The Potential and Limitations of Conversational Agents for Chronic Conditions and Well-being

Ekaterina Uetova*1,*,*, Lucy Hederman*2*, Robert Ross*1* and Dympna O'Sullivan*1*

1 Technological University Dublin, Dublin, Ireland
2 Trinity College Dublin, Dublin, Ireland

Abstract

Conversational agents are becoming more common in the health and wellness domains in part due to assumptions regarding potential improvements in individuals' outcomes. This paper presents initial findings from a review of conversational agent use in healthcare for chronic conditions and well-being. A search of the literature was performed on electronic databases PubMed, ACM Digital Library, Scopus and IEEE Xplore. Studies were included if they were focused on chronic disorder management, disease prevention or lifestyle change and if systems were tested on target user groups. This paper investigates the health domains, the user profiles and reasons why conversational agents may be helpful in the self-management of chronic disease and well-being. This paper also discusses how these tools may be used to improve the health and well-being of different groups of people.

Keywords

Conversational Agent, Chronic Disease, Health and Well-being.

1. Introduction

The growing pressure on healthcare systems worldwide highlights a need to shift focus towards preventative healthcare and increase the overall population health. While many people may have intentions to change their behavior, there is a significant gap between intention and action. Achieving healthy lifestyle behavior changes independently can be difficult, as it requires identifying and implementing effective health behavior interventions that align with personal goals, preferences, and the physical and socio-economic context of the individual [28]. Moreover, despite the willingness to use health technologies, many people lack the necessary knowledge to analyze collected data to determine the appropriate actions required to reach their health objectives without seeking guidance from healthcare professionals. Unfortunately, access to health experts may not be feasible or affordable.

If harnessed correctly, digital interventions can potentially be more accessible alternatives to in-person support and supervision. One mechanism for intervention is so-called conversational agents (CAs), which are computer systems designed to mimic human-like conversations through natural language user interfaces involving images, text, and voice [12, 27]. CAs potentially offer scalable, less costly, less stigmatizing, and more personalized health support that can help people at any time [4, 18, 31] and some research indicates that they appear to be effective in improving certain outcomes [26]. CAs are typically delivered in one of two modalities, i.e., text or speech, which makes them versatile across different target populations, such as children or older people. CAs are capable of meeting various healthcare needs, such as the provision of timely information [1], the support of mental health management [22], assistance with chronic disease self-management [37], and the delivery of lifestyle change interventions - including physical activity and changes in diet [25].

This paper provides the first results of an analysis of how CAs can be applied for well-being and chronic conditions management. In this work, we focus on three aspects: the health domains in which CAs are used, the profiles of users who are targeted for using CAs, and why and how CAs may be useful for these groups of people. By exploring these questions, this paper aims to shed light on the gaps in CA usage in healthcare and provide insights into how these tools can be used to improve the health and well-being of different groups of people.

2. Methods

We conducted a search of the literature using the electronic databases PubMed, ACM Digital Library, Scopus and IEEE Xplore. These databases were chosen as they cover relevant aspects of health, technology, and interdisciplinary research and have also been used in other reviews covering similar topics. The main keywords used were "conversational agent" and "health" which were searched in titles and abstracts.

We included articles on chronic disorder management (e.g., treatment, monitoring), disease prevention and lifestyle change (e.g., eating healthier, increasing physical activity). Studies focusing only on technical aspects and design features of CAs (e.g., language models, personality design) and studies using the Wizard of Oz method were excluded. This review doesn't include studies where CAs focus on video- and image-based diagnosis (e.g., skin cancer) and whose aim was screening before appointments, filling hospital forms, checking doctors' availability, answering frequently asked queries, explaining medication instructions and providing diagnoses based on the user's reported symptoms.

3. Health Domains

A common application area of CAs has been in chronic conditions (e.g., cancer, mental health, diabetes, obesity, addiction and substance abuse) and general physical and mental well-being.

