How Healthcare Technology Shapes Health Literacy? A Systematic Review

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Abstract

There have been efforts to develop technologies for low health literate users and evaluate them for effectiveness. We address how technology improves health literacy by identifying salient technical features to support health literacy processes and the specific needs of user populations. A systematic review of 45 published studies on technology to improve health literacy in PubMed, Direct Science, and Google Scholar up to 2014 was performed. Thirteen evaluation studies were reviewed to analyze their effectiveness. Among technological features used in technologies to improve health literacy, multimedia, interactive didactic forms with simple contents, followed by ease of use, are gaining popularity in technology to support health literacy process. Video game and virtual world are effective for young users to be engaged in learning. For seniors, technical features with ease of use like practical assistance are commonly used. This paper shows some technologies' effectiveness and discusses difficulties for the technologies failed to achieve desirable outcomes.

Keywords

Health literacy, health education technology, decision aids, knowledge, behavior change.

Introduction

Health literacy is concerned in information-driven health care. Activities, such as medical choices or communication with healthcare providers, require the understanding of basic medical information. In order for consumers to take responsibilities for their healthcare choices, they must have an adequate level of health literacy (McQueen et al. 2007). The role of health literacy has become and will be more critical, as more biomedical sensors are used for self-monitoring and electronic health records become accessible to patients.

Health literacy contributes to a wide range of positive health outcomes, including improved health condition, reduced costs of healthcare, and reduced disparities in health care service use (Berkman et al. 2011a). Some research models with health literacy include health condition as an outcome component (Sorensen et al. 2012; Squiers et al. 2012). It indicates that health literacy plays a role as a predictor to detect relations on health outcome (Baker 2006). A study focused on the effects of health literacy on health status such as physical and mental health and self-reported health, but the results showed health literacy explains a small to moderate portion of the health variation (Howard et al. 2006). More papers focused on a segmentation of health literacy instead of whole population, and successfully showed poor health literacy is associated with bad health condition; Low level of health literacy significantly affects health behaviors (Ferguson et al. 2011) and health condition (Andrus et al. 2002; Wolf et al. 2005). This study also tries to solve the critical problem by focusing technical aspects for those with low health literacy.
Low health-literate consumers show generally bad health conditions (Kay et al. 2006; Wolf et al. 2005). Low level of health-literacy means a lack of ability to understand basic medical concepts such as how to read over-the-counter medication labels and administer medications correctly. Misinterpretation of medication instructions is common with low health literate population, and generates poor adherence or possible medication interactions (Ferguson et al. 2011). The negative influence of low health-literacy is significant in terms of the use of health care services. Persons with low health-literacy are less likely to get preventive care and more likely to use emergency rooms, often with more serious symptoms due to delays in treatment. For example, limited health knowledge lead to higher chronic disease rates (DeWalt et al. 2004; Ferguson et al. 2011) and higher inappropriate health services (Sanders et al. 2009). That is the reason health care costs more for those with low health literacy, about 3–5% of the total health care spending (Kennedy et al. 2002).

Research in health literacy has made efforts to advance in the availability of information through the expanded access and the use of technology. These innovative technologies brought some new avenues to improve consumer’ health literacy through electronic delivery methods and efficient education interventions (White et al. 2001). Electronic technology transcends geographic and time limitations, providing consumers with greater freedom to access information that they previously deemed unattainable. One characteristic of the technology, anonymity, makes patients feel less of intrusion with online communication if they feel stigmatized with their specific diagnosis. There should be salient features in the technologies effective in improving health literacy level.

Some prior literature reviewed the effects of healthcare interventions, including online and offline healthcare technologies, on various outcome measures (Sheridan et al. 2011; Berkman et al. 2011b). Other papers showed the impacts of healthcare technologies on health literacy, but did not investigating how the technologies improve health literacy (Clement et al. 2009; Taggart et al. 2012). This present study systematically investigates how healthcare technologies improve health literacy, more specifically, it examines what technical features support health literacy process and satisfy the needs for specific user populations with low health literacy.

