Acceptance Evaluation of a COVID-19 Home Health Service Delivery Relational Agent

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Abstract. Relational Agents (RAs) may be helpful in supporting the social distancing mandate during the COVID-19 pandemic by providing essential health services to patients at home and eliminating the need for in-person hospital visits. We conceptualized and developed a prototypical RA to visualize how this can be done in four major COVID-19 related health scenarios. In this paper, we present acceptance evaluation of the proposed RA using a survey based approach. A total of 105 participants were asked to interact with and analyze the prototype. Participants then indicated perceived usefulness and willingness to accept and use the proposed RA on Likert scales. The findings show that overall 80.77% of participants found the suggested RA useful. 59.67% of participants accepted it as an alternative to healthcare professionals as long as the scenario is not life-threatening. Furthermore, 78.29% of the participants indicated that they would be willing to use the proposed RA, if needed. Further research is needed to understand what factors can improve the uptake of the proposed RA among individuals $\leq$30 years and with no COVID-19 infection history.

Keywords: COVID-19 · Relational agent · Health service · mHealth · Healthcare professional · User-centered design

1 Introduction

A relational agent (RA) is a computational artifact (virtual agent (VA)) that is able to maintain a long-term virtual socio-emotional relationship with its user. An RA may be able to replace a healthcare professional (HCP) [12] and provide an alternative to telehealth services [19] by digitally delivering the required healthcare services to patients remotely. RAs and their cousins, conversational agents (CAs), have been previously used for providing health behavior education and counseling to patients [2,12,14,18] in various settings. For example, Tielman et al. [21,22] used RAs for delivering post-therapy stress management solutions at home and for delivering motivational messages for treatment of post-traumatic

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stress disorder (PTSD). It has also been demonstrated that RA-enabled health interventions can successfully improve healthcare access in remote areas [6,24].

During the COVID-19 pandemic, the need for social distancing prompted many researchers to explore alternate ways to deliver essential health services outside the healthcare settings. A variety of CA-based interventions were developed [7,15,16], wherein VAs helped patients check their symptoms and find answers to specific questions about COVID-19. Other solutions attempted to explore whether VAs can act as emotional support companions. Ouerhani et al. [17] proposed a cloud-based mobile CA that helped people cope with various emotions during COVID-19 quarantine period by increasing their consciousness about the real dangers of psychological disturbances, e.g., unintended and sudden fear, stress, anxiety, and depression, even the tendency of committing suicide. Ishii et al. [9] developed ERICA, an empathy-driven mobile VA that employs both verbal and non-verbal methods to help persons in self-quarantine feel less isolated. A user study with 19 participants showed that gestures and facial expressions of ERICA can be effective in showing empathy and attention.

While the existing research shows that the VA-based solutions have the potential to provide a variety of COVID-19 related services to people in the comfort of their own homes, there are three important limitations of these works. First, the existing VAs are mainly targeted towards healthy individuals. Second, it remains unknown whether general public is willing to accept a VA-based COVID-19 intervention. Third, it is unknown what socio-demographic factors might influence people's willingness to use and accept a such interventions in COVID-19 pandemic. To address these gaps, we designed an RA-based prototypical intervention [11], which targets four scenarios that a COVID-19 patient is likely to encounter during their journey through the disease. In this paper, we present a study wherein we investigated these questions.

2 Proposed System

2.1 Design Process

We followed the user-centered design (UCD) methodology to develop our RA-enabled intervention. The detailed design process of proposed RA is reported in forthcoming publications. In a nutshell, the design process is divided into four stages:

- **User Persona Creation:** Three user personas were identified in a prior study [10]. We conducted background research on the CDC's COVID-19 prevention guidelines [4] and analyzed published interviews with HCPs (n = 19). This led to the identification of three user personas (Table 1) at different stages of COVID-19. *Oli Smith*, an individual with no existing co-morbidity, was selected to play the roles of all these personas to emphasize the relationship building aspect of the RA.
- **Interaction Scenario Development:** At this point, another interview study was conducted with persons (n = 12) who had been infected with

COVID-19 and therefore had firsthand experience with each persona. The study's goal was to determine which tasks an RA should be able to perform for each persona. Based on the identified tasks, four potential RA-user interaction scenarios were established. More details about the developed scenarios can be found in [11].

