A Structured Literature Review on Conversational Agents that Empower Health Interventions

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***Abstract*— Conversational agents (CAs) are becoming increasingly popular in people's everyday lives. CAs are illustrative of recent technological advancements that have disrupted numerous domains, including healthcare, where they promise engaging, personalized, and effortless interactions that go further than static exchanges, and have the potential to improve users' behavior. To be effective as a vital instrument for enhancing users' well-being, CAs have to be designed for the task. However, research on how the CA should be designed to attain the intended behavior, specifically compliance, remains scant. Against this background, a systematic literature review was conducted, identifying 48 papers that cover CA features required for users to achieve the intended behavior in health interventions. Based on the results, this paper provides novel implications for future research.**

Keywords—Conversational Agents, Health, Behavioral change, Compliance

I. Introduction

Digitalization has changed almost every aspect of our lives, from how we work and communicate to how we consume information and entertain ourselves [1], [2]. As conversational agents (CAs) are increasingly being introduced, our engagement with technology is about to change once again [3], [4]. CAs are software-based systems that engage with users using natural language [5]. Prominent examples are Amazon's Alexa and Microsoft's Cortana. Recently, the development of ChatGPT and Google Bard has marked the next frontier: the 5^{th} wave of CAs [6]. The broad applicability and the advantages of CAs, such as 24/7 availability, delivering personalized information, independence of geographical barriers, scalability [7], and cost-efficient usage [8], have brought multiple benefits to education, business, and travel industries [9], [10]. Broadly, CAs have proven to be a valuable tool for automating tasks, improving customer engagement, and enhancing users' experience [11], [12]. As technology continues to evolve, CAs are expected to become prominent in the field emerging within healthcare [13].

One prime example of CAs in healthcare is their use in encouraging behavioral change among users. In the US alone, around 50% of individuals are non-compliant in taking their medication as directed, which results in costs of approximately $500 billion [14]. Thus, ensuring users' compliance behavior is important for running an effective healthcare system and increasing individuals' overall well-being [15].

In this context, CAs offer significant advantages since, as digital assistants, they can guide patients through treatment therapies, advise users on checking for COVID-19 symptoms, or assist in behavioral changes and compliance contexts [16], [17]. For example, El Hefny et al. [18] have shown that personalized CAs can be an effective mechanism in combating misinformation to users in COVID-19 contexts. Prior research has also investigated CA implementation as reminder systems (e.g., for taking and complying with medication plans). Specifically, past research has studied how CAs can work as mechanisms to restrain individuals' tobacco use or as motivational assistants toward healthier lifestyles [19], [20].

To fully unlock CAs' potential to improve user behavior, prior research has drawn on interdisciplinary knowledge from various disciplines, such as psychology, healthcare, and IS, to investigate CA design factors and their impact on users. For example, users' engagement, motivation, and the human-like design of CAs have been identified as effective drivers in attaining intended user behavior [21], [22]. However, despite the increased importance and future relevance of studying how CAs ensure sensible healthcare behavior, there is currently no comprehensive overview on this topic that could guide future CA designers to devise their CA appropriately. Therefore, this study aims to investigate the following research question:

What is known about designing CAs to ensure compliance, and what are the related important areas of future research?

To investigate this question, a systematic literature review is conducted, analyzing 48 papers to reveal the factors likely to attain users' behavior, specifically their compliance with CA advice. This review provides comprehensive guidance regarding effective CA design for practitioners and it draws implications for future research.

II. Related Work

A. *Examples of CA Types and State-of-the-Art Applications in Healthcare*

CAs can appear in different forms of communication, with three types that dominate the field in research and practice, namely text-based CAs (e.g., pre-scanning of COVID-19 symptoms [16]) [23], voice-based CAs (e.g., Amazon's Alexa) [24], and a combination of the two forms [25].

The various types of CA can be classified into physically embodied, virtually embodied, and disembodied systems. Physically embodied CAs refer to robots like SoftBank's 'Pepper' [26]. Virtually embodied CAs describe online animated face-to-face interactions like Laura, a virtual coach that promotes physical activity [27]. In contrast, disembodied CAs are defined by their rudimentary design, mostly focusing on the execution of simple tasks such as FAQs [28]. More recently, embodied CAs (e.g., chatbots with human-like characteristics, such as a name) have gained significant attention due to the possibilities of increased engagement with users and overall enhanced user experiences [29].

