research is needed to improve the eHealth Literacy Scale to better categorize patient deficits in finding, evaluating, and applying electronic health information to solve health problems.

Chapter 1. Introduction

Health literacy is defined as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services they need to make appropriate health decisions." [1] Approximately 78 million Americans are considered to have limited health literacy and lack the requisite skills to function effectively in a healthcare environment. [2] Limited health literacy is associated with worse outcomes including lower utilization of preventative services, decreased medication compliance, greater use of emergency care, and increased hospitalizations. [3,4] To properly address these disparities, researchers and major health organizations including the Department of Health and Human Services have placed significant effort to better understand subdimensions of health literacy, such as print literacy (i.e. skills to read and understand text) and numeracy (i.e., skills to manipulate numbers and perform calculations), and associate deficits in these subdimensions of health literacy to specific health outcomes. [3]

Two of the primary instruments utilized to measure health literacy are the Rapid Estimate of Adult Literacy in Medicine (REALM) [5] and Test of Functional Health Literacy in Adults (TOFHLA) [6], which were developed in 1991 and 1995 respectively. The REALM measure print literacy, and the TOFHLA measures both print literacy and numeracy. While these instruments provide insight to the patient's ability to process and understand health information, they neglect to measure one's ability to *obtain* information. Reconceptualizations of health literacy have looked more

broadly at the scope of the problem by examining how patients interact with the healthcare system in a variety of settings. As more patients increasing obtain health information from the internet, [7] it becomes increasing important to reconceptualize health literacy in the context of electronic health resources. [8–10]

The use of the internet for health information, requires a larger set of skills compared to patients who solely get their information from their physician. Due to the vast number of resources on the internet and variability in quality of information, patents require skills to both find and appraise health information online before they can apply that information to solve a health problem. This additional skill set is referred to as eHealth Literacy. [11]

While there are currently multiple instruments to measure traditional health literacy that have been validated in multiple clinical contexts, [12] there is only one published instrument which intends to measure eHealth Literacy, called the eHealth Literacy Scale.[13]

The eHealth Literacy Scale is an 8-item, self-report questionnaire to assess a patients perceived eHealth literacy. eHealth literacy is defined as the skills associated with "finding, evaluating, and applying electronic health information to health problems."[14] However, there are three major limitations of the scale (1) It does not explicitly contain subscales to categorize deficits patients face at they attempt to find, evaluate and apply health information found online. Development of subscales within the larger measure, and focused on estimating distinct eHealth literacy skills

may help provide actionable information to researchers and patients to target their efforts in alleviating disparities, (2) The validation of this scale was performed in a set of high school students as part of a larger project on eHealth smoking prevention.[14] In order to use this instrument in an adult clinical and research setting, further psychometric evaluation of this measure and its associations to relevant explanatory and outcome variables is warranted in a sample of adult patients with disease. (3) There are no established cutoffs to define high vs low eHealth literacy. Standardized cutoffs which are relevant to outcomes of interest allow for comparisons between studies.

Objectives

The primary objectives of this study are to:

(1) Analyze the items of the eHealth Literacy Scale using a reflective conceptual model with the intention pooling items together to develop meaningful subscales that categorize eHealth literacy deficits.

(2) Evaluate the internal consistency, and mean scores of the eHealth Literacy scale, and hypothesized subscales, in adult outpatients with disease and perform factor analysis to test and revise the conceptual model.

(3) Identify patient characteristics that are associated with low eHealth literacy, defined by those below the median composite eHEALS score of the cohort, and then determine associations between low eHealth literacy and outcomes relevant to health-related internet searching behavior.

(4) Explore which health-related websites are most frequently used, and which online information about a physician is most commonly sought

after by otolaryngology patients with high and low eHealth Literacy scores.

Chapter 2. Background

2.1 Health Literacy

2.1.1 Definition of Health Literacy

There are multiple descriptions of health literacy in the literature. One of the most commonly used definitions was published in the 2004 landmark Institute of Medicine report. *Health Literacy: A Prescription to End Confusion*, defines health literacy as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services they need to make appropriate health decisions." [1] In this definition, the term "capacity" refers to a set of skills that an individual must possess to function effectively in a healthcare environment. Considering the demands placed on the individual by the healthcare system in different healthcare contexts helps to elucidate these prerequisite skills. For example, in order for patients to function effectively in a traditional health-care environment they need to be able to:

- Read and understand printed health information given to them by their doctor (e.g., print literacy)
- Manipulate numbers and make basic calculations to correctly take their medications (e.g., numeracy)
- Listen to a doctor's instructions and speak to ask appropriate questions (e.g., oral literacy).

However, over the last two decades, healthcare providers and major healthcare organizations have come to appreciate that a significant portion of patients lack these basic health literacy skills, and that a lack of these skills places a significant burden on one's health and increases inefficiencies in the healthcare system. [15]

2.1.2 Limited Health Literacy in the United States

The true prevalence of limited health literacy in the United States was largely unknown until 2003 when the US Department of Education performed the largest, cross-sectional, direct assessment of both literacy and health literacy to date[2]. The National Assessment of Adult Literacy (NAAL) was a study that interviewed over 19,000 participants in their home and asked participants to complete a series of tasks to directly measure their ability to read and interpret documents (e.g., print literacy) and perform simple calculations (e.g., numeracy). Furthermore, to directly assess health literacy, a subset of the tasks in the NAAL pertained specifically to common situations encountered in health care settings.

The motivation to complete the 2003 NAAL study came from the results of an extremely similar study completed by the US Department of Education a decade earlier, called the National Adult Literacy Survey (NALS).[16]Conducted in 1992, the NALS was the first survey to provide detailed information on the literacy of American adults as a whole. The original purpose of quantifying limited skills in the US was to help understand its implications on job opportunities for adults and global competitiveness of America's workforce. It is important to note that the NALS did not address questions specific to health literacy tasks. Nonetheless, the NALS individually interviewed over 26,000 randomly selected adults across the US, and showed that approximately 40 million Americans were functionally illiterate. This patients were unable to correctly identify information from a bar graft, enter

information into a car maintenance record, or write a brief letter regarding an error on a credit card bill.

Prior to the NALS, limited literacy was primarily viewed as an individual problem that affected ones job prospects, however, researchers began to realize limited literacy was a national problem with implications on multiple domains of an individual's life including their health. NALS served as a catalyst that increased attention to the construct of health literacy. In the following decade, multiple measures were created to access health literacy in patients.[17,18] However, until the NAAL study in 2003, no studies had the sample size to adequately measure the prevalence of limited health literacy across the US. [19]

The results of NAAL, which contained questions specific to health literacy, were disconcerting to healthcare researchers. [20] After stratification into four groups (Below Basic, Basic, Intermediate, Proficient), 36% of the sample, or approximately 78 million Americans, fell into the basic or below basic category. These individuals are considered to have *limited* health literacy. The health-related tasks that Basic or Below Basic respondents were unable to correctly perform included: reading a drug label to determine what time they should take a medication, or understanding a chart to determine the age at which a child should receive a particular vaccine. Once the prevalence of limited health literacy across the US was published, it became a rallying call for multiple healthcare organizations, including the American Medical Association,[19] the Department of Health and Human Services, and other researchers

across the globe to focus their resources to better understand and help alleviate the burden of limited health literacy.

2.1.3 Tests to Measure Health Literacy

Two of the most commonly used health literacy assessment instruments currently in use are the Rapid Estimate of Adult Literacy in Medicine (REALM) and Test of Functional Health Literacy in Adults. [5,21]

Rapid Estimate of Adult Literacy in Medicine (REALM)

The REALM is an instrument that measures a patient's ability to read and pronounce a list of health-related words from a piece of paper.[5] The number of words pronounced correctly determines the raw score, which corresponds to a reading grade estimate. The instrument is meant to screen for patients with reading levels below the 9th grade. Patients who read below this level are likely to need additional help understanding basic health information.

Test of Functional Health Literacy in Adults (TOFHLA)

The TOFHLA goes beyond measuring a patient's ability to correctly pronounce words, and was developed to measure "functional health literacy" which includes reading comprehension and numeracy skills. [6] To test reading comprehension, the TOFHLA uses modified Cloze procedure where words in a passage are omitted and the respondent must select which word was omitted from four options.[22] The numeracy component is administered by a proctor and individuals are presented

with a cue and asked to respond to questions that assess their numeracy skills. The patient's raw score on both reading comprehension and numeracy places them into one of three literacy categories: inadequate, marginal, or adequate. Those with inadequate or marginal health literacy may need additional help understanding health information.

Problems with REALM and TOFHLA

The use of both the REALM and TOFHLA in a clinical setting has been considered time consuming and impractical. [13] Also, the content validity and conceptual framework underpinning both the REALM and TOFHLA have been brought into question.[12] For example, in the context of the Institute of Medicine's (IOM's) working definition of health literacy:

> "The degree to which individuals have the capacity to obtain, process, and understand basic health information and services they need to make appropriate health decisions"

both of these instruments appear to measure the "process" or "understand" components of the aforementioned IOM's definition of health literacy. However neither attempts to measure the capacity to obtain information, which may be vital for a sick patient in need of medical advice in the clinical setting or at home on the computer.