Chronic conditions have long-lasting and persistent effects that require challenging lifestyle and behavioral changes and long-term management by individuals and health professionals [33]. Moreover, they reduce life expectancy and quality of life and can increase personal healthcare costs due to disability, repeated hospitalization, and multiple treatment procedures. CAs can provide affordable personalized digital solutions to respond to these challenges and slow down health deterioration by delivering interventions, such as coaching, monitoring, support and education to patients suffering from chronic diseases [33]. Additionally, CAs can be used to mirror a therapeutic process using cognitive behavioral therapy or motivational interviewing. In such processes, a CA has the potential to help people to learn essential components of chronic disease self-management, such as setting goals, self-monitoring and overcoming obstacles [11].

It is common for disease-specific CAs to include general well-being features (e.g., stress management, physical activity exercises), in part due to the fact that individuals with chronic conditions are at a higher risk of developing depression [24]. For example, embodied conversational agent Laura for type 2 diabetes [3] provides education and support not only for blood glucose level monitoring but also for physical activity and healthy eating, while virtual coaches Anna and Lukas for obesity [35] encourage participants to perform relaxing breathing exercises that help to lower the emotional stress connected with eating disorders [38].

Most reviewed CAs are aimed at supporting people who already have a chronic condition. For example, the health coaching chatbot TREVOR [13] educates patients on sickle cell disease self-management and self-care practices that reduce the incidence of vaso-occlusive pain crises and the conversational agent MAX [19] increases knowledge about asthma and teaches inhalation techniques to 10-15-year-olds with asthma. However, there are only a few studies that focus on prevention. As an example, a multimodal embodied conversational agent Tanya [45] plays the role of a genetic counselor communicating breast cancer risk and recommending medical guidelines to women.

Prevention is an essential aspect of healthcare as it helps to identify and mitigate health risks before they escalate into more severe and permanent conditions. Many studies indicate that chronic diseases are largely preventable [6, 39, 43]. Multidisciplinary approaches that include lifestyle interventions in several health aspects (e.g., nutrition, physical activity) and involve the whole family [23] or health experts (e.g., dietitians or exercise physiologists) [41] are more effective in preventing chronic disease than individual interventions targeting one aspect and in one setting of people's life.

4. User Profiles Targeted for CAs

In many studies, the target user group is often broad, with inclusion and exclusion criteria frequently limited to age and health conditions, without taking into account other criteria (e.g., demographic and socio-economic context). Additionally, there is often limited information about study participants, despite the potential for significant variation within user groups [25, 36, 44]. Such information can provide important insights into the usability and effectiveness of created systems for different people and can be useful in the personalization of systems for the diverse user needs.

Recently, research on the personalization of health interventions, both inside and outside of the CA application space, has been increasing in number.

Personalization in CAs is possible through the adaptation of content presented to users or the customization of the conversational style of the system [17, 18]. The information for personalization can be derived from previous user conversations with CA or from information and preferences that the user explicitly provides initially [40].

Four types of intervention have previously been defined according to the level of personalization [32]. The generic type has no personalization. The personalized type adds only the name of the user to the information they receive without changing anything else. The targeted type customizes content according to psychographic (i.e., interests, goals, attitudes toward illness) and sociodemographic characteristics of the subgroup the user is in. The tailored type changes content based on specific individual characteristics that are determined through previous interaction with the system. Multiple studies provide evidence that tailored messages for particular users can result in significant improvements in health interventions compared to generic ones [18, 30, 32]. Additionally, to enhance user engagement in the long term, technologies need to have not only simple customizations (e.g., notification settings) but a robust user profile that includes psychographic information and other factors that could help the system to adapt its behavior to the user's needs [28].

Race and ethnicity are one of the demographic characteristics that have not received significant attention to this point [10]. The lack of alignment with users' unique characteristics, socio-economic status, and cultural settings may be a reason for the lower usage of health applications among underserved groups [8]. For illustration, most studies about the effectiveness of health technologies have been conducted with a predominantly white population [10], neglecting the specific needs of non-white communities. To demonstrate, research on non-white communities' attitudes to physical activity shows that they may have different attitudes towards physical activity, viewing it as a waste of time, and have diverse norms regarding weight and body shape, while also placing a high value on social support with close family ties and obligations [16,21].