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Particularly in healthcare, CAs have found mainstream attention due to increased labor shortages. For example, CAs might substitute physicians in communicating with older adults [30]). Research has also considered addressing labor issues through optimized processes regarding diagnosis and treatment management, as well as patient education (e.g., [31] [32], [33]). In the healthcare context, CAs are becoming increasingly relevant for behavioral change interventions, such as promoting physical activity, improving medication compliance, and correcting substance misuse [34], [35]. Because individuals often find these intervention strategies challenging to pursue alone, CAs offer them practical guidance and support without assistance through physical presence [36]. For example, Beinema et al. [22] examined how different coaching strategies affect the users' motivation toward healthy living. Davis et al. [37] developed a virtual CA, 'Paolo', that supports users in improving their diet quality by acting as a personal assistant. However, research on the factors ensuring appropriate user behavior regarding these health interventions remains scant, emphasizing the need for a comprehensive overview. To shed light on the current possibilities, the following section outlines the main mechanisms applied in CA research to ensure the intended users' behavior.

Behavioral Change and Compliance in CAs

To maximize CAs' effectiveness regarding health interventions, users need to comply with recommendations the CA provides [38]. This paper follows Murphy & Coster [39], defining compliance as the individual's willingness and ability to follow a recommendation.

To attain users' compliance behavior, CA research has used different routes, factors, and theories to explain the underlying mechanisms [35], [40]. For example, the cognitive-motivational theory states that behavioral change and compliance are driven by individuals' attitudes and intentions toward the intended behavior [41], [42]. In this regard, attitudes to, e.g., perceived risks or costs of behaving non-compliantly, were shown to be effective mechanisms in attaining users' behavior [43], [44].

Further, the transtheoretical model for behavioral change [45] has been applied in CA research to support the users' health intervention [46]–[48]. The model describes a six-stage process to prevent setbacks and reach the termination stage (e.g., to stop cigarette smoking). Besides mechanisms that aim to adjust the user's cognition, behavioral change and compliance can be driven by visible and persuasive factors.

In this regard, the computers are social actors paradigm (CASA) and the social response theory have been applied to understand how computers can bring improved change to users' behavior [49], [50]. The CASA concepts describe how computers are perceived as social entities and how users tend to attribute human traits to them, and are ultimately persuaded. This is crucial because persuasive design elements have been shown to influence users' behavior [51], [52]. For instance, a CA's human-like design (e.g., name or avatar) can effectively promote sustainability beliefs [53]. In this regard, personalized interaction has been shown to be a fruitful factor in driving behavioral change [54]. Further, persuasive messages (e.g., motivational cues) can enhance users' learning behavior [55]. In healthcare and CA research, using persuasive strategies (e.g., reminders) has positively impacted the mediation treatment of users, positively affected their choices by motivation, and thus, attained the intended behavior [56], [57].

However, factors used to design CAs for improving users' well-being and attaining the intended users' behavior, remains diffused. Next, the research approach of this study will be explained.

III. Research Approach and Methodology

To understand the status quo and trends that determine factors influencing behavioral change in users through CAs, this study follows an approach established by Fettke [58] and Webster & Watson [59] to systematically collect, structure, and analyze the literature (see Figure 1). This approach can identify trends and research gaps to derive future research directions regarding behavioral change factors. Our review is conducted based on Fettke's [58] five phases approach, which is integrated with the corresponding coding and literature analysis based on Webster & Watson [59]. The following sections outline the main phases.

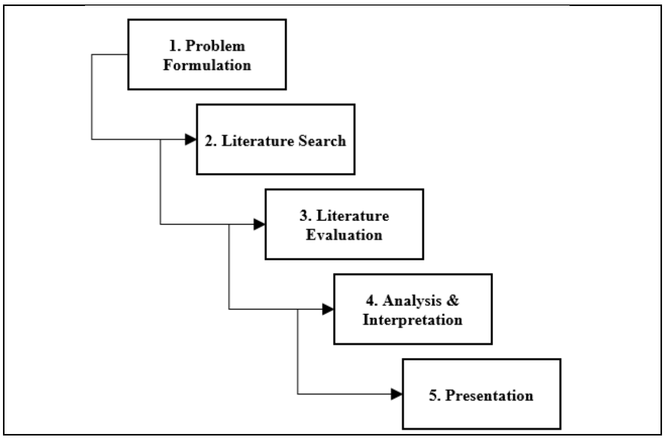

Fig. 1. Research Approach by Fettke [58]