Recent reconceptualizations of health literacy have looked more broadly at factors that might hinder one's ability to effectively function in different health care contexts. Considering the rapid adoption of health-related electronic resources and the use of

the internet to obtain health information, patients now require an additional skill set to effectively find, evaluate, and utilize information from electronic resources. This skill set is referred to eHealth Literacy and will be discussed in depth in the next section.[11]

2.2 eHealth Literacy

2.2.1 Health-related Internet Use in the United States

The 2013 Pew Health Online survey of 3,014 adults revealed that 81% of adults surveyed use the internet at least occasionally, and of those, 72% searched online for health-related information in the prior year.[7] Patients use the internet to investigate symptoms, search for information about their doctor, research medication side effects, and learn about potential surgical treatments. On a typical day, over 6 million people in the US search for health-related information online, which is more than the number of physician office visits (2.27 million) and ambulatory care visits to hospital outpatient and emergency departments (2.75 million) combined. [23]

2.2.2 The Need for a valid instrument to assess eHealth Literacy

The use of the internet for health information, requires a larger set of skills compared to patients who solely get their information from their physician. In a traditional healthcare setting, a physician acts as information mediator and provides accurate recommendations tailored to the problem of the individual. Conversely, when the internet is used as the information mediator, the patient requires additional skills to

sort through the vast number of available resources and appraise information that can significantly vary in quality of information. This additional skill set is referred to as eHealth Literacy. [11]

Considering the percentage of Americans described in both the NALS and NAAL study lacked basic literacy skills, it is likely that many of these people will also face challenges when attempting to use electronic health resources. Instruments commonly used to assess traditional health literacy do not include this these types of skills.

In order to develop a comprehensive and targeted solutions to help these patients, a proper understanding of the problem and its subdimensions are required. A valid instrument to measure eHealth literacy would aid in this regard.

More recently, physicians have started 'prescribing' websites to assist interested patients in finding appropriate medical information online.[24] However, in a similar context to health literacy, patients have various degrees of knowledge, comfort, and computer-related skills required to find, understand, and utilize the information on the internet effectively. As it would be inappropriate to prescribe a complex treatment regimen to a patient with limited health literacy, it would also be inappropriate to refer a patient to an eHealth intervention website that they could not find or understand. This type of patient would be considered to have limited eHealth Literacy. Prior to the development of the eHealth Literacy Scale there were no validated instruments to identify this group of patients.

2.2.3 Conceptual Model for eHealth Literacy

In 2006, the eHealth Literacy Scale (eHEALS) was developed by Norman and Skinner in Canada.[14] Similar to IOM definition of health literacy, Norman and Skinner defined eHealth Literacy as the ability to "find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem."[14] The following section will look more closely at the components of eHealth literacy and describe the conceptual model described by Norman and Skinner.

Six Types of Literacy Which Comprise eHealth Literacy

eHealth Literacy, as a construct, encompasses six types of literacy or core skills:[11] science literacy, health literacy, traditional literacy and numeracy, media literacy, information literacy, and computer literacy. The conceptual framework for this model, described by Norman and Skinner in 2006, utilizes the metaphor of a lily, to describe the reflective model (Figure 1). The individual six literacies represent the petals of a lily, and the center represents the eHealth literacy, or the pistil of the lily. According to Norman and Skinner "the petals (literacies) feed the pistil (eHealth literacy), and yet the pistil overlaps the petals, tying them together."[11]

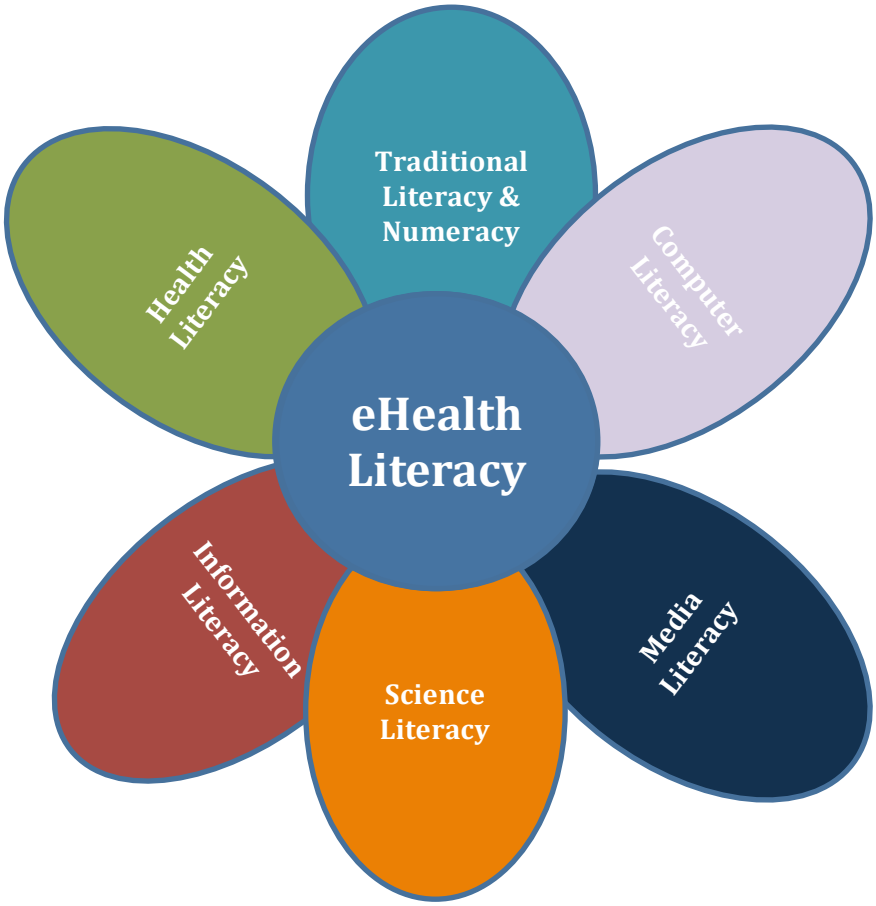

Figure 1: eHealth Literacy Conceptual Model – adapted from "eHealth Literacy: Essential Skills for Consumer Health in a Networked World," by Norman CD and Skinner HA (see citation #11). Adapted with permission under Creative Commons License.

These six skills are broadly divided into 2 categories - context-specific literacy and analytic literacy.

Context-specific literacy

Context-specific literacy relies on situation-specific skills including: computer literacy, scientific literacy, and health literacy.

- **Computer literacy** includes familiarity with basic computer terms such as mouse, email, webpage as well as the ability to use computers to solve basic problems.

- **Science literacy** includes familiarity with science terms, the process of discovery, and understanding limitations and the applicability of research.
- **Health literacy** was previously defined as "the degree to which individuals can obtain, process, and understand the basic health information and services they need to make appropriate health decisions." This includes familiarity with basic health terms, understanding drug labels, and the ability to follow self-care directions.

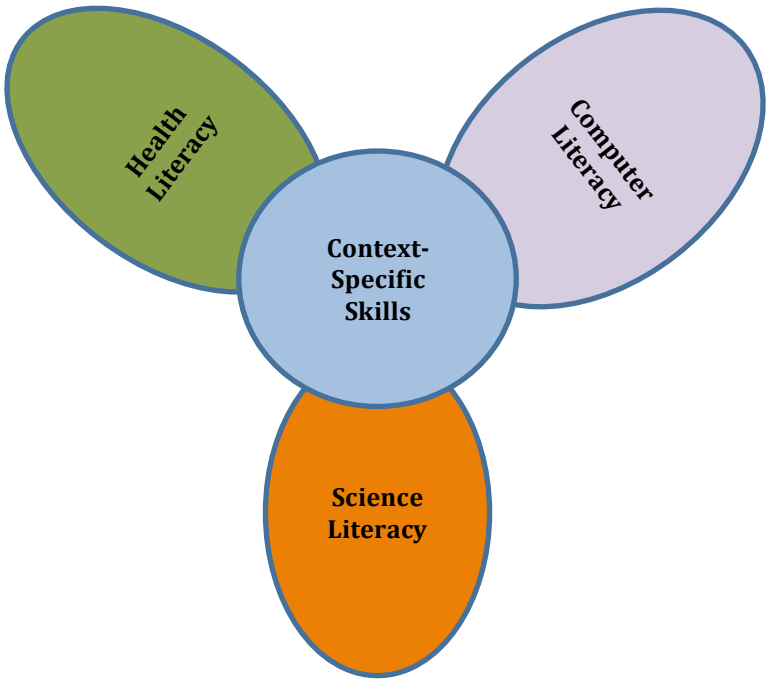

Figure 2: eHealth Literacy context-specific skills. Adapted from "eHealth Literacy: Essential Skills for Consumer Health in a Networked World," by Norman CD and Skinner HA (see citation #11) with permission under Creative Commons License.

Analytic Literacy

Analytic literacy/skills involves literacy skills irrespective of context. These include traditional literacy, media literacy, and information literacy.

- **Traditional literacy and numeracy** includes the ability to read simple language, perform basic mathematic functions (e.g., subtraction, addition, division, and multiplication) and understand simple charts.
- **Media literacy** includes being aware of media bias, and is a skill that enables people to understand the social and political context of the information presented.
- **Information literacy** includes knowing what resources to consult in order to find information on a topic, to develop a search strategy, and to filter results to extract desired information.