- **Interaction Dialogue Development:** Four sets of dialogues were formed for RA-user interaction for each scenario. These conversations were then validated and refined based on the input from another group of HCPs (n = 43) in a separate study.
- **Prototype Design:** A web-based conversational interface design tool named *BotSociety* [1] was used to build an interactive prototype for the proposed RA. Section 2.2 contains the details of the designed prototype.

Table 1. User personas identified in context of different COVID-19 scenarios.

Suspecting infection	Quarantining at home	Recovering after infection
Oli has been suffering from fever, cough, and headache many days. They are worried that they have caught the COVID-19 virus but they do not want to go for a test unless they are sure it is necessary. Moreover, they do not know where to go for testing and what precautions to take	Oli is experiencing mild COVID-19 symptoms. They do not require hospitalization at this time. However, they have been advised to self-isolate at home until symptoms subside. They want to know what they can do to accelerate recovery and prevent emergencies	Oli has recently recovered from severe COVID-19 symptoms that required hospitalization and a week in the intensive care unit (ICU). They are back at home and wish to recover as soon as possible. But they are experiencing PTSD and need both emotional and material assistance

2.2 Interactive Prototype

The RA interfaces were multi-modal consisting of verbal (voice recognition) and non-verbal (touch, prompts, visuals) interaction modes. Figure 1 illustrates the user interface of proposed RA. The voice prompts were also appeared as text on the interface to encourage user attention and engagement with the interface. The RA was designed to build a user model by tracking their input data (e.g., symptoms and interactions). The prototype interfaces enabled users to perform the following tasks (scenarios):

- **Testing Guidance**: The RA provides testing guidance to Oli who suspects getting infected by periodically engaging in a dialog to obtain up-to-date symptom status and health metrics (Fig. 2a). Also, the RA navigates Oli to the nearest COVID-19 testing center (Fig. 2b).
- **Support During Self-isolation**: The RA provides wellness tips and companionship to Oli during self-isolation at home. The RA also monitors their symptoms to avert and prevent emergencies (Fig. 2c).

- **Handling Emergency Situations**: The RA takes appropriate steps to detect critical situations and connects Oli to emergency services, if needed (Fig. 2d).
- **Post-infection Care**: The RA provides companionship and mental health counseling to help Oli recover from the stress of the infection during the recovery phase (Fig. 2e).

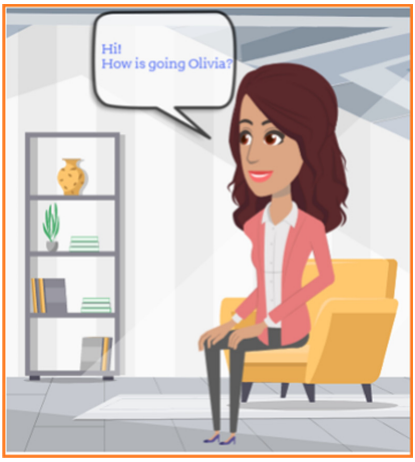

Fig. 1. The RA is available as an avatar as well as a chat interface, allowing Oli to choose between voice and text/touch modalities.

3 Preliminary Evaluation

The goal of the study was to assess whether people would find the proposed RA intervention beneficial and whether they would be willing to use and accept it. In addition, the following hypotheses were tested:

- perceived usefulness of the proposed system is dependent on history/status of infection, participants' demographics, and/or previous experience with mHealth apps,
- acceptance of the proposed system is dependent on history/status of infection, participants' demographics, and/or previous experience with mHealth apps,
- willingness to use the proposed system is dependent on history/status of infection, participants' demographics, and/or previous experience with mHealth apps.