A. *Step 1: Problem Formulation*

To be effective and support users in health interventions, CAs have to be designed to fit the purpose. However, understanding how CAs have been designed to influence users' behavior and knowing which factors have been applied to achieve the intended user behavior, specifically compliance, remains a current challenge [35]. Therefore, this study aimed to identify the status quo of factors that have attained suitable users' behavior. It provides guidance for practitioners on how to design CAs accordingly. Addressing these factors is important to design and implement effective CAs that support the process of users' behavioral change and compliance behavior. Based on the broad spectrum of CA applications, this review focuses on health contexts, excluding domains such as marketing, education, or business. Further, only patient and user-related interactions will be considered because this study focuses on individuals' behavioral changes (thus, excluding CAs that concentrate on commercial B2B interactions).

B. *Step 2: Literature Search*

The literature search was conducted in January 2023. To cover various disciplines that study CAs in healthcare, multiple databases were used, thereby encompassing various research fields. The search included the major databases covering medicine, psychology, IS research, and cross-sectional disciplines: PubMed, IEEE, APA PsychArticles, ACM, and, to include IS literature, also Scopus. Given the novelty of this topic, besides journal articles, conference proceedings were included as well. Further, this study focuses on articles published after 2011 since modern CAs emerged around that time [60].

The search string was developed using an iterative process, ensuring it consisted of three components, i.e., conversational agents, behavior and compliance, and healthcare. The components were combined using Boolean operators. Following Diederich et al. [60], Jin et al. [61], and Melki et al. [62], numerous synonyms were used for the term 'conversational agent' and 'compliance'. Further, different word endings and grammatical variations were included using the asterisk symbol. Consequently, the following search string was applied to 'title' and 'abstract':

(((conversational OR digital OR virtual OR embodied OR disembodied)
AND (agent OR assistant)) OR chatbot OR chatterbot)
AND (behavio OR compl* OR persua* OR intent*)*
AND (ehealth OR mhealth OR health OR medic*)*

C. Step 3: Literature Evaluation

The literature evaluation describes the process of distinguishing between relevant and non-relevant articles [58]. In the evaluation process, the titles, abstracts, and full texts were assessed. In sum, the initial sample consisted of 3512 publications. After identifying studies ineligible for reasons of language (i.e., not English), subject area (not medicine, health, psychology, social sciences), and context (non-human subjects, e.g., animals), 453 studies were removed. Further, 595 duplicates were identified and withdrawn. In addition, another 2197 studies were removed after screening titles and abstracts, resulting in a sample of 267 for the full-text analysis. The final sample, having completed the full-text analysis, consisted of 48 papers.

Subsequently, the publications were classified based on appropriate criteria according to the Webster & Watson [59] approach and on established dimensions given in the literature. The dimension ***Research Design*** was derived and adapted from Dhinagaran et al. [63]. The dimensions and characteristics of CA research (***CA Type***, ***Embodiment***, and ***Design***) were derived from [8], [60], [64], and [65]. In addition, the ***Context*** was adopted from Laranjo et al. [11] and Parmer et al. [66] and refined through an iterative process using the health domains mentioned in the samples. Similarly, the ***Factors Attaining the Intended User Behavior*** and compliance were defined by using an iterative process and based on the factors mentioned in the sample. These are summarized below in Table 1. The factors refer to the measurable parameters and design choices used in the studies that aimed to attain suitable user behavior. For example, engagement refers to the time users invested interacting with the CA. Activities and choices describe the users' actions (e.g., a CA sends praising messages if an individual decides to walk instead of using a car). The ability to perform a task refers to the CA adjusting its behavior to keep the user in the loop. CAs were summarized based on their communication regarding patient characteristics (e.g., age, gender) in this dimension. Similarly, if physiological data is collected (e.g., an individual's height, symptoms, movement), CAs can respond in personalized ways to attain the intended user behavior. Lastly, non-verbal behavioral cues refer to the user's attention. CAs (e.g., with eye-movement tracking functions) can adapt their conversation and act correspondingly.