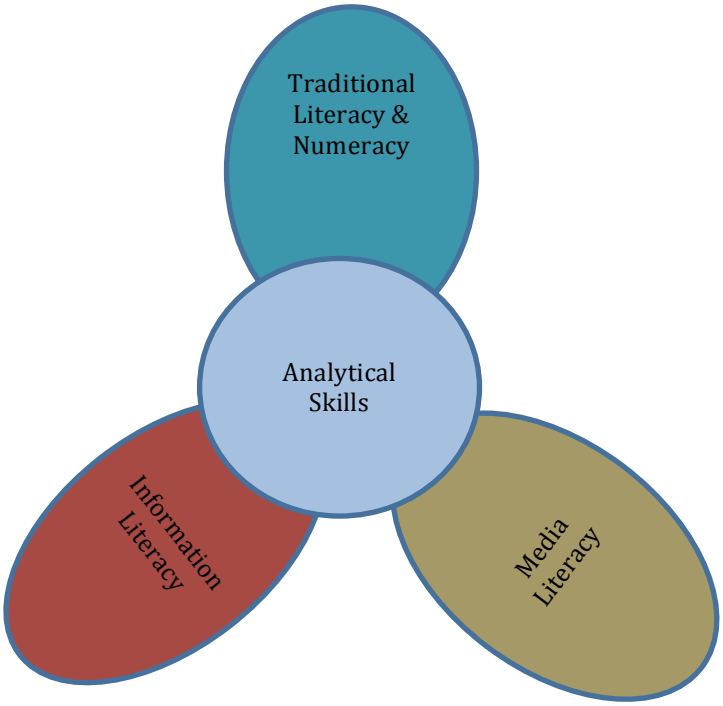

Figure 3: eHealth Literacy analytical skills

Adapted from "eHealth Literacy: Essential Skills for Consumer Health in a Networked World," by Norman CD and Skinner HA (see citation #11). Used with permission under Creative Commons License.

2.2.4 Tests to Measure eHealth Literacy

There is currently only one instrument that intends to measure the construct of eHealth Literacy. As previously mentioned, the eHealth Literacy Scale (eHEALS),

attempts to measure patients' perceived skills at finding, evaluating, and applying electronic health information to health problems.

The eHealth Literacy Scale

The eHealth Literacy Scale is comprised of 8 statements shown in Table 1. Each statement uses a 5-point Likert scale that ranges from "(1) Strongly Disagree" to "(5) Strongly Agree."

Psychometric Properties of eHealth Literacy Scale (eHEALS)

The eHealth Literacy Scale was originally validated in a youth group, aged 13-21 as part of larger study examining eHealth smoking prevention. Psychometric analysis was conducted on 644 students and revealed Cronbach's alpha of 0.88. Principle component analysis using this sample was consistent with a single factor solution with eigenvalue of 4.479, and explained 56% of variance. Among the 8 items, factor loading ranged from .60 to .84.

When comparing eHEALS score to other measures, no significant relationships were found between eHealth literacy and age, or the use of information technology such as mobile phones.

Chapter 3. Methods

3.1 Setting and Participants

A paper-based questionnaire was administered to 79 patients or their caregivers prior to a physician visit in a tertiary care Otolaryngology Head and Neck Surgery (OHNS) outpatient office at the University of California-Irvine Medical Center between December 2013 and February 2014. Nearly all specialties of otolaryngology are represented at the clinic with the exception of pediatric otolaryngology. Prior to completing each questionnaire, a research assistant reviewed the questionnaire with each patient to ensure completeness and address any questions.

3.2 Instruments and Study Variables

This study explored eHealth literacy, health-related internet usage, general internet usage, and demographic data through a 22 item, paper-based survey.

3.2.1 Primary Independent Variable

eHealth Literacy Scale (eHEALS)

The primary independent variable in this study was eHealth literacy, measured using the eHealth Literacy Scale (eHEALS), which is an 8-item instrument shown in Table 1, and described previously in Section 2.2.4.

3.2.2 Secondary Independent Variables

eHealth Literacy Subscales: Finding, Evaluating, and Applying Information

Based on the definition of eHealth literacy, it was hypothesized that the eHealth Literacy Scale was comprised of three latent subdimensions: finding skills, applying

skills, evaluating skills and that each subdimension could be represented by pooling items from the eHealth Literacy Scale to form subscales.

To create the subscales, a reflective conceptual model was created and definitions were developed for each of the following three subdimensions: (1) finding electronic health information (i.e., "Finding Skills"), (2) applying electronic health information to health problems (i.e., "Applying Skills"), and (3) evaluating electronic health information (i.e., "Evaluating Skills"),.

The operational definitions developed in this study are described below:

(1) **Finding Skills:** perceived ability to find health-related information on the internet. Requires computer literacy (e.g., knowing how to use a computer and mouse) and traditional literacy (e.g., knowing how to read) and information literacy (e.g., knowing how to search for information).

(2) **Applying Skills:** perceived ability to use information found online for a particular purpose, such as answering a question. The required types of literacy include computer literacy, traditional literacy, information literacy, and health literacy..

(3) **Evaluating Skills:** perceived ability to determine the quality of health information found online, understand its limitations, and identify potential bias. The required types of literacy overlap with applying skills: traditional literacy, computer literacy, and to a lesser extent, information literacy. However, evaluating skills relies heavily on media literacy (to identify bias), and science literacy (to understand limitations of information).

3.2.3 Primary Outcome: Health-Related Internet searching Behavior

Health-related internet searching behavior was assessed by exploring whether patients had used any high-quality website to search formation about their disease and by exploring whether patients had searched the internet for any information regarding the quality of their physician.

Use of Any High-Quality Website

The first primary outcome, Use of Any High-Quality Website for Disease-Related Information, was assessed with two questions adapted from the 2013 Pew Health Online Survey:

> 11a. "Have you ever looked online for health-related information related to your problem today?"
>
> 11b. "If yes, which online resources have you used to look for information about your ear, nose, or throat problem (select all that apply)?"

Potential answer choices included: search engines, dedicated health websites, Wikipedia, social media, university or hospital websites, YouTube, and the Academy of Otolaryngology –Head and Neck Surgery website.

High-quality websites were defined as those where a majority of the information is either written or reviewed by a healthcare professional. For the purposes of this manuscript, high-quality websites included:

- Dedicated health websites such as WebMD
- University or hospital websites
- Academy of Otolaryngology- Head and Neck Surgery website

If the participant chose one or more of these websites, the response was recoded to indicate that a high-quality website was used.

Internet Search Related to the Quality of the Physician

The second primary outcome, Internet Search for Any Information Related to the Quality of the Physician, was assessed using a similar two-part question:

> 12a. "Have you ever searched online for information about the doctor you are seeing today?"
>
> 12.b "If yes, what type of information have you looked up about your doctor? (Select all that apply)"

Potential answer choices included: reviews about the doctor, if the doctor is board certified, where the doctor trained, malpractice claims linked to the doctor, and reviews of the hospital or clinic where the doctor works.

If the participant chose one or more of these answers, the response was recoded to indicate that an internet search for doctor quality was performed.

3.2.4 Explanatory Variables

General Internet Use

Three explanatory variable related to general internet included:

- "Do you have access to the internet and a computer at home?"
- "Do you have access to a smartphone or tablet?"
- "How many hours do you use the internet each day?"

Demographic Information

Demographic information included: gender, age, ethnicity, and education. The ethnicity variable was reported as the percentage of White patients. The education variable was reported as the percentage of patients who graduated from college or have a higher level of training.

3.3 Statistical Analysis

3.3.1 Objective #1 Analysis

Item Analysis and Subscale Development

To determine the items which would be pooled into the subscales (Finding, Applying, Evaluating), the Principle Investigator (A.S.), health researcher, and healthcare professional analyzed the eight items in eHEALS and labeled the types of broad eHealth literacy skills involved and the literacy skills involved (e.g., computer, information, health, traditional, media, science) per item. Broad and specific skills that were considered necessary to answer "Agree" or "Strongly Agree" to the item were included. Any disagreements were discussed amongst members until consensus was reached.

Based on the overlap between the types of literacy skills per item, and the operational definitions of finding, applying, evaluating, the eight items were group into three subscales.

3.3.2 Objective #2 Analysis

Internal Consistency of eHEALS and Subscales

All statistical analysis was performed with SPSS v23. Internal consistency was calculated using Cronbach's Alpha of eHEALS and the hypothesized subscales. Values between 0.70 to 0.95 were considered acceptable.

Mean Composite Score

The mean composite score was transformed to a 0-100 scale, with standard deviation and transformed median composite score also reported.

