Perspectives
Potential application of conversational agents in HIV testing uptake among high-risk populations

Renee Garett1, Sean D. Young2,3
1ElevateU, Irvine, CA 92617, USA
2Department of Emergency Medicine, University of California, Irvine, Orange, CA 92868, USA
3Institute for Prediction Technology, Department of Informatics, University of California, Irvine, CA 92617, USA
Address correspondence to Sean D Young, E-mail: syoung5@hs.uci.edu

ABSTRACT
Human Immunodeficiency Virus (HIV) continues to be a significant public health problem, with ~1.2 million Americans living with HIV and ~14% unaware of their infection. The Centers for Disease Control and Prevention recommends that patients 13 to 64 years of age get screened for HIV at least once, and those with higher risk profiles screen at least annually. Unfortunately, screening rates are below recommendations for high-risk populations, leading to problems of delayed diagnosis. Novel technologies have been applied in HIV research to increase prevention, testing and treatment. Conversational agents, with potential for integrating artificial intelligence and natural language processing, may offer an opportunity to improve outreach to these high-risk populations. The feasibility, accessibility and acceptance of using conversational agents for HIV testing outreach is important to evaluate, especially amidst a global coronavirus disease 2019 pandemic when clinical services have been drastically affected. This viewpoint explores the application of a conversational agent in increasing HIV testing among high-risk populations.

Keywords infectious disease

Background
Human Immunodeficiency Virus (HIV) continues to be a public health crisis. In the USA, ~1.2 million people are living with HIV, with ~14% unaware of their infection.1 Individuals unaware of their infection account for 40% of ongoing community transmission.2 Current Centers for Disease Control and Prevention recommendations suggest routine screening in health-care settings among patients 13 to 64 years of age, with those from high-risk populations (e.g. African American, men who have sex with men) to test at least annually.3 Studies show that individuals who discover their recent seroconversion were more likely to change their sexual risk behaviors.4,5 Aside from prevention of transmission, testing and early HIV diagnosis present opportunities for better health outcomes. The HIV Care Continuum aims to increase the number of those living with HIV who receive treatment and decrease viral load.6 Initiation into the continuum begins with diagnosis followed by linkage to care. Studies show that early initiation to antiretroviral treatment has positive health benefits for those living with HIV and can reduce the risk of progressing serious illness or death.7

Despite the current recommendations, those at higher risk are not screened annually, leading to delayed diagnoses.8,9 In 2017, 46% of adults 18 to 64 years old reported ever having tested, with 8% having tested in the past year.10 Testing rates vary by age, ethnicity, region and other factors.9,10 Similarly, barriers and facilitators to testing vary among high-risk populations.11–15 This paper will discuss the role of a conversational agent, a recent technology, in increasing HIV testing among high-risk populations.

Digital tools and artificial intelligence
Digital tools have the potential to provide solutions to public health problems because they are flexible, more accessible and cost-effective than traditional methods. Applications of digital technology such as social media, electronic health record, mobile/smartphones and applications (apps) are evident in both public health research and clinical practice.16–18
Artificial intelligence (AI) is a branch of computer science focused on building machines that mimic human intelligence to perceive, learn, reason and problem solve, and has a multitude of applications. AI and machine learning have been utilized in various HIV prevention research studies, from bench science to clinical settings and community interventions. For example, investigators examined the impact of an AI-based mobile app to increase pre-exposure prophylaxis (PrEP) adherence among young men who have sex with men (MSM). The app was rated positively by participants, had high level of use throughout the study period, and resulted in PrEP adherence of 91%. Machine learning algorithms may play an important role in research aimed to identify target populations. For example, investigators have used machine learning algorithms to predict HIV status among patients using electronic health records. Models have performed well and had high level of accuracy in identifying patients at high risk of HIV diagnosis. Similarly, in a study using peer models to deliver HIV prevention messages to youth experiencing homelessness, investigators compared a standard method of selecting peer models with a method using AI. Findings indicate that youth whose peer model was selected by AI had higher rates of HIV testing and condom use compared with youth whose peer model was selected via the standard method.

