Providing Accessible and Supportive User Experience through conversational UI and digital humans

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Abstract— **Designing E-Health services that are accessible, engaging, and provide valuable information to patients is an endeavor that requires research and validation with potential users. The information needs to be perceived as trustworthy and reliable, in order to promote people's ability to make informed decisions about their health. This article focuses on understanding the potential of conversational user interfaces featuring digital humans as communication agents to provide healthcare-related information to users. The main insights inform whether this interaction style can provide a higher level of accessibility and engagement for users, thus creating a better user experience. Since digital humans are not yet extensively adopted in the healthcare domain, few design guidelines are available. The work followed the human-centered design approach to gather requirements and feedback from users. This led to defining six guidelines and an extensive set of observations about user experience and accessibility.**

Keywords- e-Health, accessibility, user experience, digital humans, conversational user interfaces

I. INTRODUCTION

Digital healthcare services are steadily developing and growing, with an increasing number of people relying on them to manage and monitor their health. However, these services often show low adoption rates and fail to meet their goals. One of the main causes of low adoption rates is the failure to meet patients and healthcare professionals' needs and expectations, due to a lack of understanding of requirements from designers and developers [1]. Other factors that hinder the adoption of e-Health services include usability issues, privacy concerns, culture, and flow disruption [2]. The involvement of patients in the design of e-Health services allows creating a better user experience and is crucial to achieve acceptability and adoption.

When a user is engaging with healthcare systems or services, the most appropriate term is "patient experience", rather than "user experience". The Beryl Institute defines PX as "the sum of all interactions shaped by an organization's culture that influence patient perceptions across the continuum of care" [3]. Changing the term from "user" to "patient" allows considering healthcare-specific concepts, such as health literacy. Research has shown that a positive patient experience is one of the strongest indicators of patient retention and adherence to therapy [4]. For this reason, patient experience becomes one of the main measures of the quality of healthcare systems and products.

e-Health services can make healthcare more accessible to everyone, and thus serve the needs of both patients and healthcare professionals and providers. To achieve this, it is crucial to provide information that is reliable and accurate to the patients. In recent years, the trend of patients turning to other patients and to the internet to find health-related information has seen an increase [5]. Despite the benefits that finding comfort and empathy from others in similar situations can bring, it is crucial to ensure that people have access to reliable and scientific information, and that they are redirected to a professional whenever it is needed.

The research took place within a specific case study proposed by Roche. The company wanted to redesign an informational ophthalmology website to feature a digital human substituting the traditional text-based website. The goal of the redesign was to make the content accessible and available to all users, regardless of their visual acuity level. The scope of the website is to provide informative material about eye conditions, how to recognize them and how to act accordingly.

Low vision and vision impairments is a global health concern: the World Health Organization [6] reports that over 2.2 billion people are living with a form of visual impairment. Additionally, Tham et al. [7] explain that ophthalmology is one of the medical fields that is most lagging in terms of digitalization and e-Health services. This generally led to the ophthalmology sector not being ready nor able to face the COVID-19 crisis. The authors believe that there is potential to develop a more digital approach to ophthalmology. e-Health services aim at extending the scope of healthcare provision [8]. To achieve this, it is crucial to provide information that is reliable and accurate to the patients.

This research activity was conducted as Master thesis work of the main author, and extensive information can be found in the original document submitted at Aalto University [9]. focused on the following research problem: e-Health services aiming at providing valuable and reliable information to potential patients often fail to be emotionally supportive and informative for people who are starting to explore the implications of health conditions.

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Following this, two research questions were formulated to guide the research.

- RQ1: Based on empirical research using human-centred design methods, can conversational user interfaces featuring digital humans help make e-Health services more accessible for patients with vision defects, to provide them with the information they need and with emotional support?
- RQ2: What guidelines can be suggested to foster the improvement of the accessibility and emotional support of e-Health services through conversational interaction?

Emotional support is a crucial aspect to consider when designing e-Health services. In fact, medical interventions are most likely to be successful when the doctors are emotionally supportive and friendly, and when they treat the patient as a peer [10]. The literature shows that, if properly designed and implemented, the natural language-based interaction can increase engagement and lead to improved patient experience [11]. However, it is important to note that conversational agents can set higher expectations from the users due to their realistic nature, which can also result in higher levels of frustration if these expectations are not met [12].