To calculate the mean composite score, the 5-point Likert response was converted to numerical values with "strongly disagree" given a value of 1, and "strongly agree" given a value of 5. The simple algebraic sum consisting of each item in the scale was then calculated. This value was then transformed to a 0-100 scale to allow for comparisons between subscales that contained different numbers of items. Figure 4 shown below describes how composite score was transformed:

Figure 4: Calculation of Composite Score Transformed to 0-100 Scale

Composite score transformed =
[(Sum – theoretical min) / (theoretical max – theoretical min)] x 100.

a. **Sum** = Algebraic sum of each item on eHEALS (1=Strongly disagree, 5= Strongly agree)
b. **Theoretical min** = Lowest possible score on all items. For an 8 item instrument on a scale of 1-5, the theoretical min = 8 x 1 = 8.
c. **Theoretical max** = Highest possible score on all items. For an 8-item instrument with a scale of 1-5, theoretical max = 8 x 5 = 40

Factor Structure

Principal component analysis was performed with normal assumptions of eigenvalues >1 to identify unique factors. Factor loadings were analyzed based of Comrey and Lee's guidelines[25] with >0.71 considered 'excellent', >0.63 considered 'very good', >0.55 considered 'good'.

Varimax rotation factor analysis was also used under the assumption of two and three forced factors to test the hypothesis of three subdimensions and evaluate factor loadings under these assumptions.

3.3.3 Objective #3 Analysis

Patient Characteristics Associated with Low eHealth Literacy Scale Scores

Chi-Squared Fisher Exact Test and Students t-test were used to identify patient characteristics that are associated with, or may act as explanatory variables to low eHealth literacy.

Prior to performing these calculations, the variable of eHealth literacy (composite score transformed to 0-100), was dichotomized into two groups via median split. Those below the median were labeled as "low eHEALS", and those above the median were labeled as "high eHEALS." Explanatory variables (categorical and continuous) included: age, sex, % White, % college degree or greater, general internet use (e.g., home internet access, access to smartphone or tablet, hours of daily internet use).

Association of Low eHEALS and Health-Related Internet Searching behavior

To determine the association between limited eHealth Literacy and (1) the likelihood of utilizing high quality websites for disease-related information, and (2) searching for information regarding the quality of one's physician, a logistic regression model was used to calculate an unadjusted odds ratio and an adjusted odds ratio. The covariates used in the adjusted model were determined by significantly significant demographic information including age, education (college degree or greater), and ethnicity (White).

3.3.4 Objective #4 Analysis

To explore which health-related websites are most frequently used, and which online information about a physician is most commonly sought after by otolaryngology patients with high and low eHealth Literacy scores, cross tables were used to calculate proportions for high and low eHEALS groups. To access the relative contribution of low eHealth literacy to the likelihood of each outcome occurring, an unadjusted and adjusted odds ratio was calculated individually for each outcome using a logistic regression, with covariates of age, education (college degree or greater), race (White) used as covariates. P-values < 0.05 were considered significant.

Chapter 4. Results

4.1 Patient Characteristics

This study achieved a 95% response rate with 75 of 79 patients completed the survey. Table 1 shows the demographic information, general internet use for the entire cohort. This patient population was older, highly educated, and had high rates of both home internet access and smartphone access.

Table 1: Patient Characteristics

Patient Characteristics	Mean N=75
Age, Mean (SD)	50.7 (16.3)
Sex,% Male	53
Ethnicity, % White	64
Education, % ≥ College Degree	60
Home Internet Access, % yes	96
Access to a Smartphone or Tablet, % yes	81
Hours of Daily Internet Use, Mean (SD)	3.4 (2.9)

Table 1 Demographic information and general internet use for the cohort.

4.2 eHEALS Item Analysis To Determine Subscales

Table 2 shows the final results of the item analysis performed by the P.I., health researcher, and healthcare professional to determine the three subscales of the eHealth Literacy Scale (Finding Info Subscale, Applying Info Subscale, and Evaluating Info Subscale). The columns in Table 2 can be divided into 3 sections from left to right: eHEALS items, Subdimensions of eHealth literacy (i.e. broad skills related to eHealth literacy), and Specific Literacy Skills. Each row represents an individual

eHEALS item and lists the broad skills and specific literacy skills associated with each item.

These six literacies include Computer Literacy (C), Health Literacy (H), Science Literacy (S), Traditional Literacy (T), Information Literacy(I), and Media Literacy (M), and were previously described in section 2.2. Items with the most overlap were grouped together to form the subscales of eHealth literacy, which are shown in green (Finding Subscale, Items 3-5), blue (Applying Subscale, Items 6 and 7), and red (Evaluating Subscale, Items 8-10).

Table 2: eHEALS Item Analysis to determine subscales

eHEALS Item*		eHealth Literacy Subdimensions –			Specific Literacy Skills	
		Find (F)	Evaluate (E)	Apply (A)	Context Specific Skills	Analytic Skills
Finding Subscale	3. I know what health resources are available on the internet	F			C	T, I
	4. I know where to find helpful health resources on the internet	F			C	T, I
	5. I know how to find helpful health resources on the internet	F			C	T, I
Applying Subscale	6. I know how to use the internet to answer my questions about health	F		A	C, H	T, I
	7. I know how to use the health information I find on the internet to help me	F		A	C, H	T, I
Evaluating Subscale	8. I have the skills I need to evaluate the health resources I find on the Internet	F	E		C, S, H	T, I, M
	9. I can tell high quality heath resources from low quality health resources on the Internet	F	E		C, S, H	T, I, M
	10. I feel confident in using information from the internet to make health decisions	F	E	A	C, S, H	T, I, M

Table 2 shows the results of eHEALS item analysis using a reflective pyschometric model. Each eHEALS item is shown on the left, and its associations to subdimensions (broad categories of eHealth literacy skills) and specific literacy skills are shown in the middle and right columns respectively. Based on the commonalities related to specific literacy skills, items were grouped into three subscales labeled by color: green = Finding Subscale, blue = Applying Subscale, red = Evaluating Subscale. Note that some items were associated with more than one subdimension (broad category) of eHealth literacy skills.

Subdimensions: F= Finding Skills, E = Evaluating Skills, A= Applying Skills.

Literacy types: C= Computer literacy, H= Health Literacy, S = Science Literacy, T= Traditional Literacy, I= Information Literacy, M = Media literacy

4.3 Reliability, and Descriptive Statistics eHEALS and Subscales

Table 3 shows the number of items, composite mean transformed to a 0-100 scale, standard deviation of mean, and Cronbach's alpha for eHEALS and for each subscale. This transformation was described in section 3.3.2. The lowest mean score, indicating the lowest perceived skills, was seen in the Evaluating Subscale.

Table 3: Reliability data of eHEALTH Literacy Scale (eHEALS) and subscales

Scale and Subscale	k of items	Mean	SD	Median	Alpha
eHealth Literacy Scale (eHEALS)	8	66.3	20.5	68.8	0.94
Finding Info Subgroup of eHEALS Questions (Q3-Q5)	3	68.9	22.4	75.0	0.93
Applying Info Subgroup of eHEALS Questions (Q6, Q7)	2	70.3	21.4	75.0	0.88
Evaluating Info Subgroup of eHEALS Questions (Q8, Q9, Q10)	3	61.0	22.9	66.7	0.82

Table 3 shows the names of hypothesized subscale and questions associated to it, the number of items in each subscale, the mean, SD, median, and reliability coefficient Alpha.

4.4 Principal Component Analysis & Varimax Rotated Factor Analysis

Table 4 shows factor loadings for each item of the eHEALS scale in relation to the predefined subscale and specific types of literacies. Principal component analysis, shown in yellow, was based on Eigenvalues > 1, and produced a single factor solution with an eigenvalue of 5.63 and 70.4% of variance explained. Factor loadings ranged from 0.71-0.93.

Varimax Rotated Factor Analysis, shown in green and orange, was also performed to test the assumptions of the theoretical model described in Table 2. Green columns

represent factor loading for two fixed number of factors, and orange represents factor loadings for three fixed factors. Under both two and three fixed factor assumption, Items 8, 9, and 10 did not have substantial loadings on Factor 1.

Table 4: Principal Component Analysis and Varimax Rotated Factor Analysis of eHEALS

Items	Subscale	Literacy Skills*	Factor Loading		Factor Loading (2 forced factors)			Factor Loading (3 forced factors)		
eHealth Literacy Scale			Factor 1		Factor 1	Factor 2		Factor 1	Factor 2	Factor 3
3) I know what health resources are available on the internet	Find	C, T, I	**0.83**		**0.85**	0.26		**0.83**	0.37	-0.02
4) I know WHERE to find helpful health resources on the Internet?	Find	C, T, I	**0.93**		**0.89**	0.37		**0.88**	0.28	0.26
5) I know HOW to find helpful health resources on the internet?	Find	C, T, I	**0.92**		**0.85**	0.40		**0.84**	0.27	0.33
6) I know HOW TO USE the internet to answer my questions about health?	Apply	C, T, I, H	**0.90**		**0.88**	0.33		**0.87**	0.26	0.24
7) I know how to use THE HEALTH INFORMATION I find on the internet to help me?	Apply	C, T, I, H	**0.88**		**0.78**	0.43		**0.78**	0.29	0.34
8) I have the skills I need to evaluate the health resources I find on the Internet?	Evaluate	C, T, I, H, S, M	**0.71**		0.27	**0.82**		0.27	0.36	**0.87**
9) I can tell HIGH QUALITY health resources from LOW QUALITY health resources on the internet?	Evaluate	C, T, I, H, S, M	**0.73**		0.31	**0.81**		0.28	**0.86**	0.24
10) I feel confident in using information from the Internet to make health decisions	Evaluate	C, T, I, H, S, M	**0.77**		0.42	**0.74**		0.40	**0.72**	0.30
		Eigenvalues:	5.63		5.63	0.84		5.63	0.84	0.45
***Literacy Skills Key:**		% of Variance	70.4		70.4	10.5		70.4	10.5	6.0
C= Computer Literacy T= Traditional Literacy I= Information Literacy H= Health Literacy S= Science Literacy M= Media Literacy		Rotation Sums of Loadings^2			3.9	2.5		3.85	1.82	1.3
		% of Variance after varimax rotation			49.3	31.6		48.2	22.7	15.6

Table 4 shows the individual items of the eHealth Literacy Scale, the subscale category of each item defined by the reflective model, the literacy skills associated required to answer "agree" or "strongly agree" to each item, the principal component analysis under normal assumption of Eigenvalues >1 (shown in yellow), Varimax Rotation Factor analysis under the assumption of 2 factors (shown in green) and the Varimax Rotation Factor analysis under the assumption of 3 factors (shown in orange). Max factor loadings per factor are in bold. Beneath the factor loadings are the respective Eigenvalues and % of variance explained per factor. When Varimax rotations were used, corresponding rotation sums of the squared loadings and percent of variance after rotation are shown.