In this study, we review prior literature on the designs and the uses of technologies. First, we identify in the literature what technical features are used for the different types of technologies to support health literacy process and for different populations of users. Then, we examine if the use of technology contributes to the improvement of health literacy. Thus, this systematic review tries to answer three following research questions: How healthcare technologies support health literacy process (RQ1), how healthcare technologies are differentiated for different user populations (RQ2), and whether the use of healthcare technology improves individual health literacy level (RQ3)?

Methods

Framework

Task technology fit (TTF) theory (Goodhue et al. 1995) is a base for us to review relevant literature. The TTF theory identifies information systems, task, and individuals and their fits (Dennis et al. 2001; Yusof et al. 2008). When a technology is configured to match the ideal profile for a task, then a fit exists between the technology and the task, and the performance improves (Venkatraman et al. 1990). Based on the TTF theory, we developed a review framework to see the relationship among technology, health literacy process, and users. We see the fits of technologies by analyzing performances the technologies showed. The review framework is reflected by the fact that health literacy is a process that involves ability in the consecutive tasks of accessing, understanding information, and using the information. It is intended for only technology to improve health literacy (health literacy technology afterwards) and features that are used in the technologies. Lastly, user populations such as senior and children are included in the analysis framework. This integrated framework guided us to straightforward review the studies on health literacy technologies and their effects in order to answer our research questions.

To understand what health literacy process is, we reviewed the definitions of health literacy defined in prior literature. The American Medical Association used health literacy with a definition as “a constellation of skills, including the ability to perform basic reading and numerical tasks required to function in the health care environment (Speros 2005).” The basic includes the ability to read written
medical instructions or to fill out health insurance forms. The definition of health literacy has evolved to emphasize communication skills and interpretation capacity (Mancuso 2008; Rootman et al. 2008), often via various forms like graphical information, digital forms, and interaction with a computer system (Ishikawa et al. 2008; Norman et al. 2006; Adkins et al. 2009; Yost et al. 2009). Recently, there appeared addition to the definition of health literacy as the individual’s capacity for ‘health decisions’ (Paasche-Orlow et al. 2007). It indicates the final goal of health literacy is to have ability to make healthcare decisions (See supplementary appendix A for detail definitions). In this paper, we define health literacy as the ability to obtain, understand, and synthesize information related to medical aspects and apply the information to make individual’s healthcare decisions. The definition implies health literacy has a process characteristic. There is an ordering of the required tasks; first is to access information, next is to understand and synthesize information, and last is to make healthcare decisions by using the information.

To decide our focal user populations which need to improve health literacy, we considered many aspects that are related to low health literacy. Many characteristics such as age, race, and socioeconomic status are identified to determine ill health-literate population (Paasche-Orlow et al. 2005; Kutner et al. 2007). Age is one of the main factors that relate to poor health literacy, and it also shows different usage of the health literacy technologies. Seniors need to get attention because they show the lowest health literacy level and more severe compounding health issues compared to other populations. Therefore, we decided to analyze health literacy technology studies according to age populations, specifically, seniors and children.

**Systematic search**

Two researchers performed a systematic search of the literature indexed in PubMed, Direct Science, and Google Scholar as database engine to identify relevant articles. Keywords searched in the abstracts and the titles of the papers are combinations of the three concepts: technology purpose (health literacy, patient education, medical knowledge, health knowledge, behavior change, and decision making aids), user population (older, senior, children), and technology. We also used hand-searched personal libraries kept by the research team.