User research with people living with low vision and their caregivers was conducted to understand whether using conversational user interfaces featuring digital humans can provide a more accessible interaction modality. A list of guidelines and best practices was created to help designers approach conversational user interfaces featuring digital humans.

II. METHODOLOGY

A. User groups

Courage and Baxter [13] define three groups of users, based on the impact that the product has on them. The first group, primary users, interacts with the service, and benefits directly from the interaction. Secondary users might not interact with the service themselves, but nonetheless benefit from primary users' interactions, or they can influence these interactions. Finally, tertiary users are people or organizations who have decision power on whether to start using a service, and thus indirectly benefit from its usage. Figure 1 shows the division of the user groups that were considered in this case study.

Primary users include people who are starting to experience a decline in their vision and want to gather information about eye conditions and the caregivers of people living with these conditions. Another potential primary user group is composed by people who have not yet started experiencing vision decline, who nonetheless heard about it and want to gather more information.

Secondary users are healthcare professionals, who might benefit from the service because it relieves them from some work burden, as it can act as a first informative encounter for patients.

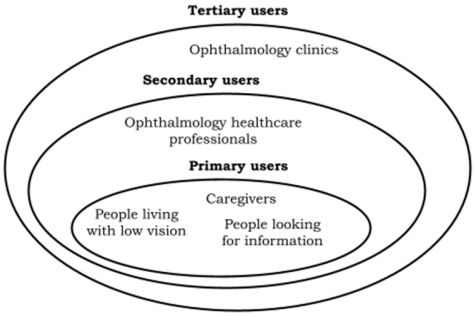

Figure 1 User groups

Tertiary users include ophthalmology clinics, which will benefit from their healthcare professionals having more quality time to dedicate to patients.

B. Research activities focus

The research evaluated several aspects of the CUI-based interface approach. The overarching goal was to ensure that the digital human can be a valuable agent to con-vey health-related information. It evaluated the usability of the conversational user interface. In order to focus the scope of the research, the ergonomic criteria presented by Bastien and Scapin [14] were adopted. In particular, the research focused on the criteria of guidance, workload, explicit control, error management and consistency. The research additionally focused on the accessibility of the conversational user inter-face. Finally, the research investigated the digital human's ability to enhance the emotional engagement and support of users receiving information about eye conditions.

In order to provide a positive experience and a pleasant interaction, the digital human should be perceived as empathic, engaging, and trustworthy. In fact, the relationship between the digital human and the user should be based on trust, to ensure acceptance of the information and the ability to act on it.

A good entry point to building trust in the digital human is having affinity between the agent and the user. Affinity with a digital agent is influenced by the perceived realism of the interaction. A project featuring digital human agents must focus on creating an experience that gives the users the impression that they are interacting with a real person [15]. To achieve this, the interaction between the person and the agent must not trigger the so-called uncanny valley effect, a negative feeling of eeriness and discomfort when interacting with human-resembling characters [16]. The uncanny valley effect theory explains that increased realism and anthropomorphism increase the affinity level that a person perceives for a digital agent. However, there is a point (the uncanny valley), where the resemblance to a real human is very high, but not high enough to be pleasant. This causes feelings of eeriness and discomfort in the users, which then leads to unpleasant experiences with the agent. Movement reinforces this effect: moving stimuli cause a much stronger effect compared to still ones [16].

This effect could strongly impact the users' perceptions of the trustworthiness and reliability of the service. The

overarching goal of the research presented in this article was to ensure that the digital human can be a valuable agent for conveying health-related information.

C. Methodology and participants

Figure 2 shows the interface presented to the participants. The digital human occupies the middle of the screen. On the top left corner there is an accessibility menu, on the bottom left corner a backward button and, on the bottom right corner, a forward button. The white band in the middle shows visual feedback of the captured words when the user is speaking. Next to the forward button, the options among which the users can choose are displayed. The buttons are in grey for non-available content and in orange for available content.

