

Alexa, Start Living Healthy!

Omar Metwally MD¹, Blake Gregory MD²

¹ University of California, San Francisco
Department of Clinical Informatics
San Francisco, CA

² Highland General Hospital
K6 Adult Medicine Clinic
Oakland, CA

Abstract

Low health literacy is a major barrier to delivering preventive healthcare. Simple technological interventions such as SMS, phone calls, and messaging reminders on social media can improve both tolerance of invasive procedures and technical outcomes. In this case report, we describe our experience implementing a colorectal cancer (CRC) educational program using Amazon's voice assistant, Echo (also referred to as "Alexa"). We specifically assessed the quality of patient and provider experiences with Alexa. Patients had the opportunity to learn from Alexa about different modalities of CRC screening. The majority of patients reported that Alexa was easy to use, the information she delivered was useful, and her presence was enriching. As "Internet of Things" (IoT) devices are subject to unique internet security vulnerabilities, we also offer suggestions for the development of a security protocol to allow patients to benefit from the educational information Alexa has to offer while also protecting their privacy.

Introduction

Health literacy

The term "health literacy" was defined by Kutner and et al as a measure of an individual's ability to synthesize information in order to make decisions about one's health¹. Kutner and colleagues' survey of health literacy among American adults revealed that 52% of adults had intermediate literacy. Male gender, Black and Hispanic race, and multi-racial ethnicity were associated with lower health literacy. Health literacy correlates positively with level of education, but negatively with age greater than 65-years-old and insurance coverage through Medicare and Medicaid.

Health literacy has significant implications for how a patient utilizes the healthcare system. A survey of nearly 5,000 patients found that health literacy correlates positively with one's use of Health Information Technology (HIT) tools such as patient EHR portals, nutrition and health coach apps, and fitness trackers². Respondents with above-average health literacy were less likely to trust the government, media, and tech companies².

Although tablet computers and smart phone applications have been used in various health outcomes studies, there is a paucity of research studies that directly compare voice-activated assistants, such as Amazon Echo, with interactive computer systems that feature a screen, in the clinical setting. Neither differences in usability nor effects on health outcomes have been compared between these two modalities, and this may be attributable to the novelty of voice-activated assistants such as Amazon Echo. In fact, no studies involving Amazon Echo in the clinical setting have been published in peer-review publications at the time of writing. This gap in knowledge is particularly relevant to a healthcare system with a large proportion of patients with low health literacy, such as a county safety net hospital.

Patient education interventions

Multiple randomized controlled trials have demonstrated that relatively simple educational interventions improve colonoscopy outcomes. Kang and colleagues delivered short educational messages through WeChat, the largest social network in China, to 770 adults undergoing outpatient colonoscopy^{3,4}. This relatively simple and inexpensive intervention was associated with significantly higher rates of cecal intubation and better bowel prep scores. Another group similarly observed better bowel prep scores, lower anxiety, and better tolerance of the procedure by using phone calls and short messaging service (SMS) to reinforce education prior to outpatient colonoscopy⁵.

Beyond CRC screening, the use of audiovisual aids in addition to standard patient-physician counseling yielded statistically significant increases in information gain and patient satisfaction among patients undergoing surgical procedures⁶.

Context

Despite the effectiveness of cancer screening, only 52.1% of adults in the United States aged 50- to 75-years-old have been screened for CRC, compared to the national Healthy People goal of 70.5%⁷. The United States preventive services task force recommends CRC screening with gTOBT or FIT annually, FIT-DNA every 1-3 years, colonoscopy every 10 years, CT colonography/flexible sigmoidoscopy every 5 years, or flexible sigmoidoscopy every 10 years if supplemented by annual FIT⁸. Patients in our urban safety-net adult internal medicine clinic are preferentially screened for CRC using FIT testing performed every year. 61.6% of 50-to-75-year-olds at our institution complete colorectal cancer screening through either FIT or colonoscopy.

Misinformation has been identified as a driver of low adherence to CRC screening. Patient embarrassment, fear of pain, and unawareness of the benefits of colorectal cancer screening contribute to low CRC screening rates at our institution and nationwide^{9,10}. Furthermore, providers are under increasing time pressure to address numerous acute as well as chronic medical problems within the confines of short appointments. This often leaves inadequate time for counseling patients on important but less urgent topics such as healthcare maintenance and cancer screening.

We identified the time that patients spend waiting to be seen by provider as an opportunity to educate patients about colorectal cancer screening. To seize this opportunity, we developed Living Healthy, an Alexa application that engages patients in dialogue while delivering information about colorectal cancer screening.