4.5 Comparison of Patient's With High and Low eHealth Literacy Scores

Table 5 compares patient characteristics between participants with high and low eHealth Literacy (separated by median split). Statistically significant differences were seen in age, the proportion of patients who identified themselves as White, the proportion of patients who indicated they had a college degree or greater, access to a smartphone or tablet, hours of daily internet use, and general eHealth interest.

Table 5: Patient Characteristics: eHealth Literacy Scale (n=75)

Patient Characteristics	High eHEALS N=37	Low eHEALS N=38	Mean Difference (95% CI)	p Value
Age, Mean	47.0	54.3	7.3 (0.0, 14.7)	**0.05**
Sex (% Male)	48.6	52.6	4.0 (-18.6, 26.6)	0.82
Ethnicity (% White)	51.4	76.3	25.1 (3.9, 46.0)	**0.03**
Extremely Confident filling out forms	83.6	76.3	-7.5 (-25.5, 10.5)	0.57
Education (% ≥ college degree)	73.0	47.4	-25.6 (-47.0, -4.2)	**0.03**
Home Internet access (% yes)	100.0	92.1	-7.9 (-16.5, 0.7)	0.24
Access to a smartphone or tablet (% yes)	94.6	68.4	-26.2 (-42.7, -9.7)	**0.01**
Hours of daily internet use (Mean)	4.1	2.6	-1.5 (-2.8, -0.2)	**0.03**
eHealth Interest (Mean)	87.5	63.8	-23.7 (-34.4, -13.0)	**0.00**

Table 5 shows patient characteristics presented as mean or percentage in the High eHEALS group and Low eHEALS group, the mean difference, 95% confidence interval and associated p Value. High versus low eHEALS was determined using a median split of the composite eHEALS score (calculated as algebraic sum of all items on the scale), transformed to a 0-100 scale. The median value used to dichotomize patients into two groups was 68.8.

4.6 Estimation of eHEALS Composite Score using patient characteristics

A linear regression was performed to estimate the eHEALS composite score based on age, education, access to smartphone or tablet, and hours of daily internet use. A significant regression equation was found ($F,(4,70) = 6.34$, $p< 0.000$), with an R^2 of .266. The results are shown in Table 6. When holding other variables constant, hours of daily internet use was not statistically significant. The resultant model is shown below. Placed into an equation: eHEALS Composite Score = 64.8 – 0.32 (Age, yrs) +

8.91 (Education, 1= college degree or greater, 0=all others) + 11.8 (Smartphone Access, 1=yes, 0=no) + 0.76 (Internet use, hrs per day).

Table 6: Linear Regression to Estimate eHEALS Composite Score

Predictor	B (95% CI)	p value
Constant	64.8 (44.13, 85.47)	0.000
Age (yrs)	-0.32 (-0.61, -0.03)	0.034
Education (% ≥ college degree)	8.91 (0.28, 17.80)	0.003
Smartphone Access (yes)	11.8 (-0.26, 23.32)	0.045
Internet Use (hrs/ day)	0.76 (-0.88, 2.41)	0.358
R square = .266, F=6.34, p=0.000		

Table 6 summarizes the results from the linear regression to estimate eHEALS composite score transformed from 0-100. Included in the table are 4 variables, age, education, smartphone access, and hours of daily internet use, the respective B coefficients, and p Value.

4.7 eHealth Literacy and Health-Related Internet Searching Behavior

To determine the association between limited eHealth Literacy and (1) the likelihood of utilizing high quality websites for disease-related information, and (2) searching for information regarding the quality of one's physician, a logistic regression model was used with the results shown in Table 7.

Each row in Table 7 represents a separate model estimating the odds of each outcome occurring (shown on the left). In the unadjusted column, odds ratios were calculated from a logistic regression model including only the dichotomy high vs low eHEALS score. In the adjusted column, the odds ratio is adjusted for the covariates: ethnicity, age, and education. Significant differences are shown in bold.

Table 7: eHEALS and Health-Related Internet Searching Behavior

	High eHEALS (n_h=37)	Low eHEALS (n_l=38)		Unadjusted Model		Adjusted model	
Primary Outcomes	$\%n_h$	$\%n_l$		Odds Ratio (95% CI)	p Value	Odds Ratio (95% CI)	p Value
Use of High-Quality Web Resource	78.4	52.6		0.31 (0.11, 0.84)	**0.02**	0.26 (0.08, 0.83)	**0.02**
Search Web for Doctor Info	64.9	39.5		0.35 (0.14, 0.90)	**0.03**	0.38 (0.13, 1.12)	**0.08**
Secondary Outcomes							
High Quality Websites Used							
Dedicated health websites	73.0	36.8		0.22 (0.08, 0.58)	**0.00**	0.16 (0.05, 0.51)	**0.00**
University or Hospital Website	54.1	31.6		0.39 (0.15, 1.01)	**0.05**	0.36 (0.13, 1.03)	0.06
AAO-HNS (Otolaryngology)	18.9	2.6		0.12 (0.01, 0.99)	**0.05**	0.13 (0.01, 1.26)	0.08
Low Quality Websites Used							
Search engines	78.4	57.9		0.38 (0.14, 1.05)	0.06	0.52 (0.16, 1.64)	0.26
Social media sites	10.8	5.3		0.46 (0.08, 2.67)	0.39	0.79 (0.11, 5.45)	0.81
YouTube	18.9	18.4		0.97 (0.30, 3.09)	0.96	1.77 (0.44, 7.13)	0.43
Wikipedia	21.6	23.7		1.13 (0.38, 3.32)	0.83	1.26 (0.38, 4.14)	0.71
Category of Doctor Information Searched							
Doctor Reviews	59.5	28.9		0.28 (0.11, 0.73)	**0.01**	0.25 (0.08, 0.74)	**0.01**
Board Certification	54.1	15.8		0.18 (0.06, 0.53)	**0.00**	0.15 (0.04, 0.51)	**0.00**
Training Institution	45.9	21.1		0.31 (0.11, 0.86)	**0.03**	0.29 (0.09, 0.89)	**0.03**
Malpractice claims	8.1	13.2		1.72 (0.38, 7.77)	0.48	2.74 (0.44, 17.1)	0.28
Clinic reviews	40.5	21.1		0.39 (0.14, 1.08)	0.07	0.42 (0.13, 1.31)	0.13

Table 7 lists outcomes concerning health-related internet search behavior in the far left column. Each row represents a separate logistic model and includes the proportion of patients with high and low eHEALS score who performed each outcome, the unadjusted odds ratio and the adjusted odds ratio with covariates of age, ethnicity (White), and education (college degree or greater). The odds ratio represents the likelihood of performing the outcome for patients with low eHEALS score compared to High eHEALS score.

Area Under the Receiver Operator Characteristics showed an AUC of 0.712. Using median eHEALS score of 69 as a cut-off point, revealed a sensitivity of 0.65 and specificity of .63.

4.8 Comparison of Subscales in Predicting Primary Outcomes

To compare the contribution of individual subscales to the likelihood of using high quality websites, a logistic regression using a single model with 2 independent variables in the same block was used. The first independent variable was Low Evaluate. Patients were labeled as having Low Evaluate if their composite evaluation score (sum of Items 8-10) was below the group median score. The second independent variable, Low (Find + Apply) was calculated in a similar fashion, however the composite was for the Find and Apply subscales combined together (sum of Items 3-7). Find and Apply subscales were combined together due significant factor loadings (shown in Table 4) indicating they likely represent a single construct. The results of this logistic regression are shown in Table 8.

Table 8: Comparison of Subscales in Single Logistic Regression Model

Primary Outcomes	Low (Find + Apply) OR (95% CI)	p Value	Low Evaluate OR (95% CI)	p Value
Use of High-Quality Web Resource	0.27 (0.08, 0.88)	0.03	0.71 (0.22, 2.31)	0.57

Table 8: Results of a logistic regression model to compare the contribution of subscales to the likelihood of using high quality websites. The second row compares the unadjusted relative odds of using a high quality web resource based on summed and transformed responses of items 3-7(Find and Apply questions) and items 8-10 (Evaluate questions). Both independent variables (low find+apply & low evaluate) were placed simultaneously in Step 1 and represent the bottom of the subgroup after median split.