There are few examples of CAs that have been developed for particular groups: BeFAB intervention [29] which was developed by taking into account social, cultural and environmental factors of Black and African American women to address postpartum weight and Bible storytelling agent [44] which targeted messages for church-going users to engage them in positive healthy eating behavior.

5. Why and How CAs May Be Useful?

There are several topics that are often mentioned in the literature as being reasons to use CAs in managing personal health and well-being. One of them is patients' limited health literacy and insufficient access to reliable health information sources [14]. Poor health literacy is prevalent among elderly people, racial and ethnic minorities, and patients suffering from chronic illnesses. This poor health literacy is associated with negative outcomes, including more frequent hospitalization and longer stays, as well as poor understanding of the condition and its management [14]. An example of CAs that provide educational interventions is a conversational virtual agent for individuals with atrial fibrillation [4] designed to be accessible to newly diagnosed patients with a wide range of literacy levels; it delivers educational materials that cover various topics, such as atrial fibrillation causes, consequences and treatments, common symptoms, medication side-effects and emergency conditions.

Another reason in favour of CA use is perceived stigma and self-stigma. Some people may feel ashamed or embarrassed to seek medical attention, particularly for issues that are considered taboo or socially stigmatized, such as mental health problems [36], sexually transmitted infections [7] or diabetes [3]. CAs, and in particular text-based CAs, can interact with users on sensitive or stigmatized topics and display empathy, potentially easing negative emotions [11]. As an example, younger users find online communication less stigmatizing, feel more in control in dealing with challenging situations through online conversations rather than in-person interactions and are more likely to use text messaging even in extreme scenarios. For instance, UK suicide-prevention charity Samaritans recorded that younger people had a higher use of text messaging services in contrast to visiting a branch or making a phone call as compared with older adults [20].

The need for support for complex management of different aspects of people's lives (e.g., exercise, diet, medication, doctor's appointments and treatment) is seen as another reason to use CAs [3, 13]. To illustrate, people with sickle cell disease (SCD), like with other chronic diseases, have complex healthcare needs [9]. Patients must pay attention to numerous factors that can provoke the appearance of symptoms, such as eating behaviors, stress, infections, dehydration, fatigue and even climate (e.g., extreme temperatures, wind), and constantly self-monitor [15]. Effectively managing such complex problems requires many skills, e.g., disease-specific knowledge, high levels of self-efficacy and problem-solving, that only few patients possess [9]. Most apps for SCD focus on monitoring pain symptoms and medication adherence and propose manual self-tracking [13]. All these features are typically perceived by patients as an additional burden and data that patients are supposed to provide can be emotionally charged [2]. As a result, these apps have low long-term engagement, and their frequency of usage decreases over time. This inconsistency or abandonment of use reduces the likelihood of achieving the desired effectiveness of health interventions. Consequently, patients who could benefit most from these systems are least likely to download or use them [34, 42].

6. Conclusion

We started this article by arguing that conversational agents have great potential to help people in chronic disease management and general well-being as they are perceived to be less stigmatizing, can provide education and support and are highly accessible.
However, CAs' current limited capacity to offer tailored treatment due to privacy issues around data, combined with the present lack of focus on prevention and limited scope of features, raise the question of whether chosen by researchers untailored interventions actually help users in the long run or are obstacles that are hard to integrate into everyday life. Another concern is that users could become over-reliant on CAs, because of their availability at the click of an icon which can exacerbate the smartphone addictive behavior.
Another factor which must be considered is that of the time of writing advancements in conversational applications of large language models are providing great opportunities in areas

such as healthcare, but this as yet has not been reflected in the available literature. It will certainly be interesting to see if and how this technology advancement can potentially mitigate some of the issues highlighted.