TABLE I. FACTORS ATTAINING USERS' BEHAVIOR

Factors Attaining Intended User Behavior (Illustrative study)	**Understanding**
Emotion [67]	Using sentiment analysis to measure a user's mood based on a scale of emotions (e.g., positive, negative) or feelings (e.g., sadness, joy).
Stress/Relaxation [68]	Using self-report questionnaires to measure users' levels of stress and relaxation.
Motivation [19]	Applying motivational framing techniques to determine a user's desire to do a specific activity (e.g., exercises, cooking).
Engagement [69]	Refers to the time the users invested in interacting with the CA (e.g., measured through click depth).
Patient knowledge [70]	Refers to users' data collected to tailor the intervention and increase the personalization of the interaction.
Activities and choices [37]	Refers to users' choices and the CA interaction adjustments (e.g., praising the user for choosing to walk instead of taking the car).
Ability to perform a task [71]	Considers users' answers and corresponding CA interaction adjustments (e.g., adjusting the interaction to maintain high motivation if users struggle).
Non-verbal behavioral cues [72]	Refers to the application of, e.g., eye-tracking systems to adjust the CAs interaction based on the user's attention level.
Achievement of objectives [73]	Applying goal-setting techniques to provide feedback indicating the user's degree of achievement.
Patient characteristics [74]	Refers to the use of demographic variables (e.g., age, race) which result in CA interaction adjustments.
Physiological data [75]	Considers the application of wearables and the corresponding personalized CA feedback (e.g., a reminder for taking medication).

D. Step 4 & 5: Analysis and Interpretation, Presentation

To analyze and interpret the results, a structured literature review was conducted. For the structured literature review, a concept matrix was developed [59]. This approach enhanced our research endeavor, providing coherence and an overview of the results [76].

IV. RESULTS

Table 2 summarizes the results regarding the structured literature analysis. Regarding the Research Design, 44% of the articles refer to experiments (e.g., randomized controlled trials, proof of concepts, pilot studies), followed by system descriptions that document CA components and features used in health applications (19%) and mixed categories (13%) (e.g., design science research projects that combine a survey and an experiment). The CA Type is dominated by text-based CAs (44%), followed by a combination of voice and text (31%), and lastly, voice-based CAs (25%). Regarding the CA Embodiment, 81% consider virtually embodied CAs, and only 4% refer to physically embodied CAs. Fully and partially embodied CAs are equally considered (42% each), whereas 15% of the studies examined CAs without embodiment. Considering the CA Design, 58% of the studies have a human identity, followed by the ability to communicate verbally (54%), and a combination of the two features (46%). The Context is mainly defined by healthy lifestyle (35%), mental health (19%), substance misuse, and other issues (e.g., cancer, autism, in rehabilitation) (each 13%). Medication management (8%), sexual and reproductive health issues (6%), and diabetes (6%) are less represented. Considering the Factors Attaining Intended User Behavior, research has mainly focused on activities and choices (60%), emotion (35%), achievement of objectives (35%), physiological data (33%), and patient characteristics

(25%). Themes less represented, were motivation (23%), non-behavioral cues (15%), stress/ relaxation (15%), patient knowledge (8%), ability to perform a task (6%), and engagement (4%).

