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Design of Interactive Cancer Education Technology for Latina Farmworkers

Ying Wu, Devan Samant, Kristen Squibbs, Alexis Chaet, Bijan Morshedi, and Laura E. Barnes

University of Virginia, ysw3kz dms7tm, kls5dw, avc4ew, bm8wr

Abstract

Latinas in the United States experience higher levels of cervical cancer (CC) incidence and mortality rates than the general population, and many lack access to healthcare or face communication, literacy, and knowledge barriers preventing proper CC screening. Interactive technological interventions, like embodied conversational agents (ECA)/virtual agents, are currently used in other populations, settings, and for other health topics, however, no known initiative has used culturally- and literacy-appropriate technological interventions to deliver Spanish-language CC education.

This study aims to create a culturally tailored Spanish-language Virtual Patient Educator (VPE) application to augment a patient navigator (PN) intervention for increasing CC screening rates among Hispanic women in a rural agricultural community. The VPE is a computer character that can simulate face-to-face conversation with an actual person and will embody the characteristics of a PN. Through iterative interviews with the target population, key cultural design factors were identified to inform the design and implementation of a prototype VPE. This paper discusses design and usability issues associated with development of the VPE for low-literacy users in addition to a framework methodology for development of similar tools and a cultural matrix of design factors. A VPE might help close the knowledge gap between Hispanic women and the general population regarding cervical cancer screening. Incorporation of culturally tailored features in technology aids in increasing overall understanding and trust of health information presented. An iterative approach that engages the patient population in design of technology is important to identify population-specific patient preferences.

Index Terms

Health Education; Information Technology; Mobile Application; Virtual Agent

Introduction

While quality of care in the United States is steadily improving, health disparities in access and quality between non-Hispanic whites and minority and low-income groups remain large [1]. U.S. Hispanic women in particular face marked disparities in cervical cancer, with incidence nearly double that of Caucasian women and mortality rates 42% higher. These stark disparities are in part influenced by cultural beliefs, linguistic barriers, socioeconomic status, and low levels of health literacy, which contribute to lower levels of CC screening

rates [2]. In addition, provider behaviors and practice patterns have been found to play a role in these disparities [3], leading to an increasing recognition of the importance of a culturally competent health care workforce [1]. Many studies have looked at cultural-competence within the context of in-person interventions [4] but less often in the context of health Information Technology (IT). Evidence supports that sources of media, such as the Internet, radio, television, and newspaper/magazines are an effective and desired way to deliver health information to the Hispanic population [5–7]. Health education delivered through multimedia and interactive technology has furthermore been shown to assist Hispanics in improving health literacy [8]. Embodied conversational agents (ECAs) are one form of interactive technology which have been used within the U.S. to deliver a variety of health information including post-hospitalization care [9], anesthesia [10], exercise for older adults [11–12], hospital discharge [13], and stress management [14]. ECAs simulate human face-to-face conversation with users and offer an interactive, personal, and user-friendly approach to communicating health information [15]. In this paper, we describe the design process for a low-literacy, Spanish language ECA to deliver information about CC prevention and screening to a rural population of Hispanic women in Dover, Florida.

Related Work

In the past decade, technology-based health outreach has been explored in detail as a way of promoting health and wellbeing within the US Latino population. These health IT applications aim to replace, supplement, or enhance efforts in areas such as patient-physician communication, community health promoter programs, and *promotora* community outreach groups [16–18]. Various levels of success have been achieved through efforts incorporating a wide range of media including web-based applications, short messaging services, interactive community health kiosks, and social media [19–21]. Despite a number of ECA health education technologies used within the English speaking population within the U.S., only one known Spanish-language ECA has been reported within the literature [22]. This intervention focused on educating Latinos on the importance of physical activity, using a technology requiring low language and computer literacy level which was delivered in a culturally and linguistically adapted manner. This study concluded that culturally tailored interactive technology might help reduce health disparities by ensuring equal benefits from electronic-health opportunities for all groups [22]. The present study aims to build upon the minimal existing literature through the design of a culturally tailored, appropriate ECA focused on cervical cancer prevention.