Advancement and refinement in technology have led to the emergence of conversation agents (CA), which often use natural language processing (NLP) and AI. NLP allows computer systems to understand the natural speech of humans, the meaning and context of the message and interact with users through text or voice interface. Applications of CA incorporating NLP include digital voice assistants such as Amazon’s Alexa, Apple’s Siri, and well as traditional chatbots. In healthcare, AI-based conversational agents have been utilized for studies in mental health, sleep disorders, asthma, sexual health, substance use and language impairment through the use of telephones, apps (mobile device, Windows computer, Web browser) and short message service.

In HIV, researchers have already explored the feasibility and acceptability of CA to promote testing. A text-based CA was developed to provide pre-test counseling for people inquiring about recent exposure, risk behaviors and symptoms, as well as tailored advice. Overall, CA were well received by users and resulted in requests for an HIV self-test provider. The United Nations Educational, Scientific and Cultural Organization Institute for Information Technologies in Education developed a text-based chatbot, Eli, geared toward youth to open a dialog about relationship, family, mental and physical health and sex. Among other things, Eli provides information about HIV prevention, testing and treatment, and offers guidance in overcoming fears and concerns. User reception has been positive with many praising developers.

Although investigators have examined the early efficacy of text-based chatbots, no known studies have looked at how conversational agents using voice technology might be utilized for pre-test counseling to encourage HIV testing. The use of smart speakers with digital voice assistants continues on an upward trend with >110 million users in the USA. Between 2019 and 2020, there was a 32% growth in new owners of smart speakers in US households alone. Information seeking topped the list of queries from digital voice assistants followed by entertainment, accessing customer service, purchasing goods and services, payment and controlling smart home devices. Data indicate a population whose daily lives are increasingly intertwined with AI. In response to this need, our team has been developing a conversational agent to address the opioid epidemic. Aimed for use by patients and caregivers, the conversational agent is being designed to assist in locating treatment facilities that are most appropriate for the patient and that are tailored to their needs.

Conversational agents may provide some respite from barriers like stigma and limited access to test kits that some individuals at high risk experience. Conversational agents may be programmed to provide factual information about different tests available that would allow the user to compare each test and determine which one best suit their needs. Additionally, CA may be a good source of science-based information that could potentially dispel any misinformation about HIV, testing and PrEP that is ubiquitous on the internet and social media. The convenience of ordering a self-test kit and having it delivered at home or through a vending machine instead of picking it up at the pharmacy or at a clinic might also increase testing uptake. This might be especially true for those living in rural areas where access may be limited.

As a result of the coronavirus disease 2019 pandemic, many people were unable to receive the health services they needed, including HIV services, due to changes in policy. Safety protocols were implemented that necessitated accommodating fewer patients than normal which led to halting many home and community-based tests or postponing in-person clinic testing. In regions with stricter measures, there was higher disruption of services, with some suspending rapid HIV testing altogether. This subsequently resulted in higher use of self-testing kits for some areas. The accessibility of CA for information or to order home test kits may alleviate some of the burden experienced by clinics that are unable to provide service to patients or the community. Additionally, patients may find it more convenient and safer to interact with AI than to go in person to obtain testing.
There are a number of limitations in the use of CA to engage with patients and health consumers. Investigators have found that privacy risk, limited conversational responsiveness, user-perceived undesirable personality (rude, unsympathetic, patronizing, judgmental) and lack of trust in app creator were barriers for users to adopt CA for mental healthcare. Concerns regarding HIV chatbots included misunderstanding the user, speech that was deemed too formal and the CA replied too quickly. As NLP and machine learning continue to evolve, so will the ability of conversational agents to recognize and respond to users’ inquiries and needs. Continuous evaluation and modification of the program may lead to improvements in the interface.