Methods

Over the course of 3 weeks, we recruited 37 English-speaking outpatients between the ages of 50 and 75 years of age in our Adult Medicine clinic for whom CRC screening was indicated. Patients were introduced to Alexa by the primary author (OM) and given an opportunity to interact with her in the context of the Living Healthy application after being roomed in an outpatient clinic room by a medical assistant and before they were seen by their physician. No one declined the invitation to speak with Alexa. The reason for a patient's visit, which included common outpatient medical problems and preventive medicine visits, was not used to select or stratify patients for this study. No acutely ill patients who required referral to the Emergency Department were allowed to interact with Alexa due to the urgent nature of these visits.

OM delivered a one-minute demonstration of the device, which involved showing the patient Alexa's ability to respond to a verbal command to play the patient's favorite song. Afterward, the patient was invited to say: "Alexa, start living healthy!" and follow a guided dialogue. After the interaction, patients were invited to anonymously complete a survey assessing their experience with Alexa. Alexa was removed from the room, and patients were unattended while they completed the surveys. None of the enrolled patients had previously interacted with Alexa. The study protocol was reviewed by Highland General Hospital's IRB committee and was deemed exempt from review. No identifying or demographic information was collected from patients.

Given the potential for any quality improvement intervention to have unintended consequences on parts of a system (so-called "balancing measures" in the Plan-Do-Study-Act quality improvement method), we also assessed the impact of utilizing Alexa in the patient care setting on provider workflow by administering a provider survey, which specifically assessed whether or not a provider attributed any changes in her/his workflow to Alexa, the provider's

impression of how Alexa was received by patients, and whether Alexa’s presence reminded her/him to screen patients for CRC.

At the completion of the 3-week study, clinic providers (physicians, physician assistants, nurse practitioners (NP), medical assistants, nurses, and social workers) were invited to complete a survey of the quality of their interactions with Alexa. Providers were not counseled on this intervention in advance as the purpose of the survey was to assess for disruptions in clinic workflow without biasing providers ahead of time to potential, real, or perceived consequences of using Alexa in the outpatient setting.

Results

A large majority of our patients found Alexa easy to use (85.3% responded “agree” or “strongly agree”), believe that Alexa understood them well (86.5% responded “agree” or “strongly agree”), and felt comfortable speaking to a computer (86.5% responded “agree” or “strongly agree”) (Table 1). 86.1% of our patients found the information helpful, and 33/36 (91.7% responded “agree” or “strongly agree”) would like to see Alexa used more often.

| | Alexa is easy to use | Alexa understands me well | I feel comfortable speaking to a computer | The information is helpful | I would like to see Alexa used more often | Comments |
|-------------------|----------------------|---------------------------|-------------------------------------------|----------------------------|-------------------------------------------|---------------------------------------------------------------------------------------------------|
| strongly agree | 20 | 17 | 14 | 15 | 17 | "I think that this is a wonderful tool for the patients" |
| agree | 9 | 15 | 18 | 16 | 16 | "Perhaps: a written (plastic covered, multi-language) instructions attached to the device" |
| neutral | 5 | 3 | 3 | 5 | 3 | |
| disagree | 0 | 2 | 2 | 0 | 0 | "It would be great if she could provide more information on high fiber diet " |
| strongly disagree | 0 | 0 | 0 | 0 | 0 | "Is there a screen... that could be utilized in conjunction with Alexa? " |
| n/a | 0 | 0 | 0 | 0 | 0 | " Tailor conversation based on why the patient is there." |
| | 34 | 37 | 37 | 36 | 36 | |

Table 1: Patient survey responses

Among clinic staff and providers who completed the Provider Survey, 14/22 (64%) were resident physicians, followed by attending physicians (3/22), NPs or PAs (3/22), and medical assistants (1/22). One respondent was a nurse. A large majority of respondents were unaware the Alexa was being used in clinic (Table 2).

| | Alexa makes my workflow more efficient | Alexa's presence in the room reminds me to screen | Overall, patients responded positively to Alexa | Comments |
|-------------------|----------------------------------------|---------------------------------------------------|-------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| strongly agree | 3 | 3 | 3 | <p>“I would love for there to be a demo where I could hear what Alexa says to patients. And does she explain how to complete the FIT? It would be nice if it were also in Spanish and if there were a visual to accompany the written. I think MAs take the longest time explaining how to actually complete the FIT to the patient.”</p> <p>“Maybe also some prompt about smoking cessation to be in line with our current panel mgmt project.”</p> |
| agree | 1 | 2 | 1 | |
| neutral | 0 | 0 | 0 | |
| disagree | 0 | 0 | 0 | |
| strongly disagree | 0 | 0 | 0 | |
| NA / unaware | 18 | 17 | 18 | |
| total | 22 | 22 | 22 | |

Table 2: Provider survey responses

Qualitative patient feedback was also collected (Table 2). One respondent asked for a greater variety of preventive health topics, and another respondent suggested that a laminated instruction sheet be affixed to the device. Qualitative provider feedback also highlights the important observation that Alexa did not interfere with providers’ workflow to any considerable degree. One provider inquired about Alexa’s ability to speak Spanish (Alexa does not have this capability at the time of writing), and another provider suggested expanding the choice of dialogues to include smoking cessation.