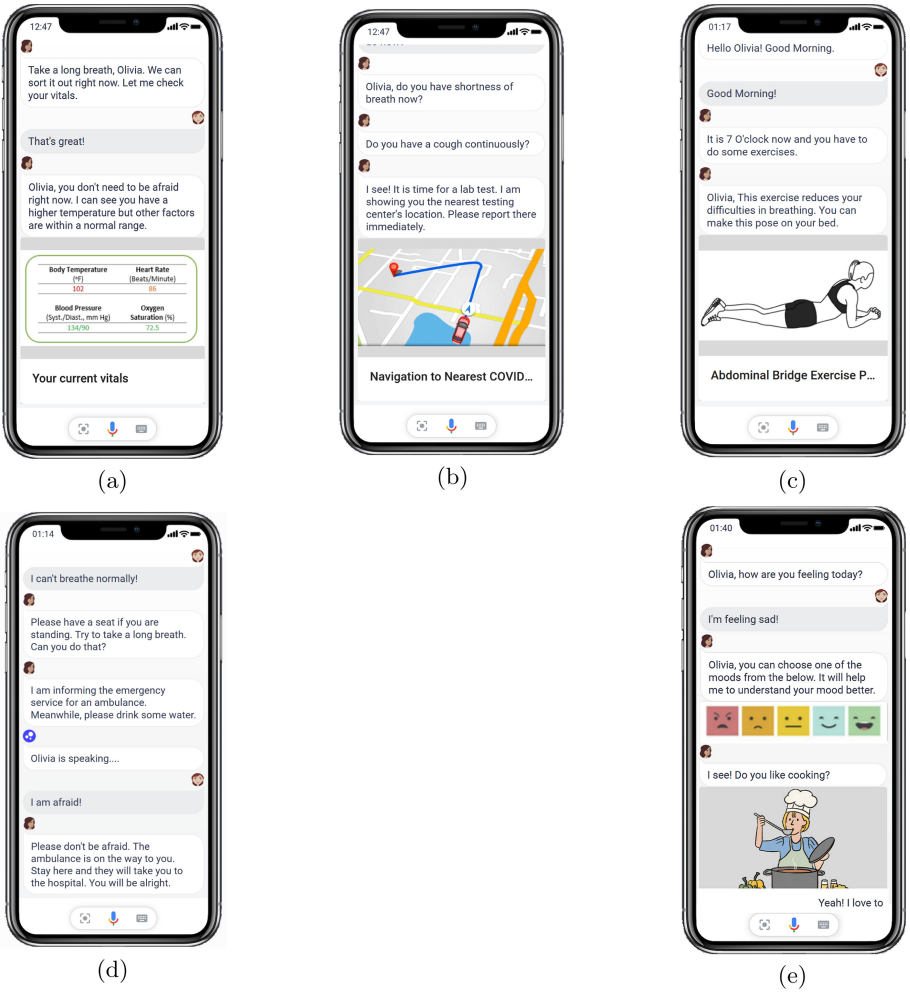

Fig. 2. Snippets from the prototype interface (smartphone view). The prototype can be simulated as a smartphone, tablet, and virtual assistant app, depending on the user's preference. (a) RA checks and displays Oli's physiological vitals; (b) RA navigates Oli to the nearest testing center; (c) RA helps Oli maintain healthy habits on a daily basis; (d) RA's interaction with Oli during an emergency situation; and (e) RA attempts to engage Oli in daily activities to reduce their PTSD symptoms.

3.1 Study Design

The research was approved by the ethical review board of our home institution. The survey started with a brief overview of the study followed by the informed consent process. After that, participants were requested to submit the basic demographic information (e.g., gender, age-range, education level, occupation, etc.). They also stated their COVID-19 infection status i.e., non-infected,

currently infected, and already recovered. Then, participants were requested to interact with the RA and experience each interaction scenario (described earlier in Sect. 2.2) independently. Participants' interaction with each scenario lasted for 3–5 min. After reviewing the scenario, participants could re-review it, if they were interested.