Methodology

Overview

An initial feasibility study using an interactive, technology-driven health education program was conducted with the patients of Catholic Mobile Medical Services in Dover, Florida. This study found that one hundred percent of the 26 participants responded positively to the concept of the computer program, the delivery method of health information, and the trustworthiness of the health information obtained in this manner [23]. An iterative design methodology with distinct but dependent phases was utilized. Phase one consists of

developing the design and functional requirements for the application. Phase two involves prototype development of the user-interface and the health content script. Phase three encompasses usability testing. Figure 1 below provides a visualization of the design methodology.

Specification

Survey results from the feasibility study were analyzed to better understand the population's experience and exposure to technology, as well as their accessibility to health information. Upon analysis of survey responses, additional survey questions were developed and delivered by a patient navigator working at the clinic covering a broad range of topics including who uses the clinic and why, what areas are patients from, and patient education levels. This user population analysis provided more insight on the technology exposure within the population that helped guide the creation of requirements. Results indicated there was an average of eight years of education with a low literacy level in reading. Some patients used their personal phone or computer for simple tasks such as emailing and searching information online. Most of the potential users were migrant farmworkers making follow-up visits to the clinic difficult. Additionally, many of the patients do not have health insurance and thus struggle to access consistent health care.

Requirements

Functional requirements were separated into two parts: agent actions and system actions. Agent action included any motions or body language of the virtual patient advisor to better convey the information from the planned script. System requirements include the sequential operation of the health content script, the interface, and the ECA display. These requirements also described the data collection needed for usability testing.

The ECA primarily interacts with users through a predefined script. The content of this script was created from low technology versions of health information such as brochures and pamphlets. Users traverse the script by selecting buttons to respond to questions as inputs and the application will route the users to different topics. After several topics, a review session will be presented to check user's knowledge comprehension level before proceeding to further topics and discussions.

The logic of the script resembles a Finite State Automata (FSA), which is depicted in Figure 2. Each topic in the script has its own distinct and independent state. Users can choose to stay within the current topic by pressing the 'Repeat' button or transition to the next state by pressing the 'Yes' or 'No' buttons which trigger different transition conditions. After one group of topics, a review session is presented to provide a knowledge check on the material. Users can also move back to the previous topics for review ('Back' button) or move to the next topic at the end of review session ('Next' button).

Key Design Elements

Key factors that have an effect on the usability and aesthetic appeal of the application were identified from the feasibility study. A list of crucial factors was enumerated to gain feedback from the population to find the optimal design features for the specific population

of users. The elements in the table below were identified as important for development of similar health information mobile applications in diverse user populations. Each factor has several levels, which were tested for user and cultural preference. For example, the three levels of background settings were clinical, contemporary domestic, and modest domestic. The target population indicated preference for a domestic background with relatable imagery, like a modestly styled living room.

Unity, a gaming engine platform, was utilized as the development environment for the implementation of the prototype due to its ease of portability between mobile device platforms and its versatility, which may prove valuable in future related applications. The first prototype had the ECA rendered in 3-dimensions, but a review of research on prototype design preferences found that participants would be more familiarized with a simple 2-dimensional agent [24]. Thus, the design integrated 2-dimensional Flash files into the functionality scripted in Unity. A screenshot of the current ECA/prototype design is depicted in Figure 2. The ECA is on the left side of the interface with buttons consistently placed on the bottom and a popup, supplementary image in the top right. Transition changes and improvement to a 3-dimensional character were discussed and implementation was deemed feasible should a future work go in that direction.

Automated data collection of user statistics from software was also implemented to provide usability feedback. The ability to automate and quantitatively assess a patient's use of the system will provide meaningful usability measurements that will ultimately influence design changes. The prototype system is designed to record the timestamp and accuracy each time a click is made, which provides a measure of comprehension of instruction and suitability of language used. The duration of time that a user spends in each module of the application is also recorded. This quantified information will allow a measurable evolution through the software design process and ultimately identify positive vs problematic software features. Review quizzes were given to the user at several points in the dialogue, the answers to which are also recorded affording a measure of content understanding and retention. A log of the user's unique path taken through the application was also stored. This log is used to ascertain the patient's ability to use the application and analyze common learning paths.

PRELIMINARY RESULTS

Survey on Prototype

A survey of the prototype was administrated to gather feedback on basic interface features. The survey focused on aesthetic preferences and symbolic representations for button and background variations.