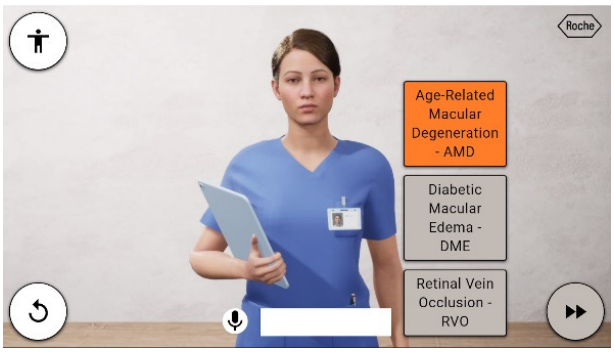

Figure 2 Interface

The interface that the participants interacted with was a high-fidelity horizontal prototype. This means that almost all the functionalities that the final product should contain were developed to a certain extent:

- It was possible to use speech interaction, but only to choose among the presented options, and not to freely interact with the digital human.
- Out of the three conditions that were meant to be addressed in the service, only one flow was working.
- The accessibility options could be explored, but only the text size control worked.

This resulted in the need to give a quite strict and detailed scenario to the participants, for them not to incur in dead ends or errors and to avoid unnecessary frustration.

The chosen research methodology was participant observation, paired with follow-up semi-structured interviews. This methodology is well-suited for the use case because it allows observing how users would naturally interact with the system on the first time that they access it. This article will focus on the user research results, which informed the six guidelines' design.

A total of eighteen participants was recruited. Fourteen of them were recruited through Roche's Patient Advisory board, and ten of them took part in one-on-one interviews. Four more participants were recruited through usertesting.com. Twelve people were living with low vision; six were caregivers or people involved in prevention and advocacy for low vision conditions. Six people were not visually impaired, six were mildly impaired, and six were severely impaired, meaning they could see very little, and three used screen readers.

67% of the participants were older than 50 years of age. This distribution represents the potential target group for an informative ophthalmology service. However, most of the participants were quite knowledgeable about eye conditions, which is not expected from potential service users. Besides this, the target group of this service would generally not be highly visually impaired but looking for more information about eye conditions.

None of the participants had used the service before, thus allowing to investigate discoverability and learnability. This also resulted in the participants having a homogeneous familiarity level with the service, making results more consistent.

The results presented in this article derive from the combination of the fourteen one-on-one calls evaluating the prototype with potential users and two focus groups organized afterwards. The one-on-one calls panel featured ten Patient Advisory board members and four people recruited through usertesting.com. The four usertesting.com participants did not join the focus groups, but four more Patient Advisory board members were involved in this phase. This means that a total of fourteen participants were recruited for both sessions. The focus groups were organized in two rounds: six participants took part in the first focus group and eight participants in the second.

III. Results

The sessions produced sixty-two items (individual observations and comments), both negative and positive, which exemplify the perceptions of the participants' panel. These items were then aggregated and will be presented here in the form of insights, divided in the different aspects that were taken into consideration. These aspects are:

- Usability and guidance: the overall appreciation level of the functionalities of the service and its ability to instruct the users on how to navigate it.
- Accessibility: with a focus on low-vision participants.
- Content, trustworthiness and reliability: quality of the presented content and people's level of trust for the information coming from the digital agent. This aspect is particularly important given the nature of the information provided.
- Emotional support: people's feeling of investment towards the digital human's speech, and the perceived support from the agent.
- Perception of realism: people's perception of the realism of the interaction. This is linked to the Uncanny Valley effect, which might hinder a positive experience with the digital human.

The participants were given a clear scenario and the unavailable content was marked. They were asked to gather more information about a specific eye condition, and they were free to go through the content in the way that they preferred

(interacting through speech or using buttons). The digital human told some information at every step and then allowed the user to select a path by presenting options.

A. *Usability and guidance*

Two participants reported that the current guidance may not be sufficient for people looking for generic information, meaning users who are not knowledgeable about eye conditions. For this reason, several participants encouraged allowing users to start the navigation from the symptoms. People's personal situations and experiences should be a focus when creating an e-Health service.

The participants noted that the available options and the digital human's speech must not create dissonance. This means that they should be consistent and not confusing. An unclear situation was when the digital human mentioned the eye conditions' names before allowing the users to select one of them. This situation was specifically problematic for visually impaired participants using screen readers, who could not read the options labels and solely rely on the spoken guidance. The research session showed the need for careful design of the options presented.