Discussion

Improving patients’ health literacy and understanding is a worthwhile endeavor. The use of voice powered assistants such as Alexa in the healthcare setting is an opportunity for patients to enjoy better access to preventive healthcare and an opportunity for providers to integrate voice-powered assistants in their practice without hindering their workflow. By utilizing the window of time that patients spend waiting to be seen, Alexa can turn this potentially wasted time into an opportunity to educate and empower patients to make informed healthcare decisions. This descriptive study is the first to assess the quality of interactions between patients and Alexa in the outpatient setting. Alexa-based patient education may also prime patients for a more productive and efficient discussion with their provider about healthcare maintenance.

There are several flaws in this preliminary study of the usability of Amazon Echo in the outpatient setting and its effects on provider workflow. A quantitative method of assessing health literacy will allow a more rigorous study of the correlation between the quality of a patient’s interaction with Alexa and a patient’s health literacy. Such an analysis will also allow this study to be broadened to other outpatient clinics within our organization and beyond Alameda Health System.

More studies are needed to assess clinical outcomes such as the impact of Alexa on CRC screening rates. In particular, this intervention did not assess the effect of interacting with Alexa on a patient’s health literacy and knowledge. Future work will also examine in a quantitative manner whether Alexa positively impacts providers’ workflow, for example by making visits more efficient or by enhancing the quality of the patient-provider interaction. Our initial data suggest that Alexa’s presence in exam rooms did not interfere with clinic flow as most providers were unaware of Alexa’s presence.

Pros and Cons

A large majority of our 50- to 75-year-old patients found Alexa easy to use and had positive experiences with her (Table 1). Prior studies of voice-activated assistants in the outpatient setting using the Google WebSpeech API and a clip-on microphone had the major limitation of relying on an intrusive piece of hardware with limited capacity to capture multi-directional sound, especially in the presence of ambient noise¹¹. Amazon Echo's 7-piece microphone array discerns voices with high fidelity. This opens the door to the development of minimally invasive software with the potential to enhance the patient-provider interaction without being obtrusive¹². The Amazon Dot has all of Echo's functionality, and with a slightly less robust speaker. Its \$50 price point makes it a more financially attractive option for equipping exam rooms with voice assistants.

Alexa's voice-to-text machine learning algorithms and application logic are run in the cloud. This allows Amazon's application developers to develop software iteratively as new features are added to the developer API. The fact that most of the application logic is executed in the cloud also means that this device requires a fast, stable, and secure Wi-Fi connection, which may not be available in all clinical facilities.

Alexa's lexicon currently includes only American English, UK English, and German. Adding more languages to Alexa's repertoire such as Spanish, Mandarin, Cantonese, and Vietnamese will allow Alexa to reach greater segments of our diverse patient population who are disproportionately affected by lower health literacy.

Another limitation in Amazon's current developer API is that the dialogue must be scripted. We anticipate that future iterations of this API will permit the development of semi-structured and unstructured dialogue through the use of machine learning-based chatbots.

Security protocol

IoT devices have received publicity for their unique security vulnerabilities¹³. They have been targeted in some of the largest DDOS attacks in history¹⁴. Accordingly, our security protocol prohibited the disclosure of identifying information when Alexa was powered on in the exam room. Alexa was muted before and after each interaction and removed from the exam room after patients completed the dialogue.

We hope that our experience with Alexa in the patient care setting can guide the development of a sound security protocol for studies employing Alexa in the patient care setting. Since Alexa's mute button is a hardware-based security mechanism, eavesdropping on a user is theoretically possible only if the device is physically tampered with¹⁵. This should reassure providers as long as the mute button is properly used and allow patients to have a private conversation with their provider in the device's presence.

Conclusion

Voice-powered assistants such as Amazon's Alexa were well-received by patients and providers in our adult medicine clinic. Educating patients through Alexa while they wait to be seen by their physician can complement the education that providers already deliver and help providers educate their patients within the time constraints of an outpatient visit. This initial study focused on usability and did not assess the effect of Alexa on patient education or health outcomes. Security protocols should focus on preventing unintentional and unauthorized transmission of audio data through misuse of these devices or malicious compromise. Future studies will study whether patient education through Alexa is associated with higher rates of preventive health screening using Alexa and Alexa's successor, the Echo Show.