Figure 1 shows the literature selection flow. Initially 113 relevant studies were identified after conducting the searching strategy. To determine whether the studies meet our eligibility criteria, we took the following steps. After reviewing the paper titles, duplicate studies and literature review papers were excluded, because the raw data are basically duplicate. Next, after reviewing the abstracts, we excluded studies if a research topic is not relevant for our topic, the use or development of health literacy technologies. Then, we examined the full contents of the remaining papers to see if the above criteria are satisfied. We finalized 45 papers for the review on health literacy technology to answer the first two research questions (RQ1, RQ2) (see supplementary appendix B for the list of the 45 studies). To review the effects of health literacy technology to answer the third research question (RQ3), we performed one more step to determine eligibility. Among the 45 studies, we included only those that evaluate health literacy technology in at least one outcome measure and utilize a randomized controlled experimental design, which left 13 papers. The outcome measures of our interest include health knowledge and health behavior changes, such as smoking cessation or decision makings.

Two leading authors coded the selected papers independently. As coding progressed, several discussion sessions were held to make sure that both coders understood the coding scheme properly and applied it consistently. When there were any discrepancies in coding results, such areas were revisited to make final agreements.

**Results**

*Technologies to support health literacy tasks*

This section tries to answer the first research question (RQ1), how health literacy technology supports health literacy process. Different types of technologies support health literacy tasks: to access health information, to build health-related knowledge, and to use the knowledge gained.
Technology to access health information

Various technologies are used to access health information or healthcare service in 39 studies, out of the 45 studies. Patients want to have information about the availability and the quality of health care services, test results and follow-ups, and communication with health care providers (Davis et al. 2005). Technologies to access health care, for example, include mobile to schedule appointments, instant messaging or emails to remind appointments, online payment systems (DeAynley et al. 2008; Klasnja et al. 2012; Liaw et al. 2010), smart phones to communicate with healthcare providers (Jacob et al. 2013), and the Internet to obtain prescriptions or purchase pharmaceutical products (Baker et al. 2003). Medical record is delivered through electronic methods such as computer-generated patient held devices (Liaw et al. 1996; Sox et al. 2010).

By aggregating the technical features in the health literacy technology, we identified an important factor, accessibility. Accessibility is a basic functionality in the other types of health literacy technologies like education technology, behavior change intervention, or decision making aids. The technical features to support accessibility include ease of making an appointment and right time response to e-mails or phone calls (Davis et al. 2005).

Technology to build health knowledge

There are 23 studies with education-purpose technologies. Health knowledge is distinguished into two forms of knowledge, explicit knowledge and tacit knowledge (Cook et al. 1999). Explicit knowledge is basic health information, while tacit knowledge is more experiential, which can guide actions. Tacit knowledge
is typically established after the explicit knowledge, and is influenced by interaction with others. We found different types of technologies are used to establish the two different types of healthcare knowledge. Explicit knowledge is usually shared using web-based education programs (Bastani et al. 2012), mobile apps (Yue et al. 2013), and programs on tablet PCs (Finkelstein et al. 2006). People exchange documents in an electronic form, which is an effective mean of education (Finkelstein et al. 2006). Tacit knowledge is usually obtained using social network technology that carries accumulative content in an interactive way. People help each other by asking and answering health-related questions, even giving insights or wisdom. The technical features are quite different for the establishment of the two types of healthcare knowledge, even though the health literacy task, to build health knowledge, is the same.

For explicit knowledge, didactic or interactive forms are identified as the most commonly used features to deliver health instructions (Franceschi et al. 2009; Grover et al. 2009; Krishna et al. 2003; van Limpt et al. 2011). Q&A type instructions and interactive features that connect consumers and healthcare providers are popular, often with the presence of virtual advisors. Multimedia is the second commonly used feature in the educational technologies. Children with asthma increased health knowledge with the uses of multimedia or game (Krishna et al. 2003). Rather than the specific technical features, contents and expressions should be easy enough for learners to effectively learn the explicit health-related knowledge. Elementary 3th through 5th grade English, not a jargon, is recommended. It is necessary to take into consideration of cognitive skill levels of low-literate people. For explicit knowledge learning, we identified that easy understanding is important. Table 1 summarizes the technical features found in the technologies to support each of health literacy tasks and important factors based on the features identified.