In the survey, prototypes were presented to the participants with different background color schemes; one is shown in Figure 4. Feedback from the participants was collected and evaluated based on three criteria: ECA/PN, background color, and background items/props. The ECA's appearance was described as "sad" by the majority of the participants. For the background color, a majority of the participants desired a lighter color, which is associated with calming, happier environment. For the items/props, participants noticed the furniture appeared to be "uncomfortable" and "unsafe", and most of them also suggested a change in

the wall painting to something less clinical. Suggestions for improvement on the prototype were the following:

- ECA should smile more for a happier and friendly atmosphere.
- Furniture should be more comfortable and recognizable
- Painting in the setting should be of plants or flowers for a more relaxing setting.

Patients were asked about different designs layouts for buttons including button colors, shapes, background color contrasts, and symbols. The figure below shows one partial set of buttons.

Overall, a distinct color contrast between the icon and the background color was preferred. Moreover, participants preferred buttons that had symbols compared to iconless buttons. Color contrast and symbols were important for button design because contrast allowed for easy identification and symbols informed functionality.

Conclusion

The ECA has the potential to reduce the incidence and mortality rates of cervical cancer in the Latina community. The application's success will be measured on participants' level of understanding on HPV, the Pap, cervical cancer, and the participants' intention of having Pap tests in a randomized group of participants, half with and half without the assistance of the VPE. The iterative software design process described in Figure 1 will be used throughout the software lifecycle fully engaging community members in each phase. Additionally, software functionality will evolve to fit the clinic and simplify the data collection process. For example, the application could incorporate automatic data transfer from each mobile device to a clinic computer for ease of collection and analysis. If culturally tailored design of interactive health technology is shown to be beneficial, future research should encompass an analogous process for designing tools for different diseases and populations.

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Biographies

Ying Wu, Undergraduate Student, Department of Systems and Information Engineering, University of Virginia.

Devan Samant, Undergraduate Student, Department of Systems and Information Engineering, University of Virginia.

Kristen Squibbs, Undergraduate Student, Department of Systems and Information Engineering, University of Virginia.

Alexis Chaet, Undergraduate Student, Department of Public Health, University of Virginia.

Bijan Morshedi, Undergraduate Student, Department of Chemistry, University of Virginia.

Laura Barnes, Assistant Professor, Department of Systems and Information Engineering, University of Virginia.

References

1. U.S. Department of Health and Human Services National healthcare disparities report Agency for Healthcare Research and Quality; 2003
2. O'Brien MJ, Halbert CH, Bixby R, Pimentel S, Shea JA. Community health worker intervention to decrease cervical cancer disparities in hispanic women. *Journal of general internal medicine*. Nov; 2010 25(11):1186–92. [PubMed: 20607434]
3. Van Ryn M. Research on the provider contribution to race/ethnicity disparities in medical care. *Medical Care*. 2002; 40(1):140–151.
4. Betancourt J. Cultural competence in health care: emerging frameworks and practical approaches. 2002; (576)
5. Livingston G, , Minushkin S, , Cohn D. Hispanics and Health Care in the United States: Access, Information and Knowledge Washington, DC: Pew Hispanic Center; 2008
6. Peña-Purcell N. Hispanics' use of Internet health information: an exploratory study. *Journal of the Medical Library Association: JMLA*. Apr; 2008 96(2):101–7. [PubMed: 18379664]
7. De Jesus M. The impact of mass media health communication on health decision-making and medical advice-seeking behavior of u.s. hispanic population. *Health Communication*. 2013; 28(5): 525–9. [PubMed: 22888787]
8. Aguirre T, Wilhelm S, Joshi A. Assessment of technology access and preference for health education of a rural Hispanic community. *Technology and health care: official journal of the European Society for Engineering and Medicine*. 2012; 20(6):521–5. [PubMed: 23187017]
9. Pfeifer LM, Bickmore T. Longitudinal Remote Follow-Up by Intelligent Conversational Agents for Post-Hospitalization Care. 2011:33–40.
10. Ehrenfeld JM, Sandberg WS, Warren L, Kwo J, Bickmore T. Use of a computer agent to explain anesthesia concepts to patients. *Annual Meeting of the American Society of Anesthesiologists*. 2010; 3
11. Bickmore TW, Pfeifer LM. Usability of conversational agents by patients with inadequate health literacy: evidence from two clinical trials. *Journal of Health Communication: International Perspectives*. 2010; 15:197–210.
12. Bickmore TW, Caruso L, Clough-Gorr K. Acceptance and usability of a relational agent Interface by urban older adults. *CHI '05 Extended Abstracts on Human Factors in Computing Systems*. 2005:1212–1215.
13. Bickmore TW, Pfeifer LM, Jack BW. Taking the time to care : empowering low health literacy hospital patients with virtual nurse agents. *Proceedings of the 27th international ACM conference on Human factors in computing systems (CHI'09)*. 2009:1265–1274.
14. Jin S-AA. The effects of incorporating a virtual agent in a computer-aided test designed for stress management education: The mediating role of enjoyment. *Computers in Human Behavior*. May; 2010 26(3):443–451.
15. Cassell J, , Bickmore T, , Billingham M, , Campbell L, , Chang K, , Vilhjalmsson H, , Yan H. Embodiment in conversational interfaces: rea. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*; Pittsburgh, Pennsylvania: ACM. 1999 520527
16. Wingood GM, DiClemente RJ, Villamizar K, Er DL, DeVarona M, Taveras J, Painter TM, Lang DL, Hardin JW, Ullah E, Stallworth J, Purcell DW, Jean R. Efficacy of a health educator-delivered HIV prevention intervention for Latina women: a randomized controlled trial. *American journal of public health*. Dec; 2011 101(12):2245–52. [PubMed: 22021297]
17. Arvey SR, Fernandez ME, LaRue DM, Bartholomew LK. When promotoras and technology meet: a qualitative analysis of promotoras' use of small media to increase cancer screening among South