The increasing number of CAs can be a signal of the demand for health support that is not met by traditional services. Although CAs will not replace healthcare professionals and should be considered as a resource to enhance the efficacy of healthcare interventions, people might rely on digital resources more and more as a substitute for professional medical care. It emphasizes the importance of working hard to make these systems effective, ethically responsible, easy to use and understand data collected by CAs without healthcare professionals' guidance. This is essential to ensure that interventions are offered in a timely manner, providing effective support to those who may be most vulnerable and most in need.

Acknowledgements

References

[1]   Amith, M. et al.: Early Usability Assessment of a Conversational Agent for HPV Vaccination. Stud Health Technol Inform. 257, 17–23 (2019).

[2]   Ancker, J.S. et al.: "You Get Reminded You're a Sick Person": Personal Data Tracking and Patients With Multiple Chronic Conditions. Journal of Medical Internet Research. 17, 8, e4209 (2015). https://doi.org/10.2196/jmir.4209.

[3]   Baptista, S. et al.: Acceptability of an Embodied Conversational Agent for Type 2 Diabetes Self-Management Education and Support via a Smartphone App: Mixed Methods Study. JMIR Mhealth Uhealth. 8, 7, e17038 (2020). https://doi.org/10.2196/17038.

[4]   Bickmore, T.W. et al.: Managing Chronic Conditions with a Smartphone-based Conversational Virtual Agent. In: Proceedings of the 18th International Conference on Intelligent Virtual Agents. pp. 119–124 Association for Computing Machinery, New York, NY, USA (2018). https://doi.org/10.1145/3267851.3267908.

[5]   Carpenter, R. et al.: Interventions for self-management of type 2 diabetes: An integrative review. International Journal of Nursing Sciences. 6, 1, 70–91 (2019). https://doi.org/10.1016/j.ijnss.2018.12.002.

[6]   De Lorenzo, A. et al.: Obesity: A preventable, treatable, but relapsing disease. Nutrition. 71, 110615 (2020). https://doi.org/10.1016/j.nut.2019.110615.

[7]   Dworkin, M. et al.: A Realistic Talking Human Embodied Agent Mobile Phone Intervention to Promote HIV Medication Adherence and Retention in Care in Young HIV-Positive African American Men Who Have Sex With Men: Qualitative Study. JMIR Mhealth Uhealth. 6, 7, e10211 (2018). https://doi.org/10.2196/10211.

[8]   Gemert-Pijnen, J.E. van et al.: A Holistic Framework to Improve the Uptake and Impact of eHealth Technologies. Journal of Medical Internet Research. 13, 4, e1672 (2011). https://doi.org/10.2196/jmir.1672.

[9]   Gobeil-Lavoie, A.-P. et al.: Characteristics of self-management among patients with complex health needs: a thematic analysis review. BMJ Open. 9, 5, e028344 (2019). https://doi.org/10.1136/bmjopen-2018-028344.

[10]   Gonzalez, C. et al.: Promoting Culturally Tailored mHealth: A Scoping Review of Mobile Health Interventions in Latinx Communities. J Immigrant Minority Health. 23, 5, 1065–1077 (2021). https://doi.org/10.1007/s10903-021-01209-4.

[11]   Griffin, A.C. et al.: Conversational Agents for Chronic Disease Self-Management: A Systematic Review. AMIA Annu Symp Proc. 2020, 504–513 (2021).

[12]   Hebbar, A.: Augmented intelligence: Enhancing human capabilities. In: 2017 Third International Conference on Research in Computational Intelligence and Communication Networks (ICRCICN). pp. 251–254 (2017). https://doi.org/10.1109/ICRCICN.2017.8234515.

[13]   Issom, D.-Z. et al.: Toward a Conversational Agent to Support the Self-Management of Adults and Young Adults With Sickle Cell Disease: Usability and Usefulness Study. Front Digit Health. 3, 600333 (2021). https://doi.org/10.3389/fdgth.2021.600333.