After exploring each scenario (task) of the prototype, participants were asked to answer a series of questions aimed at assessing the quality of the interaction and helpfulness of the RA in each scenario. (The analysis of these data has been presented in a separate publication [11]). After completing their overall interaction with the prototype, participants were asked to assess the usefulness of the entire system on a Likert Scale. Participants then indicated their willingness to use the proposed RA on another Likert Scale. Finally, they indicated whether they were willing to accept the proposed system as an alternative to HCPs in non life-threatening situations.

3.2 Participants

We shared the survey link on different social media sites and email lists to obtain a diverse group of participants for the study. The following criteria were required for participation: (a) being at least 18 years old, (b) having a basic understanding of English, (c) having familiarity with a smartphone, and (d) having a basic understanding of how to operate a computer to explore the prototype. Participation was entirely voluntary, and no personally identifiable information, such as name, email address, or other contact information, was recorded. The average survey completion time was 45 min, and no incentives were given for completing the survey.

Our recruitment resulted in 105 (male = 74) responses from individuals between 18 and 64 years with a mean of 31.30 years and SD of 10.88 (18–30 years = 67, 31–40 years = 15, 41–50 years = 13, and 51–60 years = 10 individuals). Out of 52 infected participants, 26 participants were infected at the time of the survey, and 26 had already recovered. Table 2 contains detailed information on the participants' basic demographics and mHealth app experience. According to the survey responses, all participants held at least a high school diploma.

3.3 Measures and Data Analysis

Table 3 shows the metrics and questions that were used for evaluation. The survey responses were obtained in different ways, such as 5-point Likert scales (e.g., 1 stands for extremely disagree, 3 for neutral, and 5 for extremely agree), multiple-choice questions (yes, no, and neutral). Microsoft Excel, which provides various filters and functionalities, was used to conduct quantitative analysis, including descriptive and inferential analysis. The descriptive analysis consisted of calculating means, SD, percentages, and frequency distributions where necessary.

Table 2. Basic demographic and mHealth experience data of study participants.

Attribute		n
Infection Status		
	Non-Infected	53
	Infected	52
Gender		
	Male	74
	Female	31
mHealth App Experience		
	Yes	50
	No	47
	Not Sure	8
COVID-19 mHealth App Experience		
	Yes	24
	No	79
	Not Sure	2

We used two-sided Wilcoxon-Rank Sum test with continuity correction for determining statistical significance of the differences in medians of compared independent groups. This test was used because it is non-parametric and does not assume any underlying distribution for data being analyzed. Due to the small sample size, this test was assumed to be appropriate. The level of statistical significance was set at $p \leq 0.05$ for all measures.

3.4 Findings

Perceived Usefulness: Overall, 80.77% of participants thought that the modeled RA would be either very useful or useful to patients. However, 17.31% of participants were neutral about the model's usefulness, and 1.92% of participants did not think the model would benefit patients.

According to the Wilcoxon-Rank Sum test, there difference between the *perceived usefulness* scores of females versus males, and COVID-19 mHealth app experience versus no COVID-19 mHealth app experience were statistically insignificant.

Table 3. Questions used for evaluating the acceptance of proposed RA.

Metric	Question
Perceived usefulness	*Rate the unusefulness/usefulness of the COVID-19 related health services provided by the RA.*
Willingness to accept	*Indicate your unwillingness/willingness to accept the proposed RA as an alternative to caregivers/HCPs for non-life-threatening situations during COVID-19.*
Willingness to use	*Indicate your unwillingness/willingness to use the proposed RA during COVID-19.*

Statistically significant differences, however, existed between *perceived usefulness* scores of other groups. Participants ≤30 years versus participants above 30 years old (W-statistic = 979, P-value = 0.03285) were statistically different, with participants above 30 years old showing higher perceived usefulness of the proposed system (mean = 4.12 versus 4.45). Second, participants with previous mHealth app experience versus no mHealth app experience also showed statistically significant difference (W-statistic = 886.5, P-value = 0.0238), with participants without previous mHealth app experience scoring the app higher on perceived usefulness (mean = 4.47 versus 4.1). Finally, perceived usefulness scores of infected versus non-infected participants were also significantly different statistically (W-statistic = 1095, P-value = 0.04837), with infected participants giving a higher score (mean = 4.46 versus 4.13).