TABLE II. CONCEPT MATRIX

	Categories	Publications
Research Design	Experiment	[19], [22], [37], [67], [70], [73], [77]–[90]
	System description	[72], [74], [75], [91]–[96]
	Survey, interviews	[97]–[101]
	Case study	[69], [102]
	Mixed methods	[56], [103]–[107]
	Other	[63], [68], [71], [108], [109]
CA Type	Text	[19], [22], [37], [63], [67], [68], [73], [78], [81], [87], [90], [92], [97], [99], [101], [102], [104], [107], [108]
	Voice	[56], [79], [82], [83], [85], [86], [89], [100], [103], [105], [106], [109], [110]
	Text & Voice	[70]–[72], [74], [75], [77], [80], [84], [88], [91], [93]–[95], [98], [111]
Embodiment	Virtual	[19], [22], [37], [63], [67]–[73], [75], [77]–[80], [83]–[86], [88]–[90], [92]–[101], [103], [105], [107]–[110]
	Physical	[82], [91]
	Fully	[22], [69]–[73], [75], [77], [79], [80], [82], [84], [88], [94], [96], [103], [105], [108]–[110]
	Partially	[19], [37], [63], [67], [68], [78], [83], [85], [86], [89], [90], [92], [93], [95], [97]–[101], [107]
	None	[56], [74], [81], [87], [102], [104], [106]
Design	Human identity	[22], [37], [63], [69]–[71], [73], [75], [77]–[80], [83]–[86], [88]–[90], [93], [94], [96], [98], [100], [103], [105], [109], [110]
	Verbal communication	[19], [22], [37], [56], [63], [67], [68], [74], [78], [81], [83], [85]–[87], [92], [95], [97]–[102], [104], [106]–[108]
	Non-verbal communication	-
	Combination	[69]–[73], [75], [77], [79], [80], [82], [84], [88]–[91], [93], [94], [96], [103], [109], [110]
Context	Mental health	[67], [68], [85], [86], [89], [98], [99], [105], [108]
	Healthy lifestyle	[22], [37], [63], [73], [78], [79], [83], [87], [90]–[92], [94], [95], [97], [101], [104], [110]
	Substance abuse	[19], [74], [80], [93], [102], [109]
	Medication management	[56], [70], [100], [106]
	Sexual & reproductive health	[69], [88], [107]
	Diabetes	[75], [77], [103]
	Others	[71], [72], [81], [82], [84], [96]
Factors Attaining Intended User Behavior	Emotion	[67], [68], [70], [72], [73], [75], [85], [94]–[96], [98], [99], [102], [105], [107], [108], [110]
	Stress/Relaxation	[63], [68], [83], [86], [89], [105], [108]
	Motivation	[22], [63], [71], [73], [80], [83], [89], [93], [104], [109]
	Engagement	[69], [73]
	Patient knowledge	[19], [70], [75], [96]
	Activities and choices	[19], [37], [56], [63], [67], [70], [74], [77]–[80], [83], [87], [88], [90]–[95], [97], [100]–[104], [106], [109], [110]
	Ability to perform a task	[63], [70], [71]
	Non-verbal behavioral cues	[56], [72], [91], [94], [95], [109], [110]
	Achievement of objectives	[37], [56], [67], [73], [75], [77], [79], [85], [87], [92], [93], [97], [100], [101], [104], [105], [110]
	Patient characteristics	[69], [71], [74], [81], [84], [86], [87], [94], [99], [102], [104], [109]
	Physiological data	[37], [75], [77], [78], [80]–[82], [87], [91], [94]–[98], [100], [107]

V. DISCUSSION

This study aims to present the status quo in CA research regarding factors that contribute to attaining intended user behavior, specifically compliance. The results show that CAs are a promising tool in healthcare interventions. The study further offers novel findings by shedding light on the different factors scholars have used to influence behavior in healthcare. Overall, most CAs are text-based ones that are either fully or partially virtually embodied, while less research attends to physically embodied CAs. Further, the contexts concentrate on healthy lifestyles and mental health. The factors attaining intended user behavior relate to activities and choices, with less emphasis on stress/relaxation, engagement, patient knowledge, and non-verbal behavioral cues. Against this background, the study's main implications will be presented in the upcoming section.

A. Implications for Theory and Future IS Research

Attaining users' compliance behavior in health interventions using CAs is vital to leverage potential positive healthcare outcomes for individuals (e.g., increased overall well-being) and the healthcare system itself (e.g., reduced financial costs through improved treatment management). This section draws numerous implications that uncover several research gaps identified in this literature review that can guide future research.

First, the CA type is dominated by text-based and virtually embodied CAs. Voice-based and fully embodied CAs are the least represented. This aligns with previous research showing that, rather than pure-textual dialogues, users tend to prefer interactions with embodied CAs and accept them more readily [57], [109]. However, because health interventions often require the physical assistance of experts (e.g., walking rehabilitation exercises), research could elaborate on future possibilities CAs assisting in these contexts. From a theoretical perspective, one explanation of why physically embodied CAs are underrepresented might relate to the 'uncanny valley' effect (e.g., humanoid robot Sophia Hansen [112]). This effect describes users' emotional response to an object and the degree to which it resembles a human being [113]. The theory suggests that users often experience a feeling of eeriness and strangeness when encountering a humanoid that too closely resembles a natural person. Designers and engineers need to be aware of this effect and its potential influence on users' experience. Studies to assess the different levels of human likeness in CA research might help inform design decisions.