[14]   Jaffee, E.G. et al.: Health Literacy and Hospital Length of Stay: An Inpatient Cohort Study. Journal of Hospital Medicine. 12, 12, 969–973 (2017). https://doi.org/10.12788/jhm.2848.

[15]   Jenerette, C.M. et al.: Self-Care Recommendations of Middle-Aged and Older Adults with Sickle Cell Disease. Nursing Research and Practice. 2011, e270594 (2011). https://doi.org/10.1155/2011/270594.

[16]   Joseph, R.P. et al.: Barriers to Physical Activity Among African American Women: An Integrative Review of the Literature. Women & Health. 55, 6, 679–699 (2015). https://doi.org/10.1080/03630242.2015.1039184.

[17]   Kim, Y. et al.: Acquisition and Use of Long-Term Memory for Personalized Dialog Systems. In: Böck, R. et al. (eds.) Multimodal Analyses enabling Artificial Agents in Human-Machine Interaction. pp. 78–87 Springer International Publishing, Cham (2015). https://doi.org/10.1007/978-3-319-15557-9_8.

[18]   Kocaballi, A.B. et al.: The Personalization of Conversational Agents in Health Care: Systematic Review. J Med Internet Res. 21, 11, e15360 (2019). https://doi.org/10.2196/15360.

[19]   Kowatsch, T. et al.: Conversational Agents as Mediating Social Actors in Chronic Disease Management Involving Health Care Professionals, Patients, and Family Members: Multisite Single-Arm Feasibility Study. J Med Internet Res. 23, 2, e25060 (2021). https://doi.org/10.2196/25060.

[20]   Kretzschmar, K. et al.: Can Your Phone Be Your Therapist? Young People's Ethical Perspectives on the Use of Fully Automated Conversational Agents (Chatbots) in Mental Health Support. Biomed Inform Insights. 11, 1178222619829083 (2019). https://doi.org/10.1177/1178222619829083.

[21]   Larsen, B.A. et al.: Physical Activity in Latino Men and Women. American Journal of Lifestyle Medicine. 9, 1, (2015).

[22]   Leo, A.J. et al.: A Digital Mental Health Intervention in an Orthopedic Setting for Patients With Symptoms of Depression and/or Anxiety: Feasibility Prospective Cohort Study. JMIR Form Res. 6, 2, e34889 (2022). https://doi.org/10.2196/34889.

[23]   Loveman, E. et al.: Parent-only interventions for childhood overweight or obesity in children aged 5 to 11 years. Cochrane Database of Systematic Reviews. 12, (2015). https://doi.org/10.1002/14651858.CD012008.

[24]   Ma, Y. et al.: Relationship between chronic diseases and depression: the mediating effect of pain. BMC Psychiatry. 21, 1, 436 (2021). https://doi.org/10.1186/s12888-021-03428-3.

[25]   Maher, C.A. et al.: A Physical Activity and Diet Program Delivered by Artificially Intelligent Virtual Health Coach: Proof-of-Concept Study. JMIR Mhealth Uhealth. 8, 7, e17558 (2020). https://doi.org/10.2196/17558.

[26]   Milne-Ives, M. et al.: The Effectiveness of Artificial Intelligence Conversational Agents in Health Care: Systematic Review. J Med Internet Res. 22, 10, e20346 (2020). https://doi.org/10.2196/20346.

[27]   Miner, A.S. et al.: Key Considerations for Incorporating Conversational AI in Psychotherapy. Front Psychiatry. 10, 746 (2019). https://doi.org/10.3389/fpsyt.2019.00746. 28.

[28]   Mulvaney, S.A. et al.: Mobile Intervention Design in Diabetes: Review and Recommendations. Curr Diab Rep. 11, 6, 486–493 (2011). https://doi.org/10.1007/s11892-011-0230-y.

[29] Napolitano, M.A. et al.: Feasibility of a Digital Intervention to Promote Healthy Weight Management among Postpartum African American/Black Women. Int J Environ Res Public Health. 18, 4, 2178 (2021). https://doi.org/10.3390/ijerph18042178.