Chapter 5. Discussion

As the internet is increasingly used as a supplement, and occasionally a substitute, a physician's advice, it becomes important to reconceptualize health literacy to include eHealth literacy skills necessary to find, evaluate and apply health information in today's healthcare setting. Unfortunately there is only one instrument which intends to measure eHealth literacy, the eHealth Literacy Scale (eHEALS). However, this scale, as originally constructed, does not delineate eHealth literacy deficits into distinct categories to help researchers better understand and address patient deficits. Furthemore, the original psychometric analysis for the eHealth Literacy Scale was completed in a healthy youth group, as part of a larger study on eHealth interventions for smoking prevention, bringing the reliability and validity of the scale into question for adult population with disease.

The goals of this study attempted to reconceptualize the original 8-item eHEALS survey into three subscales and use psychometric analysis to support the reflective conceptual model described in this study.

5.1 Re-examining eHealth Literacy Scale for Latent Subdimensions

This study showed high internal consistency and reliability for the eHealth Literacy scale as a whole in an adult population with disease. The results of the principle component analysis also supported a single overall construct. The eHealth Literacy Scale was developed to assess a single construct, eHealth Literacy.

However, the construct was defined as patient's perceived skills at *finding, evaluating, and applying* information from electronic health resources to solve health problems. It was hypothesized therefore that three latent sub-dimensions lay within the larger construct of eHealth literacy: *Finding skills*, *Evaluating skills*, and *Applying skills*. To identify more accurately the eHealth deficiencies faced by patients, this study developed a reflective psychometric model to classify each item of the eHealth Literacy Scale into one of three subscales: Finding Skills, Evaluating Skills, and Applying skills.

Reliability analysis to test this model showed high internal consistency of each of the 3 subscales, indicating that the items in each subscale correlated with each other. While the mean scores for "Finding Info" subscale (Items 3-5) and "Applying Info" subscale (Items 6,7) were similar. The "Evaluating Info" subscale (Item 8-10) had a lower mean score. Considering that the mean score of "Evaluating Info" subscale differed from the other items of the scale, provides preliminary evidence that evaluating health information maybe different from the other subscales. In other words this provides preliminary evidence that at least two subdimensions of eHealth Literacy Scale exist.

This factor analysis did not support the three unique subdimensions even under three distinct testing conditions: eigenvalue> 1 (normal), two forced factor extractions, and three forced factor extractions. However there was preliminary evidence for 2 sub-dimensions. Items 3-7 had substantial loading on the first factor

in all three factor analyses suggesting that these items represent a single dimension which likely combines these finding and applying principles.

Examination of the "Literacy skills" column of Table 4 shows that Items 3,4,5 (Finding Skills Subscale) have high overlap with items 6,7 (Applying Skills Subscale). This may have led to little variance in patient responses, thus making two unique solutions (between finding and applying) unlikely. Considering the large overlap between the Finding and Applying literacy skills, in addition to factor loadings which supported expressing these items as one factor, it was decided that it was appropriate to revise the reflective model and describe Items 3-5 and items 6-7 as one subdimension, simply titled: "Utilizing Skills." Utilizing the internet for a health problem, requires both finding information and applying that information to solve a problem. However, the conceptual model here still differentiates "utilizing" information from "evaluating" information for its quality, resulting in 2 latent subdimensions. That is, people can be good utilizers of information which they may not be able to adequately evaluate or appraise for quality.

Further support for a two subdimensional approach came from examining the Evaluating subscale items (Items 8-10) using Varimax rotated factor analysis, which revealed that Items 8-10 loaded on a separate factor from items 3-7 under a 2 forced factors assumption. Furthermore, under the two forced factors assumption, the factor loadings of items 8-10 were >0.71, suggesting that these items together represent a common construct.

Again, examining the literacy skills of items 8-10 helps explain the phenomenon. The Evaluating Info subscale has the two distinct types of literacies (science literacy (S) and media literacy (M) present in these items but not found in items representing the Find and Apply subscale. The increased literacy requirements for evaluating information, compared to finding and applying information, may explain why patient's reported lower mean scores for the evaluating subscale compared to finding and applying subscale.

To summarize, each Evaluating question appears to be similar to other Evaluating questions, but different from Finding (3-5) & Applying (6,7) questions in this patient population. However, there was no evidence for a distinction to be made between Finding and Applying. Based on these results, the reflective psychometric model developed in this study was revised to combine Finding and Applying skills into one subdimension: Utilizing skill.

5.2 Patient Characteristics associated with Low eHealth Literacy

The results of the bivariate analysis in this study revealed several statistically significant differences between patients with high and low eHealth Literacy scores including age, education, access to a smartphone or tablet, and hours of daily internet use. However, when performing multivariate linear regression, hours of daily internet use no longer became an independent predictor of eHEALS composite score.

These results sugest that having a smartphone independently improves one's perception of their eHealth literacy skills, but simply using the internet more often does not have the same effect. This implies that the use of a smartphone infers a certain skill set that helps increase one's perception of eHealth literacy. However once those basic skills are acquired, simply using the internet more (likely for unrelated purposes) does not appear to help one's perception of their eHealth literacy.

One notably absent statistically significant association in this study was between home internet access and eHealth literacy. One possible explanation is that is no association between internet access and eHealth literacy as a whole. However, when exploratory analysis was performed to analyze the association of patient characteristics in each subscale, there was a significant association between the lack of home internet access and low Finding skills (see Appendix-Table 1b). An alternative explanation is that the lack of statistical significance was heavily influenced by the lack of variance due to the high prevalence of internet access in this population. Taken together, this supports that simple access to the internet does not necessarily significantly increase one's perception of their eHealth literatry. However, the lack of internet access makes it much more difficult to have the skills to effectively find health information online. Examination of this association with other populations with lower rates of home internet access are needed to confirm or refute these assumptions.

Inverse Relationship Between Age and eHEALS Score

There are multiple potential explanations for the significant inverse relationship between age and eHEALS composite score. The first may be due to disease burden. Older individuals are more likely to have chronic diseases that are more difficult to manage. As a result, their perceived skills at using the internet may be lower as their problems are more difficult to solve. Second, the mean age of this cohort was 50 years old, therefore older patients have had less exposure to the internet in their adult life which may limit their computer literacy.

Comparison To Original Validation Data

The relationship between eHEALS Score and other variables in this study differed from the original validation study[14] in several important ways. First, the original study did not show a significant relationship between age and eHEALS score, and this is likely due to the differences in sample characteristics. The original study by Norman and Skinner included mostly high school students, whereas the mean age in this study was 50 years old.

Second, the study by Norman and Skinner did not show a significant relationship between eHealth literacy and use of information technology (e.g., World Wide Web or mobile phones). The significant differences seen in this study with regard to smartphones or tablets use may be a reflection of the technological revolution over the last decade. The first iPhone was released in 2007, which was one year after the original eHEALS study was published. As a result of the technological revolution,

over the last decade the reliance on mobile technology for health information has also grown. Support for this finding comes from the 2013 Pew Health Online study which showed that 52% of smartphone owners have used their phone to look up health-related information, and 20% had downloaded a health-related app to manage their care. With this in mind, those who do not have access a smart phone or other forms of information technology in this study, may perceive themselves to be at a greater disadvantage compared to a cohort from one decade ago.

5.3 Low eHEALS Score & Health-Related Internet Searching Behavior

This study also examined the use high quality websites as a primary outcome for patients with high and low eHealth literacy. The likelihood of using high quality web resources was approximately 69-74% lower for patients with low eHEALS in the unadjusted and adjusted model respectively. This analysis supports the convergent validity of the eHealth Literacy Scale, as it would be expected that those with low eHealth literacy would be less likely to use high quality websites. Similarly, as expected, this study revealed decreased likelihood of searching the internet for information related to the quality of one's physician for patients with low eHEALS score in the unadjusted model, however the adjusted model did not reach statistical significant ($p=0.08$).

A similar analysis was performed to assess the discriminant validity of the subscales and the relative contribution of each subscale to decreasing the likelihood of using high quality websites. However, instead of using low eHEALS as the independent variable, both low Evaluate and low Utilize (originally referred to as Find and Apply)

were placed in block one to determine the relative contribution. As expected the OR of using high quality websites was significantly decreased (p=0.03) for those with low utilization scores, whereas low evaluate did not independently decrease the likelihood of using of high quality websites. This provides further support that the Evaluation subscale (Items 8-10) may be measuring a separate construct than the Utilization subscale (Items 3-7).

5.4 eHealth Literacy and Specific Website Usage

Finally, this study explored the frequency of specific websites used and doctor information sought by patients with low vs high eHealth literacy scores. The most commonly used website for all patients was search engines such as Google. This is similar to the findings of other studies, which shows that this methodology is a very common, if not the most common, manner in which patients access health related information. [26–28] Patients most often visit one of the first results displayed by the search engine, rather than pursuing results further down the list for high quality information. [28] Illustrating the danger of this, Roshen et al., showed that highly ranked search engine links for "tonsillectomy" were often commercially motivated and inaccurate. [26] Those with limited eHealth literacy may be particularly susceptible to this type of misinformation. In fact respondents with lower eHealth literacy scores in this study were nearly 84% less likely to use dedicated health websites such as eMedicine or WebMD after controlling for age, race, and education with logistical regression.