<table>
<thead>
<tr>
<th>Health literacy Task</th>
<th>Access</th>
<th>Build health knowledge</th>
<th>Use the knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technology purpose</strong></td>
<td><strong>Access</strong></td>
<td><strong>Explicit Knowledge</strong></td>
<td><strong>Tacit Knowledge</strong></td>
</tr>
<tr>
<td>Mobile (8), Internet (4), Tablet PC (2)</td>
<td>Didactic forms (5), Multimedia (4), Simple contents (1)</td>
<td>Virtual world (5), Interactive feature (3), Social network (2)</td>
<td>Monitoring with visual components (8), Tailoring (4), Social support (3)</td>
</tr>
<tr>
<td><strong>Technical feature</strong></td>
<td><strong>Factor</strong></td>
<td><strong>Accessibility</strong></td>
<td><strong>Interaction</strong></td>
</tr>
<tr>
<td><strong>Accessibility</strong></td>
<td>Easy understanding</td>
<td>Interaction</td>
<td>Personalization</td>
</tr>
</tbody>
</table>

- The number in parenthesis represents studies using the specific feature.
- Underlined content means that the feature showed to generate positive effects, indicating its effectiveness.

**Table 1. Summary of health literacy technical features commonly used**

Tacit knowledge, on the other hand, is usually obtained through interactive technologies such as virtual world social network technology. They facilitate the activities of support groups available to patients, ranging from self-help groups, to group therapy (Ali et al. 2012; Arntson et al. 1987; Winston et al. 2012; Cline et al. 2001; Franceschi et al. 2009; Kummervold et al. 2002; Song et al. 2010). Technology-mediated discussion to connect patients and medical experts is effective for knowledge transfer. Participation in such groups is shown to help patients better understand the nature of their medical conditions (Campbell et al. 2004; Lévy 1997). Personalized social network systems and social dialog systems develop the relationships between patients and healthcare providers, which is beneficial to increase patients’ knowledge (Bickmore et al. 2006). Another way to build the tacit knowledge is indirect experience via a simulation or a virtual reality technology (Franceschi et al. 2009). A study of Ackermann tested a simulation tool to acquire Cardio-Pulmonary Resuscitation (CPR) skills, and it shows its effectiveness (Ackermann 2009). Skills are enhanced by doing in a simulated situation, rather than by passive reading. When considering all the popular features in the technology for tacit knowledge learning, we termed interaction as an important factor.
Technology to use health knowledge

The goal to use health knowledge obtained is healthcare decision makings, such as a decision to take a screening test or a decision not to smoke as behavior change. We identified 7 studies designed for behavior changes and 5 studies for decision makings. Those technologies incorporate various features, but three features are of salience. One feature is to provide users with tailored information (Meis et al. 2002; Simon et al. 2011). Decision making aids deliver relevant health information delivered (Miller et al. 2011). However, providing users with explicit information alone does not play a critical role in health decision-makings (Kennedy et al. 2002). Second feature is social interaction (Murray et al. 2005; Baranowski et al. 2008). Knowledge obtained through online consultations with medical professionals and online support communities evoke actions (van Uden-Kraan et al. 2008). Social networking is identified as a way to promote health life-style (Kuo et al. 1986), such as smoking cessation (Meis et al. 2002) and asthma (Wise et al. 2007). With the social interaction, people gain psychological benefits like self-efficacy to promote desired behavioral changes. Interestingly, tailored information and social interaction are identified as important factors for explicit knowledge and tacit knowledge, respectively. Monitoring is the last distinguished feature in the technologies for behavior changes. Most disease management tools provide with users monitoring functionality (Eyles et al. 2014; Oermann et al. 2003). They carry graphs, emotional graphics, or convenient calculators like body mass index calculators. An intervention uses traffic light label visualizations to show the levels of positive nutrients and negative nutrients of food products so that users can make food choices (Eyles et al. 2014). Visualized graph is a useful technical feature that helps consumers to easily detect information.