[30] Noar, S.M. et al.: Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. Psychological Bulletin. 133, 673–693 (2007). https://doi.org/10.1037/0033-2909.133.4.673.

[31] Pereira, J., Díaz, Ó.: Using Health Chatbots for Behavior Change: A Mapping Study. J Med Syst. 43, 5, 135 (2019). https://doi.org/10.1007/s10916-019-1237-1.

[32] Revere, D., Dunbar, P.J.: Review of Computer-generated Outpatient Health Behavior Interventions: Clinical Encounters "in Absentia." Journal of the American Medical Informatics Association. 8, 1, 62–79 (2001). https://doi.org/10.1136/jamia.2001.0080062.

[33] Schachner, T. et al.: Artificial Intelligence-Based Conversational Agents for Chronic Conditions: Systematic Literature Review. J Med Internet Res. 22, 9, e20701 (2020). https://doi.org/10.2196/20701.

[34] Singh, K. et al.: Many Mobile Health Apps Target High-Need, High-Cost Populations, But Gaps Remain. Health Affairs. 35, 12, 2310–2318 (2016). https://doi.org/10.1377/hlthaff.2016.0578.

[35] Stasinaki, A. et al.: Effects of a novel mobile health intervention compared to a multi-component behaviour changing program on body mass index, physical capacities and stress parameters in adolescents with obesity: a randomized controlled trial. BMC Pediatr. 21, 1, 308 (2021). https://doi.org/10.1186/s12887-021-02781-2.

[36] Suganuma, S. et al.: An Embodied Conversational Agent for Unguided Internet-Based Cognitive Behavior Therapy in Preventative Mental Health: Feasibility and Acceptability Pilot Trial. JMIR Ment Health. 5, 3, e10454 (2018). https://doi.org/10.2196/10454.

[37] Ter Stal, S. et al.: An Embodied Conversational Agent in an eHealth Self-management Intervention for Chronic Obstructive Pulmonary Disease and Chronic Heart Failure: Exploratory Study in a Real-life Setting. JMIR Hum Factors. 8, 4, e24110 (2021). https://doi.org/10.2196/24110.

[38] Teufel, M. et al.: Impact of Biofeedback on Self-efficacy and Stress Reduction in Obesity: A Randomized Controlled Pilot Study. Appl Psychophysiol Biofeedback. 38, 3, 177–184 (2013). https://doi.org/10.1007/s10484-013-9223-8.

[39] The Diabetes Prevention Program (DPP) Research Group: The Diabetes Prevention Program (DPP): Description of lifestyle intervention. Diabetes Care. 25, 12, 2165–2171 (2002). https://doi.org/10.2337/diacare.25.12.2165.

[40] Thompson, C.A. et al.: A personalized system for conversational recommendations. J. Artif. Int. Res. 21, 1, 393–428 (2004).

[41] Tuomilehto, J. et al.: Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. N Engl J Med. 344, 18, 1343–1350 (2001). https://doi.org/10.1056/NEJM200105033441801.

[42] Vaghefi, I., Tulu, B.: The Continued Use of Mobile Health Apps: Insights From a Longitudinal Study. JMIR mHealth and uHealth. 7, 8, e12983 (2019). https://doi.org/10.2196/12983.

[43] World Health Organization. Regional Office for Europe: Childhood Obesity Surveillance Initiative (COSI): physical activity habits of children aged 6-9 in the WHO European region. World Health Organization. Regional Office for Europe (2020).

[44] Yun, H.S. et al.: Motivating health behavior change with a storytelling virtual agent. In: Proceedings of the 22nd ACM International Conference on Intelligent Virtual Agents. pp. 1–3 Association for Computing Machinery, New York, NY, USA (2022). https://doi.org/10.1145/3514197.3549684.

[45] Zhou, S., Bickmore, T.: A Virtual Counselor for Breast Cancer Genetic Counseling: Adaptive Pedagogy Leads to Greater Knowledge Gain. In: Proceedings of the 2022 CHI Conference on