- Texas Latinos. Health education & behavior: the official publication of the Society for Public Health Education. Jun; 2012 39(3):352–63. [PubMed: 21986243]
18. O'Brien MJ, Halbert CH. Community health worker intervention to decrease cervical cancer disparities in hispanic women. Journal of General Internal Medicine. Nov; 2010 25(11):1186–92. [PubMed: 20607434]
 19. Leeman-Castillo B, Beaty B, Raghunath S, Steiner J, Bull S. LUCHAR: using computer technology to battle heart disease among Latinos. American journal of public health. Feb; 2010 100(2):272–5. [PubMed: 20019305]
 20. Baig AA, Wilkes AE, Davis AM, Peek ME, Huang ES, Bell DS, Chin MH. The use of quality improvement and health information technology approaches to improve diabetes outcomes in African American and Hispanic patients. Medical care research and review: MCRR. Oct; 2010 67(5 Suppl):163S–197S. [PubMed: 20675350]
 21. Vyas AN, Landry M, Schnider M, Rojas AM, Wood SF. Public health interventions: reaching Latino adolescents via short message service and social media. Journal of medical Internet research. Jan.2012 14(4):e99. [PubMed: 22789678]
 22. King AC, Bickmore TW, Campero MI, Pruitt LA, Yin JL. Employing virtual advisors in preventive care for underserved communities: results from the compass study. Journal of Health Communication. 2013; 18(12):1449–64. [PubMed: 23941610]
 23. Barnes LE, Rivera M, Meade CD, Proctor SK, Gutierrez LM, Wells KJ. Feasibility Study for Technology-Based Cancer Education for Latina Women from an Agricultural Community. Cancer Epidemiology Biomarkers & Prevention. 2011; 20(10)
 24. Mori M. The Uncanny Valley. Energy. 1970; 7(4):33–35.

FIGURE 1.
PROCESS OVERVIEW

FIGURE 2.
PORTION OF ECA SCRIPT

FIGURE 3.
CURRENT VERSION OF THE PROTOTYPE

FIGURE 4.
USER PREFERRED PROTOTYPE

FIGURE 5.
DIFFERENT DESIGNS FOR “YES” BUTTON

TABLE I

Design Elements considered during development

	Usability	Aesthetic
ECA	Spoken Language Dialect Talking Speed Tone and Volume	Identity (Gender, Age, Weight, Height, Hair Styles, Skin Tone, Eye Colors, Clothing) Movement (Hand Motion, Walking posture, Facial Expression)
Content	Language Formality Medical Terminology	Graphic (Location, Detail)
Environment	Camera Angle Ambient Sound	Background (Setting, Color Scheme, Lighting)
User Interface	Symbols Input Response	Buttons (Size, Shape, Color, Locations)

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TABLE 2

Variable elements in prototypes

Background	Buttons
Color	Color
Furniture	Shape
painting	Icon/Iconless
overall Familiarity	Background Color Contrast

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