For decision making aids, we identified more features added to the three features above in the technology for behavior changes. Calculator, such as risk estimate (Schapira et al. 2007) or test comparison (Miller et al. 2011), and virtual experts are incorporated. The virtual experts communicate with patients by answering questions that patients have, but with more presence sense (Simon et al. 2011). From the technologies for behavior changes or decision makings, we extract handy functionality with ease of use as well as personalized contents as their common characteristics.

Technologies for different population with low health literacy

As mentioned before, we analyzed health literacy technology studies for different user populations to answer the second research question (RQ2), how health literacy features are differentiated for different user populations. Some technologies are designed for low health literate population such as children (Sallam et al. 2013) or the old (McKinley et al. 2009a). In this section, we represent the analysis results with technologies designed for children and senior populations.

Children

Video games (Baranowski et al. 2008) and multimedia are commonly used in technologies for children, often with animated real life scenarios, graphical components, and interactive vignettes to carry information (Grover et al. 2009; Krishna et al. 2003). In the same vein, virtual world social network (e.g. Second Life) is designed for teenagers who enjoy altered persons provided by avatars (Boulos et al. 2007; Norman et al. 2006; Zhao 2009). Voice chat feature enables them to talk to other virtual humans, enhancing interaction (Franceschi et al. 2009). When teenagers encounter a virtual world first, they feel it is like a game which makes them engaged. Mobile is identified as an effective medium for teenagers (Yue et al. 2013). They are extensive users of mobile devices, especially for social networking. They view mobile devices as important symbols to stay current with trends (Ito 2005).

A key factor for young users is engagement. One promising technology is online gamification that facilitates engaging learning (Quinn et al. 2005). An example is a game-based learning program that engages users to role-play in virtual healthcare setting in Second Life. It pops up with questions on medical information when a virtual human passes a certain area, which gets into learning phase through quiz-solving on health information.
**Senior**

Not many technologies are designed for seniors in our paper pool. The elderly population relies on diverse sources, not only the Internet, to get information (Hesse et al. 2005). However, smartphones or iPad are identified as growing in the usage for seniors. One of the technological benefits is versatility. Seniors use the technologies for multiple purposes, such as collecting information relating to certain diseases, communicating with healthcare providers, discussing with others, and watching online programs for entertainment. We found practical assistance embedded in the technology. An example is a homecare tele-assistive mobile robotic system (Michaud et al. 2010). While a mobile robot interacts with a senior patient in home environment, another person, from a potentially distant location, can operate the robot.

A key factor in the health literacy technologies for seniors is ease of use. Simple and convenient feature, such as virtual advisor to get recommendations, is mostly found in the technologies for seniors. The salient technical features are summarized in Table 2 according to different user populations.

<table>
<thead>
<tr>
<th>User population</th>
<th>Children</th>
<th>Senior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical feature</td>
<td>Audiostreamual (2), Virtual world (2), Game (1), social network in mobile (1)</td>
<td>Voice (1), Telelrobot (1)</td>
</tr>
<tr>
<td>Factor</td>
<td>Engagement</td>
<td>Ease of use</td>
</tr>
</tbody>
</table>

- The number in parenthesis represents studies using the specific feature.
- Underlined content means that the feature showed to generate positive effects, indicating its effectiveness.

**Table 2. Summary of commonly used health literacy technical features**

**Effects of the technologies on health literacy**

This section represents the analysis of 13 evaluation studies with a randomized controlled experimental design on the effects of the health literacy technologies, examining the relation between technology use and its outcome (RQ3). The details of the 13 studies are summarized in Table 3.

Five studies assessed education-purpose technologies. Four of them evaluated on health knowledge, and all the results are positive. Two studies tested on behavior change (Liaw et al. 1996) and health condition (van Limpt et al. 2011), and they reported all positive impacts. It indicates that the use of education-purpose technology generates positive impacts on knowledge, behavior change, and health condition. However, most studies focus on only the changes in knowledge. Factors for knowledge improvement with e-learning systems are interactive features to accommodate multiple learning styles (Holubar et al. 2009), to tailor information to users’ diseases (McKinley et al. 2009b), and multimedia (Holubar et al. 2009; Krishna et al. 2003). This finding confirms that multimedia and interactive features are effective in the education-purpose technology.