Several recently published studies may shed light on why many patients perceive that they lack the skills to utilize the internet to make health decisions. Most patient education materials found on major professional society websites, including that of the American Academy of Otolaryngology – Head and Neck Surgery (AAO-HNS) Foundation, were well above the average reading abilities of most patients.[29–31 32] Based on data showing that the average reading level in the US is at an 8th grade level, the NIH and AMA have suggested that all patient educational materials be comprehensible at the 4th-6th grade level to be understood by the majority of patients.[33,34] Reducing the demands placed on patients by making the information more readable, may improve patients ability and confidence in using information online to make health decisions.

5.6 Implications for Health Care Organizations and Providers

Physicians should recognize that the majority of patients treated have referenced online resources and may not have the eHealth skills to determine if sources consulted are accurate. It will likely benefit patients if physicians specifically inquire about their patients understanding of their disease, and to clarify any misinformation they may have acquired online. Furthermore, considering the large number of patients that use the internet for health information, physicians should feel comfortable directing patients to legitimate third party websites that can help patients to better comprehend their disease. Special considerations should be made for the elderly, for those with less education, and individuals who do not have a smart phone, as this group of patients is at

a greater risk for low eHealth literacy, and alternative educational interventions may be more appropriate.

On a more global level, there is certainly a role for larger organizations to be leaders in dispersal of high quality, easy-to-find information that is also easy to use. The quality and accuracy of otolaryngology information online has been shown to be variable even among the most commonly referenced online resources. [35] Thus it may benefit patients if major health organizations collaborate with search engine providers to ensure acute and easily accessible information is available to all patients.

5.6 Limitations of This Study

First, this study is clearly limited by its sample size and sample population, which limit the generalizability of the data. However, by exploring the problem in a highly educated population with extremely high rates of Internet access, the results of this study may represent a boundary condition for eHealth literacy. Problems faced by patients in this study likely underestimate the problem nationally.

Second, the eHealth Literacy Scale measures perceived skills and not actual skills. It is unknown how well perceived skills correlate with actual skills for eHealth literacy as a whole, or for the subdimensions described in this study.

Third, there are no published cutoff values for low or high eHealth literacy. As a result this study categorized patients into two groups based on a median split. The median level

will likely vary depending on population sampled, making comparisons between this study and future studies utilizing a median split difficult. To help alleviate this, our median cut off value was described with sensitivity and specificity for detecting whether patients used a high quality website.

Fourth, this study was cross-sectional and not longitudinal; therefore it is only able to describe associations and not predictions.

5.7 Areas for Future Research

Areas for future research include developing a more robust eHealth literacy instrument to better differentiate between finding, evaluating, and applying electronic health information. There is also a need to define cutoff levels for low and high eHealth literacy and determine how they impact relevant outcomes utilizing a longitudinal study design. These results should be compared to traditional health literacy measures for validity. Furthermore, additional research is needed to understand the determinants of eHealth literacy by developing a more comprehensive set of explanatory variables to account for much of unexplained variance in estimating eHEALS composite score from patient characteristics. Finally, as our understanding of health literacy grows, the lily model should be reevaluated to include other key skills that should be included in the model.

6. Conclusion

The goal of this study was to determine whether subscales within the eHealth Literacy Scale could be used to help categorize more specific eHealth literacy deficiencies, to better understand associations between limited eHealth literacy and patient characteristics, and finally to understand how limited eHealth literacy affects health-related internet searching behavior. Principal component analysis most strongly supported a single factor. However, preliminary evidence supports that two factors may be present (Utilizing info & Evaluating info). Age, education, and access to smart phone were significantly associated with eHealth literacy. Furthermore, the eHealth Literacy Scale showed high internal consistency and content validity in relation to health-related internet searching behavior. Further research is needed to improve the eHealth Literacy Scale to better categorize deficiencies in finding, evaluating, and applying electronic health information to solve health problems.

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Appendix A: Patient Characteristics for Subscales

Table 1b: Patient Characteristics of eHEALS Subscale: "Finding Info"

Patient Characteristics	High Finding Info Skills (N=50)	Low Finding Info Skills (N=25)	Mean Difference (95% CI)	p Value
Age (Mean)	48.1	56.0	7.9 (0.1, 15.7)	**0.05**
Sex (% Male)	50.0	52.0	2.0 (-22.0, 26.0)	1.00
Ethnicity (% White)	58.0	76.0	18.0 (-3.6, 39.6)	0.20
Education (% ≥ college degree)	68.0	44.0	-24.0 (-47.4, -0.6)	0.08
Extremely Confident filling out form	86.0	68.0	-18.0 (-38.7, 2.7)	0.12
Home Internet access (% yes)	100.0	88.0	-12.0 (-24.7, 0.7)	**0.03**
Access to a smartphone or tablet (% yes)	92.0	60.0	-32.0 (-52.6, -11.4)	**0.00**
Hours of daily internet use (Mean)	3.9	2.4	-1.5 (-2.9, -0.1)	**0.03**

Table 1 shows patient characteristics in mean and standard deviation for continuous variables, and the percentage of patients who responded yes to categorical variables dichotomized by median split for the Finding Info Subscale.

Table 1c: Patient Characteristics of eHEALS Subscale: "Applying Info"

Patient Characteristics	High Applying Info Skills (N=51)	Low Applying Info Skills (N=24)	Mean Difference (95% CI)	p Value
Age (Mean)	48.0	56.8	9.1 (1.3, 16.9)	**0.02**
Sex (% Male)	51.0	50.0	-1.0 (-25.2, 23.3)	1.00
Ethnicity (% White)	60.8	70.8	10.0 (-12.5, 32.6)	0.45
Education (% ≥ college degree)	66.7	45.8	-20.8 (-44.6, 2.9)	0.13
Extremely Confident filling out form	82.4	75.0	-7.4 (-27.6, 12.9)	0.54
Home Internet access (% yes)	96.1	95.8	-0.2 (-9.9, 9.4)	1.00
Access to a smartphone or tablet (% yes)	90.2	62.5	-27.7 (-48.7, -6.7)	**0.01**
Hours of daily internet use (Mean)	3.9	2.2	-1.7 (-3.1, -0.3)	**0.02**

Table 1c shows patient characteristics in mean and standard deviation for continuous variables, and the percentage of patients who responded yes to categorical variables dichotomized by median split for the Applying Info subscale.

Table 1d: Patient Characteristics of eHEALS Subscale: "Evaluating Info"

Patient Characteristics	High Evaluating Info Skills (N=38)	Low Evaluating Info Skills (N=37)	Mean Difference (95% CI)	p Value
Age (Mean)	46.0	55.6	9.6 (2.4, 16.8)	**0.01**
Sex (% Male)	44.7	56.8	12.0 (-10.4, 34.5)	0.36
Ethnicity (% White)	55.3	73.0	17.7 (-3.6, 39.0)	0.15
Education (% ≥ college degree)	68.4	51.4	-17.1 (-38.9, 4.8)	0.16
Extremely Confident filling out form	84.2	75.7	-8.5 (-26.6, 9.5)	0.40
Home Internet access (% yes)	94.7	97.3	2.6 (-6.3, 11.4)	1.00
Access to a smartphone or tablet (% yes)	92.1	70.3	-21.8 (-38.9, -4.8)	**0.02**
Hours of daily internet use (Mean)	3.7	3.1	-0.6 (-2.0, 0.70)	0.34

Table 1 shows patient characteristics in mean and standard deviation for continuous variables, and the percentage of patients who responded yes to categorical variables dichotomized by median split for the Evaluating Info subscale.

Table 1e: Summary of Patient Characteristics Compared Across Subscales

Patient Characteristics	Low eHealth Literacy	Low Finding Info Skills	Low Applying Info Skills	Low Evaluating Info Skills
Age (Mean)	+	+	+	+ +
Sex (% Male)				
Ethnicity (% White)	+			
Education (% ≥ college degree)	- -	-		
Home Internet access (% yes)		-		
Access to a smartphone or tablet (% yes)	- -	- -	- -	-
Hours of daily internet use (Mean)	-	-	- -	
Extremely Confident filling out forms				

Table 1e is a summary of significant differences described in Tables 1-1e.
Legend: "+" or "-" in the table represent a significant relationship with p<0.05 (the sign represents the direction of the relationship). Cells with "+ +" or "- -" have p values <0.01.