Three participants remarked that the list of options available at each stage of the interaction was very long. The number of options and their quite complex names make it hard to remember the label for the one to choose. The spoken text should therefore be as short as possible when presenting options. Besides, options should be selectable by number or synchronously with the speech. This means that, when the options are presented, the interface should respond to speech commands such as "this one" or "the first option". Finally, options must be available for restatement at any time.

About 20% of the participants questioned whether the user group of people older than seventy years would be able to use the service, meaning whether they could operate the website and know how to interact with the digital human. This user group could make up a big portion of the intended users, since many eye conditions onset in late life stages. More research would be needed to explore this topic, involving less educated and technically skilled participants.

B. *Accessibility*

Many of the accessibility issues that were found came from people who were using screen readers or struggled to see the screen in any other way.

As discussed in the previous section, screen reader users struggled the most with presenting options. However, the combination of the digital human's speech and the screen reader listing the different buttons on the screen seemed to work fine. Screen reader users need the assistive technology and appreciate it, so it is not advisable to disable it or force the users not to use it.

One participant said: *"I like my screen reader because I'm now used to the way it speaks. At the beginning I was skeptical about this service for this reason. But after trying it, I have to say I really enjoyed it and I would prefer it over the screen reader"*. Despite this very positive feedback, there was no clear consensus across participants about the added value of the digital human over the screen readers. Some participants said they would prefer to get information from a plain text website using their screen reader because it might be more efficient, while others appreciated the interaction with the digital human.

The research session showed that the possibility of pausing the conversation is a fundamental feature of this kind of service. Some participants reported that they might want to take notes or talk to someone else, but without pausing, they could not do it because they would miss content. Besides this, some participants reported that the service should provide the possibility to enable and disable the speech recognition.

Participants appreciated the flexibility provided by having both speech interaction and buttons. Three participants reported that providing users with as many options as possible is crucial to cater to different preferences and needs.

C. *Content, trustworthiness and reliability*

In general, the digital human seemed to inspire the impressions and feelings that the team envisioned. Participants perceived the digital human as trustworthy, knowledgeable, invested, and friendly. This suggests that people are likely to build a positive relationship with the digital human, and that they would trust it. In fact, the participants reported that they consider the information reliable.

Over 75% of the participants were highly educated in the field of eye conditions. For this reason, they reported that the level of depth of the content would not be very suitable for them, but that it would have been perfect for someone who is just starting to approach eye conditions for the first time. Almost all participants reported that the service should provide the possibility to go into detail to cater to users with different knowledge levels. For example, they wished to receive more daily life coping suggestions.

D. *Emotional support and engagement*

About 70% of the participants reported that they found the conversation engaging. One participant said that had there been more content, they "would have liked to explore more". This was not the only positive content in this sense, with another person saying they were *"kind of hooked into it"*.

About 20% of the participants explicitly reported that the DH version of an informative service would be *"less impersonal"* than plain written text. Some participants mentioned that it looked like the digital human was invested and interested in what they were saying.

However, the two focus groups gave very different and contrasting results regarding emotional support, making it hard to draw overarching conclusions. The general trend seems to be that the digital human can provide a generic form of emotional support better than plain text but that the core of the emotional support work should be left to real humans. One participant explained that it would be beneficial to have testimonials from other patients, but that this cannot be provided by the DH, which needs to *"step aside"* and leave space for videos of real people to convey this kind of information.

E. Perception of realism (Uncanny Valley effect)

Most participants (about 90%) considered the voice realistic enough to be both engaging and informative. Sighted participants reported that the digital human looked realistic, up to the point that one participant said that the digital human *"made her feel like she was real"*. Two participants said that they did not like the experience, but there seemed to be no evidence of a strong uncanny valley effect among the participants. The movements of digital humans are crucial to determine perceived realism but only one participant reported that they were distracted by the lack of syncing of the speech and the lips movements. Besides this, some participants did not like some of the movements that the DH was performing, especially while waiting (such as looking at an imaginary watch), because they felt like they were not respectful. These comments show the importance of carefully designing the movements of a digital human.

F. General insights

The results of the user research are encouraging to keep investigating the potential of digital humans and speech interaction to provide information about ophthalmic conditions. However, more work needs to be done to provide a completely accessible service that would answer the needs of all users. The main accomplishment of the case study service is that people consider it a reliable source of information that they would trust and listen to. This is a great achievement that contributes to moving towards the goal of informing people and fostering prevention.