Four studies evaluated technologies for behavior change, and 4 studies for decision makings. The purposes of these two types of technologies are same from the views of the health literacy tasks, to apply health knowledge for specific healthcare situations. The ultimate goals of these types of the health literacy technology include changes in dietary habits, exercise, or smoking as well as medical decisions. All 4 studies with the behavior change technologies show significantly positive results in behavior change. Interestingly, Glasgow’s study (Glasgow et al. 2003) and Bastani’s study (Bastani et al. 2012) investigate the relationship between intention and behavior change using the self-efficacy theory. They showed improvements in both behavioral and psychosocial aspects (Glasgow et al. 2003).

For the 4 studies with decision making aids, the results are not simple. Miller et al. (2011) evaluated a web-based decision aid with multimedia for senior patients, and found that participants with the decision aid had more a screening preference and increased readiness to receive a screening (Miller et al. 2011). Two studies reported positive results in both knowledge and behavior change (Jibaja-Weiss et al. 2011; Simon et al. 2011). The results indicate decision making aids help user not only to make decisions but also to improve medical knowledge. One study explicitly addresses that having more information is good for making decisions (Simon et al. 2011). Didactic feature (Jibaja-Weiss et al. 2011) and multimedia (Miller et
<table>
<thead>
<tr>
<th>Study</th>
<th>User population</th>
<th>Health literacy technology Purpose</th>
<th>Technology description</th>
<th>K</th>
<th>B</th>
<th>Comments related to health literacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Krishna et al (Krishna et al. 2003)</td>
<td>Children patients</td>
<td>Education</td>
<td>Interactive multimedia self-management education</td>
<td>+</td>
<td></td>
<td>Knowledge is correlated to fewer urgent visits</td>
</tr>
<tr>
<td>(Holubar et al. 2009)</td>
<td>General</td>
<td>Education</td>
<td>Multimedia e-Learning</td>
<td>+</td>
<td></td>
<td>E-learning module could improve colon cancer literacy in a community-based group</td>
</tr>
<tr>
<td>(McKinley et al. 2009b)</td>
<td>Patients</td>
<td>Education</td>
<td>One-on-one nursing education and counselling intervention</td>
<td>+</td>
<td></td>
<td>Knowledge, attitudes and beliefs are significantly related each other</td>
</tr>
<tr>
<td>(Liaw et al. 1996)</td>
<td>Patients</td>
<td>Education</td>
<td>Computer-generated patient held medical record summary</td>
<td>+</td>
<td>+</td>
<td>Medical record summary with explanatory booklet were evaluated</td>
</tr>
<tr>
<td>(van Limpt et al. 2011)</td>
<td>Patients</td>
<td>Education</td>
<td>Computer cardiovascular prevention intervention by a health advisor</td>
<td></td>
<td></td>
<td>This longitudinal study shows health improvements of patients in BMI and HDL-cholesterol</td>
</tr>
<tr>
<td>(Glasgow et al. 2003)</td>
<td>Patients</td>
<td>Behavior change</td>
<td>Self-management with tailored training and peer support</td>
<td>+</td>
<td></td>
<td>Website usage among community was greatest, but declined over time</td>
</tr>
<tr>
<td>(Bastani et al. 2012)</td>
<td>Female students</td>
<td>Behavior change</td>
<td>Web-based lifestyle education</td>
<td>+</td>
<td></td>
<td>Internet is effective to facilitate learning anytime and anywhere.</td>
</tr>
<tr>
<td>(Hamilton-Shield et al. 2014)</td>
<td>Children</td>
<td>Behavior change</td>
<td>A device to slow down speed of eating</td>
<td>+</td>
<td></td>
<td>The ways to engage target populations are considered for effective technology development</td>
</tr>
<tr>
<td>(Sallam et al. 2013)</td>
<td>Children</td>
<td>Behavior change</td>
<td>Audiovisual modelling on behavioral change</td>
<td>+</td>
<td></td>
<td>Video modelling promotes faster acquisition of target behavior</td>
</tr>
<tr>
<td>(Miller et al. 2011)</td>
<td>Senior patients</td>
<td>Decision aid</td>
<td>Web-based multimedia CRC screening patient decision aid</td>
<td>+</td>
<td></td>
<td>The decision aid increased patients' ability to form a test preference and their intent to receive screening, regardless of literacy level</td>
</tr>
<tr>
<td>(Simon et al. 2011)</td>
<td>Patients</td>
<td>Decision aid</td>
<td>Web-based decision aid with evidence-based information</td>
<td>+</td>
<td></td>
<td>Knowledge and decision making preparation are significant. Knowledge scores are different depending upon diseases</td>
</tr>
</tbody>
</table>
Study | User population | Health literacy technology Purpose | Technology description | K | B | Comments related to health literacy
--- | --- | --- | --- | --- | --- | ---
(Jibaja-Weiss et al. 2011) | Patients with low health literacy | Decision aid | Entertainment-based decision aid | + | + | Didactic soap opera episodes hold attention and easy to understand
(Schapira et al. 2007) | Female patients | Decision aid | Computer-based hormone therapy decision-aid | 0 | | No differences in knowledge, decision conflict technology were found when comparing the use of pamphlets. Tailored risk calculation is easy to use and useful