Appendix B: Subscales and Health-related Internet Searching Behavior

Table 4b: Low Finding Skills and Health-related Internet Searching Behavior

	High Finding (n=50)	Low Finding (n=25)		Odds Ratio (95% CI)		Odds Ratio (95% CI)	
Primary Outcomes				Unadjusted	p Value	Adjusted	p Value
Used High-Quality Website	76	44		0.25 (0.09, 0.69)	0.01	0.22 (0.07, 0.69)	**0.01**
Searched Web for Doctor Info	60	36		0.38 (0.14, 1.01)	0.05	0.34 (0.12, 1.02)	**0.05**
Secondary Outcomes							
High Quality Websites							
Dedicated health websites	68	28		**0.18 (0.06, 0.53)**	**< 0.00**	0.15 (0.05, 0.49)	**<0.01**
University or Hospital Website	52	24		0.29 (0.10, 0.85)	0.02	0.27 (0.09, 0.86)	**0.03**
AAO-HNS (Otolaryngology)	16	0		0*	0.05	0	0
Low Quality Websites							
Search engines	80	44		**0.20 (0.07, 0.56)**	**<0.01**	0.24 (0.08, 0.76)	**0.02**
Social media sites	8	8		1.0 (0.17, 5.87)	1	1.98 (0.27, 14.5)	0.50
YouTube	20	16		0.76 (0.21, 2.72)	0.68	1.08 (0.26, 4.54)	0.91
Wikipedia	26	16		0.54 (0.16, 1.88)	0.33	0.56 (0.15, 2.10)	0.39
Category of Doctor Information							
Doctor Reviews	54	24		0.27 (0.09, 0.79)	**0.02**	0.26 (0.08, 0.83)	**0.02**
Board Certification	42	16		0.26 (0.08, 0.88)	**0.03**	0.26 (0.07, 0.93)	**0.04**
Training Institution	40	20		0.38 (0.12, 1.16)	0.09	0.37 (0.11, 1.25)	0.11
Malpractice claims	10	12		1.23 (0.27, 5.61)	0.79	1.45 (0.23, 9.02)	0.69
Clinic reviews	36	20		0.44 (0.14, 1.39)	0.16	0.48 (0.14, 1.65)	0.24

Footnote: Table 4b shows the individual items of the eHealth Literacy Scale, the subscale category of each item defined by the reflective model, the literacy skills associated required to answer “agree” or “strongly agree” to each item, the principal component analysis under normal assumption of Eigenvalues >1 (shown in yellow), Varimax Rotation Factor analysis under the assumption of 2 factors (shown in green) and the Varimax Rotation Factor analysis under the assumption of 3 factors (shown in orange). Max factor loadings per factor are in bold. Beneath the factor loadings are the respective Eigenvalues and % of variance explained per factor. When Varimax rotations were used, corresponding rotation sums of the squared loading and percent of variance after rotation are shown.

Table 4c: "Applying Subscale" and Internet Searching Behavior

	High Applying (n=51)	Low Applying (n=24)		Odds Ratio (95% CI)		Odds Ratio (95% CI)	
Primary Outcomes				Unadjusted	p Value	Adjusted	p Value
Used High-Quality Website	78.4	37.5		0.17 (0.06, 0.48)	**0.01**	0.15 (0.05, 0.46)	**0.01**
Searched Web for Doctor Info	58.8	37.5		0.42 (0.16, 1.14)	0.09	0.46 (0.16, 1.32)	0.15
Secondary Outcomes							
High Quality Websites							
Dedicated health websites	66.7	29.2		0.21 (0.07, 0.59)	**0.00**	0.18 (0.06, 0.57)	**0.00**
University or Hospital Website	52.9	20.8		0.23 (0.08, 0.72)	**0.01**	0.21 (0.06, 0.71)	**0.01**
AAO-HNS (Otolaryngology)	13.7	4.2		0.27 (0.03, 2.36)	0.24	0.36 (0.04, 3.34)	0.37
Low Quality Websites							
Search engines	78.4	45.8		0.23 (0.08, 0.66)	**0.01**	0.31 (0.10, 0.97)	**0.04**
Social media sites	7.8	8.3		1.07 (0.18, 6.28)	0.94	1.81 (0.27, 12.10)	0.54
YouTube	17.6	20.8		1.23 (0.36, 4.16)	0.74	1.64 (0.42, 6.38)	0.48
Wikipedia	25.5	16.7		0.59 (0.17, 2.03)	0.40	0.66 (0.18, 2.47)	0.54
Category of Doctor Information							
Doctor Reviews	52.9	25.0		0.30 (0.10, 0.87)	**0.03**	0.29 (0.09, 0.93)	**0.04**
Board Certification	41.2	16.7		0.29 (0.09, 0.96)	**0.04**	0.27 (0.08, 0.98)	**0.05**
Training Institution	41.2	16.7		0.29 (0.09, 0.96)	**0.04**	0.27 (0.08, 0.97)	**0.05**
Malpractice claims	9.8	12.5		1.31 (0.29, 6.02)	0.73	1.35 (0.23, 7.80)	0.74
Clinic reviews	35.3	20.8		0.48 (0.15, 1.51)	0.21	0.49 (0.14, 1.69)	0.26

Footnote: Table 4 shows the individual items of the eHealth Literacy Scale, the subscale category of each item defined by the reflective model, the literacy skills associated required to answer "agree" or "strongly agree" to each item, the principal component analysis under normal assumption of Eigenvalues >1 (shown in yellow), Varimax Rotation Factor analysis under the assumption of 2 factors (shown in green) and the Varimax Rotation Factor analysis under the assumption of 3 factors (shown in orange). Max factor loadings per factor are in bold. Beneath the factor loadings are the respective Eigenvalues and % of variance explained per factor. When Varimax rotations were used, corresponding rotation sums of the squared loading and percent of variance after rotation are shown.

Table 4d: Low Evaluating Skills and Internet Searching Behavior

	High Evaluating (n=38)	Low Evaluating (n=37)		Odds Ratio (95% CI)		Odds Ratio (95% CI)	
Primary Outcomes				Unadjusted	p Value	Adjusted	p Value
Used High-Quality Website	76.3	54.1		0.37 (0.14, 0.98)	**0.05**	0.34 (0.12, 0.97)	**0.05**
Searched Web for Doctor Info	57.9	45.9		0.62 (0.25, 1.54)	0.30	0.72 (0.27, 1.92)	0.50
Secondary Outcomes							
High Quality Websites							
Dedicated health websites	68.4	40.5		0.32 (0.12, 0.81)	**0.02**	0.27 (0.09, 0.78)	**0.02**
University or Hospital Website	52.6	32.4		0.43 (0.17, 1.10)	0.08	0.42 (0.15, 1.15)	0.09
AAO-HNS (Otolaryngology)	15.8	5.4		0.31 (0.06, 1.62)	0.16	0.36 (0.06, 2.20)	0.27
Low Quality Websites							
Search engines	76.3	59.5		0.46 (0.17, 1.23)	0.12	0.71 (0.23, 2.14)	0.54
Social media sites	10.5	5.4		0.49 (0.08, 2.83)	0.42	0.80 (0.12, 5.48)	0.82
YouTube	15.8	21.6		1.47 (0.46, 4.75)	0.52	2.63 (0.63, 10.98)	0.19
Wikipedia	23.7	21.6		0.89 (0.30, 2.62)	0.83	1.03 (0.32, 3.33)	0.96
Category of Doctor Information							
Doctor Reviews	50	37.8		0.61 (0.24, 1.53)	0.29	0.69 (0.26, 1.88)	0.47
Board Certification	44.7	21.6		0.34 (0.12, 0.94)	0.04	0.32 (0.11, 0.96)	0.04
Training Institution	42.1	24.3		0.44 (0.16, 1.19)	0.11	0.43 (0.15, 1.26)	0.13
Malpractice claims	5.3	16.2		3.48 (0.66, 18.5)	0.14	5.57 (0.79, 39.32)	0.09
Clinic reviews	34.2	27		0.71 (0.27, 1.91)	0.50	0.84 (0.28, 2.51)	0.76

Footnote: Table 4 shows the individual items of the eHealth Literacy Scale, the subscale category of each item defined by the reflective model, the literacy skills associated required to answer “agree” or “strongly agree” to each item, the principal component analysis under normal assumption of Eigenvalues >1 (shown in yellow), Varimax Rotation Factor analysis under the assumption of 2 factors (shown in green) and the Varimax Rotation Factor analysis under the assumption of 3 factors (shown in orange). Max factor loadings per factor are in bold. Beneath the factor loadings are the respective Eigenvalues and % of variance explained per factor. When Varimax rotations were used, corresponding rotation sums of the squared loading and percent of variance after rotation are shown.

Table 4f: Summary of Responses Significant Differences

	Low eHeals	**Low Finding**	Low Applying	Low Evaluating
Primary Outcomes				
Used High-Quality Website	*	**	**	*
Searched Web for Doctor Info	*	*	*	
Secondary Outcomes				
High Quality Websites				
Dedicated health websites	**	**	**	*
University or Hospital Website	*	*	**	
AAO-HNS (Otolaryngology)	*	**		
Low Quality Websites				
Search engines		**	**	
Social media sites				
YouTube				
Wikipedia				
Category of Doctor Information				
Doctor Reviews	**	*	*	
Board Certification	**	*	*	*
Training Institution	*		*	
Malpractice claims				
Clinic reviews	*			

Table 4f shows a summary of from tables 4-4e, which shows significant differences with low vs high eHealth literacy subscales and primary outcomes. "*" = significant differences ($p<0.05$) found between those with low eHEALS scales and subscale, "**" = $p<0.01$