Willingness to Accept: Overall, the majority (60.00%) of the participants agreed that the proposed RA could be an alternative to caregivers or HCPs for non-life-threatening situations. However, 4.76% of participants declined to accept it as an alternative and the rest (35.24%) were unsure, i.e., neutral.

There was no statistically significant difference between *willingness to accept* scores of females versus males, mHealth app experience versus no mHealth app experience, and COVID-19 mHealth app experience versus no COVID-19 mHealth app experience.

Statistically significant differences, however, existed between *willingness to accept* scores of other groups. Participants ≤30 years versus participants above 30 years old (W-statistic = 1017, P-value = 0.04767) were statistically different, with participants ≤30 years old showing higher willingness to accept the proposed system (mean = 1.52 versus 1.32).

Willingness to Use: Overall, 78.10% of the participants expressed willingness to use the proposed RA, i.e., they were either willing or very willing in this regard. However, only 0.95% of participants were unwilling to use the RA. Nobody voted for 'Very Unwilling' and 20.95% of participants were neutral.

There was no statistically significant difference between *willingness to use* scores of infected versus non-infected participants, female versus male, and prior mHealth/COVID-19 app experience versus no mHealth/COVID-19 app experience. There was, however, a statistically significant difference between the *willingness to use* scores of participants ≤30 years versus participants above 30 years old (W-statistic = 946, P-value = 0.019), with participants above 30 years showing higher willingness to use the proposed system (mean = 4.12 versus 4.45).

Table 4 illustrates the Wilcoxon-Rank Sum test outcomes that are only statistically significant ($p < 0.05$). The Wilcoxon-Rank Sum test were experimented on the participants' votes on metrics used for the evaluation.

Table 4. Statistically significant Wilcoxon-Rank Sum test outcomes that are obtained from participants' votes on metrics used for evaluation (*suggests statistical significance i.e., P-value < 0.05).

	Perceived usefulness		Willingness to accept		Willingness to use	
	W-statistic	*P-value*	*W-statistic*	*P-value*	*W-statistic*	*P-value*
Infected vs. non-infected	1095	**0.04837***	1128	0.06308	1151.5	0.1179
Age (18–30 vs. 30–60 years)	979	**0.03285***	1017	**0.04767***	946	**0.019***
Male vs. female	1116.5	0.8183	1038	0.3757	1018	0.3298
mHealth experience (yes vs. no)	886.5	**0.0238***	1064	0.3523	1029	0.2544
COVID-19 mHealth experience (yes vs. no)	785	0.1657	849	0.3691	899.5	0.6853

4 Limitations

There are several limitations of this study. First, our findings can only be viewed as preliminary and indicatory. Although our sample size is large enough to run tests of statistical significance, we do not have a large enough sample size to claim generalizability. Recruiting more participants would have improved the statistical power of our findings. Second, we did not collect any qualitative data to understand the reasoning behind participants' responses to the questions explored in this study. Third, we did not have equal number of participants in each age group to help us conduct more appropriate statistical analysis. The two major groups that we analyzed in this study (i.e. $\leq$30 years and $>$30 years) were formed to compare similar sample sizes. Finally, we did not conduct a field trial of our proposed RA, the results were collected based on a one-time interaction with the RA. However, our aim was to understand the acceptability and perceived usefulness of the RA before we conducted a long-term trial, since technology trials are expensive and time consuming.