Acknowledgments

We thank our patients for their curiosity, openness, and invaluable feedback. We appreciate the tireless work of Leslie Aguilar, Alma Pacheco, and the K6 Clinic's medical assistants in enrolling patients and helping to conduct this study.

Funding

This study did not receive funding.

Competing interests

The authors have no conflicts of interest to disclose.

References

1. Kutner M, Greenberg E, Jin Y, Paulsen C. 2006. The Health Literacy of America's Adults: Results From the 2003 National Assessment of Adult Literacy (NCES 2006-483). Washington DC: U.S. Department of Education, National Center for Education Statistics. September 1. <https://nces.ed.gov/pubs2006/2006483.pdf>.
2. Cho, Jaehee, Dongjin Park, and H. Erin Lee. 2014. Cognitive Factors of Using Health Apps: Systematic Analysis of Relationships among Health Consciousness, Health Information Orientation, eHealth Literacy, and Health App Use Efficacy. *Journal of Medical Internet Research J Med Internet Res* 2014;16(5):e125.
3. Liu, Xiaodong, Hui Luo, Lin Zhang, Felix W. Leung, Zhiguo Liu, Xiangping Wang, Rui Huang, et al. 2014. Telephone-Based Re-Education on the Day before Colonoscopy Improves the Quality of Bowel Preparation and the Polyp Detection Rate: A Prospective, Colonoscopist-Blinded, Randomised, Controlled Study. *Gut* 2014;63(1): 125-30.
4. WeChat: Number of Users 2016 | Statista. 2017. Statista. Accessed April 18. <https://www.statista.com/statistics/255778/number-of-active-wechat-messenger-accounts/>.
5. Lee, Yoo, Eun Kim, Jae Choi, Kyung Lee, Kyung Park, Kwang Cho, Byoung Jang, Woo Chung, and Jae Hwang. 2015. Impact of Reinforced Education by Telephone and Short Message Service on the Quality of Bowel Preparation: A Randomized Controlled Study. *Endoscopy* 47;11:1018–27.
6. Kaur, Haramritpal, Gurpreet Singh, Amandeep Singh, Gagandeep Sharda, and Shobha Aggarwal. Evolving with Modern Technology: Impact of Incorporating Audiovisual Aids in Preanesthetic Checkup Clinics on Patient Education and Anxiety. *Anesthesia, Essays and Researches* 2016;10 (3): 502–7.
7. Cancer | Healthy People 2020. Accessed April 18th 2017. <https://www.healthypeople.gov/2020/topics-objectives/topic/cancer/objectives>.
8. Final Update Summary: Colorectal Cancer: Screening - US Preventive Services Task Force. 1AD. January 1. <https://www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFinal/colorectal-cancer-screening2?ds=1&s=colorectal%20cancer>.
9. Wee CC, McCarthy EP, and Phillips RS. Factors associated with colon cancer screening: the role of patient factors and physician counseling. *Prev Med* 2005;41(1):23-9.
10. Ghanouni A, Plumb A, Hewitson P, Nickerson C, Rees CJ, and von Wagner C. Patients' experience of colonoscopy in the English Bowel Cancer Screening Programme. *Endoscopy* 2016;48:232-40.
11. Metwally O And Sinha. 2016. A Novel Voice-Activated Web Application for Rapid Knowledge Generation and Information Retrieval Through Semantic Parsing of Verbal Communication. Presented at Digestive Disease Week in San Diego, California. May 26th 2016.
12. iFixit. 2014. Amazon Echo Teardown - iFixit. December 16. <https://www.ifixit.com/Teardown/Amazon+Echo+Teardown/33953>.
13. Schlesinger, Jennifer, and Andrea Day. 2016. Why 2017 Is Gearing up to Be a Year of Cyber Attacks on 'Insecure' Smart Home Gadgets. CNBC. CNBC. December 23. <http://www.cnbc.com/2016/12/25/suddenly-hot-smart-home-devices-are-ripe-for-hacking-experts-warn.html>.
14. Selyukh, Alina. 2017. Internet Of Things' Hacking Attack Led To Widespread Outage Of Popular Websites. NPR.org. Accessed April 18. <http://www.npr.org/2016/10/22/498954197/internet-outage-update-internet-of-things-hacking-attack-led-to-outage-of-popula>.
15. Balakrishnan, Anita. 2016. Jeff Bezos Explains Why the Echo Is Harder to Hack than Smartphones. CNBC. October 20. <http://www.cnbc.com/2016/10/20/jeff-bezos-explains-why-the-echo-is-harder-to-hack-than-smartphones.html>.