Conclusion
Advancement in technology proffers novel solutions to dealing with public health issues. The use of AI has the capacity to reach individuals at high risk for HIV infection; it is feasible, convenient and well accepted in the community. As current societal behavior trends toward the use of conversational agents in daily life, CA may play a role in providing accurate information about HIV tests to those who seek them. Despite limitations of using a new technology, the benefits of reaching out to those at high risk may have huge implications in mitigating this public health crisis.

Acknowledgements
This work was supported by the National Institute of Mental Health [grant #MH106415], the National Institute on Drug Abuse and the National Institute of Allergy and Infectious Diseases. We wish to thank Romina Romero for assistance on a previous version of this manuscript.

Funding
National Institute of Allergy and Infectious Diseases (NIAID), National Institute on Drug Abuse (NIDA), National Center for Complementary and Integrative Health (NCCIH).

References
1. HIV.gov. U.S. Statistics [Internet]. HIVGov. 2020 [cited 2020 Oct 13]. Available from: https://www.hiv.gov/hiv-basics/overview/data-and-trends/statistics
2. Gopalappa C, Farnham PG, Chen Y-H, Sansom SL. Progression and transmission of HIV/AIDS (PATH 2.0). Med Deis Mal Int J Soc Med Deis Mak 2017;37(2):224–33.
3. Branson BM, Handsfield HH, Lampe MA et al. Revised recommendations for HIV testing of adults, adolescents, and pregnant women in health-care settings. MMWR Morb Mortal Wkly Rep 2006;55(RR14):1–17.
4. Eaton LA, Kalichman SC. Changes in transmission risk Behaviors across stages of HIV disease among people living with HIV/AIDS. J Acquir Immune Defic Syndr 2009;50(1):39–49.
5. Marks G, Crespaz N, Senterfitt JW, Janssen RS. Meta-analysis of high-risk sexual behavior in persons aware and unaware they are infected with HIV in the United States: implications for HIV prevention programs. J Acquir Immune Defic Syndr 1999;20(4):446–53.
6. HIV.gov. HIV Care Continuum (Internet). HIV.Gov. 2020 [cited 2020 Oct 14]. Available from: https://www.hiv.gov/federal-response/policies-issues/hiv-aids-care-continuum
7. National Institutes of Health. Starting antiretroviral treatment early improves outcomes for HIV-infected individuals [Internet]. National Institutes of Health. 2015 [cited 2020 Oct 29]. Available from: https://www.nih.gov/news-events/news-releases/startin-antiretroviral-treatment-early-improves-outcomes-hiv-infected-individuals
8. Bailey AF, Hoots BE, Hall HI et al. Vital signs: human immunodeficiency virus testing and diagnosis delays — United States. MMWR Morb Mortal Wkly Rep 2017;66(47):1300–6.
9. Pitasi MA, Delaney KP, Oraka E et al. Interval since last HIV test for men and women with recent risk for HIV infection — United States, 2006–2016. MMWR Morb Mortal Wkly Rep 2018;67(24):677–81.
10. Kaiser Family Foundation. HIV testing in the United States [Internet]. KFF 2019 [cited 2020 Oct 14; Available from: https://www.kff.org/hivaidsfact-sheet/hiv-testing-in-the-united-states/.
11. Clark HA, Oraka E, DiNeno EA et al. Men who have sex with men (MSM) who have not previously tested for HIV: results from the MSM testing initiative, United States (2012–2015). AIDS Behav 2019;23(2):359–65.
12. Frye V, Wilton I, Hirshfeld S, Chasson MA, Lucy D, Usher D, et al. Preferences for HIV test characteristics among young, black men who have sex with men (MSM) and transgender women: implications for consistent HIV testing. PLoS ONE [Internet] 2018 Feb 20 [cited 2020 Oct 29];13(2). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5819791/
13. Gwadz M, Leonard NR, Honig S et al. Doing battle with “the monster:” how high-risk heterosexuals experience and successfully manage HIV stigma as a barrier to HIV testing, Int J Equity Health [Internet] 2018 Apr 20 [cited 2020 Oct 29];17. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5910579/.
14. Levy MF, Wilton L, Phillips G et al. Understanding structural barriers to accessing HIV testing and prevention services among black men who have sex with men (BMSM) in the United States. AIDS Behav 2014;18(5):972–96.
15. Noble M, Jones A, Bowles K et al. HIV testing among internet-using MSM in the United States: systematic review. AIDS Behav 2017;21(2):561–75.
16. Garett R, Young SD. Geolocation, ethics, and HIV research. Health Technol [Internet]. 2021 Oct 25 [cited 2021 Nov 4]; Available from: https://doi.org/10.1007/s12553-021-00611-0
17. Young SD, Crowley JS, Vermund SH. Artificial intelligence and sexual health in the USA. Lancet Digit Health 2021;3(8):e467–8.
18. Romero RA, Klausner JD, Marsch LA, Young SD. Technology-delivered intervention strategies to bolster HIV testing. Curr HIV/AIDS Rep 2021;18(4):391–405.