5 Discussion

The results show that the majority of participants found the proposed RA useful (80.77%) and the majority was willing to use it too (78.29%). The 59.67% majority was willing to accept the RA as a substitute for HCPs but this percentage is smaller compared to percentages of other metrics. Participants who had

COVID-19 infection, those who were >30 years old, and those who had no prior mHealth app experience perceived the RA to be more useful compared to their counterparts. Participants who were >30 years old showed higher willingness to use the RA compared to participants ≤30 years old. Finally, in comparison to their counterparts, participants ≤30 years old were more willing to accept the proposed RA as a HCP substitute for receiving COVID-19-related health services at home.

The acceptability and feasibility of RAs have been established in several studies [5,20,23]. For example, Wang et al. found that an underserved patient population was willing to use and accept an RA that collected their family health histories [23]. Similarly, Thompson et al.'s study showed that the use of behavior change RA by adolescents with diabetes and their patients demonstrated that they found the RA feasible and acceptable [20]. The majority of published studies are concerned with assessing feasibility and acceptability of RAs in patient populations. Our study differs from earlier studies in two ways. First, we investigated and compared the perceived usefulness and acceptability of the proposed RA in both patients and non-patients. Second, we also investigated perceived usefulness and acceptability based on user's prior mHealth experience and demographics (i.e., age and gender). Our findings suggest that RAs can be used by people to handle a broader variety of health issues at home.

The findings show that age may play an important role in the acceptability and perceived usefulness of the proposed RA. The higher willingness to use and perceived usefulness of the RA among individuals >30 years may have been due to infection history. Indeed, there was a higher proportion of infected individuals among participants >30 years old compared to participants ≤30 years (proportions: 0.68 versus 0.38). Moreover, we also found that participants with infection history considered the RA to be more useful as compared to participants with no infection history. This finding suggests that the proposed RA may be suitable for COVID-19 patients before, during, and after the infection. Moreover, we are behooved to explore whether the endorsement of the RA technology by infected participants will encourage the wider uptake of the proposed RA (i.e. among newly infected individuals).

We did not collect any information about participants' health status but it is also possible that participants ≤30 years were healthier as compared to participants >30 years. This may also explain why participants ≤30 years were more comfortable in terms of accepting the RA as a substitute for HCPs. Although we did not have any older adults (≥65 years) in our study, research has shown that older adults are generally accepting of RAs for receiving health related services [3]. Thus, our study may be considered as supporting the hypothesis that participants with advanced ages find RA technology more accepting.

Finally, we found that participants with no prior mHealth experience found the RA more useful compared to participants with prior mHealth experience. There are many important implications of this findings. It is possible that the RA needs additional features in order to be considered more useful by people who had used mHealth before. It is also possible that participants with prior mHealth

experience did not have positive experiences with mHealth apps/interventions that they had previously used, or they did not use them long enough to see any positive changes. Several studies indicate that the apps available in the online app stores are often of low quality, compromise or pose a risk to user's private information [8], and are not based on evidence [13]. Unfortunately, we did not collect any information about participants' past experiences with other mHealth apps, e.g. for long they used them, for what purpose, why (and if) they gave up using them, etc. More information about participants' prior experience with mHealth may have shed more light on this issue.

6 Conclusion

We have presented a RA-based health service intervention that can provide essential health services during COVID-19-like pandemic. The preliminary evaluation of the intervention indicates that participants found the proposed intervention useful and there was a general willingness to use the system. Participants also thought that the intervention could be a suitable substitute for HCPs. Perceived usefulness was influenced by age, previous mHealth app experience and infection history. Willingness to accept the RA as a viable alternative to HCPs and willingness to use the RA were also influenced by age. The results suggest that the proposed system may be useful for COVID-19 patients before, during, and after the infection but certain barriers may hinder its uptake. Further research is needed to understand what factors can improve the perceptions of usefulness of the tool among users $\leq$30 years and non-infected participants. Understanding the reasons behind why people with prior mHealth experience are unwilling to use the RA may also help improve the widespread uptake of this useful tool during the pandemic.

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