- K = Change of health knowledge, B = Change of health behavior

Table 3. The 13 evaluation studies for effectiveness of health literacy technology

al. 2011) are also found in the decision making aids, the feature that facilitate learning. However, consideration of patients’ values and health conditions generates additional complexity in the decision making aids (Simon et al. 2011). The studies of Volk and Jibaja-Weiss emphasize Human Computer Interface with ease of use, which can be a successful factor for dealing with complex situations (Jibaja-Weiss et al. 2011). Schapira et al. (2007) also address ease of use to deal with the possible complexity due to patient centeredness and shared decision makings, but the results do not reach a significant level (Schapira et al. 2007).

Discussion

Our objective is to identify in the literature salient technical features to support health literacy tasks and for specific user populations. There are variations in the features of the health literacy technology, but we found the important factor to support the health literacy tasks is utility that comes with multimedia or ease-of-use features. The uses of the features show performance improvement, which indicate good fit between the features and the health literacy tasks. Ease-of-use is identified as an important factor in decision making aids involving complex situations and technology for seniors who need additional help due to low health literacy. Besides, we identified different technical requirements for different user populations. While seniors need handy features in the technology, young generation want features like games or simulated training to get engaged (Foss et al. 2014; To et al.). However, we acknowledge that such a small number of the studies let us hardly conclude about the effectiveness of health literacy technology.

Digital divide and health literacy disparity become critical in public health. Problems may grow as electronic information sources are increased; Digital divide increases between ones with ability to use digital devices and ones without. Health literacy gap increases when high quality health information is delivered via electronic technologies. Older adults may suffer these problems due to lack of digital device usage. Besides, they may have loss of hearing, vision, and cognitive skills which can be blocks for health literacy. However, there are not many studies targeted for the old. More efforts should be made to address this problem and provide solutions for them.

With health literacy technologies, a person would achieve higher level of health literacy. He or she would understand medical risks and health benefits, become more involved with their treatment choices. This concept is very similar with patient-centered care. However, incorporating the patient-centered care concept into health literacy technology does not generate positive results for those with low health literacy. In order for technology to support patient-centered care, careful consideration should be made. For true patient-centered care, health literacy technology needs to support all the tasks of health literacy, from accessing information, understanding, and using the information for choices, not just supporting
health care knowledge building. There should be appropriate cutoffs for health literacy level for individuals. We believe that the final destination of health literacy could be somewhere for individuals to have sufficient confidence to make healthcare decisions with relevant information. Technology can mitigate cognitive workload, if it exceeds one’s cognitive ability when someone has compounding health conditions. In the same vein, ease-of-use is necessary to consider for decision making aids and for older population. Besides, the patient centered care requires the culture changes of clinical healthcare providers, because it forces shared decision makings with healthcare providers and a patient. Therefore, health literacy technology for patient centered care needs to be carefully designed, and is considered as a major health investment that needs long-term commitment through changes in health care technology and culture.