19. Corporation M, Corporation M (eds). The future computed: artificial intelligence and its role in society. Redmond, Washington: Microsoft, 2018, 149.

20. Marcus J, Sewell WC, Balzer LB, Krakower DS. Artificial intelligence and machine learning for HIV prevention: emerging approaches to ending the epidemic. Curr HIV/AIDS Rep 2020;17(3):171–9.

21. Garrett R, Young SD. Digital public health surveillance tools for alcohol use and HIV risk Behaviors. AIDS Behav [Internet]. 2021 Mar 17 [cited 2021 Nov 4]; Available from: https://doi.org/10.1007/s10461-021-03221-2.

22. Zheng C, Wang Y, Young SD. Identifying HIV-related digital social influencers using an iterative deep learning approach. AIDS 2021;1(35):885.

23. Altamirano-Flores JS, Guerra-Palomares SE, Hernandez-Sanchez PG et al. Identification of HIV-1 Vif protein attributes associated with CD4 T cell numbers and viral loads using artificial intelligence algorithms. IEEE Access 2020;8:87214–27.

24. Marcus J, Hurley LB, Krakower DS et al. Use of electronic health record data and machine learning to identify candidates for HIV pre-exposure prophylaxis: a modelling study. Lancet HIV 2019;6(10):e688–95.

25. Shen Y, Liu T, Chen J et al. Harnessing artificial intelligence to optimize long-term maintenance dosing for antiretroviral-naive adults with HIV-1 infection. Adv Ther 2020;3(4):1900114.

26. Liu AY, Laborde ND, Coleman K et al. DOT diary: developing a novel mobile app using artificial intelligence and an electronic sexual diary to measure and support PrEP adherence among Young men who have sex with men. AIDS Behav [Internet]. 2021;25(9):2675–85.

27. Ahlström MG, Ronit A, Omland LH et al. Algorithmic prediction of HIV status using nation-wide electronic registry data. EClinicalMedicine 2019;1(17):100203.

28. Rice E, Yoshioka-Maxwell A, Petering R et al. Piloting the use of artificial intelligence to enhance HIV prevention interventions for youth experiencing homelessness. J Soc Work Res 2018;9(4):551–73.

29. Nilsson NJ. Principles of artificial intelligence. Morgan Kaufmann 2014;493.

30. Sarikaya R. The technology behind personal digital assistants: an overview of the system architecture and key components. IEEE Signal Process Mag 2017;34(1):67–81.

31. Laranjo L, Dunn A, Tong H et al. Conversational agents in healthcare: a systematic review. J Am Med Inform Assoc 2018;25(9):1248–58.

32. van Heenden A, Ntinga X, Vilakazi K. The potential of conversational agents to provide a rapid HIV counseling and testing services. In: 2017 International Conference on the Frontiers and Advances in Data Science (FADS). 2017. p. 80–5.