IV. Discussion

A. Answers to RQ1

The results of the research suggest that people tend to react positively to a digital human conveying information about eye conditions. This type of agents seems to have the potential to provide more personalized explanations, which results in a deeper connection with the user. Users reported feeling *"as if someone was there with them"*. The concept was generally well accepted, despite the idea that this kind of interaction might not be for everyone.

People with high visual impairment generally appreciated being talked to rather than going through a static webpage. Caregivers also reported that it could have been beneficial to have this kind of service when their loved ones started to experience symptoms. A conversational user interface embodied by a digital human can provide personalization and a human touch, which people appreciate.

For people with a low-severity condition, speech interaction allows avoiding the fatigue from reading content on a screen. People living with a high-severity condition enjoy hearing a human-like voice instead of the more robotic screen reader's voice (albeit the latter being much faster and possibly more efficient). Furthermore, providing content optimized for listening and not for reading is an advantage because written content follows a generally more complex structure than spoken one.

In conclusion, conversational user interfaces using digital humans as communication agents appear to have great potential in providing users (especially low-vision users) with healthcare-related information. This information is perceived as factual and trustworthy, and the additional support that a conversational agent can provide is appreciated and can contribute to a better user experience.

B. Answers to RQ2

The research insights allowed building a set of six guidelines that designers and researchers should consider when creating a conversational user interface-based service. These guidelines are shown in Table 1.

TABLE I. Resulting guidelines

Code	Guideline
G1	Ensure that the digital human is as realistic as possible, not only in its looks, but also in its movements.
G2	Create a conversation flow that is clear and easy to follow. Do not use long sentences and reduce the language complexity as much as possible. Focus on UX writing.
G3	When presenting options, do it in the simplest and most rapid way possible, and allow users to listen to the options as many times as they want. Allow flexibility on how the options can be chosen.
G4	Ensure that a text version of the content is also available.
G5	Ensure that navigation is easy and as self-explanatory as possible.
G6	Ensure compatibility with assistive technologies and provide flexibility, personalization and integration.

1) Guideline 1

To provide a good user experience and smooth interaction, the digital human's appearance must be realistic in looks and movements. Movement appears to be a determinant for the perception of realism and therefore needs to be both fluid and plausible. The design of the digital human should not only focus on the fluidity of movements (which is utterly important), but also on their plausibility. This is well documented by Mori's work [14] and was observed during the tests.

One practical example from the case study is that when the digital human was waiting for the user to make a choice, she would scratch her head or look at her watch. This is something that no real human would ever do because it can easily be perceived as rude or inappropriate. It then results in a lower score in terms of realism.

2) Guideline 2

The content must be optimized for speech. The ways written and spoken content are structured are very different. For this reason, it is important to focus efforts on user experience writing to provide a conversational flow that feels natural to the listener, easy to understand, and provides all the necessary information.

Optimising content for speech allows to avoid flow disruptions, one of the main reasons for missed adoption and dropout of e-Health services [2].

3) Guideline 3

One factor that seems to play a major role in the perception of CUI is how options are presented and selected. Choosing among options must be as simple and as straightforward as possible to achieve a successful interaction. Choosing entails a high cognitive load for the receiver, who needs to remember all the options and then go through the decision process.

In spoken interaction, losing track of the different options and forgetting them is easy. The digital human must also be able to repeat the options as often as needed. Finally, it is extremely important to provide flexibility in choosing options. The conversational user interface should be trained to recognize synonyms, cardinal indications, partial answers, and answers synched to the speech. Implementing a good mechanism for choosing options allows to act on the ergonomic criteria of guidance, workload, explicit control [14]. This allows for much more natural interaction and, thus a better user experience.

4) Guideline 4

The service must provide a written version of the content as well as a spoken one. This can benefit users with hearing impairment, users who do not appreciate conversational user interfaces, and users who are in a hurry or already know what content they want to look for. Providing a text-based version of the content would greatly enhance the user-friendliness of the website, and it is a standard accessibility practice.

5) Guideline 5

One area of concern that needs to be addressed is the navigation of the service, especially when a lot of content organized on different topics is added to the information structure. It is worth considering whether it would be beneficial to have a menu, using standard navigation within the CUI.