**Conclusions**

This review investigates how health literacy technology improves health literacy by showing how health literacy technologies are designed to support the health literacy process and how technical features are designed for different user populations. The educational technologies provide learning opportunities that are more interactive, more didactic forms of health instructions. The decision making aids help people to act with ease-of-use and personalized features. Different populations, such as young consumers and old consumers, show difference in the use of health literacy technologies. In addition, the education-purpose technologies and behavior-changing purpose technologies generate desirable outcomes in learning and behavior changes, respectively. However, decision making aids show relatively complex results because more components are incorporated for patient-centeredness or complex situations. These findings give a hint about the health literacy technical requirements for specific purposes or user populations. This review was not intended to be a comprehensive, cumulative review of evidence regarding the use and effects of health literacy technologies. Rather than, this study focuses on the most used technical features and those most like to be associated with effectiveness to improve health literacy.

**References**

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Appendix A. The definitions of health literacy

<table>
<thead>
<tr>
<th>Reference</th>
<th>Definition of health literacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Medical Association's (1999)</td>
<td>&quot;The constellation of skills, including the ability to perform basic reading and numeral tasks required to function in the healthcare environment&quot;</td>
</tr>
<tr>
<td>Nutbeam (2000)</td>
<td>&quot;The personal, cognitive and social skills which determine the ability of individuals to gain access to, understand, and use information to promote and maintain good health&quot;</td>
</tr>
<tr>
<td>WHO (1998)</td>
<td>&quot;The cognitive and social skills which determine the motivation and ability of individuals to gain access to understand and use information in ways which promote and maintain good health&quot;</td>
</tr>
<tr>
<td>Institute of Medicine (2004)</td>
<td>&quot;The individuals' capacity to obtain, process and understand basic health information and services needed to make appropriate health decisions&quot;</td>
</tr>
<tr>
<td>Mancuso (2008)</td>
<td>&quot;A process that evolves over one's lifetime and encompasses the attributes of capacity, comprehension, and communication. The attributes of health literacy are integrated within and preceded by the skills, strategies, and abilities embedded within the competencies needed to attain health literacy&quot;</td>
</tr>
<tr>
<td>Rootman &amp; Gordon-Elbithety (2008)</td>
<td>&quot;The ability to access, understand, evaluate and communicate information as a way to promote, maintain and improve health in a variety of settings across the life course&quot;</td>
</tr>
<tr>
<td>Ishikawa &amp; Yano (2008)</td>
<td>&quot;The knowledge, skills and abilities that pertain to interactions with the healthcare system&quot;</td>
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<tr>
<td>Yost et al. (2009)</td>
<td>&quot;The degree to which individuals have the capacity to read and comprehend health-related print material, identify and interpret information presented in graphical format (charts, graphs and tables), and perform arithmetic operations in order to make appropriate health and care decisions&quot;</td>
</tr>
<tr>
<td>Adkins et al. (2009)</td>
<td>&quot;The ability to derive meaning from different forms of communication by using a variety of skills to accomplish health-related objectives&quot;</td>
</tr>
<tr>
<td>Paasche-Orlow &amp; Wolf (2006)</td>
<td>&quot;An individual's possession of requisite skills for making health-related decisions, which means that health literacy must always be examined in the context of the specific tasks that need to be accomplished. The importance of a contextual appreciation of health literacy must be underscored&quot;</td>
</tr>
</tbody>
</table>
Appendix B. The paper pool for health literacy technology review
List of 45 studies identified for the review of health literacy technology <online link>