33. Verney K, Daas CD, Zweers W, Bergen JV, Bos H. P046 Ensuring quality-assured and personalized online self-testing within a market-driven context. In: July 15, 2019 [Internet], Vancouver, Canada: BMJ Publishing Group Ltd, 2019 [cited 2020 Oct 19]. Available from: https://sti.bmj.com/content/95/Suppl_1/A99/1.

34. UNAIDS. Chatbot answers young people’s questions about HIV, health and relationships [Internet]. UNAIDS.org 2020 [cited 2020 Oct 19]. Available from: https://www.unaids.org/en/resources/presscentre/featurestories/2020/october/20201015_chatbot.

35. Tankovska H. Number of voice assistants in use worldwide 2019-2024 [Internet]. Statista 2020 [cited 2020 Oct 29]. Available from: https://www.statista.com/statistics/973815/worldwide-digital-voice-assistant-in-use/.

36. Rinsella B. Nearly 90 Million U.S. Adults have smart speakers, adoption now exceeds one-third of consumers [Internet]. Voicebot.ai 2020 [cited 2020 Oct 20]. Available from: https://voicebot.ai/2020/04/28/nearly-90-million-u-s-adults-have-smart-speakers-adoption-now-exceeds-one-third-of-consumers/.

37. Tankovska H. Level of usage of voice assistants across various functions worldwide, as of November 2017 [Internet]. Statista 2020 [cited 2020 Oct 30]. Available from: https://www.statista.com/statistics/801963/worldwide-level-usage-voice-assistant-various-functions/.

38. Su Z, Schneider JA, Young SD. The role of conversational agents for substance use disorder in social distancing contexts. Subst Use Misuse 2021;56(11):1732–5.

39. Meadows R, Hine C, Suddaby E. Conversational agents and the making of mental health recovery. Digit Health 2020;6(6):2055207620966170.

40. Kalichman SC, Cherry C, White D et al. Use of dietary supplements among people living with HIV/AIDS is associated with vulnerability to medical misinformation on the internet. AIDS Res Ther 2012;9(1):1.

41. Romm T. Facebook ads push misinformation about HIV prevention drugs, LGBT activists say, ‘harming public health. Washington Post [Internet] 2019 Dec 9 [cited 2020 Nov 19]; Available from: https://www.washingtonpost.com/technology/2019/12/09/facebook-ads-are-pushing-misinformation-about-hiv-prevention-drugs-lgbt-activists-say-harming-public-health/.

42. Medline A, Daniels J, Marlin R et al. HIV testing preferences among MSM members of an LGBT Community Organization in Los Angeles. J Assoc Nurses AIDS Care 2017;28(3):363–71.

43. Young SD, Daniels J, Chiu CJ et al. Acceptability of using electronic vending machines to deliver oral rapid HIV self-testing kits: a qualitative study. PloS One 2014;9(7):e105790.

44. Rosengren AI, Huang E, Daniels J et al. Feasibility of using Grindr™ to distribute HIV self-test kits to men who have sex with men in Los Angeles. California Sex Health 2016. https://doi.org/10.1071/SH15326.

45. Young SD, Schneider J. Clinical care, research, and telehealth services in the era of social distancing to mitigate COVID-19. AIDS Behav 2020;24(7):2000–2.

46. Lagat H, Sharma M, Karthi E et al. Impact of the COVID-19 pandemic on HIV testing and assisted partner notification services. Western Kenya AIDS Behav 2020;2(1):1–4.

47. Cairns G. European AIDS treatment group documents the impact of COVID on HIV services throughout Europe [Internet]. aidsmap.com 2020 [cited 2020 Oct 15]; Available from: https://www.aidsmap.com/news/oct-2020/european-aids-treatment-group-documents-impact-covid-hiv-services-throughout-europe/.

48. Prakash AV, Das S. Intelligent conversational agents in mental health-care services: a thematic analysis of user perceptions. Pat Asia J Assoc Inf Syst 2020;12(2):1–34.