Second, most examined studies focused on contexts defined as healthy lifestyle and mental health. This unequally distributed sample is surprising because, for aging populations, numerous other contexts in health interventions are equally important (e.g., cancer [114], sleep disorders [115], or diabetes [116]. In this context, e-health interventions have become increasingly important in providing 'healthy aging' recommendations [117]. Researchers and policymakers should broaden their focus and include a more diverse range of health contexts. Here, a more comprehensive and inclusive research design that focuses on the intersections of various health domains could identify possible cross-over effects and lead to a more enhanced understanding of the most efficient factors in each context.

Lastly, this study reveals several factors that predominate in users' compliance behavior and in health interventions. This contributes to filling the CA research gap on factors used to attain intended user behavior through human-computer interactions [34], [40], [118]. Further, it contributes to the current discourse about scarce theoretical foundations in CA research and regarding user behavior [119], [120]. The main findings correspond to existing literature and highlight that factors regarding emotions, activities and choices, and achievement of objectives are vital in aiming to attain intended user behavior [19], [120], [121]. However, the factors this study identifies are limited by the sample. Factors like credibility, trust, or perceived risks (e.g., in sharing sensitive health data) that focus on acceptance of the CA are probably equally important in attaining the intended user behavior [122], [123]. Thus, to guide future research, the IS community would benefit from a more diverse range of research designs than currently available to study CAs' effectiveness in health applications. Further, scholars could focus on how physically embodied CAs can attain users' compliance behavior in health contexts by assessing the different levels of human likeness, encouraging interdisciplinary research (e.g., marketing), and identifying possible cross-over effects of factors attaining users' intended behavior.

TABLE III. SUMMARY OF FINDINGS

Domain	Main Results & Trends	Avenues for Future Investigation
Study design	Most papers are explorative studies, relying on controlled trials, pilot experiments, and proof of concepts, which indicates a trend toward experiments.	IS Research should participate more actively in conducting non-experimental research to test in non-controlled environments and for long-term effects.
Context	Most CAs are used in contexts like healthy lifestyles, mental health, and substance abuse with no clear trend over time.	Additional research is required in healthcare fields, based on knowledge of different disciplines, to leverage potential cross-over outcomes. Further, contexts relevant for aging populations (e.g., diabetes, cancer) remain underrepresented.
Factors	Many studies examine activities and choices, emotions, achievement of objectives, and physiological data.	The IS community could benefit from a comprehensive 'CA Style Guide' summarizing the factors for attaining intended user behavior.
CA Type, CA Embodiment, CA Design	The majority of CAs are text-based and virtually embodied. Most CAs have a human identity and communicate verbally.	Future IS research can benefit from voice-based CA research by focusing on specific target groups. Studies can examine the role of physically embodied CAs in attaining users' compliance behavior.

B. *Limitations*

This study's literature review comes with three fundamental limitations that require attention in future research. First, this research is limited by time constraints by including only articles published after 2011. Second, it considered only major databases, leading to possible omissions of studies in smaller databases. Third, although our comprehensive search strategy covered multiple synonyms, redefining the frame could lead to different factors attaining intended user behavior. Still, concerning CAs and behavioral change drivers in healthcare, this study presents a representative sample.

VI. CONCULSION

CAs are becoming increasingly relevant and represent a potentially valuable tool in attaining intended user behaviors, specifically in health contexts. This study's objective was to examine the status quo in research on how CAs are designed to attain potentially ideal users' behavior and to reveal the factors used in designing CAs accordingly. This objective was achieved by conducting a systematic literature review covering 48 studies. The results show that CAs were primarily applied to the contexts of healthy lifestyle and mental health. The main factors used in designing CAs to attain intended user behavior are activities and choices, emotions, and achieving objectives. Against this background, future research can investigate factors that focus on how to attain ideal user behavior through the use of computer visioning. This would enable the CA to tailor its communication to the patient's capabilities, influencing their motivation and ensuring long-term user retention. Further, researchers need to explore how physically embodied agents can improve interactions with users and attain their improved behavior. By addressing these future avenues, the IS community can endeavor to provide transdisciplinary research guidance across disciplines and reveal new insights (e.g., design principles). For future IS research, healthcare practitioners can build on the provided implications and embrace CAs to further improve patient outcomes.

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