Otherwise, navigation possibilities should be provided in another form, for example by requesting the DH to navigate to a different section. The ability to pause, go backward, and skip forwards in the digital human's speech is fundamental to providing a positive user experience because it allows flexibility. Speech commands should be intuitive and easy to trigger. This once again improves the flow of the interaction with the system, which is crucial to increase adoption and improve the user experience [2].

6) Guideline 6

Screen readers should not be disabled or discouraged during the interaction. For this reason, compatibility between the conversational user interface and assistive technologies should be the goal instead of complete substitution. The digital human is, in this case, an improvement of the user experience in that it makes the user feel like they are interacting with a more human entity, rather than to a digital system, which improves engagement [11].

However, the need for assistive technologies should be reduced as much as possible by providing self-explanatory ways to navigate and interact with the interface. The digital human's speech and the screen reader output should not be antagonizing one another but working synergically to provide the best user experience possible. This requires testing with users who regularly utilize screen readers to navigate digital services.

C. Limitations

The research has limitations that need to be acknowledged, and that can inform the planning of future research. In summary, the main methodological limitations are:

- The small number of participants in the user-based sessions.
- Their rather homogeneous demographics and background.
- The little availability of testable content, which impacts the ability to test how people would navigate the content and whether the information architecture could support meaningful exploration.
- The inability to run complete and thorough tests with a consistent group of primary users with lower technological skills, lower or no knowledge about eye conditions and starting to experience vision loss.

A qualitative study like the one performed in this case study relies on a small amount of in-depth data coming from individuals rather than a big sample of quantitative data. For this reason, future work should focus on incorporating quantitative analysis to complement the insights coming from a qualitative-based approach.

Acting on these limitations would provide more generalizable results, allowing for an experience that caters to all users' needs. Future research should be conducted to ensure that the concept of receiving healthcare-related information is well accepted by people who are not very skilled with digital services. Testing whether different cultural backgrounds or different age groups show different opinions about the experience could also provide valuable insights.

Future research is also needed to gauge the limits of the potential of CUIs and digital humans. Having a clear overview of the areas where the digital human cannot provide a positive user and patient experience is important for the development of similar services.

In general, more research is needed to be able to confidently affirm that CUIs using a digital human as a conversational agent are a good tool to provide healthcare-related information. Nonetheless, the results that have been presented in this article are encouraging and show the potential of such solutions.

V. CONCLUSIONS

This work focused on the case study suggested by Roche of re-imagining an ophthalmology patient's website to leverage a conversational user interface approach. The goal was to evaluate whether using a digital human as a conversational agent would provide a better user experience and higher emotional support to users looking for information about eye conditions. The case study allowed for a broader discussion about the potential that digital humans have in offering healthcare-related information. Understanding whether people would consider the information

coming from such an agent to be trustworthy and reliable is crucial for the success of this kind of services.

The research provides insights into the positive and negative aspects of having digital humans as agents in a conversational user interface. Users generally appreciated the concept: they found it engaging, trustworthy and easy to use. However, there are some aspects that could not be addressed during this research, and which need further understanding.

The primary areas that need to be addressed are guidance, navigation, and error management. Nonetheless, the positive feedback gathered from the participants of the evaluation sessions indicates that it is worth investing in the research and development of this relatively new services. In fact, the work showed that conversational user interfaces and digital humans have the potential to positively impact the user experience of informational websites providing healthcare-related content, both in terms of accessibility and engagement.

The six guidelines that resulted from the research activity give initial directions for designers and developers to build conversational user interface featuring digital humans. However, they will need to be complemented with other guidelines emerging from further research.

Future research should be conducted to ensure that the concept of receiving healthcare-related information is well accepted by people who are not very skilled with digital services. In fact, conversational user interfaces might have the potential to make websites more accessible for people who generally struggle with technology and the Internet, but this needs to be checked systematically, to provide a generalizable result. Besides this, conducting more quantitative research might be valuable to ensure that the appreciation of the interaction with digital humans can be proved through statistical evidence as well.

More research can also ensure the generalizability of the results, but the current outlook is positive. In fact, the results showed that the current level of technological ability to reproduce a human generally manages to provide a positive experience for users interacting with the agent. Besides this, people find the information trustworthy and reliable, which is crucial when conveying healthcare-related information.

Based on the results and insights collected through this research, e-Health services can leverage the capabilities of conversational user interfaces and digital humans to provide a better user experience.

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